

SNOWY MONARO REGIONAL COUNCIL

Kalkite

Infrastructure Study

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Executive Summary

This report is an infrastructure study that provides a summary of existing and recommended future infrastructure for Kalkite. It looks to facilitate a more streamlined planning process for driving the sustainable development. The township of Kalkite is currently experiencing high interest for growth partly as a result of a recent planning proposal to rezone land which would have added 220 lots south of the existing village. Additionally, an approved subdivision of 43 lots currently under construction is expanding the population of the village.

While Kalkite is not directly within the Snowy Mountains Special Activation Precinct (SAP), the Draft Settlement Strategy anticipates approximately 10% of future regional growth to occur in smaller villages like Kalkite. The Infrastructure Study's objectives are to support proactive development of these villages through strategic master planning. It assesses both the current and future capacity of essential infrastructure networks and recommends necessary augmentation to accommodate the anticipated population increase. The report includes an implementation plan with short-term, medium-term, and long-term infrastructure upgrade horizons. The study focuses on infrastructure needs within and surrounding Kalkite, a town situated approximately 21km southeast of Jindabyne and 56km southwest of Cooma, with one point of access via Kalkite Road. SMEC has been engaged by Snowy Monaro Regional Council (SMRC) to prepare an assessment of infrastructure needs to support the growth of Kalkite.

The recommendations and findings provided in this report have been developed in accordance with the potential population growth scenarios outlined in the Snowy Monaro Draft Settlement Strategy (the Draft Settlement Strategy) and specific guidance provided by SMRC. Under this strategy, Kalkite could potentially reach a population of 1,315 people by 2041 and as such there is a need to assess the capability and capacity of existing infrastructure.

This report provides an aspirational vision for the sustainable development of Kalkite and sees a variety of recommendations for traffic and transport, electricity, potable water supply, sewerage, and stormwater. The objectives of the Infrastructure Study are to provide a high-level guide for the Snowy Monaro Regional Council (SMRC) to undertake potential further steps of infrastructure planning and development such as:

- Enabling long-term financial planning through consideration of investments; and
- Understanding funding requirements and explore options for alternative (non-government) funding or arrangements.

Given the potential of Kalkite's population growth, staging and delivery is critical to understanding the required infrastructure upgrades, associated costs and trigger points to ensure infrastructure is provided inline with growth. This report commences with an introduction to the key features and challenges of the township and a summary of the know development applications (DA's) for key subdivisions. A baseline assessment of the infrastructure currently servicing Kalkite is then provided. This report then considers how infrastructure will need to be modified over time to accommodate the growth anticipated by the Draft Settlement Strategy and SMRC.

Kalkite's road network primarily relies on Kalkite Road as the main arterial route, connecting the town to key destinations and serving as the primary access road. Public transportation options are limited, with residents heavily dependent on private vehicles, resulting in traffic congestion and environmental concerns. The town's infrastructure currently lacks alternative transportation modes like cycling paths and dedicated walking routes, except for certain local roads. Notably, the Lake Jindabyne Shared Trail project is planned to provide a 60km trail network around the southern half of the lake, catering to various recreational activities and in the medium and long-term connecting Kalkite to Jindabyne through East Jindabyne, enhancing outdoor opportunities and visitor experiences in the region.



Figure 1: Aerial image of Kalkite (Metromap 2023)

Kalkite is serviced by two 132KV transmission lines from the Cooma substation and the town is facing some capacity constraints in the local electricity network. It is likely that new infill and greenfield subdivision developments will continue to place constraints on this system and a review of required upgrades has been provided.

Lake Jindabyne is Kalkite's main source of water. Raw water is pumped from the lake via submersible pumps which transfer water two (2) existing town reservoirs with 452KL of capacity. A large portion of Kalkite's water infrastructure network was laid in 1980s. A review of the Kalkite Water Infrastructure Study undertaken by Westlake Punnett provides detail of works required based on the hydraulic model for the current and future population predictions. The study notes that the existing water supply network is incapable of accommodating the required firefighting flows in the elevated areas of Banskia Avenue and Lotus Avenue. Potential solutions include either installing a continuously operating booster pump or constructing new elevated storage at an appropriate height to enhance service delivery to the local area via gravity.

It is expected that if further development of Kalkite takes place, it would result in an increase of stormwater runoff into lake Jindabyne with the potential to affect the lakes water quality. Future development needs to consider the entire water cycle through minimising hard surfaces and implementing Water Sensitive Urban Design (WSUD) principles. Several recommendation measures have been identified to address the existing stormwater issues and include asset management, maintenance and monitoring, and structural upgrades. It is recommended that a mainstream and overland flood study is undertaken for the township to better understand the flood behaviour of Taylor's Creek and the capacity of the existing drainage system.

When developing these recommendations, we have sought to limit over capitalisation of unnecessary infrastructure to build flexibility into the network and ensure that SMRC can be responsive to the needs of Kalkite as the town develops and grows further. The infrastructure recommendations provided in this report intend to guide SMRC in the planning and preparation of specific infrastructure upgrades.

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Glossary

AEP	Annual Exceedance Probability
AADT	Annual Daily Traffic
ADWF	Average Daily Dry Weather Inflow
DA	Development Application
DCP	Development Control Plan
EE	Essential Energy
FPA	Flood Planning Area
FPL	Flood Planning Level
LEP	Local Environment Plan
LGA	Local Government Area
LSPS	Local Strategic Planning Statement
PRSR	Preliminary Route Safety Review
PCT	Plant Community Type
PMF	Probable Maximum Flood
RFS	Rural Fire Services
SES	State Emergency Service
SMRC	Snowy Monaro Regional Council
TEC	Threatened Ecological Community
TfNSW	Transport for New South Wales
TWL	Top Water Level
WSUD	Water Sensitive Urban Design
WWTP	Waste Water Treatment Plant



Project Background

1. Project Background

1.1. Project Introduction

This report provides a summary of the current network conditions of existing infrastructure and outlines necessary upgrades that will support a more informed planning process that in-turn looks to facilitate the sustainable growth of Kalkite.

SMEC has been engaged by Snowy Monaro Regional Council (SMRC) to prepare an assessment of infrastructure needs. This report provides an assessment of the existing (baseline) conditions relating to infrastructure within and surrounding Kalkite. Through targeted consultation with SMRC and State stakeholders, a picture of future planning infrastructure is summarised. Considering the potential future populations provided in the Snowy Monaro Draft Settlement Strategy (the Draft Settlement Strategy), an assessment of future demand has been completed to determine the following:

- Required infrastructure network upgrades to service the additional demand anticipated by development across electricity, potable water supply, sewer, and stormwater.
- Focused attention is given to the Kalkite Road with a safety and compliance audit being undertaken by the project that identifies areas of possible risk to safety or non-conformities to modern road standards.

Kalkite is located approximately 21km southeast of Jindabyne and 56km southwest of Cooma and has one point of access via Kalkite Road. Expanded employment opportunities in the region, particularly Snowy Hydro 2.0 and the Snowy Mountains Special Activation Precinct (SAP), are also driving increased demand for housing.

The report commences with an introduction to the key challenges, attributes and opportunities of Kalkite, and then provides a baseline analysis of existing infrastructure (transport network, electricity, water, sewerage and stormwater) currently servicing the town. The report then considers how infrastructure will need to be modified over time to accommodate potential growth anticipated by the the Draft Settlement Strategy. Kalkite could reach a population of 1,315 people by 2041 representing an 126% increase from the 2021 population.

The future possible growth of Kalkite looks to be delivered ,primarily through major developments either planned or currently underway. One such development is the the 3-Rivers development - 43 lot subdivision. A Planning Proposal has previously been lodged to rezone land from RU1 Primary Production to RU5 Village and C4 Environmental Living. It would have delivered 220 lots to Kalkite.

However, the proposal was resolved by Council to not proceed at the November 16th, 2023 Council meeting.

An approved subdivision located east of Kalkite - 3 River has provided an additional 43 lots. The Draft Settlement Strategy notes that whilst Kalkite is not incorporated within the Snowy Mountains SAP, approximately 10% of growth is expected to occur outside of Jindabyne in smaller villages such as Kalkite.

Further analysis and recommendations have been made in consideration of the expected population growth to ensure that infrastructure is of sufficient capacity to meet the demands of future residents. With increasing development interest in Kalkite, there is a need to understand the capacity of essential infrastructure and plan for augmentation to provide certainty and confidence for the sustainable development of the town.



Figure 2: Kalkite Road looking east towards Kalkite

1.2. Project Objectives

The Infrastructure Study provides an opportunity to proactively assist the development of Kalkite through strategic infrastructure planning. The focus of this report is to review the existing and future capacity of existing infrastructure networks (transport, water, sewer, power etc) and recommend necessary additional augmentation required to support the anticipated population increases. This report includes an assessment of current (baseline) conditions to develop an understanding of infrastructure investment that may be required to support the projected population of Kalkite and support opportunities for residential development. An implementation plan is provided which introduces planning horizons for infrastructure upgrades over the short term (less than 4 years), medium term (4 to 8 years), and long term (8+ years).

1.3. Report Objectives

The objective of this report is to disseminate the technical assessment, consultation and desktop studies conducted in this engagement in a succinct and clear manner. This report will provide a high-level guide for SMRC to undertake potential further steps of infrastructure planning and development such as:

- Enabling long-term financial planning through consideration of infrastructure investments in the 20-year planning horizon; and
- Understanding funding requirements and explore options for alternative (non-government) funding or arrangement.
- The areas of infrastructure assessment include:
  - Transport and access
  - Power
  - Potable Water
  - Sewer
- A stormwater management strategy for the township
- Assess the safety of Kalkite Road

Project Background

1.4. Project Location and Key Features

Kalkite is located in the Snowy Monaro Local Government Area (LGA) approximately 21km north of Jindabyne and 56km southwest of Cooma along the eastern shore of Lake Jindabyne. The topography rises steeply to the west of the township where the Kalkite Waste Water Treatment Plant is located. Primary access to Kalkite is provided by Kalkite Road which is a dual lane sealed road connecting to Kosciuszko Road (via Eucumbene Road), which runs in a north-south direction approximately 5km east of the township. An alternative access route between Berridale and Kalkite is provided via Hilltop Road.

The township of Kalkite is small and primarily consists of single and two storey residential dwellings with some tourist accommodation. There are currently no commercial or retail land uses within the township and residents rely heavily on the services provided by Jindabyne and Cooma.



Figure 3: Kalkite township water supply [Site Visit: 01]

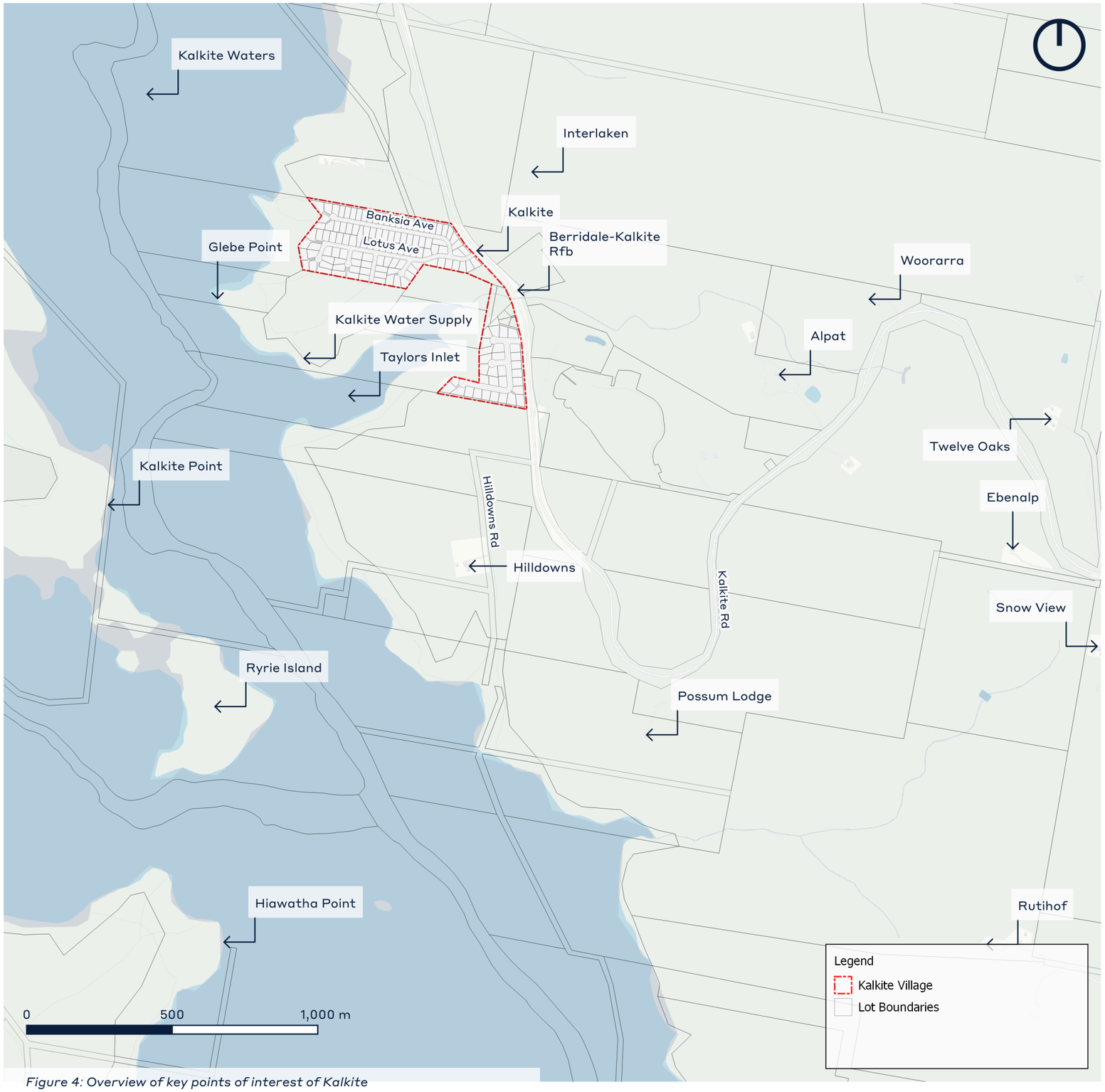


Figure 4: Overview of key points of interest of Kalkite

Project Background

1.5. Site Visit



Figure 5: View of Kalkite township from Kalkite Road [Site Visit: 02]



Figure 7: View of future development site on Kalkite Road [Site Visit: 03]

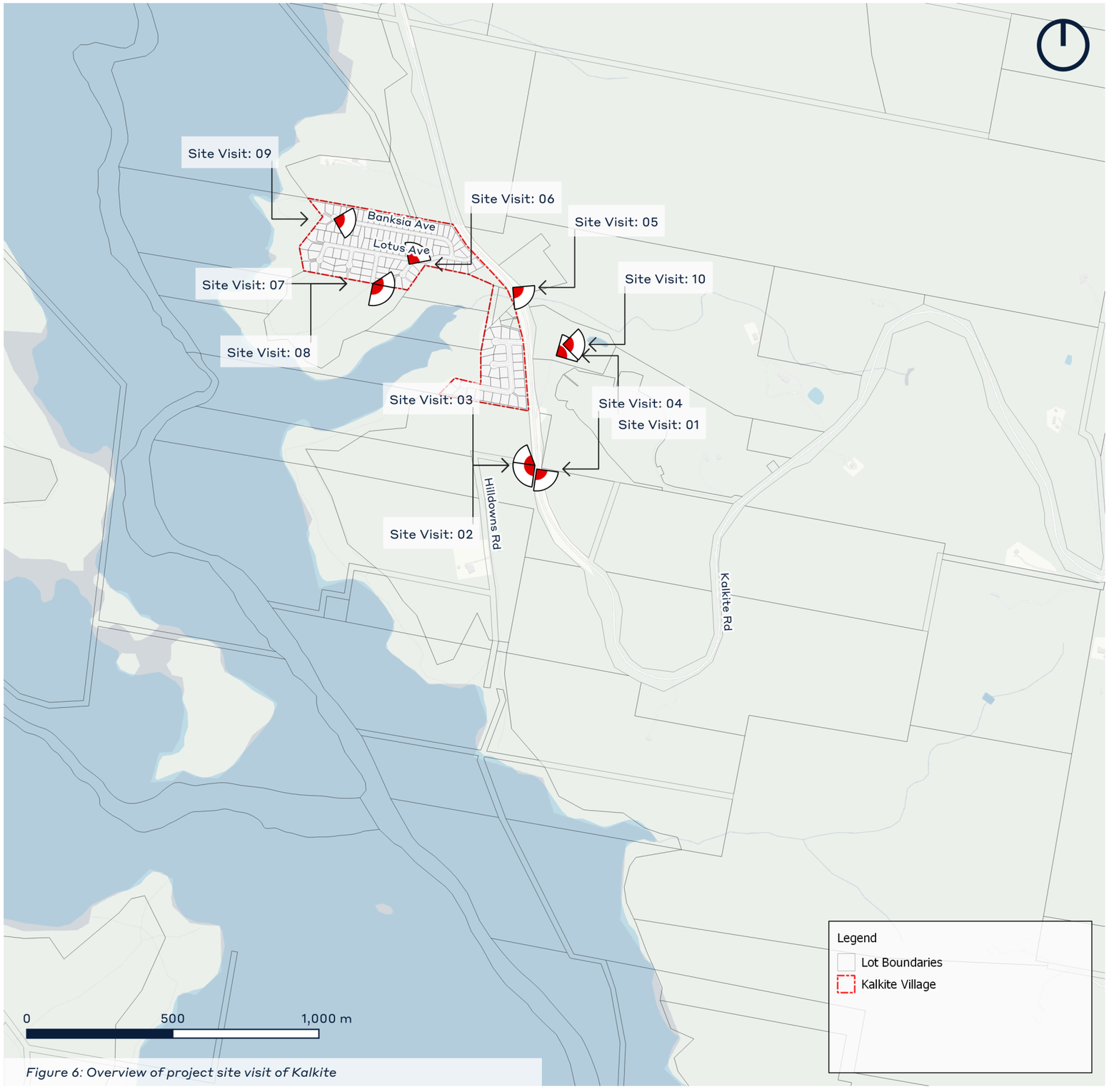


Figure 6: Overview of project site visit of Kalkite

Project Background



Figure 8: View looking west along Kalkite Road [Site Visit: 04]



Figure 9: View of Kalkite's RFS shed on Kalkite Road [Site Visit: 05]



Figure 10: View of Lotus Ave from Nemesia Ct [Site Visit: 06]



Figure 11: View looking south on Nemesia Ct [Site Visit: 07]



Figure 12: View looking south on Nemesia Ct [Site Visit: 08]



Figure 13: View looking east on Banksia Ave [Site Visit: 09]

Project Background

1.6. Key attributes, opportunities and challenges

Kalkite is located at an elevation of approximately 1,063 metres above sea level and boasts a temperate climate characterised by cool to cold winters and mild summers. The township is framed by Lake Jindabyne to the west and transitions to rolling hills to the east which showcase a diverse range of flora and fauna across distinct vegetation zones. A small waterway, Taylors Creek, runs through the centre of the township and forms a distinct divide between the two clusters of urban land that make up Kalkite. Further to the west and beyond Lake Jindabyne, the steep slopes of the Great Dividing Range provide a prominent feature within western viewsheds.

Kalkite is considered a competitive location for the provision of additional residential housing given it is within commuting distance to the employment and commercial services provided by nearby Jindabyne. The alpine ski resorts of Thredbo, Perisher and Charlottes Pass are also located within close proximity and offer year-round attractions for tourists. A number of visitor accommodation services existing within the town that support the alpine tourism industry and as well as the opportunities for water sports provided by Lake Jindabyne.



Figure 14: Aerial of Kalkite (Henley Property 2023)

Project Background

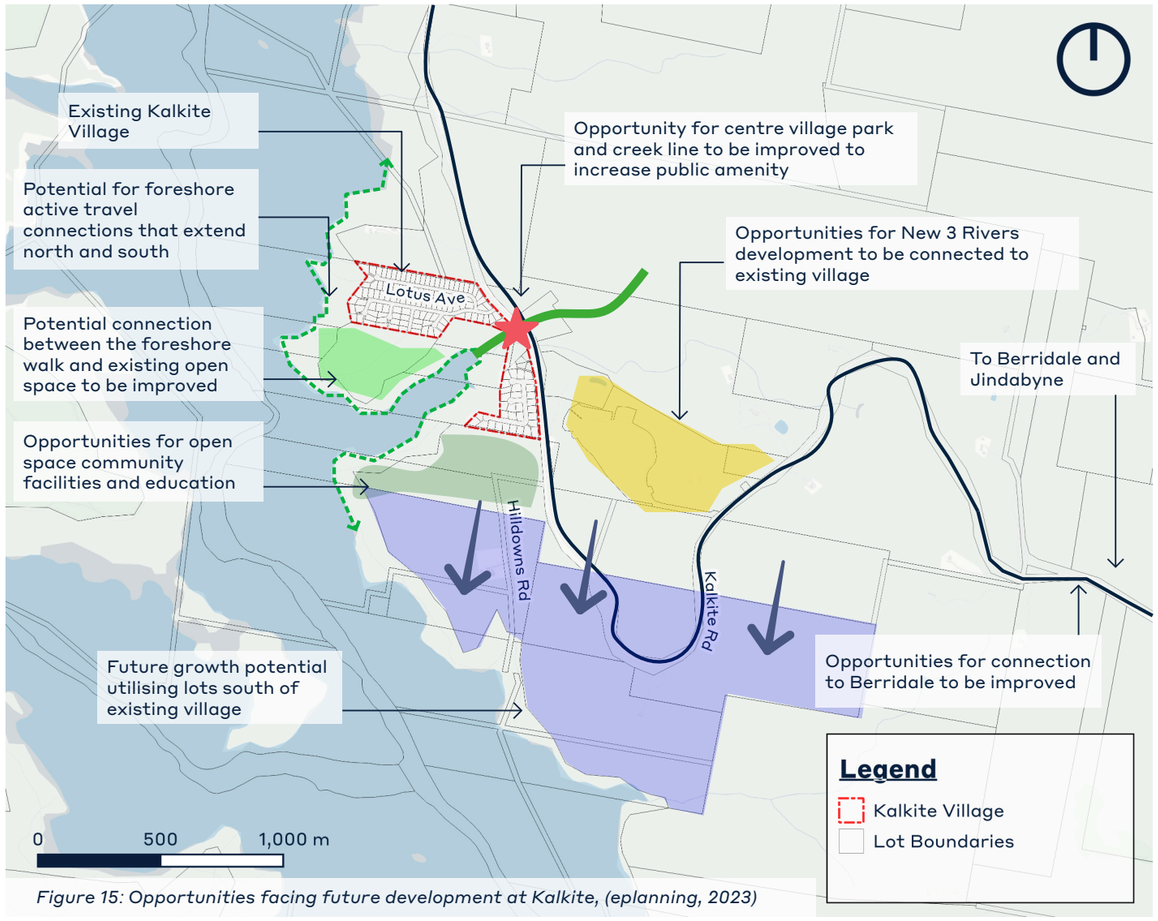


Figure 15: Opportunities facing future development at Kalkite, (eplanning, 2023)

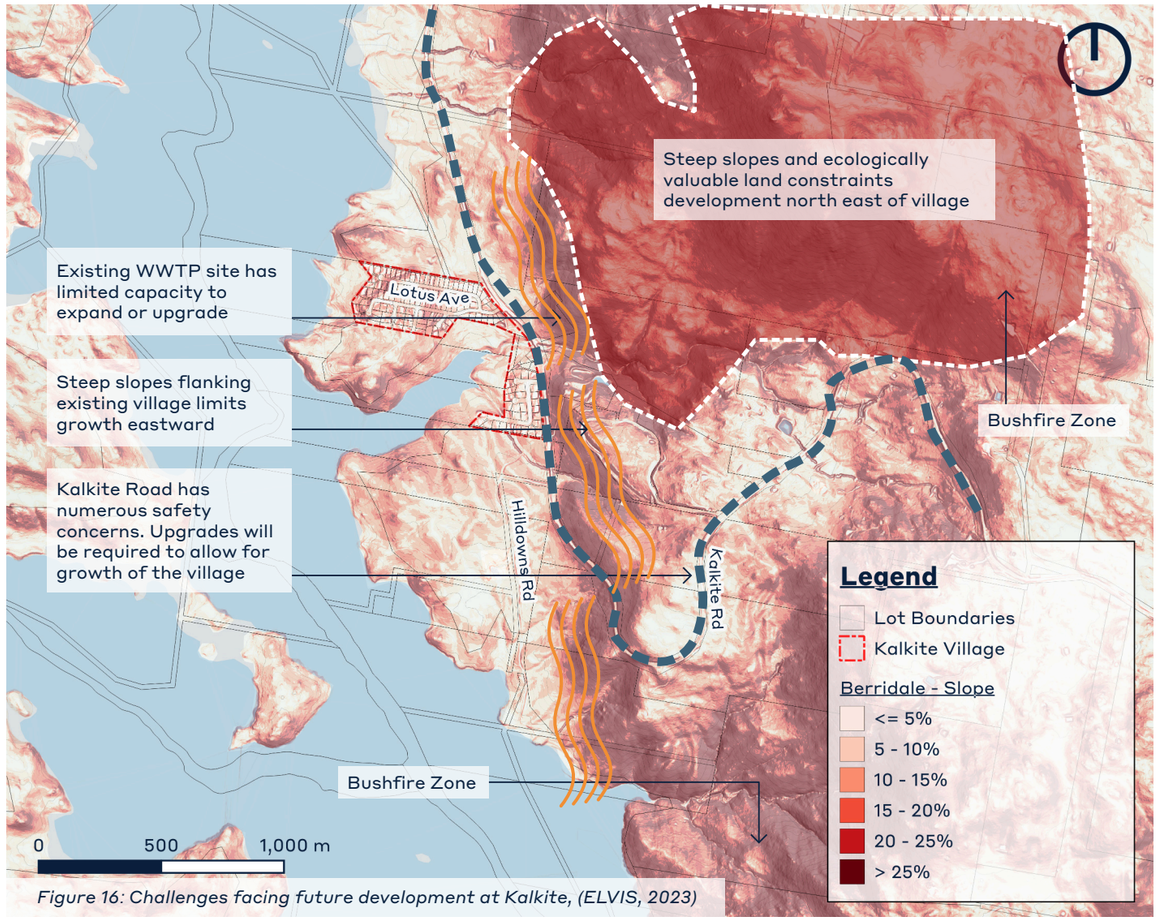


Figure 16: Challenges facing future development at Kalkite, (ELVIS, 2023)

1.6.1. Opportunities

- Given Kalkite's close proximity to nearby regional centres and the tourism and recreational opportunities provided by the surrounding region, there are multiple opportunities available to continue supporting local industries in Kalkite, as well as to provide additional housing for the region.
- Lake Jindabyne is arguably Kalkite's most prominent feature with the majority of existing dwellings and some short stay accommodation located within easy walking distance. It is noted that there is a distinct lack of existing infrastructure, including formal pedestrian access points and amenities along the foreshore of the lake within the township. One existing access point is located approximately 2 km north of the town and is identified as the Kalkite Boat Ramp providing access to the lake for boating and recreation. Further opportunities to increase utilisation of the lake, particularly during the summer months should be explored.
- The Draft Settlement Strategy notes the opportunity to extend trails and recreational facilities to connect Jindabyne and Kalkite and increase tourism which could also result in smaller scale retail and commercial activity to support tourism which is currently lacking.

1.6.2. Challenges

- There are several constraints which will need to be addressed and managed to ensure that the expected growth of Kalkite occurs sustainably. Kalkite is surrounded by land identified as being bushfire prone (Category 1 and 3) reflecting the extent of grassland and native vegetation surrounding the town, particularly to the east. It is noted that whilst grasslands pose a significant fire risk these risks can be appropriately managed through land management processes meaning that residential development on Category 3 land could be supported.
- Kalkite is currently only serviced by Kalkite Road. The road is steep due to the surrounding terrain and has poor visibility, pavement conditions and grades in some sections raising challenges for existing and future residents as well as for emergency service vehicles. An increase to the number of residents in Kalkite may cause further challenges to the capacity of Kalkite Road unless upgrade works are undertaken.
- Kalkite also has some capacity constraints in the local electricity networks. Electricity is supplied to Berridale from the Jindabyne East Zone Substation. The JYE3B2 feeder supplies power to both Berridale and Kalkite. Consultation with Essential Energy (EE) revealed that the construction of an additional 214 lots associated with the current planning proposal would necessitate the construction of a dedicated feeder for Kalkite.

Project Background

1.7. Populations and Demographics

1.7.1. Historical and Current

According to 2016 Census data from the ABS, Kalkite had a population of 214 people in 2016 which increased by 80 people to a total population of 294 by 2021. There has been an increase in the number of occupied private dwellings with an average number of 2.6 people per household. As there is limited residential subdivisions in Kalkite, the increase in the number of occupied dwellings suggests infill development or development in the rural areas surrounding the township. The number of people aged between 0 to 14 years and 25 to 44 years has increased, as well as the number of families living in Kalkite.

Most dwellings in Kalkite are separate houses, with a smaller number of semi-detached, row or townhouse dwellings. The home ownership rate in Kalkite was relatively high, with a significant proportion of residents owning their homes outright or with a mortgage.

Table 1: Population socio-demographic statistics

Kalkite – population socio-demographic profile (ABS)			
Metrics	**2016 Census**	**2021 Census**	**% Change**
People	214	294	37.4%
Families	60	70	16.7%
Age			
0 to 14 years	18.6%	20%	7.5%
15 to 24 years	8.8%	10.5%	19.3%
25 to 44 years	24.2%	32.3%	33.5%
45 to 54 years	12.6%	14.9%	18.3%
55 to 64 years	12.6	8.1	-35.7%
65+	23.8%	16.6%	-30.3%
Households			
Occupied private dwellings	77	103	33.8%
Dwellings not occupied	46	64	39.1%
Average no. of bedrooms per dwelling	3.3	3.2	-3.0%
Average no. of people per household	2.6	2.6	0.0%
Type of house			
Separate house	74	97	31.1%
Semi-detached, row or terrace house, townhouse etc	3	3	0.0%
Flat or apartment	0	0	Nil
Other	0	0	Nil

1.7.2. Population projections

SMRC's Draft Settlements Strategy and ABS Census data show a trend of increasing population in the Kalkite area partly as a result of expanded employment opportunities in the region and the townships proximity to Jindabyne. Projects such as the Snowy Mountains SAP and Snowy 2.0 are likely to continue to deliver employment opportunities for the region and increase demand for housing. Kalkites proximity to Jindabyne and Cooma make it an attractive option for the location of additional housing and short-term accommodation.

For this infrastructure study a planning horizon of 2041 has been adopted. It has been separated into 10-year ranges and presents a linear growth for the purposes of future infrastructure.

Future population data provided by the SMRC outlines the population growth scenarios for Kalkite and surrounding areas. SMRC's main growth scenario shows Kalkite is expected to grow from the current population of 297 (ABS, 2016) to a future potential population of 1,315 by 2041.

Table 2: Population forecasting statistics (abs, SMRC, 2023)

	2016 Census	2021 Census	2031	2041
Population	214	297	625	1,315
Year on year % change	-	6.8%	7.7%	6.7%

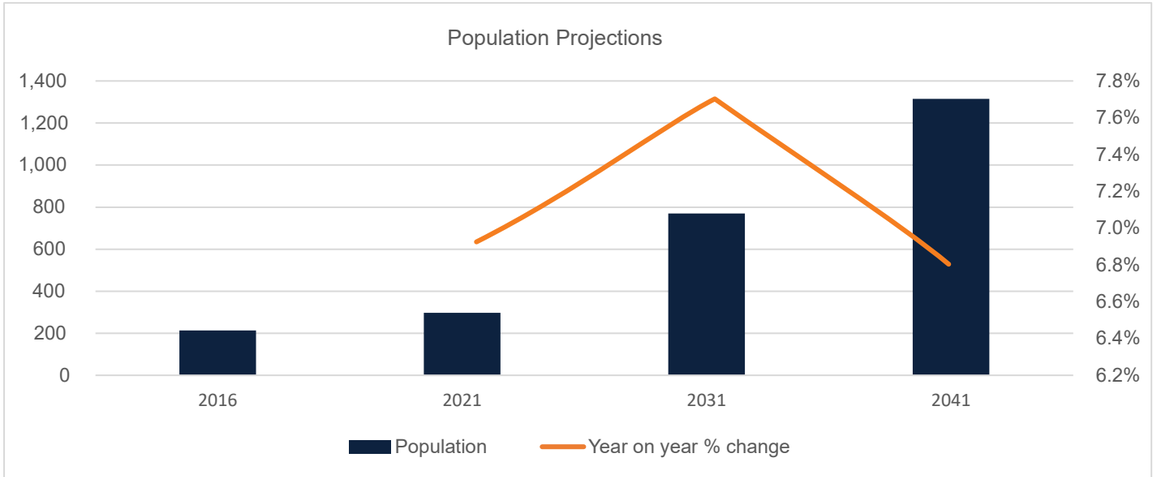


Figure 17: Kalkite population projections through to 2041

Project Background

1.7.3. Industry and Employment

Comparison between 2016 and 2021 Census data on industry and employment in Kalkite is important to help identity the services and infrastructure required to support local employment industries. The 2021 Census data shows an increase in people undertaking work as Community and Personal Services Workers, as well in Clerical and Administrative. In general, there is a decrease in the number of people undertaking work in sales and labourers.

It is noted that the 2021 Census was conducted during the COVID-19 pandemic and these results may reflect lockdowns or restricted movements, including the steep increase in the number of people working from home in 2021.

Table 3: Kalkite Industry and Employment Profile

Industry and Employment profile (ABS)			
Metrics	**2016 Census**	**2021 Census**	**% Change**
Industry of employment			
Technicians and Trades	14.2%	14.2%	0.0%
Professionals	11.5%	10.1%	-12.2%
Community and Personal Service Workers	15%	18.9%	26.0%
Managers	21.2%	19.6%	-7.5%
Labourers	11.5%	9.5%	-17.4%
Clerical and Administrative	10.6%	13.5%	27.4%
Sales	10.6%	6.8%	-35.8%
Machinery Operators and Drivers	5.3%	7.4%	39.6%
Mode of travel to employment			
Worked at home	9.3%	14.9%	60.2%
Walked	2.8%	0%	-100.0%
Car (either as passenger or driver)	79.6%	68.9%	-13.4%
Public transport	0%	0%	0
Other	N/A	9.5%	0

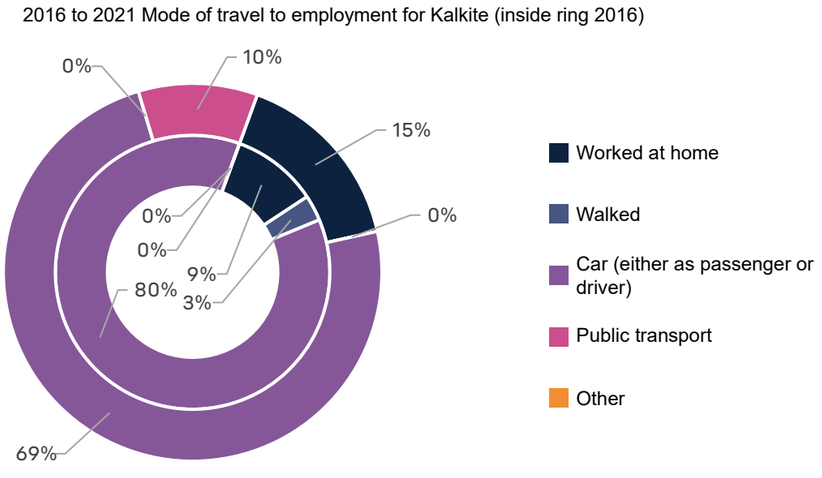


Figure 18: Mode of travel to employment for Kalkite

1.8. Stakeholder consultation

Targeted stakeholder engagement and consultation play a pivotal role in infrastructure planning, serving as fundamental pillars for successful and sustainable projects. By involving relevant stakeholders, such as local communities, businesses, and governmental bodies, valuable insights and perspectives can be gained, ensuring that infrastructure projects align with the specific needs and aspirations of the people they will directly impact.

This inclusive approach fosters transparency, builds trust, and reduces the likelihood of conflicts and resistance during the project's execution. Furthermore, engaging stakeholders early in the planning process allows for the identification of potential challenges and opportunities that might have been overlooked otherwise. It also enhances the likelihood of incorporating innovative ideas and harnessing the collective wisdom of diverse stakeholders, leading to more resilient and socially responsible infrastructure solutions.

This engagement has undertaken a targeted stakeholder consultation process, speaking with key government and non-government agencies to support this Infrastructure Study and is summarised in Table 4 below. It should be noted that no public consultation was carried out for this study. Detailed minutes of the conversations had with the entities outlined in Table 4 can be found in Appendix F.

Table 4: Project consultation summary

Entity	Date	Key Outcomes
SMRC Transport and Stormwater	30/05/2023	The objective of this meeting was to discuss the road and stormwater network at Berridale and Kalkite, including key concerns and future considerations for the network. It was noted that Kalkite's road conditions were steep, narrow and the pavement was variable. It was also discussed that the vegetation and speed has affected the roads within the town. A second access for the town is necessary however would be very difficult. The existing stormwater network has limited information available and no studies. It was discussed that Kalkite is reliant on council for insight and there is push back from council for insight.
SMRC Planning and Environment	31/05/2023	An initial meeting was held with the SMRC Planning and Environment team to understand any proposed and active development applications within Berridale and Kalkite. It was discussed that there is a need to update Kalkite Road with a secondary access.
SMRC Water and Sewer	01/06/2023	An initial meeting was held with the SMRC Water and Sewer team to understand the existing sewer network conditions and any planned upgrades. SMRC noted that the system is experiencing capacity issues and there is a need to look at a whole of town approach to delivering water and sewer infrastructure.
Transport for New South Wales (TfNSW)	08/06/2023	TfNSW were engaged to understand any transport and traffic requirements for Berridale and Kalkite. As Kalkite is remote from the state road network, the main interest from TfNSW is around the intersection Kosciusko Road and the single access into to the town. TfNSW have noted that single access may be supported provided it can be capacity can be demonstrated.
Essential Energy (EE)	19/07/2023	EE provided an overview of the network in proximity to Berridale and Kalkite, noting that Berridale and Kalkite are on the same feeder and that there are plans for each township to have their own feeder.
Rural Fire Services (RFS)	18/08/2023	RFS were consulted on the projects intentions and in consideration of the land surrounding Kalkite a bushfire prone land. Given Kalkite has one access point, access during an emergency is problematic and may warrant additional RFS presence in the area as the town grows.

Strategic Context

2. Strategic Context

2.1. Planning and Land Use

The township of Kalkite is situated between Kalkite Road and Lake Jindabyne and is subject to RU5 Primary Production zoning under the Snowy River LEP 2013. The urban form of the township generally comprises of smaller scale urban allotments with separate one and two storey dwellings. There is no commercial town centre in Kalkite.

A large area of land located to the south of Kalkite is subject to RE1 Public Recreation zoning and contains the Kalkite Water Pumping Station. To the east of Kalkite, land is predominantly zoned RU1 Primary Production reflecting its use as agricultural land and steep topography.



Figure 19: Kalkite Areial

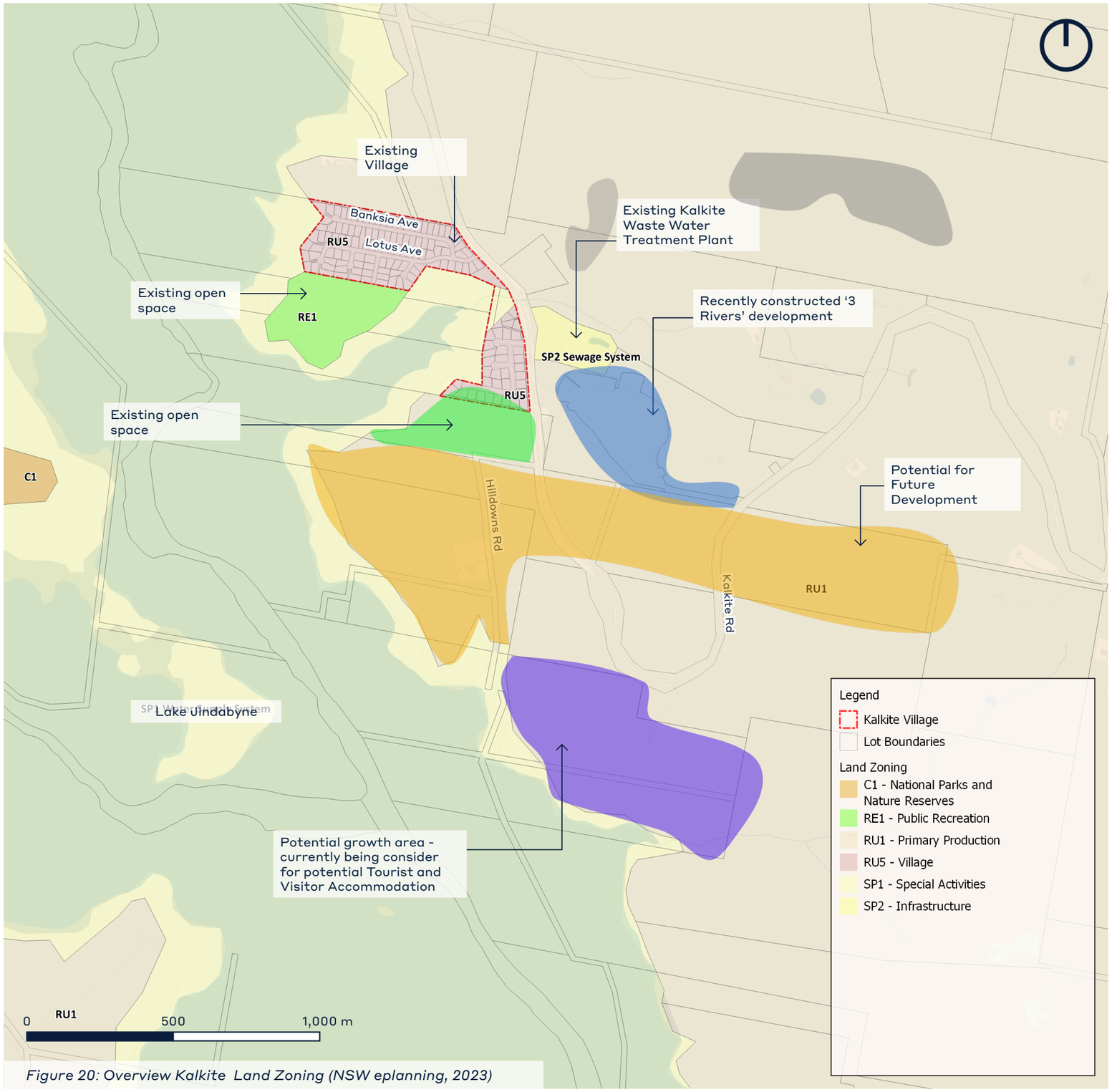


Figure 20: Overview Kalkite Land Zoning (NSW eplanning, 2023)

Strategic Context (Cont.)

2.2. Heritage

Three heritage items located within close proximity to Kalkite, identified as Wee Wah (Listing No. I139) and Hilltop (Listing No. I138) Homesteads and Lake Jindabyne (Listing No. C4). All heritage items are located outside the area identified as possible future development. A review of the Protected Matters Search Tool (PMST) was undertaken which identifies one protected place identified as the Kosciuszko National Park and one National Heritage Place identified as the Australian Alps National Parks and Reserves Snowy Mountains Scheme. Both sites are located within 5 km of Kalkite and on the western side of Lake Jindabyne, however, would not be affected by any proposed infrastructure upgrades or urban expansion of Kalkite.

An Aboriginal Heritage Information Management System (AHIMS) search was undertaken on the 27 July 2023 and did not show any Aboriginal sites or places recorded within the Kalkite township. It is noted that there are recorded Aboriginal places located south of Kalkite, however, are outside of any potential development area. Further investigation of Aboriginal cultural heritage is needed across the LGA to understand the significance of the land to traditional owners and Aboriginal significance. An overview of nearby heritage sites surrounding Kalkite is provided in Figure 22.



Figure 21: View of the existing Kalkite village

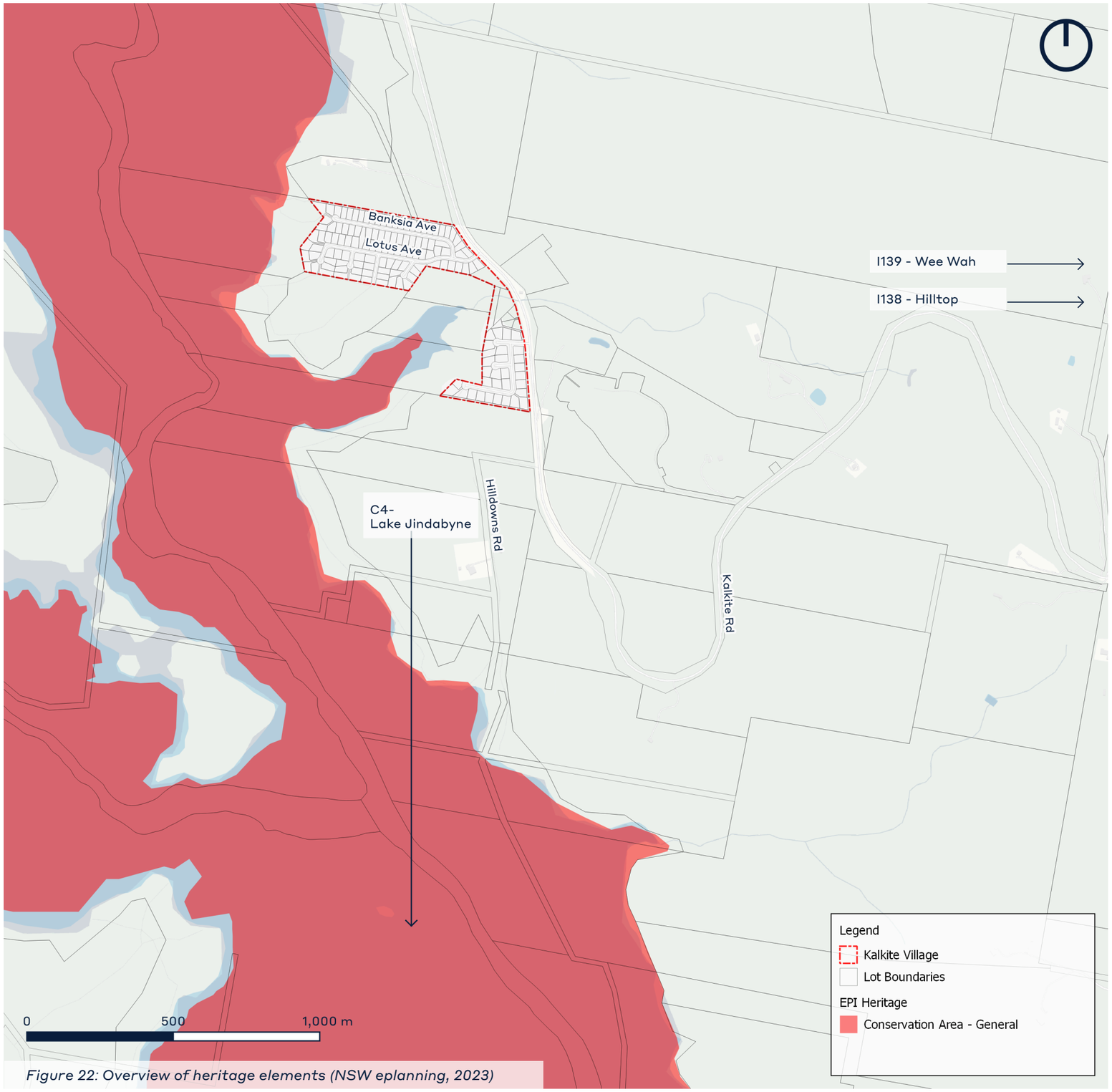


Figure 22: Overview of heritage elements (NSW eplanning, 2023)

Strategic Context (Cont.)

2.3. Environment

There are several areas of noteworhty biodiversity value surrounding Kalkite including native vegetation communities and threatened flora and fauna species. It is noted that there have been no targeted biodiversity studies commissioned by SMRC that include Kalkite and as such this assessment has been limited to available online databases and available studies completed for local developments.

2.3.1. Vegetation Communities

Four native vegetation communities have been identified around the Kalkite township and along Kalkite Road (Department of Planning and Environment 2022b) (Figure 23). Two of these PCTs are associated with Threatened Ecological Communities (TECs) listed under the NSW *Biodiversity Conservation Act 2016* and/or Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Plant Community Type (PCT) and their listing under relevant legislation are provided in Table 5.

Table 5: Summary of vegetation communities

PCT ID	PCT Name	BC Act status	EPBC Act status
3341	Monaro-Gourock Frost Hollow Grassy Woodland	Critically Endangered*	Not listed
3413	Monaro Kangaroo Grass Woodland-Grassland Complex	Critically Endangered**	Critically Endangered***
3741	Monaro Mountains Peppermint Shrub Forest	Not listed	Not listed
3375	Monaro-Queanbeyan Rolling Hills Grassy Forest	Not listed	Not listed

** Relates to the NSW Monaro Tableland Cool Temperate Grassy Woodland TEC*

*** May relate to the NSW Monaro Tableland Cool Temperate Grassy Woodland TEC where it occurs as derived grassland in southern parts of its distribution*

**** Relates to the Commonwealth Natural Temperate Grassland of the South Eastern Highlands TEC where a patch meets condition thresholds as per Section 1.5 of the Conservation Advice*

Monaro Tableland Cool Temperate Grassy Woodland in the South Eastern Highlands Bioregion has also been identified as a serious and irreversible impact (SAII) entity.



Figure 23: Native vegetation communities around Kalkite (NSW SEED, 2023)

More detailed biodiversity surveys have been undertaken at various sites around Kalkite to support Development Applications (DAs) for residential subdivisions. Some of the surveys included ground-truthing of vegetation communities. The findings of these are summarised in Table 6.

2.3.2. Threatened flora and fauna

Matters of National Environmental Significance (MNES) are protected under the EPBC Act. The Protected Matters Search Tool (DAWE 2023) identified the following MNES that may occur within ten kilometres of Kalkite:

- Four threatened vegetation communities
- 18 threatened flora species
- 36 threatened flora species
- 11 migratory species.

Two threatened flora and 19 threatened fauna species have been recorded within ten kilometres of the Kalkite township, although some records are from the opposite side of Lake Jindabyne. The nature of the records suggests that few targeted surveys have been conducted in the area and PCT associations are a more suitable method of determining the threatened species that are likely to occur.

Eighteen threatened flora species and 50 threatened fauna species (five frogs, 25 birds, 12 mammals, six reptiles and two invertebrates) are associated with the PCTs mapped around Kalkite (Appendix E) in the Monaro IBRA subregion of the Southern Eastern Highlands IBRA region (IBRA Version 7). These species should be considered as potentially occurring where the related PCTs occur, and suitable habitat is available.

For all species, further consideration and possibly targeted surveys would be required to determine their presence within the designated study area.

Table 6: Summary of biodiversity findings around Kalkite

Lot/DP	Date	Report type	Summary
Lot 5 DP529579	2022	Planning Proposal	Vegetation mapping for the site identified two threatened PCTs, one listed under the BC Act (PCT 3341) and the other under the EPBC Act (PCT 3413). An additional PCT that is not on the State Vegetation map for the area, PCT 3742, was also found to occur. Targeted surveys identified eight threatened species (two flora and six fauna) listed under the BC and/or EPBC Acts. Potential impacts include clearing of TECs, removal of fauna habitat features and removal of threatened species habitat.
Lot 190 DP756727	2023	Biodiversity Assessment Report	
Lot 4 DP250236	2019	Planning approval	No additional survey data available Clearing of native vegetation not permitted

Strategic Context (Cont.)

2.3.3. Biodiversity Values

Areas of Biodiversity Value have been identified in the region surrounding Kalkite. On the western and northern side of Kalkite Road near Kalkite areas of Old Growth Forest have been mapped. The Taylors Creek riparian corridor flowing to Taylors Inlet have also been identified as Biodiverse riparian land (Biodiversity Values Map and Threshold Tool).

2.3.4. Biodiversity corridors

Vegetation to the west of Kalkite has been mapped as part of the region's network of biodiversity corridors in the Draft South East and Tablelands Regional Plan 2041 (DPE 2022b). This habitat provides north-south connectivity along the eastern shore of Lake Jindabyne.

2.3.5. Legislation

Depending on the nature of future development in Kalkite and the biodiversity values present on site, some state and commonwealth legislation listed below may apply:

Commonwealth

- Environment Protection and Biodiversity Conservation Act 1999
- EPBC Act Environmental Offsets Policy

State

- Biodiversity Conservation Act 2016 (BC Act)
- Environmental Planning and Assessment Act 1979 (EP&A Act)
- Biodiversity Conservation Regulation 2017
- Fisheries Management Act 1994
- Bio security Act 2015
- The NSW Biodiversity Offsets Scheme
- State Environmental Planning Policy (Biodiversity and Conservation) 2021
- Koala SEPP 2020 and 2021.

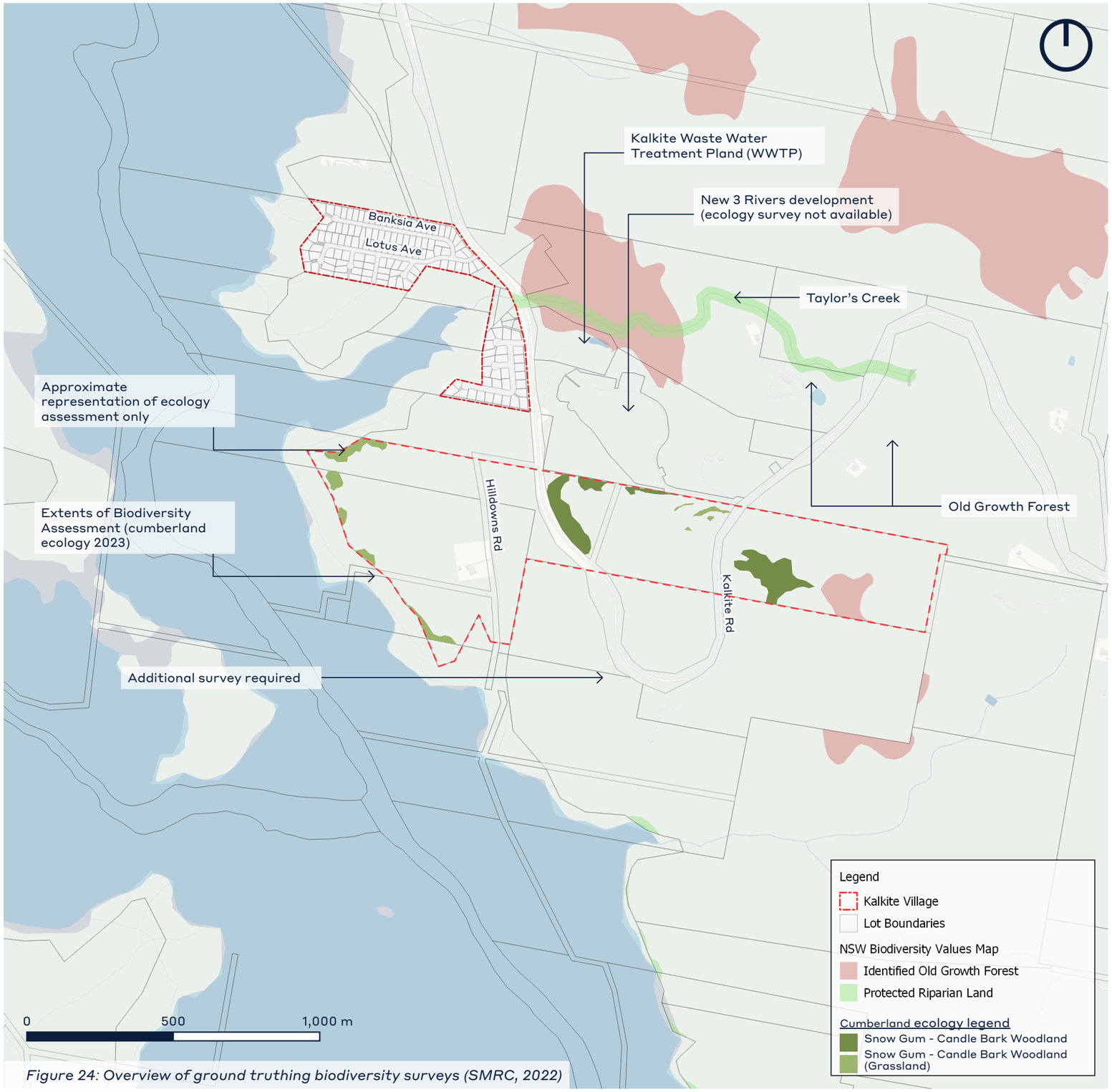


Figure 24: Overview of ground truthing biodiversity surveys (SMRC, 2022)

Strategic Context (Cont.)

2.3.6. Recommendations

Areas of highest priority for protection should be:

- Entities that are at risk of serious and irreversible impacts
- Areas mapped as Biodiversity Values
- Threatened ecological communities
- Vegetation that provides local and landscape connectivity
- Habitat that supports threatened flora and fauna species.

Recommendations before proceeding with development include:

- Further survey required in areas where there is no ground-truthed survey work available. This would initially include verification of the presence/absence of mapped native vegetation communities
- The vegetation communities present would then be used to identify the potential for threatened flora and fauna species to occur
- Consideration would need to be made about the potential impact of development on any threatened vegetation community or species, with demonstrated evidence of efforts to avoid, minimise and mitigate these impacts
- The subsequent actions under relevant legislation would be determined based on the approval pathway and governing body.



Figure 25: Aerial image of Kalkite (Metromap 2023)

Strategic Context (Cont.)

2.4. Future development

This section of the report aims to summarise the extent of the development currently planned or underway in Kalkite, along with changes to policies within the LGA that will influence future growth in and around Kalkite. This information establishes the scope of development known to this project, as provided by SMRC.

Draft Snowy Monaro Local Environment Plan

The Snowy Rivers LEP 2013 will be repealed by the new Snowy Monaro LEP and will be more enabling towards growth, providing a variety of minimum lot sized across a wider range of land zonings. Table 7 provides a comparison between the existing and draft LEP's.

Table 7: Snowy Monaro LEP zoning provisions

Developm ent type	Snowy Rivers LEP 2013	Draft Snowy Monaro LEP
Subdivision	700 m² in the RU5 zone, unless it is not services where the min. lot size is 2000	500 m² min. lot size in the R1 zone, 700 m² in the R2 zone, 500 m² in the MU1 zone and 8000 m² in the R5 zone.
Dual occupancy	One per 700 m² (attached) & one per 750 m² (detached) in the RU5 zone.	One per 500 m² (attached) & one per 700 m² (detached) in the R1 zone.
Dual occupancy	One per 3000 m² (attached) & one per 13500 m² (detached) in the R5 zone.	One per 700 m² (attached) & one per 850 m² (detached) in the R2 zone.
Dual occupancy	N/A	One per 500 m² (attached) & one per 700 m² (detached) in the MU1 zone.
Dual occupancy	N/A	One per 3000 m² (attached or detached) in the R5 zone.

Four (4) categories of future growth around Kalkite have been identified:

- Future Possible Development
  - Areas already identified for future development opportunities and council planning is enabling such with infrastructure augmentation.
- Future Growth Potential
  - Areas identified for future development. Currently no planning or infrastructure investment underway. Further investigations will will be necessary to confirm suitability
- Development Application - Pending
- Development Application - Approved

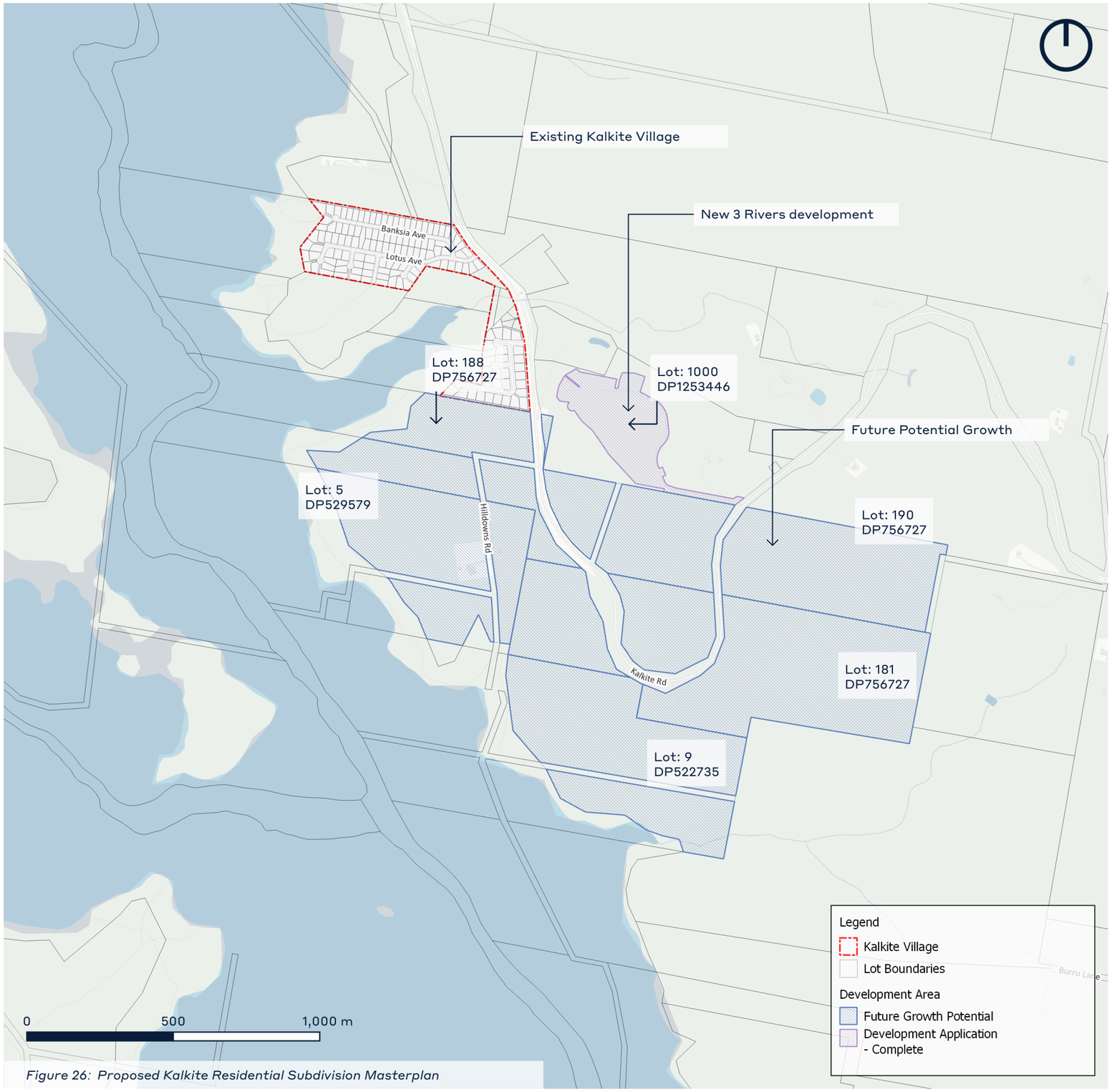


Figure 26: Proposed Kalkite Residential Subdivision Masterplan

Strategic Context (Cont.)

2.4.1. Planning proposals

2.4.1.1 Future Tourist Development, Kalkite

The project has not reviewed any documentation relating to a future tourist development near Kalkite. However, consultation with SMRC suggests that 40 Residential lots and an 80 bed visitor accommodation is being considered in planning for the purposes of power, water and sewer servicing.

2.4.2. Development Applications

2.4.2.1 Three Rivers Estate, Jindabyne

The Three Rivers Estate is another significant project currently being constructed near Kalkite village, consisting of a planned 43 lot gated community approximately 2.5km east of Kalkite at 374 Kalkite Road, Jindabyne.

The Three Rivers Estate is intended to provide a distinctive natural, built and safe living environment reflecting modern Australian architectural styles and will be delivered in four stages.

It is noted that development of the estate will be managed in accordance with the Three Rivers Estate Development Control Plan 2022.

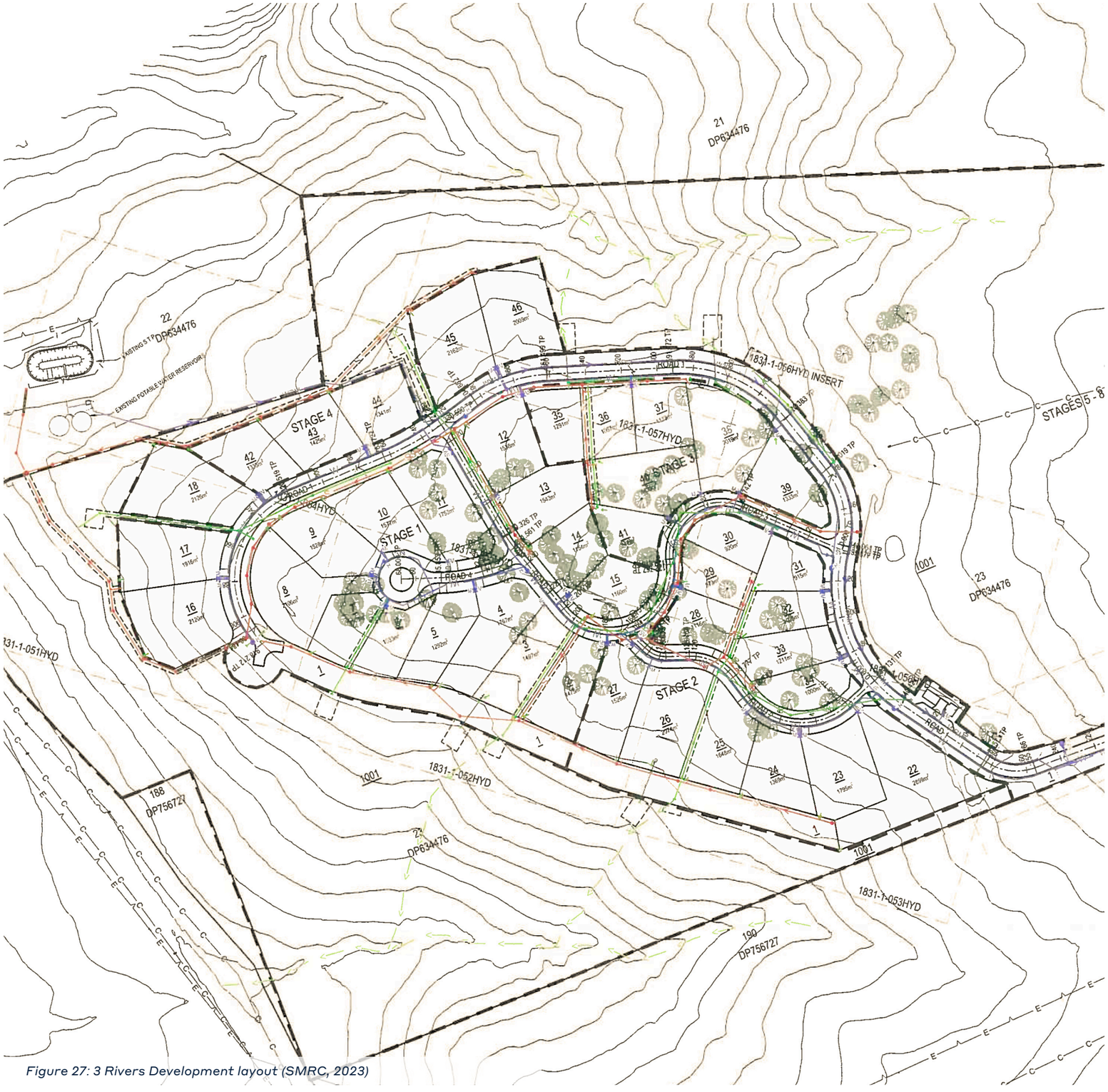


Figure 27: 3 Rivers Development layout (SMRC, 2023)

Infrastructure Assessment

3. Infrastructure Assessment

An assessment of current (baseline) conditions has been provided to develop an understanding of possible infrastructure upgrade required to support the projected population of Kalkite and support opportunities for residential development. This is supported by recommendations for infrastructure upgrades across the short, medium and long term as well as indicative costs.

A range of reports and drawings were made available for the analysis as well as a review of additional data. A summary of data reviewed for this infrastructure assessment is provide in Appendix A.

3.1. Transport and Access

3.1.1. Existing Conditions

Kalkite currently faces several transport issues that impact its residents and visitors. While it is a small town, its size and location at the end of a single access road result in a number of unique challenges. To better identify the challenges, and provide recommendations for solutions, the following transport system components have been assessed:

- Road network
- Public transport
- Alternative transport modes
- Traffic volumes and trends
- Transport connectivity
- Infrastructure provision and maintenance
- Future plans

Each of these components and associated issues are discussed in the following sections.

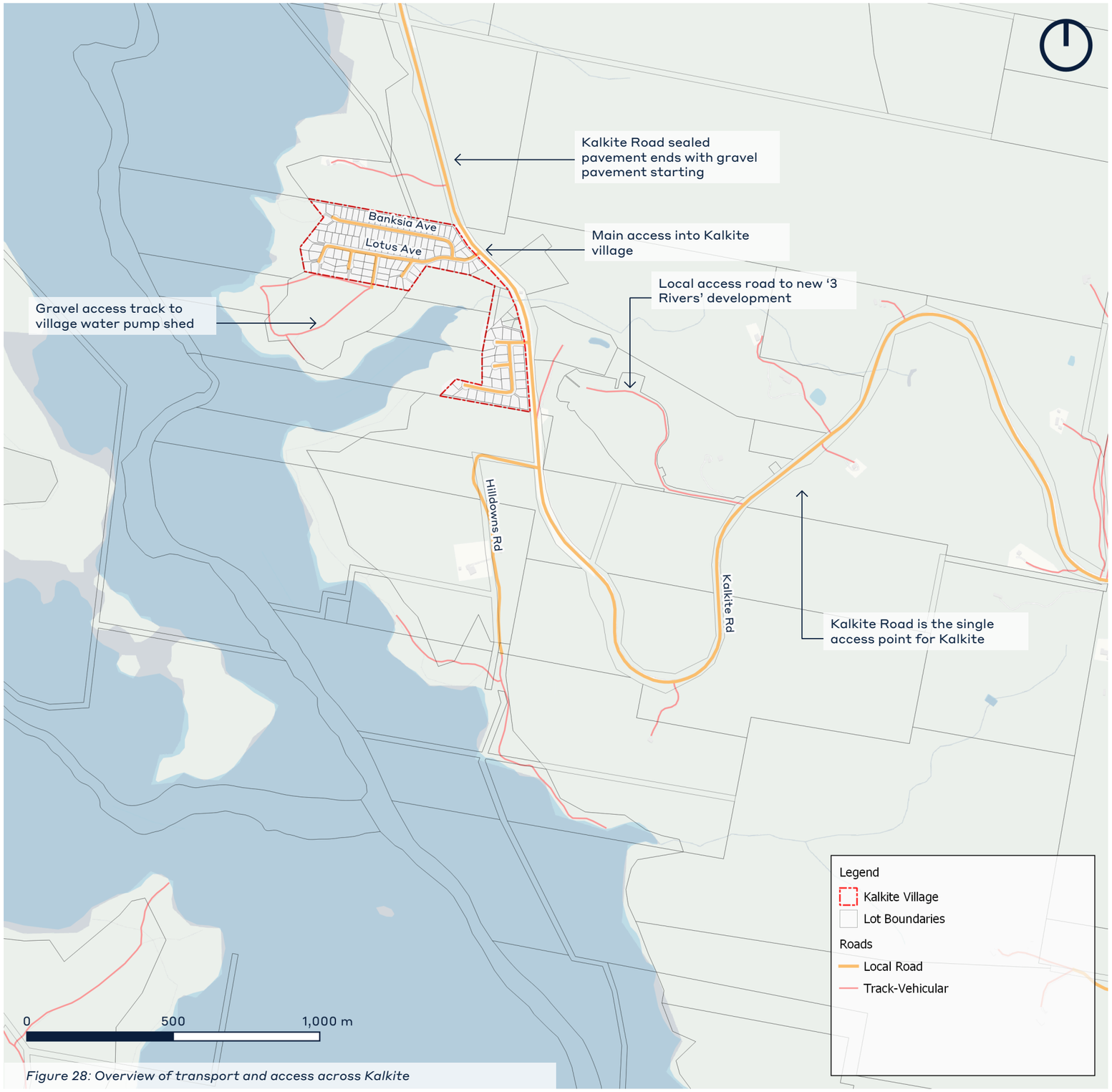


Figure 28: Overview of transport and access across Kalkite

Transport and Access

Road network

The Kalkite road network is the primary transport network serving local residents, commuters, and visitors. The road network is relatively simple and consists of two types of roads. Kalkite Road runs generally north-south along the eastern side of the town and acts as an arterial road with limited property access points. All other roads in the town are lower order access roads and provide direct property access.

Kalkite Road acts as the main arterial road through Kalkite and connects the town with other major destinations in the region via Eucumbene Road and Kosciuszko Road. A more in-depth assessment of Kalkite Road can be found in Section 3.5. The closest key destinations include Jindabyne, Thredbo, and Perisher Valley. The road runs in a generally north-south direction through town and provides access for trips starting or ending in Kalkite.

All other roads in Kalkite are considered local roads, which provide direct access to residential lots.

Public transport

Kalkite has limited public transportation options, particularly when it comes to regular bus services. The town's residents generally rely on private vehicles for travel, which can lead to increased traffic congestion and environmental concerns. This lack of public transport options is reflected in the average vehicles per household being over 2.0 for the township.

Kalkite has one local bus service for general users and two for school students providing access to Berridale and Jindabyne. There are no other regional buses providing access to or from Kalkite.

Alternative transport modes

Kalkite currently has no provision for alternative transportation modes such as cycling infrastructure, dedicated walking paths, or ridesharing services. This limits the options available to residents and visitors who prefer or require alternatives to private vehicles.

There is no dedicated walking or cycling infrastructure provided. Most local roads are wide enough to cycle along, but parked cars reduce the attractiveness and safety of cycling. Traffic volumes on local roads would generally be low enough for shoulders to be suitable for walking and cycling. The exception to this is Kalkite Road. People walking or cycling between the northern and southern parts of Kalkite would be exposed to high traffic speeds and narrow shoulders.

Recreation

The Lake Jindabyne Shared Trail project aims to provide a 60km trail network around the southern half of the lake. The trail design will target mountain bike riders, walkers and trail runners. The project will complement existing trail experiences in our region which will encourage increased visitation and provide a valuable recreation asset for our community. The project will involve extending the existing trail network to Kalkite Village on the East side of the lake and the Thredbo Valley Track to both Creel and Hatchery Bay on the West. Project funding will also cover improvements to the existing trail network along with supporting infrastructures such as car parking, trails heads and visitor day-use areas. Upon completion, this trail will connect Kalkite to Jindabyne, through East Jindabyne.

A shortfall of project funding has meant the East Jindabye to Kalkite section will not be completed in the short term. It is considered a long term upgrade opportunity or be developed if further funding is sourced.

Traffic volumes and trends

An assessment of traffic volumes and trends was undertaken using data sourced from TfNSW for the Snowy Mountain Highway approximately 1.5 km north of its intersection with Kosciusko Road. It is acknowledged that traffic volumes here will be different to the volumes in Kalkite, but the daily and annual peaks and patterns are likely to be applicable to the counts available for local roads in Kalkite. From 2007 to 2023, the available count data shows annual growth of approximately 2.7%.

Figure 31 shows the hourly traffic volume as a proportion of total daily flow for the years 2007 to 2021. The figure shows that traffic volumes do not show strong AM and PM peaks, and largely remain between 7-9% of total daily flows each hour from 8:00 AM to 5:00 PM. This suggests that commuting and school trips form a relatively small proportion of the traffic generated in the area.

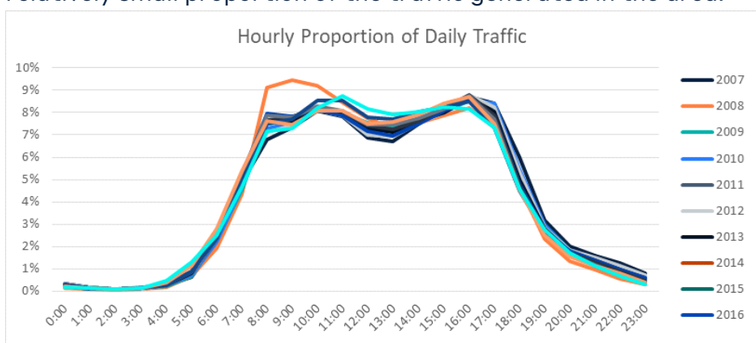


Figure 29: Daily Traffic Volume Trends

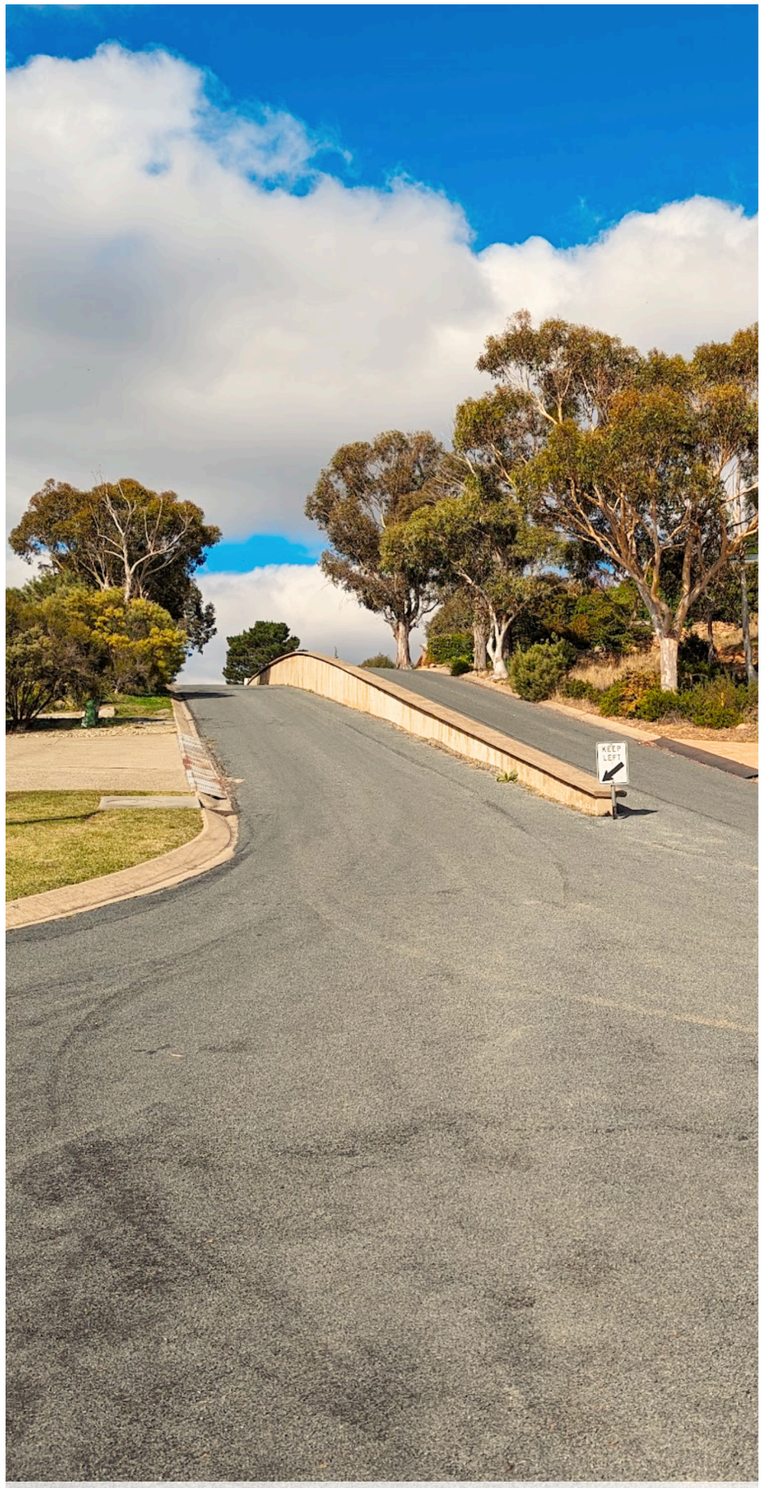


Figure 30: View looking from 52 Banksia Road, Kalkite

Transport and Access

The region experiences significant seasonal tourist traffic, particularly during the winter months when visitors come for snow sports in the nearby resorts. The influx of tourists can lead to congestion on the roads and parking difficulties, affecting both local residents and visitors. Analysis of nearby traffic counts suggests that the winter snow season leads to a significant increase in traffic volumes in the alpine area. Figure 33 shows the average daily traffic each month as a proportion of the Average Annual Daily Traffic (AADT). The figure shows that daily traffic volumes for the 10 months from September to June are within approximately 80-120% of the AADT, but the volumes during July and August are between 140-180% of the AADT. While this is only for two months of the year, the significant increase in traffic means that this period should be considered in addition to AADT for design and analysis purposes.

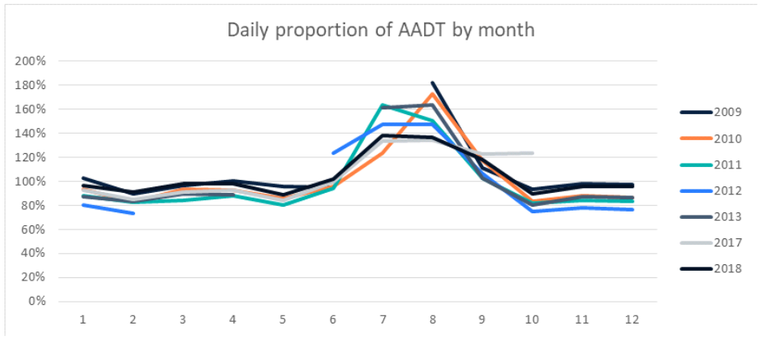


Figure 31: Annual Traffic Patterns

Traffic volume surveys were recently collected at the intersections of Kosciuszko Road with Eucumbene Road and Hilltop Road during July and August 2023. The data was collected from 5:00am to 11:00pm for the period from 26 July 2023 to 8 August 2023 (inclusive).

Table 8 shows the average daily volumes across this period at each of the intersections.

The table shows that most of the traffic at each intersection is confined to Kosciuszko Road travelling east and west, with total daily volumes around 6,500-7,000 (combined directions). The next highest volume is on Eucumbene Road, with around 800 vehicles per day. The lowest recorded volume is Hilltop Road, with around 260 vehicles per day at its intersection with Kosciuszko Road.

Table 8: Intersection Turning Movements on Kosciuszko Road (daily)

Intersection	North Approach			Kosciuszko Road (East)			Kosciuszko Road (West)			Total
	U	R	L	U	R	WB	U	EB	L	
Kosciuszko Road/ Eucumbene Road	1	323	80	0	69	3,156	1	3,244	322	7,195
Kosciuszko Road/ Hilltop Road	1	83	53	0	44	3,164	0	3,251	80	6,676

Further traffic surveys undertaken around the intersection of Kalkite Road with Hilltop Road and Eucumbene Road for the same time period are shown in Table 9. This table suggest that the daily volumes on Hilltop Road are about 89 vehicles. This difference between the eastern and western ends of Hilltop Road is likely due to the fact that most land uses are located near the eastern end of Hilltop Road and are accessed via Kosciuszko Road.

Table 9 also shows that most traffic travelling to and from Kalkite uses Eucumbene Road to access Kosciuszko Road. A small amount appears to use Hilltop Road, but it is not clear from the surveys whether these trips are accessing land uses along Hilltop Road, or travelling further to the east. Similarly, there appears to

Table 9: Midblock Volumes (daily)

Kalkite	Daily Volume (two- way)
Eucumbene (south)	670
Hilltop Road (east)	89
Eucumbene (north)	160
Kalkite (west)	529

be little demand for travel to the north of Kalkite Road.

Travel to Work

A large proportion of travel demand, particularly in peak periods, is travel for work purposes. The ABS Census captures data on work travel every five years. The most recent census was in August 2021. During this time, travel behaviour tended to be atypical due to the COVID-19 pandemic, but conclusions can still be drawn about the general patterns. Table 10 shows the method of travel to work on census day for residents of Kalkite.

The data in Table 10 indicates that there are limited transport modes available to residents of Kalkite. No workers travelled to work by any mode other than car, with most people driving alone. Of the people who travelled for work (i.e., excluding those who did

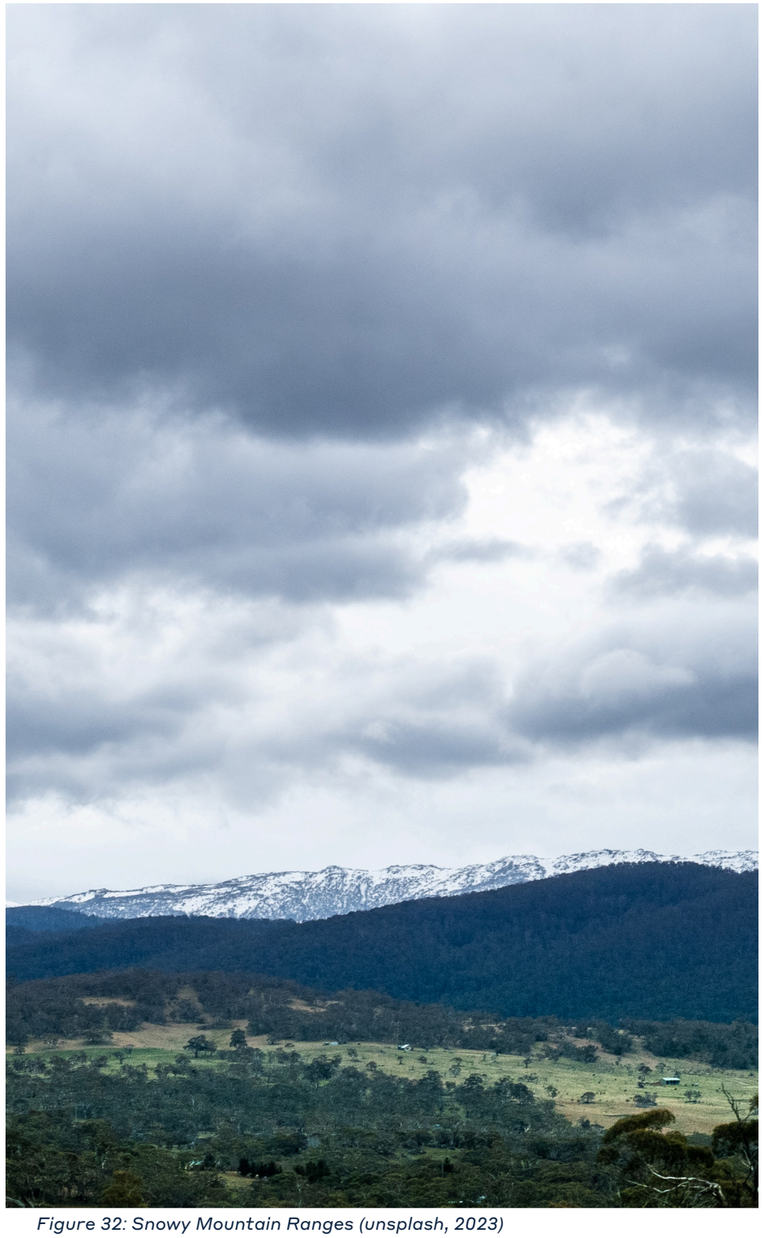


Figure 32: Snowy Mountain Ranges (unsplash, 2023)

Transport and Access

not work, or who worked from home), 100% travelled by car, with 93% as driver and 7% as passenger.

Table 10 shows the distance that people travelled to work on census day. The total numbers are slightly different to Table 10,

Table 10: Method of Travel to Work

SAL (UR)	Kalkite
Car, as driver	95
Car, as passenger	7
Truck	0
Walked only	0
Other Mode	0
Worked at home	22
Did not go to work	14
Total	**142**

potentially due to randomisation and anonymisation undertaken by ABS for small data sets.

Table 11 shows that 19 people travelled less than 2.5 km to work. This is a distance that is generally considered to be walkable, but only nobody actually walked. Similarly, there are a total of 24 work trips that are less than 10 km, which is a cyclable distance, but no workers chose to cycle.

The data shown in Table 11 also allows the work destinations to be inferred. The two largest distance bands are 10-30 km and 50-250 km. Jindabyne falls into the 10-30 km range and Cooma into the 50-250 km range. Regardless of final destination, all trips leaving

Table 11: Distance of Travel to Work

Distance travelled to work	Kalkite
Nil distance	9
Over 0 km to less than 2.5 km	10
2.5 km to less than 10 km	5
10 km to less than 30 km	59
30 km to less than 50 km	12
50 km to less than 250 km	45
250 km and over	9
Total	**149**

Kalkite must travel via Kalkite Road.

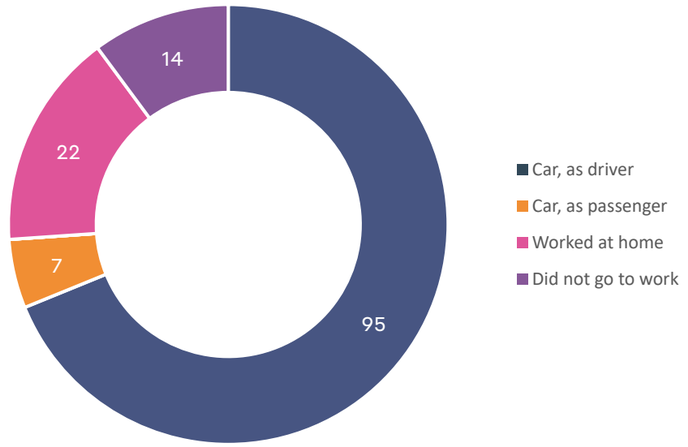


Figure 33: Method of Travel to Work

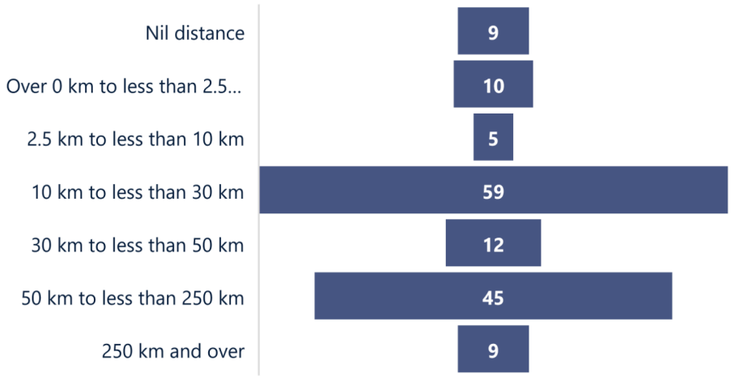


Figure 34: Distance of Travel to Work

Transport connectivity

Kalkite's geographical location poses significant connectivity challenges. The town is situated on the eastern shore of Lake Jindabyne and is only accessible via Kalkite Road, which connects to Eucumbene Road at its intersection with Hilltop Road. From this point, drivers can choose to travel to Kosciusko Road via Eucumbene Road or Hilltop Road. Hilltop Road offers a route that is approximately 2km shorter than Eucumbene Road for traffic travelling north to Berridale and Cooma but is unsealed and time savings are likely to be small.

Due to Kalkite's relative isolation, access to major urban centres and transportation hubs can be time-consuming and limited. It is likely that most day-to-day requirements (e.g., work, education, shopping and recreation) could be fulfilled in Cooma and Jindabyne, which are 40 and 20 minutes away, respectively, and only accessible by car. Canberra is located around 1 hr 50 min drive and is likely to be a much less common destination.

In terms of network resilience and redundancy, Kalkite could be entirely isolated if there is incident on Kalkite Road.

Infrastructure provision and maintenance

Like many regional areas, Kalkite generally has less comprehensive transport infrastructure than larger urban areas. This includes road shoulder/verge widths, path provision, signage, and adequate lighting, which can impact safety and accessibility for both road users and vulnerable travellers. In particular, the lack of a path network reduces the safety and attractiveness of active travel modes.

3.1.2. Planned infrastructure works and upgrades

The SMRC *Operational Plan 2023-2024* and *Delivery Program 2022-2026 (2023 Revision)* were reviewed to understand any planned and committed changes to the transport network. The review found that there are no significant changes planned for the transport network in Kalkite, but the following items are likely to improve its condition and operation, or provide additional information to assist the development of upgrade options:

- Active Travel Plan
- Resealing, heavy patching, reactive maintenance
- Black Spot, Fixing Local Roads, Local Roads and Community Infrastructure Program
- Country Passenger Transport Infrastructure Grants Scheme
- TfNSW and RMCC Agreement
- Other grant programs
- Condition Assessment of the Road Network
- Traffic Count Program

Transport and Access

3.1.3. Future anticipated demand

As discussed in Section 1.7, Kalkite has the potential to grow by approximately 1,030 people to a total population of 1,315 by 2041. The increase in population is from residents only and has not considered potential expansion of the tourism sector.

Using published traffic generation rates, existing traffic generated by Kalkite is estimated to be in the order of 1,600 vehicle trips/day, or approximately 144 trips/hour. However, traffic counts conducted in 2023 show only 529 trips per day entering and exiting Kalkite. This lower trip generation is likely due to the remote location whereby a single trip would be used to fulfill multiple purposes. In a more urban setting, people return to their homes more frequently between different trip purposes, which tend to generate more vehicle activity in the residential areas.

Based on the potential population growth and surveyed traffic volumes, traffic is estimated to increase to approximately 2,350 trips/day, or 210 trips/hour, in 2041. This is noted to be a conservative assessment, which does not take the change in population demographics into account. The proportion of retirees, who tend to travel less than families and younger people, is expected to increase over time, which will tend to reduce the overall traffic generated by Kalkite.

3.1.4. Recommended Upgrades

Based on the review of existing conditions, along with the expected increase in transport demand from the potential increased population, the following upgrades to the transport network are recommended:

Short to Medium Term to Recommendations

- Active travel connections throughout Kalkite, particularly across Taylors Creek, where there is no separation between cars and vulnerable road users.
- Upgrades to Kalkite Road to support increased usage, improve safety for road users and increase network resilience for emergencies.

Long Term Recommendations

- More comprehensive active travel network, pending the more detailed findings and recommendations of the ongoing Active Travel Strategy project.
- Active travel connection between Kalkite Village and East Jindabyne as part of 'Lake Jindabyne shared trail' Project

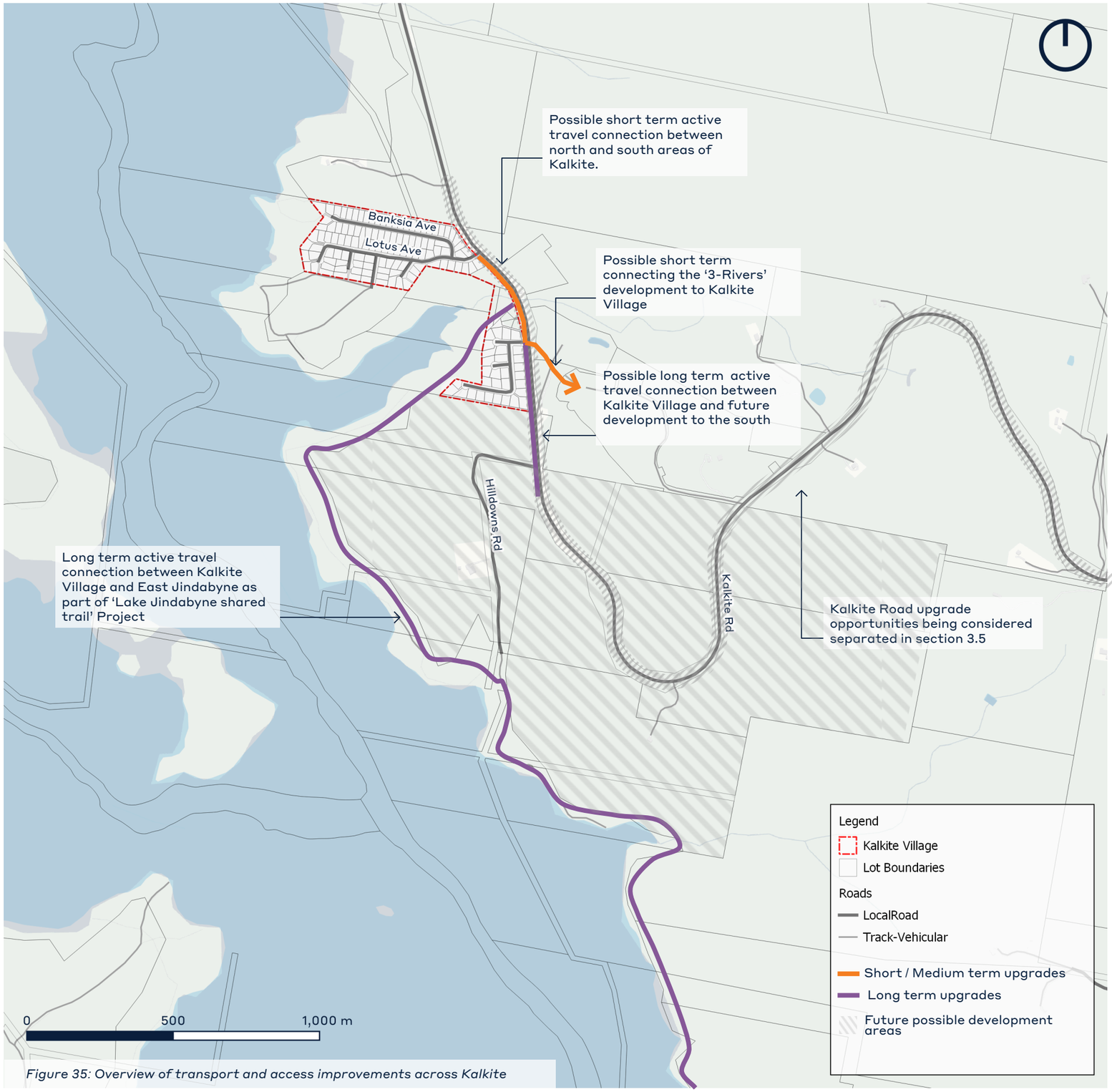


Figure 35: Overview of transport and access improvements across Kalkite

Transport and Access

3.1.5. Emergency Services

Existing Conditions

The interaction of each emergency service agency with the Kalkite transport network is a critical aspect of ensuring timely and effective response during emergencies. Below is an overview of how the RFS, police, ambulance services, and State Emergency Service (SES) interface with the local transport network:

- **Rural Fire Service:** The RFS's use of the transport network in Kalkite is primarily evident during bushfires and other rural emergencies, noting that RFS acts as a general fire brigade and attends all emergencies. RFS personnel rely on the transport network to access fire-affected areas swiftly. In the case of Kalkite's hilly terrain, road access becomes paramount for deploying firefighting equipment and personnel to strategic points. During bushfire incidents, the transport network aids in establishing firebreaks, positioning firefighting appliances, and facilitating evacuation routes for affected communities. Key issues for the RFS in Kalkite are road capacity during evacuations and congested conditions along Kalkite Road. Kalkite's RFS station will require upgrades to meet the projected demand from any potential future population growth.
- **Police:** During emergencies, police officers use the road network to reach incident locations promptly, but only have access via Kalkite Road.
- **Ambulance Services:** Ambulance services' interaction with the transport network is crucial for rapid medical response. Ambulance vehicles utilize the roads to reach patients in need, assess their condition, and provide immediate medical assistance. The transport network's condition and accessibility directly influence response times, especially in situations requiring time-sensitive medical attention. Ambulance services also depend on clear and accessible roadways for efficient patient transportation to medical facilities. The closest ambulance station to Kalkite is located in Jindabyne. During emergencies, the ambulance would need to access Kalkite via Kalkite Road.
- **State Emergency Service:** The SES's interaction with the transport network is multifaceted, reflecting its diverse responsibilities during emergencies. During severe weather events like storms or floods, SES volunteers may be called upon to clear debris from roads, repair infrastructure, and secure hazardous areas. The transport network's accessibility is crucial for SES personnel to reach affected

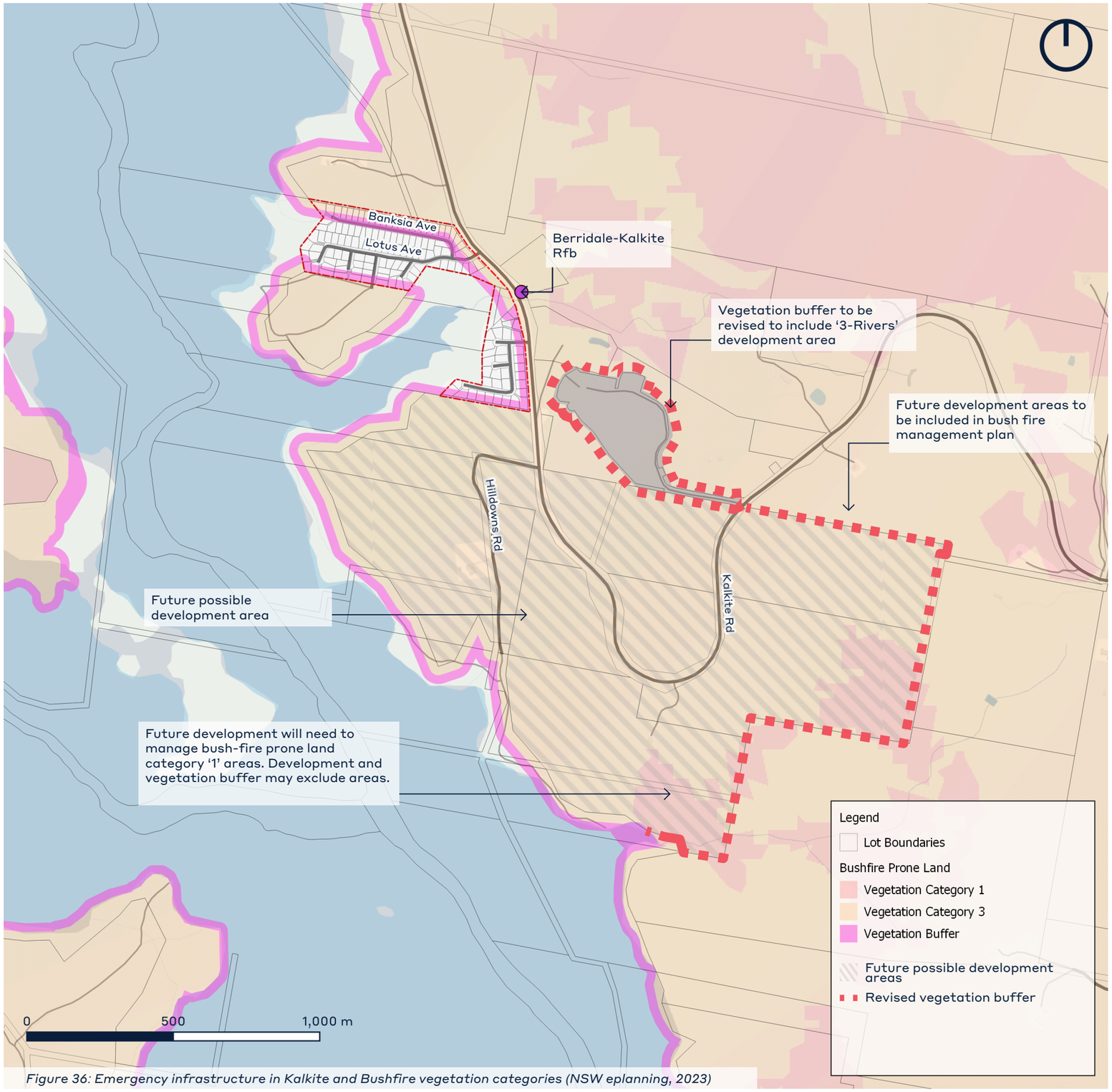


Figure 36: Emergency infrastructure in Kalkite and Bushfire vegetation categories (NSW eplanning, 2023)

Transport and Access

sites promptly and execute tasks such as tree removal, flood response, and structural assessments. The current Kalkite Road arrangement makes it vulnerable to storm damage, which would limit access to Kalkite.

Considerations for future planning

Planning for future transport infrastructure, with a focus on emergency services, involves consideration of several key issues to enhance response capabilities. These issues pertain to the physical road network, accessibility, and connectivity:

- **Road Network Resilience**: Ensuring the robustness of the road network is paramount for emergency services. Future planning should include strategies to fortify road infrastructure against extreme weather events, including landslides, flooding, and snow accumulation. Reinforcing vulnerable sections, such as those prone to erosion or washouts, will prevent disruptions during emergencies.
- **Alternative Routes**: Developing alternative routes that bypass challenging terrain, congestion points and locations that could be blocked in emergencies is essential. These routes serve as backups in case the shortest routes are compromised. Identifying and improving the network, complete with signage and road markings, can significantly improve access for emergency services. Currently with Kalkite Road being the only access point in and out of the village. This presents a safety concern and challenge for any further development
- **Road Widening and Intersection Upgrades**: Widening roads and improving intersections can more easily accommodate emergency vehicles, enabling them to navigate corners and intersection safely and efficiently. Designing intersections with clear sightlines and turning radii for larger vehicles enhances emergency access, particularly for the busier intersections along Jindabyne Road.
- **Maintenance and Timely Repairs**: Regular road maintenance and prompt repairs are essential for preserving the integrity of the transport network. Ensuring that road damage is identified and repaired promptly will reduce transport disruptions during emergencies.

Consideration of these issues will allow emergency services to operate in Kalkite. The importance of these issues when planning for the future is necessary to allow emergency services to perform and keep the community at Kalkite safe.



Figure 37: Mountainous terrain throughout SMRC (unsplash,2023)

Transport and Access

3.1.6. Implementation Plan

The existing traffic volumes, along with the increases due to the proposed developments and population forecasts, do not warrant changes to existing roads and intersections. However, allowances for safe and convenient active travel should be provided as part of any growth in the area

Table 12: Transport Infrastructure Implementation Plan

ID	Transport Infrastructure	Key Entities Involved in upgrades	Capital Cost	Time-frame	Staged	Funding mechanisms
T_01	Improved active travel connections, particularly across Taylors Creek	TfNSW, SMRC, private land holders	$100,000 - $500,000	Short term	No	Council funded
T_02	Improved active travel network to support larger population and potential development area	TfNSW, SMRC, private land holders	$100,000 - $500,000	Long term	Yes	Council funded
T_03	Improvements to Kalkite Road	TfNSW, SMRC	$1mil +	Long term	Yes	Council funded with state contributions



Figure 38: Snowy Mountain Ranges (unsplash, 2023)

Electricity

3.2. Electricity

3.2.1. Existing Conditions

Preliminary consultation with EE has been completed to gain insight into the existing electricity supply arrangement for Kalkite and surrounds. Based on the initial consultation, EE has indicated the existing electricity supply to Kalkite comes from the Jindabyne East Zone Substation which consists of two (2) x 10MVA (132kV/11kV) transformers.

Jindabyne East Zone Substation has six (6) feeders in total, currently there are two (2) feeders in service and has an existing peak load of 5.3MVA:

- JYE3B2 feeder - Supplies power to Berridale and Kalkite.
- JYE3B3 feeder – Supplies power to East Jindabyne and Tyrolean

Power infrastructure in the region

- All zone substations in the Cooma area are in the EE South Eastern region.
- The Cooma area sub-transmission system is supplied from Transgrid's 132/66kV sub-transmission substation at Cooma.
- A 5MW hydro generator is located at Brown Mountain Hydro and is connected to Steeple Flat 132/66kV sub transmission substation at 66kV via feeder 810.
- A 114MW wind generator is located at Boco Rock wind farm and is connected to the Steeple Flat 132/66kV sub transmission substation which is connected to Transgrid's Cooma 132/66kV sub-transmission substation at 132kV via the feeder 97R.
- A 1MW hydro generator is located at Jindabyne Dam and is connected to the Jindabyne zone substation 11kV busbar via feeder JIN22.

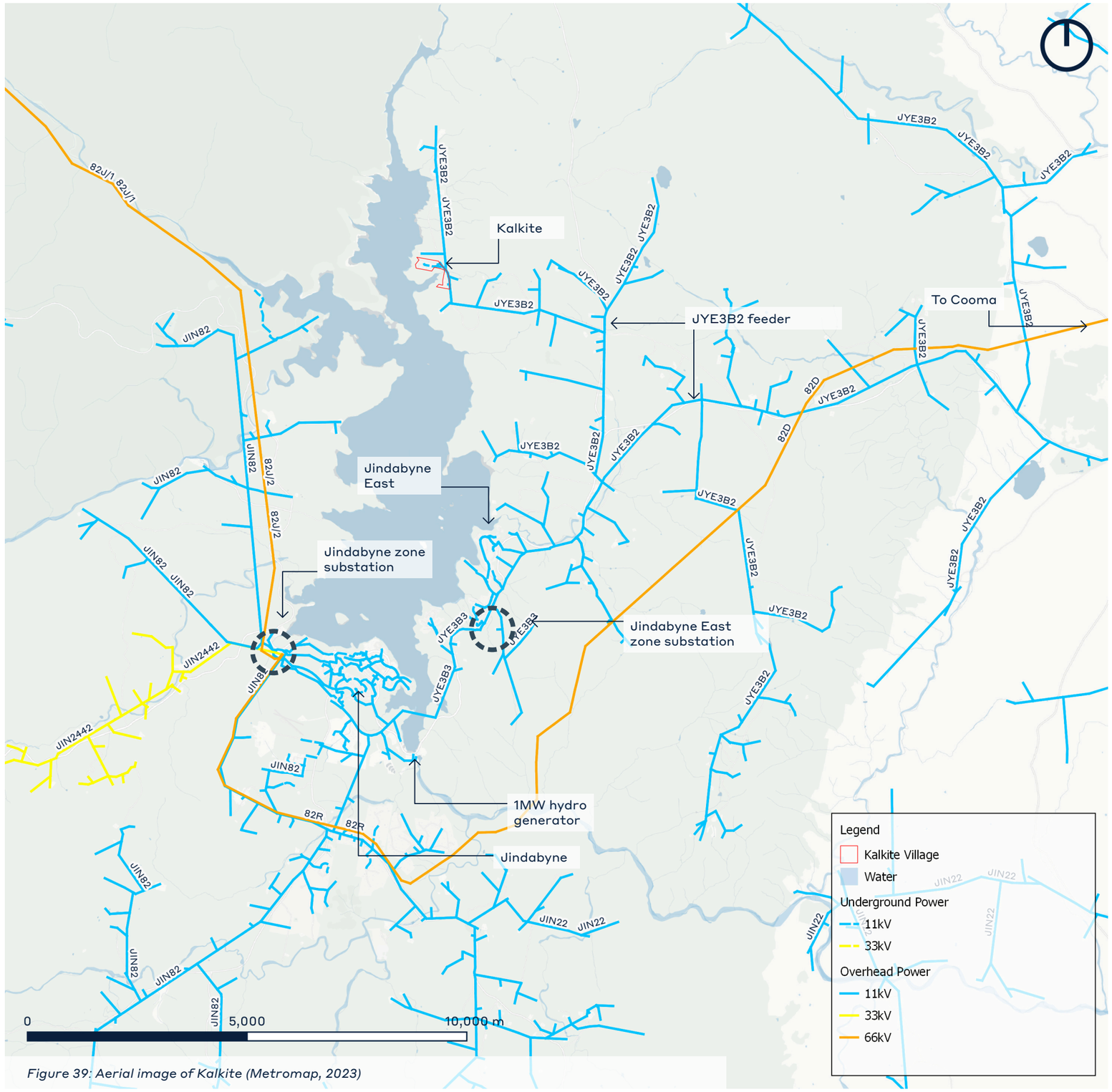


Figure 39: Aerial image of Kalkite (Metromap, 2023)

Electricity (Cont.)

Power infrastructure in Kalkite

- JYE3B2 11kV Feeder from the west Jindabyne Depot extends to various Pole Top substations that Step down to Low Voltage to supply customers.
- JYE3B2 11kV Feeder continues north beyond village to service private land.
- Kalkite has not backup or second feeder connection
- The existing EE Local LV network reticulation is underground head power conduits, servicing each lot.

3.2.2. Planned infrastructure works and upgrades

EE has indicated there are current plans in place, subject to increased demand growth, to provide Kalkite with a new dedicated feeder, this may result in feeder JYE3B2 splitting into two separate feeders, which will subsequently increase the capacity for Kalkite. Additionally, EE have indicated based on initial consultation with SMRC that the growth in the Kalkite area may be supplied from the Jindabyne East Zone substation.

The network transfer capacity is assessed by EE using reasonable endeavours, to determine the capability of the network to support the proposed Kalkite development. EE have noted that the continued development of subdivisions and dual occupancy remain a concern for network transfer capacity and are in the process of projecting forecasts for 5 – 10 years.

This planning includes the Western rural feeder out of Cooma COO3B7. Feeder JYE3B2 is interconnected with COO3B7 for reliability and support in the event of a network outage. EE have indicated they are looking to boost the capacity on COO3B7.

3.2.3. Future anticipated demand

EE is to be consulted for all future connections, as such all future works will be subject to EE assessment upon receipt of a connection application. EE has indicated there are anticipated OH 11kV feeder Augmentation plans in place to provide Kalkite with a new dedicated feeder.

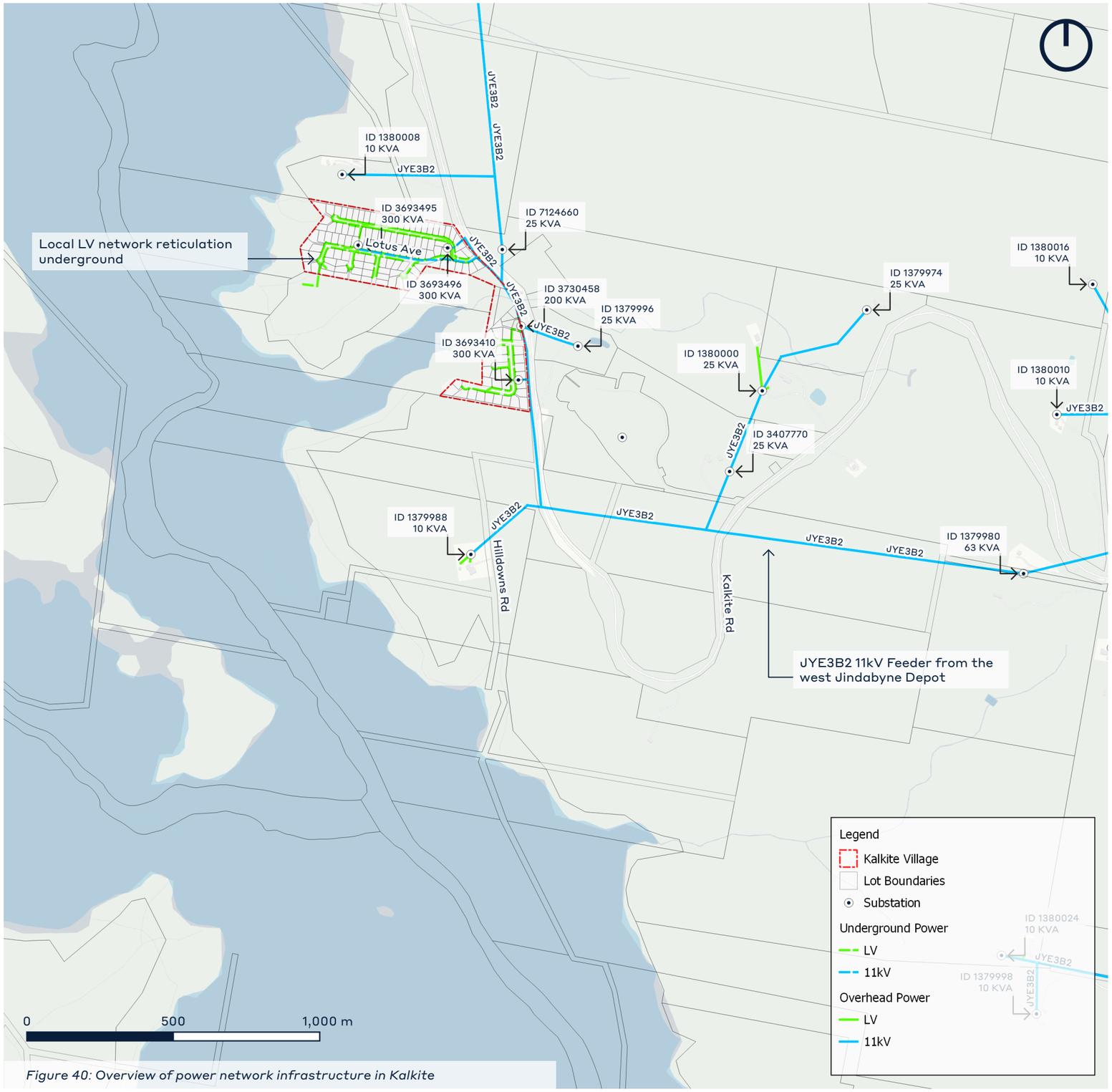


Figure 40: Overview of power network infrastructure in Kalkite

Electricity (Cont.)

3.2.4. Recommended Upgrades

The initial consultation with EE to facilitate the connection of Kalkite indicates the network capacity to support the continued growth will require the existing Over Head mains to be upgraded in addition to establishing at least one new dedicated feeder. Based on the information provided by EE the following network upgrades are anticipated:

Short Term Recommendations

- Upgrade all 11kV OH conductor to minimum CHERRY ACSR Conductor or equivalent and Install new dedicated Feeder to Kalkite supply catchment.
- Split of existing Feeder, dedicate feeder to Berridale catchment resulting in a capacity increase to Kalkite

Medium to Long Term Recommendations

- Install new 11kV OH conductor voltage regulation infrastructure as required.

When assessing network capacity, a limit of 90% of the conductor thermal rating under normal operating scenarios is used.

Assessment of the steady state voltage range at all nodes on the distribution network (with regulator tap changers enabled) is either:

- Maintained within 8% on urban feeders;
- Maintained within 12% on rural feeders; or
- Not exacerbated by the addition of the load (where the voltage range already exceeds the above values).

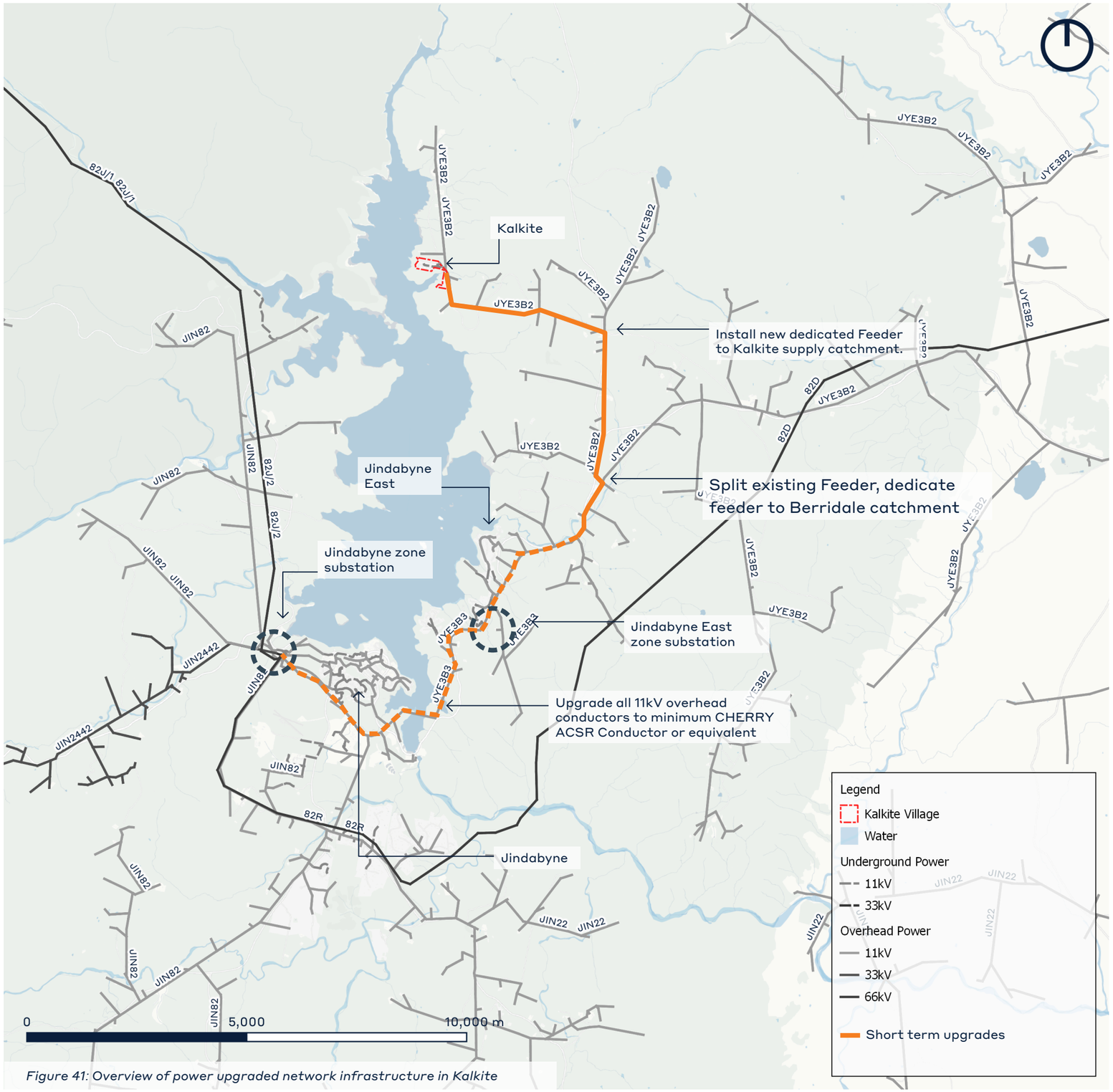


Figure 41: Overview of power upgraded network infrastructure in Kalkite

Electricity (Cont.)

3.2.5. Implementation Plan

The implementation plan for the electricity upgrades encompasses several essential stages outlined below to ensure a successful outcome. These stages are designed to manage the project from its inception to post-implementation compliance.

The first steps involve Pre-Feasibility and Connection Enquiries (> 3 months), where initial research and preliminary assessments are made to gauge the project's viability and its potential impact on the existing infrastructure. This is followed by the Feasibility Connection Enquiry (>6 months), which involves more in-depth studies to confirm the project's feasibility. Upon confirming feasibility, the next stage is the Application to Connect (9 months), where the formal process of requesting approval and connection to existing infrastructure begins. Contract Development (12 months) follows, where the terms and agreements between parties involved are established and documented. Once the contracts are in place, the Design and Construct (24 months) stage commences, focusing on the actual planning and construction of the infrastructure.

Pre-Commissioning Program involves preparing the infrastructure for operation, including testing, inspections, and necessary adjustments. Testing and Commissioning is the stage where the newly constructed infrastructure is rigorously tested to ensure it functions as intended. Finally, the project moves to the Post Connection Compliance phase, ensuring that the infrastructure complies with all relevant regulations and standards. This comprehensive approach helps guide the project from its initial concept to a fully functional and compliant asset, effectively addressing the various challenges and considerations throughout its development.

Table 13: Power Network Infrastructure Implementation Plan

ID	Power Network Infrastructure	Key Entities Involved in upgrades	Capital Cost	Time-frame	Staged	Funding mechanisms
E_01	Upgrade all 11kV overhead conductors to minimum CHERRY ACSR Conductor or equivalent.	EE, private and public landholders	TBC	TBC	Yes	EE, Developer contributions
E_02	Split existing Feeder, dedicate feeder to Berridalev catchment.	EE, private and public landholders	TBC	TBC	Yes	EE, Developer contributions
E_03	Install new 11kV overhead conductor voltage regulation infrastructure as required.	EE, private and public landholders	TBC	TBC	Yes	EE, Developer contributions



Figure 42: Aerial image of Kalkite (Metromap, 2023)

3.3. Potable Water Supply

An assessment of Kalkite's water infrastructure was completed by aGnR Consultants (2022), the complete report can be found in Appendix B. The following section provide an executive summary of the observations and recommendations outlined in their report. It introduces the existing and proposed water infrastructure and necessary actions are advised across a future planning horizon.

3.3.1. Existing Conditions

Existing Network

Lake Jindabyne is a source of raw water to the community of Kalkite via submersible pumps which transfer water to a balancing tank with a volume of 26 KL. There are high lift pump stations downstream of the balancing tank which supply water to the reticulation system of the town as well as a pair of reservoirs (226KL) located at the eastern side of the Kalkite. Prior supply to the town, water is chlorinated at the high lift pump stations near the lake.

There is an additional pump station downstream of the town reservoirs which supplies water to the private development (3 Rivers development). This asset is owned and operated by the council while the additional tanks east of the development are privately owned. A schematic of the water supply system can be found in Figure 44.

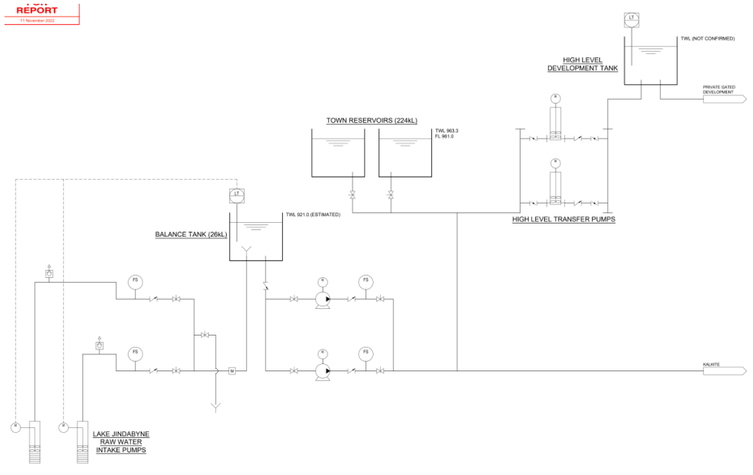


Figure 43: Schematic diagram of Kalkite's water supply (source)

Snapshots of raw water intake, chlorinated & lift pump station, inlet pipeline and storage reservoirs are provided in Figures 45 - 47.

Kalkite town consists of residential town with no commercial or industrial area. There are total 147 lots in the Kalkite, the boundary of the town and service area is provided in Figure 48.

SMRC current level of services in terms of availability of supply which are outlined in Table 14.

Table 14: Existing water infrastructure summary

Availability of supply	Minimise number of watermain breaks	Number of water main breaks per 100Km per year	<30
	Minimise unplanned water supply interruptions	Number of unplanned interruptions per 1000 connections per year	<50
	Reduce response time to emergency water interruptions	Average response time to water incidents	< 4 hours



Figure 45: Two (2) town reservoirs



Figure 44: 26KL Balancing Tank



Figure 46: Raw water intake location

Potable Water Supply (Cont.)

Existing water infrastructure

The existing pipe diameter is predominately 100mm and 150mm Asbestos Cement piping and was laid in 1982 as sumarised in Table 15.

Table 15: Existing water infrastructure summary

Diameter (mm)	Material	Year)	Length (m)
100	AC	1982	2,277
150	AC	1982	870

Storage Capacity

There are various storage infrastructure including balancing tanks and reservoirs in the Kalkite town itself as well, the details are provided in Table 16 :

Table 16: Water Storage in Kalkite

Tank location	# of Tanks	Top Water Level (m)	Storage Capacity (ML)
Balance tank	1	1004.4	0.026
Town Reservoirs	2	963.3	0.452
3 Rivers Development	-	-	-

Pump stations

There are two sets of pumps to supply potable water to Kalkite. The schematic of the pumps and the reservoirs capacity are provided in Figure 51. Table 19 summaries the pump characteristics:

Table 17: Summary of Kalkite's pump location

Pump Location	# of Pumps	Duty Point
Lake Jindabyne high lift pumps	1 Duty + 1 Standby	12 L/s @ 66m
3-Rivers reservoir transfer pumps	1 Duty + 1 Standby	2 L/s @ 125m

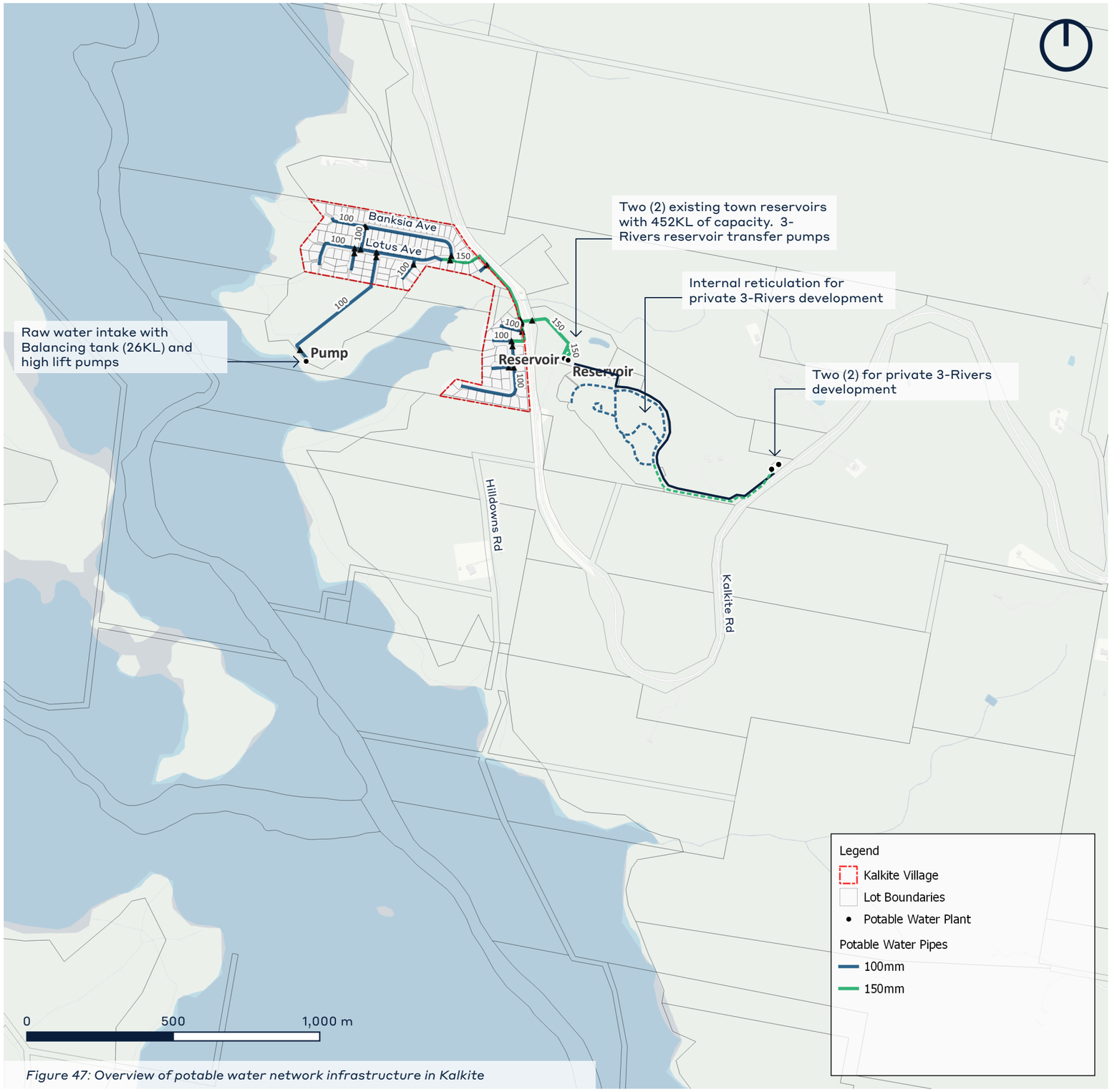


Figure 47: Overview of potable water network infrastructure in Kalkite

Potable Water Supply (Cont.)

Other water uses

Firefighting

Modelling conducted by aGnR Consultants has revealed that the existing water supply network is incapable of accommodating the required firefighting flows in the elevated regions of Banksia Avenue and Lotus Avenue. To address this issue, potential solutions could involve either installing a continuously operating booster pump or constructing new elevated storage at an appropriate operational height to enhance service delivery to the local area via gravity.

However, considering the number of affected customers, the capital investment per property for the aforementioned improvements would be prohibitively high. Therefore, it is advised that the Council continue to operate the network using the current arrangement until future development necessitates a substantial system upgrade.

Existing demand calculations

As per SMRC planning, the minimum lots sizes are 700m2 for the residential area. There are different categories to estimate the water demand for Equivalent Tenements (ETs) as per Section 64 Determinations of Equivalent Tenements Guidelines.

As per the guideline, the standard ET water consumption are 630 L/ET/day. By following the defined categories and per ET consumption, the existing demands relevant to Kalkite are summarised in Table 18.

Table 18: Demand Calculations

WD Category	Sub Category	Unit	Water ET
Detached Residential (Housing)	Standard (450 to 2000 m^2)	Lot	1
	Small (< 450 m^2)	Lot	Use Units
	Large (> 2000 m^2)	Lot	1.2
Multi Residential (Units)	1, 2 Bedroom	Dwelling	0.5
	3 Bedroom	Dwelling	0.8
Short Term Accommodation	Camp Site	Site	0.5
	Caravan Site / Cabin	Site	0.5
	Motel / Hotel / Resort Room	Room	0.3
Retail / Business	Retail / Shop	Floor Area (m2)	0.002
	Supermarket Floor Area		0.002
	Offices (Professional)		0.004
	Takeaway / Fast Food Outlet		0.015
Entertainment	Hotel / Bar	Floor Area (m2)	0.03

aGnR Consultants outline in their report the current water demand on the Kalkite water network. These parameters are summarised in table 19.

Table 19: Water Demand (Current)

Description	Value
Population (used in aGNR report)	c. 294
Approximate number of existing allotments	146
Connections	c.140 (100% residential)
ET/EP	2.2
Average day unit demand (ADD)	620 L/ET/day
Peak day factor (PDF)	2.5
Peak daily demand (PDD)	1550 L/ET/day

3.3.2. Planned infrastructure works and upgrades

SMRC has planned infrastructure works upgrades specified in the Delivery program (2023 revision). The upgrade plans for whole council region includes Kalkite are listed in Table 20 below.

Table 20: Summary of planned infrastructure works

Project	Description	Objectives	Cost
Raw water pump station replacement	Capital works program to replace raw water pump station equipment	To meet the growth in demands	$ 1,000,000 *(SMRC wide funding)*
SCADA replacement - water	Telemetry and SCADA systems updated to current standards	To meet the growth and provide security through resilient infrastructure	$ 1,000,000 *(SMRC wide funding)*
Water Mains Replacement Program	Capital Works Program to replace water main	To meet the growth in demands	$ 8,000,000 *(SMRC wide funding)*

3.3.3. Future anticipated demand

The current and future projected demand are provided in section 1.7 of this report by considering short, medium and long term which is up to 2041.

It is noted that the recent water studies conducted by aGnR Consultants, the future population projections used for their investigations are ~30% less at 2041 then as compared to the projections provided in section 1.7. Table 21 summarises aGnR Consultants population projections compared against section 1.7 population projections.

The recommendations provided by aGnR Consultants and summarised in this section of the report are based on a potential 2041 population of 1,047 as opposed to 1,315

Table 21: Future anticipated demand

	2021	2031	2041
aGnR Consultants study population assumptions	294	-	1,047
SMRC forecasts provided for this commission	297	770	1,315

Potable Water Supply (Cont.)

3.3.4. Recommended Upgrades

Planning and Investigation report by AGNR (October 2022)

The recent study of the Kalkite Water Infrastructure by aGnR Consultants provides details of the upgrade works required based on the hydraulic model for the current and future population predictions. It identifies necessary works in the village's water infrastructure to address immediate concerns across the network and enable future growth. The complete report can be found in Appendix B. The list of the infrastructure works required are listed below:

Medium Term Recommendations

- Upgrade the existing reservoirs by increasing the capacity up to 2.2 ML. And increase the elevation of the reservoir to improve the pressures in the system.
- Construct 200mm pipeline from high lift pump to new reservoir
- Upgrade of intake and high lift pump station to the town

Long Term Recommendations

- Upgrade existing ageing water mains in Kalkite potable network
- Eliminate dead end mains across Kalkite's potable network

Snowy Monaro Villages Water Safety Scoping Study report by hunterH2) (September 2020)

Medium Term Recommendations

- Construct a new 300kL/day membrane filtration plant on land already owned by council between the raw water pumping station and the community.

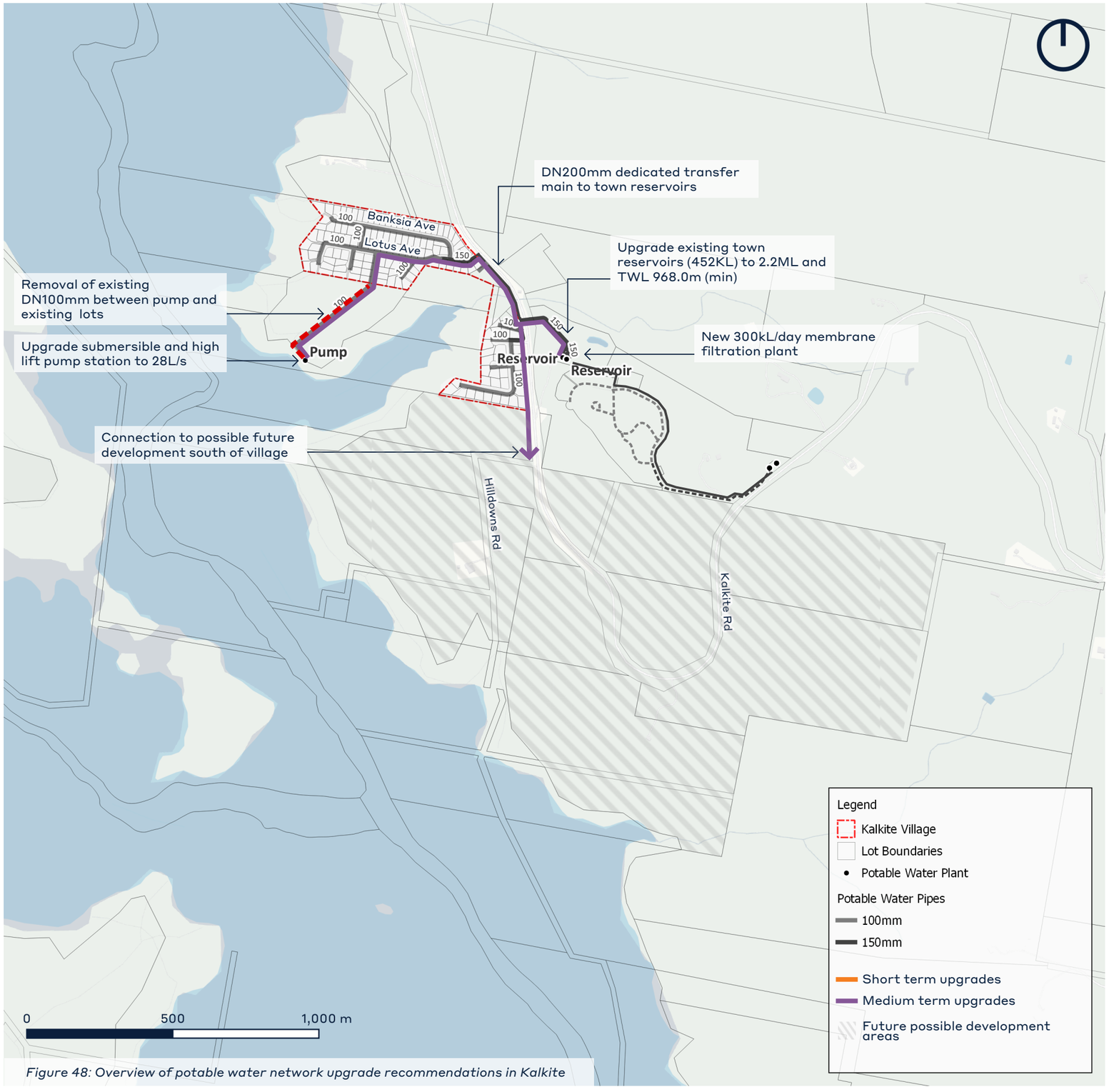


Figure 48: Overview of potable water network upgrade recommendations in Kalkite

Potable Water Supply (Cont.)

3.3.5. Implementation Plan

In aGnR Consultants' hydraulic model report, the capital cost of the listed upgrades and new work required to cope with the future requirements is provided in Table 22:

Table 22: Potable Water Implementation Plan

ID	Water Infrastructure	Key Entities Involved in upgrades	Capital Cost	Time-frame	Staged	Funding mechanisms
WP_01	Upgrade town reservoir to increase capacity up to 2.2 ML	SMRC	$2,500,000	Medium term	No	Council funded, developer contributions
WP_02	New DN200mm transfer main (1.4km)	SMRC, private landowners, TfNSW	$1,600,000	Medium term	No	Council funded, developer contributions
WP_03	Upgrade high lift pump station	SMRC, EPA	$1,000,000	Medium term	No	Council funded, developer contributions
WP_04	New packaged water treatment plant (WWTP)	SMRC, private landowners, TfNSW	$3,500,000	Long term	No	Council funded, developer contributions
WP_05	Upgrade existing ageing water mains in Kalkite potable network	SMRC, private landowners	$1mil +	Long term	Yes	Council funded
WP_06	Eliminate dead end mains across Kalkite's potable network	SMRC, private landowners	$1mil +	Long term	Yes	Council funded



Figure 49: View of Lake Jindabyne looking south

3.4. Sewer Network

The assessment of the current sewer network at Kalkite and subsequent recommendations for upgrade and augmentation was completed by consultants, aGnR Consultants and Westlake Punnett in 2022 and 2023. The section provides an overview of the existing infrastructure and summaries the outcomes from the other studies. The original reports, modelling and recommendations can be found in Appendix C.

3.4.1. Existing Conditions

3.4.1.1 Existing Network

Kalkite sewer system comprises of 4.5 km pipe reticulation network that discharges sewage by gravity to one of three rising mains. The sewer is then pumped up to the local Waste Water Treatment Plant (WWTP) located on the eastern side of the town. The current WWTP comprises of an oxidation ditch with maturation and evaporation ponds. The overview of the sewage system is provided below and in Figure 51 with WWTP location:

- The gravity network is comprised of three catchment areas that discharge to three (3) pumping stations (Ps13, Ps14 and Ps15). All sewerage is pumped to and processed by the local WWTP.
- The sewer network of Kalkite consists of 150mm AC pipe with maximum depth of greater than 4.5m.
- Properties beyond the town's pipe network have private on-site septic systems.

Table 23 provides a breakdown of Kalkite's sewer network's pipe size, material, age and max depth.

Table 23: Summary of Kalkite's sewer network pipe infrastructure

Diameter (mm)	Material	Year	Length (m)	Max Depth (m)
150	AC	1980	3,388	0 to 1.5
150	AC	1980	1,119	1.5 to 3.0
150	AC	1980	67	3.0 to 4.5

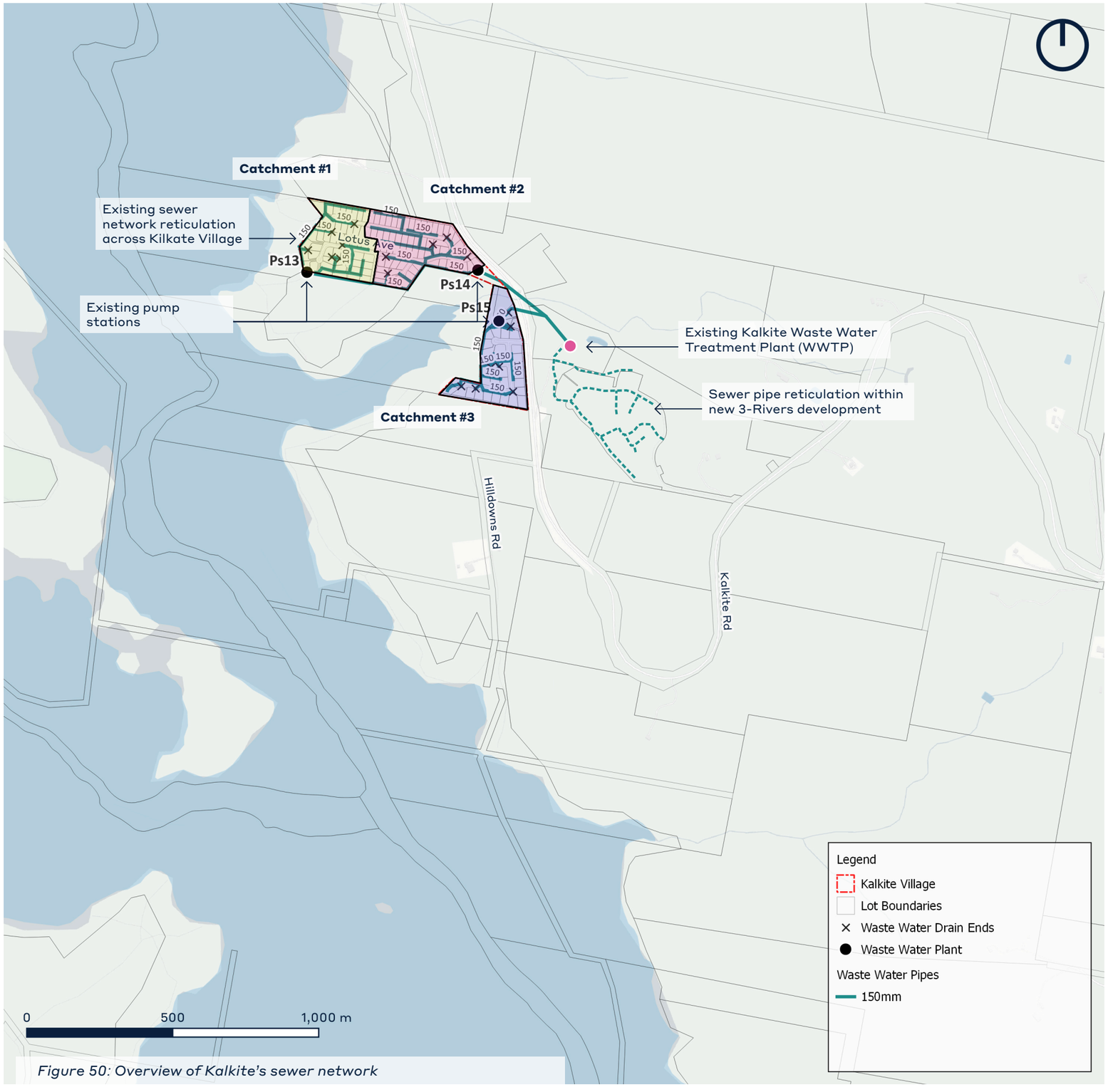


Figure 50: Overview of Kalkite's sewer network

Sewer Network Cont.

Existing Demand Assessment

The sewerage generation from the existing catchment is estimated based on the approach in WSA02-2014. The existing sewerage flow to the WWTP is obtained from the existing studies (Westlake, 20220) and summarised in Table 24:

Table 24: Existing sewerage flow

Item	Value
Total no. of lots	146
Equivalent Person (EP) per unit	3.5
Total EP	514
Average Dry Weather flow (ADWF) L/s	1.07
Peak dry weather flow (PDWF) L/s	3.82
Peak wet weather flow (PWWF) L/s	10.2

3.4.2. Planned infrastructure works and upgrades

In SMRC future proofing wastewater infrastructure works, it highlights that the 3.8 Km's of sewage network in Kalkite is to be upgraded. In addition to above, council plans to commission CCTV inspection and condition assessments of sewer and wastewater infrastructure (project started).

As per the Council delivery plan 2022-2026, Table 25 present the key infrastructure upgrades planned for whole council region including Kalkite:

Table 25: Planned sewer infrastructure for Kalkite

Project	Description	Objectives	Cost
SCADA replacement - water	Telemetry and SCADA systems updated to current standards	To meet the growth and provide security through resilient infrastructure	$500,000 *(SMRC wide funding)*
Sewer Main Replacement Program	Capital Works Program to replace sewer mains	To meet the growth in demands	$3,000,000 *(SMRC wide funding)*
Kalkite sewage plant upgrade	Augmentation of existing plant to cope with future developments	To meet the growth in demands	$1,400,000 *(SMRC wide funding)*
Sewer pump station replacement program	Capital works program to replace sewer pump station equipment	To meet the growth in demands	$800,000 *(SMRC wide funding)*

3.4.3. Future anticipated demand

The future projected population for Kalkite are provided in Section 1.7 of this report. It presents a forecast for future potential population growth through to 2041.

It is noted that the recent water studies conducted by aGnR Consultants and Westlake Punnett list difference forecasting population projection assumptions. It should be noted that the variation of these assumptions can influence the ultimate preferred option for infrastructure upgrade. Table 26 summarises the cited assessments' population projections compared against SMRC provided population projections.

Table 26: Sewer network future anticipated demand

	2021	2031	2041
Westlake Punnett study population assumptions	514 (EP)	-	1,340 (EP)
aGnR Consultants study population assumptions	321 (EP)	-	1,500 (EP)
SMRC forecasts provided for this commission	297	770	1,315



Figure 51: View of Kalkite Village looking west

Sewer Network Cont.

3.4.4. Kalkite Waste Water Treatment Plant (WWTP)

The Kalkite WWTP is located on the east side of the town. It consists of oxidation ditch, maturation pond and evaporation pond. There are three (3) sewer pump stations that collect the village's sewage via a gravity system and convey it to the WWTP through rising mains. The sketch of the overall system with the location of pump stations and WWTP is provided in Figure 54.

In 2022, Westlake Punnett conducted hydraulic assessment of the Kalkite WWTP. The report assessed and determined the water balance for the current plant. It considered the availability of on-site irrigation, the need for additional irrigation land and ultimately established volumes of wet-weather storage required for the site. It considered solutions that brought the current arrangement inline with current design and operational standards as well as introduced design solutions that catered for developments scenarios of ~1,500 EP.

It identified that there are cracks in the maturation pond - in the downward embankment. The report highlighted the a challenge to effectively dispose of treated effluent, due to the slope of the current site. It outlines the quantity and quality parameters, as well as physical constraints (setbacks etc) surrounding the identification of suitable on-site effluent irrigation areas. Presented a site stormwater management plan and recommended that a partial on-site effluent irrigation system be installed. It also recommended SMRC develop a more comprehensive and tailored management plan for the plant. The detailed recommendations and the WWTP hydraulic capability is provided in the report found in Appendix C.

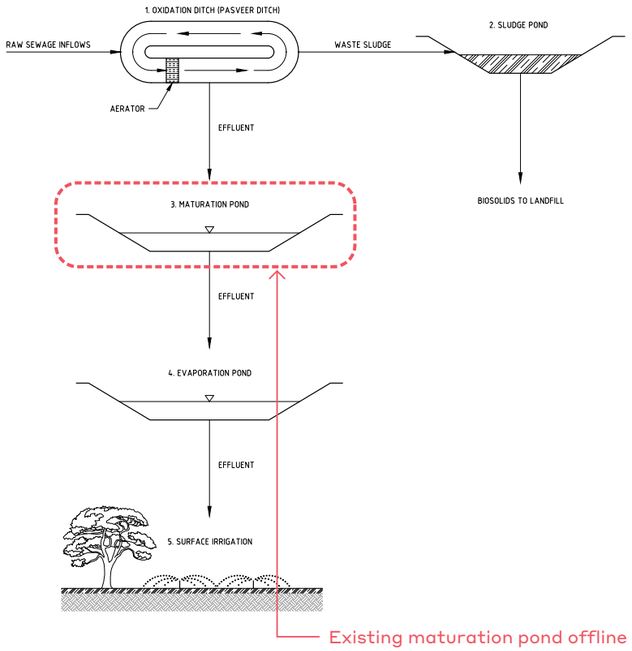


Figure 53: Kalkite's WWTP treatment process diagram (Westlake, 2022)

Table 27: EP assumptions

	Scenario Eps assumptions			
	~500	~826	~1000	~1500
Westlake Punnett, 2022	✓	✓	✓	✓
aGnR Consultants, 2023	✓		✓	✓

In 2023, aGnR Consultants completed a WWTP upgrade options study. Building on the work Westlake Punnett, aGnR Consultants undertook an analysis of effluent quality and quantity considering current measured results and calculated statistics against operational requirements . In a similar approach to the previous work, they consider several future growth scenarios. The EPs used in the two studies are summarised in Table 27.

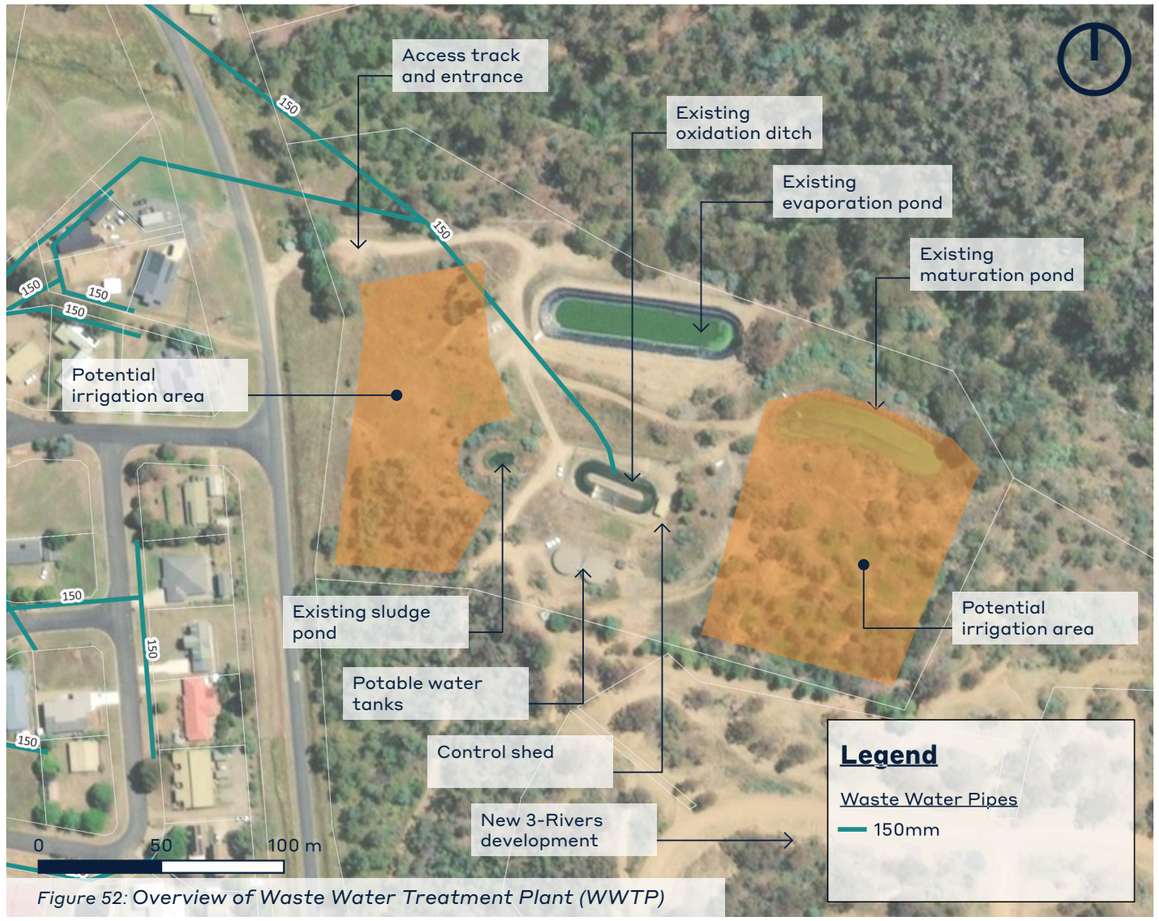


Figure 52: Overview of Waste Water Treatment Plant (WWTP)

It concluded that, the option to do nothing, or to undertake minor augmentation to the existing plant is no longer an suitable option. The existing elements of the existing WWTP are well aged, and essentially near the end of their functional life. They acknowledged the limitations of the site and tailored their recommendations to respond to the constrained topography. They presented several options, all with a common element, SMRC must locate an area for effluent disposal outside the current WWTP site once sewage inflows are consistently above 50 kL/day.

- **Option A**: Invest in infrastructure that will get the effluent outcomes but re-uses as much of the existing elements as possible.
- **Option B**: Invest in a new WWTP plant. No re-use of any element at the site, with a design that can cope with all future loadings.
- **Option C**: A hybrid of options A and B, minimising the economic impact but maximising the environmental outcomes, knowing that if Kalkite continues to experience substantial growth, then the current site has limitations to accommodate further expansion.
- **Option D**: Abandon the existing site with the view that sewage treatment and effluent disposal will not occur at the area. All sewage will be collected at a new pump station and pumped via a rising main to East Jindabyne.

Sewer Network Cont.

3.4.5. Recommended Upgrades

Kalkite Sewer Network Hydraulic modelling and Servicing Strategy, 2022

The recent studies conducted by Westlake Punnett outlined the proposed alignment for a main trunk sewer that will support Kalkite's potential future developments and growth. The sketch of the proposed trunk sewer is provided in in Appendix C.

Medium Term Recommendations

Option 1 - Extend Gravity Sewer Network from Ps15

Due to the proposed development, the sewage flow is expected to increase from 4.37 to 25 L/s. To accommodate this additional flow, following modifications are required in the existing system:

- Upgrade the existing trunk main from 150mm to 225mm
- Extend the sewer network to serve potential future developments
- Lowered the wet well of Ps15 to receive sewage from future developments to the south.

Option 2 - Construct new pump station and rising Main

- Divert the sewage to the lowest elevation of any future development (~914 m AHD used in report)
- Install new pump station at this lowest point
- Install new rising main from the new pump station to the WWTP

Other infrastructure augmentation recommendations

Medium to Long Term Recommendations

- Upgrade the ageing reticulation network e.g., part of the network is laid back in 1980s)
- Upgrade or replace Kalkite Waste Water Treatment Plant (WWTP) to perform for current needs and support future growth
- Upgrade or replace existing sewer pump stations - Ps13, Ps45 and Ps15

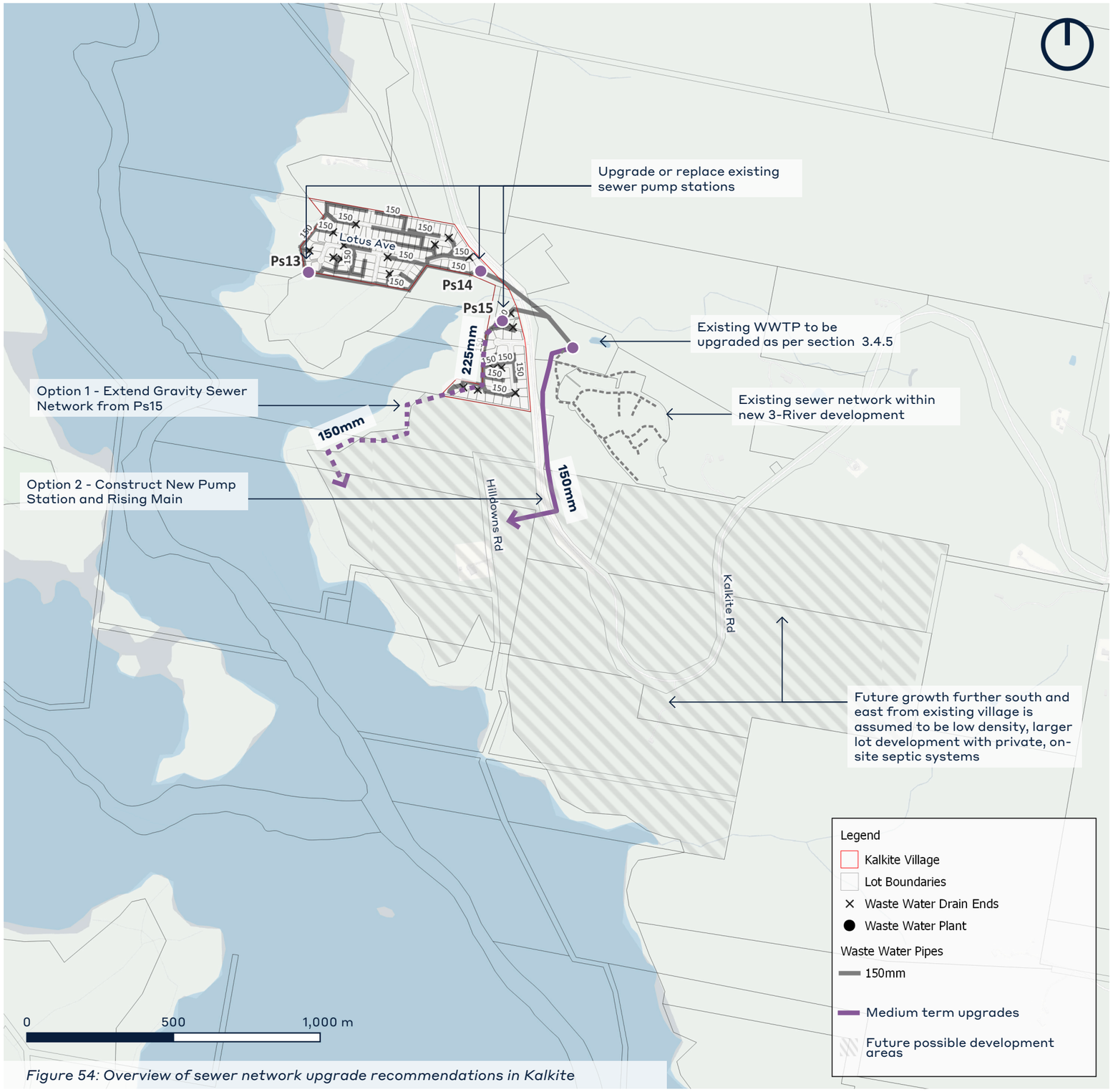


Figure 54: Overview of sewer network upgrade recommendations in Kalkite

Sewer Network Cont.

3.4.6. Implementation Plan

The upgrades recommended by Westlake Punnett (2022) and aGnR Consultants (2023) introduce the infrastructure upgrades listed in Table 28.

Table 28: Sewer Network Infrastructure Implementation Plan

ID	Sewer Network Infrastructure	Key Entities Involved in upgrades	Capital Cost	Time-frame	Staged	Funding mechanisms
S-01	Upgrade existing or install new sewer network to facilitate development south of Kalkite Village	SMRC, private developers, private landowners	$1mil +	Medium term	Yes	Council funded, developer contributions
S_02	Upgrade the ageing reticulation network	SMRC, private landowners	$1mil +	Medium term	Yes	Council funded
S_03	Upgrade or replace Kalkite Waste Water Treatment Plant (WWTP)	SMRC	$1mil +	Medium term	Yes	Council funded
S_04	Upgrade or replace existing sewer pump stations - Ps13, Ps45 and Ps15	SMRC	$1mil +	Medium to long term	Yes	Council funded, developer contributions



Figure 55: Aerial of Kalkite (Henley, 2023)



Kalkite Road Safety Review

4. Kalkite Road Safety Review

4.1. Overview and Methodology

A Route Safety Review is an investigation intended to identify existing safety concerns within a road corridor and provide recommendations to improve the safety performance of the route.

This section provides an summary of the Kalkite Road Safety Review completed by SMEC and Insight Infrastructure in 2023. The complete assessment can be found in Appendix F.

The Preliminary Route Safety Review (PRSR) for Kalkite Road presented here is based on the model applied to numerous regional highway corridors by Transport for NSW (TfNSW), noting it has been adapted to the needs of the Kalkite Infrastructure Study in several ways including:

- Whilst there are numerous safety deficiencies noted on the route, Kalkite Road does not have a substantial crash history. This is considered likely a result of the very low traffic volumes on the road. As such, the route safety review aims to anticipate parts of the corridor that are likely to perform poorly from a safety perspective if and when volumes on the route increase significantly.
- Given the early stage of the development life cycle that the Infrastructure Review lies; the limited availability of information; the scale of the route (traffic volumes, hierarchy, and length); and the fact that the review is seeking to forecast safety performance rather than assessing existing performance, the Kalkite Road PRSR is necessarily preliminary in nature and does not carry out the level of detailed analysis undertaken by TfNSW for larger and more significant corridors.

The approach used for route safety reviews aims to recommend road safety treatments that are known to be effective and can be implemented without major engineering works. The PRSR for Kalkite Road has been developed to examine and report on various road safety issues including:

- Current crash performance and how it may evolve with significant increases in traffic volumes
- General road conditions along the route and road safety issues identified at specific sites including those raised by the community
- Facilities, including intersection treatments, safety barriers, signage, line marking and direct accesses.
- The appropriateness of current speed limits and speed zones

4.1.1. Route Investigated

The review considers a portion of Kalkite Road between Eucumbene Road and the Kalkite village. The route is approximately 6 km long and connects Kalkite to the broader road network via Kosciuszko Road through either Eucumbene Road (a two way sealed carriageway) or Hilltop Road (unsealed). Kalkite Road is the only road connection for the village to the broader transport network and navigates a route through relatively steep mountainous terrain utilising highly curvilinear geometry and steep grades. The Kalkite Road route assessed is shown in Figure 56.

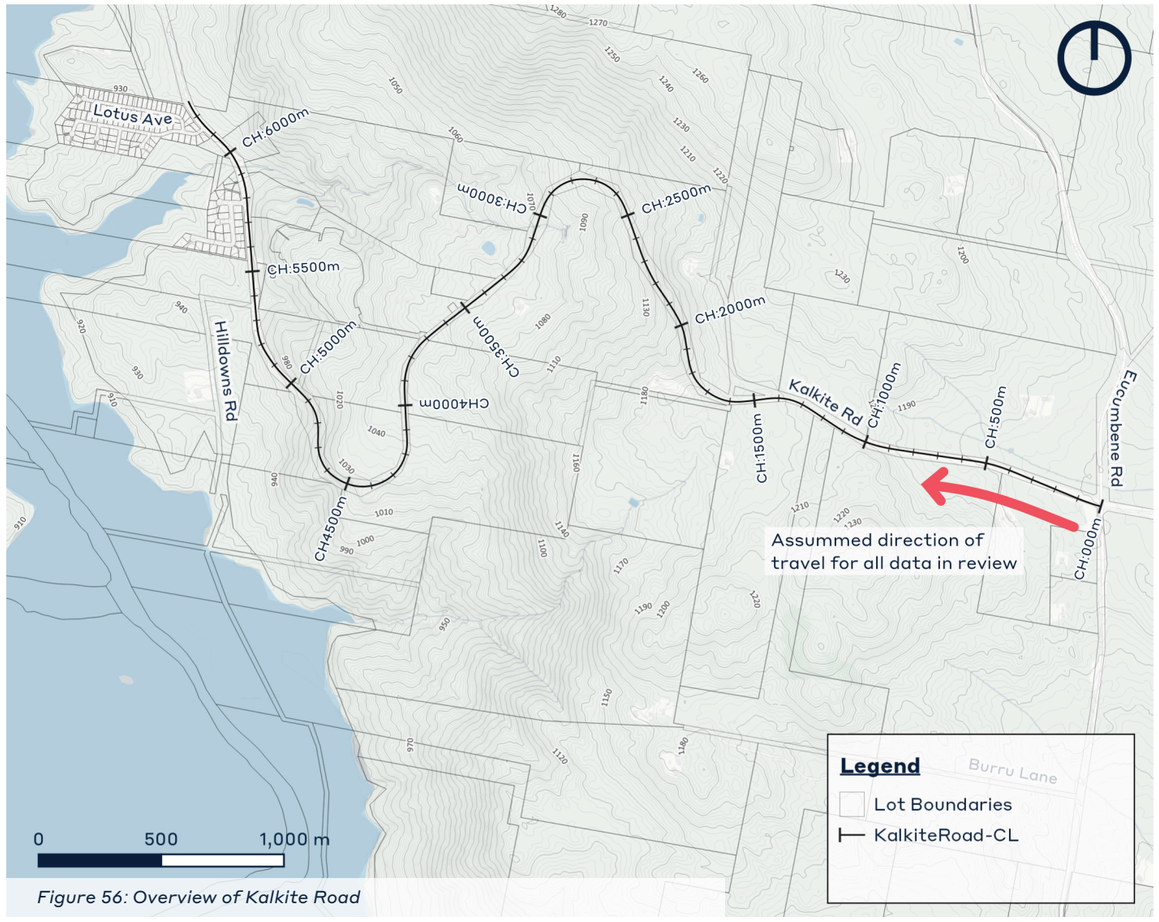


Figure 56: Overview of Kalkite Road

Kalkite Road has a current posted speed limit of 80 km/h over most of its length that reduces to 60 km/h on approach to the residential village zone of the corridor. It is a two-way single sealed carriageway that generally adopts a 6m wide cross section. The corridor currently experiences very low traffic volumes, although these volumes are forecast to increase by over 400% over the coming 20 years, albeit these forecast volumes are also considered relatively low and well below the capacity of the road and its intersections.

4.1.2. Traffic

A demand analysis for the Kalkite road corridor has been undertaken and is documented in the Kalkite Infrastructure Study. This analysis notes that 2023 traffic surveys indicate that Kalkite Road currently conveys 529 vehicle movements per day (vpd) in both directions. Classification of these movements is not available so it is unclear what proportion of these movements are by heavy or commercial vehicles. In terms of public transport, the Kalkite Infrastructure Study notes that there is currently one general local bus service and two school bus services that use the route.As future developments and increased population in Kalkite eventuate, the Infrastructure Study forecasts that trips on the route will increase to 2,350 trips per day (both directions).

Kalkite Road Safety Review (Cont.)

4.2. Safety Review

4.2.1. Crash History

Whilst the crash history of a corridor is not necessarily a predictor of future vehicle accidents, it can be used as an indicator understand the general safety of a route. As such, a review of crashes for the five years between 2018-2022 has been undertaken as part of the PRSR for Kalkite Road. Despite numerous identified safety issues on the route (discussed below), there has only been one crash in the corridor in the five years to 2022. The location of this crash is indicated in orange in Figure 55 which occurred during daylight hours in 2018 and was a single vehicle, non-casualty run off road crash on the bend just after CH 3000m. Given the safety concerns noted with the existing corridor discussed below, this relatively good crash performance is considered more likely to be a function of the low number of vehicle movements on Kalkite Road rather than the inherent quality of the route. With the expected increase in movements resulting from the development of the Kalkite village it is anticipate that without improvements to the road the annual crash rate on the route will increase as there will be more trips on corridor (increased exposure), and more interaction between vehicles (increased likelihood of crashes).

4.2.2. Kalkite Road Cross Section

Desirable Cross Section

Austroads GRD Part 3 provides guidance on appropriate cross section elements for rural roads in Australia. Key features of these requirements include:

- Lane width – 3.1-3.5m lane width for carriageways with 500-1000 vpd (3.5m for 1000-3000 vpd)
- Shoulder width - 1.5m (0.5 m sealed) for carriageways with 500-1000 vpd (2.0m incl. 1.0 m sealed for 1000-3000 vpd)
- Crossfall – 3% desirable, 7% max. for 70-89 km/h, 10% max. for speeds less than 70 km/h
- Verge width – 1.0m min to allow guidepost installation, 1.5 m if safety barrier is required, and >1.0m where batter rounding is required
- Turn lane width – 3.0m min (GRD Part 4A)

Existing Cross Section

Much of the existing Kalkite Road route is estimated to have a standard 6.0m wide rural road profile (ie 2 x 3.0 m lanes), noting that there are areas along its length where the road widens to allow for a turning lane . The typical cross section of Kalkite Road between Eucumbene Road and Lotus Avenue (CH 6150) is depicted in Figure 58 and Table 29 provides commentary on compliance with the GRD

Table 29: Lane Width Summary

Chainage (m)	Cross section(m)	Observations & Compliance with GRD Part 3
CH0m-CH6150m	6.0m (Profile 1)	3.0 m lanes marginally deficient for current volumes, substantially deficient for development volumes
CH3630m-CH3760m	Up to 13m (Profile 2)	Includes right turn lane to Three Rivers Estate. Approx 3.0 m wide through lanes (deficient) and 2.7 m wide turn lane. It is also noted that the turn lane length is insufficient for full deceleration off the mainline



Figure 57: Overview of posted speed, cross section and crash history along Kalkite Road

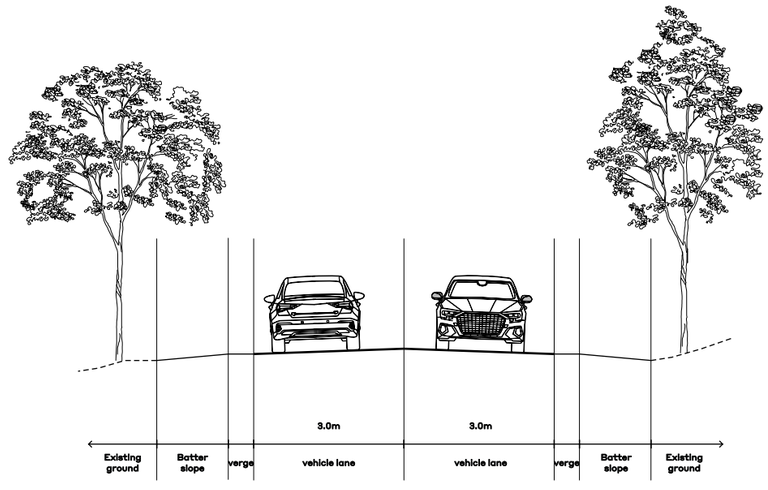


Figure 58: Typical cross section

Kalkite Road Safety Review (Cont.)

4.3.3. Kalkite Road Alignment

Road geometry plays a critical role in ensuring the safety of a road corridor. Deficient horizontal or vertical road alignment (or a combination of both) can create unsafe driving conditions and lead to road accidents. The GRD Part 3 provides guidance on appropriate road geometry for routes such as Kalkite Road, and has been used as a basis to assess whether the existing geometry of the road complies with current guidelines and good design practice. A brief summary of the general degree of compliance of the Kalkite Road alignment with the requirements of the GRD Part 3 is outlined below. However, a more comprehesive review is provided Appendix F.

Horizontal curves

Kalkite Road between Eucumbene Road and the Kalkite Village adopts a highly curvilinear alignment in response mountainous terrain of the corridor. It has numerous small-radius curves, many of which are considered substandard in the context of current design guidelines. It is further noted that any safety risks created by deficient horizontal geometry on Kalkite Road will be exacerbated by potential future developments in Kalkite and the associated expected increase in traffic volumes on the route.

Vertical curves

As noted above, the route navigates mountainous terrain, utilising relatively steep grades to negotiate the descent from the Eucumbene Road intersection to the Kalkite township. The grade of road alignment is presented in Figure 60. The GRD Part 3 recommends maximum grades of 6 – 9% for roads with operating speeds between 80-100 km/h, however it does acknowledge that there are circumstances when steeper grades are acceptable, several of which are applicable to the Kalkite Road route. These include:

- Comparatively short sections of steeper grade which can lead to significant cost savings
- Difficult terrain in which general maximum grades are not practical
- Where absolute numbers of heavy vehicles are generally low
- Less important local roads where the costs or impact of achieving higher standards are difficult to justify.

4.3.4. Roadside Hazards

This section of the review explores key roadside hazards present along Kalkite Road. The corresponding section in the complete memo is accompanied by additional figures and tables.

Road batter slopes

Kalkite Road is situated in mountainous topography and as a result there are numerous examples of fill batter slopes adjacent to the carriageway. Depending on slope and height, fill batter slopes can be a safety hazard for road users as they can cause loss of control and roll-over for errant vehicles.

Figure 58 presents an overview of slope topography in the region and used to identify notable identified cut/fill batter slopes on the route. The assessment estimates approximate fill batter slope and location, noting that these are generally the longer sections of substantial edge batter slops in the corridor and that there are many more shorter lengths of steep and unprotected batter drops in close proximity to the carriageway edge also present on the Kalkite Road route.

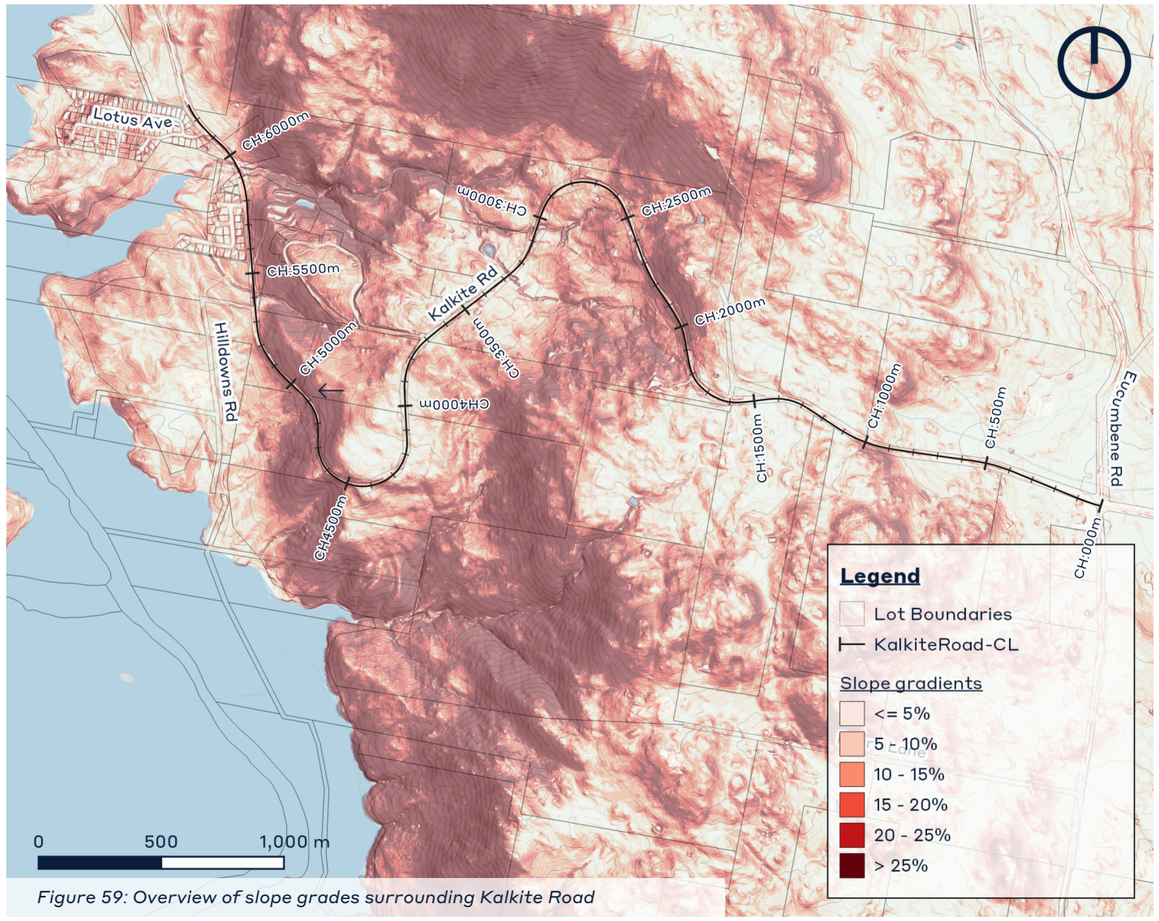


Figure 59: Overview of slope grades surrounding Kalkite Road

Drainage structures

Drainage structures under and adjacent to roadways can be a hazard as associated head walls can either create vertical drops and the risk of vehicle rollover or provide a non-frangible face that vehicles can impact. Several drainage structures have been identified on the route through a combination of aerial imagery, ARRB 2019 data and field observations.

Roadside objects

There are numerous unprotected roadside objects throughout the route in both directions of travel. Many of these objects are a safety hazard for errant vehicles that leave the carriageway, particularly in locations where they are on the outside of curves. These hazards include trees, rocks and power poles

Roadside furniture

The route lacks sufficient road furniture, with sporadic and often inconsistent placement of guideposts, especially in terms of post spacing and reflector orientation, not meeting AS 1742 .2 requirements. Additionally, the observed W-Beam safety barrier along a curved section (CH4420 – 5080) protecting a steep batter has not been assessed for its condition.

Kalkite Road Safety Review (Cont.)

4.3.4.1 Pavements

Whilst the safety review exercise was not intended to be a review of pavement condition or an asset management exercise, it is noted that defective pavements can pose a safety hazard for road users. The International Roughness Index data recorded by ARRB 2019 suggested that the pavement surface condition on the Kalkite Road route at the time was predominantly satisfactory, indicating that 61% could be classified as Very Good; 22% Good; 14% Fair; and only 2% poor in accordance with the National Association of Australian State Road Authorities classification framework.However, it is noted that localised pavement defects were observed during field validation activities.

4.3.4.2 Direct Property Accesses

There are numerous direct private property accesses onto Kalkite Road. Accesses that join collector roads can create safety issues as they:

- Can require vehicles to prop and hold in through lanes as they wait for a gap to turn right into the property access, creating a risk of rear end crashes
- May have deficient sight lines, resulting in vehicles entering the mainline from the property access unsafely, again resulting in the risk of collision

While these are unlikely to be significant safety concerns with the very low volumes that are currently use Kalkite Road, they will increasing become a safety issue as potential future development generates higher volumes on the corridor.

4.3.4.3 Sight line

There was insufficient information available to undertake a quantitative analysis of sight lines along the route. Notwithstanding, it is clear from visual field observations that there is a failure to achieve stopping sight distance requirements articulated in the GRD Part 3 in many locations along the route. There are several causes of these sight distance deficiencies, including:

- Cut Batter slopes – there are numerous locations where horizontal curves are located within cuttings. In many of these locations, cut batter faces impede sight lines through the curve
- Vegetation – vegetation on the inside of horizontal curves compromises sight distance in several locations.
- Crests – there are numerous vertical crest curves that impede stopping sight distance on the route.

Compromised sight distances on curvilinear mountain roads pose significant safety concerns, reducing drivers' reaction time to various hazards and increasing the risk of crashes. These challenges are exacerbated by the absence of lane line markings. Despite being typical in mountainous terrain, addressing these sight distance issues is crucial for enhancing road user safety.

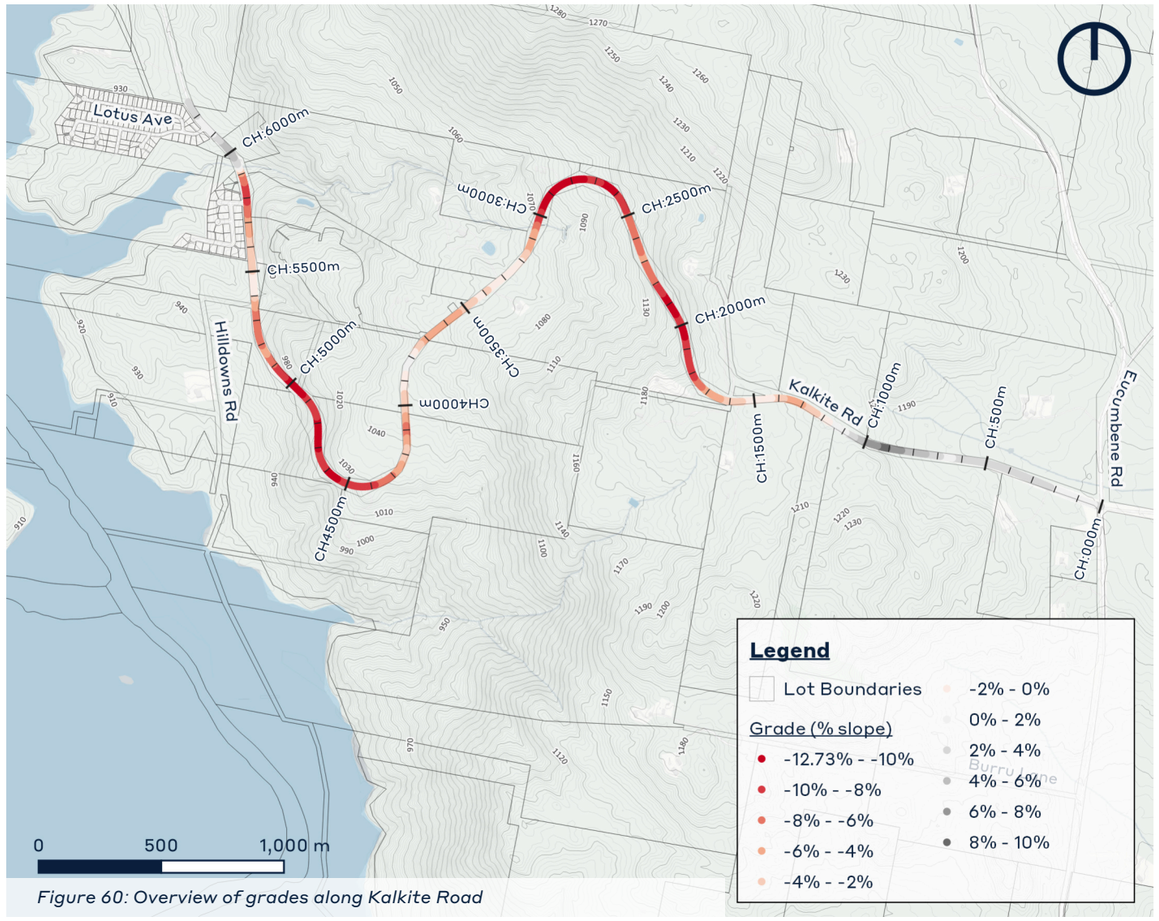


Figure 60: Overview of grades along Kalkite Road

4.3.4.4 Signage and Delineation

As noted above, there is no linemarking or raised pavement markers present on the route that delineate road geometry or lane extents. Whilst guideposts have been used in some locations, their use is inconsistent and the general absence of lane delineation significantly increases the risk of run off road and head on accidents.

There are several signage categories present on the route, including:

- Regulatory signage
- Warning signage
- Guide signage

Kalkite Road Safety Review (Cont.)

4.3.4.5 Intersections

Kalkite Road / Eucumbene Road Intersection

The existing four-leg priority controlled intersection at Eucumbene Road, Kalkite Road, and Hilltop Road meets general compliance standards, but it is considered undesirable according to Austroads Guide to Traffic Management. Visual cues are lacking, especially from the Kalkite Road approach, increasing the risk of crashes. Despite compliance, the design suggests that the provision of turn lanes is unlikely, as outlined in AGTM Part 6.

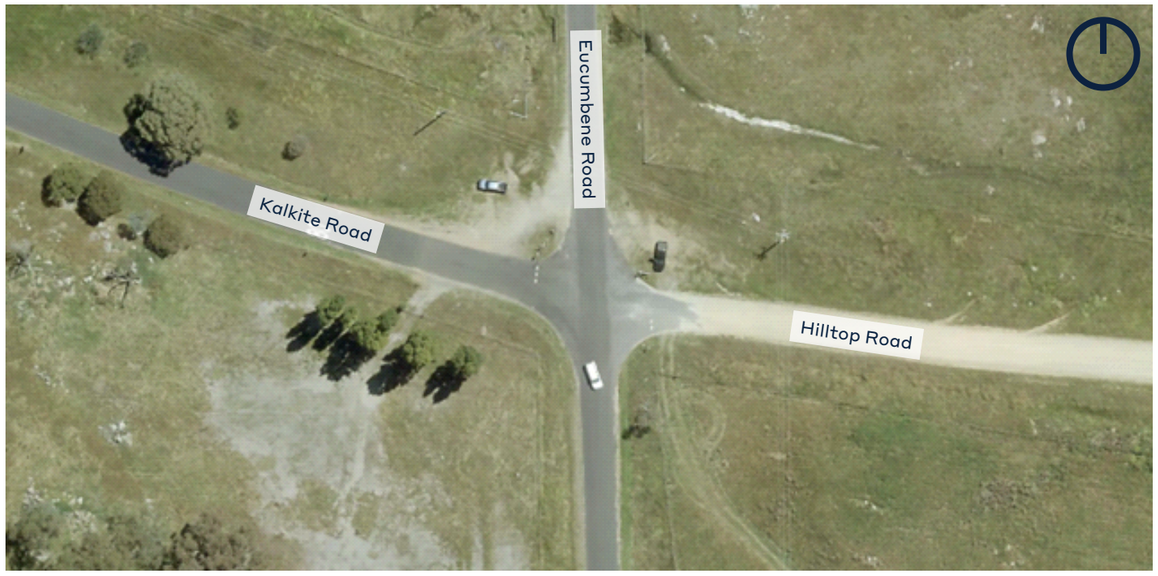


Figure 61: Kalkite Road / Eucumbene Road Intersection (metromaps, 2023)

Gardenia Circuit Intersection

The Gardenia Circuit intersection is T intersection (Kalkite Road being the major leg) providing access to residential properties. It is priority controlled by a give way sign, however does not have threshold line marking. Safe intersection sight distance appears good in both directions, and intersection geometry appears appropriate.

Lotus Avenue Intersection

The Lotus Avenue intersection is also T intersection with Kalkite Road as the major leg, and provides access to residential properties. It is priority controlled by a give way sign, however does not have threshold line marking. Safe intersection sight distance appears to be achieved to the north, however is potentially deficient to the south.

4.3.5. Kalkite Access

Kalkite Road serves as the sole access to the township of Kalkite, presenting challenges in terms of network redundancy, maintenance operations, emergency access, and community safety. The absence of alternative road connections poses risks, particularly with the potential growth of the population and heightened bushfire risk due to climate change. This situation may face opposition from emergency service providers like the NSW Rural Fire Service, concerned about potential isolation during emergencies. The Planning for Bush Fire Protection guidelines emphasises the need for strategic planning to exclude inappropriate development in bushfire-prone areas with challenging evacuation prospects. To address these challenges, potential approaches include developing a second access, enhancing the resilience of Kalkite Road and the township, and exploring alternative emergency access arrangements. Managing these risks is expected to be a growing focus for the future.

4.3.5.1 Second Kalkite Access

The ideal development of Kalkite would benefit from a second access to the village, but challenges arise due to local topography, environment, and property ownership. One potential option is extending Kalkite Road northward, using existing road gazettal and private property, looping back onto Eucumbene Road. This would necessitate property acquisition or a Right of Way agreement, along with constructing a road meeting standard dimensions and requirements. The feasibility in terms of environmental impact and cost needs confirmation, and alternative routes may also be considered. A formal second access would enhance network redundancy, especially for emergency access concerns with a growing population in Kalkite. However, its feasibility is yet to be confirmed. If deemed unviable, alternative approaches to managing safety risks would be explored through consultation with emergency service providers.

4.3.5.2 Resilience of Kalkite Road and Township

A potential alternative to a second access (or to complement it) and subject to consultation and support of the relevant emergency service providers, would be to improve the resilience of the existing Kalkite Road route such that it remains operational either through a bushfire event, or soon thereafter. These improvements could include:

- General enhancements such as improved cross section, geometry, delineation and pavement condition
- Vegetation removal to a specified setback from the road edge

This improvement in the access route resilience could be accompanied by enhancements in the Kalkite township itself, including:

- Supplementation of existing bushfire response infrastructure and equipment
- Vegetation management and regular fuel reduction activities
- Ensuring robust communication infrastructure is in place to allow comprehensive and reliable communication is facilitated during emergencies
- Enhanced development requirements for new dwellings

4.3.6. Conclusions

The PRSR has identified several safety concerns on the Kalkite Road corridor that present various degrees of risk to road users. Whilst the identified safety issues have not generated a poor crash history on the route in the past 5 years, this is considered likely a product of the low volumes in the corridor more so than the standard of the road. These identified safety risks include:

- Substandard road cross section - lane widths, shoulders, verge and cross fall not complying

Kalkite Road Safety Review (Cont.)

with modern design standards

- Substandard road geometry - vertical and horizontal alignment not complying with modern standards
- Unprotected roadside hazards - non-fragile objects, vertical drops and steep batters
- Deficient sight lines

The deficiencies in the road's design stem from value judgements and pragmatic decisions made by designers during its development, particularly in response to the challenging topography. Additionally, the road was designed according to standards and guidelines that differed from current ones, contributing to its non-compliance with current design standards, a common characteristic of rural roads in mountainous regions. Despite these challenges, there are opportunities to enhance safety for corridor users, especially considering the anticipated growth in demand on the route.

4.3.7. Recommendations

Given that upgrading Kalkite Road to current design standards is highly likely to be both cost prohibitive and economically nonviable, a suite of recommended improvements are proposed that are intended to improve safety on the route in a financially sustainable way. It is suggested that these recommendations be part of a long term programme of works for Kalkite Road, responding to growth in traffic volumes over time and in observed changes to crash patterns. The recommendations include five broad categories

Short Term Recommendations

Signage improvements

Provision of enhanced v is a relatively low cost and effective way to improve safety performance. It is recommended that a review of existing signage and improvement opportunities be undertaken, which is expected to consider the following signage types observed in AP-R449-14 to be effective in improving safety:

- Advanced warning signage with speed advisory warnings
- Chevron Alignment Markers for small radius curves, particularly those with high safety risks
- Guidepost repair and installation in accordance with current design standards

Revised Speed Regime

Many of the horizontal curves on the route between CH 1500 – 5300 m are deficient either in terms of side friction, sight lines, or both, for the current posted and expected operating speed. Similarly, there are several vertical crest curves that appear likely to provide deficient sight distance for the existing operating speed. It is therefore recommended that investigation of speed limit reduction be undertaken for the route from CH1400 onwards to 60 km/h (or potentially 70 km/h if compliance is considered unlikely to be achieved). If it is found that the Eucumbene / Kalkite Road intersection develops a significant crash history as traffic volumes grow in response the further development in Kalkite, consideration could be given to a Reconfiguration of the intersection, including:

- Roundabout
- Staggered T
- General enhancements (signage, line marking, splitter islands etc)

Medium Term Recommendations

Protection / Removal of Roadside Hazards

Austroads (AP-R691-23) identifies safety barriers as a highly effective safety solution to reduce the severity of run-off-road accidents. Given the nature of many of the identified safety issues (including substandard horizontal geometry and numerous roadside hazards) it is recommended that a programme of flexible safety barrier installation be undertaken, targeting highest risk areas. Recommended installation sites include:

- Zones on the route that have steep batters, including those adjacent to residential dwellings
- Locations of vertical drops in close proximity to the carriageway edge, particularly transverse culvert headwall sites
- Instances of non-frangible hazards eg large diameter trees, boulders and power poles in close proximity to the carriageway.

Long Term Recommendations

Cross Section Improvements

It is recommended that a program of carriageway widening be undertaken along the route to improve the cross section of Kalkite Road, coordinated with rehabilitation works of edge damage as it occurs. There are two primary cross-sectional improvements recommended:

- Provision of 3.5 m lane widths
- Provision of 0.5 m minimum sealed shoulders

Where the existing formation and topographical constraints do not allow substantial carriageway widening it is recommended that provision of 0.5 m shoulders be prioritised over 3.5m lanes (ie a minimum treatment should target 3.1 m lanes and 0.5 m shoulders). It is recommended that pavement rehabilitation be undertaken in defect areas as part of cross section improvement works.

Delineation Improvements

Currently lanes including carriageway edges are not delineated on the entire Kalkite Road route. It is recommended that in conjunction with the proposed cross section improvements describe above, lane delineation line marking (edge and centre) in addition to raised pavement markers (Raised Reflective Pavement Markers and potentially audio tactile line marking) be provided for the entirety of the route. It should be noted that it is not advised to provide lane delineation improvement along Kalkite Road prior to cross section improvements as it will result in highly substandard lane widths and could potentially be counterproductive in terms of crash reduction.

It is also recommended that delineation on approach to Eucumbene / Kalkite Road intersection be enhanced in all directions (potentially including a splitter island on the Kalkite Road approach) to enhance the legibility of the intersection.

Stormwater and WSUD Management Strategy

5. Stormwater and WSUD Management Strategy

Stormwater management is the planning and implementation of actions that manage urban stormwater runoff from various surfaces. It can be classified into three categories.

- **Flooding** – Flooding is inundation of normally dry land. This may occur when rivers and creeks overtop their banks due to excessive flows from upstream catchments (riverine flooding) or flow paths are formed with flood waters pooling in low-lying flat areas (overland flooding).
- **Drainage** – Drainage is the natural (grassed channels and drains) or artificial (pits and pipes) systems that remove surface water and discharge into waterways.
- **Water Quality** – Water quality determines the condition or health of existing waterways such as creeks, rivers, and coastal waters.

This stormwater strategy has been developed to help Council deliver the required stormwater service that caters for future growth while maintaining and improving existing stormwater infrastructure.

5.1. Existing Conditions

5.1.1. Flooding

Draft Snowy Monaro Local Environmental Plan 2022

SMRC was formed through an amalgamation of the Bombala, Cooma- Monaro and Snowy River Shires. Council previously has two planning policies as follows:

- Cooma, Bredbo and Michelago: Cooma-Monaro Local Environmental Plan (LEP) 2013
- Berridale: Snowy River Local Environmental Plan (LEP) 2013

Council recently developed the Draft Snowy Monaro LEP 2022. The LEP includes two clauses dedicated to flooding. Clause 5.21 includes Flood Planning (compulsory) and clause 5.22 includes the special flood considerations (optional) which is based on the NSW government flood prone land package which commenced in July 2021.

The flood planning clauses apply control to land at or below the Flood Planning Level (FPL) as well as to land identified as Flood Planning Area (FPA). These are defined as:

- **Flood Planning Level (FPL):** 1:100 Annual Exceedance Probability (1% AEP) Plus 0.5m freeboard
- **Flood Planning Area (FPA)**: is the area of land at or below the flood planning level (FPL).

The special flood considerations apply to land between the FPL and Probable Maximum Flood (PMF) for the following sensitive and hazardous development land uses:

- correctional centres,
- early education and care facilities,
- educational establishments,
- emergency services facilities,
- group homes,
- hazardous industries,
- hazardous storage establishments,
- hospitals,
- hostels,
- respite day care centres,
- seniors housing.

In addition, the special flood considerations clauses apply to development where in the event of a flood the land is considered to cause a risk to life and requires evacuation of people or other safety considerations.

Snowy River Shire Development Control Plan (2013)

To ensure development does not adversely increase the flood affectation on other development or properties, either individually or in combination with the cumulative impact of similar development/s likely to occur within the same catchment, the Development Control Plan (DCP) specifies the following requirements for development in flood prone land:

- Residential development (new and extensions) minimum floor levels for all habitable rooms are to be 500mm above the 1:100 Annual Exceedance Probability (1% AEP) flood level. Freeboard requirement can be decreased to 300mm for overland flooding if significant scaling of flood levels is not noted for larger events.
- Commercial development (new and extensions) minimum floor levels are to be a minimum 1:20 Annual Exceedance Probability (20% AEP) (plus 300 mm).
- The filling of land up to 1% AEP is not permitted.
- All developments must satisfy the requirements contained in the Flood Planning Control Matrix shown below in Figure 59and Figure 60.

2.5.2 FLOOD PLANNING CONTROL MATRIX

FLOOD PLANNING CONTROL MATRIX

FLOOD EVENT	PROBABLE MAXIMUM FLOOD TO 1:100 AEP							1:100 AEP FLOOD TO 1:20 AEP FLOOD							1:20 AEP TO RIVER/CREEK						
LAND USE	LAND USES SPECIFIED IN CLAUSE 5.22 OF LEP	ESSENTIAL COMMUNITY FACILITY	CRITICAL LIFELINES	SUBDIVISION AND FILLING	RESIDENTIAL	COMMERCIAL AND INDUSTRIAL	RECREATION AND AGRICULTURE	MINOR DEVELOPMENT	LAND USES SPECIFIED IN CLAUSE 5.22 OF LEP	ESSENTIAL COMMUNITY FACILITY	CRITICAL LIFELINES	SUBDIVISION AND FILLING	RESIDENTIAL	COMMERCIAL AND INDUSTRIAL	RECREATION AND AGRICULTURE	MINOR DEVELOPMENT	LAND USES SPECIFIED IN CLAUSE 5.22 OF LEP	ESSENTIAL COMMUNITY FACILITY	CRITICAL LIFELINES	SUBDIVISION AND FILLING	RESIDENTIAL	COMMERCIAL AND INDUSTRIAL	RECREATION AND AGRICULTURE	MINOR DEVELOPMENT
FLOOR LEVEL	3		3		2								2	1	1							1	1	
BUILDING COMPONENTS	2		2										1	1	1	1						1	1	1
STRUCTURAL SOUNDNESS	3		3										4	1	1	2	2				1	1	1	1
FLOOD EFFECTS	1												1	1	1	1	1				1	1	1	1
EVACUATION/ACCESS	3		2	3	3	3							3	1, 3	1, 3	1					3	3	1	
FLOOD AWARENESS	1, 2		1	1	1	1	1						1, 2	1, 2	1, 2	1, 2	1, 2			1, 2		1, 2	1, 2	1, 2
MANAGEMENT AND DESIGN	3												2		1					2		1		

Where the table indicates 1,2 this implies both requirements are applicable

Colour Key: UNSUITABLE LANDUSE; NOT RELEVANT

NOTE:
A Numbers in the categories are outlined in the table below
B Essential Community Facility includes development such as hospital, aged care facility
C Critical Utilities include water and sewer control buildings, electrical substation, telephone exchange, emergency centre

Figure 62: Flood Planning Control Matrix

2.5.3 Flood planning control matrix – Key

No.	FLOOR LEVEL	BUILDING COMPONENTS	STRUCTURAL SOUNDNESS	FLOOD EFFECTS	EVACUATION/ACCESS	FLOOD AWARENESS	MANAGEMENT AND DESIGN
1	All floor levels to be equal to or greater than the 1:20 Annual Exceedance Probability flood plus 0.3 metres (freeboard).	All structures to have flood compatible building components below or at the 1:100 Annual Exceedance Probability flood level that can withstand the force of floodwater, debris and buoyancy up to a 1:100 Annual Exceedance Probability flood.	Engineer's report by a suitably experienced and qualified professional to prove any structure subject to a flood up to and including the 1:100 Annual Exceedance Probability flood level can withstand the force of floodwater, debris and buoyancy.	Engineer's report by a suitably experienced and qualified professional required to prove that the development will not increase flood affection elsewhere.	Suitable access for pedestrians required during a 1:100 Annual Exceedance Probability flood.	Condition to be placed on consent advising of minimum floor levels required in relation to the flood level.	Applicant to demonstra that there is an area where goods may be stored above the 1:100 Annual Exceedance Probability flood level equivalent to 25% of th display area or storage during floods.
2	Habitable floor levels to be equal to or greater than the 1:100 Annual Exceedance Probability flood plus 500mm metres (freeboard).	All structures to be constructed of flood compatible building materials below or at the possible maximum flood.	Any structure subject to a flood up to and including the 1:100 Annual Exceedance Probability flood shall withstand the force of floodwater, debris and buoyancy.		Suitable access for pedestrians and vehicles required at or above the possible maximum flood level.	S10.7(2) Certificates to notify affectation by the 1:100 Annual Exceedance Probability flood.	Applicant to demonstra that the potential development as a consequence of subdivision proposal ca be undertaken in accordance with this Pla
3	All floor levels to be equal to or greater than the possible maximum flood.		Any structure subject to a flood up to and including the possible maximum flood level shall withstand the force of floodwater, debris and buoyancy.		Consideration required regarding an appropriate flood evacuation strategy and pedestrian/vehicular access route for both before and during a flood.		Applicant to demonstra ongoing functionality during and after a flood event.
4			Geotechnical Engineer's report by a suitably experienced and qualified professional required to specify appropriate filling earthworks and the means of retention of batters against scoring/erosion.				

Figure 63: Flood planning control matrix – key

Stormwater and WSUD Management Strategy (Cont.)

Technical Study Report – Engineering Infrastructure (WSP, 2021)

The report studies existing infrastructure networks and makes recommendations to upgrade or construct new services to meet the master planning needs of the Snowy Mountains Special Activation Precinct (SAP) project. The Snowy Mountains SAP aims to:

- Increase year-round tourism to grow the regional economy.
- Create year-round employment opportunities.
- Invest in the region's infrastructure to meet the growing needs of residents, seasonal workers, and temporary visitors.
- Attract more visitors to the region from Australia and the world, transforming the Snowy Mountains into Australia's Alpine Capital.

As per this study increased developed land and population will result in an increase of stormwater runoff into Lake Jindabyne. While the Lake has enough storage to absorb the stormwater runoff and not be affected by sediment and nutrient laden runoff, there is still potential for poor stormwater practices to affect the aesthetics of Lake Jindabyne. Therefore future development needs to manage stormwater runoff to ensure all surface water that reach the lake is clean such that it enhances uses of the lake for fishing, water sports and recreational uses on the foreshore.

The Department of Planning and Environment has put together a series of aspirations for the Snowy Mountains SAP. The study identifies those that are relevant to flooding and water quality, and has proposed the following recommendations to align with the aspirations:

- Future development needs to consider the entire water cycle through minimising hard surfaces and encouraging stormwater runoff to infiltrate and be treated through Water Sensitive Urban Design (WSUD) measures that mimic the natural filtration and storage processes of the hydrologic cycle. This may include:
  - Planting of vegetation adjacent to new roads and footpath such as garden beds and small shrubs. Increased planting assists in water pollution capture of run off, and minimises velocities of minor flood events to prevent scouring of water ways and reduce the volume of water the flood zones from a large influx to a gradual increase over time.
  - Using open grass channels in areas instead of pit and pipe networks. The channels benefit from increased vegetation as mentioned above, and also minimise the construction impact on environment and reduce capital cost.
- Ensure future development of the waterfront land considers stormwater runoff and overland flow path connections to the Lake. Poor stormwater quality draining into the Lake will detract from use of the area around the stormwater connections and mismanaged overland flow paths may erode land at the foreshore reducing use of the land. The varying Lake levels will also need to be considered when designing waterfront amenities. Proposed infrastructure to accommodate these design principles include:
  - Construction of appropriate new stormwater pit and pipe networks are the location of lakeside developments with outfalls to the lake.
  - Construct floating wetlands.
- Ensure future transport networks are designed to meet future rainfall climate conditions, consider at source treatment of stormwater and design the transport networks to be free from regular flooding and the risk understood for extreme flood events. Proposed infrastructure to accommodate these design principles include:
  - Stormwater capture for new developments and households. Council has the opportunity upon reviewing development applications, to do with the Snowy Mountains SAP or otherwise, to promote and require an applicable amount of onsite water retention and recycling.
  - Appropriate stormwater pits and pipes to capture increase run off from new road areas

Snowy Monaro Draft Settlements Strategy 2022

For the Kalkite town centre, the strategy recommends the following:

- Review land use zoning and controls to ensure LEP controls are consistent and compliment SAP Master Plan and desired future character.
- Council advocate for Implementation of SAP Master Plan to be informed by evidence and the local community.

5.2. Drainage

Snowy River Shire Development Control Plan (2013)

A stormwater management plan is required for all major developments and in some cases when requested by Council. The plan is to demonstrate compliance with water quantity, conveyance, water quality, discharge, and flood protection criteria. The following requirements have been identified in the DCP:

- All new developments demonstrate that post-development peak flows do not exceed pre-development peak flows.
- Major drainage systems are to demonstrate that the peak 1% AEP flow is contained within roads, drainage swales, easements, public space, or suitable areas.
- Minor drainage systems are to be designed to safely control and convey the critical 20% AEP event, including the design provision of a 50% blockage to all inlet structures.
- Stormwater harvesting measures are to be implemented to maximize stormwater reuse and prevent an increase in the quantity of stormwater discharge from the development site which can impact on downstream environments.
- Permeable paving is to be designed and installed where practical to minimize runoff from roads.
- On-site infiltration systems are to be used where the suitability of insitu soils in relation to hydraulic conductivity can be demonstrated (typically by site testing using 'falling' and 'constant head' tests).

Snowy Monaro Local Strategic Planning Statement (2020).

- The Snowy Monaro Local Strategic Planning Statement encourages best practice stormwater management in new developments including use of rainwater tanks for capture and use for non-potable purposes.

5.2.1. Stormwater Drainage Network

There is limited stormwater drainage network within the township of Kalkite with majority being kerb and gutter drainage system. Based on the data provided, the following drainage network service the township:

- Gardenia Ct (450mm diameter), Rosemary Ct (300mm diameter) and Magnolla Ave (300mm diameter) collect stormwater runoff from the area and discharge into the

Stormwater and WSUD Management Strategy (Cont.)

open space adjoining Taylors Creek.

- A 450mm diameter pipe from Banksia Ave collects stormwater runoff and connects into a 300mm diameter pipe along Lotus Ave which then connects into a 750mm diameter pipe that discharges into an existing open channel south of Lotus Ave. Another 750mm diameter pipe also connects into the 300mm diameter pipe along Lotus Ave with the 450mm diameter pipe.
- 375mm diameter pipes from Lotus Ave and Nemesia Ct discharging into the existing open channel south of Lotus Ave.
- 375mm diameter pipes from Banksia Ave discharging into the open space adjoining Lake Jindabyne.
- Two parallel networks of 375mm diameter pipes that collects runoff from Lotus Ave and Oleander Ct and discharge into the open space adjoining Lake Jindabyne.

5.2.2. Water Quality

Snowy River Development Control Plan (2013)

The Snowy River DCP specifies the following the stormwater pollutant reduction targets required for stormwater discharges into the waterways. These are provided in Table 28 below.

Table 30: Stormwater Pollution Reduction Targets

Pollutant	Removal Target
Total Suspended Solids (TSS)	80% retention of the average annual load*
Total Nitrogen (TN)	45% retention of the average annual load
Total Phosphorus (TP)	45% retention of the average annual load
Litter (>50mm)	Provide mechanisms to retain litter from frequent flows

**Average Annual Load is the yearly weight of pollutants (kg/yr) from the developed site with no pollution controls installed.*

New developments are required to undertake a quantitative analysis demonstrating compliance with these targets. The DCP recommends WSUD principles to be incorporated into the design of stormwater drainage and in the orientation of development.

There are currently no Council maintained WSUD assets within the township.

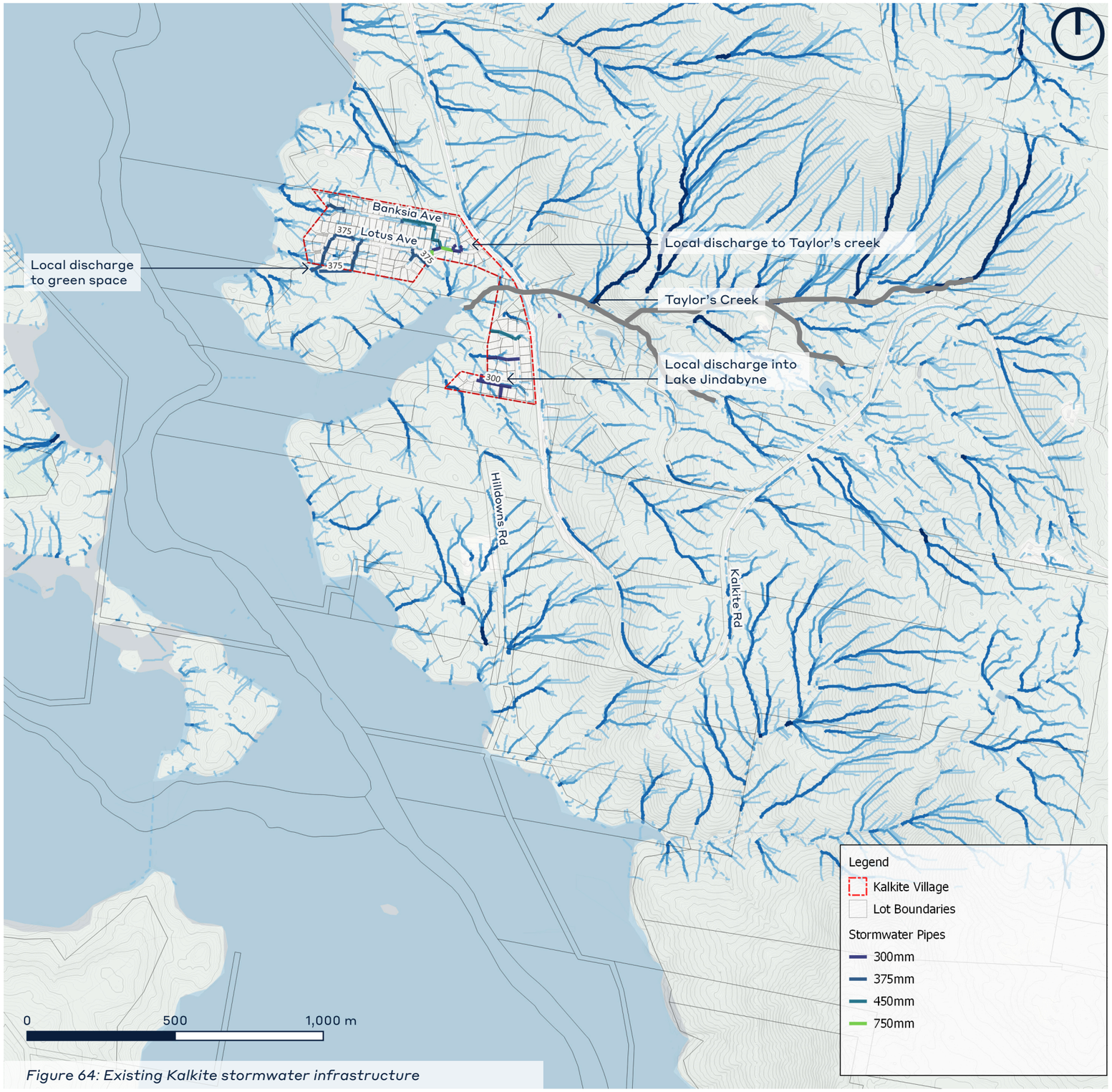


Figure 64: Existing Kalkite stormwater infrastructure

Stormwater and WSUD Management Strategy (Cont.)

5.3. Planned infrastructure works and upgrades

As per Council's 2022-2026 Delivery Program no stormwater infrastructure upgrade has been identified for the township of Kalkite.

5.4. Future Anticipated Demand

The population of Kalkite is 294 as per the ABS 2021. It is anticipated that the population will increase to 1,315 by 2041. To help Council deliver the required stormwater service that caters to this future demand, a list of management measures has been identified and described in the following sections.

5.5. Recommended Management Measures

A range of structural and non-structural management measures have been identified to address the existing stormwater management issues and respond to future growth. The stormwater management measures comprise of five main approaches:

- Asset Management
- Education and Awareness
- Planning and Development
- Maintenance and Monitoring
- Stormwater Infrastructure

5.5.1. Asset Management

Improve the condition of Council's current stormwater infrastructure data set starting with areas subject to high-risk flooding issues

During data review process gaps in stormwater drainage data has been identified. Developing a stormwater management asset data base with suitable information, including condition, will allow identification of appropriate actions for those assets requiring maintenance, renewal or upgrade to improve performance including associated costs and priority. Council can then develop an asset renewal program to allow regular maintenance and upgrades of stormwater infrastructure.

5.5.2. Maintenance and Monitoring

Regularly maintain stormwater structures including grassed areas within and adjacent to open urban stormwater channels

Regular cleaning of stormwater structures such as open channels, culverts, pits and pipes will reduce the potential for blockages and subsequently reduce localised flooding issues.

5.5.3. Education and Awareness

Develop education campaigns targeted at Building and Construction industry on the implementation of soil and water management controls during construction

When land is cleared of vegetation for construction, the soil is exposed and is vulnerable to erosion from rainfall events. Eroded soils lead to blocked drains and contribute to stormwater turbidity and waterways pollution. Engaging with the building and construction industry and increasing their knowledge and awareness on soil and water management controls during construction will help reduce the impact to downstream creeks and waterways.

Develop a stormwater pollution and management education program for local schools and community organisations

Local schools and community organisation can be a valuable resource to educate the wider local community on stormwater quality and waterways health. Partnerships can be formed and education programs can be delivered through them to raise knowledge and awareness within the community on stormwater management issues and the role they can play to reduce the impact to the downstream receiving environment. The stormwater education programs can be combined with Council's other existing education programs such as waste management, water efficiency, sustainability, etc.

Publish regular stormwater information on Council's website, social media accounts and newsletters

This is the traditional engagement approach wherein Council disseminates regular stormwater management information through its website, social media and newsletters to help raise knowledge and awareness within the community on stormwater management issues and the role they can play to reduce the impact to the downstream receiving environment.

5.5.4. Planning and Development

Undertake a Flood Study for Kalkite

There is currently no information available on flooding within the township of Kalkite. It is recommended that an mainstream and overland flood study is undertaken for the township under the NSW Floodplain Management process. Developing this flood study will:

- Identify the existing flood behaviour of Taylors Creek, overland flow paths within the township and its interaction with water levels in Lake Jindabyne.
- Identify the capacity of the existing drainage system.
- Identify the areas of flood prone land to assist with stormwater infrastructure requirements, flood planning and risk management.
- Establish the likely flood risk and flood hazard for existing properties and future development in the township.
- Provide flood intelligence to Council and the NSW State Emergency Services to assist in flood emergency response and planning.
- Undertake climate change assessment to understand the impact of climate unpredictability on flood behaviour and assist with planning for resilience. New developments and road networks can be designed to future climate conditions to be free from regular flooding.

Stormwater and WSUD Management Strategy (Cont.)

Incorporate Stream Erosion Index (SEI) target in DCP to compliment the water quality targets

Stream erosion is assessed using a measure of the increase in the relative frequency in flows from the site greater than the identified 'stream forming flow' resulting from the urbanisation of the catchment. The Stream Erosion Index (SEI) is defined by Department of Planning and Environment (DPE) as the post development duration of flows greater than the 'stream forming flow' divided by natural duration of flows greater than the 'stream forming flow'. This provides an appropriate means of assessing and addressing the impacts of urbanisation on the frequency of regular flows to the waterways.

SEI will provide a means of waterway erosion assessment for new developments that will set easily reviewable outcomes based on simplified hydrologic and geomorphologic principles. This will help to ensure that waterway stability is considered for future developments as a requirement of development controls in the DCP.

The DPE guidelines recommend a SEI of between 3.5-5.

Empower developers and designers to consider urban stormwater management at the early stages of their master planning

This strategy looks to promote consideration of urban stormwater management from the beginning of planning for developers. By emphasising stormwater management considerations in discussions with developers, it will encourage development layouts that prioritise stormwater and water quality outcomes rather than tailoring non-best practice stormwater solutions to developments at the end of the planning and designing process.

Review erosion control procedures on new developments including training of relevant Council staff to enable this

When land is cleared of vegetation for construction, the soil is exposed and is vulnerable to erosion from rainfall events. Eroded soils lead to blocked drains and contribute to stormwater turbidity and waterways pollution. Inspection and auditing of construction sites is typically conducted by Council and hence having suitable procedures in place with trained Council staff undertaking inspections, will ensure improved implementation of erosion control procedures.

Implement stormwater management service charge to allow Council to raise stormwater management revenue in addition to that already provided through Council's general income

In regional NSW, responsibility for stormwater management is shared between State Government, water corporations, local government, and private owners / developers. Funding for stormwater management is provided through a variety of mechanisms including:

- Council general revenue
- Stormwater management service charge
- Special rate variation (which excludes the ability to levy the service charge)
- Developer contributions and special development levies.

Council currently does not have a stormwater management service charge for its LGA. Introducing this charge for the townships in the LGA will allow Council to raise additional revenue to cover some of the capital and operating costs associated with providing stormwater management services including the management measures developed as part of this strategy to service future growth.

5.5.5. Stormwater Infrastructure

Structural on-ground measures are aimed at preventing / avoiding / reducing the likelihood of flood risks, improving stormwater runoff quality, and enabling water conservation through hard engineering. These measures are discussed in the following sections.

Upgrade the existing 300mm pipe along Lotus Ave

As discussed in Section 4.1.3, a 300mm diameter pipe collects discharge from a 750mm diameter pipe and 450mm diameter pipe. It is recommended that a survey is undertaken to confirm the size of this pipe. If the size onsite is 300mm then there is an opportunity to upgrade the pipe size to a 750mm pipe to ensure no surcharge of pits and overland flows.

WSUD devices to treat stormwater runoff prior to discharge into Lake Jindabyne

There is an opportunity to investigate the suitability of installing WSUD devices such as bioretention swales and basins to provide water quality treatment to the stormwater runoff from the two

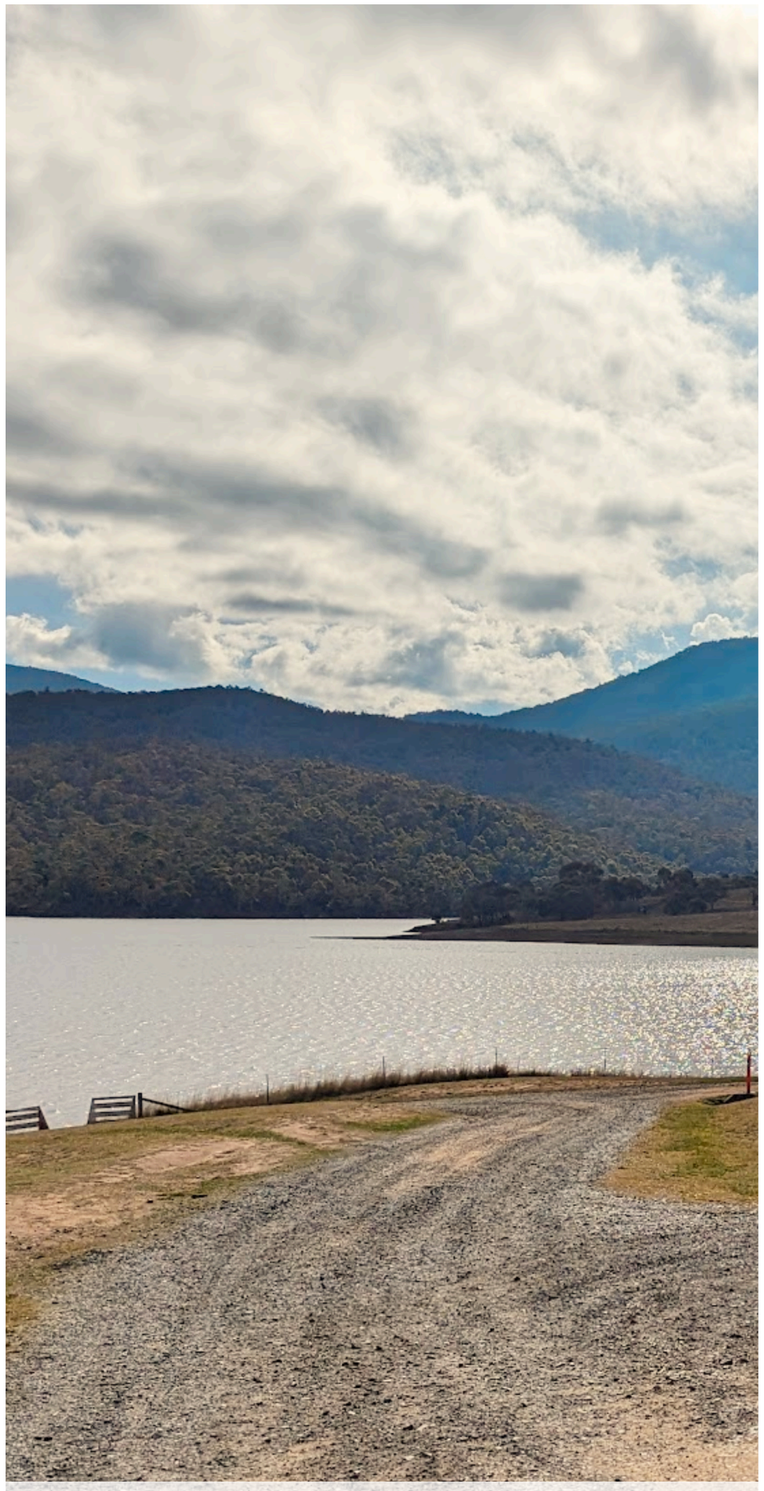


Figure 65: Kalkite picnic area and boat ramp

Stormwater and WSUD Management Strategy (Cont.)

375mm diameter pipes from Lotus Ave and Oleander Ct prior to discharge into Lake Jindabyne.

WSUD devices to treat stormwater runoff prior to discharge into Taylors Creek

There is an opportunity to investigate the suitability of installing WSUD devices such as bioretention swales and basins to provide water quality treatment to the stormwater runoff from the 750mm diameter pipe that connects to the existing open channel this eventually discharges into Taylors Creek. The WSUD device could be located further south to also capture the runoff from the 375mm diameter pipe network from Nemesia Ct.

Construct floating wetlands (WSP, 2021)

Floating wetlands consist of rafts of vegetation that float on the surface of the water and the roots grow into the water and absorb nutrients and other dissolved substances thus removing them from the water. These could be considered as a treatment solution at stormwater outlets from the township around Lake Jindabyne with the advantage that they can rise and fall as the Lake water levels change and potentially move horizontally to account for the change in the Lake edge.

There is an opportunity to install these at the outlets from Banksia Ave, Lotus Ave and Oleander Ct.

5.5.6. Recommended Upgrades

Based on the review of existing conditions, along with the expected increased population, the following upgrades to the stormwater and WSUD are recommended:

Medium to Long Term Recommendations

- Upgrade the existing 300mm pipe along Lotus Ave
- Construct WSUD devices to treat stormwater runoff prior to discharge into Taylors Creek
- Construct floating wetlands on Lake Jindabyne at stormwater discharge points

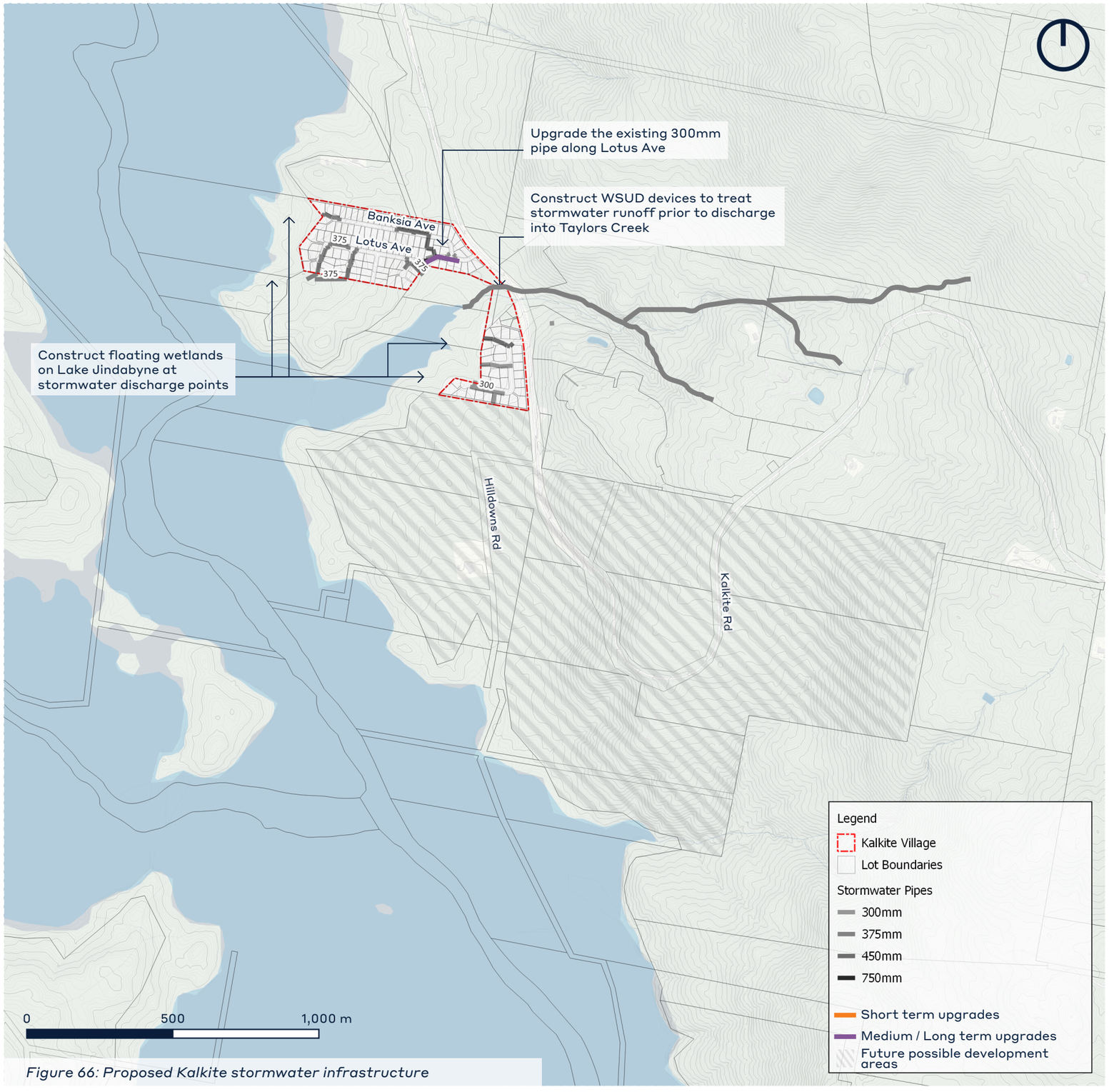


Figure 66: Proposed Kalkite stormwater infrastructure

Stormwater and WSUD Management Strategy (Cont.)

5.5.7. Implementation Plan

The implementation plan for the management measures recommended has been developed. This includes:

An approximate estimate of the capital costs including design & construction (note that land acquisition costs have not been considered).

Suitable funding sources for implementation. These include:

- Council's capital works funds/budget.
- New stormwater management service charge introduced via Council rates.
- Development contributions from private landholders.
- Stakeholder partnerships such as with TfNSW and DPE.
- Various other state and federal grants available such as Floodplain Management grants.

Table 31: Stormwater and WSUD Implementation Plan

ID	Stormwater and WSUD Upgrades	Key Entities Involved in upgrades	Capital Cost	Time-frame	Staged	Funding mechanisms
SW_01	Improve the condition of Council's current stormwater infrastructure data set	SMRC	< $100,000	Short term	Yes	Council funded
SW_02	Regularly maintain stormwater structures including grassed areas within and adjacent to open urban stormwater channels	SMRC	< $100,000	Ongoing	No	Council funded , Stormwater service charge
SW_03	Develop education campaigns targeted at Building and Construction industry on the implementation of soil and water management controls during construction	SMRC	< $100,000	Short-term	No	Council funded
SW_04	Develop a stormwater pollution and management education program for local schools and community organisations	SMRC	< $100,000	Short-term	No	Council funded, Other state/federal grants
SW_05	Publish regular stormwater information on Council's website, social media accounts and newsletters	SMRC	n/a	Short-term	No	Council funded
SW_06	Undertake a Flood Study for Kalkite	SMRC	<$100,000	Short-term	Yes	Council funded, Other state/federal grants

Table 32: Stormwater and WSUD upgrades continued

ID	Stormwater and WSUD Upgrades	Key Entities Involved in upgrades	Capital Cost	Time-frame	Staged	Funding mechanisms
SW_07	Incorporate Stream Erosion Index (SEI) target in DCP to compliment the water quality targets	SMRC	n/a	Medium-term	No	Council funded
SW_08	Empower developers and designers to consider urban stormwater management at the early stages of their master planning	SMRC, private developers	< $100,000	Short-term	No	Council funded, Other state/federal grants
SW_09	Review erosion control procedures on new developments. Provide relevant Council staff with training to enable this	SMRC	< $100,000	Short-term	No	Council funded, Other state/federal grants
SW_10	Implement stormwater management service charge to allow Council to raise stormwater management revenue in addition to that already provided through Council's general income	SMRC, private developers	n/a	Medium-term	No	Council funded
SW_11	Upgrade the existing 300mm pipe along Lotus Ave	SMRC	$500,000 - $1m	Medium-term	No	Stormwater service charge,Other state/federal grants
SW_12	WSUD devices to treat stormwater runoff prior to discharge into Lake Jindabyne	SMRC	$500,000 - $1m	Medium-term	No	Stormwater service charge,Other state/federal grants
SW_13	WSUD devices to treat stormwater runoff prior to discharge into Taylors Creek	SMRC	$500,000 - $1m	Medium-term	No	Council funded , Stormwater service charge,Other state/federal grants
SW_14	Construct floating wetlands on Lake Jindabyne at stormwater discharge points	SMRC, Snowy Hydro, State Government, EPA	$1m +	Long-term	No	Council funded , Stormwater service charge,Other state/federal grants

Action Plan

6. Action Plan

6.1. Short Term (1-5 years)

Table 33 presents short-term infrastructure improvements and initiatives for Kalkite, primarily related to transportation, electricity, and stormwater management. Improved active travel connections across Taylor's Creek are recommended, funded by the council.

Electricity projects involve upgrading conductors and splitting a feeder, funded by the Essential Energy and potentially developers will need to be completed to facilitate any potential growth in Kalkite. Several stormwater management initiatives are proposed, including data infrastructure improvement, regular maintenance of existing assets, educational campaigns, and website updates. These are to be funded by the council with some potential for external grants for a Kalkite flood study. Overall, the Short Term action plan for Kalkite outlines various initiatives and projects that will enhance transportation, electricity and stormwater infrastructure/management in Kalkite.

Table 33: Short Term actions (1-5 years)

ID	Description	Key Entities Involved in upgrades	Capital Cost	Time-frame	Staged	Funding mechanisms
T_01	Improved active travel connections, particularly across Taylors Creek	TfNSW, SMRC, private land holders	$100,000 - $500,000	Short term	No	Council funded
E_01	Upgrade all 11kV overhead conductors to minimum CHERRY ACSR Conductor or equivalent.	EE, private and public landholders	TBC	TBC	Yes	EE, Developer contributions
E_02	Split existing Feeder, dedicate feeder to Berridale catchment.	EE, private and public landholders	TBC	TBC	Yes	EE, Developer contributions
E_03	Install new 11kV overhead conductor voltage regulation infrastructure as required.	EE, private and public landholders	TBC	TBC	Yes	EE, Developer contributions
SW_01	Improve the condition of Council's current stormwater infrastructure data set	SMRC	< $100,000	Short term	Yes	Council's capital works funds/budget
SW_02	Regularly maintain stormwater structures including grassed areas within and adjacent to open urban stormwater channels	SMRC	< $100,000	Ongoing	No	Council's capital works funds/budget/ Stormwater management service charge
SW_03	Develop education campaigns targeted at Building and Construction industry on the implementation of soil and water management controls during construction	SMRC	< $100,000	Short-term	No	Council's capital works funds/budget

Table 34: Short Term actions (1-5 years) continued.

ID	Description	Key Entities Involved in upgrades	Capital Cost	Time-frame	Staged	Funding mechanisms
SW_04	Develop a stormwater pollution and management education program for local schools and community organisations	SMRC	< $100,000	Short-term	No	Council's capital works funds/budget Other state/ federal grants
SW_05	Publish regular stormwater information on Council's website, social media accounts and newsletters	SMRC	n/a	Short-term	No	Council's capital works funds/budget
SW_06	Undertake a Flood Study for Kalkite	SMRC	< $100,000	Short-term	Yes	Council's capital works funds/budget/ Other state/ federal grants
SW_08	Empower developers and designers to consider urban stormwater management at the early stages of their master planning	SMRC, private developers	< $100,000	Short-term	No	Council funded, Other state/federal grants
SW_09	Empower developers and designers to consider urban stormwater management at the early stages of their master planning	SMRC	< $100,000	Short-term	No	Council's capital works funds/budge Other state/ federal grants

Action Plan

6.2. Medium Term (5-10 years)

Table 35 summarises proposed potable water, sewer, and stormwater infrastructure projects for Kalkite over the Medium Term planning horizon. Water projects include a reservoir upgrade, a new transfer main, and upgrades to existing pipe assets. These projects are funded by the council and developer contributions. Sewer projects involve upgrades to the network and the wastewater treatment plant, funded similarly to water projects.

Stormwater management projects focus on implementing devices to treat runoff before discharge into waterways and potentially establishing a dedicated stormwater management service charge. Overall, the table highlights various infrastructure investments for the medium term in Kalkite's water and sewer systems.

Table 35: Medium Term actions (5-10 years)

ID	Description	Key Entities Involved in upgrades	Capital Cost	Time-frame	Staged	Funding mechanisms
WP_01	Upgrade town reservoir to increase capacity up to 2.2 ML	SMRC	$2,500,000	Medium term	No	Council funded, developer contributions
WP_02	New DN200mm transfer main (1.4km)	SMRC, private landowners, TfNSW	$1,600,000	Medium term	No	Council funded, developer contributions
WP_03	Upgrade high lift pump station	SMRC, DPE	$1,000,000	Medium term	No	Council funded, developer contributions
S-01	Upgrade existing or install new sewer network to facilitate development south of Kalkite Village	SMRC, private developers, private landowners	$1mil +	Medium term	Yes	Council funded, developer contributions
S_02	Upgrade the ageing reticulation network	SMRC, private landowners	$1mil +	Medium term	Yes	Council funded
S_03	Upgrade or replace Kalkite Waste Water Treatment Plant (WWTP)	SMRC	$1mil +	Medium term	Yes	Council funded
SW_07	Incorporate Stream Erosion Index (SEI) target in DCP to compliment the water quality targets	SMRC	n/a	Medium-term	No	Council's capital works funds/budget
SW_10	Implement stormwater management service charge to allow Council to raise stormwater management revenue in addition to that already provided through Council's general income	SMRC, private developers	n/a	Medium-term	No	Council's capital works funds/budget

Table 36: Medium Term actions (5-10 years) continued.

ID	Description	Key Entities Involved in upgrades	Capital Cost	Time-frame	Staged	Funding mechanisms
SW_11	Upgrade the existing 300mm pipe along Lotus Ave	SMRC	$500,000 - $1m	Medium-term	No	Stormwater management service charge/ Council's capital works funds/budget
SW_12	WSUD devices to treat stormwater runoff prior to discharge into Lake Jindabyne	SMRC	$500,000 - $1m	Medium-term	No	Stormwater management service charge Council's capital works funds/budget
SW_13	WSUD devices to treat stormwater runoff prior to discharge into Taylors Creek	SMRC	$500,000 - $1m	Medium-term	No	Council's capital works funds/budge/ Stormwater management service charge

Action Plan

6.3. Long Term (10+ years)

Table 37 outlines various infrastructure projects proposed for the Kalkite area, categorised by type and funding source. Several transportation improvements are considered in the long term planningh horizon, like an expanded active travel network and safety upgrades to Kalkite Road. These projects are funded primarily by the council with possible state contributions. Water projects involve a new treatment plant and network upgrades, funded jointly by the council, developers, and potentially private landowners. Sewer projects focus on pump station upgrades, funded similarly to transportation projects. A ambitious proposal for floating wetlands relies solely on the council's budget and potential external grants.

Table 37: Long Term actions (10+ years)

ID	Description		Capital Cost	Time-frame	Staged	Funding mechanisms
T_02	Improved active travel network to support larger population and development area	TfNSW, SMRC, private land holders	$100,000 - $500,000	Long term	Yes	Council funded
T_03	Improvements to Kalkite Road	TfNSW, SMRC	$1mil +	Long term	Yes	Council funded with state contributions
WP_04	New packaged water treatment plant (WTP)	SMRC, private landowners, TfNSW	$3,500,000	Long term	No	Council funded, developer contributions
WP_05	Upgrade existing ageing water mains in Kalkite potable network	SMRC, private landowners	$1mil +	Long term	Yes	Council funded
WP_06	Eliminate dead end mains across Kalkite's potable network	SMRC, private landowners	$1mil +	Long term	Yes	Council funded
S_04	Upgrade or replace existing sewer pump stations - Ps13, Ps45 and Ps15	SMRC	$1mil +	Medium to long term	Yes	Council funded, developer contributions
SW_14	Construct floating wetlands	SMRC	$1m +	Long-term	No	Council's capital works funds/budget Stormwater management service charge / Other state/ federal grants



Figure 67: View of Kalkite Village South

7. Conclusion

This report provides an assessment of the potential demand and associated short fall for services infrastructure to facilitate the sustainable development of Kalkite. With the town considering potential future population growth it is crucial to assess and enhance existing infrastructure to meet future demands.

The recommendations and findings presented within this report align with the population growth projections provided by SMRC as part of this commission, anticipating a population of 1,315 people by 2041. This study offers a strategy for infrastructure augmentation that will support the town's sustainable development - encompassing various aspects such as traffic and transport, electricity, water supply, sewerage, and stormwater management.

Recognising the a need to plan for Kalkite's growing population, this report emphasises and addresses the following items:

- Critical need for staging and delivery to ensure that infrastructure upgrades occur promptly, within budget, and at the appropriate trigger points. It begins with an overview of the town's key features and development applications for key subdivisions, followed by a baseline assessment of the existing infrastructure.
- Challenges presented by increased traffic into Kalkite via Kalkite Road. A Preliminary Route Safety Review has been completed for Kalkite Road which explores possible upgrade opportunities to improve safety into and out of Kalkite
- Concerns in the local electricity network, underscoring the need for upgrades to support continued development and the growing demand for electricity.
- Challenges faced by the water infrastructure in Kalkite. A detailed review, based on hydraulic modelling, outlines the necessary upgrades to the water infrastructure, ensuring it can accommodate the future population.
- The Kalkite Waste Water Treatment Plant (WWTP) has been reviewed by others and summarised in this report present the future possible upgrades to Kalkite's WWTP.

7.1. Next Steps

The steps that need to be taken by SMRC will depend on the scale and type of infrastructure initiative recommended in this report. However, there are several key areas of action that council planners and engineers will need to by mindful as they plan for Kalkite's future.

Stakeholder Engagement and Community Consultation

The success of any infrastructure development is deeply rooted in the active involvement of the community and relevant stakeholders. SMRC should initiate a stakeholder engagement plan that includes town residents, local businesses, government agencies, and community organisations. Allow for community consultations to gather feedback, address concerns, and ensure that the infrastructure development aligns with the needs and aspirations of the town's population.

Funding and Resource Allocation

SMRC needs to identify and pursue funding opportunities to support the proposed infrastructure projects. Exploration in both government grants and private partnerships should begin immediately to secure the necessary financial resources for infrastructure upgrades

Detailed Project Planning and Design

The recommendations outlined in this report are high-level in nature. SMRC will need to engage with qualified professionals to undertake detailed project planning and design for most of identified infrastructure projects. This phase should include feasibility studies, environmental impact assessments, and engineering designs. Collaborate with experienced consultants to ensure that the infrastructure projects adhere to industry standards and regulatory requirements.

Regulatory Approvals

SMRC will need to be mindful of regulatory landscape beyond the local level (state government, state transport etc, EPA) to secure the necessary approvals for the proposed infrastructure projects. For many of the recommendations SMRC will need to work closely with local and state government agencies to obtain planning permissions, environmental clearances, and any other required permits. Streamline the approval process to expedite project timelines while ensuring compliance with all relevant regulations.

Continuous Monitoring and Evaluation

SMRC should maintain or implement a system for continuous monitoring and evaluation of the infrastructure projects. Regularly assess progress against milestones, budgetary considerations, and community expectations. They should be able to then make necessary adjustments based on feedback and changing circumstances to ensure that the infrastructure development remains responsive to the evolving needs of Kalkite.

Future Planning and Adaptability

The overarching pursuit and objective for this report is to assist SMRC in considering the long-term sustainability of the infrastructure investments by incorporating future growth projections and technological advancements into the planning process. SMRC should strive to build adaptability into the infrastructure projects to accommodate evolving needs and changes in the town's demographic, economic, and environmental conditions.

By systematically addressing these next steps, Kalkite can lay the foundation for a sustainable and resilient infrastructure that enhances the quality of life for its residents and promotes overall community well-being.

Appendix A:
Review Register

Member of the Surbana Jurong Group

Infrastructure Assessment Data Table

Type	Title / Description	Author	Year of Publication
General			
Guidelines	Snowy River Shire Development Control Plan	Snowy Monaro Regional Council	2013
DA Information	Development Application	Various	2019 -2023
Strategy	Snowy Monaro Draft Settlements Strategy	Snowy Monaro Regional Council	2020
Strategy	Snowy Monaro Local Strategic Planning Statement	Snowy Monaro Regional Council	2020
Legislation	Snowy Monaro Local Environmental Plan 2022	Snowy Monaro Regional Council	2022
Data	GIS data supplied by SMRC: - Boundaries - Property - Planning - Water and Sewer assets - Topography	Snowy Monaro Regional Council	2023
Data	Australian Bureau of Statistics (ABS) - Average persons per dwelling (2016) (Berridale | Region summary | Data by region | Australian Bureau of Statistics (abs.gov.au))ABS 2021	ABS	2023
Data	Bureau of Meteorology (BoM) - Rainfall data (Climate Data Online - Map search (bom.gov.au)) BoM 2023	BoM	2023
Water Infrastructure Assessment			
Report	Network model, Planning & investigation Report for the Water supply scheme in Kalkite	aGnR Consultants	2022
Report	Snowy Monaro Villages Water Safety Scoping Study	Hunterh$_2$0	2020
Manual	Water Supply Investigation Manual	NSW Public Works	1990
Manual	Section 64 Determinations of Equivalent Tenements Guidelines – Water Directorate NSW	Water Directorate	2017
Manual	Water supply code of Australia	Water Services Association of Australia	2018
Report	Development Servicing Plans for Water Supply and Sewerage	Snowy Monaro Regional Council	2022
Sewer Network			
Code	• WSAA 02 – Sewerage code of Australia • WSAA 04 – Sewerage Pumping Station Code		

Type	Title / Description	Author	Year of Publication
	• European Standard BS EN 1091 – Vacuum Sewerage Systems • WSAA 02 Part 4 – Standard Drawings • Building Code of Australia – Part E1, Fire Fighting Equipment • Water services association of Australia gravity sewerage code of Australia WSA 02-2002 • Water services association of Australia sewage pumping code of Australia WSA 04-2005 • Water services association of Australia pressure sewerage code of Australia WSA 07-2007		
Manual	Manual of Practice: Sewer Design	Public Works Department	1984
Manual	Manual of Practice: Sewage Pumping Station Design	Public Works Department	1986
Manual	Section 64 Determinations of Equivalent Tenements Guidelines – Water Directorate NSW	Water Directorate	2017
Report	Annual System Performance Report	Snowy Monaro Regional Council	2022
Report	Kalkite sewer network hydraulic modelling and servicing strategy	Westlake Punnett	2023
Maps / Plans	Kalkite sewage treatment plant upgrade options study	Snowy Monaro Regional Council	2023
Stormwater and WSUD Management Strategy			
Report	Jindabyne and Berridale Stormwater Harvesting Schemes Feasibility Report	Footprint	2015
Report	Snowy Monaro Regional Council Flood and Floodplain Risk Management Studies	SMEC	2020

Appendix B: Potable water network assessment reports - hunterh20 and AGnR Consultants

SNOWY MONARO REGIONAL COUNCIL

NETWORK MODEL, PLANNING & INVESTIGATION REPORT FOR THE WATER SUPPLY SCHEME IN KALKITE

REPORT No.: SMRC-005-RO1
REV: DRAFT
DATE: 20th October 2022

Rev	Author	Reviewed	Approved	Date	Comment
P1	TPB	HLF		20/10/2022	Preliminary issue for review
A	TPB	HLF	HLF	10/11/2022	Final Issue

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DISCLAIMER

This report has been prepared on behalf of and for the exclusive use of the Snowy Monaro Regional Council (SMRC) and their authorised representatives and is subject to and issued in accordance with the assumptions, conditions and limitations described herein.

AGNR accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this report by any third party. Copying or use of the model or this report without the permission of AGNR and / or SMRC is strictly prohibited.

1 INTRODUCTION

AGNR Consultants Pty Ltd were engaged by Snowy Monaro Regional Council (SMRC) in June 2022 to develop a network model and to prepare a Planning Report for the upgrading of the water supply scheme in Kalkite, NSW. This engagement was prompted via SMRC operators reporting concerns with the town's water supply scheme, namely with the ability of the network to service future development.

The main objective of this study is to investigate operational deficiencies within the network, to improve system performance and to provide reliable service to existing and future development in the region.

1.1 Study Area and Planning Considerations

Kalkite is located within the jurisdiction of the Snowy Monaro Regional Council and located approximately 56 km west of Cooma and 20 km north of Jindabyne. Refer Figure 1.1 in Appendix A for a Locality Plan of Kalkite, NSW.

Kalkite is a village located on the northern banks of Lake Jindabyne about 10 minutes' drive from Kosciuszko Road and approximately 20-minute drive to the town centre in Jindabyne. Kalkite has no specific retail or commercial services and relies on the neighbouring town of Jindabyne for these facilities.

The Snowy Monaro Regional Council (Council) has advised that there is significant interest from private developers to build new land releases in Kalkite and its surrounds. Further advice suggests that there is significant growth potential for Kalkite in the foreseeable future.

Whilst there is potential for significant growth within Kalkite, Council has advised that the capacity of the towns water supply system is not sufficient and must be upgraded before considering any further development in the region.

Further information in respect to development opportunities and related prospects in Kalkite is provided later in this report.

1.2 Overview of Water Supply Scheme

The Kalkite water supply network services approximately 140 residential properties. There is no commercial centre nor retail services located within the township.

Water for Kalkite is sourced from Lake Jindabyne using a submersible pump station. The lake pumps transfer water a short distance to a small balance tank located adjacent to a second (high lift) pump station. From this tank, water is pumped towards the reticulation network as well as to the town's reservoirs located on the eastern side of town off Kalkite Road.

Water is chlorinated at the high lift pump station. There is no direct link between the high lift pump station and the town reservoirs which according to operators causes issues with the quality of water delivered to consumers.

There is a small Grundfos multistage pump station located adjacent to the town reservoirs that operates to transfer water via a 100 PE main to a private development (consisting of about 40 lots) located further to the east of the town reservoirs. This development is referred to hereafter as the "3 Rivers" development. Council owns and operates the pump station supplying water to the 3 Rivers development tank, the tank itself and the associated communications equipment.

The SMRC has no immediate intention to modify the way in which Kalkite is currently serviced. Figure A2 (Appendix A) illustrates the general layout of the network. Figure A3 illustrates schematically the network elements associated with the Kalkite water supply system and their operation.

1.3 Objective

The objectives of this study are as follows,

to develop a hydraulic model that can replicate, as close as practical, the operation of the existing water supply system and to make use of it to identify any specific concerns regarding system operation, capacity, reliability, safety and / or performance.

Identify and document any necessary system improvements required to facilitate reliable service to both existing and planned future development in Kalkite and to address any operational issues identified or raised by Council.

2 POPULATION & DEMAND REVIEW

2.1 Historical Population (Census)

According to 2021 Census, the estimated resident population of Kalkite and its surrounds is 294. Historical population statistics for the local Kalkite region are summarised in Table 2.1.

Table 2.1 Kalkite Population Statistics (Census)

	2001	2006	2011	2016	2021
Kalkite	N/A	167	173	214	294

2.2 Equivalent Tenancy

Estimates for Equivalent Tenancy (ET) for Kalkite are based on the following assumptions and qualifications.

100% occupancy rates were adopted for existing established residential areas.

100% occupancy rates were adopted for all future development areas including residential and visitor accommodation facilities. An outline of anticipated future development opportunities in Kalkite is presented later in this report.

Equivalent Tenements (ET's) for various types of development were calculated based Section 64 of the Water Directorate for Determination of Equivalent Tenement Guidelines (January 2005).

Table 2.2 summarises the various categories and subcategories used to generate ETs and unit demands for the model.

Table 2.2 Water Directorate (WD) Categories & ET Calculations

WD CATEGORY	SUBCATEGORY	UNIT	WATER ET
Detached Residential (Housing)	Standard (450 to 2000 m2)	Lot	1
	Small (< 450 m2)	Lot	Use Units
	Large (> 2000 m2)	Lot	1.2
Multi Residential (Units)	1, 2 Bedroom Unit	Dwelling	0.5
	3 Bedroom Unit	Dwelling	0.8

2.3 Future Development

With reference to planning documentation provided by SMRC, it is predicted that Kalkite will experience significant growth over the next 20 years or so.

It is expected that this growth will occur mostly via subdivisional development on vacant parcels of land located on the south side of the town. Below is a summary of the locations where development is most likely to occur: -

- 3 Rivers residential development (42 Lots).
- Hillsdowns Road, Kalkite (210 Lots); and
- Tourist development (40 Residential lots and 80 bed visitor accommodation).

SMRC also requires the capacity of the water supply scheme be capable of servicing a population not less than 1500 EP or 681 ET. This is to ensure alignment with the ultimate capacity of the Kalkite sewage treatment plant (STP).

Figure A4 (Appendix A) illustrates the general location of the above referenced development regions.

2.4 Demands

2.4.1 Historical Records

An assessment of historical water consumption records for Kalkite was undertaken. A summary of the adopted model demands is presented in Table 2.3.

Table 2.3 Historical Flow Meter Data

Description	Historical Meter Readings	Modelled Demands (2)
2022 AD Demands	50 kL / day	87 kL/day
2022 PD Demands (Peak)	214 kL / day (1)	220 kL / day
Peak Factors	**4.1**	**2.5 (Avg)**

1. Peak day demands 2021 & 2022
2. Assumes nil vacant allotments within existing developed areas

Peak day modelled demands align reasonably well with flow meter records.

The model accounts for 100% of existing allotments albeit whether they have been improved or remain vacant. Future capital works or improvements identified as part of this study must take into consideration any "as of right" use attributable to existing unimproved vacant lots that are entitled to a water connection.

2.4.2 Adopted Demands

Table 2.4 summarises the adopted population, connections and demands for Kalkite.

Table 2.4 Water Demands (Current)

Description	Value
Population according to Census (EP)	c. 294
Approximate number of existing allotments	146
Connections	c. 140 (100% Residential)
ET/EP	2.2
Average Day Unit Demand (ADD) (kL/d)	620 L/ET/day
Peak Day Factor (PDF)	2.5
PDD (kL/d)	1,550 L/ET/day

Based on population forecast from Census data

Model demands were assessed based on ETs and were modelled as fixed unit demands for residential properties. Unaccounted for water use and / or leakage was assumed to be included within the adopted unit demands.

2.4.3 Diurnal Patterns

Whilst Council is yet to formally adopt diurnal patterns that are specific to land zoning or development types, patterns will eventually be developed by Council and used for modelling purposes.

Once patterns have been established and verified, SMRC will endeavour to update the model to improve its accuracy. Until this occurs, the diurnal patterns are based on previous experience and local industry standards.

2.4.4 Fire Fighting

Refer Chapter 4 of this report for design criteria and firefighting flow conditions.

2.4.5 Irrigation & Non-Essential Use

No specific irrigation demands were included in the model.

2.5 Summary

Based on the population and equivalent tenancy (ET) assessment, the following conclusions are made:

The estimated number of water connections (as at the most recent billing period, June 2022) is 140.

The current population of Kalkite (based on Census data) is estimated to be in the order of 294. The projected (2041) population of the town is subject to Council approval in respect to future land development, most of which is likely to occur via subdivisional development on vacant parcels of land located on the south side of the town (refer Figure A4 in Appendix A).

Further to the proposed future development, SMRC requires that the water supply system in Kalkite be sized to service a population not less than 1500 EP (or 681 ET). This is to ensure close alignment between the water supply system and the ultimate capacity of the Kalkite sewerage treatment plant.

The capacity of the existing water supply system is not sufficient to accommodate future identified development growth. Upgrading of the system will be necessary.

Water demands were assessed based on equivalent tenancies and an adopted Average Day Unit Demand (ADD) value equivalent to 620 L/ET/day and a Peak Day Demand (PDD) of 1,550 L/ET/ day.

Demands entered into the model were based on unit demands and ET's defined in Table 2.2.

Diurnal demand patterns for the model were based on previous experience and local industry standards.

Design criteria for firefighting are based on the Water Directorate requirements (ref 4). Irrigation demands were calculated based on irrigation area and an approximate weekly application rate.

3 HYDRAULIC MODEL ESTABLISHMENT

3.1 Model Software & Scenarios

A water supply network model was established using Bentley WaterGEMs Connect Edition Update 4 software. Modelling was undertaken based on an extended period simulation (EPS) over a continuous 24-hour period for 3 x consecutive days. The following scenarios were modelled.

- Peak Day Demands.
- Fire Fighting; and
- Future Development.

Characteristics of the various elements of the model developed for this investigation are summarised in the following chapters of this report.

3.2 Water Mains / Junctions

Existing water mains and junctions were incorporated into the model based on GIS ESRI shape file data. The model incorporates the following key characteristics relating to pipes and junctions: -

- Location (GDA94 coordinates).
- Elevation (namely surface level at junctions to AHD).
- Pipe diameter.
- Pipe length
- Pipe material (where known).
- Pipe friction coefficient (Hazen Williams), as per following table: -

Pipe Size (Nominal Bore)	Hazen Williams C
< = 150	100 to 110
200 to <=300	110 to 120
>300	130

3.3 Pump Stations

Pump stations were incorporated into the model to replicate as close as practical their operation in the field. Data sources including As Constructed records, trend data, GIS and other relevant information sources were used where available.

In summary the following key characteristics were incorporated into the model for each pump station.

- Location.
- Pump characteristic curves (excluding the submersible pump station mounted in Lake Jindabyne).
- Operational controls and characteristics.
- Miscellaneous data (e.g., base level and alarm levels).
- Pump discharge main (size and fitting losses).
- Details and elevation for the receival location for pumped discharge main (e.g., connection to existing main reservoir etc).

Table 3.1 and 3.2 summarises the pump data incorporated into the model.

Table 3.1 Lake Jindabyne High Lift Pumps (supplying water to the Town Reservoirs)

WTP Lift PS	Manufacturer / Type	Duty	Motor
Pump 1 (Duty)	Southern Cross Centrifugal Pump Model RG-B (2" x 1.5") 2900 RPM (226mm impeller)	12 L/s at 66m (#)	15 kW
Pump 2 (Standby)	As above	As above	As above

pump duty was estimated based on the system curve functionality within the hydraulic model

Table 3.2 Kalkite Tourist Village Residential Estate Reservoir Transfer Pumps

WTP Lift PS	Manufacturer / Type	Duty	Motor
Pump 1	Grundfos Vertical Multistage Pump Set 96501918_CRI_159_AFGJAEHQQE 2900 RPM	2 L/s @ 125 m (#)	7.5 kW
Pump 2 (Standby)	As above	As above	As above

pump duty was estimated based on the system curve functionality within the hydraulic model.

The following were not considered nor included in the development of the model.

- Characteristics associated with the Lake Jindabyne submersible intake pumps.
- Pump operating efficiencies.

The boundary condition for the model is the point of discharge to the balance tank for the Lake Jindabyne submersible pumps.

3.4 Reservoirs

Kalkite's water supply scheme comprises two main reservoirs (226kL each situated side by side) servicing a single pressure zone. There is a second reservoir which is also owned by Council which operates to service the 3 Rivers estate development located further to the east of Kalkite. The 3 Rivers Estate is a private gated development serviced via a system of privately owned network mains. Characteristics incorporated into the model for each reservoir include: -

- Location.
- Diameter or cross-sectional area of tank and operational capacity.
- Operational controls and related characteristics.
- Miscellaneous data (e.g., floor level and TWL).
- Local pipework and valves.

Table 3.3 Kalkite Water Supply Network Reservoir Details

Reservoir / Tank	Capacity (ML)	Dia (m)	TWL	Base Level	Material
Reservoir #1 (town reservoir #1)	0.226	11.2	961 #	963.3 #	Concrete
Reservoir #2 (town reservoir #2)	As above				Concrete

base level was estimated from site contour information.

3.5 Asset Condition

Most of Kalkite's water network comprises asbestos cement pipes which according to Council's GIS have been in service for about 60 years.

Council is in the process of developing a strategy aimed specifically at addressing issues associated with the condition of existing water mains in Kalkite as well as dead end mains and associated water quality issues.

This study applies to all water mains and related passive assets in the Snowy Monaro Local Government Region and is being undertaken in parallel to this investigation by Westlake Punnet Consulting Engineers (WP). A summary of the recommendations from the WP study are presented under the cover of a separate report.

3.6 Future Development

Future development over the course of the next 20 years (i.e., 2022 to 2041) is most likely to occur on a number of vacant parcels of land situated on the south side of Kalkite.

Existing and proposed future development regions and corresponding ETs for the township of Kalkite are summarised in Table 3.4.

Table 3.4 Existing and Future Development ETs

Future Development	Approx No. Lots (ET)
Existing Development	146 ET
Three Rivers Estate (approved by Council).	40 ET
Hilldowns Road Development	210 ET
Tourist Accommodation (80 beds) and 40 Residential Lots	80 ET
Total Estimated (Existing and Future)	**476 ET (1047 EP)**

Figure A4 in Appendix A shows the location of the existing developed regions and the approximate location of future development areas.

To ensure alignment with the capacity of the STP, the water supply system must be capable of servicing not less than 1500 EP or 681 ET. This equates to an additional population of about 453 EP (or 205 ET) that will need to be included in the modelling assessment.

4 HYDRAULIC ASSESSMENT

4.1 Design Criteria

The adopted design criteria for the assessment of the water supply network accords generally with WSA and the Water Directorate guidelines for firefighting. Table 4.1 below presents a summary of the design guidelines adopted for this investigation.

Table 4.1 Network Pressures and Design Guidelines (WSA)

Description	Criteria
Network Residual Pressure (non-firefighting)	
Minimum	< 200 kPa
Maximum	< 600 kPa
Reservoir capacity	24 hrs peak day demand plus 1/3 Peak Day (Reserve) #
Maximum pipeline velocity	< 2 m/s (excluding FF)
Head Loss in pipelines	
Reticulation mains	< 5m loss per 1000m
Trunk Mains >200mm dia	< 3m loss per 1000m
Fire Fighting	Refer Table 5.2

WSA guideline. Minimum capacity should be based on site specific risk assessment

The criteria and standards for fire flows were based on the Water Directorate's Fire Flow Design Guidelines (June 2011). Refer Table 4.2 below.

Table 4.2 Fire Flow Guidelines (NSW Water Directorate)

Description	Criteria
Fire Flow Provision	
Residential (< 3 Storeys)	10 L/s
High Rise Residential	20 L/s
Commercial / Industrial Areas	N/A
Residual Pressure	
Desirable Pressure (in main u/s of hydrant)	150 kPa
Minimum Pressure (WD guideline)	Must be positive #
Minimum Pressure (Adopted)	120 kPa in main u/s of hydrant, 60 kPa elsewhere.
Background Demand	95%ile PHD
Reservoir Storage Capacity (for FF)	4 hours

60kPa was adopted as a minimum pressure "elsewhere in the network ".

The minimum pressure criterion nominated in Table 4.2 was adopted to ensure protection to reticulation mains and to ensure surrounding properties have access to water albeit at minimal pressures.

4.2 Scenarios

An analysis was undertaken on the existing Kalkite water supply network to identify necessary upgrade works to mitigate concerns with hydraulic capacity during peak day demands. More specifically the focus of the investigation was to assess hydraulic aspects of the network when subject to the following scenarios: -

a) Peak Day demands.
b) Firefighting flows.
c) Future Development

A top-down approach was adopted to examine the behaviour and capacity of the network when subject to the above scenarios. Results from the hydraulic assessment are discussed and summarised in the following sections of this report.

4.3 Peak Day Demand

Modelling of the existing water supply network was undertaken with the objective being to examine the impact on the Kalkite distribution system resulting from the application of peak demands and firefighting flows.

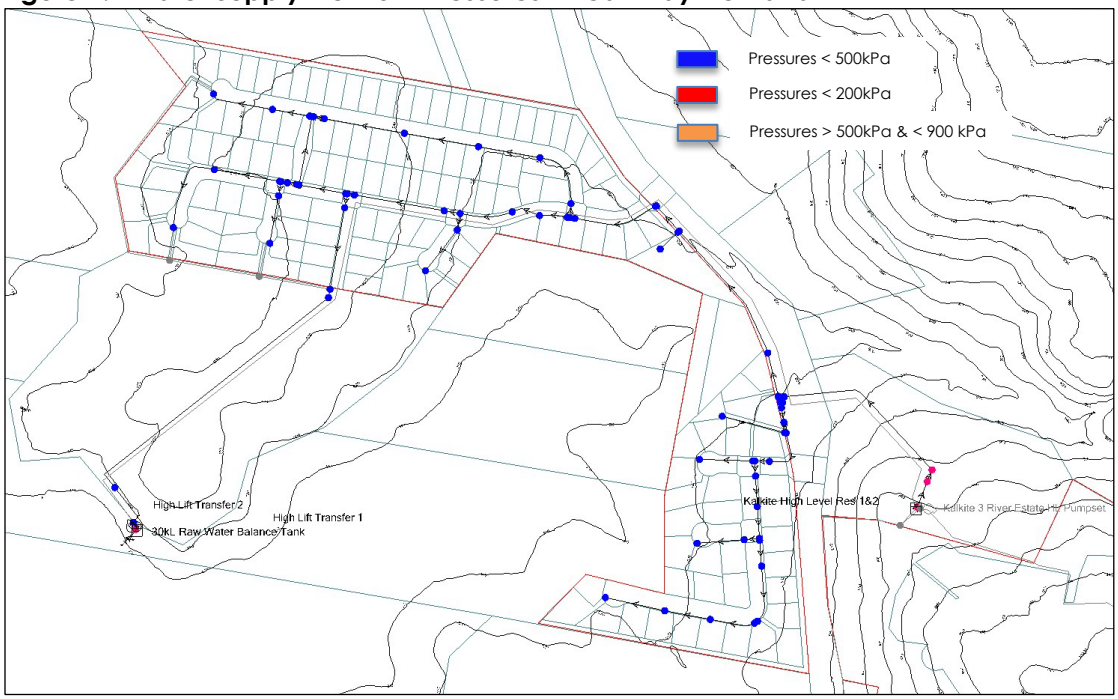
A further objective of the investigation was to identify the necessary system upgrades to improve capacity, pressures, security of supply and more importantly to ensure that SMRC customer service obligations are met. Council is also interested to confirm the extent of upgrade works necessary to ensure that future development can be reliably serviced.

Model scenarios were run under peak day demands and firefighting flows in line with Water Directorate guidelines. The results from each analysis are summarised with respect to the following criteria:

- Incidences of High Pressure >600 kPa.
- Incidences of Low Pressure <200 kPa.
- Excessive head loss characteristics in network mains.
- Breach of Water Directorate and design guidelines as outlined in Table 4.1 & 4.2.

An assessment of the existing water supply network revealed that minimum residual pressures in the network are in the order of 220 kPa during peak day demand periods whereas maximum pressures were observed in the order of about 500 kPa. Figure 4.1 illustrates indicatively the minimum nodal pressures within the network during peak demand periods.

Figure 4.1 Water Supply Network Pressures – Peak Day Demand



Modelling of the water supply network in Kalkite revealled that residual pressures remain reasonably consistent within the township in line with the conditions set down in the Water Directorate Guidelines, NSW. More specifically, nodes highlighted as navy-blue indicate pressures less than 500 kPa.

Pressures in the network did not exceed the maximum value as recommended by the NSW Water Directorate of 600 kPa.

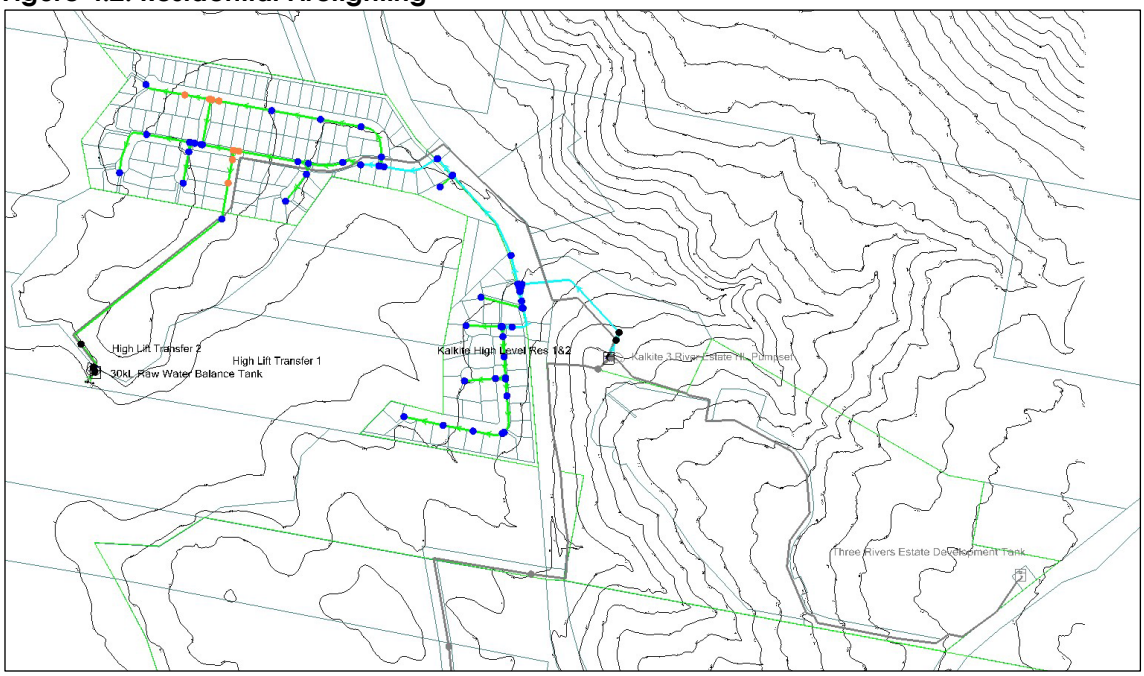
Modelling revealled that headloss conditions within existing network mains remained in line with recommended guidelines even when future development demands were introduced.

4.4 Firefighting

Modelling was undertaken to assess the capacity of the existing network when subject to residential firefighting flows. Based on the Water Directorate guidelines, the capacity of the network must be capable of accommodating firefighting flows of 10 L/s in residential areas. Hydraulic modelling revealed issues regarding the capacity of the network in being able to service firefighting flow rates.

The nodes highlighted in orange in Figure 4.2 indicate regions of noncompliance with firefighting guidelines for existing residential areas.

Figure 4.2: Residential Firefighting



A summary of the model results for firefighting capacity within the existing residential network is presented below.

Modelling revealled that the network is not able to accommodate firefighting flows in the vicinity of the elevated regions of Banksia Avenue and in the vicinity of Lantana Drive and Lotus Avenue intersection (refer nodes highlighted in orange in Figure 4.2).

Options to mitigate the identified low pressures concerns in the distribution network may include the implementation of a continuous operating booster pump station or

new elevated storage at sufficient height to facilitate reliable servicing of the local region by gravity. Having said this, based on the number of customers impacted, and the capital investment per household, the above works would be cost prohibitive and would probably not align with strategic planning objectives for the region. For this reason, it is recommended that Council continue to service the network viz the current arrangement until such time as future development warrants the need for a major system upgrade.

4.5 Future Development

As commented previously, there is significant interest from private developers to release new subdivisions within the Kalkite area. A summary of existing and future land development areas identified for Kalkite is as follows.

Table 4.1 Existing and Future Development Areas and ETs

Future Development	Approx No. Lots (ET / EP)
Existing Developed areas	146 ET
Three Rivers Estate (approved by Council).	40 ET
Hilldowns Road Development	210 ET
Tourist Accommodation (80 beds) and 40 Residential Lots	80 ET
Additional population (required to match capacity of STP)	205 ET
Total Estimated ETs and EPs (Existing and Future)	**681 ET (1500 EP)**

Figure A4 in Appendix A shows the approximate location of the future development areas for the Kalkite region.

The extent of future development in Kalkite ultimately remains subject to a reliable water supply system. Figure 4.3 illustrates the model trend data for the high lift pump station and main town reservoirs when development demands are introduced.

Figure 4.3: Model Trend Data - Reservoir Levels and Pump Station

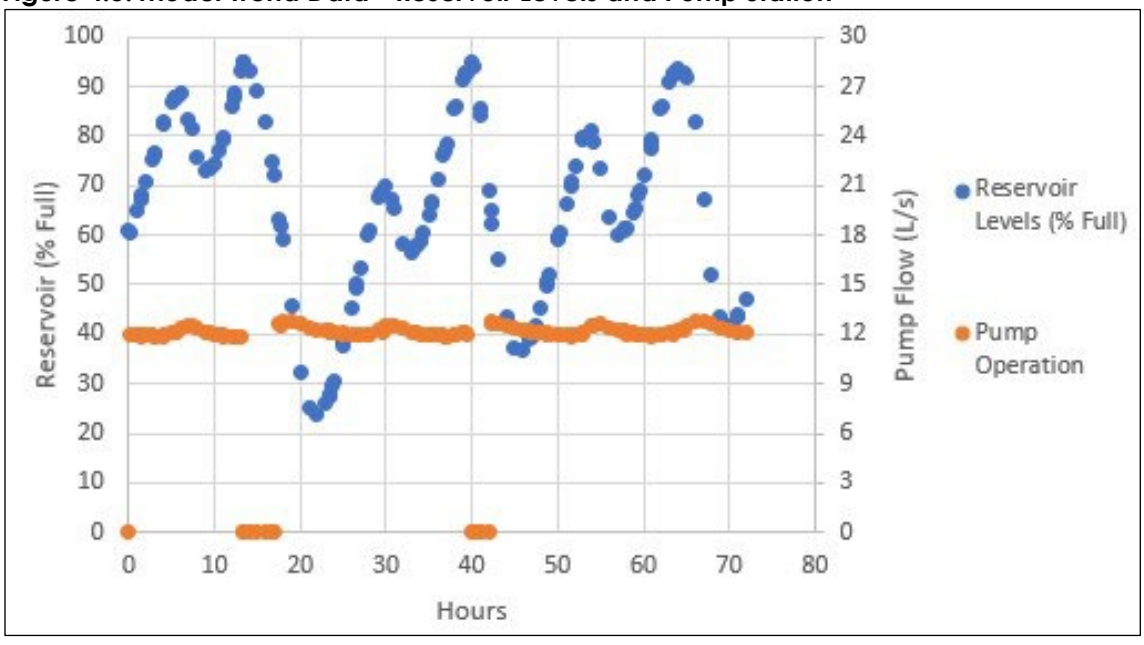


Figure 4.3 indicates that that when future development demands were introduced the pumps operate almost continuously and uninterrupted throughout a 7-day

simulation period and the reservoir turns over multiple times every 24 hours. Modelling revealled that under these circumstances, the risk of supply disruption increases substantially mainly due to inadequate "existing" storage reserves as well as inadequate flow and performance of the high lift pumps supplying these reserves.

To ensure reliable service is provided to the existing network and also to future development areas, upgrading of the existing storage reserves and pumping infrastructure is deemed necessary. A discussion on the recommended upgrade works is provided below.

The capacity of the potable water storage reserves for Kalkite must be upgraded to accommodate existing and future development demands, firefighting reserve, 50% additional effective storage capacity and allowance for freeboard and ineffective storage within the tank. A minimum effective storage capacity of 2.2 ML is hereby recommended.

It is also recommended that the operating TWL be upgraded by at least 5 metres above existing to ensure adequate residual pressures and firefighting flow capacity is available to the elevated regions in Banksia Street and Lotus Avenue.

The modelling investigation also revealled that upgrading of the supply system servicing the new reservoir will need to be upgraded. The following upgrade and improvement works should be considered.

Construction of a dedicated 200mm (nominal) diameter supply main from high lift pump station to the reservoir. It is recommended also that new main be designed to refill the town reservoir/s direct without intercepting or actively connecting to the reticulation network. SMRC may consider implementing a "closed" emergency connection with pressure reducing provisions between the reservoir supply main and the reticulation for emergency use of if the reservoir is required to be removed from service for the purpose of unplanned maintenance and / or repairs.

Upgrade high lift pump facilities as the performance characteristics associated with the existing high lift pumps are not suited to revised supply arrangement, this being due to the upgraded rising main between the pump station and the tank reservoir.

The recommended (concurrent) minimum capacity of the submersible Lake pumps and high lift pump system is 28 L/s. This pump rate combined with a 200mm diameter rising main will provide Council with the opportunity to refill the reservoir within a nominal 10-hour window and will allow the pumps to operate predominantly within favourable off-peak power tariff periods. Pump selection should take into consideration operation at best efficiency point whilst ensuring that the minimum required pumped flow rate is achieved.

Provisions for variable speed operation and control system programming is recommended for both the submersible lake pumps and high lift pumps to minimise the potential for intermittent starting and stopping.

The capacity and performance characteristics of the existing lake pump will need to be checked and confirmed if suitable and sufficient for the upgraded system.

Upgrade the water network to facilitate reliable service to future development areas on the south side of Kalkite. Such works probably won't be realised until new land subdivisions are eventually introduced. The design of the reservoir must consider an

allowance for a future service connection to facilitate supply to the southern development areas.

Upgrade / replace ailing water mains and related infrastructure and eliminate dead ends in the network to improve firefighting capacity (refer Westlake Punnett Report).

Following completion of the system upgrade works, the operation, performance, and functionality of the broader network is expected to improve significantly. The above-mentioned system upgrade works are shown conceptually in Figures A4 and A5 in Appendix A.

4.6 Water Treatment

Council have been considering the implementation of a packaged water treatment plant (WTP) to ensure that the quality of water supplied to Kalkite consistently meets desired drinking water quality standards. If the proposal for a new treatment plan is accepted by Council, the location of the system will need to incept the existing pumped line from Lake Jindabyne and will need to be sized to service a population of at least 1500 EP.

The implementation of a water treatment plant will require intensive water quality testing and associated investigations, all of which are not part of this study.

5 CONCLUSIONS

Hydraulic modelling was undertaken to identify the necessary system upgrade works to ensure future development demand firefighting flows can be safely and reliably serviced. Key findings from the assessment are as follows.

Council is in the process of developing a strategy aimed specifically at addressing issues associated with existing water mains in poor structural condition as well as elimination of dead-end mains within the reticulation system. A study into aged and ailing water infrastructure and dead-end water mains in Kalkite is being undertaken in parallel to this investigation by Westlake Punnet Consulting Engineers.

A modelling assessment of the existing network revealed that minimum residual pressures of about 220 kPa during peak day demand periods whereas maximum pressures were observed to be in the order of about 500 kPa. Pressures remained reasonably consistent within the township in line with the conditions set down in the Water Directorate Guidelines, NSW.

Modelling revealled that the existing water supply network is not able to accommodate firefighting flows within the elevated regions of Banksia Avenue and Lotus Avenue. Options to mitigate concerns with firefighting flow capacity may include the implementation of a continuous operating booster pump or new elevated storage at suitable operational height to facilitate improved service to the local region via gravity. Having said this, based on the number of customers impacted, the capital investment associated with the above-mentioned works on a per property basis would be excessive. For this reason, it is recommended that Council continue to service the network viz the current network arrangement until such time as future development warrants the need for a major system upgrade.

To ensure reliable service is provided to existing and future development, a major upgrade to the existing network is required. A summary of the recommended capital improvements and upgrades is presented below.

- Construct new 2.2 ML reservoir (effective capacity), decommission, and remove existing reservoirs. The reservoir must be designed to facilitate future service connections to proposed development areas located on the south side of Kalkite. Upgrade operating of the reservoir by at least 5m to improve pressures and firefighting capacity in the existing developed areas on the north side of town.
- Construct dedicated 200mm diameter supply main (1400m) from high lift pump station to new reservoir.
- Upgrade Lake and high lift transfer pump station to town reservoir, the recommended (minimum) performance of the Lake pumps and high lift pumps is 28 L/s. The pumps must include provisions for variable speed operation to minimise the potential for intermittent pump starts.
- Council has been considering the implementation of a water treatment plant for Kalkite. The proposed location of the plant must be arranged to incept the water sourced from Lake Jindabyne. Implementation of WTP for Kalkite remains subject to further testing, assessments and a scope of work which does not form part of this study.

Conceptual illustrations showing the proposed system upgrade works for Kalkite are shown on Figures A4 and A5 in Appendix A.

6 OPINION ON COSTS

Opinion on cost estimates for recommended capital improvements and upgrade works is presented in Table 6.1.

Table 6.1 Capital Works Cost Estimates

Description	Amount (excludes GST)
2.2 ML reservoir, including: - Preliminary Works (Site access, establishment etc.); Ground treatment and earthworks. Decommission and remove existing reservoirs, Site access and civil works (allowance only), Reinforced concrete pits Structural concrete slab and walls Roof and access Electrical, control, instrumentation, and telemetry Pipework including future service connection to future southern development areas.	$2,300,000
200mm diameter reservoir transfer main (1. 4 km) from high lift pump station: - Construct DN200 water main (OD250 PE100 PN16) Closed emergency interconnection with PRV to existing retic Testing and Chlorination.	$1,550,000
Upgrade high lift pump station (the recommended performance of the Lake pumps and high lift pumps is 28 L/s).	$900,000
Water Treatment Plant (subject to further investigations and Council approval)	Not Costed
Design, PM and Oncosts. Reservoir Pipelines and Pump Station Upgrade Works	$550,000
Total (excluding GST)	**$5,300,000**

7 RECOMMENDATIONS

Based on the assessment works carried out, it is recommended that SMRC:

1. Adopt this report as a basis for the establishment of the Kalkite water supply network model as well as recommendations for the proposed network improvements and upgrade works.
2. Check and confirm Lake pump characteristics to assess that its capacity aligns with the capacity of the high lift transfer pumps. If it doesn't, Council will need to allow for the necessary upgrade works to ensure alignment with proposed high lift pump upgrade works.
3. Continue to build and update the hydraulic model to ensure its continued accuracy and data capture. Document and date changes to the model when modifications are made (e.g., as new network elements are introduced). Check and verify model anomalies as and when encountered.
4. AGNR recommends that yearly maintenance be carried out on the model to ensure that it remains up to date by capturing new works when as constructed data for same is released and continues to reflect actual system performance. The model will ultimately provide Council with a useful tool to make informed operational decisions throughout the implementation of the proposed capital works and network improvements as well as when future property development is proposed.

8 REFERENCES

1. Snowy Monaro Regional Council, Snowy Monaro Draft Settlements Strategy Part 11 – Housing Strategy (2020), Draft for Public Exhibition.

2. Water Services Association of Australia WS03, Water Supply Code of Australia. (2016)

3. Water Directorate Section 64 Determinations of Equivalent Tenements guidelines, Technical Guidelines, January 2005.

4. Water Directorate Fire Flow Design Guidelines – June 2011.

5. Icon Water, Water Demand Criteria Review 2021, Investigation for Update to STD-SPE-G012 April 2021.

9 REPORT LIMITATIONS AND ASSUMPTIONS

9.1 Modelling, Investigations and Report Content

Important information concerning the investigations, analysis and findings is as follows.

1. In preparing this document, including all relevant calculations, and modelling, AGNR (AGNR) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

2. AGNR have used reasonable endeavours to inform themselves of the parameters and other requirements of the project and has taken reasonable steps to ensure that the model is as accurate and comprehensive as possible given the information upon which it has been based.

3. Results obtained from the network model are based solely on input data, some of which had not been verified in the field nor confirmed as accurate by SMRC. Unverified elements of the model include GIS information used to establish the water distribution network for the model, contour information used to define elevations at nodes and at other critical system elements.

4. The network model developed for this project assesses pressures in pipes and services that are owned and operated by Council not by private developers.

5. Use of the model to assess and remedy possible adverse network performance issues and future development should only be carried out by competent modelling engineers who are experienced in the use of Bentley software (WaterGEMs) and consultants / users who are approved by SMRC. Note also that the model has been developed using industry-based data that may not be representative of the parameters that apply specifically to the Kalkite network. Use of the model as it currently stands for resolution of network performance issues should be used with caution. Validation of model results by way of in-service testing is required prior to further more in-depth use of the model.

6. Water quality testing, treatment and associated performance assessment etc was not undertaken.

7. The accuracy of the results obtained from the model is reliant on the accuracy, limitations and characteristics of the unverified data used and the model itself.

8. AGNR does not provide any warranty nor accept any liability in relation to the completeness nor accuracy of the model input data as well as results obtained thereof which inherently relies on data obtained using industry standards.

9. It is not intended that this report represents a final assessment of the Kalkite water supply network model. SMRC will commit to provide continual updates and maintenance to the model when updates and verified information become available. Updates when released, will be documented in this report.

9.2 Cost Estimates

Important information concerning cost estimates derived as part of this study are as follows.

1. Cost estimates exclude GST however an allowance for engineering and associated on-costs has been included.

2. Whilst it is considered that the infrastructure components identified in this report is likely to be a reasonable account of the required works, it is likely that they may not represent the works involved in the final delivery of the project.

3. The estimates prepared for this report have been developed based on:

    - reasonable engineering judgement.
    - Historical contract rates obtained from similar recent and relevant projects; and
    - risk mitigation (e.g., inclusion of a contingency allowance).

4. The estimates provided may not fully encompass the extent of works involved in the final delivery of the project and furthermore, material supply and contract rates will vary based on market conditions.

5. For a project of this size and nature, variations in material supply costs and supplier rates may result in a significant cost variation to the project budget. For example, the estimates given for the likes of steel, pipework and valves will vary based on the materials selected and this could have a major impact on the final outturn costing for the project (either increase or decrease depending on life cycle preferences).

6. Estimates provided for the likes of reservoir construction and maintenance vehicle accessibility as well as construction access in steep and difficult terrain remain subject to detailed survey and land tenure definition all of which will need to be reconfirmed during later development stages of the project. This applies to the proposed reservoir upgrade works.

7. On-costs for engineering and supervision (including administration) have been based on knowledge of the current consulting industry for engineering services.

8. In summary the accuracy of the estimates cannot be guaranteed. A higher degree of confidence could be obtained via the provision of survey and geotechnical data, attendance to a comprehensive market assessment of the products proposed or by way of employment of an experienced contract estimator which has not been included in the scope of the concept estimates.

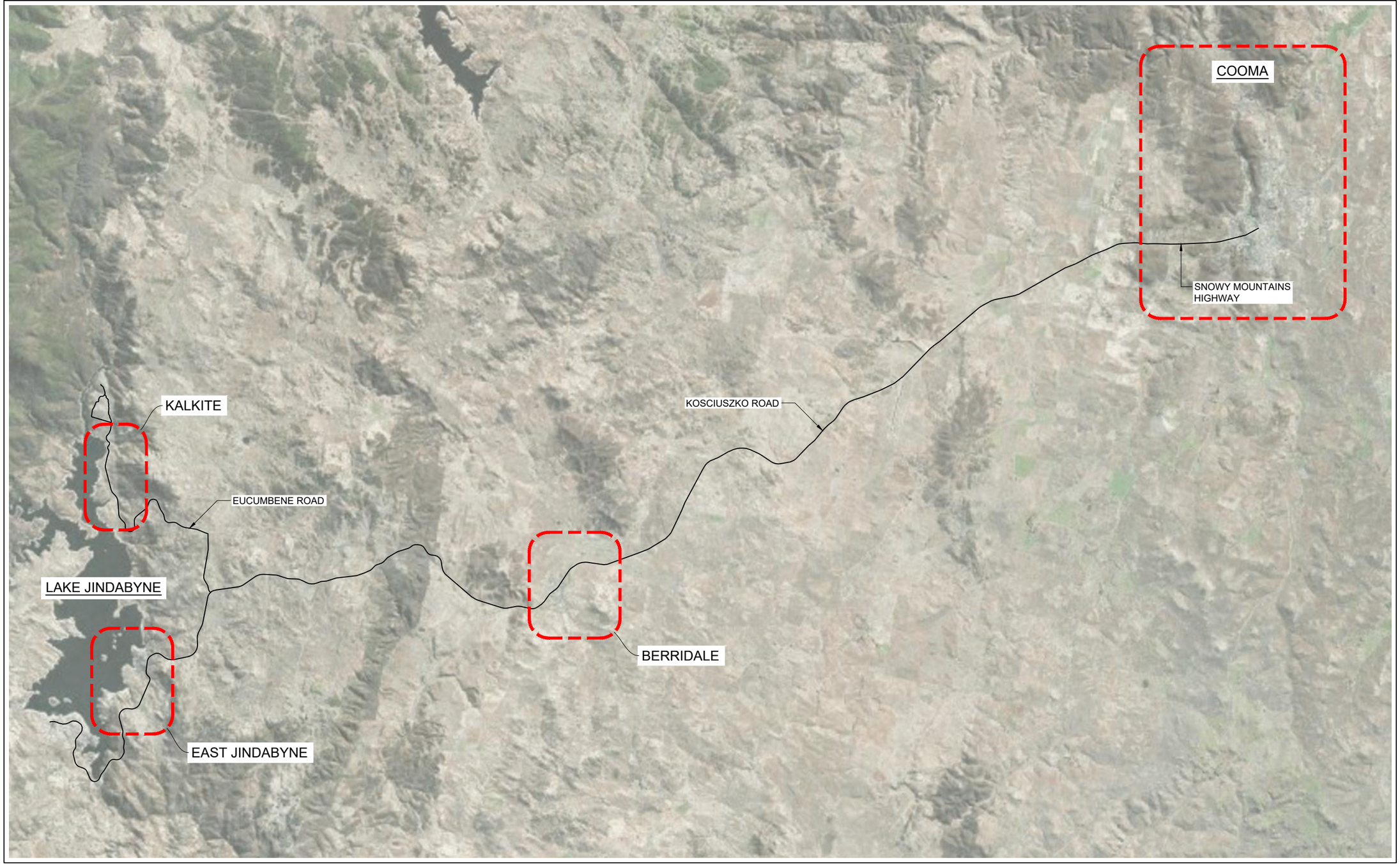
9. Alternatively, a higher percentage for contingencies could be allowed for to provide greater confidence in the estimate not being exceeded. Further, the estimates should be regularly updated as the project continues to develop to ensure that they reflect movements in the market conditions as closely as possible.

APPENDIX A SKETCHES AND ILLUSTRATIONS

Figure	Drawing Description
A1	Locality Plan
A2	Water Supply Network – Existing Layout
A3	Water Supply Network – Schematic
A4	Proposed (Future) Development Areas
A5	Water Supply Network – Future Upgrades

FOR REPORT

20 October 2022



KALKITE LOCALITY PLAN

SCALE N.T.S.

Rev	Revision Description	Certification	Date
A	PRELIMINARY ISSUE (FOR REPORT)	-	-

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KALKITE
LOCALITY PLAN

Drawn: Z.BYRNE

Designed: T.BRADSHAW

ENGINEERING CERTIFICATION (RPEQ)				
ENG. AREA	NAME	SIGNATURE	NO.	DATE
CIVIL	THOMAS BRADSHAW		-	-

Job No.	SMRC-0005
Drawing No.	FIG. A1
Revision	A
Series Number	

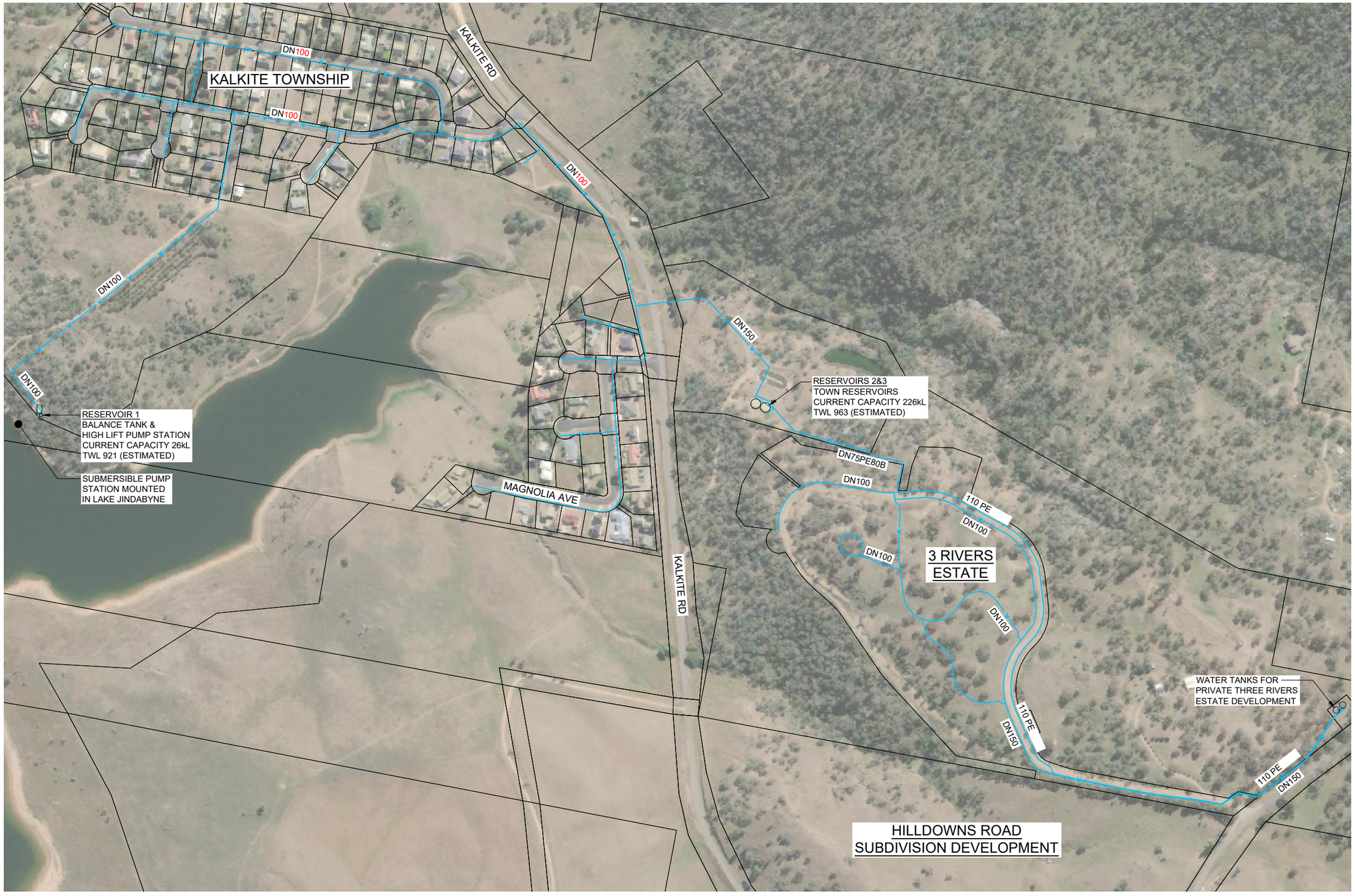
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FOR REPORT

20 October 2022



N

LEGEND

- W — EXISTING WATER MAIN
- RM — EXISTING SEWER RISING MAIN
- DNXX — NOMINAL PIPE SIZE TBC

KALKITE WATER NETWORK

SCALE N.T.S.

XREFS :- XC_Kalkite_Cadastre.dwg ; XC_Kalkite_WM_Network.dwg ; XC_Kalkite_Proposed_WM_Network.dwg

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Title: KALKITE WATER SUPPLY NETWORK
KALKITE
EXISTING WATER NETWORK LAYOUT

Drawn: Z.BYRNE

Designed: T.BRADSHAW

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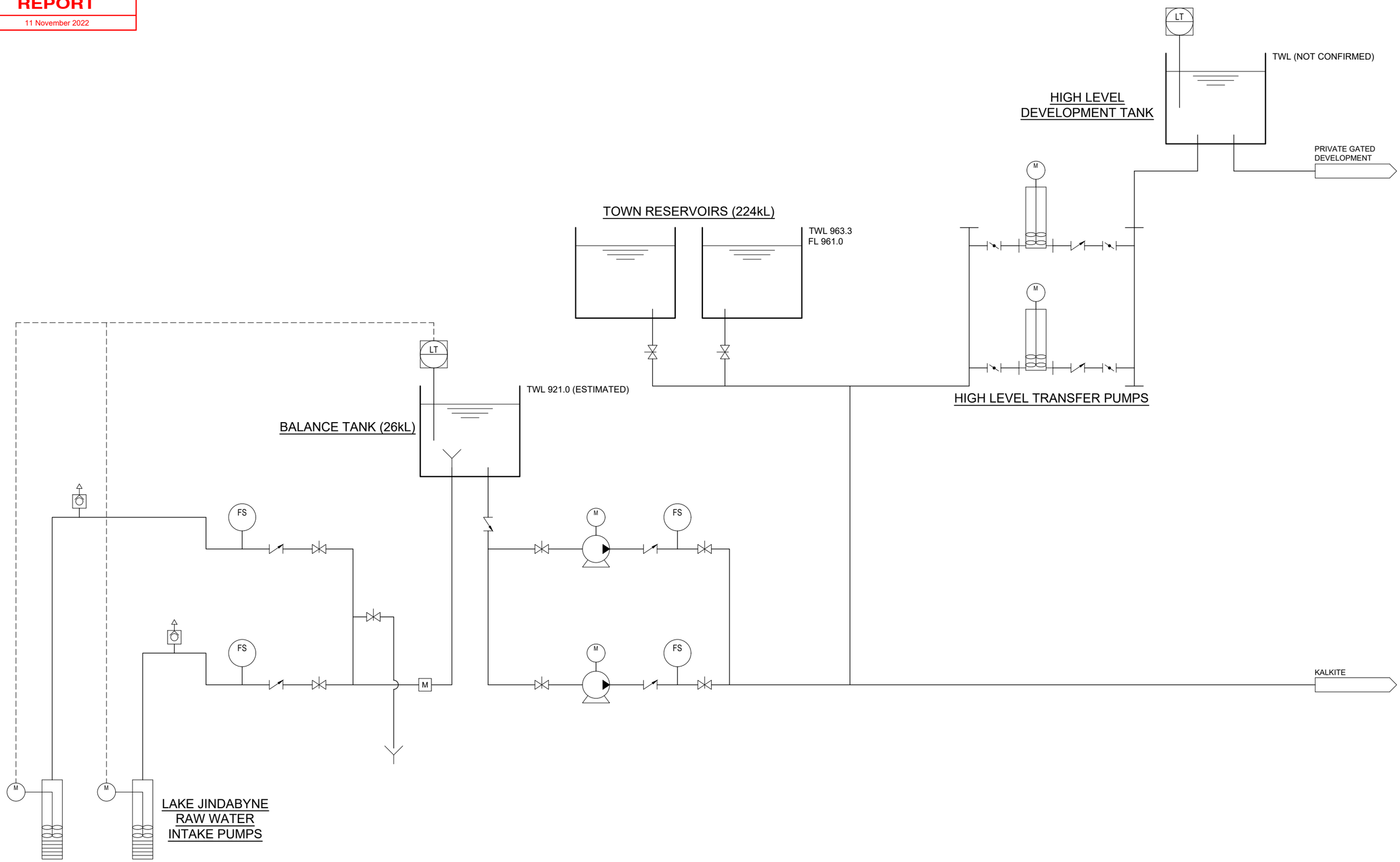
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Job No.	SMRC-0005
Drawing No.	FIG. A2
Revision	A
Series Number	

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11 November 2022



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KALKITE
EXISTING SYSTEM SCHEMATIC

Drawn: Z.BYRNE

Designed: T.BRADSHAW

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Job No.	SMRC-0005
Drawing No.	FIG. A3
Revision	A
Series Number	

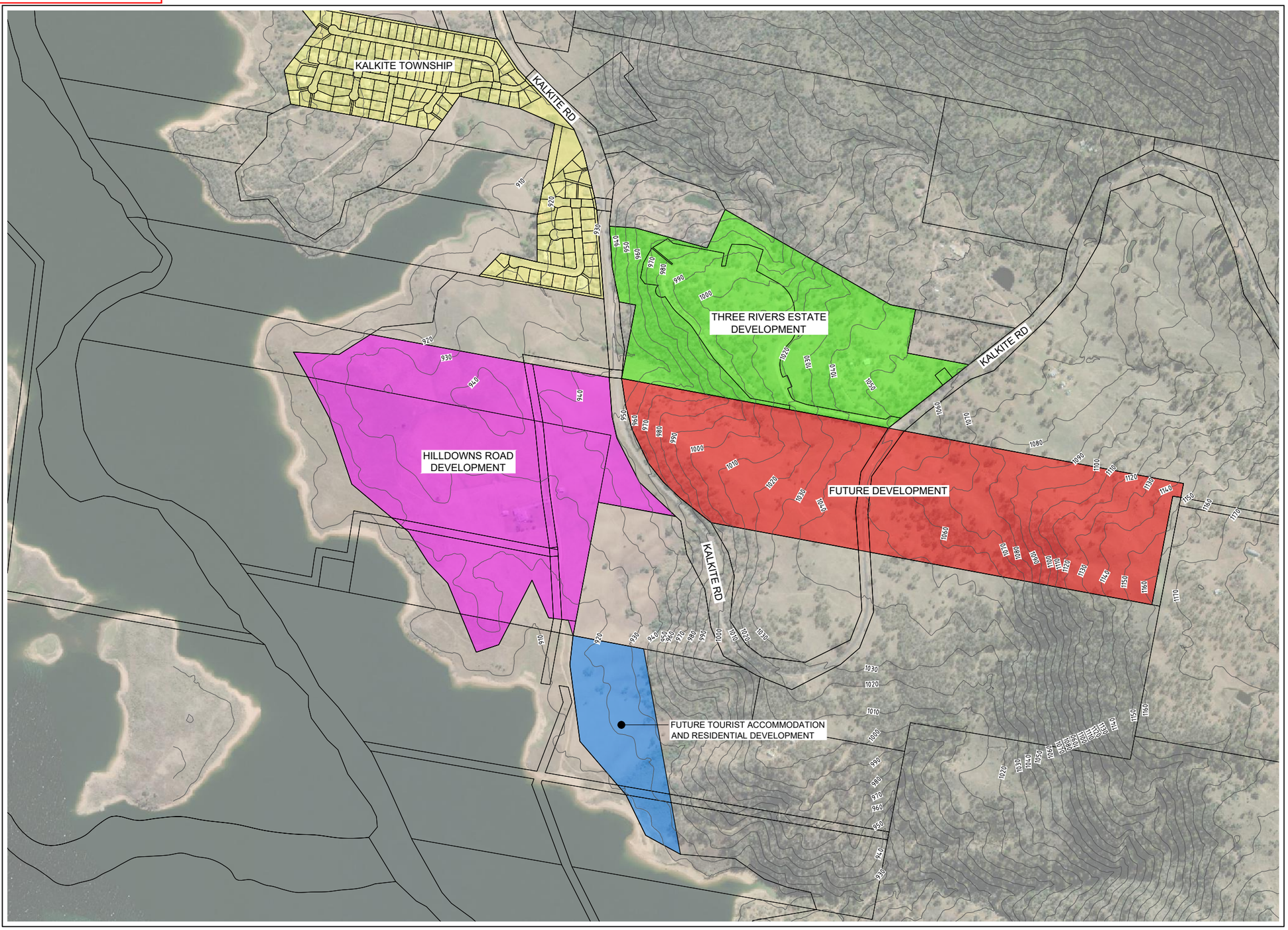
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FOR REPORT

20 October 2022



LEGEND

- KALKITE TOWNSHIP (APPROXIMATELY 146 LOTS)
- THREE RIVERS ESTATE (42 LOT SUBDIVISION)
- HILLDOWNS RD DEVELOPMENT (210 LOT SUBDIVISION)
- TEMPORARY DEVELOPMENT (80 BED TOURIST/VISITOR ACCOMMODATION & 40 LOT RESIDENTIAL SUBDIVISION)
- FUTURE DEVELOPMENT (NOT SERVICED BY WATER SUPPLY SYSTEM)

KALKITE DEVELOPMENT AREAS

SCALE N.T.S.

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KALKITE FUTURE INVESTIGATION
DEVELOPMENT AREAS

Drawn: Z.BYRNE
Designed: T.BRADSHAW

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ENG. AREA	NAME	SIGNATURE	NO.	DATE
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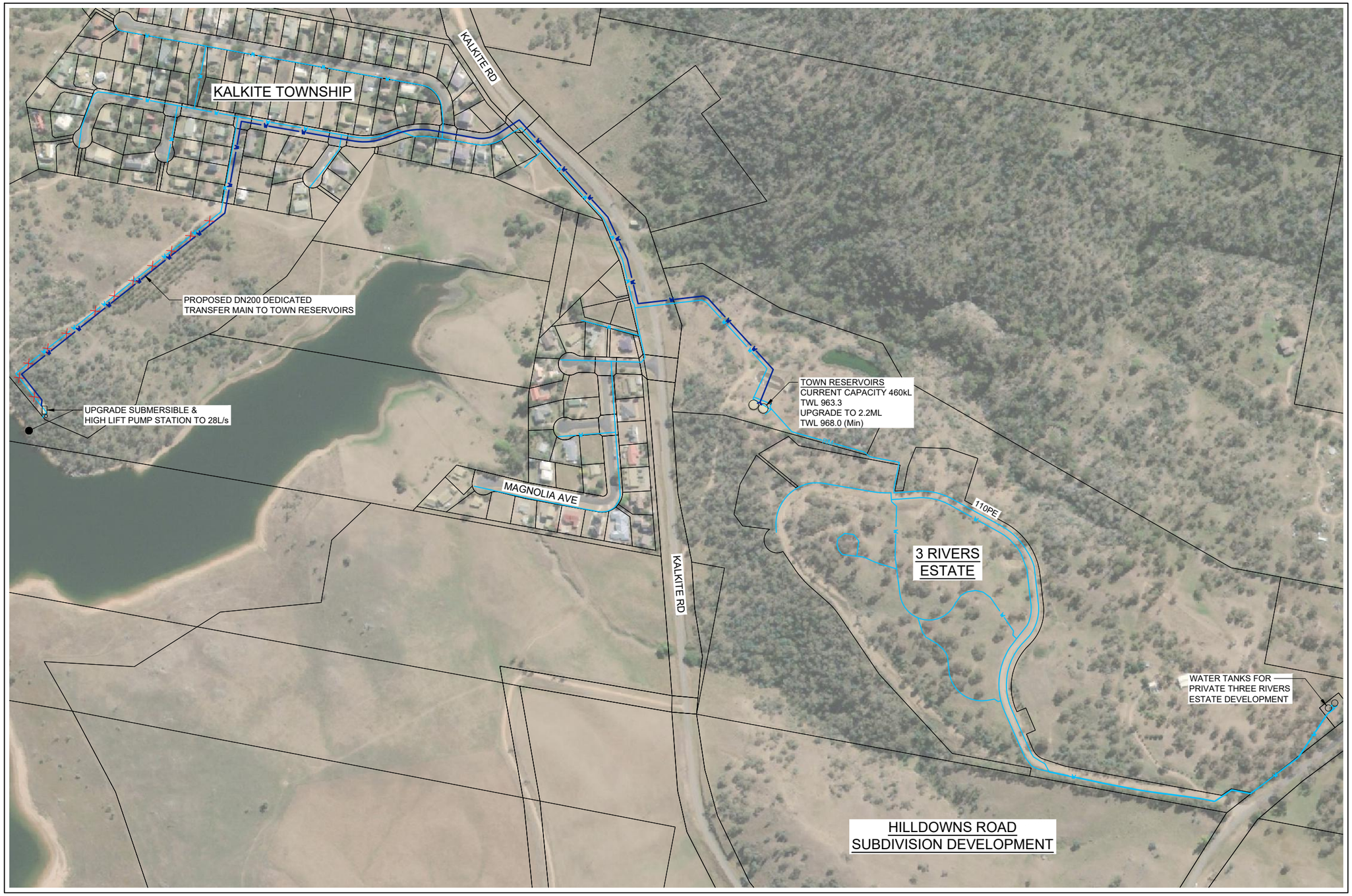
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FOR REPORT

11 November 2022



LEGEND

- DISUSED WATER MAIN
- EXISTING WATER MAIN
- EXISTING SEWER RISING MAIN
- PROPOSED WATER MAIN

KALKITE WATER NETWORK UPGRADES

SCALE N.T.S.

Rev	Revision Description	Certification	Date
A	PRELIMINARY ISSUE (FOR REPORT)	-	-

Scales: NOT TO SCALE

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Client: SNOWY MONARO REGIONAL COUNCIL

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Title: WATER SUPPLY NETWORK INVESTIGATION
KALKITE
PROPOSED NETWORK UPGRADES & IMPROVEMENTS

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Snowy Monaro Villages Water Safety Scoping Study

Final

Snowy Monaro Regional Council

SEPTEMBER 2020

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Executive Summary

The Snowy Monaro Regional Council (SMRC) covers an area of 15,158 square kilometres and has an approximate population of 20,753 (2015 estimate). Of the numerous small villages, the five villages involved in this project have been identified as a priority to investigate and implement additional treatment barriers to improve water safety. The five villages share some common traits, being relatively isolated with small populations and a water supply that receives chlorination as the single treatment barrier. However, each locality has unique challenges to be addressed in improving the water safety and aesthetics

The objective of the Water Safety Scoping Study is to identify one, or more, preferred options to improve water safety at each location. This report meets this objective by providing a concise evaluation that clearly conveys the objectives, design basis and process that was undertaken to determine the preferred options.

The report includes the following sections;

- Section 1 provides an introduction and background to the project
- Section 2 provides the treated water quality targets for the Villages
- Section 3 to 7 provide the water safety scoping study for each Village
- Section 8 provides order of magnitude cost estimates
- Section 9 provides the Conclusions and Recommendations.

A number of reports have been developed as part of the scoping study and provide background detail to support the outcomes of the Scoping Study. The reports and a summary of their content are;

- *Service Area and Demand for Villages Scoping Study Memo, Revision A. from Hunter H2O to Jessica Dunstan (SMRC), 07/09/2020*
  - Provides a summary of available production and consumption data for the villages and compares this to guidance from the water Services Association of Australia as a benchmark.
  - Outlines the existing service area of the villages
  - Provides an estimate for the 2050 demand and hence capacity for treatment infrastructure.
- *Snowy Monaro Villages Water Safety Scoping Study, Source Water Assessment, September 2020, Revision B*
  - A desktop, high level assessment of pathogen risk was completed in line with the Water Services Association of Australia guidance manual (Water Services Association of Australia, September 2015) to nominate a microbiological risk for each source.
  - Chemical and physical hazards were assessed through statistics as well as creating and considering time series charts and summarised for each location and each source.
  - Typical water quality as well as key challenges for each source were nominated
  - A sampling program was provided (included in this report as Appendix B) to better inform the raw water design envelope moving forward.
- *Water Treatment Options Overview, Memo, from Hunter H2O to Jessica Dunstan (SMRC), 23/09/2020*
  - Presents a long list of treatment options for the identified raw water hazards and their strengths and weaknesses
- *Snowy Monaro Villages Water Safety Scoping Study, Options Assessment Report, September 2020, Revision B*
  - Used previous outputs to consider two or three options to improve water safety at each of the villages, compared the associated strengths and weaknesses and selected a preferred option
  - Considered existing assets and available land area to determine a preferred location for siting new treatment infrastructure.

The Water Safety Scoping has combined key outputs from the previous reports and investigations into a single document that clearly conveys the objectives, design basis and process that was undertaken to determine the preferred options to improve water safety. Each Village is presented within a dedicated section of the report, in summary;

Bredbo

To address raw water health and aesthetic hazards it is recommended to construct a new 400kL/day conventional pressurised direct filtration plant, taking water from the existing aeration tower and incorporating UV disinfection as a mutli-barrier approach to chlorine resistant protozoa. The infrastructure would be located on land purchased adjacent to the existing Reservoir site and raw water pumping upgrades will be required.

Kalkite

To address raw water health and aesthetic hazards it is recommended to construct a new 300kL/day membrane filtration plant on land already owned by council between the raw water pumping station and the community. Due to the location and size of the WTP, raw water pumping upgrades will be required. A new dedicated rising main would be constructed to allow for treated water to be sent direct to the existing Reservoirs to improve the consistency of supply to the community and negate the need to construct a dedicated Chlorine contact tank at the new WTP.

Adaminaby

To address raw water health and aesthetic hazards it is recommended to construct a new 500kL/day membrane filtration plant on land already owned by council at the Adaminaby reservoir site. Chlorination and fluoridation equipment at Observation point would be re-located to Adaminaby or abandoned to reduce the requirement to attend the remote pumping station daily. A small number of rural customers would be impacted and receive 'raw water' after the change.

Nimmitabel

To address raw water health and aesthetic hazards it is recommended to construct a new 400kL/day membrane filtration plant on land to be purchased adjacent to the Lucan St Bore. The plant would utilise coagulation to address true colour and organics and treat a blend of River and bore water from 80:20 to 50:50 to take advantage of available groundwater yield and supply a consistent level of hardness. Given the raw water catchment UV disinfection would be incorporated as a mutli-barrier approach to chlorine resistant protozoa.

The water will maintain a moderate alkalinity and hardness and there remains the ability to run 100% groundwater during emergency scenarios. Further investigation and community engagement is recommended to determine the frequency and duration of needing to run 100% bore water and the community willingness to pay for hardness reduction during these events.

Eucumbene Cove

It is recommended that a containerised membrane filtration plant is provided to treat water before it enters the existing reservoir. To address water age and chlorine decay issues, tank mixing is recommended with chlorine monitoring of the bulk tank volume with the ability to dose sodium hypochlorite directly to the tank as a 'top up' dose.

Recommendations that span across all of the Villages are;

- Incorporate the provided sampling program for routine and event monitoring, to better inform the raw water design envelope and reduce risk for SMRC and Contractors.
- Undertake a fire attack study of the proposed sites to inform the construction materials required of the new assets.
- Confirm the availability of power at each of the sites to inform the construction of the new assets
- Jar Testing:
    - At Bredbo - to determine the effectiveness of coagulation and typical dose rates for conventional filtration.
    - At Nimmitabel - to determine the effectiveness of coagulation and typical dose rates for membrane filtration at carious blend ratios.
    - At Eucumbene Cove - to assess the impact of maintaining a chlorine residual on the water quality, in particular the pH gives the low alkalinity of the water.

- At Kalkite and Adaminaby jar testing is not essential but could be undertaken to consider the advantage, if any, of coagulation against direct membrane filtration without coagulation. Essentially considering the true colour and chlorine decay of the coagulated and direct filtered water.

Finally an order of cost estimation was undertaken using the NSW reference Rates Manual (Department of Primary Industries, Office of Water, 2014) and a comparison based on recent projects with Hunter H2O visibility. The outputs are provided in the table below with a total project cost for the Villages water safety improvement project being estimated to be in the order of $10.5M (NSW reference rate) to $15.5M.

Table EC1: NSW Reference rates and Recent Project Cost Estimate Comparison.

	NSW Reference Rate	Recent Projects Estimate	Comment
Adaminaby (500kL)	$2.93M	$4.09M	Does not include 1000m of new dedicated rising main
Bredbo (400kL)	$2.45M	$3.68M	Land acquisition required
Nimmitabel (400kL)	$2.45M	$3.68M	Land acquisition required Does not include 500m of new rising main to the WTP location
Kalkite (300 kL)	$1.98M	$3.27M	Does not include 1000m of new dedicated rising main
Eucumbene Cove (60kL)	$0.66M	$0.81	Based on 20 foot shipping container solution.

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Appendices

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Appendix B Proposed Sampling Program

1 Introduction

1.1 Background

The Snowy Monaro Regional Council (SMRC) covers an area of 15,158 square kilometres and has an approximate population of 20,753 (2015 estimate). Of the numerous small villages, the five villages involved in this project have been identified as a priority to investigate and implement additional treatment barriers to improve water safety.

The five villages share some common traits, being relatively isolated with small populations and a water supply that receives chlorination as the single treatment barrier. However, each locality has unique challenges to be addressed in improving the water safety and aesthetics. An overview of the water supply for the Villages, including previously identified hazards, is included in Table 1-1.

Table 1-1: Village Overview.

Village	Source	Raw Water Cat.	Identified Hazards
Bredbo	Shallow Groundwater under the direct influence of surface water.	4	Iron and possibly free CO_2 and pathogens from direct Murrumbidgee River influence on the bores. Possibility of organics and true colour, in particular, following flooding. Bores impacted by floods and see the turbidity increase above 20 NTU.
Nimmitabel	Bores + Maclaughlin River	4	Lucan St bore has a median total hardness of ~ 300 mg/L as $CaCO_3$ and Alkalinity in excess of 400 mg/L as $CaCO_3$. River water turbidity routinely spikes to 20 and 30 NTU after small amounts of rainfall and includes organics and true colour. Bore water turbidity is low but variable. Source of the variability needs to be confirmed.
Kalkite	Northern end of Lake Jindabyne	3	No history of algae, taste or odour, true colour or significant organics. Water is taken from depth and the turbidity is typically less than 5 NTU with the possibility of turbidity up to 10 NTU. Water is soft with a pH in a good range. Possibility of low oxygen and soluble metals.
Eucumbene Cove	Deep intake Lake Eucumbene (Dam Wall)	3	No history of algae, taste or odour, true colour or significant organics. Water is taken from depth and the turbidity is typically less than 5 NTU. Water is soft with a pH in a good range. Possibility of low oxygen and soluble metals.
Adaminaby	Deep intake Lake Eucumbene (Observation Point)	3	No history of algae, true colour or significant organics. One taste and odour event linked to Tantangara. Water is taken from depth and the turbidity is typically less than 5 NTU. Water is soft with a pH in a good range. Possibility of low oxygen and soluble metals.

Operationally the five villages are located to the north, south and west of Cooma, as shown in Figure 1-1. Whilst the sites appear relatively close to each other, operational travel distances are complicated by a lack of direct routes.

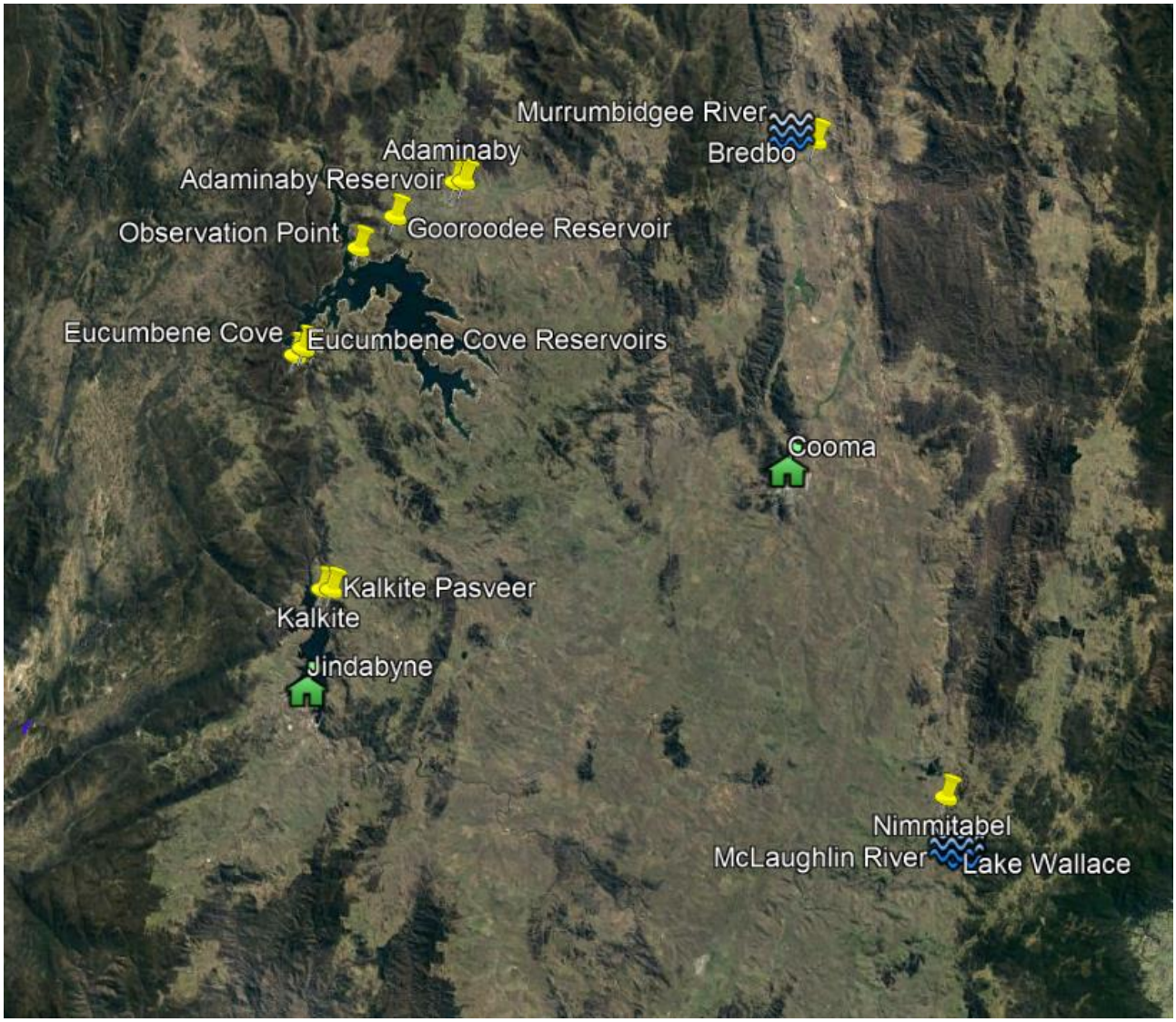


Figure 1-1: Village Location Overview.

1.2 Project Objective

The ultimate objective of the project is to deliver infrastructure and processes that will consistently and reliably deliver water to the residents of the villages that is safe, meets the requirements of legislation, is approved by regulators and is able to be efficiently and effectively operated and maintained by SMRC.

1.2.1 Water Safety Scoping Study Objectives

The objective of the Water Safety Scoping Study is to identify one, or more, preferred options to improve water safety at each location. To successfully meet this objective there is to be a concise evaluation that clearly conveys the objectives, design basis and process that was undertaken to determine the preferred options.

The Water Safety Scoping Study will set the framework for community engagement, SMRC planning and provide the basis to take the project, with DPIE concurrence, into the Concept Design and Business Case phase.

2 Treated Water Quality Targets

2.1 Treated Water Quality

The treated water quality proposed for all of the treatment plants is provided in Table 2-1 as a starting point.

Table 2-1: Preliminary Treated Water Quality Targets.

Parameter	Units	Value and Comment [note 1.]	ADWG
Turbidity	NTU	• Individual Filter turbidity of <0.15 NTU for 95% of samples. • Individual filter turbidity not to exceed 0.3 NTU for more than 15 minutes consecutively. Individual filter results are to be taken at least every 5 minutes from a continuous online analyser. • Membrane filtered water turbidity of <0.10 NTU for 95% of samples.	Insufficient data for health limit <5 NTU (aesthetic) <1 NTU for Disinfection
		The turbidity targets above are to achieve the highest log credits and are suggested for all sites.	
True colour	Hazen	< 5 Grab sample at the treated water tank outlet	<15 HU (aesthetic)
		True Colour target is valid for Bredbo and Nimmitabel where coagulation is part of the treatment train. For Kalkite, Eucumbene cove and Adaminaby there may not be a need for coagulation (with membrane filtration) and if so the true colour target would be relaxed or removed.	
Total iron	mg/L	< 0.1 Grab sample at the treated water tank outlet	Insufficient data for health limit <0.3 mg/L (aesthetic)
		Required at Bredbo and for other sites this is a typical requirement to ensure that filtration is effective.	
Total manganese	mg/L	Not Applicable	<0.5 mg/L (health) <0.1 mg/L (aesthetic)
		None of the sites have been identified as requiring a barrier to soluble manganese and as such a manganese target will not be incorporated as it would drive risk and the inclusion of additional treatment barriers (pre chlorine, potassium permanganate, oxidation or coated media)	
Total aluminium	mg/L	< 0.1 Grab sample at the treated water tank outlet.	Insufficient data for health limit <0.2 mg/L (aesthetic)
		Standard requirement to ensure that coagulation has been optimised	
pH		6.5 < pH < 8.5 Measured continuously with the free chlorine level	6.5 to 8.5
		Standard requirement to match the ADWG	
Fluoride	mg/L	Fluoride addition for Adaminaby No fluoride addition at any other site	

Free available chlorine	mg/L	1.0 < Free Chlorine < 2.0 90th percentile within 0.3 mg/L of an operator entered free available chlorine set-point at the entry to the treated water tank of between 1 and 4 mg/L.	<5 mg/L Total Chlorine (health)
		At an Option level the intent is that all sites will have online chlorine monitoring on the outlet of the WTP/inlet to the reservoir. At this location the chlorine level can be used to trim the chlorine dose to target a specific level going into the treated water storage and as such the designer can be held responsible for the performance. At Kalkite and Nimmitabel the proposed location of the treatment infrastructure is remote from the treated water storage and 'top up dosing' of the reservoir from the chlorine storage and dosing system in the WTP is not practical. At Bredbo and Adaminaby best practice would be to incorporate reservoir mixing and free chlorine monitoring of the water in/leaving the treated water storage tank with an associated top up dose with a performance requirement. Due to low usage it has been recommended that Eucumbene Cove has a tank mixer and a recirculation loop that measures the free chlorine level in the reservoir to allow for a target level in the reservoir through a chlorine top up dose.	
Chlorine C.t	mg.min/L	Not Applicable	Minimum C.t must be achieved to attain target levels of pathogen inactivation; a free chlorine residual of >0.2 mg/L must be maintained throughout the distribution system; but the total chlorine residual must be kept at <5 mg/L (health)
		Direct feed to the treated water storage tank has been proposed for all of the Villages and the C.t achieved in the reservoir has been calculated in the *Options Assessment Report* (Hunter H2O, September 2020) as sufficient using minimal storage. As such C.t will not be a performance requirement for the Contractor.	
E coli and faecal coliforms	CFU/100mL	No Detects Grab sample at the outlet of the WTP.	N/A
Chlorination Disinfection By-products	Total THM	Not applicable to WTP Contract	< 250µg/L
		Measurements to be taken by SMRC and compared against the targets below, not to be included as part of the D&C contract as the designer is unable to guarantee. < 250µg/L, Chloroacetic acid: 150µg/L, Dichloroacetic acid: 100µg/L, Trichloroacetic acid: 100µg/L	
Alkalinity	mg/L as $CaCO_3$	Alkalinity adjustment is not part of the proposed solution at Bredbo	N/A
		Current position is Bredbo and Nimmitabel – Have sufficient natural alkalinity for use of ACH as a coagulant. Jar testing would be recommended to confirm. Kalkite, Adaminaby and Eucumbene Cove – Sampling required, to confirm level and requirement if coagulation is undertaken.	
Hardness	mg/L as $CaCO_3$	Hardness adjustment is not being considered at any of the Villages. Nimmitabel to have blending of 10% to 50% groundwater	Should not exceed 200 mg/L as $CaCO_3$ to minimise undesirable build-up of scale in hot water systems

Note 1 - For all parameters, except for the chlorine C.t and the filter turbidity, which have their own percentile requirements, the limits presented above represent 95th percentiles for all flows and quality within the raw water design envelope.

3 Bredbo

Table 3-1: Bredbo Summary.

Component	Bredbo – 400 kL/day		
Demand (kL/day)	2020 ADD	2020 PDD	2050 PDD
	74.8	271.9	366.5
Reservoir Capacity	500kL which meets the general rule of thumb of holding a peak day volume.		
Offline Capacity	2020 ADD ~ 4 days 2020 PDD ~ 1 day		
Key Water Quality Challenges	The key hazardous event to be overcome, given the demonstrated link of the raw water to surface water, is the increase in turbidity and by inference, pathogen loading, during and following heavy rainfall when the turbidity increases rapidly. Raw water hazards ▪ Turbidity / suspended solids ▪ Pathogens (Category 4 source water) ▪ Iron (soluble and total) ▪ Colour		
Raw Water Quality Uncertainties	Whilst the aeration tower appears to be effective it is recommended to confirm levels of free CO_2 and the typical levels of soluble and total iron for each bore.		
C.t	Minimum level to achieve a C.t of 15 mg.min/L of 17% in the reservoir		
Raw Water Pumping	Bore 2 instantaneous capacity is less than required 5.3 L/sec and needs to be investigated to increase capacity or design the treatment infrastructure to suit. Pumping modifications will be required.		
Site location			
Land Acquisition Required?	Yes - Proposed to purchase land adjacent to the existing reservoir site.		
Shortlisted Options Considered	▪ Direct Media Filtration ▪ DAF/F ▪ Direct Membrane Filtration		
Preferred Option	The relatively stable raw water quality from the shallow bores, the availability and relative simplicity of pressure media filters, in combination with UV as a		

	multi barrier approach, means that Direct Media Filtration is the preferred option for Bredbo.
Residuals Management	Sludge Lagoons including an opportunity for local irrigation
UV Disinfection	Recommended due to the preliminary catchment categorisation of 4. “Unprotected Catchment”
Recommendations	In addition to the recommendations of previous reports ▪ Fire Attack Study ▪ Confirmation of availability of Power ▪ Coagulation Jar testing ▪ Raw water pumping investigation (Section 3.5.1) ▪ Confirmation and documentation of the design and operation of the aeration tower

3.1 Overview

Bredbo is located 82km south of Canberra and 34km north of Cooma on the Monaro Highway, at the confluence of the Bredbo and Murrumbidgee Rivers.

The town has a population of 352 people (2016 Census) with 110 supply connections (SMRC).



Gravel access road to reservoir location



Aeration tower and reservoir



Bore headworks



View from the bores back to the reservoir



Looking up to the bore location from the Murrumbidgee River meander



Reservoir access

Figure 3-1: Overview of Bredbo Infrastructure.

3.2 Service Area

GIS data from SMRC was used to provide an indicative service area for each Village and is presented below in Figure 3-2.

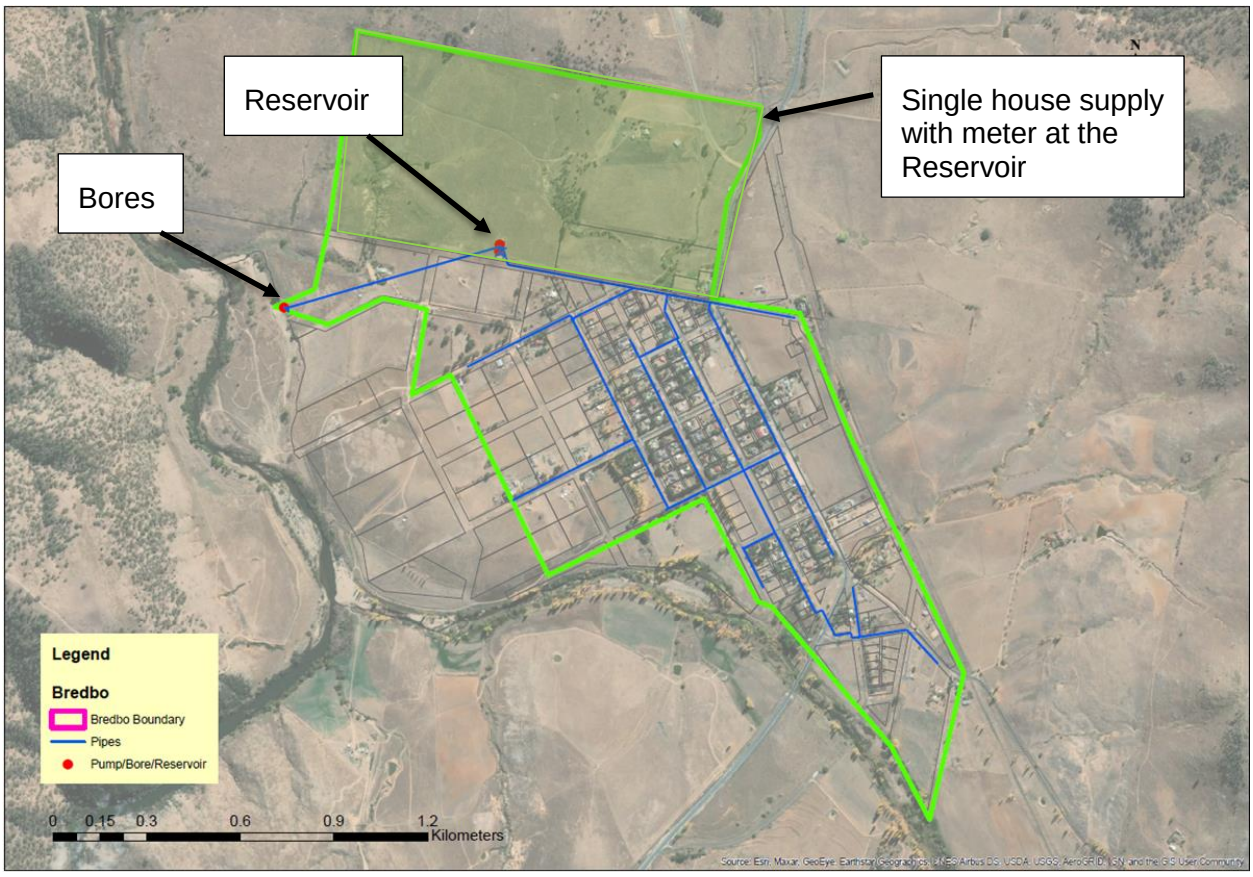


Figure 3-2: Bredbo Service Area.

3.3 Historical and Forecast Demand

Figure 3-3 shows the production of the Bredbo bores over the last 10 years as a time series. Table 3-2 provides a summary of this data and includes the forecast 2050 PDD and the proposed treatment plant capacity to service this demand (*Service Area and Demand Memo* (Hunter H2O, 2020)).

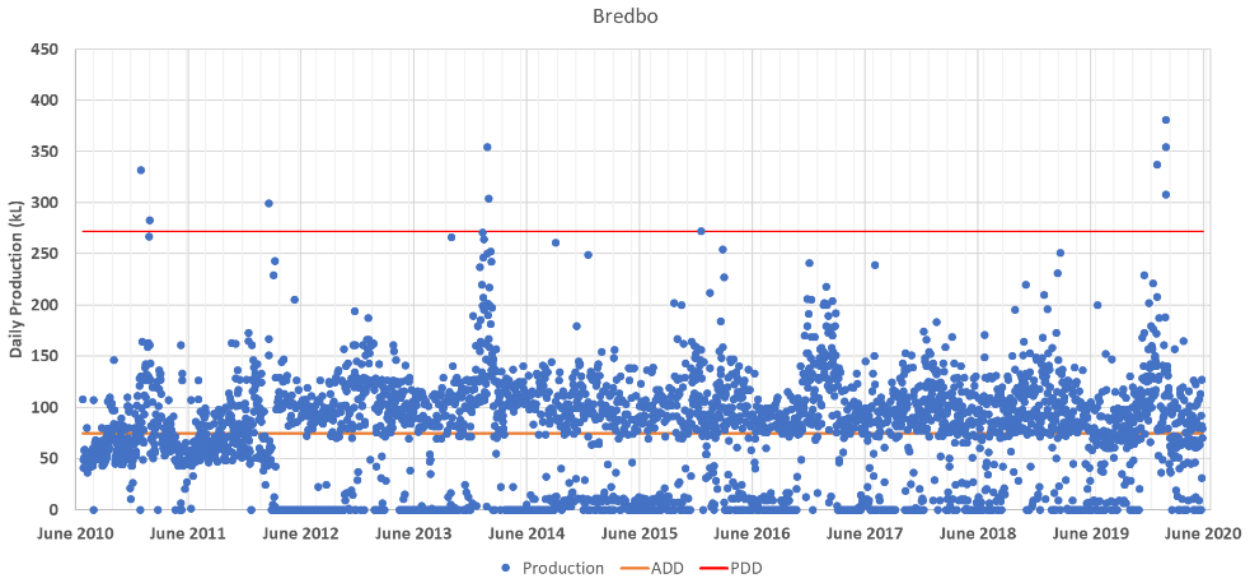


Figure 3-3: Bredbo Daily Production.

Table 3-2: Bredbo Historical and Future Demand and the Raw Water Pumping Capacity.

Village	Source	Raw Water Pumping Capacity (kL/d)	Historical PDD (kL) (2020)	Historical ADD (kL) (2020)	2050 PDD for Treatment Capacity[1]	2050 PDD for Treatment Capacity[1]
Bredbo	Groundwater under the direct influence of surface water.	Bore 1 – 460 Bore 2 – 340 Total – 800	272	75	366.5	400

Note 1. 1% annual population growth was adopted for the 2050 projections

3.4 Source Water Assessment

The Bredbo raw water supply was considered and is presented in detail in the *Source Water assessment Report* (Hunter H2O, 2020). The following sections provide a summary of the typical raw water hazards and challenges to be managed day to day to improve the aesthetic quality and water safety.

Beyond the day to day challenge, the key hazardous event and challenge to be overcome to improve the water safety of Bredbo, given the demonstrated link of the raw water to surface water, is the increase in turbidity and by inference, pathogen loading, during and following heavy rainfall when the turbidity increases rapidly.

The variability of turbidity associated with the direct connection to surface water is demonstrated in Figure 3-4, Figure 3-5 and Figure 3-6. Whilst the variability is not entirely explained by the river level, the relationship is strong and supports a direct connection to surface water.

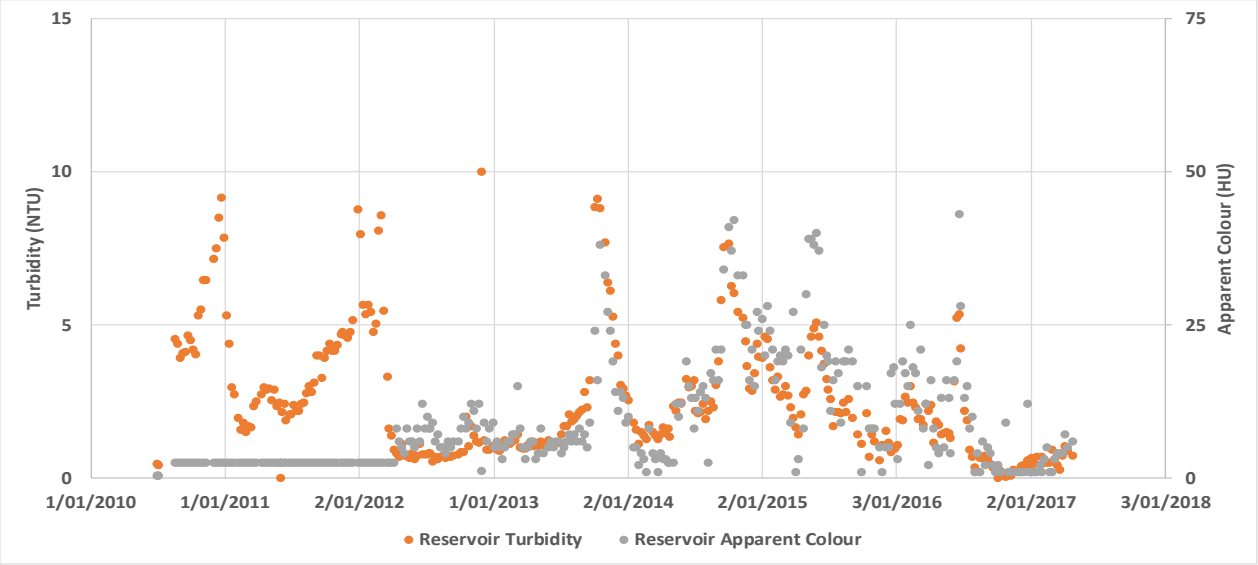


Figure 3-4: Reservoir Water Turbidity and Apparent Colour Data (July 2010 – May 2017).

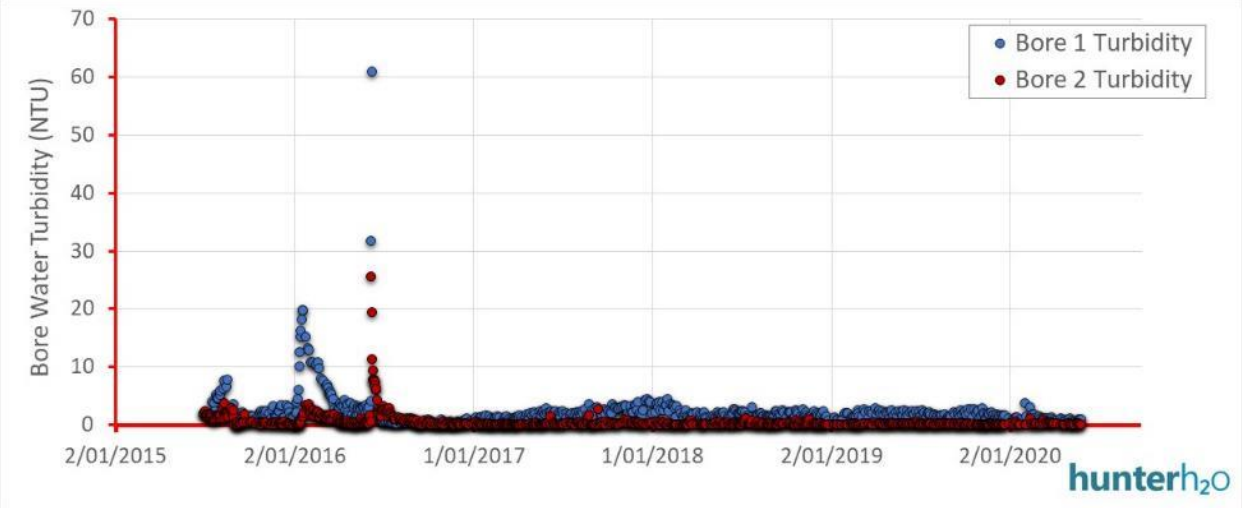


Figure 3-5: Bore Water and Reservoir Water Turbidity Data (July 2015 – May 2020).

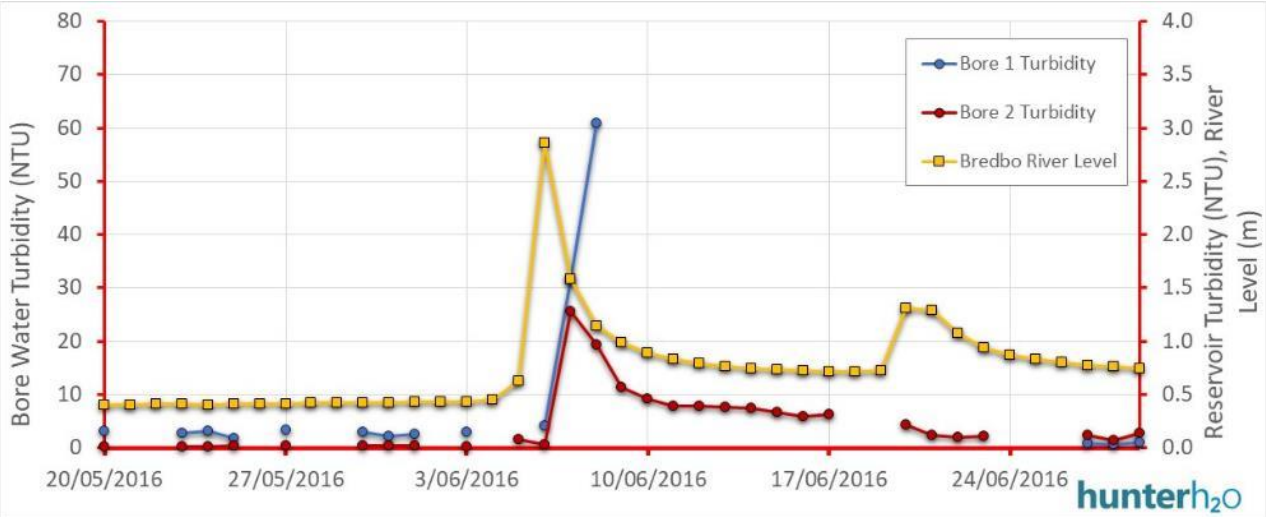


Figure 3-6: Bore Water Turbidity and Bredbo River Level Data During High Turbidity Event in June 2016.

3.4.1 Pathogens

A high level assessment of pathogen risk was undertaken using the Health Based Targets (HBT) guidance manual (Water Services Association of Australia, September 2015) and is presented in the Source Water Assessment (Hunter H2O, 2020). The assessment determined that the Bredbo source was conservatively a Category 4 source (Hunter H2O, 2020).

As a Category 4 source to achieve a target of an additional health burden, from potable water, of less $1x10^{-6}$ DALY's (Disability Adjusted Life Years) the following log reductions are recommended by the guidance manual and will require a multi barrier approach.

- **6.0 log_{10} reduction in Bacteria**
- **6.0 log_{10} reduction in Viruses and**
- **5.5 log_{10} reduction in Protozoa**

3.4.2 Chemical/Physical

From a review of the available raw water and reservoir water data the following are considered the key raw water hazards which require mitigation/barriers to reduce the associated health or aesthetic risk to an acceptable level at Bredbo.

Turbidity / Suspended Solids

- Both bores are consistently less than 5 NTU but more than 1 NTU
- Bore 1 has a consistently higher turbidity than bore 2
- Turbidity spikes following river level rise and flooding of the Murrumbidgee river meander local to the bores of up to 60 NTU but a more typical a spike has a turbidity of 10 to 20 NTU

Metals

- Soluble iron is present in both bores
  - Unknown ratio of total to soluble iron and effectiveness of current aeration tower.
- No data to nominate if the bores have equivalent levels of total/soluble iron

Colour

- Apparent colour is variable and has been recorded up to 30 HU
- True colour is suspected to be present during periods of increased turbidity due to connection with the river water and surface water organics/colour.

Organics

- No data available, suspected of being low due to low apparent colour
- Increase in organics expected following rain events when the bores are influenced by surface water.

pH and Alkalinity

- Raw water pH is typically less than 7 with the reservoir pH being 7.5 to 8.
  - Stripping of free CO_2 in the aeration tower suspected on being the cause of the pH rising.
  - Some increase through addition of sodium hypochlorite.
- Alkalinity is variable but is sufficient to allow for coagulation if required without impacting stability.

Hardness

- Hardness is reasonable with a historical medium of 65 mg/L as $CaCO_3$

3.4.3 Raw Water Quality Design Envelope

Table 3-3 outlines the preliminary raw water design envelope for the Bredbo WTP following consideration of available raw water data, its quality, and the impact of various elements. The envelope is intended as a living document to be considered through the project and adjusted as more information becomes available to balance risk and cost.

A monitoring program has been recommended, and provided separately, with key gaps for Bredbo that are recommended to be filled being;

- Dissolved CO_2 presence and removal across the aerator
- The presence of soluble iron and its oxidation across the aerator

- Level of total and dissolved organic carbon, particular as the turbidity increases
- Presence of microbiological contamination in the bores, typically and through events

Table 3-3: Preliminary Raw Water Design Envelope.

Parameter	Units	Preliminary Raw Water Design Envelope			
		5th percentile	Median	95th percentile	Maximum
Temperature	Celsius	5	15	25	25
pH		6.5	6.9	7.0	7.5
TDS	mg/L	91	164	306	406
Alkalinity	mg/L as $CaCO_3$	52	97	168	194
Turbidity	NTU	0.4	1.6	15[1.]	61
True Colour	Hazen	0.5	0.5	9.0	32
Calcium	mg/L (Ca)	8.6	17	31	38.4
Magnesium	mg/L (Mg)	4.3	7.0	10.6	10.6
Total Hardness	mg/L $CaCO_3$	42	65	101	101
Total Iron	mg/L	0.02	0.75[1.]	1.50[1.]	2.0[1.]
Soluble Iron	mg/L		0.5[1.]	1.0[1.]	2.0[1.]
Total Mn	mg/L	0.003	0.004	0.008	0.008
Soluble Mn	mg/L				
Free CO_2	mg/L				
TOC	mg/L				
DOC	mg/L				
Fluoride	mg/L	0.14	0.17	0.27	0.27

1. Values highlighted in green are estimates that are believed, following a review of data, site visit and discussion with Operators, to better represent the raw water challenge. These are TBC during the next phase.

3.5 Existing Instructure

The following is based on information provided and visual inspection during site visits. The scope did not include a detailed condition assessment to allow nomination of remaining life of assets.

3.5.1 Raw Water Pumping

Raw water is drawn from two bores in the Murrumbidgee River aquifer on the Murrumbidgee flood plain next to an ephemeral meander of the Murrumbidgee River (Viridis, August 2018). Council is licensed to extract up to 49 ML/year from the two bores.

The bore pump control structure is raised above natural ground and is nominated as RL 701.5 AHD with the bore casings ending around 300mm above natural ground and are at risk of inundation in a large flood event (Figure 3-7).




Figure 3-7: Bore Pump Control Structure (Left) and Bore Headworks.

There are two shallow bores located in the same area that operate alternately at fixed speed. Bore 1 is equipped with a pumping capacity of 5.3 L/sec which matches the proposed treatment infrastructure instantaneous flow. Bore 2 operates at ~74% of the proposed instantaneous flow rate at 3.9 L/s.

For small WTP's the operation is simplified if the WTP operates at a fixed rate and as such it is recommended to investigate;

- the opportunity to run both bores at a 50/50 blend (or other blend) hydraulically and electrically with variable speed drives (VSD) on both bore pumps;
- Confirm the yield available from bore 2 to see if it is able to match the extraction of bore 1 and avoid upgrading to VSD on both pumps.
- Consider raw water storage at the WTP to allow WTP operation at a higher instantaneous rate than bore 2 can supply.
    - For example a 30kL buffer volume would allow for 4 hours operation of Bore 2 before needing to pause and allow the buffer to refill
- Allow for the WTP to operate at different raw water flows based on the bore supplying water at the time.
    - Noting that the plant capacity is reduced to ~ 290 kL/day if only Bore 2 is available at 3.9 L/s

3.5.2 Bredbo Aeration

It is recommended that the aeration tower is maintained in the treatment process to remove free CO_2 (TBC) and oxidise soluble iron.

It is recommended that the design, and operation, of the aeration tower is confirmed and documented in the next stage of the project so that this can be provided to any 3rd party undertaking works.

3.5.3 Reservoir

Key capacity information on the Bredbo Reservoir from the *Options Assessment Report* (Hunter H2O, September 2020) is,

- The 2020 PDD is 54% of the reservoir capacity of 500kL
- The minimum level required for C.t, with a target of 1 mg/L and flow at 3xPDD is less than 20%
- 60% of the reservoir provides 4 days to repair an issue for the average day demand
- 60% of the reservoir provides 1 day to repair an issue for the PDD
- The Aerator is hydraulically linked to the reservoir

Based on the available information capacity upgrades are not recommended for the Bredbo Reservoir.



Figure 3-8: Bredbo Reservoir and Aeration Tower.

3.5.4 Disinfection

Sodium hypochlorite dosing between the aeration tower and the reservoir is employed for disinfection with the storage and dosing equipment located inside a lined and heated room to avoid the lines freezing (Figure 3-9). The hypo is diluted to extend the life of the product.

The building is in reasonable condition and could be reused in any upgrade with a new dosing system integrated into the WTP control system.



Figure 3-9: Bredbo Hypo Dosing.

3.6 Proposed Site Location

On review of the reservoir location, the infrastructure is located on approximately 1,500m^2 lot DP570008, surrounded by DP 852025. Access is from North Street/Yaouk Street by an easement on an informal gravel road.

In considering water treatment plants in the 200 to 500 kL/day capacity range (Hunter H2O, September 2020) at a scoping level the footprint allowance for Bredbo is suggested as 500 m^2 for process and 1500m^2 for sludge lagoons.

In considering the available lot there are two areas, one to the front and one to the rear of the lot where there is land available for treatment infrastructure. The front area is used for vehicle access, in particular for water trucks to deliver water into the reservoir. The rear area is approximately 13m x 18m (Figure 3-10).

The area to the rear of the lot may be able to be used for a process building and the associated access, parking and tankage, however it would be a very tight fit and not an ideal solution over the medium to long term. In addition, this would constrain residual handling options to collection and irrigation on privately held land. With only one option for the irrigation this would leave SMRC exposed to the whims of the land owner.

As such it is recommended to investigate the purchase of land adjacent to the existing lot to remove constraints around land area and management of residuals. Following the site visit, the area to the west is preferred as it is more level with an indication of the area provided in Figure 3-10.

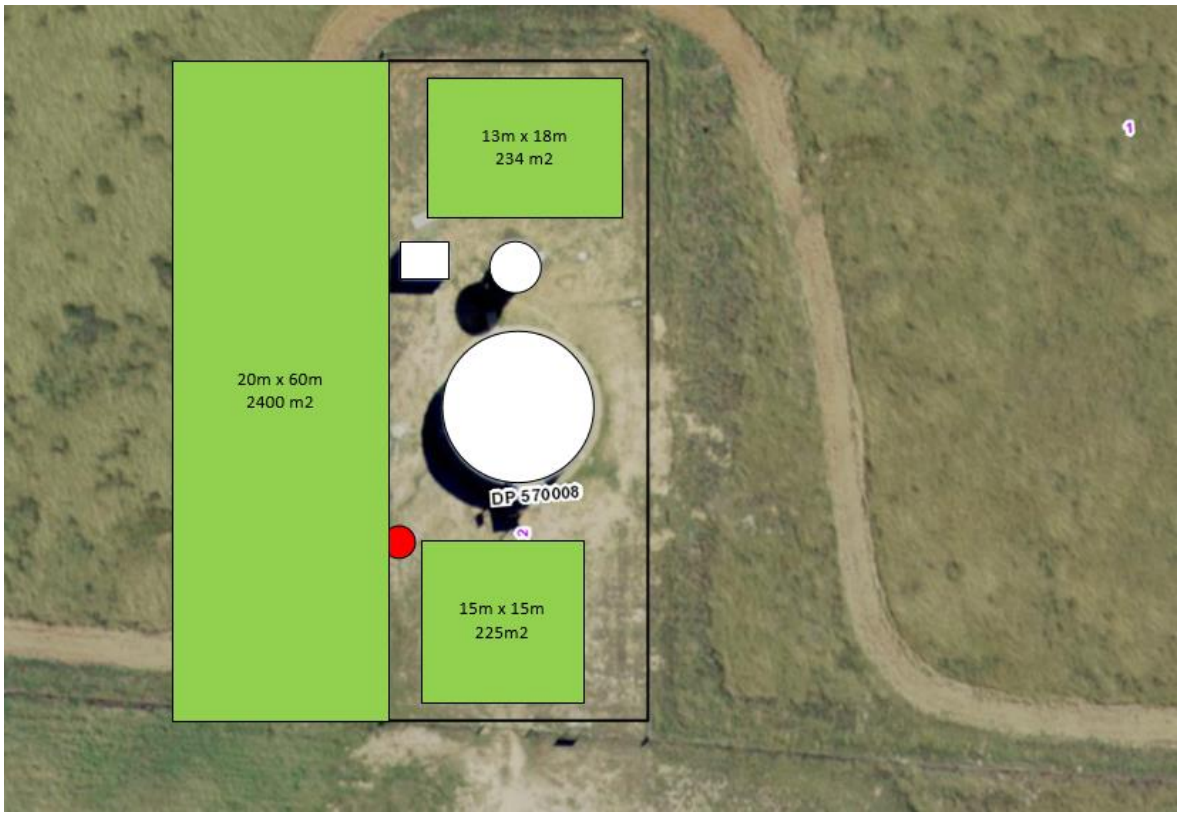


Figure 3-10: Bredbo Reservoir Lot Showing Location Option to the West.

3.7 Shortlisted Options

Following a consideration of barriers available to manage the identified raw water hazards for Bredbo, the following three treatment trains were shortlisted for further assessment and comparison.

- Option 1 – Direct Media Filtration
- Option 2 – DAF/F
- Option 3 – Direct Membrane Filtration (MF or UF)

The existing aerator will be retained to be part of the treatment process for iron removal (and CO_2 reduction). Confirmation of condition and design is required during the next phase of the project.

3.7.1 Comparison of Options Against Health Based Targets

Table 3-4 presents the LRV removal expectation for the shortlisted options. The pathogen removal credits are taken from the WSAA guideline (WSAA 2015) and for membranes are indicative. As membrane suppliers have had to work with log removals for the last 20 years, each manufacturer has their own validation information for the rejection of virus and protozoans.

None of the options reaches the best practice benchmark for a Category 4 with all having some level of shortfall. Noting that the assessment of a Category 4 raw water was conservative and based on a desktop assessment that concluded a direct connection to surface water and the presence of microbiological hazards.

Based on industry best practice UV disinfection is recommended for all options to provide a multi barrier approach.

Table 3-4: LRV Expectation for the Shortlisted Options.

	Log Reduction Values			
	Bacteria	**Virus**	***Cryptosporidium***	**Process Critical Limits**
Required Treatment (Category 4 Source)	**6.0**	**6.0**	**5.5**	
Option 1				
Direct Filtration	1.0	1.0	2.5 – 3.5	Log removals based on a 95th percentile of <0.3NTU. *Crypto* reduction dependent on the filtered water turbidity.
Chlorination	4.0	4.0	0.0	C·t > 15 mg·min/L with pH < 8.5 at all water temperatures. Feed water turbidity < 1.0 NTU.
Total	***5.0***	***5.0***	***2.5 – 3.5***	
Shortfall or Excess Log Removal	***1.0***	***1.0***	***2.0 to 3.0***	Shortfall can be addressed by UV
Option 2				
DAFF	2.0	2.0	3.0 – 4.0	Log removals based on a 95th percentile of <0.3NTU. *Crypto* reduction dependent on the filtered water turbidity.
Chlorination	4.0	4.0	0.0	C·t > 15 mg·min/L with pH < 8.5 at all water temperatures. Feed water turbidity < 1.0 NTU.
Total	***6.0***	***6.0***	***3.0 – 4.0***	
Shortfall or Excess Log Removal	***0***	***0***	***1.5 to 2.5***	Shortfall can be addressed by UV
Option 3				
Direct Membrane Filtration	4.0	2.0	4.0	Log removals based on a 95th percentile of <0.3NTU
Chlorination	4.0	4.0	0.0	C·t > 15 mg·min/L with pH < 8.5 at all water temperatures. Feed water turbidity < 1.0 NTU.
Total	***8.0***	***5.0***	***4.0***	
Shortfall or Excess Log Removal	***2.0***	***0***	***1.5***	Shortfall can be addressed by UV

3.7.2 Common Elements

3.7.2.1 Residuals Handling

The preferred option for residuals handling is to utilise two sludge lagoons for balancing instantaneous flows and capturing, and ultimately drying, solids. Supernatant will then be returned to the WTP or irrigated locally.

As a backup, to allow for the lagoon level to be lowered, irrigation of council or private land should be considered as during Winter only in the order of 5kL/day can be returned through the WTP whilst meeting the good practice target of returning less than 10% as an instantaneous flow. Suitable irrigation locations would need to be identified and confirmed in the concept design.

3.7.2.2 UV Treatment Barrier

Based on the assessment of the source as being a Category 4, UV is recommended to ensure a multi barrier approach to chlorine resistant protozoa. Hence regardless of the process train a UV system is recommended.

3.7.2.3 Chlorine Disinfection

Liquid sodium hypochlorite is preferred (verbal communication site visit 02/09/2020) with a new dosing system to be provided with any new treatment infrastructure.

3.7.2.4 Aeration

The existing aerator will be retained but will require modification to divert water from the aerator to the new infrastructure.

3.7.2.5 Fire Risk

The site is close to town and surrounded by open grassland, hence the fire attack level is expected to be low.

Recommend a fire attack study be completed to inform the materials and construction methods for the WTP.

3.7.2.6 Power Availability

Site power is delivered via overhead lines and available capacity will need to be confirmed during the next phase.

3.7.3 Option 1 – Direct Media Filtration

Raw water would be pumped to the WTP from one or both bores at a constant rate to the existing aeration unit. From the aerator collection well the water will be pumped through a bank of media filters, receiving a coagulant (likely ACH to have minimal impact on the pH) and coagulation/flocculation time in an empty pressure media filter prior to filtration.

Depending on the raw water pH and the selected coagulant, pH correction (through acid or alkali dosing) may be required prior to coagulant dosing to achieve the optimal coagulation pH range. Filtered water would then pass through a UV unit prior to chlorination and entry into the treated water storage reservoir.

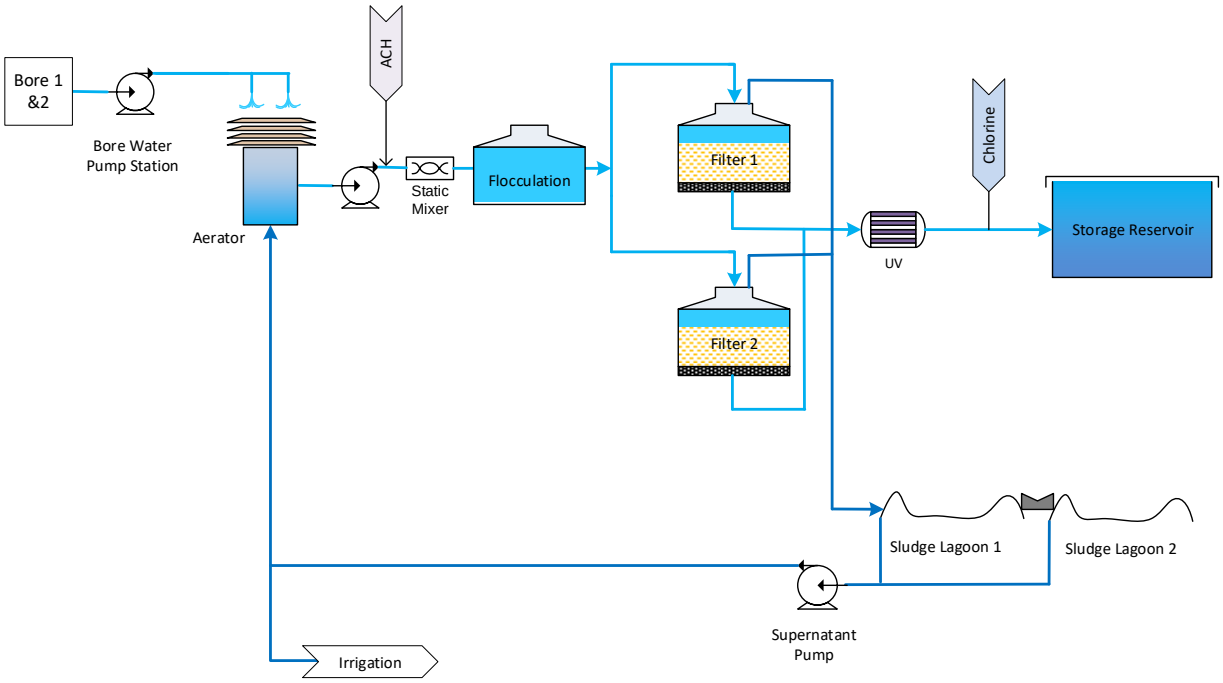


Figure 3-11: Schematic of the Bredbo Direct Media Filtration WTP.

The key elements of Option 1 are:

1. Aeration
   i. Oxidation of soluble metals and stripping of free CO_2 from the groundwater in the existing aerator.
2. Coagulation and flocculation
   i. Addition of a coagulant to bring particles together and convert some dissolved organic carbon into total organic carbon that can be filtered
   ii. Flocculation time of 10 to 15 minutes to assist the growth of coagulated particles to enhance their capture in the filter.
      a. High level estimate for coagulant usage is less than 500L/annum allowing for delivery of 15L packages with small pumped transfer into a 100L to 200L tank.
3. Pressure media filtration
   i. Water pumped from the aerator collection well through the process and into the reservoir
   ii. Filtration rate of less than 10 m^3/hr per m^2 of surface area (m/hr)
   iii. In the order of 2.5m^2 of filtration surface area provided in 2 to 5 individual pressure media filters
4. Sludge lagoons, At a yearly production of 33 ML (90 kL/day)
   i. An estimated TSS of 20 mg/L (conservative)
   ii. There is a production of 21.8m^3 of 3% TSS sludge
   iii. Provide 2 lagoons, each at least 15m long and 5m wide
   iv. Supernatant pump station to return supernatant to the outlet of the aerator
5. Ultraviolet disinfection
   i. Dose of 40 mJ/cm^2 to target protozoa
6. Chlorine disinfection with C.t in the reservoir

3.7.4 Option 2 – DAFF or DAF followed by Filtration

Raw water would be pumped to the WTP from one or both bores at a constant rate to the existing aeration unit. From the aerator collection well the water will be dosed with a coagulant, ACH, and transferred to a coagulation/flocculation tank at a constant rate. The coagulated and flocculated water will then enters the DAFF cell and is contacted with small microbubbles, released from solution, following the introduction of an air saturated water stream, which attach to flocs as they rise to the surface. The clarified water is either

removed from underneath the DAF (in the case of a straight DAF process) or passes directly onto the filter under the DAF (in the case of an in-filter DAF or DAF on filter process – commonly referred to as a DAFF process). The float is removed periodically using a mechanical scraping mechanism or a temporary flooding process and is assisted via water sprays to separate the float from the walls.

The saturated air stream is prepared by pumping clarifier or filtered water into a high pressure saturator where air is introduced. Under these high pressure conditions, the water becomes saturated with air. The air saturated water is then returned to the DAF injection system and bubbles are released via a pressure drop provided from a dispersion valve. This pressure drop releases the micro bubbles from the water and allows them to contact with the flocs and a float is formed.

Depending on the raw water pH and the selected coagulant, pH correction (through acid or alkali dosing) may be required prior to coagulant dosing to achieve the optimal coagulation pH range.

Filtered water would then pass through a UV unit prior to chlorination and entry into the treated water storage reservoir.

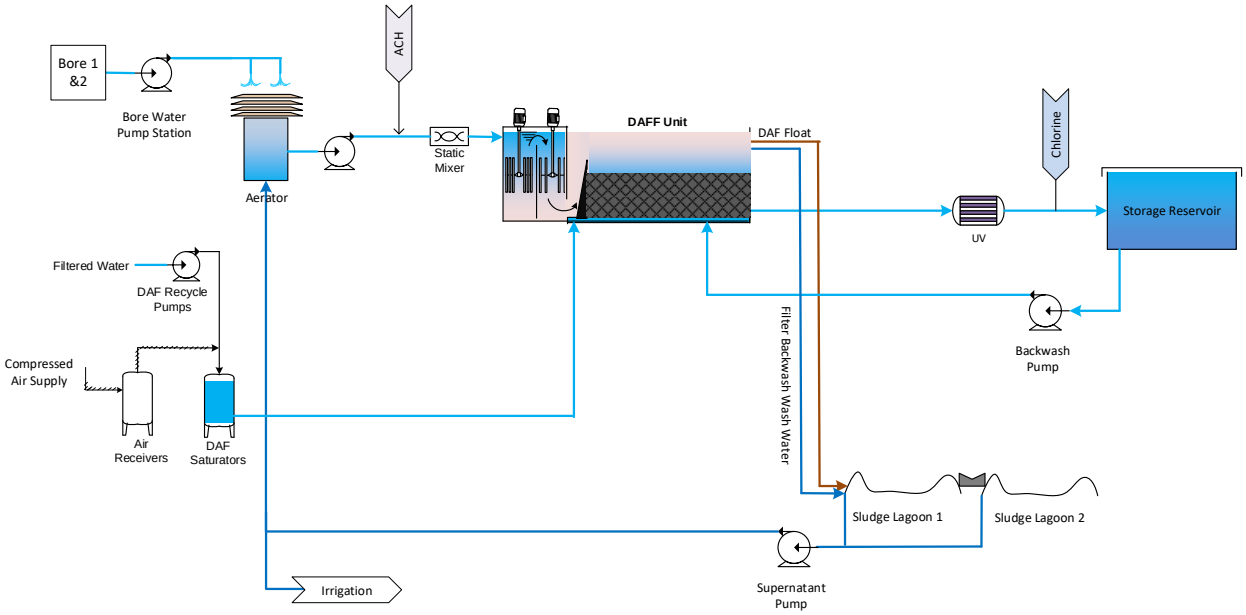


Figure 3-12: Schematic of the Bredbo DAFF WTP.

The key elements of Option 2 are:

1. Aeration
   i. Oxidation of soluble metals and stripping of free CO_2 from the groundwater in the existing aerator.
2. Coagulation and flocculation
   i. Addition of a coagulant to bring particles together and convert some dissolved organic carbon into total organic carbon that can be filtered
   ii. Flocculation time of 10 to 15 minutes to assist the growth of coagulated particles to enhance their capture in the filter.
   iii. High level estimate for coagulant usage is less than 500L/annum allowing for delivery of 15L packages with small pumped transfer into a 100L to 200L tank.
3. Floatation
   i. Floatation of the flocculated water through contacting with microbubbles with the maximum recycle rate of 15% and loading rate of 10 m/h.
   ii. In the order of 2.2 m^2 of DAF surface area provided in 2 to 5 individual DAF as a straight DAF process or as DAFF process.
4. Gravity Media filtration
   i. Filtration of the clarified water through passing onto the media filter under the DAF or in separate gravity media filters
   ii. Filtration rate of 10 m^3/hr per m^2 of surface area (m/hr)

iii. In the order of 2.2 m^2 of filtration surface area provided in 2 to 5 individual gravity media filters or underneath the DAF units.

5. Sludge lagoons
   i. At a yearly production of 33 ML (90 kL/day)
   ii. An estimated TSS of 20 mg/L (conservative)
   iii. There is a production of 21.8m^3 of 3% TSS sludge
   iv. Provide 2 lagoons, each at least 15m long and 5m wide
   v. Supernatant pump station to return supernatant to the outlet of the aerator
6. Ultraviolet disinfection
   i. Dose of 40 mJ/cm^2
7. Chlorine disinfection

3.7.5 Option 3 – Membrane Filtration

Raw water would be pumped to the WTP from one or both bores at a constant rate to the existing aeration unit. From the aerator collection well the water will be dosed with a coagulant, ACH, and transferred to a coagulation/flocculation tank at a constant rate.

The coagulated and flocculated water will then be pumped through a strainer, a membrane filter, a UV unit and be dosed with chlorine prior to entering the clear water tank.

Membrane fouling through solids accumulation and adsorption of dissolved contaminants (including iron and manganese) will occur. Regular backwashing, every 30 to 60 minutes, is required to remove accumulated particles, with chemical cleaning undertaken monthly.

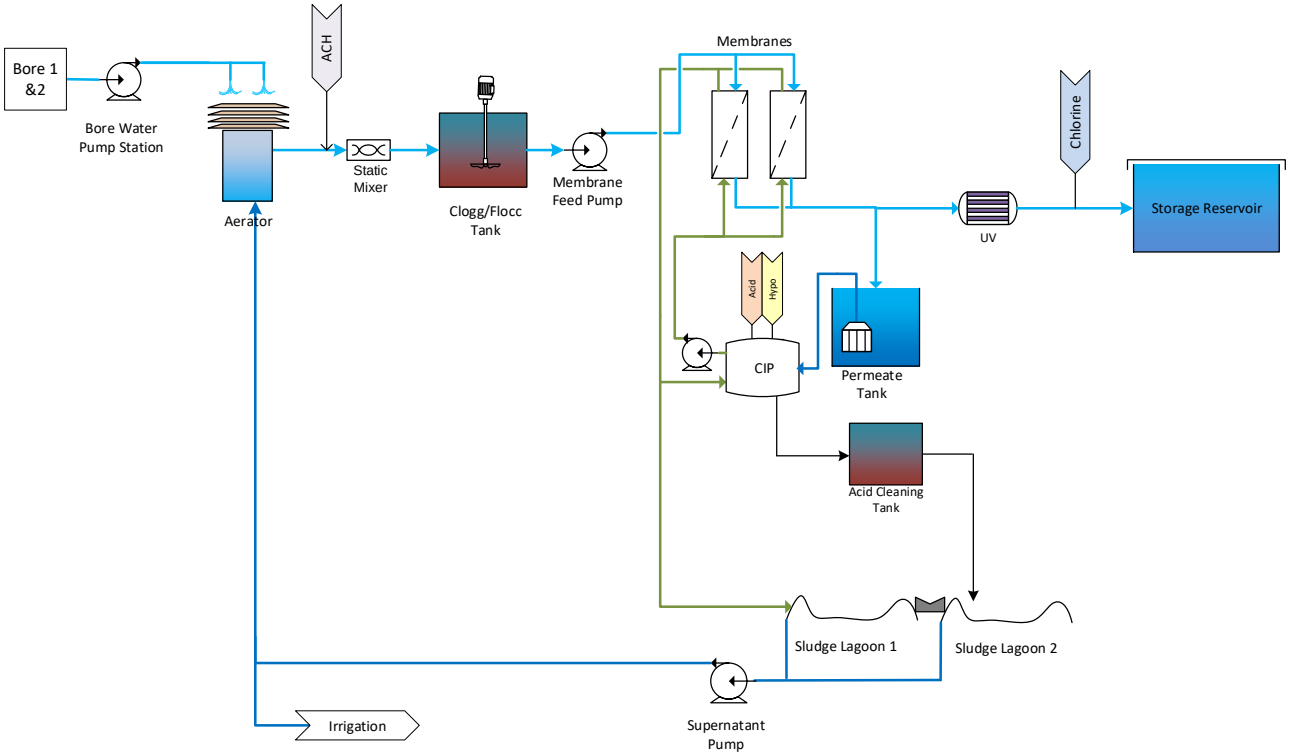


Figure 3-13: Schematic of the Bredbo Membrane Filtration WTP.

The Key elements of Option 3 are:

1. Aeration
   i. Oxidation of soluble metals and stripping of free CO_2 from the groundwater in the existing aerator.
2. Coagulation and flocculation
   i. Addition of a coagulant to bring particles together and convert some dissolved organic carbon into total organic carbon that can be filtered

ii. Flocculation time of 10 to 15 minutes to assist the growth of coagulated particles to enhance their capture in the filter.
iii. High level estimate for coagulant usage is less than 500L/annum allowing for delivery of 15L packages with small pumped transfer into a 100L to 200L tank.

3. Membrane filtration
   i. Membrane feed pumps take water from the coagulation/flocculation tank and push it through strainers and the membrane all the way to the treated water storage reservoir
   ii. Due to the low temperature and to minimise chemical cleaning the flux would be limited to a value of < 35 l/m^2/hour
   iii. In the order of 550m^2 of filtration surface area provided by 10 to 20 membrane filtration modules.
   iv. Cleaning chemicals for a surface water with coagulation and organics will include citric acid for low pH clean to remove scaling and in organics and a chlorine clean of ~500mg/L to manage organic and biological fouling.
   v. Tankage (or a separate lagoon) required for the collection and storage of citric acid cleaning solution for pump out and transport to Cooma WWTW.
4. Sludge lagoons – As per option 1
5. Ultraviolet disinfection
   i. Dose of 40 mJ/cm^2
6. Chlorine disinfection

3.7.5.1 Membrane Chemical Cleaning

Chemical cleaning residuals can be a challenge at small remote. Strategies for managing chemical cleaning for small membrane WTP's include.

- Specification of minimum use of chemicals, for example chemical cleaning interval of at least 6 weeks with no intermittent "maintenance" or "enhanced" chemical cleaning.
- Collection of all cleaning waste in a single tank and transfer to a regional WWTW by a pump out truck sizing the tank to ensure a minimum of truck movements
- Collection of cleaning waste in a dedicated lagoon and allowing for evaporation and removal when required.
- Collection and neutralisation of sodium hypochlorite cleaning waste and recycle through the sludge lagoons back to the plant feed at a low rate
    - Nut suitable for citric acid or phosphorous based cleaners which need to be treated separately.

3.8 Preferred Option

The strengths and weaknesses of the shortlisted options have been compared and scored in Table 3-5;

- 1 is given for an option that has the most weaknesses
- 2 is given for an option that has both strengths and weaknesses
- 3 is given for an option that demonstrates strengths that align with the requirements of the location.

The simplified scoring suggests that Option 1, direct media filtration and Option 3, direct membrane filtration are comparable solutions across the criteria selected with a score of 16 and 15 respectively.

In considering these options the relatively stable raw water quality from the shallow bores, the availability and relative simplicity of pressure media filters, in combination with UV as a multi barrier approach means that Option 1, direct media filtration, is the preferred option for Bredbo.

It is recommended that jar testing is undertaken to confirm that good filtered water quality is able to be obtained by using a coagulant (no polymer) and without pH correction. This will reduce uncertainty and risk for the Contractor and should reduce the risk value that they use in any offer.

Table 3-5: Bredbo Comparison of Key Strengths and Weaknesses.

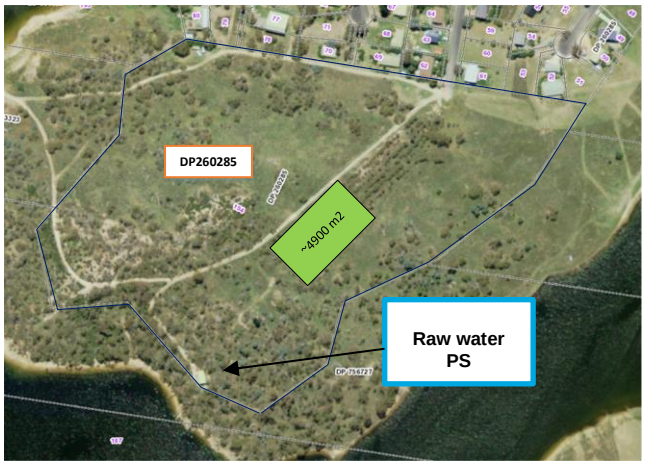
	Option 1 Direct Media Filtration	Option 2 DAF/F	Option 3 Direct Membrane Filtration
Total Score	**16**	**12**	**15**
Footprint	Relatively small and compact	Relatively small and compact	Filtration unit is the smallest of the options but there are requirements for additional tankage and strainers which evens out the footprint.
	2	**2**	**2**
Water Quality/Quantity Typical	Easily able to manage the typical water quality	Easily able to manage the typical water quality. Quick to start so can be run for short periods on/off.	Easily able to manage the typical water quality. No coagulant required which simplifies operation. Automatic test to demonstrate integrity of membrane. No issue with multiple start/stop operation.
	Typically not as 'deep' as gravity filters which can reduce run times with early breakthrough. Cant 'see' the process to confirm the condition of the filtration media and confirm the backwash process.	DAF not typically required for typical Bredbo raw water turbidity, so wasted.	Coagulant utilised to remove organics. If no coagulant is used then backwash water not able to be returned, would need to be irrigated.
	2	**2**	**3**
Water Quality/Quantity during "Events" (For Bredbo this is a rapid increase in turbidity from ~2 NTU to 30 NTU)	Automatic backwashing on differential pressure and turbidity breakthrough as the raw water quality changes.	Consistent filter run times and backwashing frequency regardless of the raw water quality with the pre-clarification of the DAF. Automatic backwashing on differential pressure and turbidity breakthrough as the raw water quality changes. *Could treat River water under most scenarios.*	Membranes are a barrier and quality (pathogens and TSS) will not be affected by raw water quality change. Can't get 'breakthrough' of turbidity.
	Will require adjustment of coagulation dose to ensure that there is no turbidity breakthrough during a change in raw water quality. Extra backwashing required with increasing turbidity and a reduction in throughput. Can quickly reach a point where the backwashing produces more water than can be returned to the raw water (>10%).	DAFF treatment requires optimisation of the upstream coagulation chemistry (coagulant dose) when the water quality changes. Polymer may be required.	Given historical maximum turbidity, events do not pose a significant operational concern. If close to needing a chemical clean, increased solids can trigger a CIP and halt production.
	1	**1**	**3**
Control and Monitoring	Simple to understand and monitor headloss and filtered water turbidity remotely.	Simple to understand and monitor headloss and filtered water turbidity remotely.	Basis of control and monitoring as per conventional filtration. Can stop and start numerous times and not impact the quality.

	Option 1 Direct Media Filtration	Option 2 DAF/F	Option 3 Direct Membrane Filtration
Total Score	**16**	**12**	**15**
	With multiple filters acting as one filter troubleshooting a problem with one filter can be difficult. Multiport valves can be problematic to trouble shoot. Rapidly changing raw water quality will require attendance to allow for optimising the process.	DAF not as common as settling processes and so support can be a little harder to receive. Optimising DAF Float requires a 'feel' for the process and can be difficult for a new Operator. Rapidly changing raw water quality will require attendance to allow for optimising the process.	Lots of different sequences to understand when troubleshooting. "Black box" control and monitoring of a proprietary system. Need to monitor over the long term to pick up slow building problems that can fall over the cliff.
	3	**1**	**2**
Ease of Maintenance	The use of multiple filters improves redundancy and maintainability. Commonly available components can be maintained in house.	Fairly standard mechanical kit and can be maintained in house. A typical media filter will only require media replacement every 10 – 20 years.	Ancillary equipment is standard and can be maintained in house.
	Need to ensure that access is provided around the filter and to the top of the filter for media removal and replacement. Repairing a broken lateral or issue inside a pressure media filter is nearly impossible insitu.	Likely to be a single process train, so whole plant offline when maintenance required on the DAF/F. Due to height of the system access for maintenance can be difficult.	Production stops for 2 – 6 hours for chemical cleaning every 4 to 8 weeks. Valves are often at awkward heights and locations due to the systems being proprietary. Typically have a third party engagement to manage membranes which has a cost. Typically involve some proprietary kit needing external assistance (e.g. membrane repair).
	3	**2**	**2**
Residuals Handling	Can keep instantaneous backwash flow down by having numerous filters in parallel.	Consistently high recovery and stable backwash water volumes as filter backwashing remains constant with increasing raw water turbidity. DAF float generally breaks up when travelling to the next process and settles well.	Small volume every 30 – 45 minutes
	For 1 or 2 filters the instantaneous backwash rate is 4 – 5 times the plant flow rate and can be a large power draw compared to the remainder of plant.	For a single filter the instantaneous backwash rate is ~ 5 times the plant flow rate and can be a large power draw compared to the remainder of plant. DAF float is not always easily settled however typically with some mixing when the float is removed on its way to a sludge lagoon the float settles well.	Typically slightly lower first pass recovery than conventional at ~ 95%. Need to manage cleaning chemical residuals. Typically collection and transport to a WWTW with associated costs. If coagulant is not used then solids will not settle and residuals will need to be irrigated.
	2	**3**	**1**
Environmental Impact	Need access to the top of the filters to load and remove media.	Would be housed indoor.	Coagulant not required to achieve low turbidity.

	Option 1 Direct Media Filtration	Option 2 DAF/F	Option 3 Direct Membrane Filtration
Total Score	**16**	**12**	**15**
Physical Visual Noise Energy	Quiet operation, backwashing can be scheduled for 'business' hours as typically once a day. Low energy and chemical use		
	Coagulant is required introducing aluminium to the backwash water and limiting reuse potential.	Tall building required. Coagulant is required introducing aluminium to the backwash water and limiting reuse potential. ***Continuous operation of the recycle pumps and compressor make this the highest base load noise option.*** Recycle of 15% of the water at 600kPa principal energy demand along with compressed air requirement.	Has to backwash every 30 - 45 minutes which makes more noise at night (supplier dependent). Membranes have a 7 – 10 year life and will end up in landfill. Uses more chemicals with hypo and citric acid required for chemical cleaning. However, practically small volumes.
	3	**1**	**2**

4 Kalkite

Table 4-1: Kalkite Summary.

Component	Kalkite – 300 kL/day		
Demand (kL/day)	2020 ADD	2020 PDD	2050 PDD
	54.7	198.8	268
Reservoir Capacity	448kL which meets the general rule of thumb of holding a peak day volume.		
Offline Capacity	2020 ADD ~ 5 days 2020 PDD ~ 1.4 day		
Key Water Quality Challenges	The key hazardous event to be overcome is the increase in turbidity and by inference, pathogen loading, during and following heavy rainfall when the turbidity increases rapidly. Raw water hazards ▪ Turbidity / suspended solids ▪ Pathogens (Category 3 source water) ▪ Soluble metals with sources taken from depth		
Raw Water Quality Uncertainties	▪ Alkalinity ▪ Level of organics and true colour ▪ The presence or absence of total and soluble iron		
C.t	Minimum level to achieve a C.t of 15 mg.min/L of 14% in the reservoir		
Raw Water Pumping	The existing pumping station has a large excess capacity above the required instantaneous flow rate of 4 L/sec to treat 316 kL raw water over 22 hours. To this end either a raw water storage will be required, or the pumps may need to be reduced in size to better match the treatment requirements.		
Site location			
Land Acquisition Required?	No		
Shortlisted Options Considered	▪ Direct Media Filtration (with Coagulant) ▪ Direct Membrane Filtration (MF or UF with or without coagulant)		
Preferred Option	The relative stability of the water, lack of true colour and available land for evaporation of cleaning residuals, means that Direct Membrane Filtration is the preferred option for Kalkite.		

Residuals Management	Sludge Lagoons including an opportunity for irrigate locally
UV Disinfection	Not recommended due to the preliminary catchment categorisation of 3. “Poorly Protected Catchment”
Recommendations	In addition to the recommendations of previous reports ▪ Fire Attack Study ▪ Confirmation of availability of Power ▪ Options and concept design of a dedicated rising main to the Reservoir ▪ Full condition assessment of the reservoirs

4.1 Overview

Kalkite is situated on the Banks of Lake Jindabyne on Glebe Point and north of Taylors Inlet. It is around 10.5km upstream of the dam wall and 5.5km from the upper limits of the Lake, where the Eucumbene river enters.

The town has a population of 214 people (2016 Census) with 147 supply connections (SMRC).



Raw Water Intake Location



Raw Water Intake Pipeline



Chlorination and lift pump building



Storage Reservoirs (top right)

Figure 4-1: Overview of Kalkite Infrastructure.

4.2 Service Area

GIS data from SMRC was used to provide an indicative service area for each Village and is presented below in Figure 4-2.

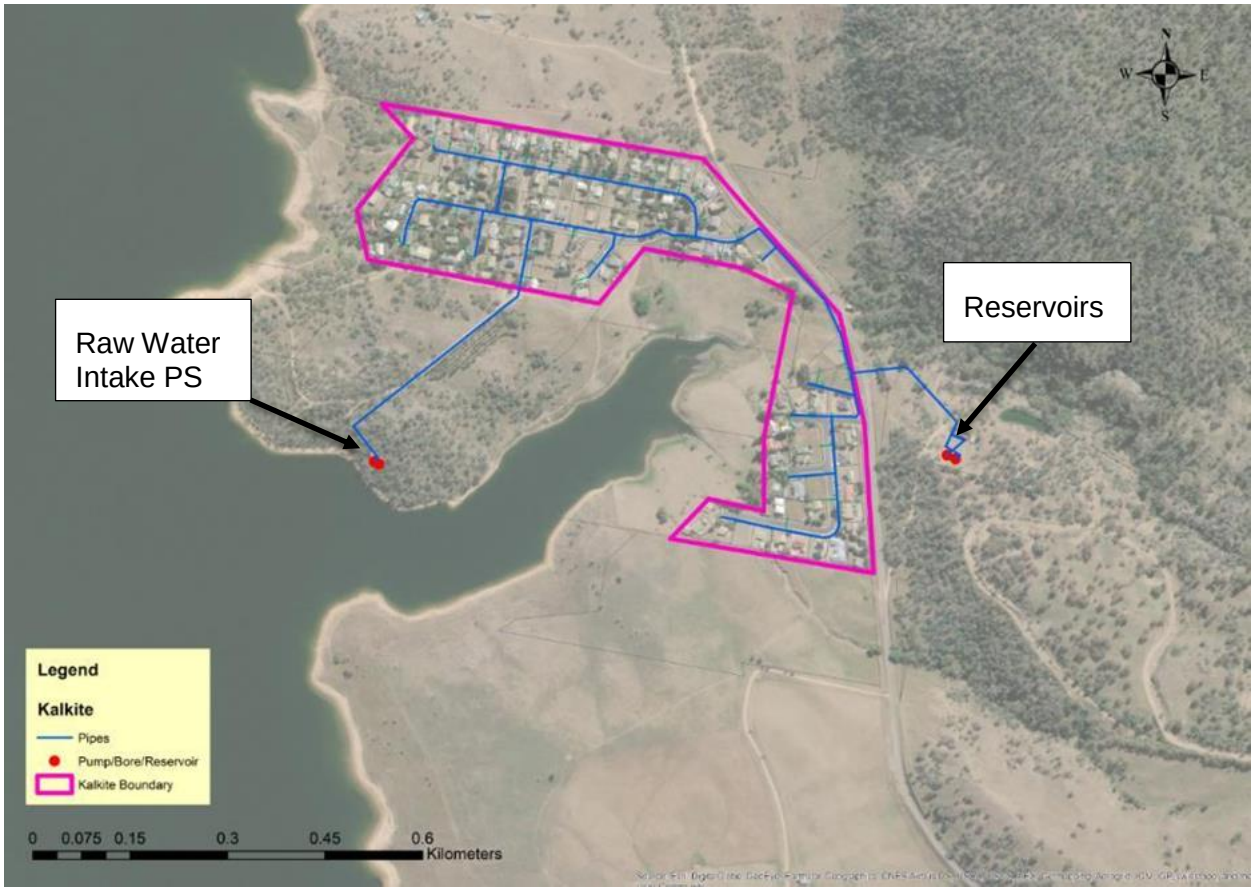


Figure 4-2: Kalkite Service Area.

4.3 Historical and Forecast Demand

Figure 4-3 shows the annual consumption for Kalkite. Table 4-2 provides a summary of this data and includes the forecast 2050 PDD and the proposed treatment plant capacity to service this demand (*Service Area and Demand Memo* (Hunter H2O, 2020)).

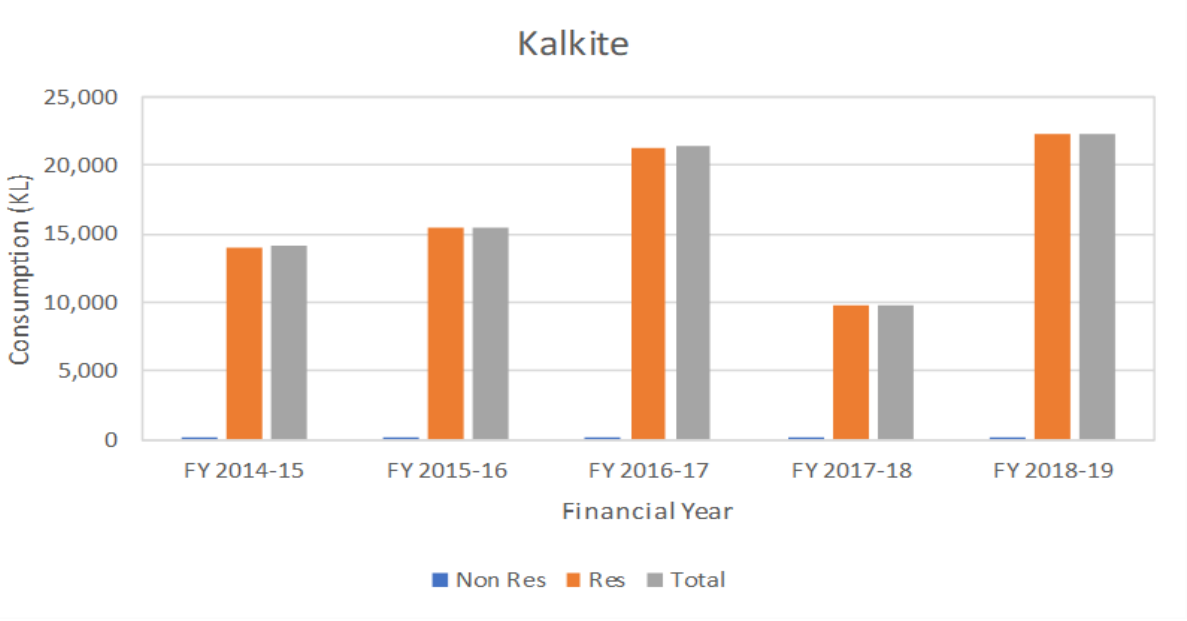


Figure 4-3: Kalkite Consumption Data.

Table 4-2: Kalkite Historical and Future Demand and the Raw Water Pumping Capacity.

Village	Source	Raw Water Pumping Capacity (kL/d)	Historical PDD (kL) (2020)	Historical ADD (kL) (2020)	2050 PDD for Treatment Capacity[1]	2050 PDD for Treatment Capacity[1]
Kalkite	Northern end of Lake Jindabyne	1,800	198.8	54.7	268.0	300

Note 1. 1% annual population growth was adopted for the 2050 projections

4.4 Source Water Assessment

The Kalkite raw water supply was considered and is presented in detail in the *Source Water assessment Report* (Hunter H2O, 2020). The following sections provide a summary of the typical raw water hazards and challenges to be managed day to day to improve the aesthetic quality and water safety.

Beyond the day to day challenge of low levels of suspended solids and pathogens, the key hazardous event and challenge to be overcome to improve the water safety of Kalkite is turbidity and by inference, pathogen loading, during and following a rapid increase in the lake level caused by heavy rainfall. During such an event the treatment process will be challenged with only a moderate turbidity, however this may be 5 to 10 times the typical challenge.

In addition, it remains possible that when the lake is at a high level the intake, being deep in the lake, may be accessing deoxygenated water with the possibility of soluble metals being present, principally iron and manganese. Whilst there is no evidence historically of this occurring it remains a risk due to the intake design being at a fixed point.

The variability of the raw water and reservoir turbidity with rainfall is demonstrated in Figure 4-4.

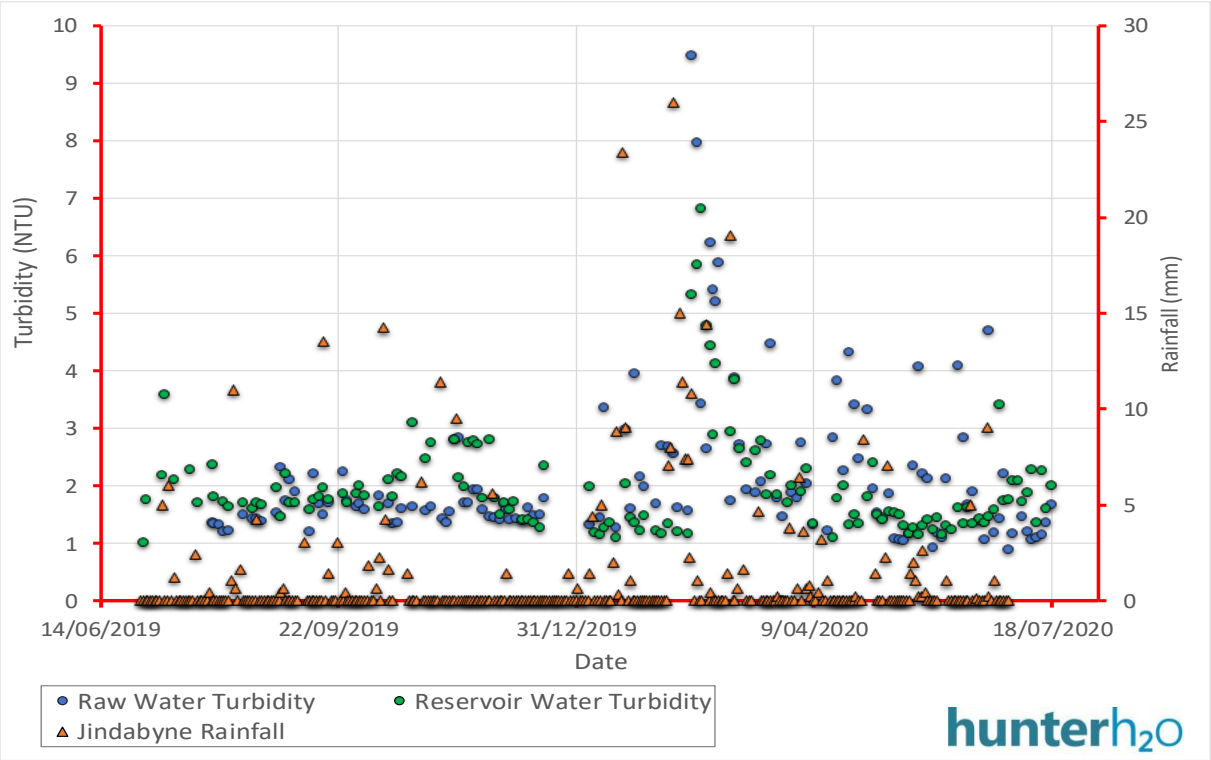


Figure 4-4: Raw Water (before chlorination) and Reservoir Water (after chlorination) Turbidity and Jindabyne Rainfall Data (July 2019– July 2020).

4.4.1 Pathogens

A high level assessment of pathogen risk was undertaken using the Health Based Targets (HBT) guidance manual (Water Services Association of Australia, September 2015) and is presented in the Source Water Assessment (Hunter H2O, 2020). The assessment determined that the Kalkite source was conservatively a Category 3 source (Hunter H2O, 2020).

As a Category 3 source, to achieve a target of an additional health burden, from potable water, of less $1x10^{-6}$ DALY's (Disability Adjusted Life Years) would require the following log reductions (Water Services Association of Australia, September 2015).

- **5.0 log_{10} reduction in Bacteria**
- **4.0 log_{10} reduction in Viruses and**
- **3.5 log_{10} reduction in Protozoa**

4.4.2 Chemical/Physical

From a review of the available raw water and reservoir water data the following are considered the key raw water hazards which require mitigation/barriers to reduce the associated health or aesthetic risk to an acceptable level at Kalkite.

Turbidity / Suspended Solids

- With a limited data set the raw water turbidity is typically low, being more than 1 NTU but less than 10 NTU
  - It is expected that at times the turbidity would be more than 10, say following a large filling event but unlikely to exceed 25 NTU.
  - The intake location is at a fixed depth and unlikely to be impacted by wind stirring up sediment on the lake margins.
- Lake Jindabyne is used as part of the Snowy Hydro scheme and the level may rise and fall due to scheme operation or climatic conditions.
  - There is insufficient data to describe, beyond doubt, the impact of the level rising and falling.

Metals

- Soluble metals are a risk with sources taken from depth where the water can lack oxygen and insoluble iron and manganese can be dissolved.
    - Available data suggests that iron, manganese and aluminium are not a major raw water hazard.
    - Whilst iron and manganese cannot be ruled out there is no data to suggest they are a hazard.

Post Workshop, the Kalkite intake was confirmed as having a minimum operating level of 896.1m which equates to a Lake Jindabyne level of ~43%. The 100% level of Lake Jindabyne is 911m placing the intake at a maximum depth of 15.1m. The minimum and maximum level over the period 2000 through 2020 is indicated on Figure 4-5 *with the last 5 years having a similar variation from ~52% through to 88%.*

With a maximum depth of 15m there remains an opportunity for low oxygen and soluble metals in the Kalkite raw water, however it remains that there is no reported history (operational or network samples) of soluble metal at Kalkite and it remains a low risk.

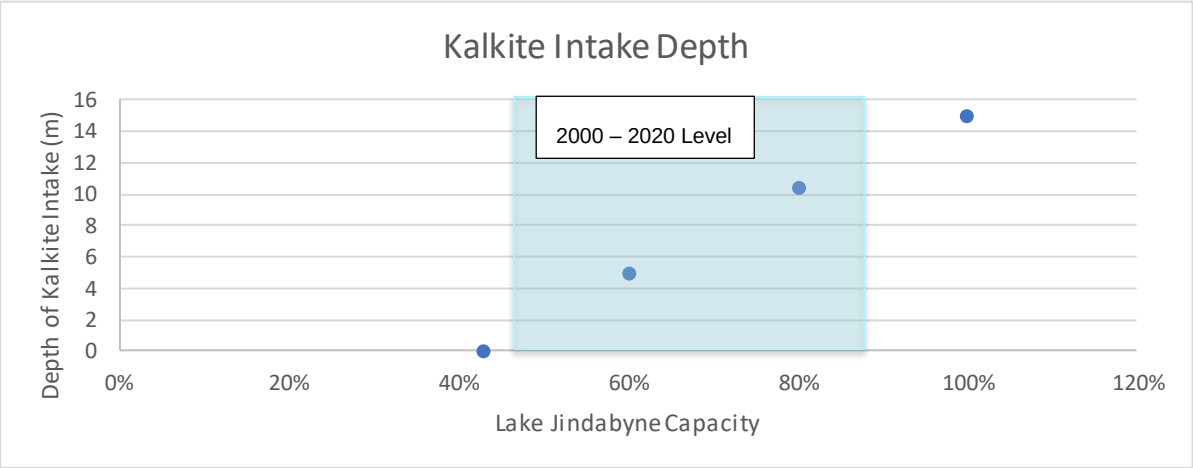


Figure 4-5 Kalkite intake depth variation with lake level

Colour

- Available true colour data suggests that the true colour of the raw and chlorinated water is below the ADWG target of 15 HU.
- Whilst 15 HU is the ADWG value, as Kalkite is a tourism destination, a best practice target of < 5 HU may be more appropriate to ensure community and visitor satisfaction.

Organics

- There was a single data point available for total organic carbon of 2.2 mg/L which is in keeping with the low true colour of the water source.

pH and Alkalinity

- The raw water pH is typically between 7 and 8.
    - There was a high degree of variation in pH for a large and relatively stable raw water source which should be investigated
- The raw water alkalinity is unknown and needs to be confirmed to allow for the consideration of coagulation.

Hardness

- The total hardness is low with the average of 13.9 mg/L as $CaCO_3$.

4.4.3 Raw Water Quality Design Envelope

Table 4-3 outlines the preliminary raw water design envelope for the Kalkite WTP following consideration of available raw water data, its quality, and the impact of various elements. The envelope is intended as a living

document to be considered through the project and adjusted as more information becomes available to balance risk and cost.

A monitoring program has been recommended, and provided separately, with key gaps for Kalkite that are recommended to be filled being;

- Alkalinity
- True colour to identify the coagulation requirements
- The presence or absence of total and soluble iron
- Level of total and dissolved organic carbon

Table 4-3: Preliminary Raw Water Design Envelope.

Parameter	Units	Preliminary Raw Water Design Envelope			
		5th percentile	Median	95th percentile	Maximum
Temperature	Celsius	5	15	25	25
pH		7.1	7.4	8.2	8.8
TDS	mg/L	20	25	41	41
Alkalinity	mg/L as $CaCO_3$	15[1.]	20[1.]	30[1.]	30[1.]
Turbidity	NTU	1.1	1.7	10[1.]	15[1.]
True Colour	Hazen	2	3.5[1.]	10[1.]	20[1.]
Calcium	mg/L (Ca)	2.9	4.6	5.9	5.9
Magnesium	mg/L (Mg)	0.5	0.7	1.0	1.0
Total Hardness	mg/L $CaCO_3$	9.9	14.2	18.2	18.2
Total Iron	mg/L	0.04	0.1[1.]	0.2[1.]	0.2[1.]
Soluble Iron	mg/L	0.02	0.1[1.]	0.1[1.]	0.1[1.]
Total Mn	mg/L	0.003	0.003	0.019	0.019
Soluble Mn	mg/L				
Free CO_2	mg/L				
TOC	mg/L				
DOC	mg/L				
Fluoride	mg/L	0.05	0.05	0.05	0.05

1. Values highlighted in green are estimates that are believed, following a review of data, site visit and discussion with Operators, to better represent the raw water challenge. These are TBC during the next phase.

4.5 Existing Instructure

The following is based on information provided and visual inspection during site visits. The scope did not include a detailed condition assessment to allow nomination of remaining life of assets.



Figure 4-6: Kalkite Overview.

4.5.1 Raw Water Pumping

Kalkite raw water is drawn from Lake Jindabyne by submersible pumps (incline mounted bore pumps) local to Kalkite to a balance tank with the volume of 26 kL. Lift pumps then transfer water to the town reservoirs.



Raw Water Balance Tank local to pumping station



Raw Water Intake Pipelines

Figure 4-7: Raw Water Intake Pipeline and Balance Tank.

The lake lift pumps have a capacity of ~ 1200 kL/day (14.2 L/s) with the lift pumps being slightly less at around 860 kL/day (10.1 L/s). In comparing the raw water flow requirements of the proposed WTP, the existing pumping station has a large excess capacity above the required instantaneous flow rate of 4 L/sec to treat 316 kL raw water over 22 hours. To this end the raw water pumps may need to be reduced in size to better match the treatment requirements, or storage will be required at the treatment plant.

4.5.2 Combined Rising Main

The rising main from the point of chlorination at Kalkite pumping station acts as a feed to the storage reservoirs and also as a distribution main. As such when the reservoir is filling the residents along the main receive an elevated chlorine residual and a water that has not has a C.t of 15 mg.min/L.

This is managed on the ground through pumping at night when demand is low but exposes SMRC to customer complaints of variable and high chlorine, and reduced water safety.

It is recommended that any upgrade includes for a dedicated rising main.

4.5.3 Reservoir

Key capacity information on the Kalkite Reservoirs from the *Options Assessment Report* (Hunter H2O, September 2020) is,

- The 2020 PDD is 44% of the reservoir capacity of 448kL (2×224 kL)
- The minimum level required for C.t, with a target of 1 mg/L and flow at 3xPDD is less than 20%
- 60% of the reservoir provides about 5 days to repair an issue for the average day demand
- 60% of the reservoir provides 1.4 day to repair an issue for the PDD

Based on the available information capacity upgrades are not recommended for Kalkite Reservoirs however, a full condition assessment is recommended.



Figure 4-8: Kalkite Reservoirs above the Kalkite STP.

4.5.4 Disinfection

Chlorine dosing at Kalkite pumping station is employed for disinfection with the storage and dosing equipment located inside a room at the raw water pumping station (Figure 4-9).

As the existing chlorination system is located at the water intake pumping station, it is not suitable to be reused for the new WTP.

Liquid sodium hypochlorite is preferred (verbal communication site visit 02/09/2020) with a new dosing system to be provided with any new treatment infrastructure.



Figure 4-9: Chlorine Dosing System Room.

4.6 Proposed Site Location

In considering water treatment plants in the 200 to 500 kL/day capacity range (Hunter H2O, September 2020) at a scoping level, the footprint allowance for Kalkite is 500 m^2 for process and 1500 m^2 for sludge lagoons.

The location of the existing infrastructure and the surrounding area was investigated during the site visit to identify a possible location for the future Kalkite WTP. The area near the storage reservoirs is very steep and is not a reasonable option for the WTP.

On review of the raw water intake infrastructure location, the infrastructure is located on lot DP260285. Along the road from the raw water intake infrastructure to the town, there is a reasonably large and level area within the same lot owned by council. The area is relatively flat and is proposed for the WTP location. Access is off Lantana Drive Road (Figure 4-10 and Figure 4-11) and would need to be formalised.

A smaller site could be achieved through utilising membrane filtration without coagulation, a smaller lagoon and irrigation of the surrounding land area if the soil profile and flora would support this.

A dedicated rising main from the new WTP with an approximate 1 km length would be incorporated into the scope of the project to transfer the treated water from the WTP to the storage reservoirs without going direct to consumers and causing issues with variable and high chlorine and requiring a dedicated CCT at the WTP.

An initial estimate for the Rising main would be 1100m of DN100, noting that this may be through residential streets and the ground up to the reservoirs will be difficult for construction of a new pipeline.



Figure 4-10: Location of the Proposed Kalkite WTP Site.



Figure 4-11: Typical vegetation around the proposed Kalkite WTP Area.

4.7 Shortlisted Options

Following a consideration of barriers available to manage the identified raw water hazards for Kalkite, the following treatment trains were shortlisted for further assessment and comparison (Hunter H2O, September 2020).

- Option 1 – Direct Media Filtration (with Coagulant)
- Option 2 – Direct Membrane Filtration (MF or UF with or without coagulant)

4.7.1 Comparison of Options Against Health Based Targets

Table 4-4 presents the LRV removal expectation for the shortlisted options. The pathogen removal credits are taken from the WSAA guideline (WSAA 2015) and for membranes are indicative. As membrane suppliers have had to work with log removals for the last 20 years, each manufacturer has their own validation information for the rejection of virus and protozoans.

Table 4-4: LRV Expectation for the Shortlisted Options.

	Log Reduction Values			
	Bacteria	**Virus**	***Cryptosporidium***	**Process Critical Limits**
Required Treatment (Category 3 Source)	**5.0**	**4.0**	**3.5**	
Option 1				
Direct Filtration	1.0	1.0	2.5 – 3.5	Log removals based on a 95th percentile of <0.3NTU. *Crypto* reduction dependent on the filtered water turbidity.
Chlorination	4.0	4.0	0.0	C·t > 15 mg·min/L with pH < 8.5 at all water temperatures. Feed water turbidity < 1.0 NTU.
Total	***5.0***	***5.0***	***2.5 – 3.5***	
Shortfall or Excess Log Removal	***0.0***	***1.0***	***1.0 to 0***	Shortfall can be addressed by UV
Option 2				
Direct Membrane Filtration	4.0	2.0	4.0	Log removals based on a 95th percentile of <0.3NTU
Chlorination	4.0	4.0	0.0	C·t > 15 mg·min/L with pH < 8.5 at all water temperatures. Feed water turbidity < 1.0 NTU.
Total	***8.0***	***6.0***	***4.0***	
Shortfall or Excess Log Removal	***3.0***	***2.0***	***0.5***	

4.7.2 Common Elements

4.7.2.1 Residuals Handling

As there is available land at the proposed WTP site, the preferred option for residuals handling at Kalkite is to construct two sludge lagoons for balancing instantaneous flows and capturing, and ultimately drying solids. Supernatant will then be returned to the WTP.

If membrane filtration is utilised without coagulant, then storage/balancing of the Washwater with irrigation is a viable option. Suitable irrigation locations would need to be identified and confirmed in the concept design.

4.7.2.2 Chlorine Disinfection

The existing chlorination system is located at the water intake pumping station and is not suitable for the new WTP.

Liquid sodium hypochlorite is preferred (verbal communication site visit 02/09/2020) with a new dosing system to be provided with any new treatment infrastructure.

4.7.2.3 Fire Risk

Recommend a fire attack study be completed to inform the materials and construction methods for the WTP.

4.7.2.4 Power Availability

Site power to operate existing infrastructure is delivered via overhead lines and available capacity will need to be confirmed during the next phase.

4.7.3 Option 1 – Direct Media Filtration

The raw water submersible pumps are too large and they would be replaced with smaller pumps capable of delivering water to the new WTP coagulation/flocculation tank, receiving a coagulant, likely ACH due to low alkalinity water. Flocculated water would then be pumped through a bank of media filters.

With small doses of a coagulant that does not consume much alkalinity, such as ACH, pH correction is not expected to be required.

Filtered water would be chlorinated and enter a treated water balance tank and lift pumps would transfer the water to the reservoirs via a dedicated rising main.

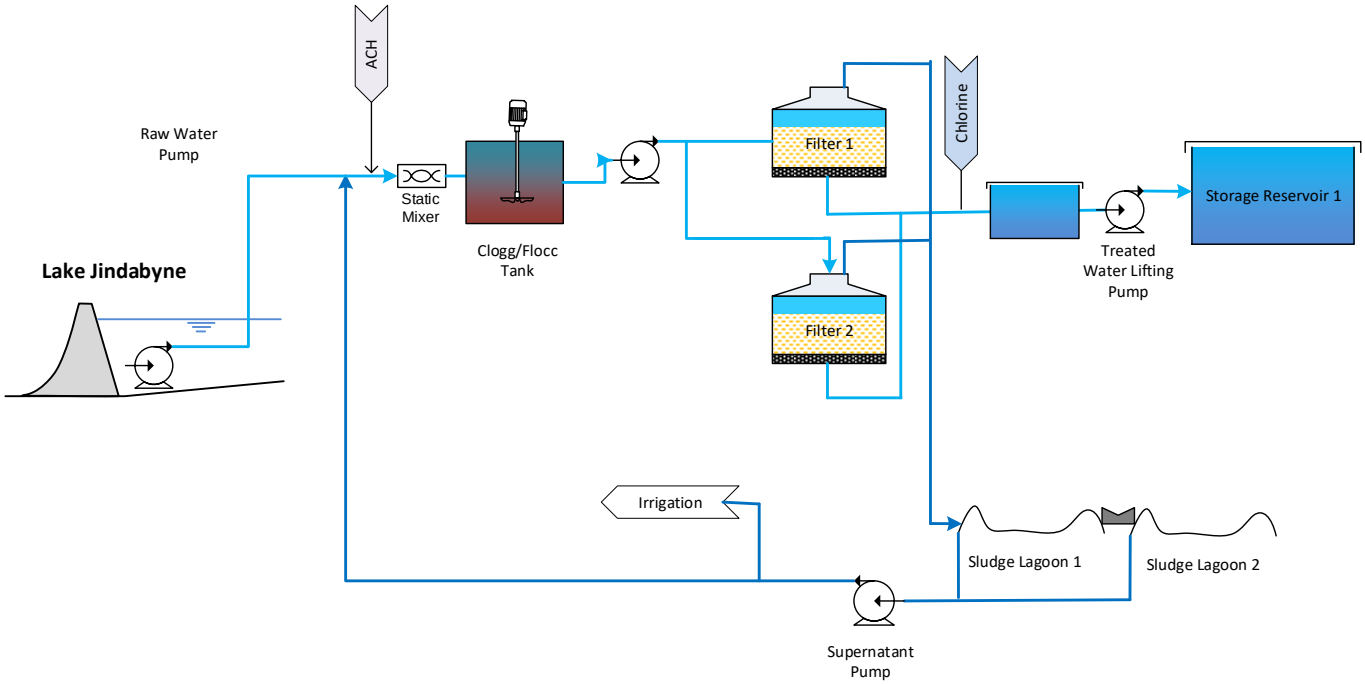


Figure 4-12: Schematic of the Kalkite Direct Media Filtration WTP.

The key elements of Option 1 are:

1. Coagulation and flocculation
   i. Addition of a coagulant to bring particles together and convert some dissolved organic carbon into total organic carbon that can be filtered

ii. Flocculation time of 10 to 15 minutes to assist the growth of coagulated particles to enhance their capture in the filter.
iii. High level estimate for coagulant usage is less than 200 L/annum allowing for delivery of 15L packages with small pumped transfer into a 100L to 200L tank every couple of months.

2. Pressure media filtration
   i. Filtration rate of less than 10 m^3/hr per m^2 of surface area (m/hr)
   ii. In the order of 1.8 m^2 of filtration surface area provided in 2 to 5 individual pressure media filters
3. Sludge lagoons
   i. At a yearly production of 20 ML (66 kL/day)
   ii. An estimated TSS of 15 mg/L (conservative)
   iii. There is a production of 10 m^3 of 3% TSS sludge
   iv. Provide 2 lagoons, each with a base area of at least 20m^2
   v. Supernatant pump station to return supernatant to the inlet of the filters or irrigation
4. Chlorine disinfection
5. High Lift pumps to transfer water direct to the reservoir through a new dedicated rising main

4.7.4 Option 2 – Membrane Filtration

The raw water submersible pumps are too large and would be replaced with smaller pumps capable of delivering water to a new WTP balance tank. From the balance tank water would be pumped through strainers and on to and through the membranes.

Whilst coagulant could be utilised, an advantage of membrane filtration is that a coagulant is not required to achieve turbidity targets.

Based on historical data if coagulant is not used then no pH correction will be required.

Membrane filtered water would be chlorinated and then pass into a treated water balance tank and lift pumps would transfer the water to the reservoirs.

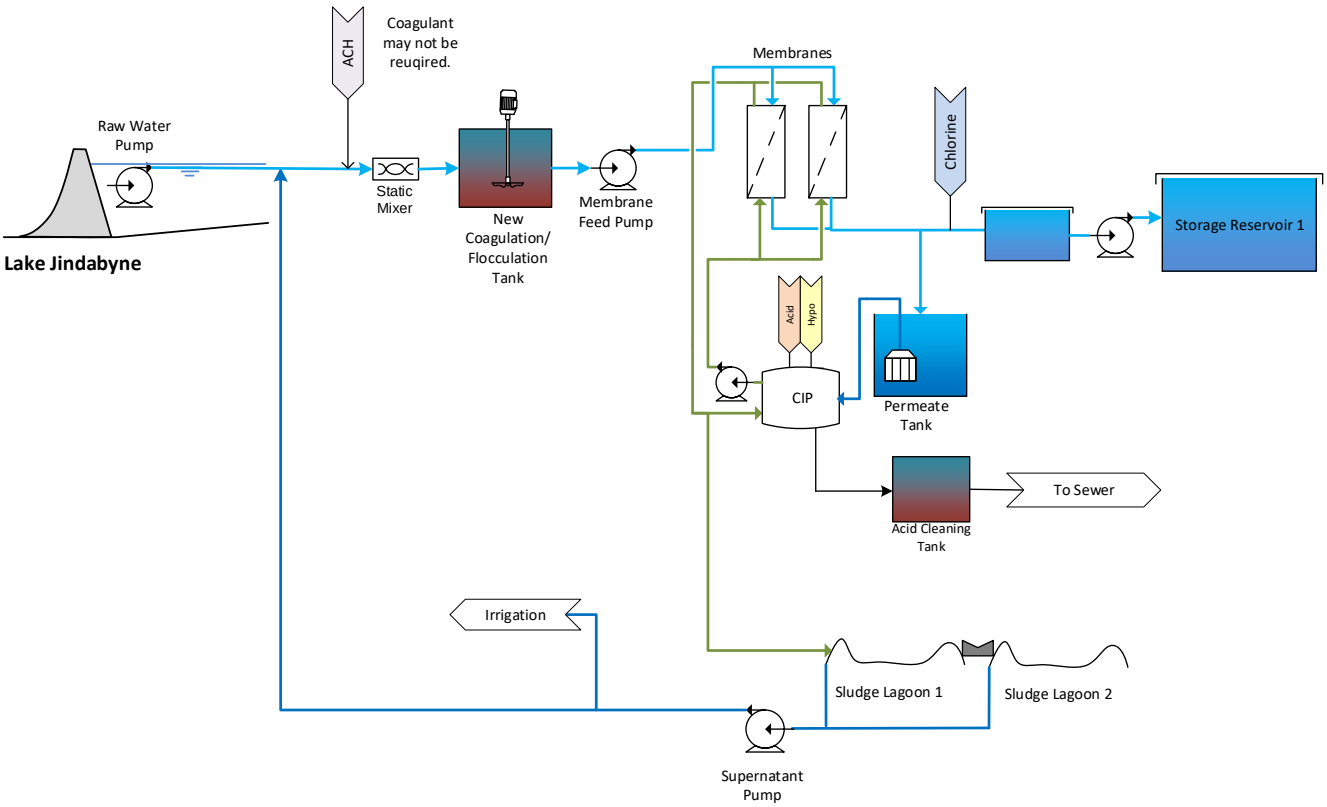


Figure 4-13: Schematic of the Kalkite Membrane Filtration WTP.

The Key elements of Option 2 are:

IF coagulant is selected to reduce colour and organics.

1. Coagulation and flocculation
    i. Only if deemed as required by the Contractor Addition of a coagulant to bring particles together and convert some dissolved organic carbon into total organic carbon that can be filtered
    ii. Flocculation time of 10 to 15 minutes to assist the growth of coagulated particles to enhance their capture in the filter.
    iii. High level estimate for coagulant usage is less than 400 L/annum allowing for delivery of 15 L packages with small pumped transfer into a 100 L to 200 L tank.

Without coagulant;

2. Membrane filtration
    i. Membrane feed pumps take water from a balance tank (coagulation/flocculation tank) and push it through strainers and the membrane all the way to the treated water balance tank.
    ii. Due to the low temperature and to minimise chemical cleaning, the flux would be limited to a value of < 35 l/m^2/hour.
    iii. In the order of 400 m^2 of filtration surface area provided by 6 to 12 membrane filtration modules.
    iv. Cleaning chemicals for a surface water with coagulation and organics will include citric acid for low pH clean to remove scaling and in organics and a chlorine clean of ~500 mg/L to manage organic and biological fouling.
    v. Small evaporation lagoon for citric acid cleaning waste
3. Sludge lagoons – As per option 1 where coagulant is utilised
    i. Irrigation opportunities would be improved through the absence of a coagulant
4. Chlorine disinfection
5. High Lift pumps to transfer water direct to the reservoir through a new dedicated rising main

4.7.4.1 Membrane Chemical Cleaning

Whilst a sewer is available for chemical cleaning waste products this is not supported by DPIE with a preference for collection and evaporation of cleaning residuals that cannot be recycled. Strategies to minimise waste include;

- Specification of minimum use of chemicals, for example chemical cleaning interval of at least 6 weeks with no intermittent “maintenance” or “enhanced” chemical cleaning.
- Collection and neutralisation of sodium hypochlorite cleaning waste and recycle through the sludge lagoons back to the plant feed at a low rate
    - Not suitable for citric acid or phosphorous based cleaners.

4.8 Preferred Option

The strengths and weaknesses of the shortlisted options have been compared and scored in Table 4-5;

- 1 is given for an option that has the most weaknesses
- 2 is given for an option that has both strengths and weaknesses
- 3 is given for an option that demonstrates strengths that align with the requirements of the location.

In considering the strengths and weaknesses of the shortlisted options, both membrane filtration and direct media filtration are considered suitable alternatives for Kalkite (score of 16 and 17 respectively), given a good specification is utilised and prosecuted that has clear minimum requirements.

On balance, to provide a single preferred option, given the opportunity for water quality to change, a lack of true colour requiring coagulant, available land area for irrigation and cleaning residual collection and evaporation, the simplified scoring suggests that Option 2 – Membrane Filtration with a score of 17 is preferred for Kalkite.

Table 4-5: Kalkite Comparison of Key Strengths and Weaknesses.

	Option 1 Direct Media Filtration	Option 2 Direct Membrane Filtration
Total Score	**16**	**17**
Footprint	Relatively small and compact	Filtration unit is smaller option but there are requirements for additional tankage and strainers which evens out the footprint.
	2	**2**
Water Quality/Quantity Typical	Easily able to manage typical water quality May naturally build up biology to manage taste and odour.	Easily able to manage typical water quality. No coagulant required which simplifies operation. Automatic test to demonstrate integrity of membrane. No issue with multiple start/stop operation.
	Typically, not as 'deep' as gravity filters which can reduce run times with early breakthrough. Cant 'see' the process to confirm the condition of the filtration media and confirm the backwash process.	Production stops for 2 – 6 hours for chemical cleaning every 4 to 8 weeks.
	2	**3**
Water Quality/Quantity during "Events" (For Kalkite this is a moderate to rapid increase in turbidity from 2 NTU to 10 NTU)	Automatic backwashing on differential pressure and turbidity breakthrough as the raw water quality changes. Based on historic water quality an "Event" is a small additional solids load that should not impact operation.	Membranes are a barrier and quality (pathogens and TSS) will not be affected by raw water quality change. Can't get 'breakthrough' of turbidity. Based on historic water quality an "Event" is a small additional solids load that should not impact operation.
	Cannot deal with soluble metals. Will require adjustment of coagulation dose to ensure that there is no turbidity breakthrough during a change in raw water quality. Backwashing increased and may overload sludge lagoons Will not treat soluble metals Will not treat taste and odour	If close to needing a chemical clean then increased solids can trigger a CIP and halt production. Will not treat soluble metals Will not treat taste and odour Will not reduce true colour
	2	**3**
Control and Monitoring	Simple to understand and monitor headloss and filtered water turbidity remotely.	Basis of control and monitoring as per conventional filtration. Can stop and start numerous times and not impact the quality.
	With multiple filters acting as one filter troubleshooting a problem with one filter can be difficult. Multiport valves can be problematic to trouble shoot.	Lots of different sequences to understand when troubleshooting. "Black box" control and monitoring of a proprietary system. Similar concept to conventional but lots of nuances. Need to monitor over the long term to pick up slow building problems that can fall over the cliff.

	Option 1 Direct Media Filtration	Option 2 Direct Membrane Filtration
Total Score	**16**	**17**
		Post dosing is stop start every 30 – 45 minutes when there is a backwash, and this can complicate monitoring of post treatment.
	3	**2**
Ease of Maintenance	The use of multiple filters improves redundancy and maintainability. Commonly available components can be maintained in house	Ancillary equipment is standard and can be maintained in house
	Need to ensure that access is provided around the filter and to the top of the filter for media removal and replacement. Repairing a broken lateral or issue inside a pressure media filter is nearly impossible on site.	Valves are often at awkward heights and locations due to the systems being proprietary. Typically have a third party engagement to manage membranes which has an associated cost. Typically involve some proprietary kit needing external assistance (e.g. membrane repair)
	3	**2**
Residuals Handling	Can keep instantaneous backwash flow down by having numerous filters in parallel	Small volume every 30 – 45 minutes Coagulant may not be required, reducing residuals and allowing for irrigation of backwash water.
	For 1 or 2 filters the instantaneous backwash rate is 4 – 5 times the plant flow rate and can be a large power draw compared to the remainder of plant. Sludge lagoons required and the associated management of drying solids.	Typically slightly lower first pass recovery than conventional at ~ 95% If coagulant is not used then solids will not settle and residuals will need to be irrigated or returned to the lake.
	2	**3**
Environmental Impact Physical Visual Noise Energy	Quiet operation, backwashing can be scheduled for ‘business’ hours as typically once a day.	Coagulant not required to achieve low turbidity. With irrigation the visual impact would be lower than for a plant with coagulation and sludge lagoons.
	Coagulant is required introducing aluminium to the backwash water and limiting reuse potential.	Has to backwash every 30 - 45 minutes which makes more noise at night. Membranes have a 7 – 10 year life and will end up in landfill. Uses hypo (can be recycled) and citric acid for chemical cleaning. Volumes are practically small and manageable.
	2	**2**

5 Adaminaby

Table 5-1: Adaminaby Summary

Component	Adaminaby – 500 kL/day		
Demand (kL/day)	2020 ADD	2020 PDD	2050 PDD
	98.5	358.1	482.6
Reservoir Capacity	450kL which meets the general rule of thumb of holding a peak day volume.		
Offline Capacity	2020 ADD ~ 2.75 days 2020 PDD ~ 0.75 day		
Key Water Quality Challenges	Raw water hazards ▪ Turbidity / suspended solids ▪ Pathogens (Category 3 source water) ▪ pH		
Raw Water Quality Uncertainties	▪ The level of organic material ▪ Level of alkalinity ▪ Soluble metals		
C.t	Minimum level to achieve a C.t of 15 mg.min/L of 25% in the reservoir		
Raw Water Pumping	The existing pumping station has sufficient capacity to provide the instantaneous flow of ~14 L/sec, more than twice of the required instantaneous flow rate of 6.6 L/sec to treat 526 kL raw water over 22 hours.		
Preferred Site location			
Land Acquisition Required?	No		
Shortlisted Options Considered	▪ Direct Media Filtration (with Coagulant) ▪ Direct Membrane Filtration (MF or UF)		
Preferred Option	The relative stability of the water, lack of true colour and land area available for collection and evaporation of cleaning residuals that cannot be recycled means that Direct Membrane Filtration is the preferred option for Adaminaby.		
Residuals Management	Sludge Lagoons including an opportunity for irrigate locally		
UV Disinfection	Not recommended due to the preliminary catchment categorisation of 3. “Poorly Protected Catchment”		
Recommendations	In addition to the recommendations of previous reports ▪ Confirmation of the intent to continue fluoridation at Adaminaby		

	▪ Fire Attack Study ▪ Confirmation of availability of Power ▪ Jar testing to investigate the benefit of coagulation

5.1 Overview

Adaminaby is located 52km to the NW of Cooma along the Snowy Mountains Highway. Adaminaby draws water from Observation point in a narrowing to the northern end of Lake Eucumbene.

The town has a population of 301 people (2016 Census) with 267 supply connections (SMRC).



Gravel access road to Adaminaby reservoir



Adaminaby reservoir



Gooroodee Reservoir, accessed through private property



Gravel road to Observation point



Bore pump well head



Chlorine gas dosing system



Sodium flouride dosing system



Chemical Building

Figure 5-1: Overview of Adaminaby Infrastructure.

5.2 Service Area

GIS data from SMRC was used to provide an indicative service area for Adaminaby and is presented below in Figure 5-2.

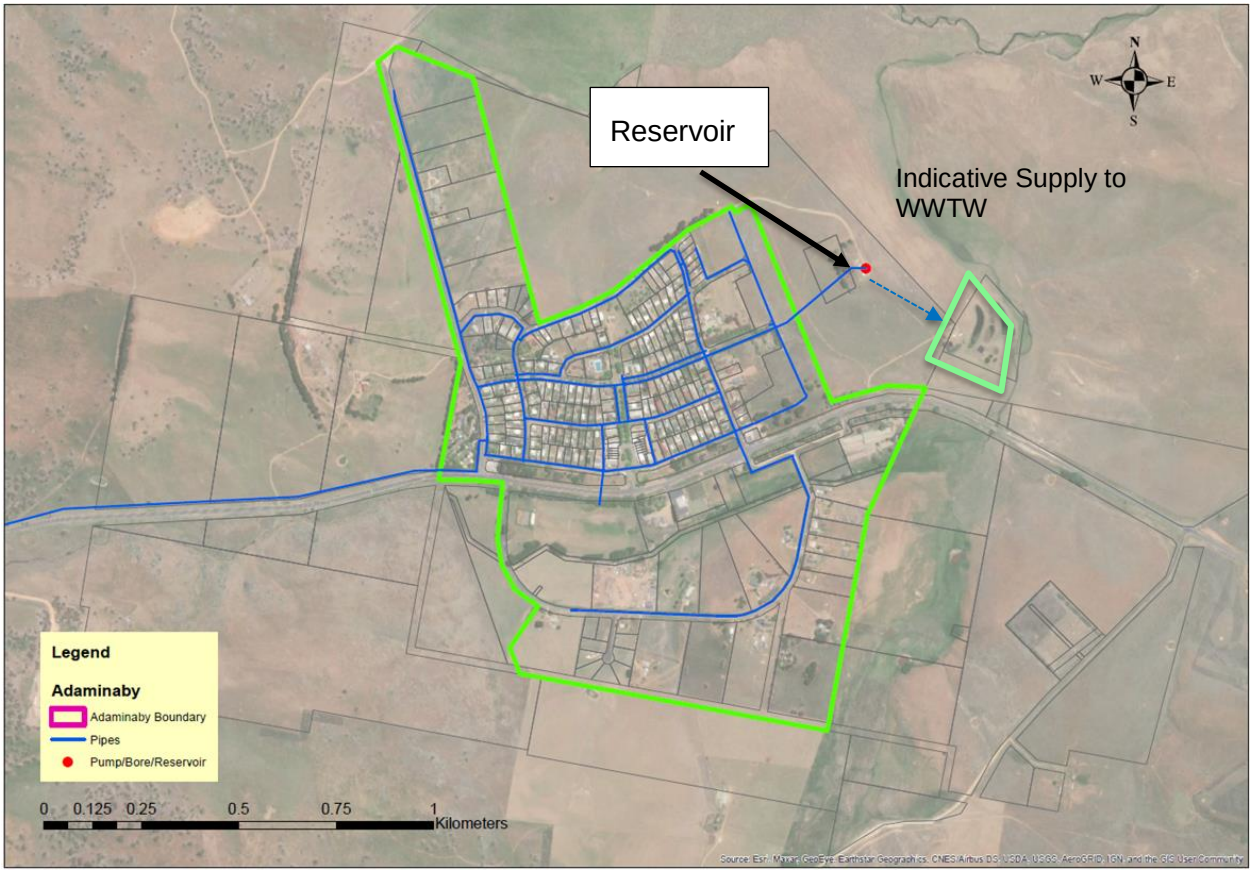


Figure 5-2: Adaminaby Service Area.

5.3 Historical and Forecast Demand

Figure 5-3 shows the annual consumption for Adaminaby. Table 5-2 provides a summary of this data and includes the forecast 2050 PDD and the proposed treatment plant capacity to service this demand (*Service Area and Demand Memo* (Hunter H2O, 2020)).

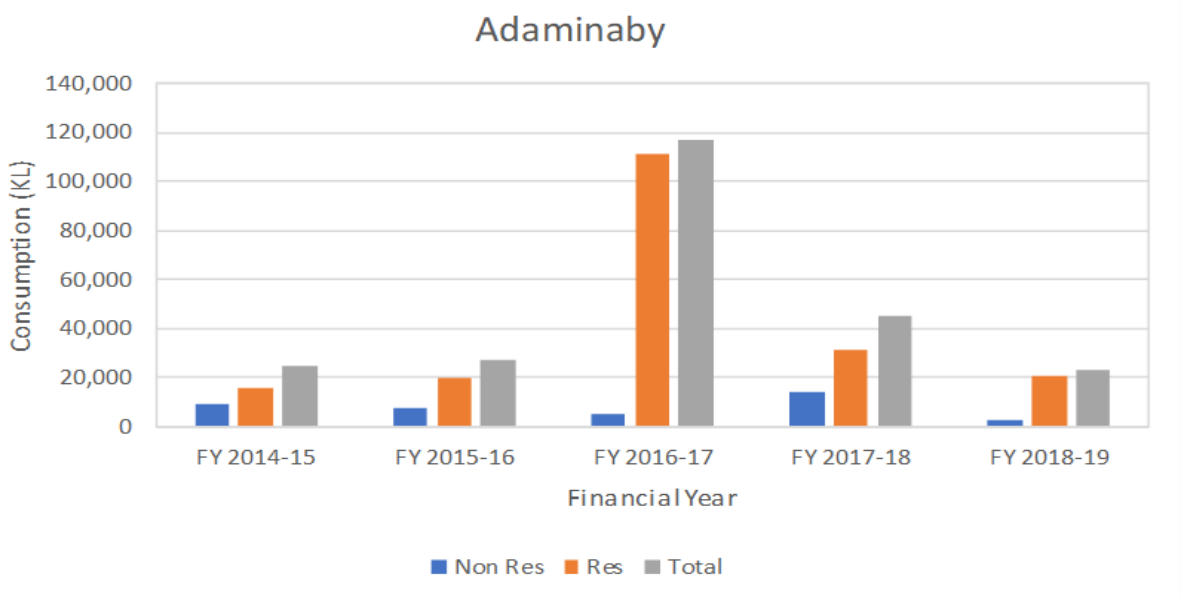


Figure 5-3: Adaminaby Consumption Data.

Table 5-2: Adaminaby Historical and Future Demand and the Raw Water Pumping Capacity.

Village	Source	Raw Water Pumping Capacity (kL/d)	Historical PDD (kL) (2020)	Historical ADD (kL) (2020)	2050 PDD for Treatment Capacity[1]	2050 PDD for Treatment Capacity[1]
Adaminaby	Lake Eucumbene (Observation Point)	1,200	358.1	98.5	482.6	500

Note 1. 1% annual population growth was adopted for the 2050 projections.

5.4 Source Water Assessment

The Adaminaby raw water supply was considered and is presented in detail in the *Source Water assessment Report* (Hunter H2O, 2020). The following sections provide a summary of the typical raw water hazards and challenges to be managed day to day to improve the aesthetic quality and water safety.

Beyond the day to day challenge of low levels of suspended solids (Figure 5-4) and pathogens, the key hazardous event and challenge to be overcome to improve the water safety of Adaminaby is turbidity and by inference, pathogen loading, during and following a rapid increase in the lake level caused by heavy rainfall. During such an event the treatment process will be challenged with only a moderate turbidity, however this may be 5 to 10 times the typical challenge.

In addition, it remains possible that when the lake is at a high level the intake, being deep in the lake, may be accessing deoxygenated water with the possibility of soluble metals being present, principally iron and manganese. Whilst there is no evidence historically of this occurring it remains a risk due to the intake design being at a fixed point.

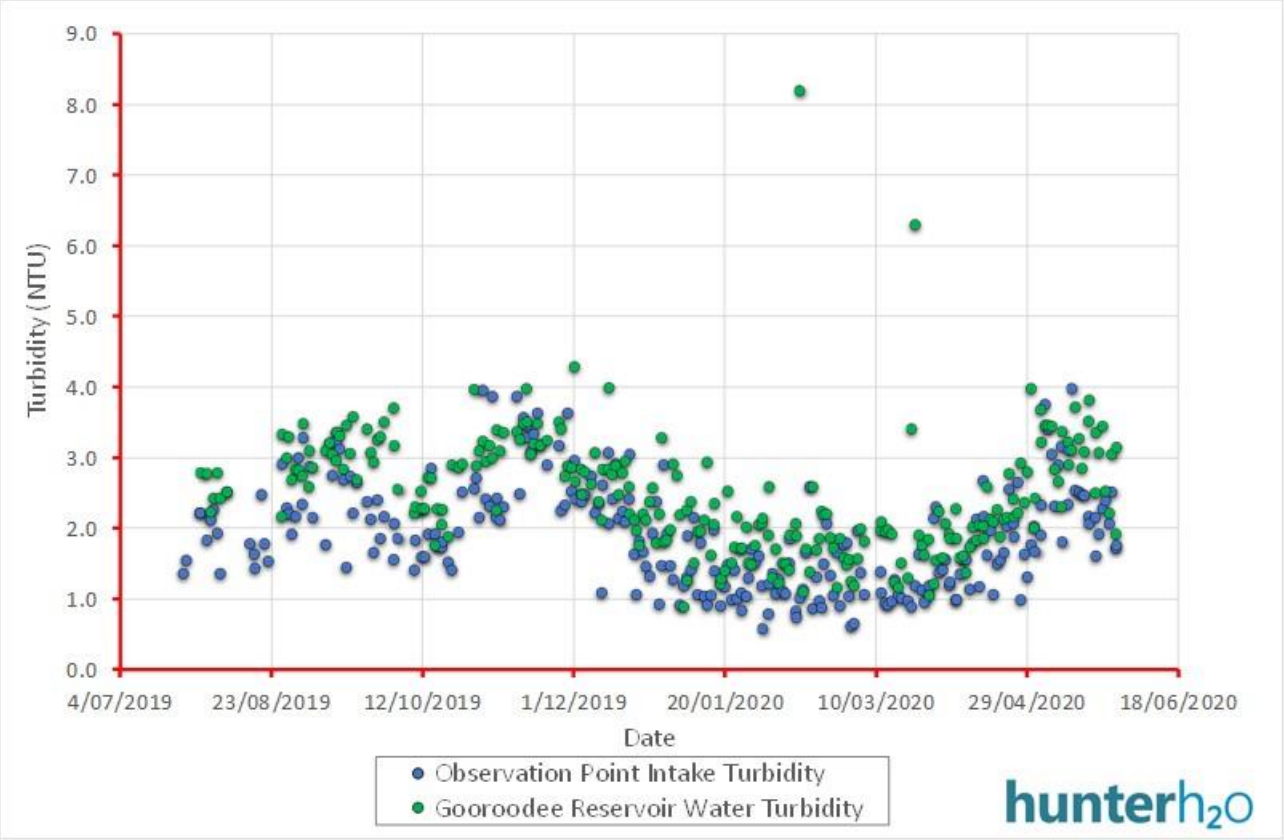


Figure 5-4 Observation Point and Gooroodee Turbidity

5.4.1 Pathogens

A high level assessment of pathogen risk was undertaken using the Health Based Targets (HBT) guidance manual (Water Services Association of Australia, September 2015) and is presented in the Source Water Assessment (Hunter H2O, 2020). The assessment determined that the Adaminaby source was conservatively a Category 3 source (Hunter H2O, 2020).

As a Category 3 source to achieve a target of an additional health burden, from potable water, of less $1x10^{-6}$ DALY's (Disability Adjusted Life Years) the following log reductions are recommended by the guidance manual and will require a multi barrier approach.

- **5.0 log_{10} reduction in Bacteria**
- **4.0 log_{10} reduction in Viruses and**
- **3.5 log_{10} reduction in Protozoa**

5.4.2 Chemical/Physical

From a review of the available raw water data the following are considered the key raw water hazards which require mitigation/barriers to reduce the associated health or aesthetic risk to an acceptable level at Adaminaby.

Turbidity / Suspended Solids

- The raw water turbidity is low but still above the target for disinfection of less than 1NTU.

Colour

- The true colour from the reticulation is typically low with a maximum of 7 HU
  - This is above the best practice target of 5 HU
- Data from the lake in 2011 showed increased colour with one result of 45 HU which is out of character.
- There is not enough information to say definitively that the colour is always below 15 HU.
- The free chlorine residual data for the reticulation network shows a low chlorine demand, which may be an indication of the low level of organic material in the raw water.

Organics

- There is no data available to nominate a level of organic material.

pH and Alkalinity

- Reticulation data suggests a mean and median of ~ 7.1
  - pH measured onsite has been variable with unexplained step changes in recorded pH.
- The water is very soft and whilst it is expected that the water has a very low alkalinity, there is insufficient data to make a definitive statement.

Hardness

- The raw water total hardness results from the reticulation of Adaminaby were in the range of 6.9 to 11.8 mg/L as $CaCO_3$ making it a soft water.
- Hardness appears similar to Kalkite, which is downstream and so from the same catchment

5.4.3 Raw Water Quality Design Envelope

Table 5-3 outlines the preliminary raw water design envelope for the Adaminaby WTP following consideration of available raw water data, its quality, and the impact of various elements. The envelope is intended as a living document to be considered through the project and adjusted as more information becomes available to balance risk and cost.

A monitoring program has been recommended, and provided separately, with key gaps for Adaminaby that are recommended to be filled being;

- Alkalinity
- True colour to identify the coagulation requirements
- The presence or absence of soluble iron
- Level of total and dissolved organic carbon

Table 5-3: Preliminary Raw Water Design Envelope.

Parameter	Units	Preliminary Raw Water Design Envelope			
		5th percentile	Median	95th percentile	Maximum
Temperature	Celsius	5	15	25	5
pH		6.5	6.9	7.7	8.0[1.]
TDS	mg/L	12	17.5	32	32
Alkalinity	mg/L as $CaCO_3$	15[1.]	20[1.]	40[1.]	70[1.]
Turbidity	NTU	0.9	3[1.]	10[1.]	15[1.]
True Colour	Hazen	0.5	2	15[1.]	45[1.]
Calcium	mg/L (Ca)	2.2	2.6	3.5	3.5
Magnesium	mg/L (Mg)	0.67	0.76	0.95	0.95
Total Hardness	mg/L $CaCO_3$	9.1	9.7	11.7	11.7
Total Iron	mg/L	0.04	0.07	0.2[1.]	0.5[1.]
Soluble Iron	mg/L		0.05[1.]	0.2[1.]	0.3[1.]
Total Mn	mg/L	0.0025	0.005	0.011	0.011
Soluble Mn	mg/L				
Free CO_2	mg/L				
TOC	mg/L				
DOC	mg/L				
Fluoride	mg/L	0.9	1.0	1.0	1.1

1. Values highlighted in green are estimates that are believed, following a review of data, site visit and discussion with Operators, to better represent the raw water challenge. These are TBC during the next phase.

5.5 Existing Instructure

The following information is based on information provided and visual inspection during site visits. The scope did not include a detailed condition assessment to allow nomination of remaining life of assets.

5.5.1 Raw Water Pumping

An intake pumping station (~14 L/s) at Observation Point supplies Adaminaby with water, first dropping into Gooroodee Reservoir before flowing by gravity via 13.7 km pipeline to Adaminaby Reservoir. Council is licensed to extract up to 102 ML/year from Lake Eucumbene. This is a yearly average day of 279 kL/day compared to the current ADD of ~ 100 kL/day.

The water supply system has a design capacity of 1.2 ML/d. In comparing the raw water flow requirements of the proposed WTP, the existing pumping station has sufficient capacity to provide the instantaneous flow of

~14 L/sec, more than twice of the required instantaneous flow rate of 6.6 L/sec to treat 526 kL raw water over 22 hours.

5.5.2 Reservoir

Key capacity information on the Adaminaby Reservoir from the *Options Assessment Report* (Hunter H2O, September 2020) is,

- The 2020 PDD is 80% of the reservoir capacity of 450kL.
- The minimum level required for C.t, with a target of 1 mg/L and flow at 3xPDD 25%.
- 60% of the reservoir provides 2.75 days to repair an issue for the average day demand
- 60% of the reservoir provides 0.75 day to repair an issue for the PDD

Based on the available information capacity upgrades are not recommended for the Adaminaby Reservoir.



Figure 5-5: Adaminaby Reservoir.

5.5.3 Disinfection and Fluoridation

Chlorine gas dosing and fluoride dosing at raw water intake is employed for disinfection and fluoridation with dosing system located inside a room at raw water intake location (Figure 5-6).

The existing chlorine and fluoride dosing systems and building are in a good condition and can be used for the future dosing if the WTP to be constructed at the raw water and chemical building location.

However, if the WTP is constructed at another location, then to align with the other Village treatment plants sodium hypochlorite would be preferred. In addition, during the next phase of delivery, the long-term application of fluoridation is recommended to be investigated consider, specifically, if location of treatment infrastructure is at Adaminaby.



Chemical building at raw water intake



Chlorine gas dosing system



Fluoride dosing system

Figure 5-6: Adaminaby Chlorine Dosing System.

5.6 Proposed Site Location

In considering water treatment plants in the 200 to 500 kL/day capacity range, at a scoping level, the footprint allowance for Adaminaby is 500 m^2 for process and 1500m^2 for sludge lagoons.

Figure 5-7 shows the location of the existing raw water infrastructure, Gooroodee Reservoir, Adaminaby reservoir and old Adaminaby.

For Adaminaby WTP, there are three options for the site location with the site (Option 2) at Adaminaby being selected as the most appropriate.:

1. At raw water intake and chemical building location:
    a. The raw water infrastructure is located on lot DP552374 (Figure 5-8) and is surrounded by a moderate amount of relatively flat land. There is access to power at this site due to the requirements of the bore pumps to transfer water to Gooroodee Reservoir.
    b. The main benefit of construction of the WTP near to the existing infrastructure is that, the existing chlorine and fluoridation dosing systems and building are in a good condition and can be used for the future dosing. From the site visit, the land could be suitable for the new WTP.

c. Raw water pumps would be replaced, and new ground mounted lift pumps would be installed. With a combined power draw equivalent or less than to the existing pumps given a reduced capacity.

2. At Adaminaby Reservoir location:
    a. On review of the Adaminaby Reservoir location, the infrastructure is located on approximately 1.3 ha lot DP729876. Access is able from Chalker street by an easement on a gravel road.
    b. In considering the available lot, there are two areas, one on the left side and one on the right side of the lot which are available for treatment infrastructure. As can be seen in Figure 5-8, the approximate area of these two areas are sufficient for the treatment process units and sludge lagoons.
    c. This site has the advantage that it is easier to access for Operators and has access to sewer. In addition, the 'common' land around the site may be suitable for irrigation which can be considered as one of the options for managing liquid residuals (filter backwash water).
    d. For this site, a new dedicated raw water rising main of about 1200m, following York St from Lette St, would be required.
3. Near Old Adaminaby:
    a. A location close to Old Adaminaby may also be suitable with a number of flat areas available.
    b. This location would have the same benefit of Option 1 in allowing Old Adaminaby to be put onto potable water but has the advantage of keeping the infrastructure in a more accessible location as compared to Observation Point.



Figure 5-7: Location of the Raw Water Intake Infrastructure, Gooroodee Reservoir, Adaminaby Storage Reservoir and Old Adaminaby.

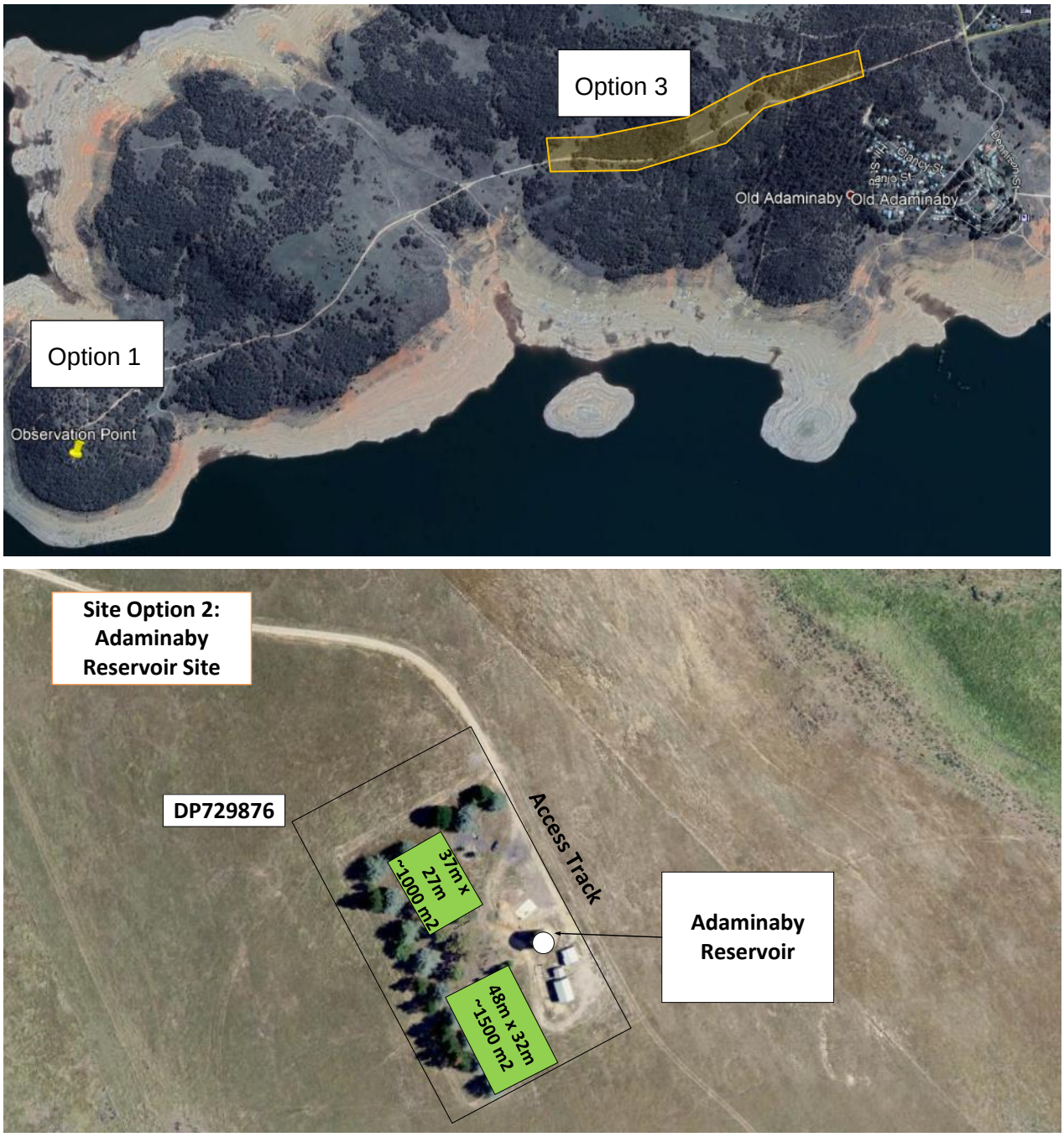


Figure 5-8: Proposed WTP Site Locations.

5.7 Shortlisted Options

Following a consideration of barriers available to manage the identified raw water hazards for Adaminaby, the following treatment trains were shortlisted for further assessment and comparison.

- Option 1 – Direct Media Filtration
- Option 2 – Direct Membrane Filtration (MF or UF)

5.7.1 Comparison of Options Against Health Based Targets

Table 5-4 presents the LRV removal expectation for the shortlisted options. The pathogen removal credits are taken from the WSAA guideline (WSAA 2015) and for membranes are indicative. As membrane suppliers have had to work with log removals for the last 20 years, each manufacturer has their own validation information for the rejection of virus and protozoans.

Table 5-4: LRV Expectation for the Shortlisted Options.

	Log Reduction Values			
	Bacteria	**Virus**	***Cryptosporidium***	**Process Critical Limits**
Required Treatment (Category 3 Source)	**5.0**	**4.0**	**3.5**	
Option 1				
Direct Filtration	1.0	1.0	2.5 – 3.5	Log removals based on a 95th percentile of <0.3NTU. *Crypto* reduction dependent on the filtered water turbidity.
Chlorination	4.0	4.0	0.0	C·t > 15 mg·min/L with pH < 8.5 at all water temperatures. Feed water turbidity < 1.0 NTU.
Total	***5.0***	***5.0***	***2.5 – 3.5***	
Shortfall or Excess Log Removal	***0***	***1.0***	***1.0 to 0***	Shortfall can be addressed by UV
Option 2				
Direct Membrane Filtration	4.0	2.0	4.0	Log removals based on a 95th percentile of <0.3NTU
Chlorination	4.0	4.0	0.0	C·t > 15 mg·min/L with pH < 8.5 at all water temperatures. Feed water turbidity < 1.0 NTU.
Total	***8.0***	***6.0***	***4.0***	
Shortfall or Excess Log Removal	***3.0***	***2.0***	***0.5***	

5.7.2 Common Elements

5.7.2.1 Residuals Handling

The preferred option for residuals handling is to utilise two sludge lagoons for balancing instantaneous flows and capturing, and ultimately drying, solids. Supernatant will then be returned to the WTP.

As a backup, to allow for the lagoon level to be lowered, irrigation of council or private land should be considered. Suitable irrigation locations would need to be identified and confirmed in the concept design.

5.7.2.2 Chlorine Disinfection

Whilst the existing gas chlorine system is in a good condition liquid sodium hypochlorite is preferred (verbal communication site visit 02/09/2020) for the other sites and for consistency it is thought that a new plant would utilise sodium hypochlorite.

5.7.2.3 Fluoridation

The fluoridation system could be moved or a new system provided at the Adaminaby site..

5.7.2.4 Power Availability

Site power is delivered via overhead lines and available capacity will need to be confirmed during the next phase.

5.7.3 Option 1 – Direct Media Filtration (WTP Location at Adaminaby)

Raw water would gravity feed from the Gooroodee Reservoir through a flow control valve at a constant rate to a raw water coagulation/flocculation and balance tank. Flocculated water would then be pumped through a bank of media filters and continue past a chlorination point into the reservoir.

With low alkalinity water the coagulant dosing regimen needs to be confirmed to determine if pH correction is required pre, post or both pre and post dosing. (jar testing recommended)

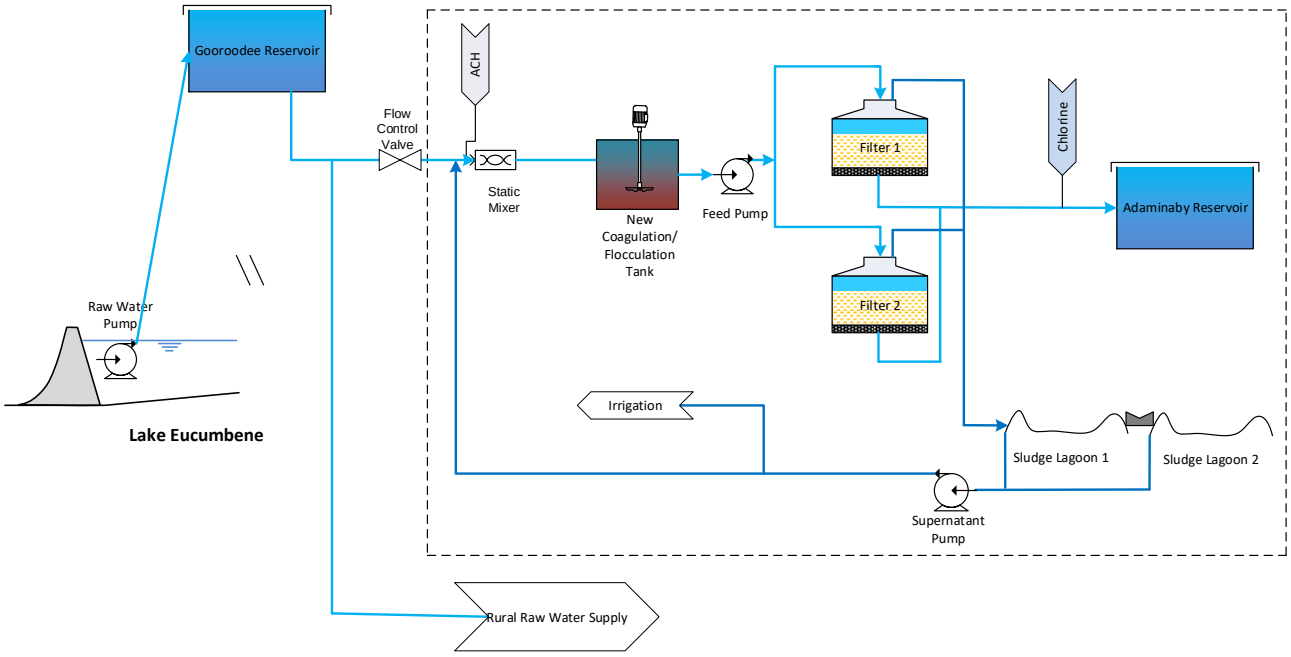


Figure 5-9: Schematic of the Adaminaby Direct Media Filtration WTP.

The key elements of Option 1 are:

1. Flow Control valve and dedicated raw water main to the Adaminaby Reservoir location.
2. Coagulation and flocculation
   i. Addition of a coagulant to bring particles together and convert some dissolved organic carbon into total organic carbon that can be filtered
   ii. Flocculation time of 10 to 15 minutes to assist the growth of coagulated particles to enhance their capture in the filter.
   iii. High level estimate for coagulant usage is less than 700 L/annum allowing for delivery of 15L packages with small pumped transfer into a 100L to 200L tank.
3. Pressure media filtration
   i. Filtration rate of less than 10 m^3/hr per m^2 of surface area (m/hr)
   ii. In the order of 3 m^2 of filtration surface area provided in 2 to 5 individual pressure media filters
4. Sludge lagoons
   i. At a yearly production of 43ML (~ 120 kL/day)
   ii. An estimated TSS of 20 mg/L (conservative)
   iii. There is a production of 28.8 m^3 of 3% TSS sludge
   iv. Provide 2 lagoons, each at least 45m^2 base area each
   v. Supernatant pump station to return supernatant to the inlet of the filters
5. Chlorine disinfection

5.7.4 Option 2 – Membrane Filtration

Raw water would gravity feed from the Gooroodee Reservoir through a flow control valve at a constant rate to a raw water coagulation/flocculation and balance tank.

Flocculated water would then be pumped through the membrane and continue past a chlorination point into the reservoir.

With low alkalinity water the coagulant dosing regimen needs to be confirmed to determine if pH correction is required pre, post or both pre and post dosing. (jar testing recommended)

Membrane fouling through solids accumulation and adsorption of dissolved contaminants (including iron and manganese) will occur. Regular backwashing, every 30 to 60 minutes, is required to remove accumulated particles, with chemical cleaning undertaken monthly.

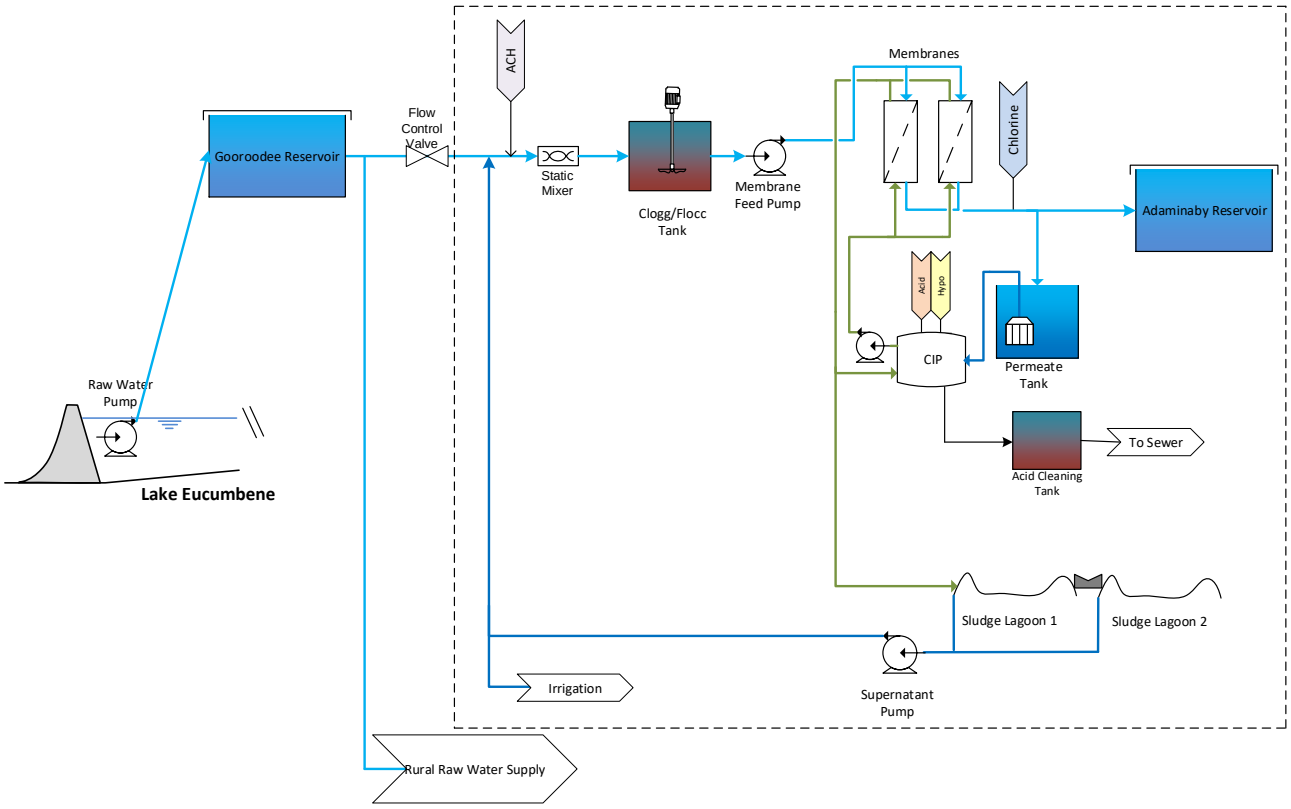


Figure 5-10: Schematic of the Adaminaby Membrane Filtration WTP.

The Key elements of Option 2 are:

1. Control valve and dedicated raw water rising main to the WTP site

IF coagulant is selected to reduce colour and organics.

2. Coagulation and flocculation
   - iv. Only if deemed as required by the Contractor, addition of a coagulant to bring particles together and convert some dissolved organic carbon into total organic carbon that can be filtered
   - v. Flocculation time of 10 to 15 minutes to assist the growth of coagulated particles to enhance their capture in the filter.
   - vi. High level estimate for coagulant usage is less than 400 L/annum allowing for delivery of 15 L packages with small pumped transfer into a 100 L to 200 L tank.

Without coagulant;

3. Membrane filtration
   - vi. Membrane feed pumps take water from a balance tank (coagulation/flocculation tank) and push it through strainers and the membrane all the way to the treated water balance tank.
   - vii. Due to the low temperature and to minimise chemical cleaning, the flux would be limited to a value of < 35 l/m^2/hour.

viii. In the order of 400 m^2 of filtration surface area provided by 6 to 12 membrane filtration modules.
ix. Cleaning chemicals for a surface water with coagulation and organics will include citric acid for low pH clean to remove scaling and in organics and a chlorine clean of ~500 mg/L to manage organic and biological fouling.

4. Membrane filtration
   i. Membrane feed pumps take water from the coagulation/flocculation tank and push it through strainers and the membrane all the way to the treated water storage reservoir
   ii. Due to the low temperature and to minimise chemical cleaning the flux would be limited to a value of < 35 l/m^2/hour
   iii. In the order of 700 m^2 of filtration surface area provided by 15 to 25 membrane filtration modules.
   iv. Cleaning chemicals for a surface water with coagulation and organics will include citric acid for low pH clean to remove scaling and in organics and a chlorine clean of ~500mg/L to manage organic and biological fouling.
2. Sludge lagoons – As per option 1 where coagulant is utilised
   i. Irrigation opportunities would be improved through the absence of a coagulant
5. Chlorine disinfection

5.7.4.1 Membrane Chemical Cleaning

Whilst a sewer is available for chemical cleaning waste products this is not supported by DPIE with a preference for collection and evaporation of cleaning residuals that cannot be recycled. Strategies to minimise waste include;

- Specification of minimum use of chemicals, for example chemical cleaning interval of at least 6 weeks with no intermittent “maintenance” or “enhanced” chemical cleaning.
- Collection and neutralisation of sodium hypochlorite cleaning waste and recycle through the sludge lagoons back to the plant feed at a low rate
  - Not suitable for citric acid or phosphorous based cleaners.

5.8 Preferred Option

The strengths and weaknesses of the shortlisted options for Adaminaby have been compared and scored in Table 5-5;

- 1 is given for an option that has the most weaknesses
- 2 is given for an option that has both strengths and weaknesses
- 3 is given for an option that demonstrates strengths that align with the requirements of the location.

In considering the strengths and weaknesses of the shortlisted options, both membrane filtration and direct media filtration are considered suitable alternatives for Adaminaby given a good specification is utilised and prosecuted that has clear minimum requirements.

On balance, to provide a single preferred option, given a lack of true colour requiring coagulant, available land area for irrigation and cleaning residuals management, the simplified scoring suggests that Option 2 – Membrane Filtration with a score of 17 is preferred for Adaminaby.

Table 5-5: Adaminaby Comparison of Key Strengths and Weaknesses.

	Option 1 Direct Media Filtration	Option 2 Direct Membrane Filtration
Total Score	**16**	**17**
Footprint	Relatively small and compact	Filtration unit is smaller option but there are requirements for additional tankage and strainers which evens out the footprint.
	2	**2**
Water Quality/Quantity Typical	Easily able to manage the typical water quality	Easily able to manage the typical water quality. No coagulant required which simplifies operation. Automatic test to demonstrate integrity of membrane. No issue with multiple start/stop operation.
	Typically, not as ‘deep’ as gravity filters which can reduce run times with early breakthrough. Cant ‘see’ the process to confirm the condition of the filtration media and confirm the backwash process.	Production stops for 2 – 6 hours for chemical cleaning every 4 to 8 weeks.
	2	**3**
Water Quality/Quantity during “Events” (For Adaminaby this is a rapid increase in turbidity from below 1 NTU to less than 10 NTU)	Automatic backwashing on differential pressure and turbidity breakthrough as the raw water quality changes. Based on historic water quality an “Event” is a small additional solids load that should not impact operation.	Membranes are a barrier and quality (pathogens and TSS) will not be affected by raw water quality change. Can’t get ‘breakthrough’ of turbidity. Based on historic water quality an “Event” is a small additional solids load that should not impact operation.
	Cannot deal with soluble metals. Will require adjustment of coagulation dose to ensure that there is no turbidity breakthrough during a change in raw water quality. Backwashing increased and may overload sludge lagoons Will not treat soluble metals Will not treat taste and odour	If close to needing a chemical clean then increased solids can trigger a CIP and halt production. Will not treat soluble metals Will not treat taste and odour Will not reduce true colour
	2	**3**
Control and Monitoring	Simple to understand and monitor headloss and filtered water turbidity remotely.	Basis of control and monitoring as per conventional filtration. Can stop and start numerous times and not impact the quality.
	With multiple filters acting as one filter troubleshooting a problem with one filter can be difficult. Multiport valves can be problematic to trouble shoot.	Lots of different sequences to understand when troubleshooting. “Black box” control and monitoring of a proprietary system. Similar concept to conventional but lots of nuances. Need to monitor over the long term to pick up slow building problems that can fall over the cliff.

	Option 1 Direct Media Filtration	Option 2 Direct Membrane Filtration
Total Score	**16**	**17**
		Post dosing is stop start every 30 – 45 minutes when there is a backwash, and this can complicate monitoring of post treatment.
	3	**2**
Ease of Maintenance	The use of multiple filters improves redundancy and maintainability. Commonly available components can be maintained in house	Ancillary equipment is standard and can be maintained in house
	Need to ensure that access is provided around the filter and to the top of the filter for media removal and replacement. Repairing a broken lateral or issue inside a pressure media filter is nearly impossible on site.	Valves are often at awkward heights and locations due to the systems being proprietary. Typically have a third party engagement to manage membranes which has an associated cost. Typically involve some proprietary kit needing external assistance (e.g. membrane repair)
	3	**2**
Residuals Handling	Can keep instantaneous backwash flow down by having numerous filters in parallel	Small volume every 30 – 45 minutes Coagulant may not be required, reducing residuals and allowing for irrigation of backwash water.
	For 1 or 2 filters the instantaneous backwash rate is 4 – 5 times the plant flow rate and can be a large power draw compared to the remainder of plant. Sludge lagoons required and the associated management of drying solids.	Typically slightly lower first pass recovery than conventional at ~ 95% If coagulant is not used then solids will not settle and residuals will need to be irrigated or returned to the lake.
	2	**3**
Environmental Impact Physical Visual Noise Energy	Quiet operation, backwashing can be scheduled for ‘business’ hours as typically once a day. Low energy and chemical use	Coagulant not required to achieve low turbidity. With irrigation the visual impact would be lower than for a plant with coagulation and sludge lagoons.
	Coagulant is required introducing aluminium to the backwash water and limiting reuse potential.	Has to backwash every 30 - 45 minutes which makes more noise at night (supplier dependent). Membranes have a 7 – 10 year life and will end up in landfill. Uses more chemicals with hypo and citric acid required for chemical cleaning. However, practically small volumes.
	2	**2**

6 Nimmitabel

Table 6-1: Nimmitabel Summary

Component	Nimmitabel – 400 kL/day		
Demand (kL/day)	2020 ADD	2020 PDD	2050 PDD
	86.5	279.7	377
Reservoir Capacity	580kL which meets the general rule of thumb of holding a peak day volume.		
Offline Capacity	2020 ADD ~ 4 days 2020 PDD ~ 1.2 day		
Key Water Quality Challenges	Raw water hazards ▪ Turbidity / suspended solids ▪ Colour ▪ Organics ▪ Pathogens (Category 4 source water) ▪ Bore Water Hardness ▪ Algae		
Raw Water Quality Uncertainties	▪ Level of TDS and alkalinity in Lake William Bore ▪ True colour and organics level in the Maclaughlin River ▪ Level of calcium and magnesium in Lake William Bore ▪ The presence of soluble iron in all sources ▪ Presence of microbiological contamination, typically and through events		
C.t	Minimum level to achieve a C.t of 15 mg.min/L of 15% in the reservoir		
Raw Water Pumping	The existing Maclaughlin River pump operates at twice the required future demand (~11 L/sec), with Lucan St. bore and Lake William Bore unable to meet the proposed instantaneous flow rate at 47% and 11% of the proposed instantaneous flow rate at 2.5 L/s and 0.6 L/s.		
Preferred Site location			
Land Acquisition Required?	Yes - Proposed to purchase land for the site at Lucan St. Bore.		
Shortlisted Options Considered	▪ Option 1 – Direct Membrane Filtration (MF or UF) ▪ Option 2 – DAF/F ▪ Option 3 – Inclined Plate Settler/ Media Filtration ▪ Hardness Reduction of bore water when 100% bore water supply		

Preferred Option	Given the historical 95th turbidity percentile of less than 15 NTU, with rapid increase and decrease that may be difficult for a clarification process to manage, Option 1 – Membrane Filtration is preferred for Nimmitabel.
Residuals Management	Sludge Lagoons including an opportunity for irrigate locally
UV Disinfection	Recommended due to the preliminary catchment categorisation of 4. “Unprotected Catchment”
Recommendations	In addition to the recommendations of previous reports ▪ Engage with the community to determine the willingness to pay for hardness reduction when 100% bore water is used. ▪ Groundwater investigation to determine the cause of fluctuating turbidity from the bores ▪ Fire Attack Study ▪ Confirmation of availability of Power ▪ Coagulation jar testing of various percentage blends of River and ground water, including event based jar testing with elevated colour, organics and turbidity.

6.1 Overview

Nimmitabel is located 37km SE of Cooma on the Monaro Highway. The town has a population of 320 people (2016 Census) with 181 supply connections (SMRC).



Maclaughlin River Water intake



Mclaughlin River water intake and pumping station



Figure 6-1: Overview of Nimmitabel Location and Infrastructure.

6.2 Service Area

GIS data from SMRC was used to provide an indicative service area for each Village and is presented below in Figure 6-2.

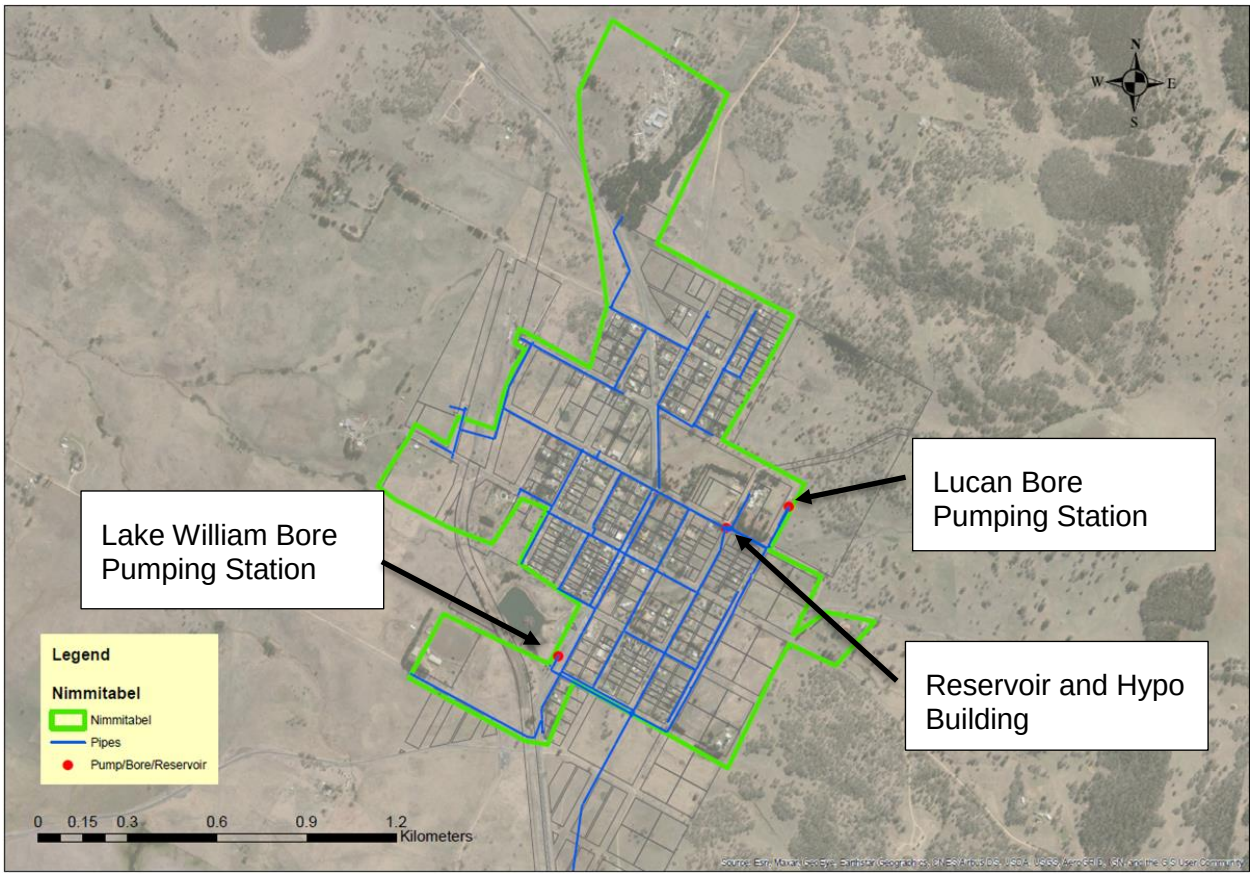


Figure 6-2: Nimmitabel Service Area.

6.3 Historical and Forecast Demand

Figure 6-3 shows the production of Nimmitabel over the last 11 years as a time series. Table 6-2 provides a summary of this data and includes the forecast 2050 PDD and the proposed treatment plant capacity to service this demand (*Service Area and Demand Memo* (Hunter H2O, 2020)).

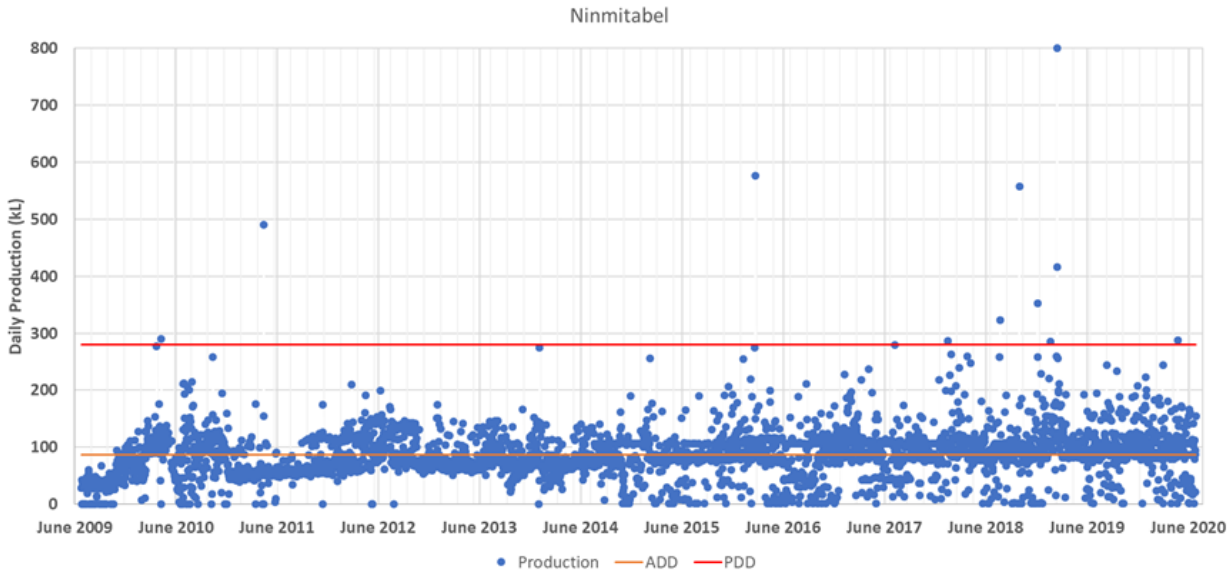


Figure 6-3: Nimmitabel Daily Production.

Table 6-2: Nimmitabel Historical and Future Demand and the Raw Water Pumping Capacity.

Village	Source	Raw Water Pumping Capacity (kL/d)	Historical PDD (kL) (2020)	Historical ADD (kL) (2020)	2050 PDD for Treatment Capacity[1]	2050 PDD for Treatment Capacity[1]
Nimmitabel	Bores + McLaughlin River + Lake Wallace (Pigring Creek)	River – 950 LS Bore – 200 LW Bore – 50	279.7	86.5	377.0	400

Note 1. 1% annual population growth was adopted for the 2050 projections

6.4 Source Water Assessment

The Nimmitabel raw water supply was considered and is presented in detail in the *Source Water assessment Report* (Hunter H2O, 2020). The following sections provide a summary of the typical raw water hazards and challenges to be managed day to day to improve the aesthetic quality and water safety.

Beyond the day to day challenge of moderate turbidity and colour, the key challenge to be overcome to improve the water safety of Nimmitabel is turbidity and by inference, pathogen loading, during and following heavy rainfall when the Maclaughlin River turbidity increases rapidly (Figure 6-4), which requires mitigation/barriers to reduce the associated health or aesthetic risk to an acceptable level. As is shown in Figure 6-5, a relationship exists between the river water turbidity and apparent colour.

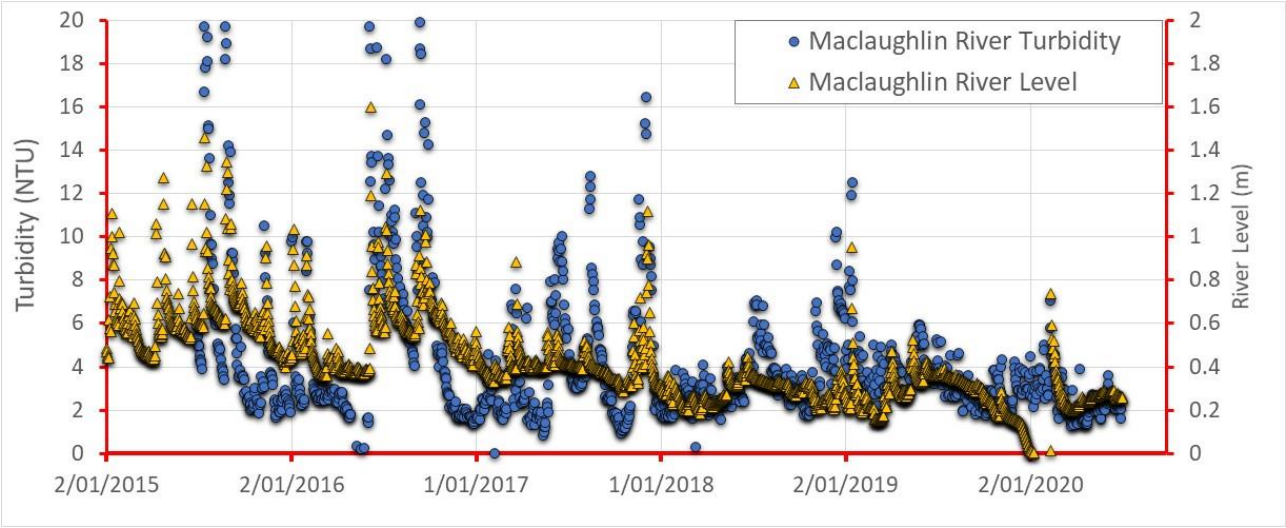


Figure 6-4: Maclaughlin River Turbidity and River Level Data (July 2015 – June 2020).

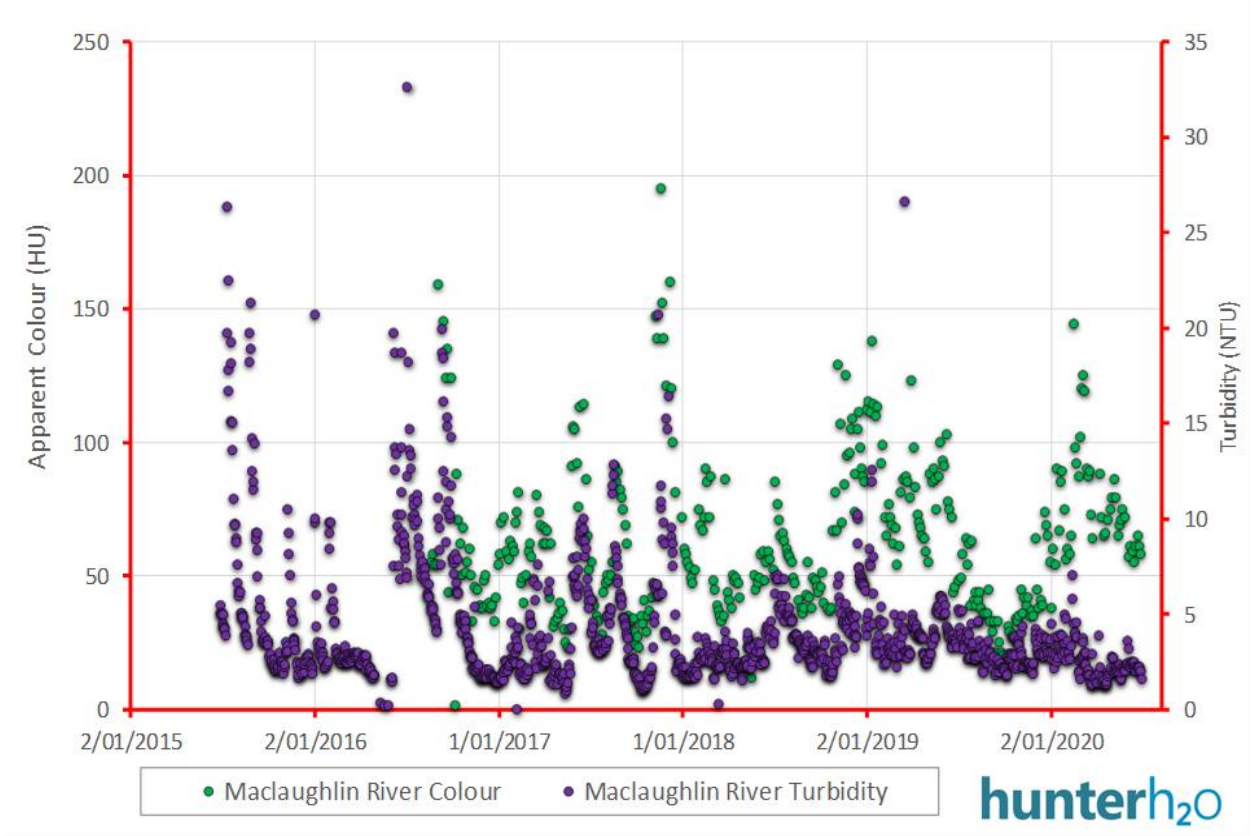


Figure 6-5: Maclaughlin River Water Apparent Colour and turbidity.

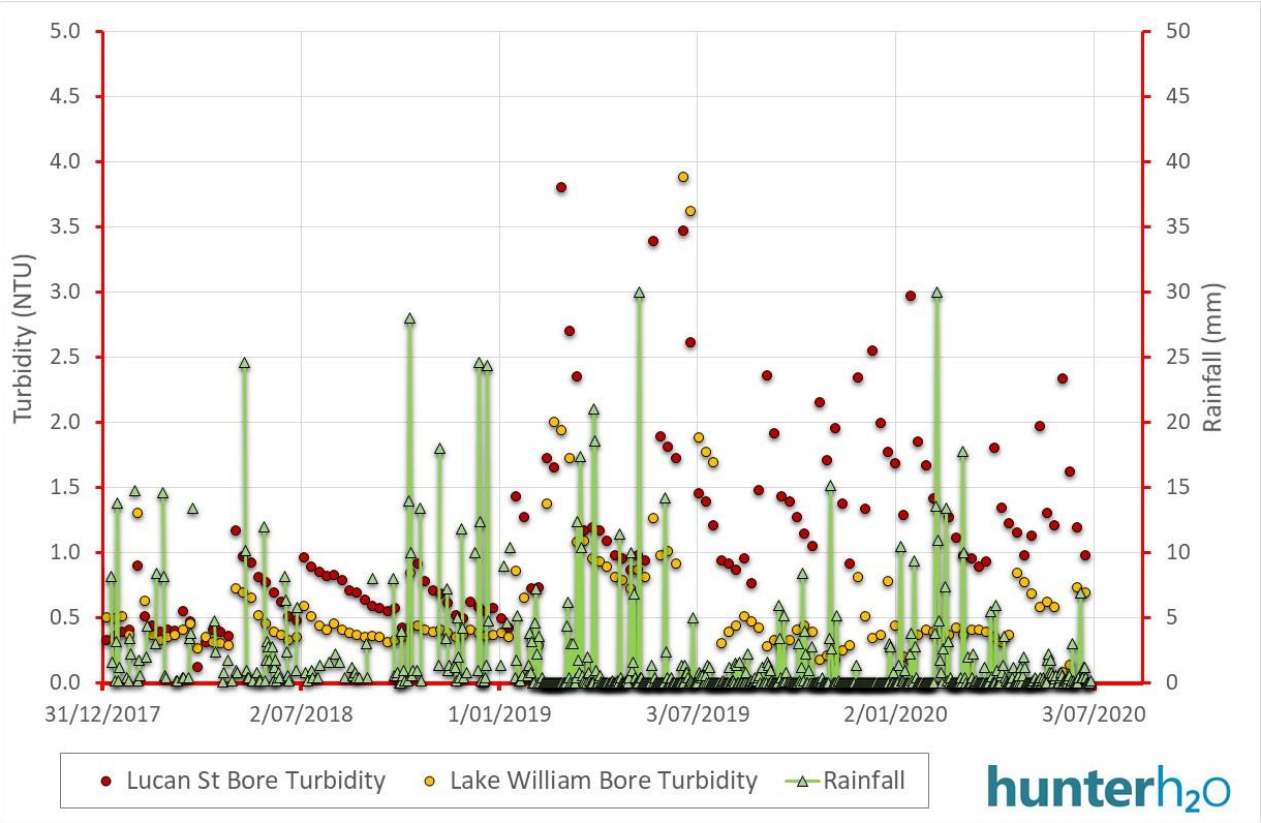


Figure 6-6: Lucan St Bore and Williams Bore Turbidity and Rainfall Data (Jan 2017 – June 2020).

6.4.1 Pathogens

A high level assessment of pathogen risk was undertaken using the Health Based Targets (HBT) guidance manual (Water Services Association of Australia, September 2015) and is presented in the Source Water Assessment (Hunter H2O, 2020). The assessment determined that the Nimmitabel sources ware conservatively a Category 4 source (Hunter H2O, 2020).

As a Category 4 source to achieve a target of an additional health burden, from potable water, of less $1x10^{-6}$ DALY's (Disability Adjusted Life Years) the following log reductions are recommended by the guidance manual and will require a multi barrier approach.

- **6.0 log_{10} reduction in Bacteria**
- **6.0 log_{10} reduction in Viruses and**
- **5.5 log_{10} reduction in Protozoa**

6.4.2 Chemical/Physical

From a review of the available raw water and reservoir water data, the following are considered the key raw water hazards which require mitigation/barriers to reduce the associated health or aesthetic risk to an acceptable level at Nimmitabel.

Turbidity / Suspended Solids

- Maclaughlin River water is consistently more than 5 NTU.
- River water turbidity spikes following rainfall and a river level rise up to more than 30 NTU
  - a more typical a spike sees the turbidity rise to 20 NTU.
- The Lucan St bore is typically less than 2 NTU but can be up to 5NTU.
  - There is no certainty on why the bore turbidity varies so much and an investigation is recommended.
- The Lake William bore is typically less than 0.5 NTU but has been measured up to 4 NTU.

Metals

- There is a limited data set from the reticulation monitoring available from FASS over a period of 2000-2020 (37 samples).
  - Iron had an average of 0.28 mg/L and a maximum of 1.64 mg/L
  - Aluminium had an average of 0.20 and a maximum of 0.67 mg/L
- Not known if the bores have equivalent levels of total/soluble iron.
- Given the shallow surface water source it is expected that these metals were all total and not soluble however it is recommended that this is confirmed for each source.

Colour

- Apparent colour is high and variable in the Maclaughlin River being consistently more than 50 HU and exceeding 100 HU routinely.
  - It is suspected that true colour in the river will be variable and from network monitoring it is suspected to be in the range of 15 to 50 HU.
- Whilst it is expected to be low, there is no information on colour in the groundwater source.

Organics

- Organics data is not available for the River however, given the apparent colour organics are expected and jar testing at various blends is recommended to determine typical doses, organics levels and effectiveness of coagulation
- It would be expected that the bores are low in organics.
  - Data is required to demonstrate

pH and Alkalinity

- The pH of the individual sources is within the ADWG range of 6.5 to 8.5
- The alkalinity of the River is a median of 53 mg/L as $CaCO^3$ and is sufficient for typical levels of coagulation
- The alkalinity of the bores is high with a median of 390 mg/L as $CaCO^3$
- The alkalinity of a blended supply will be in the order of 100 to 200 mg/L as $CaCO^3$

Hardness

- The estimated typical total hardness of the Lucan St bore water is in the order of 300 mg/L as $CaCO^3$. This aligns reasonably with a FASS maximum of 370 mg/L as $CaCO^3$.
  - Lucan St bore calcium has a median calcium hardness of 162.5 mg/L as $CaCO^3$.
  - No magnesium results are available except for FASS database with a maximum of 47 mg/L attributed to a period when bores were run exclusively, with a hardness contribution of ~ 190 mg/L as $CaCO^3$.
- At the historical blend ratio of 60:40 the hardness of ~ 135 mg/L as $CaCO_3$, whilst elevated, is in a good range and softening is not required.
  - A blend using more River water could also be used to reduce the hardness further (70:30 giving a hardness of ~ 100 mg/L as $CaCO^3$). However, during drought, if the river is not available there will be a noticeable increase in hardness that will be noticeable by some residents.

Algae

- Given the shallow and low flowing nature of the River, Algae remains a risk.

6.4.3 Raw Water Quality Design Envelope

Table 6-3 outlines the preliminary raw water design envelope for the Nimmitabel WTP following consideration of available raw water data, its quality, and the impact of various elements. The envelope is intended as a living document to be considered through the project and adjusted as more information becomes available to balance risk and cost.

A monitoring program has been recommended, and provided separately, with key gaps for Nimmitabel that are recommended to be filled being;

- Level of TDS and alkalinity in Lake William Bore
- True colour and organics level in the Maclaughlin River
- Level of calcium and magnesium in Lake William Bore
- The presence of soluble iron in all sources
- Presence of microbiological contamination, typically and through events

Table 6-3: Preliminary Raw Water Design Envelope.

Parameter	Units	Preliminary Raw Water Design Envelope			
		5th percentile	Median	95th percentile	Maximum
Temperature	Celsius	5	15	25	25
pH		6.6	7.4	7.7	8.1
TDS	mg/L	81	156	247	393
Alkalinity River	mg/L as $CaCO_3$	25	53	116	134
Alkalinity Bores	mg/L as $CaCO_3$	280	390	460	515
Turbidity	NTU	0.2[2.]	5[1.]	15[1.]	40[1.]
True Colour	Hazen	5[1.]	15[1.]	30[1.]	70[1.]
Calcium River	mg/L (Ca)	5.1	9.7	19.5	64.7
Calcium Bores	mg/L (Ca)	47	69	83	100[1.]
Magnesium	mg/L (Mg)	1.81[3.]	12.97[3.]	28.4[3.]	46.93
Bore	mg/L (Mg)	10[1.]	30[1.]	80[1.]	100[1.]
Total Hardness[3.]	mg/L $CaCO_3$	19.7	126.1	226.8	373
Total Hardness Bores	mg/L $CaCO_3$	150[1.]	220[1.]	320[1.]	373[1.]
Total Iron	mg/L	0.02	0.6[1.]	1.20[1.]	2.0[1.]
Soluble Iron	mg/L	0.02	0.4[1.]	0.8[1.]	2.0[1.]
Total Mn	mg/L	0.0025	0.007	0.023	0.029
Soluble Mn	mg/L				
Free CO_2	mg/L				
TOC	mg/L				
DOC	mg/L				
Fluoride	mg/L	0.05	0.05	0.19	0.79

1. Values highlighted in green are estimates that are believed, following a review of data, site visit and discussion with Operators, to better represent the raw water challenge. These are TBC during the next phase.

6.5 Existing Instructure

The following information is based on information provided and visual inspection during site visits. The scope did not include a detailed condition assessment to allow nomination of remaining life of assets.

6.5.1 Raw Water Pumping

Nimmitabel raw water is drawn from a weir pool on the Maclaughlin River with the ability to maintain the level in the weir through releases from Lake Wallace down the River if required. Further, water is supplied from 2 bores, the Lucan St Bore and the Lake William Bore.

A summary of the supply is:

- Maclaughlin River
  - Weir constructed in 1968
  - Licence to draw 68 ML/year (Yearly average of 186kL/day)
  - Pumping station constructed in 2005
- Lake Wallace (Pigring Creek)
  - Lake Capacity of ~320 ML
  - Outlet depth is able to be adjusted
  - Used during drought when the River ceases to flow
  - Releases into Pigring creek and travels around 2.5km down the Maclaughlin River to the weir pool
- Bores (bore construction logs not available)
  - Located in lower fractured rock aquifers
  - Noted as experiencing elevated levels of iron, carbon dioxide and hydrogen sulphide
    - Hydrogen sulphide and associated smell not raised as an issue.
  - Lucan St Bore (47 ML/year license)
    - Constructed 1996
    - Capacity 1 to 2.5 L/s (NSW Public Works, 2012)
    - Wellhead not integral and vermin could enter
  - Lake William bore (19 ML/year license)
    - Low flow and rarely utilised
    - Constructed 1996
    - Wellhead not integral and vermin could enter

Post Workshop – There is a third bore, referred to as the "School Bore" which supplies water into the outlet of the Lucan St bore when it is operated. The quality of the water and condition of the bore are unknown and should be investigated.

In comparing the raw water flow requirements of the proposed WTP, the existing Maclaughlin River pump operates at twice the required future demand (~11 L/sec), with Lucan St. bore and Lake William Bore unable to meet the proposed instantaneous flow rate at 47% and 11% of the proposed instantaneous flow rate at 2.5 L/s and 0.6 L/s respectively.



Maclaughlin River Water intake



Mclaughlin River raw water intake and pumping station



Maclaughlin River raw water pumping



Maclaughlin River weir



Lake William Bore water intake



Lucan Street Bore water intake

Figure 6-7: Nimmitabel Raw Water Intake and Pumping Infrastructure.

6.5.2 Reservoir

Key capacity information on the Nimmitabel Reservoir from the *Options Assessment Report* (Hunter H2O, September 2020) is,

- The 2020 PDD is 48% of the reservoir capacity of 580kL
- The minimum level required for C.t, with a target of 1 mg/L and flow at 3xPDD is less than 20%
- 60% of the reservoir provides 4 days to repair an issue for the average day demand
- 60% of the reservoir provides 1.2 day to repair an issue for the PDD

Based on the available information capacity upgrades are not recommended for the Nimmitabel Reservoir.



Figure 6-8: Nimmitabel Reservoir.

6.5.3 Disinfection

Sodium hypochlorite dosing at the reservoir site is employed for disinfection with the storage and dosing equipment located inside a lined and heated room to avoid the lines freezing (Figure 6-9).

The building is in reasonable condition however there is limited opportunity to co-lo ate treatment infrastructure to allow for reuse of the building. However, there would be an opportunity to use the system for 'top up' dosing in combination with a sample instrumentation, a small recycle and tank mixing.



Figure 6-9: Nimmitabel Hypo Storage and Dosing.

6.6 Proposed Site Location

Figure 6-10 shows the location of the Maclaughlin River, Lake Wallace, Lucan Bore, Lake William Bore and storage reservoir.

In considering water treatment plants in the 200 to 500 kL/day capacity range at a scoping level the footprint allowance for Nimmitabel is 500 m^2 for process and 1500 m^2 for sludge lagoons.

Three options for the location of the Nimmitabel WTP were identified:

1. At Lake Wallace with the bore water receiving chlorination only.
2. At Lucan Bore location and near the reservoir with all water sources receiving treatment
3. At Nimmitabel STP site location

Considering the first option, if there was sufficient evidence to verify that the bore water is from a confined aquifer, then there is an opportunity to locate a treatment plant at Lake Wallace with the bore water receiving chlorination and at worst chlorination and UV. A conservative position has been taken that assumes that the ground water is under the influence of surface water and requires equivalent treatment to the Maclaughlin River water. This constrains the location of the treatment infrastructure to a location where all of the raw water is available.

From the review of the location of the raw water pumping stations and water storage reservoir, as shown in Figure 6-10, the proposed locations for Nimmitabel WTP is near the reservoir and the area near the Lucan St Bore.

On review of the Lucan Bore location, where private land next to the Lucan Bore infrastructure is on lot DP756849. Access is off West of Miller Street by an easement on an informal gravel road. In considering the DP756849 lot, there is a large open area which can be sufficient for the WTP infrastructure (Figure 6-11), which is required to be purchased. The Maclaughlin River water and Bore water would be mixed in a balance tank before treatment. The treated water then is pumped to the reservoir. In addition, the land nearby appears to be suitable for irrigation which can be considered as one of the options for managing liquid residuals (filter backwash water).

The land available at Nimmitabel STP is located on lot DP623283, as shown in Figure 6-12. Although there is enough space to construct the Nimmitabel WTP on this land, with relocation of sludge drying, the land is not ideal, in addition to the requirement for new pipeline from the raw water sources and to the reservoir which would add cost.



Figure 6-10: Lake Wallace, Maclaughlin River, Bores, Reservoir and STP Location.



Figure 6-11: Proposed Nimmitabel WTP Location Near the Lucan Bore and Reservoir.



Figure 6-12: Nimmitabel STP Lot Location.

6.7 Shortlisted Options

Following a consideration of barriers available to manage the identified raw water hazards for Nimmitabel, the following three treatment trains were shortlisted for further assessment and comparison.

- Option 1 – Direct Membrane Filtration (MF or UF)
- Option 2 – Dissolved Air Flotation and Filtration (DAF/F)
- Option 3 – Inclined Plate Settler/ Media Filtration

6.7.1 Comparison of Options Against Health Based Targets

Table 6-4 presents the LRV removal expectation for the shortlisted options. The pathogen removal credits are taken from the WSAA guideline (WSAA 2015) and for membranes are indicative. As membrane suppliers have had to work with log removals for the last 20 years, each manufacturer has their own validation information for the rejection of virus and protozoans.

Noting that the assessment of a Category 4 raw water was conservative and based on a desktop assessment.

Based on industry best practice UV disinfection is recommended for all options to provide a multi barrier approach.

Table 6-4: LRV Expectation for the Shortlisted Options.

	Log Reduction Values			
	Bacteria	**Virus**	***Cryptosporidium***	**Process Critical Limits**
Required Treatment (Category 4 Source)	**6.0**	**6.0**	**5.5**	
Option 1				
Direct Membrane Filtration	4.0	2.0	4.0	Log removals based on a 95th percentile of <0.3NTU
Chlorination	4.0	4.0	0.0	C·t > 15 mg·min/L with pH < 8.5 at all water temperatures. Feed water turbidity < 1.0 NTU.
Total	***8.0***	***6.0***	***4.0***	
Shortfall or Excess Log Removal	***2.0***	***0***	***1.5***	Shortfall can be addressed by UV
Option 2				
DAFF	2.0	2.0	3.0 – 4.0	Log removals based on a 95th percentile of <0.3NTU. *Crypto* reduction dependent on the filtered water turbidity.
Chlorination	4.0	4.0	0.0	C·t > 15 mg·min/L with pH < 8.5 at all water temperatures. Feed water turbidity < 1.0 NTU.
Total	***6.0***	***6.0***	***3.0 – 4.0***	
Shortfall or Excess Log Removal	***0***	***0***	***1.5 to 2.5***	Shortfall can be addressed by UV
Option 3				
Coagulation/Flocculation/Sedimentation/Media Filtration	2.0	2.0	3.0-4.0	Log removals based on a 95th percentile of <0.3NTU
Chlorination	4.0	4.0	0.0	C·t > 15 mg·min/L with pH < 8.5 at all water temperatures. Feed water turbidity < 1.0 NTU.
Total	***6.0***	***6.0***	***3.0-4.0***	
Shortfall or Excess Log Removal	***0***	***0***	***1.5 to 2.5***	Shortfall can be addressed by UV

6.7.2 Common Elements

6.7.2.1 Blending

The intent for all options is to continue blending bore water and River water. This is based on an assumption that whilst there is a license to supply up to ~186kL/day from the River every day of the year, there is a benefit in reducing extraction of surface water through supplementing with ground water. This operating scenario means that there is a smaller change in hardness and alkalinity when transferring to bore only supply during emergency scenarios.

With a bore water flow of 2.5 L/sec the current 'base' blend for instantaneous flow is for ~20% bore water and 80% River Water (2.5 L/sec and 11 L/sec). The intent would be to investigate the installation of variable

speed drives on the raw water pumps to provide a ratio of up to 50:50 by slowing down the River Water supply to ~ 2.5 L/sec.

6.7.2.2 Residuals Handling

The preferred option for residuals handling is to utilise two sludge lagoons for balancing instantaneous flows and capturing, and ultimately drying, solids. Supernatant will then be returned to the WTP.

The lagoon design should consider that the supernatant return flow should be less than 10% as an instantaneous flow and during winter only in the order of 7 kL/day can be returned through the WTP due to the daily demand. Hence an ability to irrigate would be advantageous.

6.7.2.3 UV Treatment Barrier

Based on the assessment of the source as being a Category 4, UV is recommended to ensure a multi barrier approach to chlorine resistant protozoa. Hence regardless of the process train a UV system is recommended.

6.7.2.4 Chlorine Disinfection

Liquid sodium hypochlorite is preferred (verbal communication site visit 02/09/2020) with a new dosing system to be provided with any new treatment infrastructure.

6.7.2.5 Fire Risk

The site is close to town and surrounded by open grassland, hence the fire attack level is expected to be low.

Recommend a fire attack study be completed to inform the materials and construction methods for the WTP.

6.7.2.6 Power Availability

Site power is delivered via overhead lines and available capacity will need to be confirmed during the next phase.

6.7.3 Option 1 – Membrane Filtration

Raw water would be pumped to the WTP from the McLaughlin River and bores at an Operator controlled blend ratio being dosed with coagulant prior to entering a coagulation/flocculation and balance tank.

The coagulated and flocculated water will then be pumped through a strainer, a membrane, a UV unit and be dosed with chlorine prior to a treated water storage tank.

Membrane fouling through solids accumulation and adsorption of dissolved contaminants will occur. Regular backwashing, every 30 to 60 minutes, is required to remove accumulated particles, with chemical cleaning undertaken monthly.

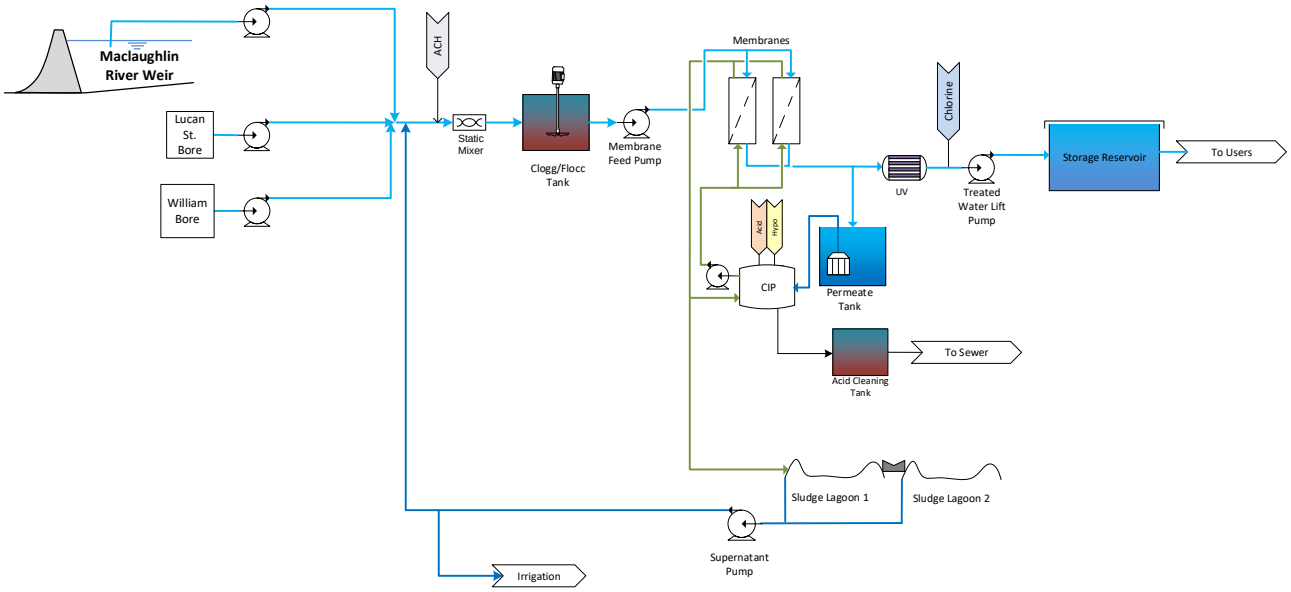


Figure 6-13: Schematic of the Nimmitabel Membrane Filtration WTP.

The key elements of Option 1 are:

1. Variable Speed transfer of River Water to blend with bore water from 10% to 50%
2. Raw Water Coagulation and flocculation
   i. Addition of a coagulant to bring particles together and convert some dissolved organic carbon into total organic carbon that can be filtered
   ii. Flocculation time of 10 to 15 minutes to assist the growth of coagulated particles to enhance their capture in the filter.
   iii. High level estimate for coagulant usage is less than 530 L/annum allowing for delivery of 15 L packages with small pumped transfer into a 100L to 200 L tank.
3. Membrane filtration]
   i. Membrane feed pumps take water from the coagulation/flocculation tank and push it through strainers and the membrane all the way to the treated water storage reservoir (or local treated water tank before pumping to the reservoir)
   ii. Due to the low temperature and to minimise chemical cleaning the flux would be limited to a value of < 35 l/m^2/hour
   iii. In the order of 550 m^2 of filtration surface area provided by 10 to 15 membrane filtration modules.
   iv. Cleaning chemicals for a surface water with coagulation and organics will include citric acid for low pH clean to remove scaling and in organics and a chlorine clean of ~500 mg/L to manage organic and biological fouling.
4. Sludge lagoons
   i. At a yearly production of 38 ML (104 kL/day)
   ii. An estimated TSS of 20 mg/L (conservative)
   iii. There is a production of 25.3 m^3 of 3% TSS sludge
   iv. Provide 2 lagoons, each approximately 50m^2 base area
   v. Supernatant pump station to return supernatant to the raw water storage tank
5. Ultraviolet disinfection
   i. Dose of 40 mJ/cm^2
6. Chlorine disinfection

6.7.3.1 Membrane Chemical Cleaning

Strategies for managing chemical cleaning for small membrane WTP's include.

- Specification of minimum use of chemicals, for example chemical cleaning interval of at least 6 weeks with no intermittent "maintenance" or "enhanced" chemical cleaning.
- Collection of cleaning waste in a dedicated lagoon and allowing for evaporation

- Collection and neutralisation of sodium hypochlorite cleaning waste and recycle through the sludge lagoons back to the plant feed at a low rate
    - Not suitable for citric acid or phosphorous based cleaners.

6.7.4 Option 2 – DAFF or DAF followed by Filtration

The key advantage of DAF/F is to ensure that a conventional filtration plant can operate effectively, safely and efficiently through dirty water events which are relatively common, if not particularly bad, on the Maclaughlin River which will challenge a direct media filter process.

Raw water would be pumped to the WTP from the McLaughlin River and bores at an Operator controlled blend ratio being dosed with coagulant prior to entering the flocculation zone of the DAF/F.

The coagulated and flocculated water then enters the DAFF cell and is contacted with small microbubbles, released from solution, following the introduction of an air saturated water stream, which attach to flocs as they rise to the surface. The clarified water is either removed from underneath the DAF (in the case of a straight DAF process) or passes directly onto the filter under the DAF (in the case of an in-filter DAF or DAF on filter process – commonly referred to as a DAFF process). The float is removed periodically using a mechanical scraping mechanism or a temporary flooding process and is assisted via water sprays to separate the float from the walls. The saturated air stream is prepared by pumping clarifier or filtered water into a high pressure saturator where air is introduced. Under these high pressure conditions, the water becomes saturated with air. The air saturated water is then returned to the DAF injection system and bubbles are released via a pressure drop provided from a dispersion valve. This pressure drop releases the micro bubbles from the water and allows them to contact with the flocs and a float is formed.

Depending on the raw water pH and the selected coagulant, pH correction (through acid or alkali dosing) may be required prior to coagulant dosing to achieve the optimal coagulation pH range.

Filtered water would then pass through a UV unit prior to chlorination and entry into a local treated water storage tank which would act as a buffer to allow the transfer pumps to operate effectively to transfer water to the reservoir.

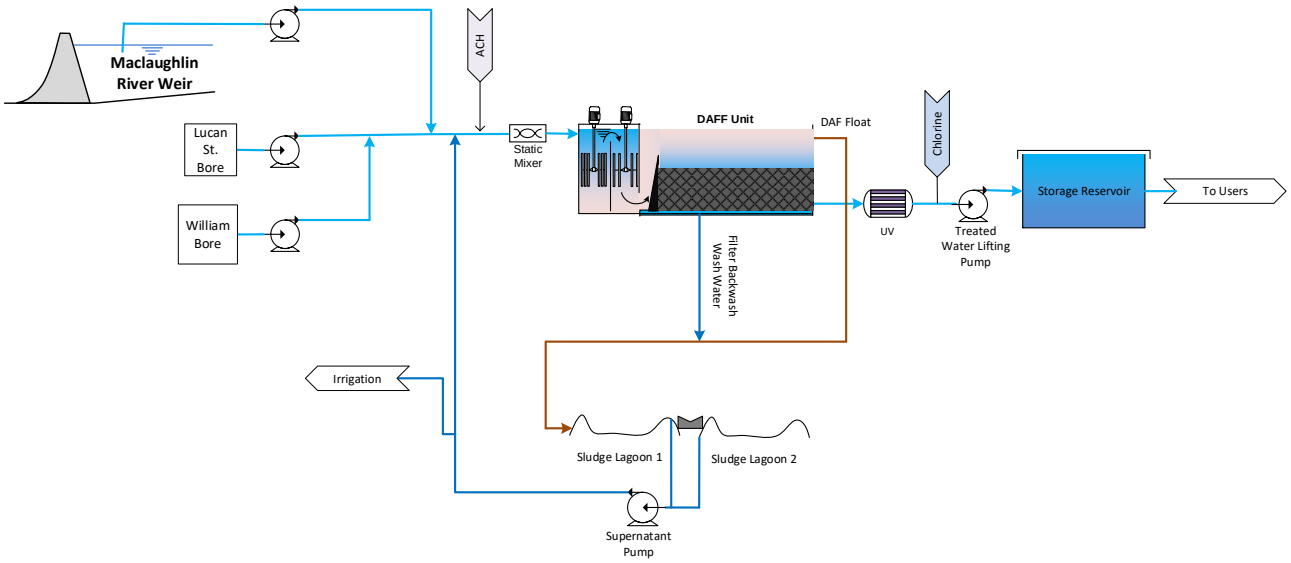


Figure 6-14: Schematic of the Nimmitabel DAFF WTP.

The key elements of Option 2 are:

1. Variable Speed transfer of River Water to blend with bore water from 10 to 50%
2. Coagulation and flocculation
    i. Addition of a coagulant to bring particles together and convert some dissolved organic carbon into total organic carbon that can be filtered
    ii. Flocculation time of 10 to 15 minutes to assist the growth of coagulated particles to enhance their capture in the filter.

iii. High level estimate for coagulant usage is less than 530L/annum allowing for delivery of 15L packages with small pumped transfer into a 100L to 200L tank.

3. Floatation and filtration
   i. Floatation of the flocculated water through contacting with microbubbles with the maximum recycle rate of 15% and loading rate of <10 m/h.
   ii. In the order of 2.2 m^2 of DAF surface area in a single DAFF.
4. Sludge lagoons – As per option 1
5. Ultraviolet disinfection
   i. Dose of 40 mJ/cm^2
6. Chlorine disinfection

6.7.5 Option 3 – Inclined Plate Settler Clarification/Media Filtration

Raw water would be pumped to the WTP from the McLaughlin River or the bores at a constant rate to a raw water storage tank, before being dosed with a coagulant, and transferring to a Inclined Plate Settler (IPS) tank at a constant rate. After settlement of the flocculated solids in IPS, the water will be passed through the media filters.

Depending on the raw water pH and the selected coagulant, pH correction (through acid or alkali dosing) may be required prior to coagulant dosing to achieve the optimal coagulation pH range.

Filtered water would then pass through a UV unit prior to chlorination and entry into the treated water storage reservoir.

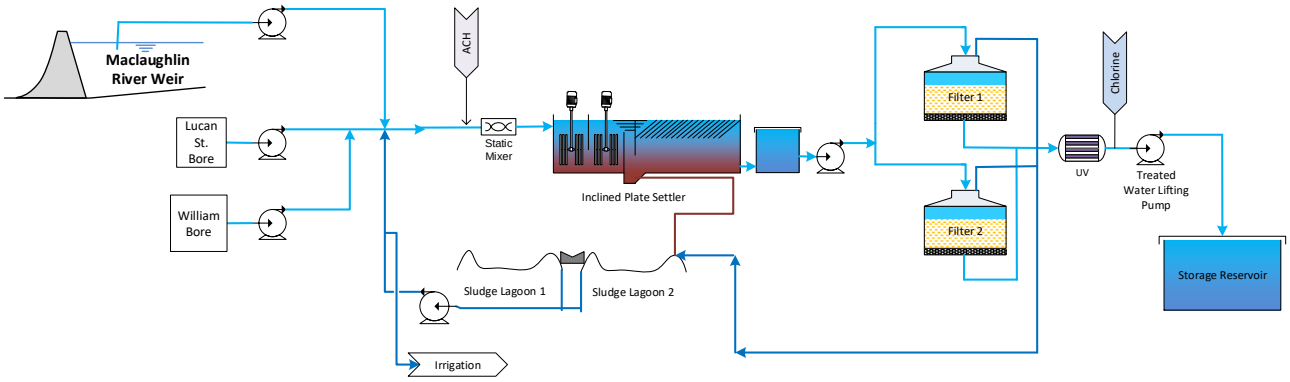


Figure 6-15: Schematic of the Bredbo Membrane Filtration WTP.

The Key elements of Option 3 are:

1. Coagulation, flocculation and sedimentation
   i. Addition of a coagulant to bring particles together and convert some dissolved organic carbon into total organic carbon that can be filtered. High level estimate for coagulant usage is less than 530 L/annum allowing for delivery of 15 L packages with small pumped transfer into a 100L to 200L tank.
   ii. Flocculation time of 10 to 15 minutes in flocculation zone of the IPS to assist the growth of coagulated particles to enhance their sedimentation in the sedimentation zone of the IPS.
   iii. Sedimentation of the flocculated solids in sedimentation zone of IPS with the loading rate of about 7 m/h and in the order of 2.7 m^2 surface area.
2. Pressure media filtration
   i. Filtration rate of less than 10 m^3/hr per m^2 of surface area (m/hr)
   ii. In the order of 2.4 m^2 of filtration surface area provided in 2 to 5 individual pressure media filters.
3. Sludge lagoons – As per option 1
4. Ultraviolet disinfection
   i. Dose of 40 mJ/cm^2
5. Chlorine disinfection

6.7.6 Hardness Reduction

At the workshop (13/10/20) a minute was made to incorporate a discussion of hardness removal in the WSSS and to engage with the community around this option. In particular, considering a willingness to pay by the community for hardness reduction when the bores were used as the sole supply. The following is a summary of the option for hardness reduction. For community engagement a detailed yield study is required to nominate the likely frequency of 100% bore use and the likely duration of these events.

6.7.6.1 Frequency and Duration of 100% Bore use and softening

Softening is not being pursued under a typical operating scenario when blending of the River and bore water is able to achieve a total hardness in the range of 100 to 140mg/L as $CaCO_3$. This is achieved through utilising the historical blend ratio of ~60% River and 40% bore water and likely a blend of up to 70% River and 30% bore water once controls are in place through a new WTP.

To consider the frequency and duration of operation with 100% bore water, the scenarios that would result in this outcome have been summarised as

- A pipe break between the River pumping station and the new WTP
  - Likelihood - possible but a low likelihood
  - Duration – Unlikely to stop supply for more than 1 week
- A major failure of the Maclaughlin River pumping station
  - Likelihood - possible but unlikely with appropriate preventative maintenance
  - Duration - weeks up to a couple of months to get a temporary solution in place
- Planned maintenance of the pipeline/pumping station
  - Can be undertaken in winter with low demand and existing storage provides 4 – 5 days before bore water would need to be used as 100%
- During extended drought
  - likelihood – will happen, with a drought needing to be more severe than the drought leading into the start of 2020
  - duration – anywhere from days to months, unable to predict.

For the above scenarios the only one that would require softening for more than a couple of weeks would be the extended drought scenario. The likelihood of the frequency and duration of such events requires a detailed yield analysis to be undertaken. However, ultimately droughts are unpredictable.

6.7.6.2 Softening Process and Target

During the Workshop it was recommended that the use of nano filtration (NF) or reverse osmosis (RO) would be the most appropriate for softening of the bore water for a small and relatively clean supply with a yield in the order of 200 kL/day. The target hardness was suggested as 100 mg/L as $CaCO_3$ to match the hardness of the water that would be supplied under a typical blend scenario of River and Bore water.

Both NF and RO require very low suspended solids and so the upstream treatment would remain essentially the same up to the inlet to the Treated water balance tank (TWBT), where a portion of the feed would be diverted to the RO Feed tank with the remainder, around 40kL/day, travelling to the TWBT without being softened.

The chlorination point, typically on the inlet to the TWBT, would be relocated to the outlet of the tank as RO membranes are not tolerant of chlorine.

From the RO Feed tank a package NF/RO plant would take the 160kL/day and return ~130kL/day to the TWBT where the blend would be transferred with the existing transfer pump to the Storage reservoir, receiving chlorination on the way.

The NF/RO would have in the order of 80% recovery with 30 kL/day of concentrate being directed to evaporation lagoons built next to the WTP. These lagoons would be lined to prevent contamination of local groundwater and be sized based on the yield study and an estimate of the maximum duration of 100% bore water supply and the demand over this period.

As a high level example, to cover 3 months of NF/RO operation to produce 15ML of potable water, in a low evaporation period an area of around 2000m^2 would be required with a storage of ~2.5ML. This in theory

would dry in 6 – 12 months with the typical pan evaporation of 1200mm/annum. Noting that it is very hard to guarantee as evaporation rates decrease as TDS increases (Figure 6-17).

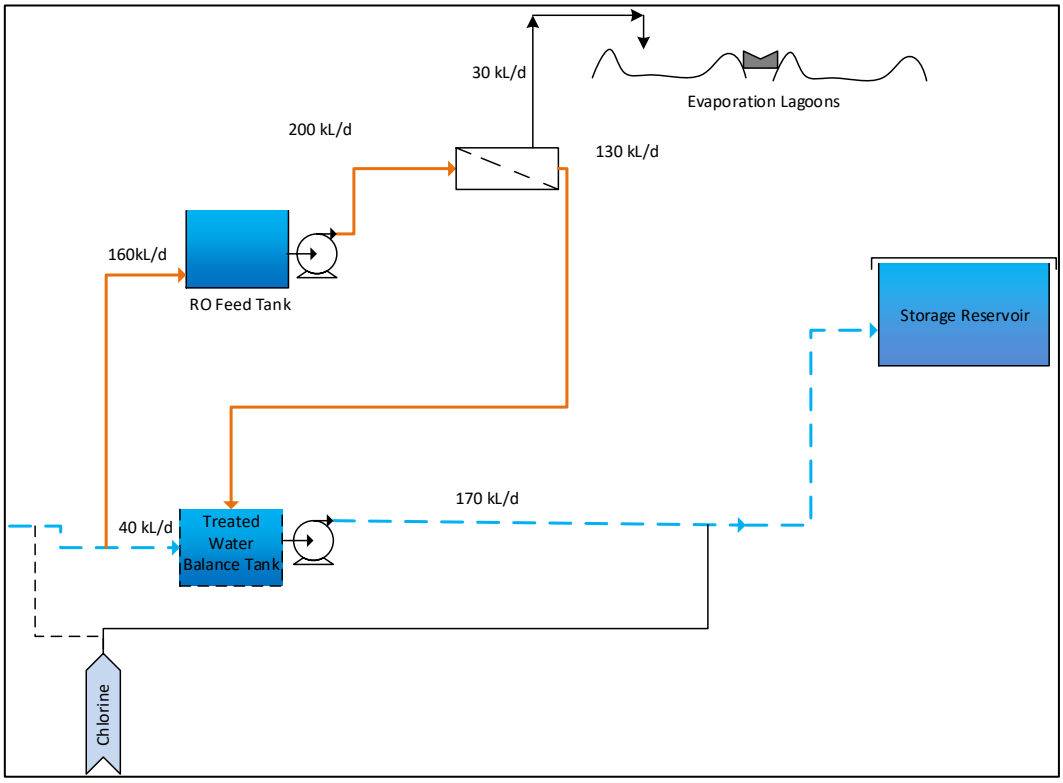


Figure 6-16 Preliminary NF/RO concept

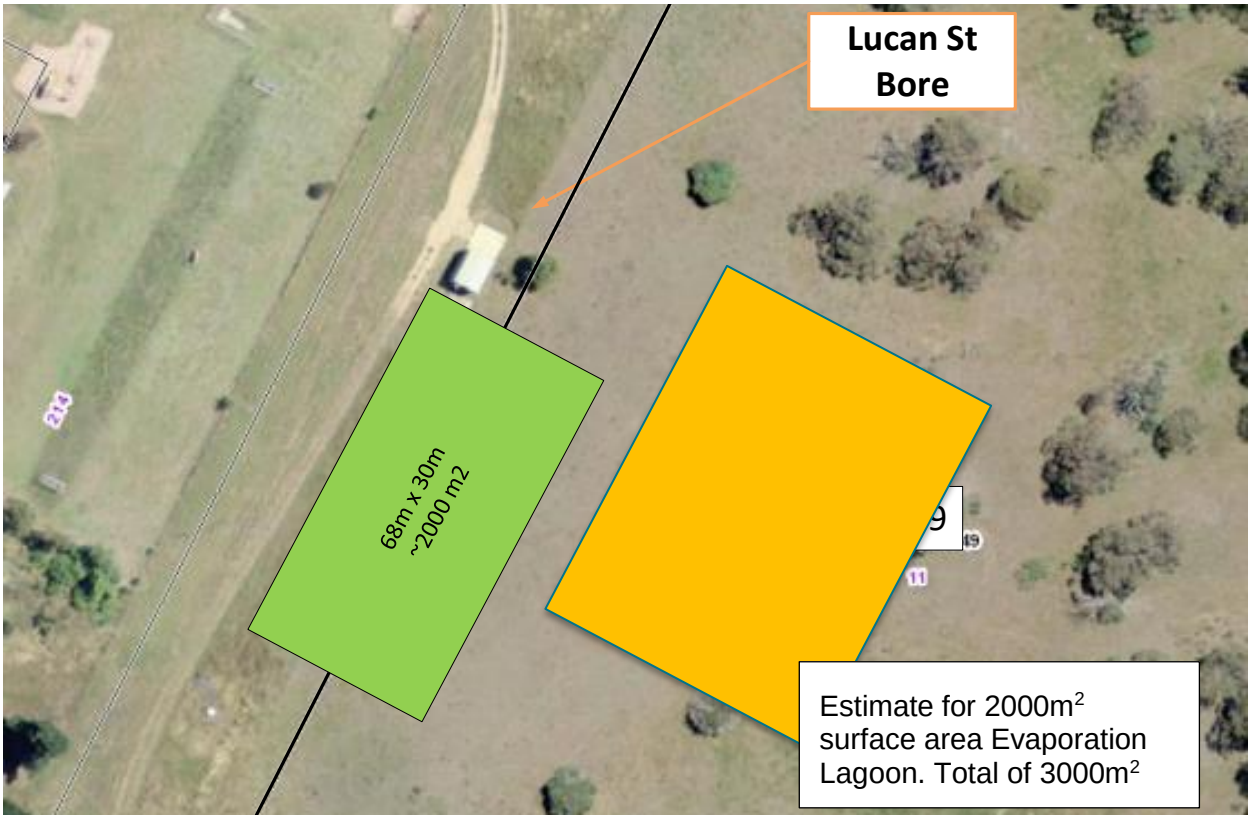


Figure 6-17 High level estimate of a "3 month" evaporation Lagoon

6.7.6.3 Order of Magnitude Costing

At a high level, a 200 kL/day RO unit in a shipping container with essentially standalone control is $300k (supplier budget quote). To this based cost it is reasonable to add $50k for integration into an existing WTP giving a total cost of $350k. This is a basic package plant cost so there is no choice of components, materials, valves, pumps, PLC etc..

An estimate for a very simple HDPE lined lagoon with a surface area of 2000m^2 would be $150k, assuming reasonably flat and suitable ground and suitable geotech.

So in total an order of magnitude estimate, without management, additional studies (eg a review of environmental factors), contingency etc, would be $500k when constructed in addition to a complete WTP.

6.8 Preferred Option

The strengths and weaknesses of the shortlisted options have been compared and scored in Table 6-5;

- 1 is given for an option that has the most weaknesses
- 2 is given for an option that has both strengths and weaknesses
- 3 is given for an option that demonstrates strengths that align with the requirements of the location.

The simplified scoring suggests that Option 1, direct membrane filtration and Option 2, DAF/F are comparable solutions across the criteria selected with a score of 15.

However, in considering the treatment trains preferred for other Village locations and to provide a single preferred option, given the historical 95th turbidity percentile of less than 15 NTU, with rapid increase and decrease that may be difficult for a clarification process to manage, Option 1 – Membrane Filtration is preferred for Nimmitabel.

Table 6-5: Nimmitabel Comparison of Key Strengths and Weaknesses.

	Option 1 Direct Membrane Filtration	Option 2 DAF/F	Option 3 Inclined Plate Settler Clarification/Media Filtration
Total Score	**15**	**15**	**14**
Footprint	Filtration unit is the smallest of the options but there are requirements for additional tankage and strainers which evens out the footprint.	Relatively small and compact.	Narrow. Filtration: Compact with skid mounted pressure media filters.
	2	**2**	**2**
Water Quality/Quantity Typical	Easily able to manage the typical water quality. Automatic test to demonstrate integrity of membrane. No issue with multiple start/stop operation.	Be easily able to comply with the ADWG, both in the quality of water produced and in the validation of the treatment process to achieve the required log removal of pathogens. Typically start easily and so can be used start/stop.	Easily able to manage the typical water quality. Some Australian installations have treated water in excess of 3,000 NTU water with IPS.
	Coagulant utilised to remove organics. If no coagulant is used then backwash water not able to be returned, would need to be irrigated. Production stops for 2 – 6 hours for chemical cleaning every 4 to 8 weeks.	Most efficient when operated at their design flow for shorter periods as opposed to running at lower flows for longer periods. With a good 'float' start and stop of the process is not a concern however the stability of the float cannot be guaranteed with the testing undertaken to date.	
	3	**3**	**3**
Water Quality/Quantity during "Events" (For Nimmitabel this is a rapid increase in turbidity from ~4 NTU to above 30 NTU)	Membranes are a barrier and quality (pathogens and TSS) will not be affected by raw water quality change. Can't get 'breakthrough' of turbidity.	Automatic backwashing on differential pressure and turbidity breakthrough as the raw water quality changes. Consistent filter run time without early breakthrough given upfront clarification. Low risk of over loading the filter and filter breakthrough if pre-treatment is optimised during an event with turbidity up to 100 NTU.	Automatic backwashing on differential pressure and turbidity breakthrough as the raw water quality changes. Consistent filter run time without early breakthrough given upfront clarification. Low risk of over loading the filter and filter breakthrough if pre-treatment is optimised during an event with turbidity up to and above 100 NTU.
	Some extra backwashing required with increasing turbidity and a reduction in throughput. If close to needing a chemical clean, increased solids can trigger a CIP and halt production. Will not treat soluble metals. Will not treat taste and odour. Can have colour breakthrough if there is 'true colour'.	Large water quality changes require the operator to optimise the pre-treatment coagulant dose to achieve low subnatant turbidity. Not suitable for turbidity over 100 NTU for long periods (days).	Large water quality changes require the operator to optimise the pre-treatment coagulant dose to achieve low supernatant turbidity. As quality improves pre-treatment must be managed to limit overdosing of coagulant that may reduce filter run times. Site visit and a level of attendance will be required during the event and as the quality improves. Some algae is difficult to settle.
	2	**2**	**1**

	Option 1 Direct Membrane Filtration	Option 2 DAF/F	Option 3 Inclined Plate Settler Clarification/Media Filtration
Total Score	**15**	**15**	**14**
Control and Monitoring	Basis of control and monitoring as per conventional filtration. Can stop and start numerous times and not impact the quality.	During periods of stable raw water quality with a proper design (online monitoring) daily attendance is not required.	IPS: Simple process to control, few variables other than chemical dosing. Very little operator intervention required. Filtration: Simple to understand and monitor headloss and filtered water turbidity. During periods of stable raw water quality with a proper design (online monitoring) daily attendance is not required.
	Lots of different sequences to understand when troubleshooting. "Black box" control and monitoring of a proprietary system. Need to monitor over the long term to pick up slow building problems that can fall over the cliff. Post dosing is stop start every 30 – 45 minutes when there is a backwash, and this can complicate monitoring of post treatment.	DAFF requires careful operation of the DAF and regular optimisation of the coagulation chemistry, particularly during raw water turbidity and colour events. Changing raw water quality will require close remote monitoring and likely daily attendance to allow for optimising the process.	Chemical dose rates and wasting require modification to adapt to changing conditions.
	2	**2**	**2**
Ease of Maintenance	Ancillary equipment is standard and can be maintained in house.	Fairly standard mechanical kit and can be maintained in house. A typical media filter will only require media replacement every 10 – 20 years.	IPS: Low - Flocculation mixers only Filters: Can incorporate multiple filters to improve redundancy. Commonly available components can be maintained in house.
	Production stops for 2 – 6 hours for chemical cleaning every 4 to 8 weeks. Valves are often at awkward heights and locations due to the systems being proprietary. Typically have a third party engagement to manage membranes which has a cost. Typically involve some proprietary kit needing external assistance (e.g. membrane repair).	Likely to only have a single DAF and Filter making maintenance on some components difficult.	Need access with a crane to pull out mixers. Need to ensure that access is provided around the filter and to the top of the filter for media removal and replacement. Sludge can build up in the sludge hopper.
	2	**2**	**1**

	Option 1 Direct Membrane Filtration	Option 2 DAF/F	Option 3 Inclined Plate Settler Clarification/Media Filtration
Total Score	**15**	**15**	**14**
Residuals Handling	Small volume every 30 – 45 minutes.	High recovery due to clarification extending filter run times. DAF float generally breaks up when travelling to the next process and settles well.	Sludge scour and filter backwash, typically around 5% of flow.
	Typically, slightly lower first pass recovery than conventional at ~ 95%. Need to manage cleaning chemical residuals.	The instantaneous backwash rate is 4 – 5 times the plant flow rate and can be a large power draw compared to the remainder of plant. DAF float is not always easily settled however typically with some mixing when the float is removed on its way to a sludge lagoon the float settles well.	For one or two filters the instantaneous backwash rate is 4 – 5 times the plant flow rate and can be a large power draw compared to the remainder of plant.
	2	**2**	**2**
Environmental Impact Physical Visual Noise Energy	Slightly less coagulant than a conventional plant.	Would be housed indoor.	Quiet operation, backwashing can be scheduled for 'business' hours as typically once a day. Low energy and chemical use.
	Has to backwash every 30 - 45 minutes which makes more noise at night (supplier dependent). Membranes have a 7 – 10 year life and will end up in landfill. Uses more chemicals with hypo and citric acid required for chemical cleaning. However, practically small volumes.	Tall building required. Coagulant is required introducing aluminium to the backwash water and limiting reuse potential. Continuous operation of the recycle pumps and compressor make this the highest base load noise option. Slightly higher power consumption in the order of 0.15kWhr/kL. Recycle of 15% of the water at 600kPa principal energy demand along with compressed air.	Coagulant is required introducing aluminium to the backwash water and limiting reuse potential.
	2	**2**	**3**

7 Eucumbene Cove

Table 7-1: Eucumbene Cove Summary.

Component	Eucumbene Cove – 60 kL/day		
Demand (kL/day)	2020 ADD	2020 PDD	2050 PDD
	No Data	No Data	58.2
Reservoir Capacity	400kL which meets the general rule of thumb of holding a peak day volume.		
Offline Capacity	2020 ADD ~ 24 days 2020 PDD ~ 4 day		
Key Water Quality Challenges	Raw water hazards ▪ Turbidity / suspended solids ▪ Pathogens (Category 3 source water) ▪ Bore Water Hardness ▪ Algae		
Raw Water Quality Uncertainties	▪ Presence or absence of soluble iron		
C.t	Minimum level to achieve a C.t of 15 mg.min/L of 5% in the reservoir		
Raw Water Pumping	The existing pump has sufficient capacity at 1.2 L/sec,150% higher than the required flow at 0.8 L/s.		
Site location			
Land Acquisition Required?	No		
Shortlisted Options Considered	The only feasible option for Eucumbene Cove is direct membrane filtration (MF or UF).		
Preferred Option	direct membrane filtration (MF or UF)		
Residuals Management	The backwash water can be stored in a small tank and directly used for local irrigation. The membrane cleaning solution can be collected by operations in a ‘back of the truck’ container to be emptied at a STP.		
UV Disinfection	Not recommended due to the preliminary catchment categorisation of 3. “Poorly Protected Catchment”		

Recommendations	In addition to the recommendations of previous reports ▪ Approach Snowy Hydro to confirm the design of the outlet and related risk of soluble metals ▪ Fire Attack Study ▪ Confirmation of availability of Power ▪ Chlorine decay testing and impact on the pH from continual top up.

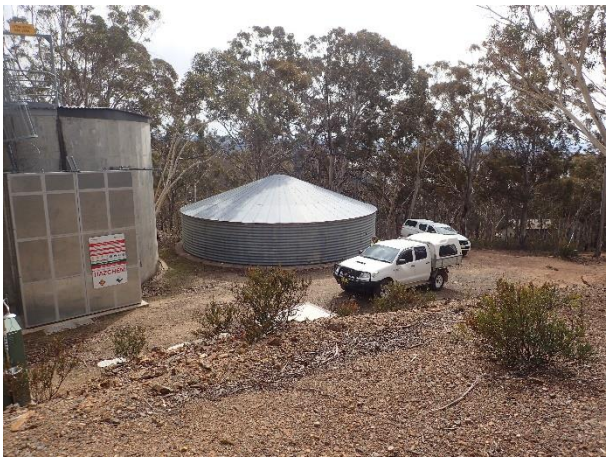
7.1 Overview

Eucumbene Cove is located approximately 60km by road from Cooma. Eucumbene Cove draws water from Lake Eucumbene. Eucumbene cove accesses raw water from the Eucumbene Dam wall outlet (controlled by Snowy Hydro).

The town is essentially a holiday destination with few permanent residents with 41 supply connections (SMRC).



Gravel access road to reservoir location



Storage Reservoir and the old storage tank

Figure 7-1: Overview of Eucumbene Cove Infrastructure.

7.2 Service Area

GIS data from SMRC was used to provide an indicative service area for each Village and is presented below in Figure 7-2.

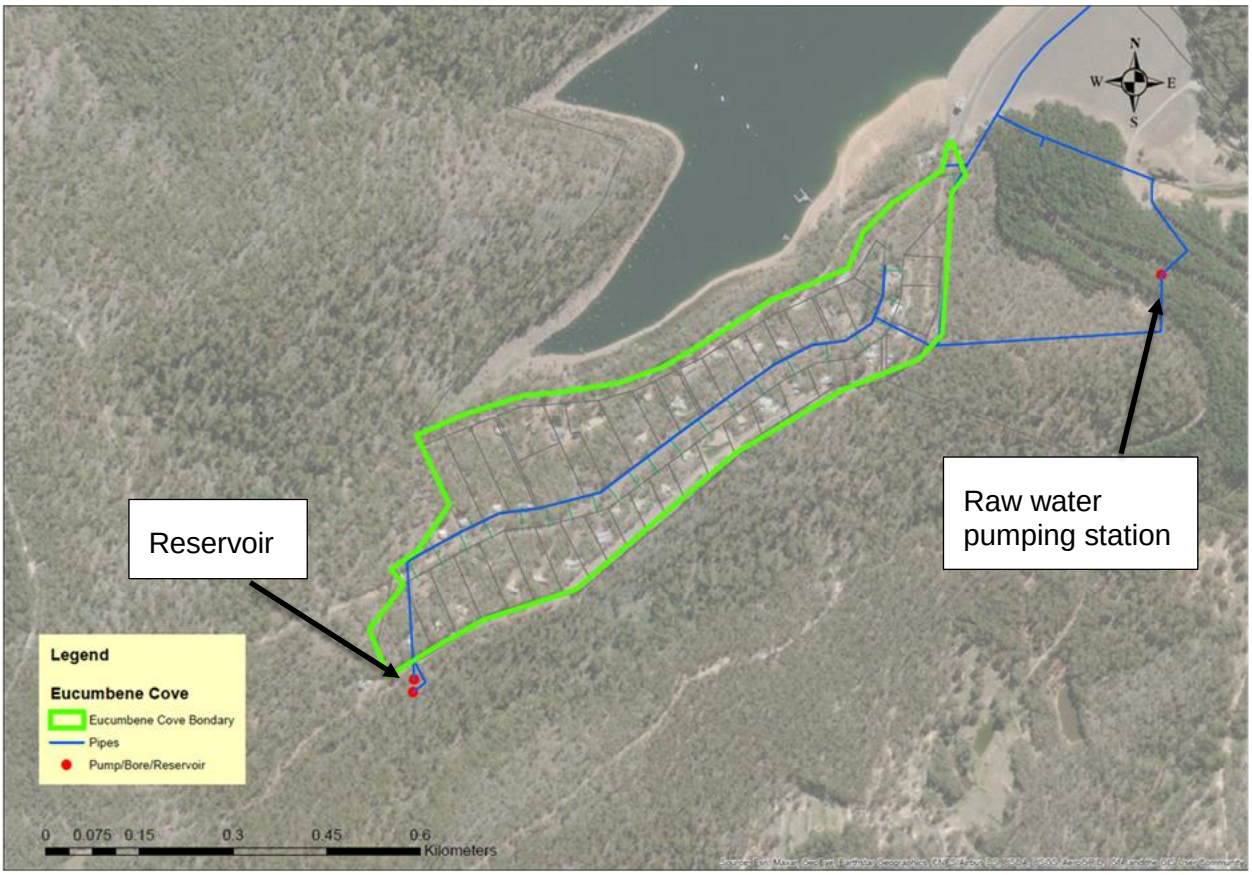


Figure 7-2: Eucumbene Cove Service Area.

7.3 Historical and Forecast Demand

Table 5-2 provides a summary of this data and includes the forecast 2050 PDD and the proposed treatment plant capacity to service this demand (*Service Area and Demand Memo* (Hunter H2O, 2020)).

Table 7-2: Eucumbene Cove Historical and Future Demand and the Raw Water Pumping Capacity.

Village	Source	Raw Water Pumping Capacity (kL/d)	Historical PDD (kL) (2020)	Historical ADD (kL) (2020)	2050 PDD for Treatment Capacity[1]	2050 PDD for Treatment Capacity[1]
Eucumbene Cove	Lake Eucumbene (Dam Wall)	104	No data	No data	58.2	60

Note 1. 1% annual population growth was adopted for the 2050 projections.

7.4 Source Water Assessment

The Eucumbene Cove raw water supply was considered and is presented in detail in the *Source Water assessment Report* (Hunter H2O, 2020). The following sections provide a summary of the typical raw water hazards and challenges to be managed day to day to improve the aesthetic quality and water safety.

7.4.1 Pathogens

A high level assessment of pathogen risk was undertaken using the Health Based Targets (HBT) guidance manual (Water Services Association of Australia, September 2015) and is presented in the Source Water

Assessment (Hunter H2O, 2020). The assessment determined that the Eucumbene Cove source was conservatively a Category 3 source (Hunter H2O, 2020).

As a Category 3 source to achieve a target of an additional health burden, from potable water, of less $1x10^{-6}$ DALY's (Disability Adjusted Life Years) the following log reductions are recommended by the guidance manual and will require a multi barrier approach.

- **5.0 log_{10} reduction in Bacteria**
- **4.0 log_{10} reduction in Viruses and**
- **3.5 log_{10} reduction in Protozoa**

7.4.2 Chemical/Physical

From a review of the available raw water data the following are considered the key raw water hazards which require mitigation/barriers to reduce the associated health or aesthetic risk to an acceptable level at Eucumbene Cove.

Turbidity / Suspended Solids

- The raw water turbidity is routinely low but still above the target for disinfection of less than 1NTU.

Colour

- The true colour from the reticulation is typically low with a maximum of 7 HU.
  - This is above the best practice target of 5 HU.

Organics

- There is no data available for any organic material level for Eucumbene Cove.

pH and Alkalinity

- The water has a very low alkalinity
- Data available suggests that the pH is typically 7 to 8.5.

Hardness

- The raw water total hardness results from the reticulation of Eucumbene cove were in the range of 6.9 to 11.8 mg/L as $CaCO_3$.

Algae (To Be Confirmed)

- Not raised as a risk
- Recommend contacting Snowy Hydro and asking them to share water quality monitoring results which may include algae.

7.4.3 Raw Water Quality Design Envelope

Table 7-3 outlines the preliminary raw water design envelope for the Eucumbene Cove WTP following consideration of available raw water data, its quality, and the impact of various elements. The envelope is intended as a living document to be considered through the project and adjusted as more information becomes available to balance risk and cost.

A monitoring program has been recommended, and provided separately, with key gaps for Eucumbene Cove that are recommended to be filled being;

- The presence or absence of soluble iron

Table 7-3 Preliminary Raw Water Envelope

Parameter	Units	Preliminary Raw Water Design Envelope			
		5th percentile	Median	95th percentile	Maximum
Temperature	Celsius	5	15	25	5
pH		6.5	6.9	7.7	8.0[1]

Parameter	Units	Preliminary Raw Water Design Envelope			
		5th percentile	Median	95th percentile	Maximum
TDS	mg/L	12	17.5	32	32
Alkalinity	mg/L as $CaCO_3$	15[1.]	20[1.]	30[1.]	70[1.]
Turbidity	NTU	0.9	3[1.]	10[1.]	15[1.]
True Colour	Hazen	0.5	2	15[1.]	30[1.]
Calcium	mg/L (Ca)	2.2	2.6	3.5	3.5
Magnesium	mg/L (Mg)	0.67	0.76	0.95	0.95
Total Hardness	mg/L $CaCO_3$	9.1	9.7	11.7	11.7
Total Iron	mg/L	0.04	0.2[1.]	0.3[1.]	0.5[1.]
Soluble Iron	mg/L		0.15[1.]	0.2[1.]	0.3[1.]
Total Mn	mg/L	0.0025	0.005	0.011	0.011
Soluble Mn	mg/L				
TOC	mg/L				
DOC	mg/L				
Fluoride	mg/L	0.9	1.0	1.0	1.1

1. Values highlighted in green are estimates that are believed, following a review of data, site visit and discussion with Operators, to better represent the raw water challenge. These are TBC during the next phase.

7.5 Existing Instructure

The following information is based on information provided and visual inspection during site visits. The scope did not include a detailed condition assessment to allow nomination of remaining life of assets.

7.5.1 Raw Water Pumping

Raw water is sourced from a take-off point inside the Eucumbene Dam outlet tunnel (Snowy Mountains Hydro-Electric Authority, 1997). The water from Lake Eucumbene to the reservoir is transferred via a pump with capacity of 1.2 L/s.

It is recommended that the operation of the outlet tunnel, in particular the level (below the surface/above the base of the dam wall) which water is drawn from, is confirmed.

In comparing the raw water flow requirements of the proposed WTP, the existing pump has sufficient capacity at 1.2 L/sec,150% higher than the required flow at 0.8 L/s.

7.5.2 Reservoir

Key capacity information on the Eucumbene Cove Reservoir from the *Options Assessment Report* (Hunter H2O, September 2020) is,

- The 2020 PDD is 15% of the reservoir capacity of 400kL.
- The minimum level required for C.t, with a target of 1 mg/L and flow at 3xPDD 20%.
- 60% of the reservoir provides 24 days to repair an issue for the average day demand.
- 60% of the reservoir provides 4 day to repair an issue for the PDD.

Based on the available information capacity upgrades are not recommended for the Eucumbene Cove Reservoir.



Figure 7-3: Eucumbene Cove Reservoir (Left).

7.5.3 Disinfection

A disinfection dosing and monitoring system was installed but has been abandoned.

7.6 Proposed Site Location

Figure 7-4 shows the location of the storage reservoir and also the old storage tank with the only location identified to locate new infrastructure being to remove the old storage tank.

There is no available land area for sludge lagoons, and mechanical dewatering is not practical for such a small plant with low TSS.

Following the high-level consideration of barriers available to manage the identified raw water hazards for Eucumbene Cove, a small containerised direct membrane filtration plant without coagulation would be suitable to meet the water quality targets. This allows the backwash water to be used for local irrigation without any treatment or settlement and prevents the construction of the high foot-print sludge lagoons. Due

to the small volume of cleaning chemicals they would be collected and removed by operations in a 'back of the truck' /trailer container to be emptied at a STP.

The membrane shipping container can be installed in place of the old storage tank, as is shown in Figure 7-4.



Figure 7-4: Eucumbene Cove Reservoir and Old Storage Tank.

7.6.1 Health Based Targets

Table 7-4 presents the LRV removal expectation for the direct membrane filtration. The pathogen removal for membranes are indicative. As membrane suppliers have had to work with log removals for the last 20 years, each manufacturer has their own validation information for the rejection of virus and protozoans.

Table 7-4: LRV Expectation for the Direct Membrane Filtration.

	Log Reduction Values			
	Bacteria	**Virus**	***Cryptosporidium***	**Process Critical Limits**
Required Treatment (Category 3 Source)	**5.0**	**4.0**	**3.5**	
Direct Membrane Filtration	4.0	2.0	4.0	Log removals based on a 95th percentile of <0.3NTU
Chlorination	4.0	4.0	0.0	C·t > 15 mg·min/L with pH < 8.5 at all water temperatures. Feed water turbidity < 1.0 NTU.
Total	***8.0***	***6.0***	***4.0***	
Shortfall or Excess Log Removal	***3.0***	***2.0***	***0.5***	

7.7 Preferred Option - Membrane Filtration

Raw water would be pumped to the WTP from Lake Eucumbene at a constant rate to a balance tank external to the package plant. The water will then be pumped through a strainer, a membrane filter and be dosed with chlorine prior to entering the clear water tank.

Membrane fouling through solids accumulation and adsorption of dissolved contaminants will occur. Regular backwashing, every 30 to 60 minutes, is required to remove accumulated particles, with chemical cleaning undertaken monthly.

A key element for Eucumbene cove is to have mixing in the treated water tank, chlorine monitoring on the outlet of the Treated water tank and a small recycle loop sufficient to allow for a top up dose of chlorine to be added to maintain the minimum free chlorine level in the reservoir.

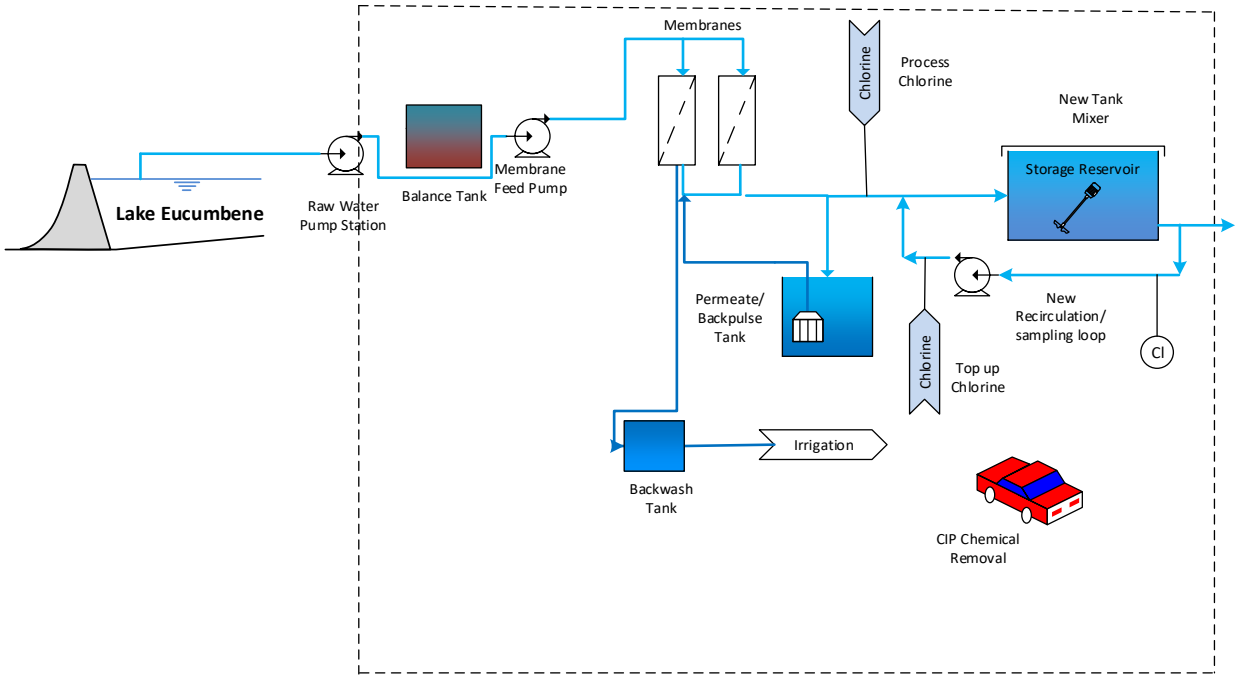


Figure 7-5: Schematic of the Eucumbene Cove Membrane Filtration WTP.

The key elements of the Eucumbene option are:

1. Raw water balance tank
2. Membrane filtration
   i. Membrane feed pumps take the raw water and push it through strainers and the membrane all the way to the treated water storage reservoir.
   ii. In the order of 40 m^2 of filtration surface area provided by about 2 - 4 membrane filtration modules.
   iii. Tankage required for the collection and storage of cleaning solution for transport to a regional WWTW.
   iv. Backwash water is collected in a tank (~1 kL) and used for local irrigation.
3. Chlorine disinfection
4. Reservoir mixing (PAX mixer or similar)
5. Treated water chlorine monitoring and the ability to top up when the WTP is not producing water.

7.7.1 Residuals Handling

The backwash water can be stored in a small tank and directly used for local irrigation.

The membrane cleaning solution can be collected by operations in a ‘back of the truck’ container to be emptied at a STP.

7.7.2 Chlorine Disinfection

Liquid sodium hypochlorite is preferred (verbal communication site visit 02/09/2020) with a new dosing system to be provided.

7.7.3 Fire Risk

The site is a high fire risk and protections will need to be considered in the next phase. Recommend a fire attack study be completed to inform the materials and construction methods for the WTP.

7.7.4 Power Availability

Available capacity is to be confirmed during the next phase.

8 Cost Estimates

8.1 Construction Cost Estimates

Two key sources have been utilised to consider the value of works proposed at the Villages. The first is the NSW Reference Rates Manual, the second is the utilisation of tendered rates for specific items and project costs for small water treatment plants with which Hunter H2O has had a role.

A comparison of the estimates is included in Table 8-1 with the Recent project estimates being at least 30% in excess of the NSW reference rates.

It is recommended to move forward with the value of the recent project estimates and revise the estimate during the next phase of the project.

Table 8-1: NSW Reference Rates and Recent Project Cost Estimate Comparison.

	NSW Reference Rate	Recent Projects Estimate	Comment
Adaminaby	$2.93M	$4.09M	Does not include 1000m of new dedicated rising main
Bredbo	$2.45M	$3.68M	Land acquisition required
Nimmitabel	$2.45M	$3.68M	Land acquisition required Does not include 500m of new rising main to the WTP location
Kalkite	$1.98M	$3.27M	Does not include 1000m of new dedicated rising main
Eucumbene Cove	$0.66M	$0.81	Based on 20foot shipping container solution.

8.1.1 NSW Reference Rates

Table 5 of the NSW Reference Rates contains a 2014 value for a 0.3 ML/d and a 0.5 ML/d conventional water treatment plant, which are considered equivalent to the proposals for the Villages.

Key inclusions are;

- Flash mixing, flocculation, sedimentation, filtration and sludge lagoons without supernatant return.

Key exclusions are

- Land acquisition, power supply, data connection, access roads and fencing.

The guidance manual states “for the valuation of future works, a contingency amount should be added to the reference Rates… may also need to be increased to allow for construction difficulty”

Contingencies are required to allow for risk and uncertainty, made up of inherent and contingent risks. Inherent risk is dependent on the type of asset and the stage that the estimate is completed with the value decreasing as the level of design increases. The manual recommends 30% contingency at a feasibility stage and will be applied to the Villages estimate.

Contingent risk are factors that are beyond the control of the designers or constructors and is dependent on each site and prevailing conditions. The manual suggests that the contingent risk should not exceed 20% and given the sites for each site are relatively accessible and flat a contingent risk of 10% is going to be applied to the Villages Estimate.

Using the reference rates (Figure 8-1), including a contingency of 40% (30% Inherent and 10% Contingent) and escalating the values to 2021 gives an estimate for the Villages presented in Table 8-1. The reference rate includes for survey, investigation, design and project management (SID) so this does not have to be added as a separate line item.

Table 5 Water Treatment Works

	Capacity (ML/d)	*Contract Rate ($) 2014*	*Reference Rate ($) 2014*
Conventional Water Treatment	0.3	958 000	1 150 000
	0.5	1 420 000	1 700 000
	0.8	1 920 000	2 300 000
	1	2 170 000	2 600 000
	2	3 670 000	4 400 000
	5	7 000 000	8 400 000
	10	11 700 000	14 000 000
	20	19 200 000	23 000 000
	40	30 800 000	37 000 000
	50	35 800 000	43 000 000
	70	46 700 000	56 000 000
	100	59 200 000	71 000 000
Lagoon Sedimentation	0.8	1 420 000	1 700 000
	1	1 580 000	1 900 000
	2	2 670 000	3 200 000
	5	4 920 000	5 900 000
	10	8 080 000	9 700 000
	20	13 300 000	16 000 000

NOTES

1. These rates are for June 2014 valuation of the capital cost of existing assets and exclude contingencies and the GST. A suitable percentage for contingencies must be included (section 2.5 on page 8) for valuation of new works. Refer to the box on page 17 for further information on the use of lagoon sedimentation for water treatment.
2. Review of recent contract rates for water treatment works has shown increases of 40% or more above the capital cost inflation rate since 2003.
3. Reference Rate = 1.20 x Contract Rate (ie. Contract Rate plus SID of 20%).
4. The rates include civil, mechanical and electrical costs for both conventional water treatment works and also for lower cost lagoon sedimentation works.
5. For treatment works of ≥ 5 ML/d, the mechanical. electrical and process components of water treatment works are each approximately 13% of the Contract Rate, while the civil component is approximately 60% of the Contract Rate for the water treatment works and includes a clear water tank with 1 hour's storage capacity.
6. Excavation is in OTR.
7. Land acquisition, power supply, data connection, access roads and fencing are not included.
8. Operation and maintenance costs are not included.

Figure 8-1: 2014 Water Treatment Works Reference Rates (Department of Primary Industries, Office of Water, 2014).

8.1.2 Recent Projects / Hunter H2O References

It is the experience of HH2O that the cost estimation of small water treatment plant projects is a difficult exercise, especially at an early stage of development, particularly as there is a general move towards bespoke WTP's for each site. Further, at an early stage it is difficult to apply first principals and assumptions around the acceptability of "package solutions" or moving forward with "council standards", PLC/SCADA and

telemetry decisions, and the 'finish' of roads and buildings to name a few, can all have a marked impact on the capital cost elevating or decreasing the value substantially.

For example, we have been involved with projects over the last few years where quotes have been received for 0.1 to 0.5 MLD containerised filtration package plants with key elements being;

- Built, tested and commissioned off site,
- limited scope that assumes washwater can be discharged to the environment or sewer
- Site prepared for others for laydown of a container
- No treated water tank and nominated termination points
- acceptance of standard electrical supply (to Australian standards but no separate MCC)
- acceptance of the supplier's standard mechanical equipment

With a stand-alone Contract price of $0.4M - $1M.

In contrast we have been involved with three recent projects where a 0.3 to 0.7 ML/d WTP that has been tendered. The plants had;

- reference designs developed with the Local Water Utility with operability and longevity in mind,
- went to the market with a detailed specification,
- blockwork plant building,
- sealed roads,
- small concrete reservoir (only one of the three),
- well-constructed lagoons with supernatant return (one of the three),
- council approved PLC/SCADA and

With a Contract value of between $3M and $4M dollars.

The take home is that there is a massive variation in the value of "small WTP's" that can, on paper, meet the water quality and quantity treatment performance objectives.

Hence at a scoping level, when there remains a reasonable level of uncertainty around the exact nature of the deliverable, the approach is to assume that the plants will be customised, and the estimated value will reflect a focus on best practice, robustness, operability, maintainability and longevity of a council asset that will increase the value.

The Adaminaby estimate is included as an Appendix A, noting key allowances of;

- Construction support – 1% of the Construction base estimate
- Construction management/supervision – 5% of the Construction base estimate
- Contractor Profit – 10% of the Construction base estimate
- PM and Commissioning – 2% of the Construction base estimate
- Contingency - 35% of the Total Base Estimate

9 Conclusions and Recommendations

The objective of the Water Safety Scoping Study was to identify one, or more, preferred options to improve water safety at Adaminaby, Bredbo, Eucumbene Cove, Kalkite and Nimmitabel. A number of reports have been developed as part of the scoping study and provide background detail to support the outcomes of the Scoping Study.

The reports, and a summary of their content, are;

- *Service Area and Demand for Villages Scoping Study Memo, Revision A. from Hunter H2O to Jessica Dunstan (SMRC), 07/09/2020*
  - Provides a summary of available production and consumption data for the villages and compares this to guidance from the water Services Association of Australia as a benchmark.
  - Outlines the existing service area of the villages
  - Provides an estimate for the 2050 demand and hence capacity for treatment infrastructure.
- *Snowy Monaro Villages Water Safety Scoping Study, Source Water Assessment, September 2020, Revision B*
  - A desktop, high level assessment of pathogen risk was completed in line with the Water Services Association of Australia guidance manual (Water Services Association of Australia, September 2015) to nominate a microbiological risk for each source.
  - Chemical and physical hazards were assessed through statistics as well as creating and considering time series charts and summarised for each location and each source.
  - Typical water quality as well as key challenges for each source were nominated
  - A sampling program was provided (included in this report as Appendix B) to better inform the raw water design envelope moving forward.
- *Water Treatment Options Overview, Memo, from Hunter H2O to Jessica Dunstan (SMRC), 23/09/2020*
  - Presents a long list of treatment options for the identified raw water hazards and their strengths and weaknesses
- *Snowy Monaro Villages Water Safety Scoping Study, Options Assessment Report, September 2020, Revision B*
  - Used previous outputs to consider two or three options to improve water safety at each of the villages, compared the associated strengths and weaknesses and selected a preferred option
  - Considered existing assets and available land area to determine a preferred location for siting new treatment infrastructure.

The Water Safety Scoping has combined key outputs from the previous reports and investigations into a single document that clearly conveys the objectives, design basis and process that was undertaken to determine the preferred options to improve water safety.

Each Village is presented within a dedicated section of the report, in summary;

Bredbo

To address raw water health and aesthetic hazards it is recommended to construct a new 400kL/day direct filtration plant with coagulation, taking water from the existing aeration tower and incorporating UV disinfection as a mutli-barrier approach to chlorine resistant protozoa. The infrastructure would be located on land purchased adjacent to the existing Reservoir site and raw water pumping upgrades will be required.

Kalkite

To address raw water health and aesthetic hazards it is recommended to construct a new 300kL/day membrane filtration plant on land already owned by council between the raw water pumping station and the community. Due to the location and size of the WTP, raw water pumping upgrades will be required. A new dedicated rising main would be constructed to allow for treated water to be sent direct to the existing Reservoirs to improve the consistency of supply to the community and negate the need to construct a dedicated Chlorine contact tank at the new WTP.

Adaminaby

To address raw water health and aesthetic hazards it is recommended to construct a new 500kL/day membrane filtration plant on land already owned by council at the Adaminaby reservoir site. Chlorination and fluoridation equipment at Observation point would be re-located to Adaminaby or abandoned to reduce the requirement to attend the remote pumping station daily. A small number of rural customers would be impacted and receive 'raw water' after the change.

Nimmitabel

To address raw water health and aesthetic hazards it is recommended to construct a new 400kL/day membrane filtration plant on land to be purchased adjacent to the Lucan St Bore. The plant would utilise coagulation to address true colour and organics and treat a blend of River and bore water from 80:20 to 50:50 to take advantage of available groundwater yield. Given the raw water catchment UV disinfectino would be incorporated as a mutli-barrier approach to chlorine resistant protozoa.

The water will maintain a moderate alkalinity and hardness and there remains the ability to run 100% groundwater during emergency scenarios.

Eucumbene Cove

It is recommended that a containerised membrane filtration plant is provided to treat water before it enters the existing reservoir. To address water age and chlorine decay issues, tank mixing is recommended with chlorine monitoring of the bulk tank volume with the ability to dose sodium hypochlorite directly to the tank as a 'top up' dose.

Recommendations that span across all of the Villages are;

- Incorporate the provided sampling program for routine and event monitoring, to better inform the raw water design envelope and reduce risk for SMRC and Contractors.
- Undertake a fire attack study of the proposed sites to inform the construction materials required of the new assets
- Confirm the availability of power at each of the sites to inform the construction of the new assets
- Jar Testing
    - At Bredbo - to determine the effectiveness of coagulation and typical dose rates for conventional filtration
    - At Nimmitabel - to determine the effectiveness of coagulation and typical dose rates for membrane filtration at carious blend ratios
    - At Eucumbene Cove - to assess the impact of maintaining a chlorine residual on the water quality, in particular the pH give the low alkalinity of the water.
    - At Kalkite and Adaminaby jar testing is not essential but could be undertaken to consider the advantage, if any, of coagulation against direct membrane filtration without coagulation. Essentially considering the true colour and chlorine decay of the coagulated and direct filtered water.

Finally an order of cost estimation was undertaken using the NSW reference Rates Manual (Department of Primary Industries, Office of Water, 2014) and a comparison based on recent projects with Hunter H2O visibility. The outputs are provided in the table below with a total project cost for the Villages water safety improvement project being $10.5M (NSW reference rate) to $15.5M.

Table 9-1: NSW Reference rates and Recent Project Cost Estimate Comparison.

	NSW Reference Rate	Recent Projects Estimate	Comment
Adaminaby	$2.93M	$4.09M	Does not include 1000m of new dedicated rising main
Bredbo	$2.45M	$3.68M	Land acquisition required
Nimmitabel	$2.45M	$3.68M	Land acquisition required

			Does not include 500m of new rising main to the WTP location
Kalkite	$1.98M	$3.27M	Does not include 1000m of new dedicated rising main
Eucumbene Cove	$0.66M	$0.81	Based on 20foot shipping container solution.

Appendix A Adaminaby Order of Cost Estimate Summary

Villages WTP Scoping Order of Cost Estimate					
Management Plans					
1	Management Plans		$ 40,000		
Milestone 2 – Design					
2	Design		$ 200,000		
Milestone 3 – Construction					
3	Site Establishment		$ 100,000		
4	Earthworks, Roads, Access and Landscaping		$ 250,000		
5	Raw Water Pumping Station (VSDs)		$ 50,000		
6	Sludge Lagoon Supernatant Pumping Station		$ 75,000		
7	Coagulation and Flocculation Tank		$ 30,000		
8	Coagulant Dosing System		$ 35,000		
9	Hypo Dosing System		$ 35,000		
10	Filtration Process Package		$ 200,000		
11	UV Disinfection		$ 85,000		
12	Sludge Lagoons		$ 200,000		
13	Process Water System		$ 30,000		
14	Instrumentation		$ 120,000		
15	Pipework and Associate equipment		$ 100,000		
16	Process, Control and Amenities Building		$ 300,000		
17	Electrical, PLC and SCADA		$ 500,000		
18	Motor Control Centre (inside building)		$ 100,000		
19	Testing and Commissioning		$ 48,000		
20	O&M Manuals		$ 20,000		
21	Work as Executed Drawings		$ 20,000		
22	Proving Period		$ 24,000		
	TOTAL			**$ 2,562,000**	**A**
	Indirect Costs				
	Construction Management				
	Contruction support including WAE, inspections etc	1% of A	$ 25,620		
	Construction Management/Supervision	5% of A	$ 128,100		
		Sub Total		***$ 153,720***	**B**
	Contractor Profit				
	Contractor Profit	*10% of A*	$ 256,200		
				$ 256,200	**C**
	Project Management & Commissioning				
	Project Management and Commissioning	*2% of A*	$ 51,240		
				$ 51,240	**D**
	Total Indirect Costs (B+C+D)			$ 461,160	
			Rounded up	**$ 470,000**	**E**
	Total Construction Base Estimate (A + E)			**$ 3,032,000**	**F**
	Contingency				
	For a 90% confidence of not being exceeded		35%	$ 1,061,200	**G**
	Total Construction Base Estimate with Contingency (F + G)			**$ 4,093,200**	

Appendix B Proposed Sampling Program

Parameter	Units	Bredbo	Nimmitabel Lucan St Bore	Nimmitabel Lake William Bore	Nimmitabel Maclaughlin River	Kalkite	Adaminaby	Eucumbene Cove	Period
E. coli	MPN/100mL	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	2 years
TDS	mg/L			Weekly					4 weeks
Alkalinity	mg/L as $CaCO_3$			Weekly		Weekly	Weekly	Weekly	12 weeks
True Colour	HU	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	Weekly	12 weeks
TOC	mg/L	Weekly	*One off Test*	*One off Test*	Weekly	Weekly	Weekly	Weekly	12 weeks
DOC	mg/L	Weekly	*One off Test*	*One off Test*	Weekly	Weekly	Weekly	Weekly	12 weeks
UVT [Note 1]	%	Weekly	*One off Test*	*One off Test*	Weekly	Weekly	Weekly	Weekly	12 weeks
THMs [Note 2]	*µg/L*	*Monthly*	*Monthly*			*Monthly*	*Monthly*		*3 months*
Calcium	mg/L (as Ca)			Weekly					4 weeks
Magnesium	mg/L (as Mg)		Weekly	Weekly					4 weeks
Total Iron	mg/L	Weekly	Weekly	Weekly	Weekly				12 weeks
Soluble Iron	mg/L	Weekly	Weekly	Weekly	Weekly				12 weeks
Herbicides and Pesticides	Various	*One off Test*	*One off Test*	*One off Test*	*One off Test*				*Single Sample*
Radiological	Various	*One off Test*	*One off Test*	*One off Test*	*One off Test*	*One off Test*	*One off Test*	*One off Test*	*Single Sample*

Note 1 – Request that this is a filtered sample UVT to estimate the UVT following the installation of filtration.

Note 2 – This is a 'treated water' sample, select a point in the Reticulation where the water is 'old', but is being turned over so has a free chlorine residual. Ie not a dead end.

Appendix C: Sewer network assessment report - Westlake Punnett



WESTLAKE PUNNETT
CIVIL AND STRUCTURAL ENGINEERS

KALKITE SEWER NETWORK HYDRAULIC MODELLING AND SERVICING STRATEGY

REPORT NO. 22421.R01

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1. Executive Summary

The purpose of this report was to undertake a hydraulic study of the existing sewer pump station facilities in Kalkite and assess the capacity of the existing sewer network.

This report estimated the design flows for each pump station as follows:

- Sewer Pump Station 1 (SPS1) design flows of 5.06 L/s
- Sewer Pump Station 2 (SPS2) design flows of 13.01L/s
- Sewer Pump Station 3 (SPS3) design flows of 4.37L/s

It was estimated that each pump station is adequately sized to handle the existing design flows from the contributing sewer catchments.

A proposed new subdivision is proposed to be constructed to the south of SPS3 on Lot 5 DP529579 which is expected to add 221 additional lots. Sewer flow generation estimates for the proposed subdivision are likely to be in the order of 20 L/s during Peak Wet Weather Flows.

Two options have been developed for Snowy Monaro Regional Council to enable sewer servicing for the new development as follows:

1 Extend existing gravity network and upsize existing trunk main and SPS3.
2 Construct a new pump station to service the proposed subdivision independently of existing infrastructure.

Due to the requirement for significant infrastructure upgrades/extensions and establishment of property easements associated with Option 1 above, it is likely that Option 2 will be the most cost effective. Provisions for siting of the new pump station and rising main should be made to enable appropriate grading of the development site. Details of the proposed site grading should also be made available to council to provide clarification on the required wet well depth and also clarity regarding pump and rising main sizing.

DRAFT

2. Background

Kalkite is a small town in the Snowy Monaro Regional Council local government area that contains 146 existing residential lots on the edge of the Eucumbene River. These lots are currently serviced by gravity sewer which drain to one of three existing sewer pump stations.

A planning proposal has been approved for a new subdivision of Lot 5 DP529579 which will yield up to 223 lots including special use areas such as community centres, sports fields and park/picnic areas. Council is seeking to determine if the existing gravity sewer network and SPS3 has sufficient capacity to service the new subdivision or if a new pump system is required

DRAFT

3. Design Assumptions

This design is based upon the following assumptions of the existing site and future proposed development.

1. Sump Level of SPS3 is 912.94m AHD as indicated on drawing 22421/SK3 Proposed Sewer Upgrade Plan.
2. Invert of inlet pipe is 914.5m AHD as indicated on drawing 22421/SK3 Proposed Sewer Upgrade Plan.
3. Minimum grade of proposed trunk main is to be 0.5%.
4. In the case of option 1 assessment, it is assumed that the proposed new subdivision will be graded to enable the site to fall by gravity sewer to a manhole sump RL of 918.17. A lower sump level will likely require lowering of the existing SPS3 wet well.
5. It is assumed the new subdivision will be constructed adopting leak tight sewer construction materials and methods and thus ground water infiltration (GWI) will be zero.
6. Design flows have been estimated in accordance with the Sewerage Code of Australia WSA 02-2002-2.2 Part 1: Planning and Design.
7. Standard residential lots are assumed to contain 3.5 equivalent persons (EP) per lot.
8. Community buildings are assumed to have an EP equal to 75 per gross hectare.
9. Sports fields and picnic areas are assumed to have an EP equal to 20 per gross hectare.
10. Leak severity coefficient assumed to be worst case scenario of 1.6 for the existing gravity sewer network.
11. Effective intensity obtained from BOM which is 16.9mm/hr.
12. Factor of containment adopted is 10 years.
13. Peaking factor calculated assuming 180L/d/EP.
14. Assumed the pipe network is 100% below groundwater tables thus $Portion_{wet} = 1$.

DRAFT

4. Sewer Pump Stations Existing Design Flows

The existing gravity flows to each sewer pump station were calculated based upon the flow estimation methodology set out in WSA 02 – 2002-2.2 Part1: Planning and Design Chapter 3: Flow Estimation. Supporting excel documentation is provided in Appendix B of this report.

4.1. SPS1 Existing Flows

Sewer Catchments

Table 1 outlines the parameters of the identified sewer catchment that contributes to the gravity sewer line flowing to SPS1. Refer to Appendix A for Catchment Map.

Table 1: Summary of The Contributing Sewer System to Pump Station 1

CONTRIBUTING CATCHMENT	LOTS	AREA (ha)	EP
1C	27	3.01	171.50
1B	6	0.68	4.50
1A	16	1.61	56.00
Total Cumulative	49	5.30	171.50

Estimated Sewer Flows to SPS1

Table 2 summarises a range of design parameters calculated using the WSA Code to determine the flow rates into Pump Station SPS1.

Table 2: Summary of Design Parameters to Estimate Total Flow to Sewer Pump Station 1

LOTS	AREA (ha)	EP	ADWF (L/s)	PDWF (L/s)	GWI (L/s)	IIF (L/s)	DESIGN FLOW (L/s)
49	5.30	171.50	0.36	1.74	0.12	3.19	5.06

DRAFT

4.2. SPS2 Existing Flows

Sewer Catchments

Table 1 outlines the parameters of the identified catchment that contribute to the gravity sewer line flowing to SPS2. Refer to Appendix A for Catchment Map.

Table 3: Summary of the Contributing Sewer System to Pump Station 2

CONTRIBUTING CATCHMENT	LOTS	AREA (ha)	EP
2D	7	1.68	24.50
2C	14	1.55	49.00
2B	35	3.45	122.50
2A	7	0.74	24.50
Total Cumulative	63	7.42	220.50

Estimated Sewer Flows to SPS2

Table 2 summarises a range of design parameters calculated using the WSA Code to determine the flow rates into Pump Station SPS2.

Table 4: Summary of Design Parameters to Estimate Total Flow to Sewer Pump Station 2

LOTS	AREA (ha)	EP	ADWF (L/s)	PDWF (L/s)	GWI (L/s)	IIF (L/s)	DESIGN FLOW (L/s)
63	7.42	220.50	0.45	2.05	0.19	4.70	13.01

DRAFT

4.3. SPS3 Existing Flows

Sewer Catchments

Table 1 outlines the parameters of the identified catchment that contribute to the gravity sewer line flowing to SPS3. Refer to Appendix A for Catchment Map.

Table 5: Summary of The Contributing Sewer System to Pump Station 3

CONTRIBUTING CATCHMENT	LOTS	AREA (ha)	EP
3C	10	1.25	35.00
3B	11	1.63	38.50
3A	14	1.93	49.00
Total Cumulative	35	4.90	122.50

Estimated Sewer Flows to SPS3

Table 2 summarises a range of design parameters calculated using the WSA Code to determine the flow rates into Pump Station SPS3.

Table 6: Summary of Design Parameters to Estimate Total Flow to Sewer Pump Station 3

LOTS	AREA (ha)	EP	ADWF (L/s)	PDWF (L/s)	GWI (L/s)	IIF (L/s)	DESIGN FLOW (L/s)
35	4.86	122.5	0.26	1.27	0.12	2.98	4.37

DRAFT

5. Subdivision Servicing Options

5.1. Option 1 - Extend Gravity Sewer Network from SPS3

Sewer Catchments

Table 7: Summary of the Contributing Sewer System to Pump Station 3

CONTRIBUTING ZONE	LOTS	AREA (ha)	EP
3C	10	1.25	35.00
3B	11	1.63	38.50
3A	14	1.93	49.00
New Subdivision	221	37.90	825.76
Total Cumulative	256	43.90	948.30

Total Flow at SPS3

Table 8: Summary of Design Parameters to Find Total Flow to Pump Station 3

LOTS	AREA (ha)	EP	ADWF (L/s)	PDWF (L/s)	GWI (L/s)	IIF (L/s)	DESIGN FLOW (L/s)
256	43.93	948.30	1.90	5.57	1.07	17.59	25.04

The additional load generated by the proposed subdivision increases the design flows into PSP3 from 4.37L/s to 25.04L/s. This increase in design flows would require the following upgrades to be undertaken:

1. Existing trunk main to PSP3 to be upgraded from a 150-diameter main to a 225-diameter main to facilitate the additional load on the system.
2. Extension of trunk gravity main to new subdivision connecting at the lowest point of the new subdivision. This extension requires the procurement of easements to facilitate a 0.5% minimum grade up to the new end of trunk main.
3. SPS3 wet well inlet main required to be lowered to achieve sufficient grade to the new subdivision
4. The existing pumps would likely require upgrading to accommodate the increased design flows
5. The existing rising main would likely require upsizing to accommodate the increased design flows.

DRAFT

5.2. Option 2 - Construct New Pump Station & Rising Main

The following assumptions were made in the development of this option:

1. The lowest contour of the proposed subdivision is at 914 m AHD and therefore this RL has been adopted for the pump station.
2. It is assumed that the entire subdivision can drain to this location with a maximum sewer depth of 4.0m. The new pump station wet well has therefore been assumed to be maximum 4.0 m deep.
3. The static head to the treatment plant is 45 metres.
4. The length of rising main from the proposed pump station to the treatment plant is less than 1500 metres.
5. Two scenarios were analysed for 20 L/s and 25 L/s design flows to enable preliminary sizing of submersible pumps and rising main.

Based on these assumptions, a preliminary sizing of 150 mm diameter rising main will be adequate to convey the design flows of 20 L/s. Should the higher design flow of 25 L/s be adopted, then a 200 mm diameter rising main is likely to be required.

Adopting the above design flows and pump requirements, a typical package pump station with dual submersible pumps should be considered. Each submersible pump should be sized to cater for the peak wet weather flows and the pump station should include provisions for emergency wet weather storage.

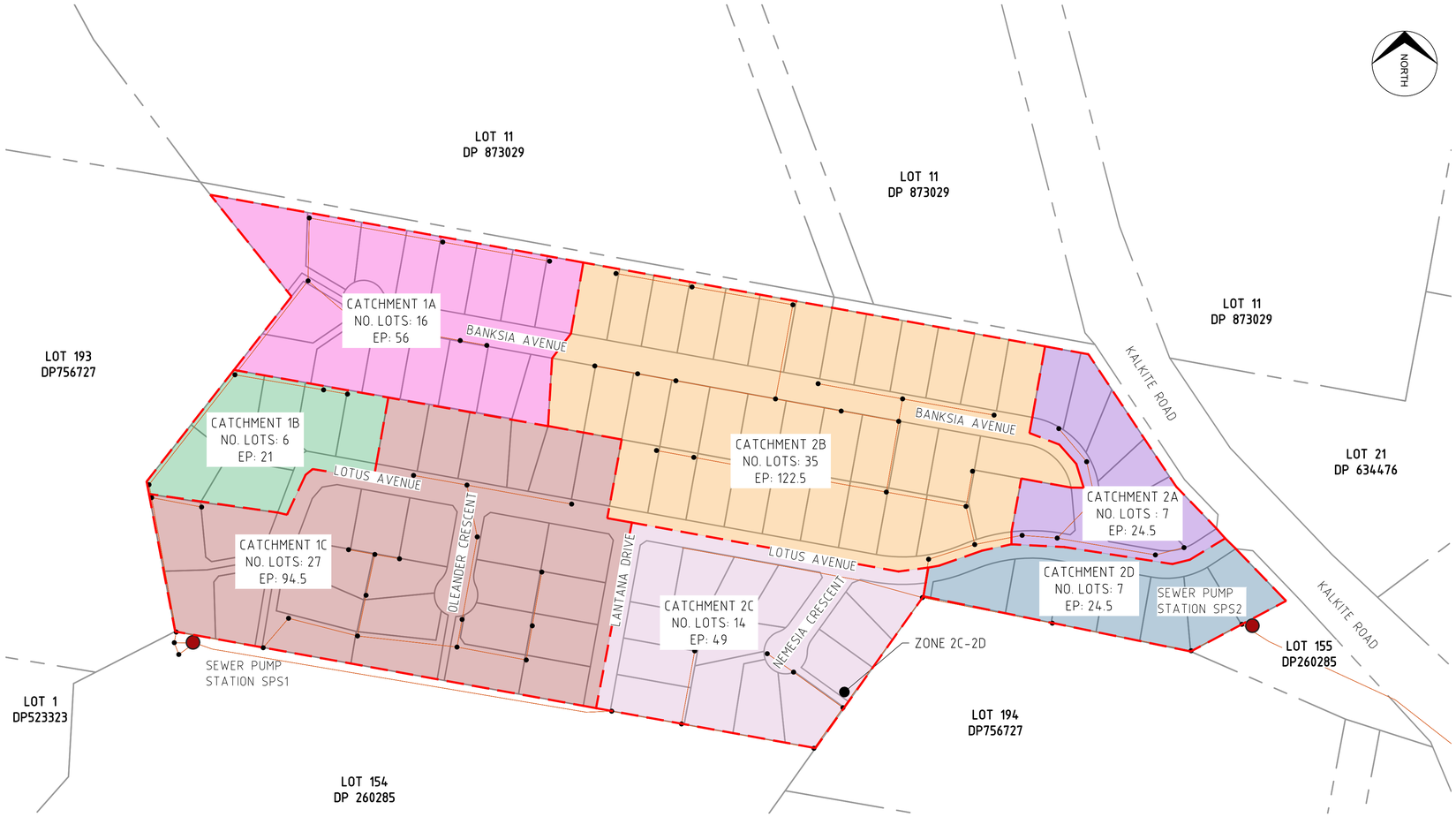
DRAFT

6. Appendix A – Catchment Map

DRAFT

7. Appendix B – Design Flow Excels

DRAFT



PUMP STATION SPS1 AND SPS2 LOCALITY PLAN

SCALE: 1:1500

LEGEND

- SEWER PUMP STATION
- SEWER MANHOLE
- SEWER LINE
- CADASTRAL BOUNDARY

0 50 100 150m

SCALE 1:1500 (A1), 1:3000 (A3)

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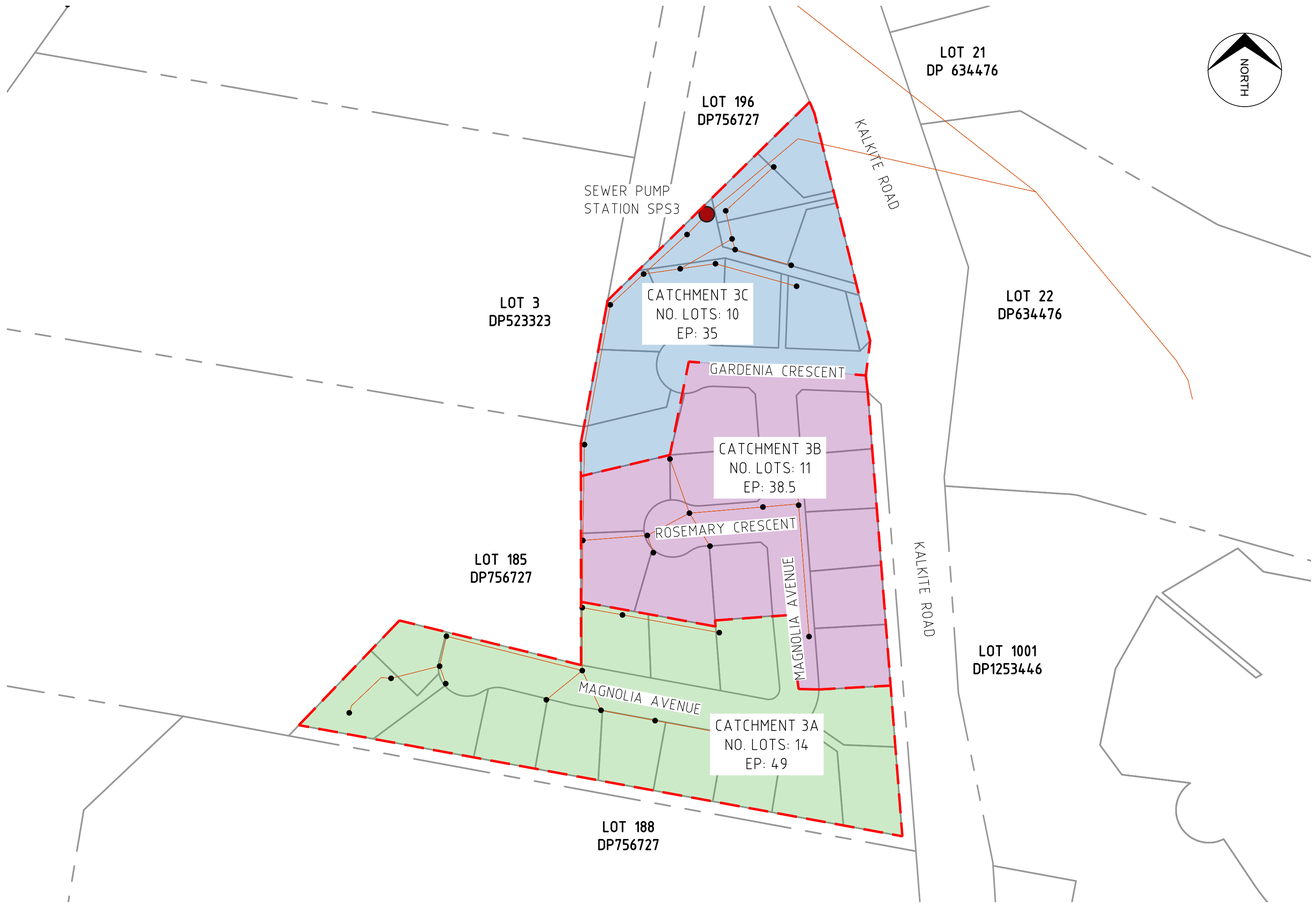
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RESIDENTIAL - COMMERCIAL - INDUSTRIAL

PUMP STATION SPS1 AND SPS2 LOCALITY PLAN

PROJECT: SEWER NETWORK MODELLING
AT: KALKITE
FOR: SNOWY MONARO REGIONAL COUNCIL

Design: M.SHEPSTONE
Drawn: M.SHEPSTONE
Checked: B.ASHE
Date: 09.01.2023
Drawing No. 22421/SK1
Rev 1



PUMP STATION SPS3 LOCALITY PLAN

SCALE: 1:1500

LEGEND

- SEWER PUMP STATION
- SEWER MANHOLE
- SEWER LINE
- CADASTRAL BOUNDARY

0 50 100 150m

SCALE 1:1500 (A1), 1:3000 (A3)

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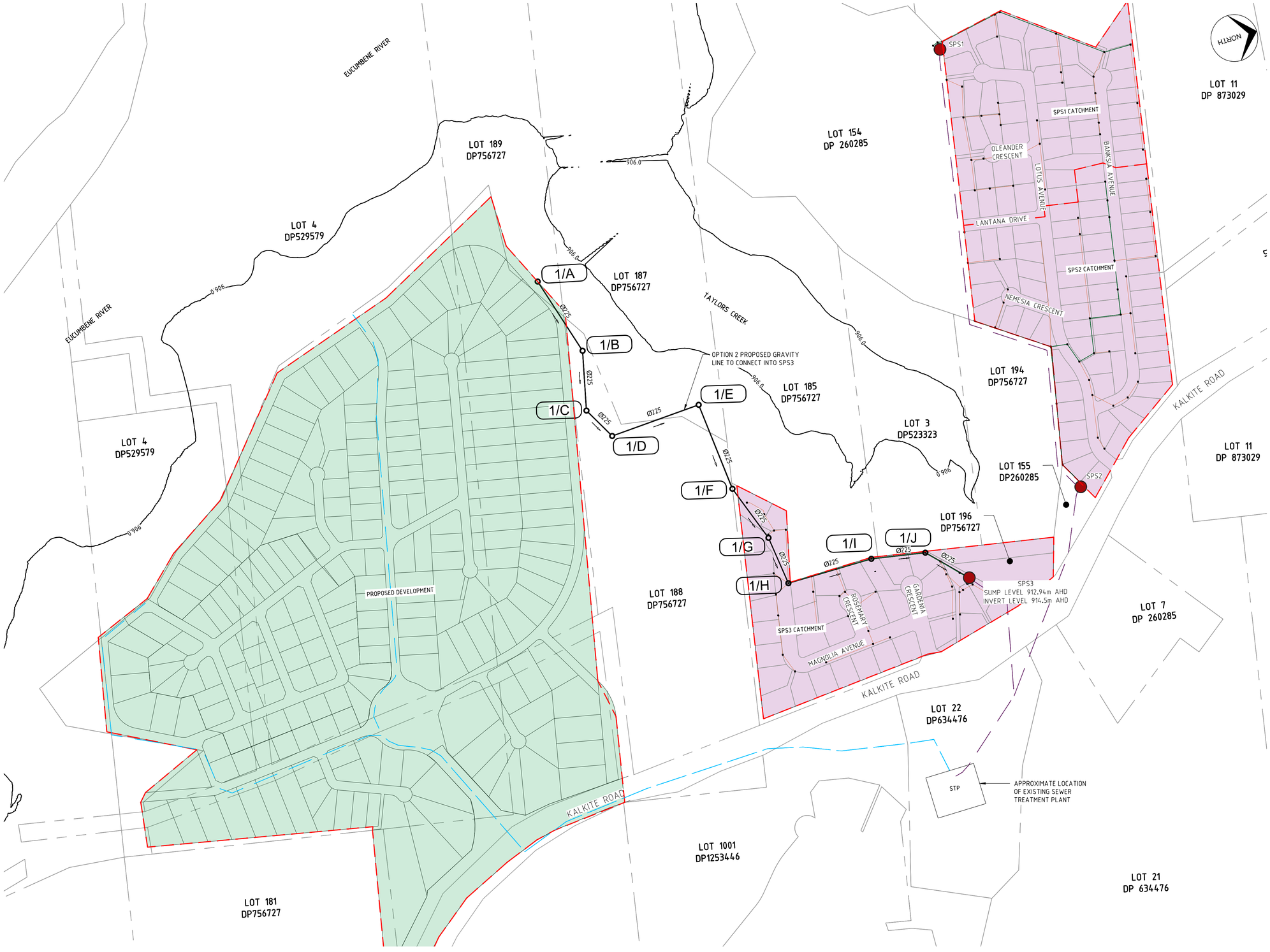
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PUMP STATION SPS3 LOCALITY PLAN

PROJECT: SEWER NETWORK MODELLING
AT: KALKITE
FOR: SNOWY MONARO REGIONAL COUNCIL

Design: M.SHEPSTONE
Drawn: M.SHEPSTONE
Checked: B.ASHE
Date: 09.01.2023
Drawing No. 22421/SK2
Rev 1



NOTES

THE FOLLOWING ASSUMPTIONS HAVE BEEN MADE WITH THIS DESIGN AND MUST BE CONSIDERED WHEN MAKING FUTURE DESIGN CHOICES:

1. SUMP LEVEL OF SPS3 IS 912.94m AHD AS INDICATED ON DRAWING 22421/SK3 PROPOSED SEWER UPGRADE PLAN.
2. INVERT OF INLET PIPE IS 914.5m AHD AS INDICATED ON DRAWING 22421/SK3 PROPOSED SEWER UPGRADE PLAN.
3. MINIMUM GRADE OF PROPOSED TRUNK MAIN IS TO BE 0.5%.
4. IN THE CASE OF OPTION 1 ASSESSMENT, IT IS ASSUMED THAT THE PROPOSED NEW SUBDIVISION WILL BE GRADED TO ENABLE THE SITE TO FALL BY GRAVITY SEWER TO A MANHOLE SUMP RL OF 918.17. A LOWER SUMP LEVEL WILL LIKELY REQUIRE LOWERING OF THE EXISTING SPS3 WET WELL.
5. IT IS ASSUMED THE NEW SUBDIVISION WILL BE CONSTRUCTED ADOPTING LEAK TIGHT SEWER CONSTRUCTION MATERIALS AND METHODS AND THUS GROUND WATER INFILTRATION (GWI) WILL BE ZERO.
6. DESIGN FLOWS HAVE BEEN ESTIMATED IN ACCORDANCE WITH THE SEWERAGE CODE OF AUSTRALIA WSA 02-2002-2.2 PART 1: PLANNING AND DESIGN.
7. STANDARD RESIDENTIAL LOTS ARE ASSUMED TO CONTAIN 3.5 EQUIVALENT PERSONS (EP) PER LOT.
8. COMMUNITY BUILDINGS ARE ASSUMED TO HAVE AN EP EQUAL TO 75 PER GROSS HECTARE.
9. SPORTS FIELDS AND PICNIC AREAS ARE ASSUMED TO HAVE AN EP EQUAL TO 20 PER GROSS HECTARE.
10. LEAK SEVERITY COEFFICIENT ASSUMED TO BE WORST CASE SCENARIO OF 1.6 FOR THE EXISTING GRAVITY SEWER NETWORK.
11. EFFECTIVE INTENSITY OBTAINED FROM BOM WHICH IS 16.9MM/HR.
12. FACTOR OF CONTAINMENT ADOPTED IS 10 YEARS.
13. PEAKING FACTOR CALCULATED ASSUMING 180L/D/EP.
14. ASSUMED THE PIPE NETWORK IS 100% BELOW GROUNDWATER TABLES THUS PORTION$_{WET}$ = 1.

LEGEND

- SEWER PUMP STATION
- SEWER MANHOLE
- SEWER LINE
- TRUNK MAIN
- RISING MAIN
- PROPOSED RISING MAIN FOR OPTION 2
- CADASTRAL BOUNDARY
- PROPOSED CADASTRAL BOUNDARIES
- EXISTING SUBDIVISION
- PROPOSED SUBDIVISION
- 906.0 EDGE OF WATER LINE

PROPOSED SEWER UPGRADE PLAN (OPTION 1 & 2)

SCALE: 1:2500

0 50 100 150 200 250m

SCALE 1:2500 (A1), 1:5000 (A3)

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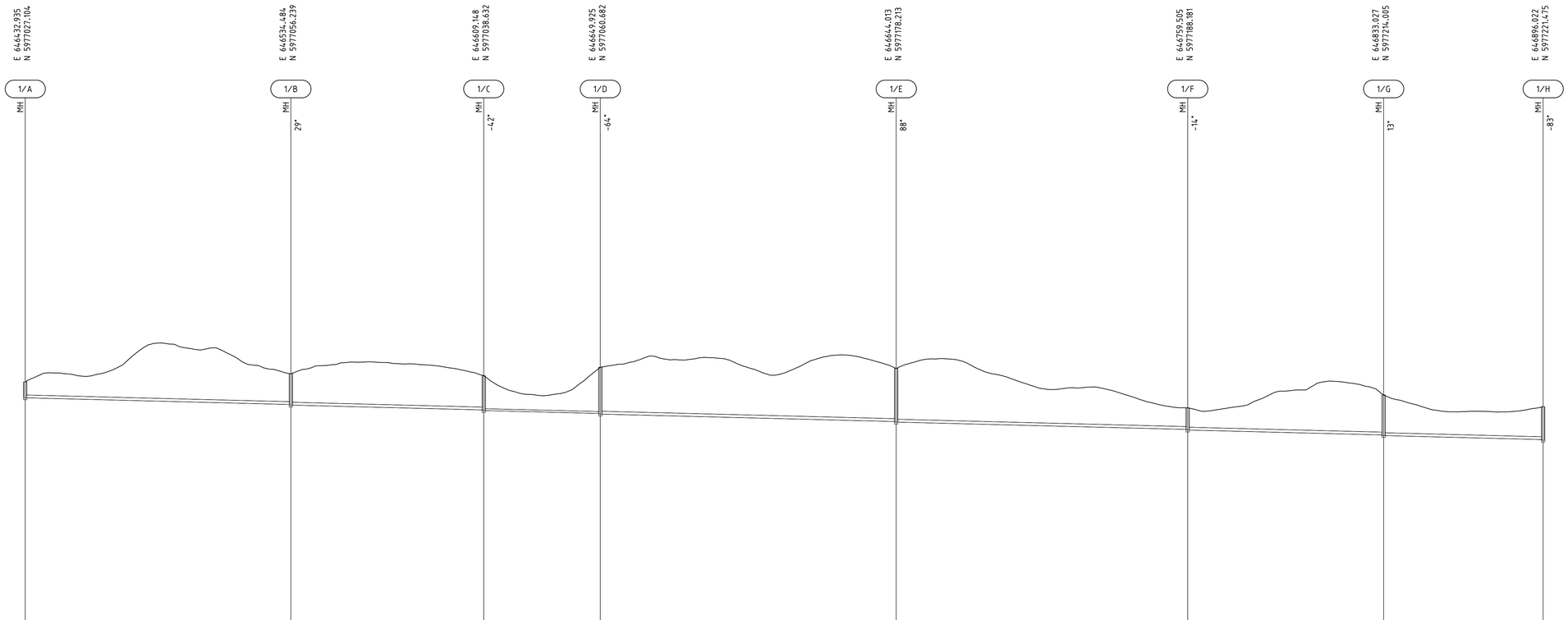
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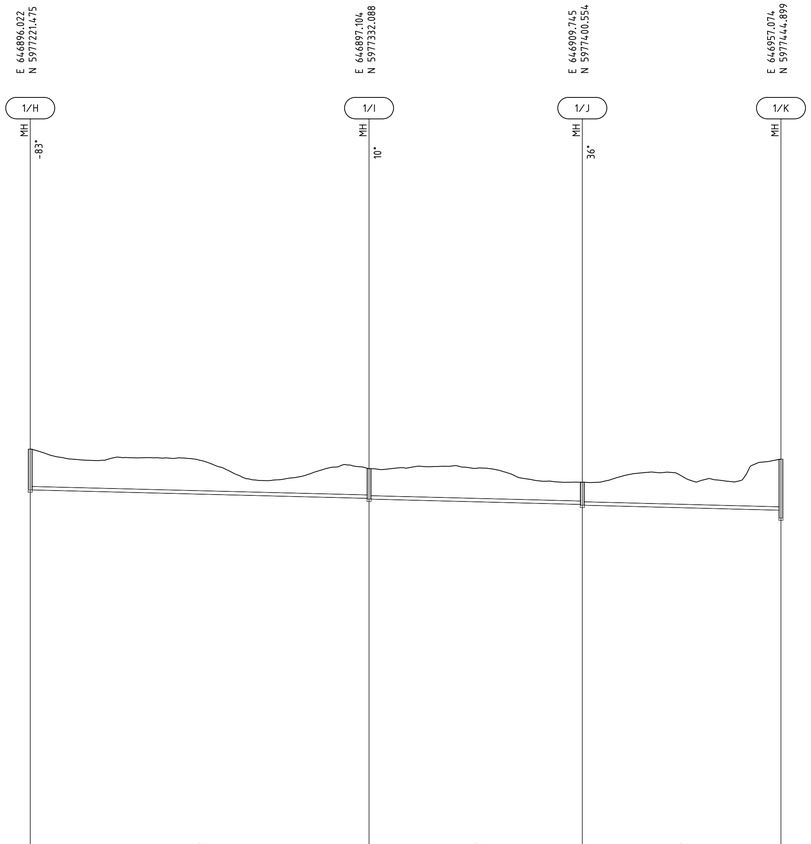
PROPOSED SEWER UPGRADE PLAN (OPTION 1 & 2)

PROJECT: SEWER NETWORK MODELLING
AT: KALKITE
FOR: SNOWY MONARO REGIONAL COUNCIL

Design: M.SHEPSTONE
Drawn: M.SHEPSTONE
Checked: B.ASHE
Date: 09.01.2023
Drawing No. 22421/SK3
Rev 1


E 646432.935
N 5977027.104
1/A
MH
E 646536.484
N 5977056.239
1/B
MH
29°
E 646609.148
N 5977038.632
1/C
MH
-42°
E 646649.925
N 5977060.682
1/D
MH
-64°
E 646644.013
N 5977178.213
1/E
MH
88°
E 646759.505
N 5977188.181
1/F
MH
-14°
E 646833.027
N 5977214.005
1/G
MH
13°
E 646896.022
N 5977221.475
1/H
MH
-83°

| | | |



GRADE %		0.5%				0.5%				0.5%				
PIPE SIZE (mm) & CLASS		DN225 PVC				DN225 PVC				DN225 PVC				
DATUM	888.000													
DEPTH TO INVERT	2.613	2.663			1.941	1.991			1.448	1.498			3.333	3.843
INVERT LEVEL	914.825	914.775			914.222	914.172			913.824	913.774			913.450	912.940
DESIGN SURFACE LEVEL	917.438				916.163				915.272				916.783	
CHAINAGE	603.677	110.618			714.296	69.623			783.919	64.858			848.777	

LINE 1

LINE 1 SEWER LONG SECTION (OPTION 1)

SCALE: 1:1000

0 20 40 60 80 100m

SCALE 1:1000 (A1), 1:2000 (A3)

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LINE 1 SEWER LONG SECTION

PROJECT: SEWER NETWORK MODELLING
AT: KALKITE
FOR: SNOWY MONARO REGIONAL COUNCIL

Design: M.SHEPSTONE
Drawn: M.SHEPSTONE
Checked: B.ASHE
Date: 09.01.2023
Drawing No. 22421/SK5
Rev 1

ABOUT THE FLOW SCHEDULE

The Schedule of SPS Design Inflows consists of two spreadsheets, a Flow Schedule and a Summary Sheet.

Within the Flow Schedule there are two sections, viz:

1. EP CALCULATIONS
2. DESIGN FLOW CALCULATIONS (including pumped flow information)

Features of the Flow Schedule include:

* All Cells other than input cells are password protected
* All input fields have data coloured light blue
* Variables fixed by Sydney Water have data coloured red
* Important output fields have coloured backgrounds
* Formulae and advisory notes are provided above the relevant data fields and
* Macros are provided for ease of printing.
* The RESET button can be used to clear all the input data fields.

To initiate macros, press {ALT}{F8}, highlight "FLOW" (printing of the Flow Schedule) or "SUMMARY" (printing of the Summary) as appropriate and click on RUN. The user will need to be in the sheet they wish to print prior to initiating the macro.

EP Calculations

The EP Calculations section of the Flow Schedule is where the catchment data is entered. The input data generally consists of the catchment area and population density (EP/Ha). For the columns Houses and Special Use (B), however, the input is slightly different to reflect the different method of EP calculation.

For Houses, Residential and Open Space columns, the population density applied to the Section A-B will be used as a default for all population densities in that column unless replaced.

The Special Use (B) column has been included so that developments like schools and hospitals can be included on an EP per unit basis. For Commercial/Industrial and Special Use areas, the percent pervious is also required.

If reliable planning or actual EP/flow data is not available, WSA 02 Appendix A should be used to calculate EP's.

Flow Calculations

The Design Flow Calculations section of the Flow Schedule calculates the average, peak and design flows from the information provided in the EP Calculations section, including connected gravity sewer and SPS contribution.

The "Additional Pumped or Existing Gravity Contribution" are the only input fields in the Flow Calculations section. The required inputs are determined from Tables SW 4.2 and SW 4.3 in Pipe Sizing and Grading Tables available at www.sydneywater.com.au / Building Developing and Plumbing / Supplier Information / Supplier Instructions / Supplementary Information.

The maximum rate of pumped discharge shall be sourced from Sydney Water or the SPS Designer as appropriate.

The Pumped Flow (PDWF Rate) shall be determined as follows:

(i) For a pumping station having a single fixed discharge rate, the pump flow rate
(ii) For a pumping station having more than one discharge rate, Sydney Water will advise the appropriate rate.

Location: Kalkite, PS01

Description Pipe Flows To Exisitng Sewer Pump Station

JOB No. (SWC use) 0

ORTHO (optional) 0

Checked by: Makayla Shepstone Date: 28-Oct-22

Checked by: Brad Ashe Date: 28-Oct-22

Plan No 22421 e-Developer No: 0

EQUIVALENT POPULATION CALCULATIONS (GRAVITY)

All areas are Gross Hectares

SUB-TOTALS FOR PORTION $_{impervious}$ CALCULATIONS

SECTION	CHAINAGE	RESIDENTIAL/OPEN SPACE										COMMERCIAL/INDUSTRIAL/SPECIAL USE																											
		HOUSES				RESIDENTIAL			OPEN SPACE			COMMERCIAL				INDUSTRIAL				SPECIAL USE (A1)				SPECIAL USE (A2)				SPECIAL USE (A3)				SPECIAL USE (B)						COM/IND/SU pervious		COM/IND/SU impervious	
		Lots	Ha	EP/Lot	EP	Ha	EP/Ha	EP	Ha	EP/Ha	EP	Ha	EP/Ha	EP	%PVS	Ha	EP/Ha	EP	%PVS	Ha	EP/Ha	EP	%PVS	Ha	EP/Ha	EP	%PVS	Ha	EP/Ha	EP	%PVS	Ha	Units	EP/Units	EP	%PVS	EP	AREA	EP	AREA
P1	17.32	49	5.3	3.5	171.5	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	0		0	-	0	0.0	0	0.0
		27	3.01	3.5	94.5	0	0	0	0	0	0	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0.0	0	0%	0	0.0	0	0.0
1C-1B	83.24	22	2.29	3.5	77	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	0		0		0	0.0	0	0.0
		6	0.68	3.5	21	0	0	0	0	0	0	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0.0	0	0%	0	0.0	0	0.0
1B-1A	143.47	16	1.61	3.5	56	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	0		0	-	0	0.0	0	0.0
		16	1.61	3.5	56	0	0	0	0	0	0	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0.0	0	0%	0	0.0	0	0.0
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				3.5	0

Compiled by: Makayla Shepstone **Date:** 28-Oct-22
Checked by: Brad Ashe **Date:** 28-Oct-22
Plan No 22421 **e-Developer No:** 0

Location: Kalkite, PS01
Description Pipe Flows To Exisitng Sewer Pump Station
Job No. 0
Ortho 0

DESIGN FLOW CALCULATIONS

$d=0.01(LogA)^4 - 0.19(LogA)^3 + 1.4(LogA)^2 - 4.66(LogA) + 7.57$

Per/capita/day(L/EP/d) = 180

Per/capita/day(L/s/EP) = 0.002083333 GWI = 0.025 x Area x Portion wet

ADWF = 0.002083333 X EP

PDWF = d x ADWF

RESIDENTIAL (RES/OS/SU_p)

A_{eff} = Area x (Density/150)$^{2.5}$<150EP/Ha

A_{eff} = Area>150EP/Ha

COMMERCIAL / INDUSTRIAL (COM/IND/SU_{Imp})

A_{eff} = Area x (1 - 0.75 Portion $_{Impervious}$)

IIF = 0.0278 x C x I x A_{eff}

I = $I_{1,2}$ x Factor $_{size}$ x Factor $_{containment}$

Factor$_{size}$ = (40/Area)$^{0.12}$

Factor $_{containment}$ = 0.77 x $10^{0.43X}$ / $10^{0.14\,X2}$

X=log10(ARI yrs)

ADDITIONAL PUMPED OR EXISTING GRAVITY CONTRIBUTION

DF=PDWF+GWI+IIF+PF+(EGS-WET)

PUMP FLOW For EP@MAX RATE (SEE TABLE SW 4.3)

EQUIVALENT GRAVITY SEWER CONTRIBUTION FLOWS ADVISED SYDNEY WATER (SEE TABLE SW 4.4)

PF=MAX RATE EGS=EXISTING (OLD) GRAVITY SEWER CONTRIBUTION

DESIGNED	AREA	ADWF	PDWF		GWI	Residential			Commercial/Industrial				TOTAL	C	$I_{1,2}$	Factor $_{size}$	ARI (years)	Factor $_{containment}$	I	IIF	MAX RATE	PDWF RATE	EQUIV.EP	EGS-DRY	EGS-WET	EQUIV.EP	Design Flow (DF)
GRAV.EP	Ha	L/S	L/S	Wet	L/S	EP	Ha	A_{eff}	EP	Ha	Portion $_{Impervious}$	A_{eff}	A_{eff}	Table B1	Table B2		Years			L/S	L/s	L/s	EP	L/s	L/s	EP	L/s
172	5	0	1.74	1	0.13	171.5	5.3	2.46	0	0.00	0.00	0.00	2.46	1.4	17.4	1.27	10	1.50	33.29	3.19	0	0	0	0	0	0	5.06
95	3																				0	0	0	0	0	0	
77	2	0	0.97	1	0.06	77	2.29	1.08	0	0.00	0.00	0.00	1.08	1.4	17.4	1.41	10	1.50	36.82	1.55	0	0	0	0	0	0	2.58
21	1																				0	0	0	0	0	0	
56	2	0	0.78	1	0.04	56	1.61	0.78	0	0.00	0.00	0.00	0.78	1.4	17.4	1.47	10	1.50	38.41	1.16	0	0	0	0	0	0	1.98
56	2																				0	0	0	0	0	0	
0	0	0	#NUM!	1	0.00	0	0	0.00	0	0.00	0.00	0.00	0.00	1.4	17.4	#DIV/0!	10	1.50	#DIV/0!	#DIV/0!	0	0	0	0	0	0	#DIV/0!
0	0

SCHEDULE OF SPS DESIGN INFLOWS (EP CALCULATIONS)

0	**Makayla Shepstone**	**28-Oct-22**
Checked by:	**Brad Ashe**	**28-Oct-22**

Plan No **22421**
e-Developer No: **0**

Location: **Kalkite, PS01**
Description **Pipe Flows To Exisitng Sewer Pump Station**

JOB No. (SWC use) **0**
ORTHO (optional) **0**

SUMMARY				
SECTION	**CHAINAGE m**	**TOTAL AREA Ha**	**TOTAL Grav EP**	**DESIGN FLOW (DF) L/s**
P1	17.32	5.3	172	5.06
1C-1B	83.24	2.29	77	2.58
1B-1A	143.47	1.61	56	1.98
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	0.00

ABOUT THE FLOW SCHEDULE

The Schedule of SPS Design Inflows consists of two spreadsheets, a Flow Schedule and a Summary Sheet.

Within the Flow Schedule there are two sections, viz:

1. EP CALCULATIONS
2. DESIGN FLOW CALCULATIONS (including pumped flow information)

Features of the Flow Schedule include:

* All Cells other than input cells are password protected
* All input fields have data coloured light blue
* Variables fixed by Sydney Water have data coloured red
* Important output fields have coloured backgrounds
* Formulae and advisory notes are provided above the relevant data fields and
* Macros are provided for ease of printing.
* The RESET button can be used to clear all the input data fields.

To initiate macros, press {ALT}{F8}, highlight "FLOW" (printing of the Flow Schedule) or "SUMMARY" (printing of the Summary) as appropriate and click on RUN. The user will need to be in the sheet they wish to print prior to initiating the macro.

EP Calculations

The EP Calculations section of the Flow Schedule is where the catchment data is entered. The input data generally consists of the catchment area and population density (EP/Ha). For the columns Houses and Special Use (B), however, the input is slightly different to reflect the different method of EP calculation.

For Houses, Residential and Open Space columns, the population density applied to the Section A-B will be used as a default for all population densities in that column unless replaced.

The Special Use (B) column has been included so that developments like schools and hospitals can be included on an EP per unit basis. For Commercial/Industrial and Special Use areas, the percent pervious is also required.

If reliable planning or actual EP/flow data is not available, WSA 02 Appendix A should be used to calculate EP's.

Flow Calculations

The Design Flow Calculations section of the Flow Schedule calculates the average, peak and design flows from the information provided in the EP Calculations section, including connected gravity sewer and SPS contribution.

The "Additional Pumped or Existing Gravity Contribution" are the only input fields in the Flow Calculations section. The required inputs are determined from Tables SW 4.2 and SW 4.3 in Pipe Sizing and Grading Tables available at www.sydneywater.com.au / Building Developing and Plumbing / Supplier Information / Supplier Instructions / Supplementary Information.

The maximum rate of pumped discharge shall be sourced from Sydney Water or the SPS Designer as appropriate.

The Pumped Flow (PDWF Rate) shall be determined as follows:

(i) For a pumping station having a single fixed discharge rate, the pump flow rate
(ii) For a pumping station having more than one discharge rate, Sydney Water will advise the appropriate rate.

Location: Kalkite, PS02

Description: Pipe Flows To Exisitng Sewer Pump Station

Checked by: Makayla Shepstone Date: 28-Oct-22

Brad Ashe Date: 28-Oct-22

Plan No 22421 e-Developer No: 0

JOB No. (SWC use) 0

ORTHO (optional) 0

EQUIVALENT POPULATION CALCULATIONS (GRAVITY)

All areas are Gross Hectares

SUB-TOTALS FOR PORTION $_{impervious}$ CALCULATIONS

SECTION	CHAINAGE	RESIDENTIAL/OPEN SPACE										COMMERCIAL/INDUSTRIAL/SPECIAL USE																											
		HOUSES				RESIDENTIAL			OPEN SPACE			COMMERCIAL				INDUSTRIAL				SPECIAL USE (A1)				SPECIAL USE (A2)				SPECIAL USE (A3)				SPECIAL USE (B)						COM/IND/SU pervious		COM/IND/SU impervious	
		Lots	Ha	EP/Lot	EP	Ha	EP/Ha	EP	Ha	EP/Ha	EP	Ha	EP/Ha	EP	%PVS	Ha	EP/Ha	EP	%PVS	Ha	EP/Ha	EP	%PVS	Ha	EP/Ha	EP	%PVS	Ha	EP/Ha	EP	%PVS	Ha	Units	EP/Units	EP	%PVS	EP	AREA	EP	AREA
P2-2D	6	63	7.42	3.5	220.5	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	0		0	-	0	0.0	0	0.0
		7	1.68	3.5	24.5	0	0	0	0	0	0	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0.0	0	0%	0	0.0	0	0.0
2D-2C	183.15	56	5.74	3.5	196	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	0		0		0	0.0	0	0.0
		14	1.55	3.5	49	0	0	0	0	0	0	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0.0	0	0%	0	0.0	0	0.0
2C-2B	48.38	42	4.19	3.5	147	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	0		0	-	0	0.0	0	0.0
		35	3.45	3.5	122.5	0	0	0	0	0	0	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0.0	0	0%	0	0.0	0	0.0
2B-2A	46.21	7	0.74	3.5	24.5	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	0		0	-	0	0.0	0	0.0
		7	0.74	3.5	24.5	0	0	0	0	0	0	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0.0	0	0%	0	0.0	0	0.0
		0	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	0		0	-	0	0.0	0	0.0
				3.5	0

Compiled by: Makayla Shepstone **Date:** 28-Oct-22
Checked by: Brad Ashe **Date:** 28-Oct-22
Plan No 22421 **e-Developer No:** 0

Location: Kalkite, PS02
Description Pipe Flows To Exisitng Sewer Pump Station
Job No. 0
Ortho 0

DESIGN FLOW CALCULATIONS

$d=0.01(LogA)^4 - 0.19(LogA)^3 + 1.4(LogA)^2 - 4.66(LogA) + 7.57$

Per/capita/day(L/EP/d) = 180

Per/capita/day(L/s/EP) = 0.002083333 GWI = 0.025 x Area x Portion wet

ADWF = 0.002083333 X EP

PDWF = d x ADWF

RESIDENTIAL (RES/OS/SU_p)

A_{eff} = Area x $(Density/150)^{0.3}$<150EP/Ha

A_{eff} = Area>150EP/Ha

COMMERCIAL / INDUSTRIAL (COM/IND/SU_{Imp})

A_{eff} = Area x (1 - 0.75 Portion $_{Impervious}$)

IIF = 0.0278 x C x I x A_{eff}

I = $I_{1,2}$ x Factor $_{size}$ x Factor $_{containment}$

Factor$_{size}$ = $(40/Area)^{0.12}$

Factor $_{containment}$ = $0.77 \times 10^{0.43X} / 10^{0.14\,X2}$

X=log10(ARI yrs)

						Residential			Commercial/Industrial				TOTAL	C	$I_{1,2}$	Factor $_{size}$	ARI (years)	Factor $_{containment}$	I	IIF	ADDITIONAL PUMPED OR EXISTING GRAVITY CONTRIBUTION: PUMP FLOW For EP@MAX RATE (SEE TABLE SW 4.3)			EQUIVALENT GRAVITY SEWER CONTRIBUTION FLOWS ADVISED SYDNEY WATER (SEE TABLE SW 4.4)			DF=PDWF+GWI+IIF+PF+(EGS-WET) PF=MAX RATE EGS=EXISTING (OLD) GRAVITY SEWER CONTRIBUTION
DESIGNED GRAV.EP	AREA Ha	ADWF L/S	PDWF L/S	Wet	GWI L/S	EP	Ha	A_{eff}	EP	Ha	Portion $_{Impervious}$	A_{eff}	A_{eff}	Table B1	Table B2		Years			L/S	MAX RATE L/s	PDWF RATE L/s	EQUIV.EP EP	EGS-DRY L/s	EGS-WET L/s	EQUIV.EP EP	Design Flow (DF) L/s
221	7.42	0.46	2.05	1	0.19	220.5	7.42	3.30	0	0.00	0.00	0.00	3.30	1.6	17.4	1.22	10	1.50	31.98	4.70	0	0	0	0	6.08	0	13.01
25	1.68																				0	0	0	0	0	0	
196	5.74	0.41	1.94	1	0.14	196	5.74	2.74	0	0.00	0.00	0.00	2.74	1.6	17.4	1.26	10	1.50	32.98	4.02	0	0	0	0	6.08	0	12.18
49	1.55																				0	0	0	0	0	0	
147	4.19	0.31	1.58	1	0.10	147	4.19	2.03	0	0.00	0.00	0.00	2.03	1.6	17.4	1.31	10	1.50	34.25	3.09	0	0	0	0	6.08	0	10.85
123	3.45																				0	0	0	0	0	0	
25	0.74	0.05	0.42	1	0.02	24.5	0.74	0.35	0	0.00	0.00	0.00	0.35	1.6	17.4	1.61	10	1.50	42.17	0.65	0	0	0	0	6.08	0	7.17
25	0.74																				0	0	0	0	6.08	0	
0	0	0	#NUM!	1	0.00	0	0	0.00	0	0.00	0.00	0.00	0.00	1.6	17.4	#DIV/0!	10	1.50	#DIV/0!	#DIV/0!	0	0	0	0	0	0	#DIV/0!
0	0																				0	0	0	0	0	0	
0	0	0	#NUM!	1	0.00	0	0	0.00	0	0.00	0.00	0.00	0.00	1.6	23

SCHEDULE OF SPS DESIGN INFLOWS (EP CALCULATIONS)

0	**Makayla Shepstone**	**28-Oct-22**
Checked by:	**Brad Ashe**	**28-Oct-22**

Plan No **22421**
e-Developer No: **0**

Location: **Kalkite, PS02**
Description **Pipe Flows To Exisitng Sewer Pump Station**

JOB No. (SWC use) **0**
ORTHO (optional) **0**

SUMMARY				
SECTION	**CHAINAGE** **m**	**TOTAL AREA** **Ha**	**TOTAL Grav** **EP**	**DESIGN FLOW (DF)** **L/s**
P2-2D	6	7.42	221	13.01
2D-2C	183.15	5.74	196	12.18
2C-2B	48.38	4.19	147	10.85
2B-2A	46.21	0.74	25	7.17
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	#DIV/0!
0	0	0	0	0.00

ABOUT THE FLOW SCHEDULE

The Schedule of SPS Design Inflows consists of two spreadsheets, a Flow Schedule and a Summary Sheet.

Within the Flow Schedule there are two sections, viz:

1. EP CALCULATIONS
2. DESIGN FLOW CALCULATIONS (including pumped flow information)

Features of the Flow Schedule include:

* All Cells other than input cells are password protected
* All input fields have data coloured light blue
* Variables fixed by Sydney Water have data coloured red
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* Formulae and advisory notes are provided above the relevant data fields and
* Macros are provided for ease of printing.
* The RESET button can be used to clear all the input data fields.

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EP Calculations

The EP Calculations section of the Flow Schedule is where the catchment data is entered. The input data generally consists of the catchment area and population density (EP/Ha). For the columns Houses and Special Use (B), however, the input is slightly different to reflect the different method of EP calculation.

For Houses, Residential and Open Space columns, the population density applied to the Section A-B will be used as a default for all population densities in that column unless replaced.

The Special Use (B) column has been included so that developments like schools and hospitals can be included on an EP per unit basis. For Commercial/Industrial and Special Use areas, the percent pervious is also required.

If reliable planning or actual EP/flow data is not available, WSA 02 Appendix A should be used to calculate EP's.

Flow Calculations

The Design Flow Calculations section of the Flow Schedule calculates the average, peak and design flows from the information provided in the EP Calculations section, including connected gravity sewer and SPS contribution.

The "Additional Pumped or Existing Gravity Contribution" are the only input fields in the Flow Calculations section. The required inputs are determined from Tables SW 4.2 and SW 4.3 in Pipe Sizing and Grading Tables available at www.sydneywater.com.au / Building Developing and Plumbing / Supplier Information / Supplier Instructions / Supplementary Information.

The maximum rate of pumped discharge shall be sourced from Sydney Water or the SPS Designer as appropriate.

The Pumped Flow (PDWF Rate) shall be determined as follows:

(i) For a pumping station having a single fixed discharge rate, the pump flow rate
(ii) For a pumping station having more than one discharge rate, Sydney Water will advise the appropriate rate.

Location: Kalkite, PS03

Description Pipe Flows To Existing Pump Station

Checked by: Makayla Shepstone Date: 28-Oct-22

Brad Ashe Date: 28-Oct-22

Plan No 22421 e-Developer No: 0

JOB No. (SWC use) 0

ORTHO (optional) 0

EQUIVALENT POPULATION CALCULATIONS (GRAVITY)

All areas are Gross Hectares

SUB-TOTALS FOR PORTION $_{impervious}$ CALCULATIONS

SECTION	CHAINAGE	RESIDENTIAL/OPEN SPACE										COMMERCIAL/INDUSTRIAL/SPECIAL USE																											
		HOUSES				RESIDENTIAL			OPEN SPACE			COMMERCIAL				INDUSTRIAL				SPECIAL USE (A1)				SPECIAL USE (A2)				SPECIAL USE (A3)				SPECIAL USE (B)						COM/IND/SU pervious		COM/IND/SU impervious	
		Lots	Ha	EP/Lot	EP	Ha	EP/Ha	EP	Ha	EP/Ha	EP	Ha	EP/Ha	EP	%PVS	Ha	EP/Ha	EP	%PVS	Ha	EP/Ha	EP	%PVS	Ha	EP/Ha	EP	%PVS	Ha	EP/Ha	EP	%PVS	Ha	Units	EP/Units	EP	%PVS	EP	AREA	EP	AREA
P3-3C	13.92	35	4.86	3.5	122.5	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	0		0	-	0	0.0	0	0.0
		10	1.25	3.5	35	0	0	0	0	0	0	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0.0	0	0%	0	0.0	0	0.0
3C-3B	167.73	25	3.61	3.5	87.5	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	0		0		0	0.0	0	0.0
		11	1.68	3.5	38.5	0	0	0	0	0	0	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0.0	0	0%	0	0.0	0	0.0
3B-3A	33	14	1.93	3.5	49	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	0		0	-	0	0.0	0	0.0
		14	1.93	3.5	49	0	0	0	0	0	0	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0.0	0	0%	0	0.0	0	0.0
		0	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	0		0	-	0	0.0	0	0.0
				3.5	0

Compiled by: Makayla Shepstone **Date:** 28-Oct-22
Checked by: Brad Ashe **Date:** 28-Oct-22
Plan No 22421 **e-Developer No:** 0

Location: Kalkite, PS03
Description Pipe Flows To Existing Pump Station
Job No. 0
Ortho 0

DESIGN FLOW CALCULATIONS

$d=0.01(LogA)^4 - 0.19(LogA)^3 + 1.4(LogA)^2 - 4.66(LogA) + 7.57$

Per/capita/day(L/EP/d) = 180

Per/capita/day(L/s/EP) = 0.002083333 GWI = 0.025 x Area x Portion wet

ADWF = 0.002083333 X EP

PDWF = d x ADWF

RESIDENTIAL (RES/OS/SU_p)

A_{eff} = Area x (Density/150)$^{2.7}$<150EP/Ha

A_{eff} = Area>150EP/Ha

COMMERCIAL / INDUSTRIAL (COM/IND/SU_{Imp})

A_{eff} = Area x (1 - 0.75 Portion $_{Impervious}$)

IIF = 0.0278 x C x I x A_{eff}

I = $I_{1,2}$ x Factor $_{size}$ x Factor $_{containment}$

Factor$_{size}$ = (40/Area)$^{0.12}$

Factor $_{containment}$ = 0.77 x $10^{0.43X}$ / $10^{0.14\,X2}$

X=log10(ARI yrs)

ADDITIONAL PUMPED OR EXISTING GRAVITY CONTRIBUTION

PUMP FLOW For EP@MAX RATE (SEE TABLE SW 4.3)

EQUIVALENT GRAVITY SEWER CONTRIBUTION FLOWS ADVISED SYDNEY WATER (SEE TABLE SW 4.4)

DF=PDWF+GWI+IIF+PF+(EGS-WET)

PF=MAX RATE EGS=EXISTING (OLD) GRAVITY SEWER CONTRIBUTION

DESIGNED	AREA	ADWF	PDWF		GWI	Residential			Commercial/Industrial				TOTAL	C	$I_{1,2}$	Factor $_{size}$	ARI (years)	Factor $_{containment}$	I	IIF	MAX RATE	PDWF RATE	EQUIV.EP	EGS-DRY	EGS-WET	EQUIV.EP	Design Flow (DF)
GRAV.EP	Ha	L/S	L/S	Wet	L/S	EP	Ha	A_{eff}	EP	Ha	Portion $_{Impervious}$	A_{eff}	A_{eff}	Table B1	Table B2		Years			L/S	L/s	L/s	EP	L/s	L/s	EP	L/s
123	5	0	1.27	1	0.12	122.5	4.86	1.99	0	0.00	0.00	0.00	1.99	1.6	17.4	1.29	10	1.50	33.64	2.98	0	0	0	0	0	0	4.37
35	1																				0	0	0	0	0	0	
88	4	0	0.98	1	0.09	87.5	3.61	1.45	0	0.00	0.00	0.00	1.45	1.6	17.4	1.33	10	1.50	34.86	2.25	0	0	0	0	0	0	3.32
39	2																				0	0	0	0	0	0	
49	2	0	0.65	1	0.05	49	1.93	0.79	0	0.00	0.00	0.00	0.79	1.6	17.4	1.44	10	1.50	37.59	1.33	0	0	0	0	0	0	2.02
49	2																				0	0	0	0	0	0	
0	0	0	#NUM!	1	0.00	0	0	0.00	0	0.00	0.00	0.00	0.00	1.6	17.4	#DIV/0!	10	1.50	#DIV/0!	#DIV/0!	0	0	0	0	0	0	#DIV/0!
0	0

SCHEDULE OF SPS DESIGN INFLOWS (EP CALCULATIONS)

0	**Makayla Shepstone**	**28-Oct-22**
Checked by:	**Brad Ashe**	**28-Oct-22**

Plan No **22421**
e-Developer No: **0**

Location: **Kalkite, PS03**
Description **Pipe Flows To Existing Pump Station**

JOB No. (SWC use) **0**
ORTHO (optional) **0**

SUMMARY				
SECTION	**CHAINAGE** **m**	**TOTAL AREA** **Ha**	**TOTAL Grav** **EP**	**DESIGN FLOW (DF)** **L/s**
P3-3C	13.92	4.86	123	4.37
3C-3B	167.73	3.61	88	3.32
3B-3A	33	1.93	49	2.02
0	0	0	0	#DIV/0!

ABOUT THE FLOW SCHEDULE

The Schedule of SPS Design Inflows consists of two spreadsheets, a Flow Schedule and a Summary Sheet.

Within the Flow Schedule there are two sections, viz:

1. EP CALCULATIONS
2. DESIGN FLOW CALCULATIONS (including pumped flow information)

Features of the Flow Schedule include:

* All Cells other than input cells are password protected
* All input fields have data coloured light blue
* Variables fixed by Sydney Water have data coloured red
* Important output fields have coloured backgrounds
* Formulae and advisory notes are provided above the relevant data fields and
* Macros are provided for ease of printing.
* The RESET button can be used to clear all the input data fields.

To initiate macros, press {ALT}{F8}, highlight "FLOW" (printing of the Flow Schedule) or "SUMMARY" (printing of the Summary) as appropriate and click on RUN. The user will need to be in the sheet they wish to print prior to initiating the macro.

EP Calculations

The EP Calculations section of the Flow Schedule is where the catchment data is entered. The input data generally consists of the catchment area and population density (EP/Ha). For the columns Houses and Special Use (B), however, the input is slightly different to reflect the different method of EP calculation.

For Houses, Residential and Open Space columns, the population density applied to the Section A-B will be used as a default for all population densities in that column unless replaced.

The Special Use (B) column has been included so that developments like schools and hospitals can be included on an EP per unit basis. For Commercial/Industrial and Special Use areas, the percent pervious is also required.

If reliable planning or actual EP/flow data is not available, WSA 02 Appendix A should be used to calculate EP's.

Flow Calculations

The Design Flow Calculations section of the Flow Schedule calculates the average, peak and design flows from the information provided in the EP Calculations section, including connected gravity sewer and SPS contribution.

The "Additional Pumped or Existing Gravity Contribution" are the only input fields in the Flow Calculations section. The required inputs are determined from Tables SW 4.2 and SW 4.3 in Pipe Sizing and Grading Tables available at www.sydneywater.com.au / Building Developing and Plumbing / Supplier Information / Supplier Instructions / Supplementary Information.

The maximum rate of pumped discharge shall be sourced from Sydney Water or the SPS Designer as appropriate.

The Pumped Flow (PDWF Rate) shall be determined as follows:

(i) For a pumping station having a single fixed discharge rate, the pump flow rate
(ii) For a pumping station having more than one discharge rate, Sydney Water will advise the appropriate rate.

Location: Kalkite

Checked by: Makayla Shepstone Date: 28-Oct-22 | Description: Pipe Flows for New Development

Brad Ashe Date: 28-Oct-22 | JOB No. (SWC use): 0

Plan No 22421 e-Developer No: 0 | ORTHO (optional): 0

EQUIVALENT POPULATION CALCULATIONS (GRAVITY)

All areas are Gross Hectares

SUB-TOTALS FOR PORTION impervious CALCULATIONS

SECTION	CHAINAGE	RESIDENTIAL/OPEN SPACE										COMMERCIAL/INDUSTRIAL/SPECIAL USE																													
		HOUSES				RESIDENTIAL			OPEN SPACE			COMMERCIAL				INDUSTRIAL				SPECIAL USE (A1)				SPECIAL USE (A2)				SPECIAL USE (A3)				SPECIAL USE (B)					COM/IND/SU pervious		COM/IND/SU impervious	
		Lots	Ha	EP/Lot	EP	Ha	EP/Ha	EP	Ha	EP/Ha	EP	Ha	EP/Ha	EP	%PVS	Ha	EP/Ha	EP	%PVS	Ha	EP/Ha	EP	%PVS	Ha	EP/Ha	EP	%PVS	Ha	EP/Ha	EP	%PVS	Ha	Units	EP/Units	EP	%PVS	EP	AREA	EP	AREA
P3-3C	13.92	256	42.71	3.5	896	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0.51	75	38.1	-	0.242	20	4.84	-	0.466	20	9.32	-	0	0		0	-	0	0.0	52	1.2
		10	1.25	3.5	35	0	0	0	0	0	0	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0.0	0	0%	0	0.0	0	0.0
3C-3B	167.73	246	41.46	3.5	861	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0.51	75	38.1	-	0.242	20	4.84	-	0.466	20	9.32	-	0	0		0		0	0.0	52	1.2
		11	1.63	3.5	38.5	0	0	0	0	0	0	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0.0	0	0%	0	0.0	0	0.0
3B-3A	33	235	39.83	3.5	822.5	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0.51	75	38.1	-	0.242	20	4.84	-	0.466	20	9.32	-	0	0		0	-	0	0.0	52	1.2
		14	1.93	3.5	49	0	0	0	0	0	0	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0.0	0	0%	0	0.0	0	0.0
Entire Sub Division	-	221	37.9	3.5	773.5	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0.51	75	38.1	-	0.242	20	4.84	-	0.466	20	9.32	-	0	0		0	-	0	0.0	52	1.2
		221	37.9	3.5	773.5	0	0	0	0	0	0	0	0	0	0%	0	0	0	0%	0.51	75	38.1	0%	0.242	20	4.84	0%	0.466	20	9.32	0%	0	0	0.0	0	0%	0	0.0	52	1.2
		0	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	0	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	#DIV/0!	0	-	0	0		0	-	0	0.0	0	0.0
				3.5	0	0	0	0	0	0	0	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0	0%	0	0	0.0	0	0%	0	0.0	0	0.0

Compiled by: Makayla Shepstone Date: 28-Oct-22
Checked by: Brad Ashe Date: 28-Oct-22
Plan No 22421 e-Developer No: 0

Location: Kalkite
Description Pipe Flows for New Development
Job No. 0
Ortho 0

DESIGN FLOW CALCULATIONS

$d=0.01(LogA)^4- 0.19(LogA)^3+1.4(LogA)^2- 4.66(LogA)+7.57$

Per/capita/day(L/EPld) = 180

Per/capita/day(Ls/EP) = 0.002083333 GWI = 0.025 x Area x Portion wet

ADWF = 0.002083333 X EP

PDWF = d x ADWF

RESIDENTIAL (RES/OS/SU_R)

A_{eff} = Area x (Density/150)$^{0.5}$<150EP/Ha

A_{eff} = Area>150EP/Ha

COMMERCIAL / INDUSTRIAL (COM/IND/SU_{Ind})

A_{eff} = Area x (1 - 0.75 Portion $_{Impervious}$)

IIF = 0.0278 x C x I x A_{eff}

I = $I_{1.2}$ x Factor $_{size}$ x Factor $_{containment}$

Factor$_{size}$ = (40/Area)$^{0.12}$

Factor $_{containment}$ = 0.77 x 10 $^{0.435X}$ / 10 $^{0.14 X2}$

X=log10(ARI yrs)

						Residential			Commercial/Industrial				TOTAL	C	$I_{1.2}$	Factor $_{size}$	ARI (years)	Factor $_{containment}$	I	IIF	ADDITIONAL PUMPED OR EXISTING GRAVITY CONTRIBUTION: PUMP FLOW For EP@MAX RATE (SEE TABLE SW 4.3)			EQUIVALENT GRAVITY SEWER CONTRIBUTION FLOWS ADVISED SYDNEY WATER (SEE TABLE SW 4.4)			DF=PDWF+GWI+IIF+PF+(EGS-WET)
DESIGNED	AREA	ADWF	PDWF		GWI																					PF=MAX RATE EGS=EXISTING (OLD) GRAVITY SEWER CONTRIBUTION
GRAV.EP	Ha	L/S	L/S	Wet	L/S	EP	Ha	A_{eff}	EP	Ha	Portion $_{Impervious}$	A_{eff}	A_{eff}	Table B1	Table B2		Years			L/S	MAX RATE L/s	PDWF RATE L/s	EQUIV.EP	EGS-DRY L/s	EGS-WET L/s	EQUIV.EP	Design Flow (DF) L/s
948	43.93	2	5.78	1	1.10	896	42.71	15.97	52	1.22	1.00	0.30	16.28	1.6	16.9	0.99	10	1.50	25.09	18.16	0	0	0	0	0	0	25.04
35	1																				0	0	0	0	0	0	
913	43	2	5.60	1	1.07	861	41.46	15.43	52	1.22	1.00	0.30	15.73	1.6	16.9	0.99	10	1.50	25.18	17.62	0	0	0	0	0	0	24.28
39	2																				0	0	0	0	0	0	
875	41	2	5.40	1	1.03	822.5	39.83	14.78	52	1.22	1.00	0.30	15.08	1.6	16.9	1.00	10	1.50	25.29	16.97	0	0	0	0	0	0	23.40
49	2																				0	0	0	0	0	0	
826	39	2	5.16	1	0.00	773.5	37.9	13.98	52	1.22	1.00	0.30	14.28	1.6	16.9	1.00	10	1.50	25.44	16.16	0	0	0	0	0	0	21.32
826	39																				0	0	0	0	0	0	
0	0	0	#NUM!	1	0.00	0	0	0.00	0	0.00	0.00	0.00	0.00	1.6	16.9	#DIV/0!	10	1.50	#DIV/0!	#DIV/0!	0	0	0	0	0	0	#DIV/0!
0	0

SCHEDULE OF SPS DESIGN INFLOWS (EP CALCULATIONS)

0	**Makayla Shepstone**	**28-Oct-22**
Checked by:	**Brad Ashe**	**28-Oct-22**

Plan No **22421**
e-Developer No: **0**

Location: **Kalkite**
Description **Pipe Flows for New Development**

JOB No. (SWC use) **0**
ORTHO (optional) **0**

SUMMARY				
SECTION	**CHAINAGE** **m**	**TOTAL AREA** **Ha**	**TOTAL Grav** **EP**	**DESIGN FLOW (DF)** **L/s**
P3-3C	13.92	43.926	948	25.04
3C-3B	167.73	42.676	913	24.28
3B-3A	33	41.046	875	23.40
ntire Sub Divisio	-	39.116	826	21.32
0	0	0	0	#DIV/0!



Appendix D: Kalkite WWTP assessment and options study - Westlake Punnett and aGnR Consutlants



WESTLAKE PUNNETT
CIVIL AND STRUCTURAL ENGINEERS

KALKITE STP HYDRAULIC ASSESSMENT

REPORT NO. 21381.R01

FOR SNOWY MONARO REGIONAL COUNCIL

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Document History

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1. Executive Summary

Westlake Punnett & Associates Pty Ltd have been engaged by Snowy Monaro Regional Council to undertake a hydraulic assessment of the Kalkite Sewerage Treatment Plant and provide an options assessment for the disposal of effluent therein.

This report assesses and determines the water balance at Kalkite Sewer Treatment Plant considering the available on-site area for irrigation and thereby establishes volumes of wet-weather storage required for the site. Further, this report provides both a stormwater management strategy and a detailed assessment of possible effluent disposal methods for the STP based on the hydraulic assessments undertaken.

2. Background

Kalkite is located on the eastern edge of Lake Jindabyne and is approximately 10 km north from Jindabyne. The Kalkite Sewerage Treatment Plant (STP) is located on the eastern side of the township of Kalkite in Lot 22 DP634476. This parcel of land is approximately 4.2 hectares total area and slopes steeply downwards to Taylor's Creek to the north. The STP sits at an approximate average elevation of 950 m AHD which is significantly higher than the town of Kalkite (approx. 920 m AHD).

The STP currently receives raw wastewater from 146 properties within the Kalkite township. Raw wastewater is pumped to the STP via sewer rising mains from three (3) sewer pump stations located throughout the town of Kalkite. Refer to **Appendix A** for sewer network catchment plan map.

The STP treatment system consists of an oxidation ditch (Pasveer ditch) followed by a maturation pond and an evaporation pond. Refer to **Appendix B** for the site layout plan and **Appendix C** for the treatment train diagram.

Previous inspections by Snowy Monaro Regional Council (SMRC) identified structural defects in the existing effluent maturation pond wall. Defects identified included tension cracks in the downslope embankment which were evident along the dam crest. SMRC were monitoring the embankment movement through regular survey. SMRC have indicated that the existing maturation pond is to be decommissioned during following construction and commissioning of a new larger evaporation pond – Refer to **Appendix D**.

The site also includes an existing evaporation pond which is currently not in use whilst undergoing critical upgrade works. Upgrade works include the following:

- Reconstruction and reinforcement of the downslope embankment.
- Excavation of material from within the pond to increase holding capacity.
- Installation of subsoil drainage to prevent groundwater surcharge within the pond structures.
- Installation of a HDPE liner system to provide a low permeability barrier that will prevent seepage of effluent into ground stores.

A pond strengthening design was prepared by D&N Geotechnical Pty Ltd and plans were prepared by Westlake Punnett & Associates Pty Ltd for the evaporation pond upgrades which are included in this report under **Appendix G**. Evaporation pond reconstruction works were completed in December 2021 and the maturation pond was removed from service in January 2022.

3. Inflow and Outflow Estimations

Wastewater generation estimates have been prepared in accordance with the Water Services Association of Australia – WSA 02-2014 Gravity Sewerage Code Australia V3.1 for the following scenarios:

1. Existing sewer catchment of 146 Torrens title residential lots
2. Proposed future development yield including 146 existing Torrens title residential lots plus an additional 90 Torrens title residential lots
3. Proposed future development yield up to maximum of 1000 EP's

In accordance with WSA 02-2014 V3.1, the following input parameters have been adopted for the wastewater generation calculations:

Table 3.1 - Wastewater Generation Inputs

Parameter	Value	Units
L/Capita/day	180	L/EP/D
EP/Lot	3.5	EP/Lot
Portion $_{wet}$	100	%
Leakage Severity Constant	1.5	Unitless
$I_{1,2}$	16.9	mm/hr
Containment ARI	5	years

It is recommended that these values be verified by undertaking flow monitoring of the inflows to the STP. It is important to note that the population of Kalkite fluctuates seasonally and therefore wastewater flows are also likely to fluctuate. Based on census data from 2016, Kalkite recorded a population of 214 people which indicates that the following calculations may over-estimate the actual Average Dry Weather Flows (ADWF); however, these estimates provide an indication of the peak season ADWF when all residences are occupied.

Flow monitoring will also provide an indication of the condition of the existing sewerage collection system and the flow rate response characteristics due to rainfall dependent flows. Should permanent flow monitoring be implemented, this information can be utilised for the management of Peak Wet Weather Flows (PWWF) at the STP.

3.1. Scenario 1 – Existing Wastewater Generation Estimate

Table 3.2 – Scenario 1 Wastewater Generation Estimate (current scenario)

Parameter	Value	Units
No. Lots	146	Lots
Total Cumulative EP	511	EP
Average Dry Weather Flow (ADWF)	91,980	L/Day
Average Dry Weather Flow (ADWF)	1.065	L/s
Peaking Factor	3.589	Unitless
Peak Dry Weather Flow (PDWF)	3.821	L/s
Ground Water Infiltration (GWI)	0.443	L/s
Rainfall Dependent Infiltration (RDI)	5.958	L/s

Peak Wet Weather Flow (PWWF - Design Flow)	10.222	L/s

3.2. Scenario 2 – Additional 90 Lots Wastewater Generation Estimate

It is assumed that the additional 90 lots will be of similar size and density to the existing township of Kalkite (approx. 9 lots/ha).

Table 3.3 – Scenario 2 Wastewater Generation Estimate

Parameter	Value	Units
No. Lots	236	Lots
Total Cumulative EP	826	EP
Average Dry Weather Flow (ADWF)	148,680	L/Day
Average Dry Weather Flow (ADWF)	1.72	L/s
Peaking Factor	3.234	Unitless
Peak Dry Weather Flow (PDWF)	5.562	L/s
Ground Water Infiltration (GWI)	0.693	L/s
Rainfall Dependent Infiltration (RDI)	8.981	L/s
Peak Wet Weather Flow (PWWF - Design Flow)	15.238	L/s

3.3. Scenario 3 -1001 EP Wastewater Generation

Table 3.4 – Scenario 3 Wastewater Generation Estimate

Parameter	Value	Units
No. Lots	286	Lots
Total Cumulative EP	1001	EP
Average Dry Weather Flow (ADWF)	180,180	L/Day
Average Dry Weather Flow (ADWF)	2.085	L/s
Peaking Factor	3.116	Unitless
Peak Dry Weather Flow (PDWF)	6.498	L/s
Ground Water Infiltration (GWI)	0.818	L/s
Rainfall Dependent Infiltration (RDI)	10.530	L/s
Peak Wet Weather Flow (PWWF - Design Flow)	17.846	L/s

3.4. Scenario 4 – 1500 EP Wastewater Generation

Table 3.5 – Scenario 4 Wastewater Generation Estimate

Parameter	Value	Units
No. Lots	429	Lots
Total Cumulative EP	1501	EP

Average Dry Weather Flow (ADWF)	269,640	L/Day
Average Dry Weather Flow (ADWF)	3.128	L/s
Peaking Factor	2.851	Unitless
Peak Dry Weather Flow (PDWF)	8.919	L/s
Ground Water Infiltration (GWI)	1.237	L/s
Rainfall Dependent Infiltration (RDI)	15.096	L/s
Peak Wet Weather Flow (PWWF - Design Flow)	25.253	L/s

3.5. Summary of Flow Estimates

Table 3.5 –Wastewater Generation Summary

Scenario	EP's	ADWF (L/day)	ADWF (L/s)	PDWF (L/s)	PWWF (L/s)
Scenario 1	511	91,980	1.065	3.821	10.222
Scenario 2	826	148,680	1.721	5.562	15.238
Scenario 3	1001	180,180	2.085	6.498	17.846
Scenario 4	1501	270,270	3.128	8.919	25.253

For the purposes of effluent disposal calculations further in this report, the above ADWF rates for Scenario 1 have been adopted and groundwater infiltration flow rate also added.

4. Proposed Evaporation Pond Works

The existing evaporation pond is currently out of service due to seepage and slope stability issues identified by SMRC. A geotechnical investigation was completed by D&N Geotechnical Pty Ltd which identified that an existing filled gully running through the base of the pond was allowing significant volumes of water to infiltrate into the surrounding soils. It was also identified that the slope of the downslope embankment was over steepened and the required factor of safety could not be achieved.

As a result of these inadequacies in the existing basin, a design has been prepared by D&N Geotechnical Pty Ltd to rectify the issues – Refer to **Appendix G**. This design includes the following:

4.1. Reconstruction and reinforcement of the downslope embankment

The reconstruction of the downslope embankment includes reworking of the existing material and installation of layers of geogrid reinforcement. The embankment material will be placed and compacted under Level 1 geotechnical supervision to ensure quality of materials and construction practices. Subsoil drainage will also be installed within the embankment to relieve pore water pressure and reduce seepage through the embankment.

4.2. Excavation of material from within the pond

The base of the pond will be excavated lower to increase the holding capacity of the pond. The holding capacity of the existing pond is approx. 1,450 m^3 which also includes 0.5 m freeboard. Following completion of the pond reconstruction, the holding capacity will be increased to approx. 2,400 m^3. This represents an increase in holding capacity of approx. 65% and provides an estimated hydraulic retention time of 26 days.

4.3. Installation of subsoil drainage

Subsoil drainage is proposed to be installed within the pond embankments and through the existing filled gully in the base of the pond. The subsoil drainage will act to prevent build-up of porewater pressure in the structural components of the pond. The subsoil drains will also act to prevent ground water accumulation under the pond liner. This will reduce the risk of the liner lifting off the base of the pond when the pond is empty.

4.4. Installation of a HDPE liner system

It is proposed to install a HDPE liner throughout the pond to provide a low permeability barrier that will prevent seepage of treated effluent into the surrounding ground stores. A sump is also to be provided at the low point of the pond base to improve sludge removal maintenance procedures. The pond is proposed to fall at approx. 1.5% from east to west to promote sludge settlement towards the lower end.

5. Evaporation Pond Efficiency

This section outlines potential improvements that may be implemented to increase the efficiency of the evaporation pond in its ability to dispose of treated effluent through evaporation. A number of technologies have been investigated which may be implemented to improve disposal of effluent which include the following:

5.1. Droplet Spraying

Droplet spraying is widely used in the mining, desalination, waste and processing industries as a wastewater disposal solution. Droplet spraying increases the natural evaporation rate by atomizing the wastewater which increases the water surface area that is exposed to the air. Droplet spraying units can increase the natural evaporation rate of the existing pond surface area by up to 12 times, subject to optimum climatic conditions. An image of a typical system is shown in **Figure 1 below**:



Figure 1 - Droplet Spray System (image courtesy of Tecpro Australia Pty Ltd)

The benefits of this system include:

- Low capital costs to install and commission
- Low operating and maintenance costs
- System is plug and play with multiple units able to be installed in one pond (subject to specific site analysis)
- Footprint of the system fits inside of the footprint of existing evaporation pond and therefore additional land is not required
- System can be floatable or fixed to the pond embankment
- System can be integrated with an onsite weather station controller and SCADA system for automatic and remote operation
- System is widely adopted and used for wastewater disposal

Some of the disadvantages of this system include:

- Production of aerosols may lead to spray drift during high winds. A site-specific assessment is required to determine site suitability and likely achievable evaporation losses.
- System requires pumps to operate which would increase operation and maintenance costs
- System is limited by climatic conditions of the area which may render the system ineffective during periods of low temperatures or high humidity. Unfortunately for the subject site, periods of low temperatures and high humidity tend to coincide with the peak tourist season and a period of very little evaporation.

5.2. Wind Aided Intensified Evaporation (WAIV)

Wind Aided Intensified Evaporation (WAIV) systems have been used to improve the evaporation of wastewater from many industrial processes in mining, manufacturing, waste and energy sectors. The WAIV system utilises wetted surfaces (sails) that are suspended within a steel frame to increase the effective evaporation surface. The sails are fed from the top with treated effluent via a pumped distribution system. As wind passes through the sails, the evaporation of effluent is intensified facilitating the disposal of up to 19 kL (approx.) per unit per day.

Surplus effluent that is not evaporated is collected by a containment system and recirculated through the system. A diagram of the system is shown in **Figure 2 below:**

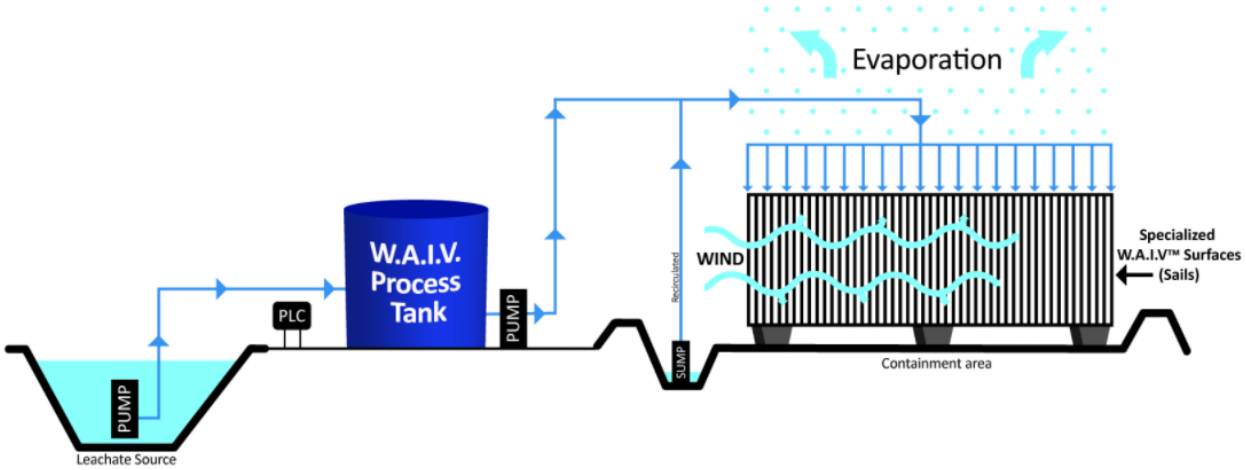


Figure 2 - WAIV evaporation system (image courtesy of http://leachate.us/waiv/)

The benefits of this system include:

- Does not generate aerosols which may drift offsite and can therefore operate during high winds
- System is modular and scalable
- System can handle high levels of total dissolved solids (TDS)
- Relatively small footprint for each module

Some of the disadvantages of this system include:

- Scaling of the sails due to high levels of TDS may result in increased maintenance requirements
- System is relatively new technology and still relatively experimental in nature
- System requires pumps to operate which would increase operation and maintenance costs
- Requires dedicated area within the STP to install
- System is limited by climatic conditions of the area which may render the system ineffective during periods of low temperatures or high humidity.

Preliminary analysis of the WAIV system at the proposed site in Kalkite indicates that a single unit is capable of evaporating up to 515 kL/month during the warmer summer months. The efficiency is reduced during the winter months where the evaporation rate reduces to 62 kL/month. As multiple units can be connected together, the evaporation volumes can be scaled up.

The approximate cost for each WAIV unit is $225,000 USD which does not include associated plumbing and site works. Each unit occupies approx. 400 m2 and is to be sited on a footing system with containment bay.

Although the evaporation rate reduces significantly during the winter months, there is benefit during the shoulder months. The implementation of the WAIV system would extend the time period that evapotranspiration exceeds inflows, thus, reducing the period of time and volume of treated effluent that would otherwise be required to be disposed of offsite.

6. Assessment of Effluent Disposal Methods

To provide an assessment of disposal options with particular focus on on-site disposal methods, a detailed site assessment is recommended to characterise the suitability of the site. The following section outlines a high-level assessment of the STP site for on-site disposal.

6.1. Onsite Effluent Disposal

As the site is a Zero Liquid Discharge (ZLD) site, onsite disposal options are generally limited to evaporation and evapotranspiration through the use of evaporation ponds or onsite irrigation respectively. Options to increase evaporation losses have been discussed in Section 5 of this report which includes technologies capable of enhancing evaporation.

Onsite irrigation involves the use of sprinklers and/or a drip irrigation system able to distribute the treated effluent over an irrigation area where the effluent can be absorbed by vegetation through evapotranspiration. The feasibility of the site for irrigation is dependent on a number of factors including:

1. Landform such as slope, available application area and buffers to adjoining properties.
2. Existing vegetation and susceptibility to salinity and/or nutrients
3. Soil structural characteristics
4. Depth of soil profile
5. Effluent quality including nutrient loading
6. Climate conditions and wet weather storage requirements

6.1.1. Landform

The site is characterised by steeply sloping valleys with a typical grade of 20 – 30% sloping down to the north and northwest. Immediately to the north of the STP site is Taylor's Creek which flows west into Lake Jindabyne via. steep, rocky gully formations. A number of gullies within the catchment upstream of the STP site divert flows around the site. The site is considered fully exposed to sun and wind due to the northerly aspect and relative elevation of the site. Due to the elevation of the STP site with respect to adjoining creeks and gullies, it is unlikely that the site is flood affected by mainstream flooding during the 1% AEP event. There are a number of existing swales across the site which control the flow of stormwater through the site. The local drainage system is assessed in Section 7 of this report to ensure incursion of stormwater flows into STP infrastructure is minimised – refer to **Appendix E**.

The site is sparsely vegetated with native grasses and various eucalyptus and acacia species. The observed growth habit of the trees was typically young trees (less than 5 m tall) with some older trees towards the southern boundary of the site.

A check of Australian Groundwater Explorer did not return any results for registered bores within the immediate vicinity of the proposed irrigation site. The nearest bores (GW055066.1.1 and GW103164.1.1) were confirmed to be approximately 1 km from the site. Provided that effluent irrigation is carried out in accordance with the approved irrigation schedule to prevent contamination of groundwater stores, the water quality measured at the nearest bores is not likely to be impacted.

The site has known occurrences of land instability which is most likely due to construction of ponds and embankments which have resulted in over-steepened batters and saturation of soils. Slope stability assessments should be conducted by a geotechnical engineer prior to establishing an effluent irrigation area.

6.1.2. Landform Suitability Assessment

Table 6.1 –Landform Suitability Assessment

Landform Property	Value	Limitation Assessment
Slope	>20%	Severe
Aspect	North Facing	Nil or slight
Exposure	Highly exposed	Nil or slight
Flooding	None or rare	Nil or slight
Landform	Concave slopes	Moderate
Surface rock outcrop	0-5%	Moderate
Land stability	To be assessed	Severe (assumed)

6.1.3. Existing Vegetation

The existing vegetation is categorised as subalpine woodlands and consists of sparse eucalyptus and acacia trees underlain by native shrubs and grasses. When compared to bushland on adjacent sites, it appears that the area has been cleared previously and the existing vegetation is relatively young and likely to be regrowth.

It is important to note that the sparse vegetation cover is likely to affect crop factors which will ultimately reduce evapotranspiration losses. This may be improved through increasing the density of vegetation over the irrigation areas with endemic species that are known to have high crop factors.

It is recommended that the existing vegetation is assessed by a qualified horticulturalist to establish acceptable limits of available nutrient and salinity levels that will reduce the risk of vegetation dieback. The treated wastewater effluent quality should also be assessed to confirm the concentrations of sodium and nutrients that will be applied to the irrigation area. This may result in the nutrient loading and/or salinity being the limiting factor in the volumetric irrigation rate.

6.1.4. Soil Assessment

A desktop analysis of the site classifies the soils as granodiorite lithology consisting of coarse sandy loam with massive structure. Following inspection of the site, a number of rocky outcrops were identified. Highly weathered rock was also evident in a number of excavation cuttings that were exposed at the time of construction of the STP.

A geotechnical investigation was carried out by D & N Geotechnical to assess the stability of the existing evaporation basin. A number of boreholes were conducted to establish the material characteristics. This report identified that the basin embankment was constructed of site won material comprised of silty sand, fine to coarse grained, subrounded to angular, with fine to coarse subrounded to angular gravel and trace of sub-angular cobbles. Grandiorite bedrock was encountered below the embankment wall between 5.8 m and 6.7 m from the crest of the embankment.

Two boreholes were also drilled in the base of the existing basin. These boreholes identified 600 mm of silty-sand fill over granodiorite bedrock. Groundwater seepage was observed at the basin floor level and significant groundwater inflows were identified at the toe of the upstream embankment.

Further testing of the proposed effluent disposal area was carried out to assess the suitability of the site for effluent disposal. Three test pits were excavated and samples taken for analysis.

Based on the soil classification of the site, the soils are determined to be Category 2 in accordance with AS1547. Category 2 soils typically exhibit high permeability and therefore result in higher irrigation rates as the risk of saturation and water ponding/runoff is low. This also means that seepage rates are higher which can be problematic on steep sites or where bedrock is shallow.

6.1.5. Measured Soil Properties for Site Soil Assessment

Table 6.2 –Site Soil Assessment

Soil Property	Site Measurement	Limitation Assessment
Exchangeable sodium (0-40 cm)	1-3% Average of 2.3%	Nil or Slight
Exchangeable sodium (40-100 cm)	1-3% Average of 2.0%	Nil or Slight
Salinity as electrical conductivity (EC) (dS/m at 0-70 cm)	0.02-0.03	Nil or Slight
Salinity as electrical conductivity (EC) (dS/m at 70-100 cm)	0.02-0.03	Nil or Slight
Depth to top of seasonal high water table (metres)	Water table not encountered up to 1 metre test depth	Nil or Slight
Depth to Bedrock (metres)	>1.5 m	Nil or Slight
Saturated Hydraulic Conductivity (Ks,mm/h)	13-36	Nil or Slight
Soil pH (surface layer)	6-6.7	Nil or Slight
Effective cation exchange capacity (cmol(+)/kg)	16-19	Nil or Slight
Emerson aggregate test	2 – Slightly Dispersive	Moderate
Phosphorus sorption (kg/ha)	3,600-5,200	Nil or Slight

6.1.6. Treated Effluent Quality

For the purposes of estimating the appropriate effluent discharge requirements, the treated effluent quality should be monitored and assessed to determine the strength of the effluent being applied to the site. Effluent quality should ideally be monitored through regular sampling and testing of key nutrients and salinity. In the absence of such information from Council records, it is assumed that the treated effluent is classified as low strength with the following effluent quality parameters:

Table 6.3 –Assumed Effluent Quality parameters

Effluent Parameter	Typical Effluent Quality
Biochemical Oxygen Demand	20-30 mg/L
Total Suspended Solids	25-40 mg/l
Nitrogen (Total Nitrogen)	20-50mg/l
Phosphorous (Total Phosphorous)	6-12 mg/l
Bacteria, viruses and protozoa	10^5-10^6 org/100 ml

Due to the unknown quality of effluent, both upper and lower values of each range in the table above will be used for subsequent calculations.

6.1.7. Selection of Irrigation System

Owing to the relatively steep slope of the site, the most suitable irrigation system for land application is a subsurface drip system. A drip irrigation system will allow for control of erosion and will also allow for reduced buffer distances to boundaries as spray drift will not be an issue. It is noted that subsurface irrigation systems require more land application area when compared to conventional absorption systems owing to the lower relative design irrigation rate. It is also important to note that the steep slope of the site and thin soil depth will require a reduction in design irrigation rate due to the risk of seepage and groundwater contamination.

In order to increase the design irrigation rate, further site analysis may be carried out by a hydrogeologist to determine a site-specific design irrigation rate that will allow for larger effluent disposal volumes whilst minimising risks of off-site contamination/nutrient leaching. It is noted that the recommended design irrigation rates are conservative and with additional site specific assessment, the design irrigation rate can be modified to maximise the potential of the site, subject to allowable nutrient loadings.

6.1.8. Irrigation Area Requirements

To assess the irrigation area suitability, a water balance has been prepared to determine the minimum area and wet weather storage requirements.

The crop factors used for the calculation of evapotranspiration depths were obtained from NSW EPA publication "Use of Effluent by Irrigation". It is noted that crop factors are largely site and species specific and therefore further horticultural advice to confirm the adopted values are suitable for the type and density of vegetation.

The water balance was extended for a further 12 months to confirm the wet weather storage returns to empty during the lower rainfall/higher evapotranspiration months. It was confirmed that the storage returns to empty in March of the second year from commencement of the irrigation scheme. It is evident from the water balance that during the months of April – September, there is a surplus of effluent owing to the relatively cold climate resulting in low evaporation rates.

As discussed in Section 5 above, the evaporation basin may be optimised during the warmer months to increase the volume of effluent lost to evaporation.

Based on the water balance calculations above, there is insufficient irrigation area available on site to dispose of all treated effluent through on-site irrigation. A summary of requirements is provided in the table below:

Table 6.4 –Irrigation Area and Wet Weather Storage Summary

ADWF	Irrigation Area Requirement (m^2)	Available Irrigation Area (m^2)	Wet Weather Storage Requirement (m^3)	Available Wet Weather Storage (m^3)
Scenario 1 - 91,980 L/d + groundwater infiltration	29,101	16,800	9,770	2,400
Scenario 2 - 148,680 L/d + groundwater infiltration	46,566	16,800	15,634	2,400
Scenario 3 - 180,180 L/d + groundwater infiltration	56,022	16,800	18,809	2,400
Scenario 4 – 270,270 L/d + groundwater infiltration	84,246	16,800	16,929	2,400

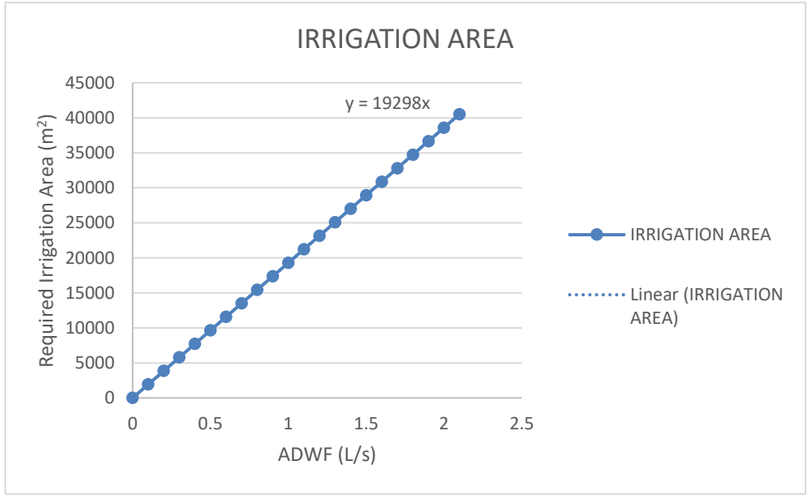
Details of the water balance are provided on the following page.

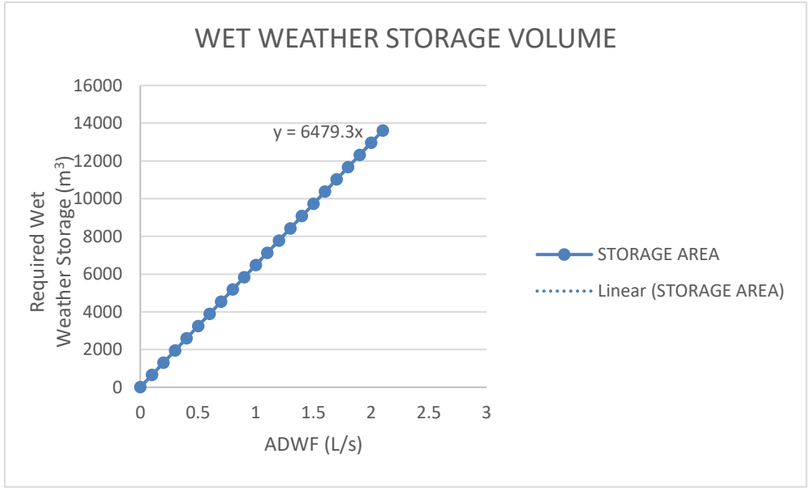
6.1.9. Kalkite STP Water Balance and Wet Weather Storage Calculations

Design Wastewater Flow	1.51	l/s	
	130,212	l/day	
	130.212	m^3/day	
Design Irrigation Rate (R)	5	mm/day	(from AS1547)
Slope Reduction Factor	50%		for slopes between 20 -30% (Table M2 AS1547)
Corrected Design Irrigation Rate	2.5	mm/day	

Parameter	**Symbol**	**Formula**	**Units**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Days in Month	D	-	days	31	28	31	30	31	30	31	31	30	31	30	31	365
Precipitation	P	-	mm/month	52.2	49.8	49.5	38.5	28.9	39.9	30.1	31.3	36	44.9	66.3	52.9	520.3
Evaporation (pan)	E	-	mm/month	190	160	130	80	40	30	30	45	70	120	175	180	1250
Crop Factor	C	-	-	0.78	0.84	0.94	1.17	1.21	1.15	1.13	1.33	1.33	1.26	0.99	0.83	-
Outputs																
Evapotranspiration	ET	E x C	mm/month	148.2	134.4	122.2	93.6	48.4	34.5	33.9	59.85	93.1	151.2	173.25	149.4	1242
Percolation	B	(R) x D	mm/month	77.50	70.00	77.50	75.00	77.50	75.00	77.50	77.50	75.00	77.50	75.00	77.50	912.5
Outputs		ET + B	mm/month	225.70	204.40	199.70	168.60	125.90	109.50	111.40	137.35	168.10	228.70	248.25	226.90	2154.5
Inputs																
Precipitation	P	-	mm/month	52.20	49.8	49.5	38.5	28.9	39.9	30.1	31.3	36	44.9	66.3	52.9	520.3
Max. Effluent Irrigation	W	(ET + B) - P	mm/month	173.50	154.60	150.20	130.10	97.00	69.60	81.30	106.05	132.10	183.80	181.95	174.00	1634.20
Effluent Production	I	H/12	mm/month	136.18	136.18	136.18	136.18	136.18	136.18	136.18	136.18	136.18	136.18	136.18	136.18	1634.20
Inputs		P + I	mm/month	188.38	185.98	185.68	174.68	165.08	176.08	166.28	167.48	172.18	181.08	202.48	189.08	2154.50
Storage	S	(P + I) - (ET+B)	mm/month	-37.32	-18.42	-14.02	6.08	39.18	66.58	54.88	30.13	4.08	-47.62	-45.77	-37.82	-
Cumulative storage	M	-	mm	0.00	0.00	0.00	5.34	44.52	111.11	165.99	196.12	200.21	152.59	106.82	69.01	

Required Irrigation Area	L		m^2	29,083
Required Wet Weather Storage			m^3	5,823





6.1.10. Nutrient Loading

An assessment of the nutrient loading rate of nitrogen and phosphorous including suitability of application to the irrigation area is provided below. The treated effluent is categorised as low strength, likely due to the absence of any trade waste connections or industrial lands in Kalkite. Typical values for low strength effluent have been adopted for the nutrient balances below which have been cross-checked against testing data.

Table 6.5 –Nitrogen Balance Summary

Nitrogen Balance	**Estimated Concentration**	**Units**
Effluent Concentration	20	mg/l
Daily Hydraulic Load	130,212	L/d
Daily Nitrogen Load	2.60	kg/d
Annual Load	950.55	kg/year
Vegetation N Uptake		
Nv	48	kg/ha/year
Ns	27	kg/ha/year
Ng	2	kg/ha/year
Total Nitrogen Uptake	77	kg/ha/year
	0.21	kg/ha/d
Vegetation N uptake data sourced from study of eucalyptus plantation in Wagga Wagga NSW.		
Area Required for Sustainable Nitrogen Disposal	**12.34**	**ha**

Table 6.6 –Phosphorous Balance Summary

Phosphorous Balance	**Estimated Concentration**	**Units**
Effluent Concentration	12	mg/l
Daily Hydraulic Load	130,212	L/d
Daily Phosphorous Load	1.56	kg/d
Annual Load	570.33	kg/year
Crop P Uptake	0	kg/year
P sorption of Soils		
P-sorption Result	3600	kg/ha
P-sorption (critical)	1200	kg/ha
Available area	1.68	ha
P-sorption capacity	2016	kg
Sustainable Site Irrigation Period	**3.53**	**years**

It is evident from the nutrient balances above that nitrogen is the limiting factor to the volume of effluent that can be applied to the site over a specified time period. It is also noted that the site is unlikely to be managed as a plantation with respect to vegetation cover and harvesting measures and therefore the vegetative nitrogen uptake figures adopted above may be slightly overestimated.

As noted above, the minimum required irrigation area required for sustainable nitrogen balance is approx. 12.34 ha. The area required is approx. 8 times that currently available on site. As such, it is

considered that the site is currently unsuitable for onsite disposal of nitrogen in the medium to long term and additional areas for effluent irrigation should be sought by Snowy Monaro Regional Council.

6.1.11. Irrigation Area Setbacks

It is imperative to consider setbacks for the irrigation area to minimise the risks of seepage/discharge from the site. The following setbacks are guidelines only and further input from Snowy Monaro Regional Council and NSW Health should be sought to establish a risk-based approach to irrigation area layout. Effluent pathogen load should also be determined prior to applying effluent to the site. The irrigation area should also be monitored during operation to verify that effluent is not seeping offsite.

Table 6.7 –Recommended Irrigation Area Setbacks

Site Feature	Setback	Justification
Taylor's Creek	50 metres	Sensitive environment Flows to Lake Eucumbene Steep slope down to creek High permeability soils Low strength effluent
Property Side Boundaries	6 metres	
Property Downslope Boundary	10 metres	Subsurface irrigation to prevent spray drift. Reduced design irrigation rate to prevent scour and runoff.
Property Upslope Boundary	3 metres	Subsurface irrigation to prevent spray drift. Reduced design irrigation rate to prevent scour and runoff.
Buildings/Structures	15 metres	
Groundwater bores	250 metres	A search of the BOM Australian Groundwater Explorer did not identify any groundwater bores within 250 metres of the site. It is noted that the raw water intake for Kalkite is located approx. 600 m from the outlet of Taylors Creek. The relative location of the treatment plant to the intake should be considered further and advice should be sought from NSW health regarding options to minimise public health risks.

A risk assessment should be developed in consultation with NSW Health to determine if the above setbacks are acceptable for the specific site when considering the measured effluent quality and any existing operating licenses. Further treatment measures such as disinfection of effluent may also be required to minimise the risks to public health from pathogens.

6.2. Partial Onsite Effluent Disposal

Analysing the calculations undertaken for full onsite effluent disposal, it is evident that the site is not suitable for effluent disposal due to the site-specific constraints paired with the effluent loading of the STP. In order to manage the surplus wastewater, it may be considered to dispose of the treated effluent at a licensed treatment plant.

Due to the low level of confidence in the actual flow rates and effluent quality parameters used in the assessment for full onsite effluent disposal, it would be prudent to undertake further monitoring to understand the financial implications of transport of wastewater offsite. This is highly recommended as the total nitrogen concentration assumed for the effluent may result in up to 90% of wastewater requiring offsite disposal.

6.3. Offsite Effluent Re-use Scheme

As discussed in Section 6.2 above, additional effluent disposal sites are required to sustainably dispose of treated effluent and reduce the risk to the public and environment. As per communications with Andrew Scharkie from Snowy Monaro Regional Council, future public recreation sites may be a viable option for a reuse scheme. In order to determine a suitable effluent disposal scheme, consultation should be undertaken with NSW Health to develop a risk based approach based on measured effluent quality parameters and gauged sewerage inflows. Land suitability assessments should also be undertaken on prospective sites to inform any planning proposals that may be required.

7. Stormwater Management Plan

A stormwater management plan has been prepared to assess the suitability of the existing drainage infrastructure and provide recommendations for improvements. The stormwater analysis was completed using 12D software to model the hydrology and channel hydraulics. The model was set up using the follows input parameters:

Modelling Inputs	**Details**
Modelling methodology	Australian Rainfall and Runoff 2019 method
IFD data	Obtained from ARR data hub for Kalkite (Lat -36.335, Lon 148.633)
Catchment routing methodology	Kinematic Wave/Direct tc
Losses	Initial Loss and Continuing Loss with a reduction factor of 0.4 as per updated guidance from ARR. Model also checked against ILSAX model using Hortons Losses – low infiltration soil.
Manning's n	0.03 selected for channel roughness

Based on the modelling analysis, it is apparent that the existing diversion swales are suitably sized to cater for the 1% AEP storm event without overtopping the swale. The swales are also suitably positioned to cut off all catchment upstream of the STP plant.

There is a small catchment upstream of the evaporation pond which is not currently intercepted by a diversion swale. Bunding and/or diversion swales should be constructed along the southern and eastern boundaries of the evaporation basin to divert all runoff from upstream. Construction of a bund for the full length of the evaporation basin may be difficult due to the slope of the existing terrain towards the eastern end of the evaporation basin.

It is not considered a requirement to construct a diversion swale upstream of the irrigation area as the existing contours direct upstream flows to the gullies on either side of the irrigation field. Refer to **Appendix E** and **Appendix F** for Stormwater Catchment Plan and Stormwater Management Plan respectively.

8. Conclusion

Based on the information provided by Snowy Monaro Regional Council, and subsequent site investigations, it is evident that the existing site is heavily constrained as a result of the slope of the site and due to the lack of available site area to sustainably dispose of the treated effluent onsite. Should Snowy Monaro Regional Council proceed to implement a partial onsite effluent irrigation system, and in the absence of an existing approval, the relevant approvals should be sought from NSW Health prior to commencement of the scheme.

It is recommended that a management plan is developed along with the irrigation design which should also incorporate a monitoring regime of the following as a minimum:

- Gauged raw wastewater inflows
- Treated effluent quality in terms of BOD_5, TSS, TN, TP, EC
- Vegetation assessment of the existing site to determine the susceptibility of existing vegetation to salinity
- Irrigation schedule in accordance with the water balance and local weather conditions
- Irrigation field monitoring (both hydrogeology and soil chemistry parameters)
- Management plan for surplus effluent and peak wet weather flows

It is also recommended that the proposed stormwater management plan is implemented to prevent surplus inflows to the evaporation basin.

On receipt of updated site-specific wastewater and effluent data it is recommended to update this report and all calculations to improve the accuracy and reduce uncertainty of assumed values.

9. Appendices

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9.2. APPENDIX B – STP EXISTING LAYOUT

9.3. APPENDIX C – STP PROCESS DIAGRAM

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9.8. APPENDIX H – GEOTECHNICAL SITE INVESTIGATION

SNOWY MONARO REGIONAL COUNCIL

KALKITE SEWAGE TREATMENT PLANT UPGRADE OPTIONS STUDY

REPORT No.: SMRC-0009-RO2
REV: P2
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DISCLAIMER

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1 Introduction

Kalkite is small village within the Snowy Monaro Regional council (SMRC)area. It is located 56km by road from the regional town of Cooma, 24 km from the small town of Berridale and 21km from Jindabyne. Kalkite is situated on the shoreline of Lake Jindabyne and is home to approximately 250 to 350 people. Kalkite is considered to be an Australian alpine town, in the snowy mountain area, near the Kosciusko National Park.

The town is serviced by both a reticulated water system and gravity sewerage system. The water for the village is sourced from Lake Jindabyne and is simply chlorinated and then reticulated around the village. The sewage from the residences is collected in a gravity sewer and directed towards three small pump stations. The three pump stations pump the collected sewage to an established sewage treatment plant (STP) located outside, but uphill of the town. The effluent that is produced by the STP is stored and then is used to irrigate land within the STP boundary and the remainder is trucked away to the Jindabyne STP.

The STP has been established for some time (circa 1980), and its upgrade is the subject of this report. Upgrades to the current STP are required because SMRC has become aware that it is the intent of private landholders near the town to develop additional blocks of land for sale and occupation. With reference to planning documentation provided by SMRC, it is predicted that Kalkite will experience significant growth over the next 20 years or so. It is expected this growth will occur mostly via subdivisional development on vacant parcels of land located on the south side of the town.

The locations where development is most likely to occur are as follows:

- 3 Rivers residential development (42 Lots).
- Hilldowns Road, Kalkite (210 Lots).
- Tourist development (40 Residential lots and an 80-bed visitor accommodation).

To this end, SMRC has commissioned this report to understand the potential upgrades required to the existing plant in the medium and long term.

1.1 Environmental Protection Licence

The SMRC currently operate the Kalkite STP and no effluent leaves the site, no effluent is re-used outside the site. The effluent that is generated is either irrigated on the site, evaporated, or trucked away from the site and hence, it is considered a no impact site. An environmental protection licence (EPL) is not available for the current arrangement. Given the statements made above it is the intent of the SMRC to pursue an EPL for the site.

2 General Site Descriptions – Current Management Plan

2.1 Site and Catchment

SMRC have a well-established understanding of the STP and the site it occupies. The Kalkite Sewerage Treatment Plant (STP) is located on the eastern side of the township

of Kalkite in Lot 22 DP634476. This parcel of land is approximately 4.2 hectares total area and slopes steeply downwards to Taylor's Creek to the north. The STP sits at an approximate average elevation of 950 m AHD which is significantly higher than the town of Kalkite (approx. 920 m AHD). The site is considered tight and flat real estate is at a premium. Additional flat areas will require creation via civil works.

The STP currently receives raw wastewater from 146 properties within the Kalkite township. Raw wastewater is pumped to the STP via sewer rising mains from three (3) sewer pump stations located throughout the town of Kalkite. The STP treatment system consists of an oxidation ditch (Pasveer ditch) followed by a maturation/ evaporation pond.

2.2 Process

The sewage is treated within the STP using an activated sludge process to consume the carbon-based pollutants within the flow. The central treatment process is reliant on the formation of an activated sludge by aeration of the liquor within the oxidation ditch. After a prescribed period of time, the volume of activated sewage in the oxidation ditch has the aeration process stopped. The activated sewage is allowed to sit, causing the sludge settle and the clear effluent to be drawn off the top. In general, the process could be described as waste activated sludge sequential batch reactor. The process is typical of small lightly loaded STPs. The process diagram for the plant is shown below:

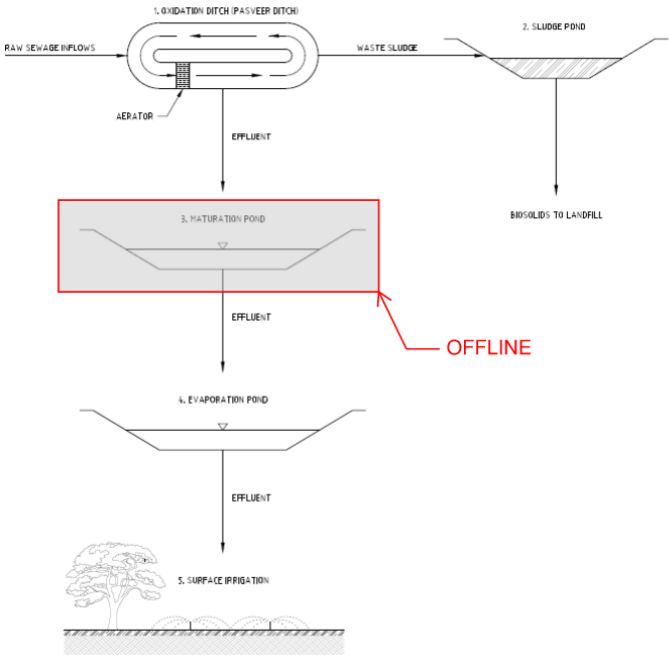


Figure 1: Kalkite STP process diagram

For noting, the Maturation Pond shown in the above process diagram, has been taken off line, due to the structural failure of the earthen wall of the pond. It is not possible at this point to bring the treatment element back online, meaning that a significant treatment process is not being undertaken.

2.3 Effluent Quality

The effluent that is produced by the STP is also representative of the technology used and in general could best be described as a Class B effluent in accordance with the NSW guidance document for recycled water management systems. The re-use options for this quality of effluent are limited. The current management plan which shows the effluent being irrigated on site, is seen as the best and lowest risk option for the site.

Recent effluent results for the existing facility are tabled below:

Table 1: Effluent Quality Parameters (Recent) – NATA laboratory

Quality parameters	Units	Test results Nov 22	Test results Dec 22	Test results Jan 23	Test results Feb 23
pH	unit	9.34	7.53	9.67	7.93
Suspended solids	mg/L	51	64	68	49
Biological Oxygen Demand	mg/L	20	4	13	8
Ammonia	mg/L	0.3	3.5	0.1	1.2
Total Nitrogen	mg/L	4.91	5.72	4.34	5.58
Total Phosphorus	mg/L	1.41	4.8	4.01	4.97
Thermotolerant Faecal Coliforms	cfu/100ml	290	2000	2	430

The effluent quality parameters tabled above, show there is significant variability in the results, which makes the process of deciding the effluent disposal end point difficult. It is clear from these results the current STP technology is struggling. The current system of on-site disposal via irrigation is suitable at this point, however, as has been stated before, once the volume of effluent exceeds 50 kL/day, effluent disposal will have to be done off site. This means that effluent quality will have to be significantly better and significantly more consistent. To achieve these two outcomes the plant will have to be upgraded. The central issue at this site is compliant effluent disposal.

2.4 Influent Volume Estimates

The influent/effluent volumes of the plant have in the past been estimated based on observations. Recently SMRC has made changes to the incoming pipework and has installed magnetic flow meters to measure incoming flows. The council plans show that Kalkite has 146 sites serviced by the sewerage system and the 2016 census state that approximately 214 people consider Kalkite their permanent home. It should be noted the number of people in Kalkite is highly seasonal, and consideration must be given to the variability of the incoming flow. The following table outlines the potential flows to the STP based on differing inputs.

Table 2: Effluent Quantities Estimated and Measured

Input source	No. of EP (est.)	Occupation rate	Estimated ADWF
146 Residential connections	511@ 180 L/EP/d	3.5 EP/lot	91 kL/day
146 Residential connections and recent water consumption results	195 @ 180 L/EP/d	2.0 EP/lot	35 kL/day
Census data	214 @ 180 L/EP/d	1.5 EP/lot	39.5 kL/day
Water Planning report 2022	300 @ 180 L/EP/d	2.0 EP/lot	54.0 kL/day
Recent flowmeter measurements (short term)	300 @ 180 L/EP/d	2.2 EP/lot	36.0 kL/day av. 54.0 kL/day peak

Estimating sewage inflows for the design of STP upgrades is a subjective process. Based on the above inputs, and for the purpose of this report, the conclusion is that Kalkite STP is seeing between 200 - 300 equivalent persons at 180 litres/person/day, with the typical industry peaking factors applicable to those inflows. Any upgrades to the plant will be based on these findings.

3 Purpose of the Option Study – Begin with the End in Mind

The purpose of the option study is to articulate the potential options open to SMRC for the augmentation/upgrade of the Kalkite STP to meet the community needs, environmental protection, and the effective operation of the STP.

SMRC have reached a clear end in mind for the Kalkite STP. SMRC have approved the Water & Wastewater Department to have designed and then construct a major upgrade at Kalkite Sewage Treatment Plant (STP) in the near future.

Kalkite has been identified as an area of substantial growth over the next 2 - 10 years. There is strong evidence (as mentioned above) that this growth will be realised.

The current STP was built in the early 1980's with an original design throughput of 1000 EP (200 kL/day). The STP has not been augmented or had a substantial upgrade since the original construction and evidence shows it can no longer achieve its original design throughput of 1000 EP.

The SMRC strategic planning department have issued an expected growth plan that aligns with a required throughput EP of 1500 (270kL/day) at the end of this augmentation process.

Given the information about known property developments to the area of Kalkite, it is expected that while flows to the plant will increase, that increase will be steady and consistent over the next six years. For the purpose of this report and given what has been found about current inflows and occupancy levels in the area, it is anticipated that the expected throughput would be closer to 1000 EP over that period (this is discussed further below).

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Notwithstanding the above, Council requires the STP to meet the following criteria:

- Sufficient capacity to last through the growth phase and into the future of the Kalkite township.
- Produce an effluent quality that can be re-used within the catchment of the significant environmental habitat that is Lake Jindabyne.
- An ergonomic, fit for purpose facility that overcomes the challenges of a steep site to provide a comfortable, safe and efficient working environment.
- The obligations as noted by NSW Department of Planning and Environment (DPIE) section 60, and the checklists that outline these obligations, with the view of establishing a compliant STP and associated environment protection licence (EPL).

4 Design Criteria for Future Development

4.1 Influent Volume of Sewage to be Treated/ Effluent to be Disposed

Significant work has previously been undertaken on the topic of sewage treatment and effluent disposal volumes. This report references Westlake Punnett & Associates (WP) report "Kalkite STP Hydraulic Assessment Report No. 21381.R01". For the convenience of this report, the original WP inflow calculations are reproduced with slight modifications to reflect recent findings along with the current inflow are shown in the following tables.

Table 3: Current inflows (calculated not measured)

Parameter	Unit	Value
No. Lots	lots	146
Total Cumulative EP	EP	321
ADWF	L/day	57,816
ADWF	L/sec	0.67
Peaking factor	unitless	3.2
PDWF	L/sec	2.1
GWI	L/sec	0.45
RDI	L/sec	6.0
PWWF	L/sec	8.5

Table 4: 1000 EP inflows (calculated based on known developments)

Parameter	Unit	Value
No. Lots	lots	400-480
Total Cumulative EP	EP	1000
ADWF	L/day	180,000
ADWF	L/sec	2.0
Peaking factor	unitless	3.0
PDWF	L/sec	6.0
GWI	L/sec	0.8
RDI	L/sec	10
PWWF	L/sec	16.8

Table 5: 1500 EP inflows (calculated based on long term planning assessment)

Parameter	Unit	Value
No. Lots	lots	600-680
Total Cumulative EP	EP	1500
ADWF	L/day	270,000
ADWF	L/sec	3.1
Peaking factor	unitless	2.8
PDWF	L/sec	8.8
GWI	L/sec	1.5
RDI	L/sec	15.0
PWWF	L/sec	25.3

After reviewing the WP report and the preceding tables, it is evident the principal constraint to the size of the STP is the capacity to dispose of the effluent in accordance with section 60. Beyond the volumes of inflow currently being experienced at the STP, it will mean that on site effluent irrigation will not be sufficient, and external re-use will have to be considered. Hence, for this report, only external effluent re-use options will be considered.

4.2 Effluent Quality and Irrigation Requirements

Given the statements above, it is clear that the effluent quality leaving the STP for external re-use of the recycled water will have to be of the highest quality possible. The relevant guideline document is the NSW Guidance for Recycled Water Management Systems (2015). This document advocates for a risk-based framework for the management of recycled water schemes. Rather than focusing on absolutes in terms of effluent quality parameters, it allows the proponent to consider many factors including economic and environmental sustainability, social benefits and protection of public health. The focus is the management and monitoring of risk from the source to the end use to ensure the water is suitable for the intended uses i.e. "Fit for Purpose".

In this case, effluent will be leaving the site and will be interacting with the public in some way. Hence, there is a limited way forward for the project in terms of effluent quality.

Experience has shown in order to get to a successful implementation of a recycled water management scheme (RWMS), a robust, multi-barrier treatment process is necessary. Usually, successful RWMS have the following common elements involving:

- High quality primary treatment, consisting of screening of the sewage to 3mm or lower, grit removal and some inflow equalisation.
- High quality secondary treatment targeting significant reduction in the level of BOD, Total Nitrogen and Total phosphorous.
- High quality membrane filtration
- Time in a holding storage
- UV sterilization
- Chemical disinfection

Given the above, the likely target profile of an effluent that could be used in an RWMS for irrigation of a public space, depending on the exact site, might be as follows.

Table 6: Final Effluent Quality Parameters Profile

Effluent quality parameter	Unit	Expected Result from Treatment	Limit type	Frequency of testing
5 day Biochemical oxygen demand (BOD)	mg/L	5 - 7	Maximum	Monthly
Total suspended solids	mg/L	3 - 5	Maximum	Online monitoring
Turbidity	NTU	2	Maximum	Online monitoring
Nitrogen	mg/L	5	Maximum	weekly
Phosphorus	mg/L	2	Maximum	weekly
Thermotolerant Faecal coliform	Organisms/100ml	2	Maximum	Monthly
pH	pH units	6.0 – 9.0	Range	Online monitoring

Taking the above into account, and the fact the effluent is of a high quality with a low contaminant content, the application of that effluent to land becomes substantially easier to manage. In general, it is expected with the type of effluent outlined above, the land within the near radius of the plant and type of weather of the general area, that an application rate of 8 – 10 ML/hectare/year could be achievable. Table 7 contains the required land area for the three flow scenarios described in Tables 3, 4 and 5 based on an application rate of 9 ML/hectare/year, or 2.5 mm/m2/day.

Table 7: Land Areas Required for Effluent Disposal (based on 9 ML/ha/year application rate)

Effluent volume	Total area required	Area available at plant	Area required outside of plant
Current effluent volume based on Table 3 above 57kL/day **	23,100 m2	16,800 m2	6,300 m2 or an area 79m x 79 m
Predicted 1000 EP effluent volume based on Table 4 above 180 kL/day	73,000 m2	16,800 m2	56,200 m2 or an area 237 m x 237m
Predicted 1500 EP effluent volume based on table 5 above 270 kL/day	109,500 m2	16,800 m2	92,700 m2 or an area 305 m x 305 m

** Currently measured daily inflows are averaging 36 kL/day well within the capacity of the irrigation area at the STP site.

A review of the areas around Kalkite shows that areas suitable for the disposal of effluent for 1000 EP is possible within a short distance of the plant.

4.3 Other Design Considerations for Upgraded/New Plant

There is appropriate evidence that the existing plant will need to be substantially upgraded. The following items are the design considerations that will impact the assessment of various design options.

- The site is steep and flat real estate is at a premium.
- The original maturation pond site is not available due to failure of the pond wall.
- Access to the site is adequate but not ample.
- The site is subject to extreme variations of weather, from very cold in the winter to hot in the summer.
- The site will be subjected to snow fall in winter.
- The site is near the shore of Lake Jindabyne, a sensitive environmental area.
- Power to the site while currently adequate, has limitations.
- The new infrastructure will have to be built in and around a working STP.
- The new infrastructure will have to cope with variations in hydraulic load due to seasonal variations in visitors to the area.

- The new infrastructure will have to produce an effluent that is low in total nitrogen and low in total phosphorus, hence biological nutrient removal will have to be included in the process design.
- The new infrastructure will have to produce an effluent that will meet the risk profile for irrigation of a public space. Multiple barriers will have to be included in the process design.
- The new infrastructure will have to allow for the efficient delivery of treatment chemicals to the site. The effective removal of screenings and other debris from the site and the regular removal of biosolids from the site.

5 Options available

Given all the above, the option to do nothing, or to do a small adjustment to the existing plant is no longer an option. The existing elements of the existing STP are well aged, and essentially near the end of the asset life. A major upgrade is required and options that explore doing nothing or doing very little are no longer considered in this report. Most of the options below have a common element, in that it will require council to find an area for effluent disposal outside the STP site once sewage inflows are consistently above 50 kL/day.

- **Option A:** Invest in infrastructure that will get the effluent outcomes but re-uses as much of the existing elements as possible.
- **Option B:** Invest in a complete new STP plant. No re-use of any element at the site, with a design that can cope with all future loadings. All future loadings could be as high as 1800 EP or 325kL/day.
- **Option C:** A hybrid of options A and B, minimising the economic impact but maximising the environmental outcomes, knowing that if Kalkite continues to experience substantial growth, then the current site has limitations on it.
- **Option D:** Abandon the existing site with the view that sewage treatment and effluent disposal will not occur at the area. All sewage will be collected at a new pump station and pumped via a rising main to East Jindabyne, with a view that it will be treated at the STP at Jindabyne. This option is not discussed in the body of this report but a short investigative report on the proposed pump station and rising main is attached as an appendix.

5.1 Option A - 1500 EP Plant Capacity (Re-using Elements of the Existing Plant)

For this option several elements at the STP can be retained in the operational design of the new STP. The existing layout of the plant would be kept with a view that civil works are minimized.

At the current site, there is currently no screening or de-gritting element, and it is crucial for the plant that this first barrier is established. A small tank to be used for flow equalisation is proposed below the screening system.

It is clear from the current effluent quality parameters discussed above, that the SBR treatment element is not producing a consistent quality effluent. The STP as part of the second barrier needs to be able to achieve that outcome. A significant upgrade of the existing secondary treatment bioreactor is required along with a change away from an SBR process to a conventional extended aeration waste activated sludge process and would require the construction of a new clarifier. The new clarifier could be built while the STP remained online, however, the modifications to the existing

Pasveer bioreactor would be extensive and require the STP to be offline during those mods.

The current and relatively new effluent lagoon can be retained. The effluent that is stored in the lagoon will need further tertiary treatment, consisting of chemically assisted sand filtration, followed by membrane-based filtration, UV disinfection and chlorination. The effluent will need to be stored in an enclosed tank prior to re-use via irrigation. The proposed process diagram is shown below.

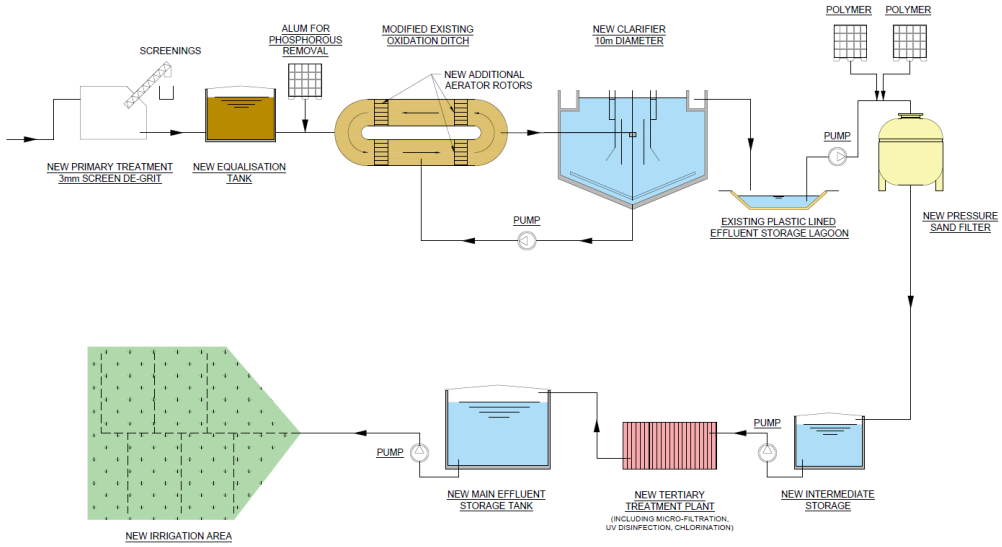


Figure 2 Process Flow Option A

Bio-solids from the plant would be stored and treated in a separate facility on site using a small belt de-watering system.

5.2 Option B - 1800 EP Plant Capacity (Completely New Plant)

For this option, extensive civil works are required at the site in order to develop enough flat area to site and construct the new plant. The proposed process would have the same primary treatment system as noted above, complete with screening of rag, rubber and rope elements in the sewage to 3 mm. A de-gritting process, with some flow equalisation built into the bioreactor structure would also be included.

The bioreactor would be designed as a submerged membrane bioreactor (MBR). The MBR tank would be purpose built in reinforced concrete. The biological process before the membrane would be designed to target biological nitrogen removal to less than 5 mg/L and chemical precipitation of phosphorus to below 1 mg/L. Flow from the MBR would be treated through UV disinfection followed by chlorination and storage. The existing storage lagoon would become redundant. The proposed process diagram is shown below.

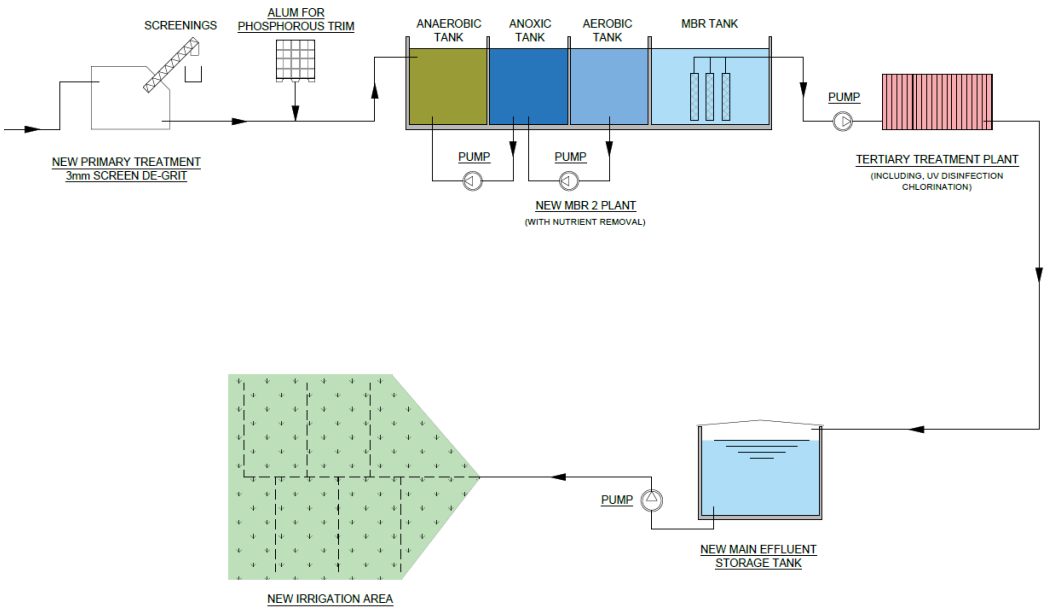


Figure 3 Process Flow Option B

Bio-solids from the plant would be stored and treated in a separate facility on site using a small belt de-watering system.

5.3 Option C - Blended proposal using elements from Options A and B, Plant capacity limited to 1000EP, but with capability to be increased to 1800 EP

It is clear, the STP needs an upgrade in order to export effluent from the site. What is not clear currently is the expected growth rate of Kalkite and the urgency around the delivery of the upgrades. Major civil works at the site are problematic and the period of time that the plant could offline is limited.

Given the above, it can be seen that both options carry common elements which will need to be included in the process design regardless. Namely a new primary screening system, the use of membranes, UV disinfection and chlorination, and a separate biosolids dewatering facility.

SMRC already have capital set aside for a tertiary treatment plant for the current inflow of effluent, and the newly constructed storage lagoon has been well engineered and should continue to be used.

This option advocates for the tertiary treatment plant to proceed based on the effluent quality currently available (this would then continue to be used even when the effluent quality improved), thus retaining the use of the current effluent lagoon. It Involves moderate civil works in and around the existing water storage tanks to create some additional real estate to house the new primary screening facility, chemical storage and biosolids facility. The secondary treatment would be via prefabricated steel MBR tank modules, trucked to site.

Hence, the STP would remain online while:

- The tertiary treatment plant was installed and commissioned.

- The additional civil works for the new real estate were undertaken.
- Primary screening and dewatering facilities were built.

Then, at the convenience of SMRC, the existing Pasveer ditch would be decommissioned, filled in and the new MBR modules set in place. The proposed process diagram is shown below.

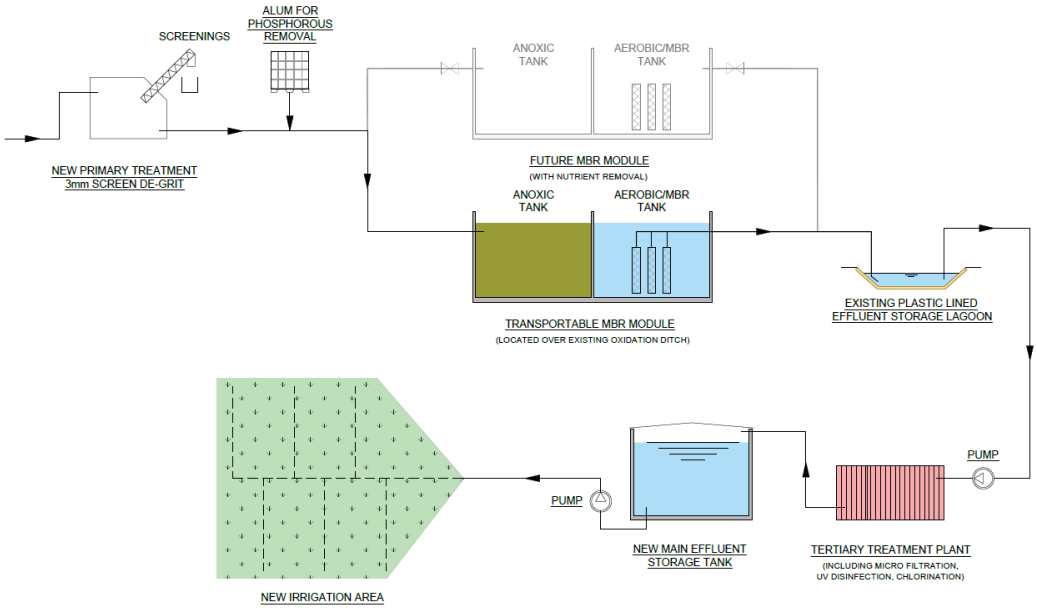


Figure 4 Process Flow Option C

5.4 Option D - No treatment capacity at Kalkite, new pump station and rising main.

As discussed above, there is a physical and capacity limitation at the STP site at Kalkite. Experience shows that for inflows beyond 250 kL/day (nearly six times the current inflow), the management of the RWMS becomes extensive. The area of land required for irrigation would also become difficult to find. It would be at that point in the development of Kalkite, that strong consideration is given to pumping the sewage collected from the catchment to east Jindabyne, with a view that it is treated at a regional STP at Jindabyne. See appendix A for further discussion on this option.

6 Cost Estimates

6.1 Impacts to be managed by Council

The principal impacts that will occur due to this project, are listed below. The cost of managing these impacts is on-going and are not reflected in the estimated options costs discussed in the next section.

- After inflows increase beyond 50 kL/day, most of the effluent will have to be disposed offsite in accordance with the new RWMS.
- An additional chemical logistic will be required at the site, namely liquid alum, sugar syrup, sodium hypochlorite, caustic soda, and citric acid. In turn, this will

mean that access to the site will have to be suitable for third party service agents. i.e., delivery trucks
- Power consumption at the site will increase.
- Additional operator time on site will be required.
- Additional operator time to manage the RWMS will be required.
- A small but additional logistic to remove screenings from the site will be required, usually undertaken by the solid waste service contractor for the area.
- A small but additional dewatered bio-solids logistic will be required.
- More on site testing will be required to be done by the operator.
- More testing by a third party will be required.

The above items will impact the operating costs of the STP, these increases in operating costs are not considered in the costings below, which are purely focused on capital costs.

6.2 Capital Cost Estimates for the Various Options

Tables 8 – 10 are engineering cost estimates for each of the identified options.

Table 8: Option A – Cost estimate 1500 EP plant capacity (re-using elements of the existing plant)

Item No.	Item description	Units	Qty	Cost ($)
1	Civil works area around water tanks	Item	1	250,000
2	New primary treatment elements including screening, de-gritting and equalisation tank	Item	1	350,000
2	New clarifier (10.0 metres in diam) supported on piles	Item	1	650,000
3	Modifications to the existing oxidation ditch, including increasing the depth and installing additional aeration equipment	Item	1	750,000
4	Additional pumps for recirculation	Item	2	80,000
5	Pressure sand filter prior to tertiary treatment plant	Item	1	120,000
6	Package tertiary treatment plant including MF cartridge filter, UV and chlorination equipment	Item	1	250,000
7	Irrigation system for effluent disposal	Item	1	100,000
8	Bio solids dewatering facility	Item	1	120,000
			Total	2,670,000

Table 9: Option B Brand new plant 1800 EP

Item No.	Item description	Unit	Qty	Cost ($)
1	Civil works required to create more area around water tanks and at the oxidation ditch level	Item	1	750,000
2	New primary treatment elements including screening, de-gritting and equalisation tank	Item	1	350,000
3	New concrete MBR bioreactor with nutrient removal process	Item	1	2,500,000
4	Package tertiary treatment plant including MF cartridge filter, UV and chlorination equipment	Item	1	250,000
5	New large and roofed effluent storage tanks	Item	2	500,000
6	Irrigation system for effluent disposal	Item	1	100,000
7	Bio solids dewatering facility	Item	1	120,000
			Total	4,570,000

Table 10: Option C - Hybrid solution 1000 EP plant with the capacity to increase to 1800 EP

Item No.	Item description	Units	Qty	Cost ($)
1	Civil works area around water tanks	Item	1	250,000
2	New primary treatment elements including screening, de-gritting and equalisation tank	Item	1	350,000
3	New prefabricated transportable MBR module 1000 EP	Item	1	1,250,000
4	Fill in the existing oxidation ditch	Item	1	10,000
5	Package tertiary treatment plant including MF cartridge filter, UV and chlorination equipment	Item	1	250,000
6	Small, roofed effluent storage tank	Item	1	150,000
7	Irrigation system for effluent disposal	Item	1	100,000
8	Bio solids dewatering facility	Item	1	120,000
			Total	2,480,000

7 Summary of Expected Outcomes and Recommendations

In summary, the cost of each option is tabled below.

Table 11: Summary of Options pros and cons

Option	Est. cost	Pro	Con
A	$ 2.7m	• Affordable • Makes the best use of the available area and existing facilities.	• The existing oxidation ditch requires significant investigation. • The final process cannot achieve consistently low nitrogen effluent
B	$ 4.5m	• This option will produce the best effluent possible	• Significant civil works. • Oxidation ditch to be offline for a significant period of time
C	$ 2.5m	• Affordable • Makes good use of the available area and existing facilities. • Shortest period for the oxidation ditch to be offline. • Flexibility to defer costs allow a combination of the following future options: • Increase treatment volumes as required, up to a limit.	• The steel MBR tanks have a shorter life span than concrete
D	$ 8.7m	• This is the ultimate regional solution. • Lowest operational cost as: • A treatment plant at Kalkite is not required. • Effluent disposal costs are not applicable.	• This is an expensive option, The Jindabyne STP is currently not sized to take this additional inflow

It is recommended, that council strongly consider adopting option C at this time. It is the option that offers the ability for council to;

- Make the best use of the existing site without major civil works.
- Achieve a consistent quality of effluent.
- Achieve the necessary EPL for the site.
- Achieve a RWMS for the site.
- Achieve early works in the form of an effluent polishing plant.
- Make the continued used of the recently constructed lined effluent lagoon
- Respond to the immediate growth pressures.

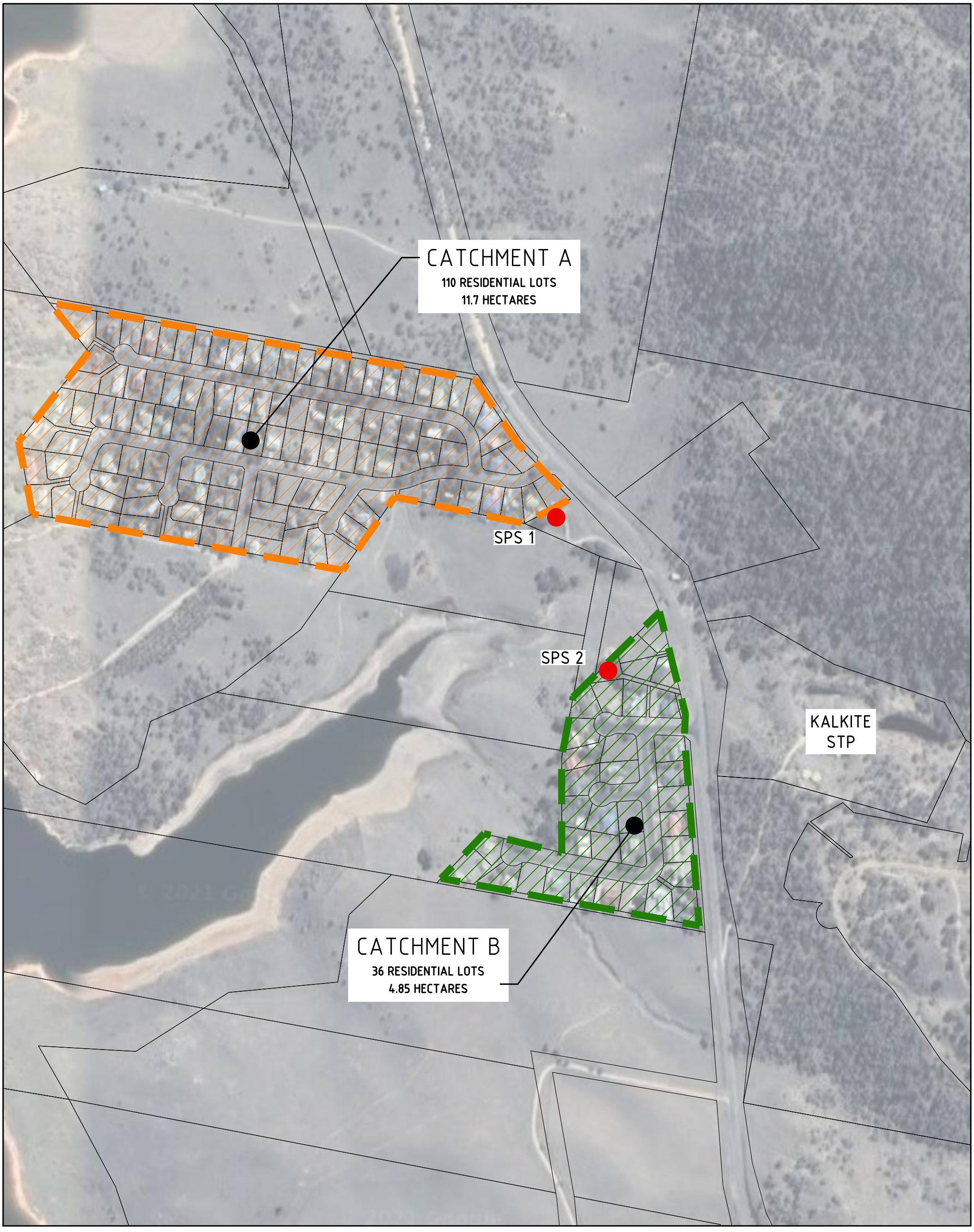
- Have the ability to expand the capacity of the plant if growth pressures continue.
- Not over capitalise the site.
- Still have the ability to abandon the site in the future to pursue a regional solution by pumping sewage to East Jindabyne.

This report supports this recommendation. This report is based on information and data only collected recently, but again, it supports this recommendation. Notwithstanding the above, the option to do nothing or little at this site, is no longer an option as real identifiable growth has occurred in and around Kalkite.

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APPENDIX A

Report - Kalkite Transfer Pump Station and Pressure Main to East Jindabyne STP



NORTH

KALKITE WWTP

SEWER CATCHMENT PLAN

WESTLAKE PUNNETT

0 50 100 150 200m

SCALE 1:2000 (A1), 1:4000 (A3)



NORTH

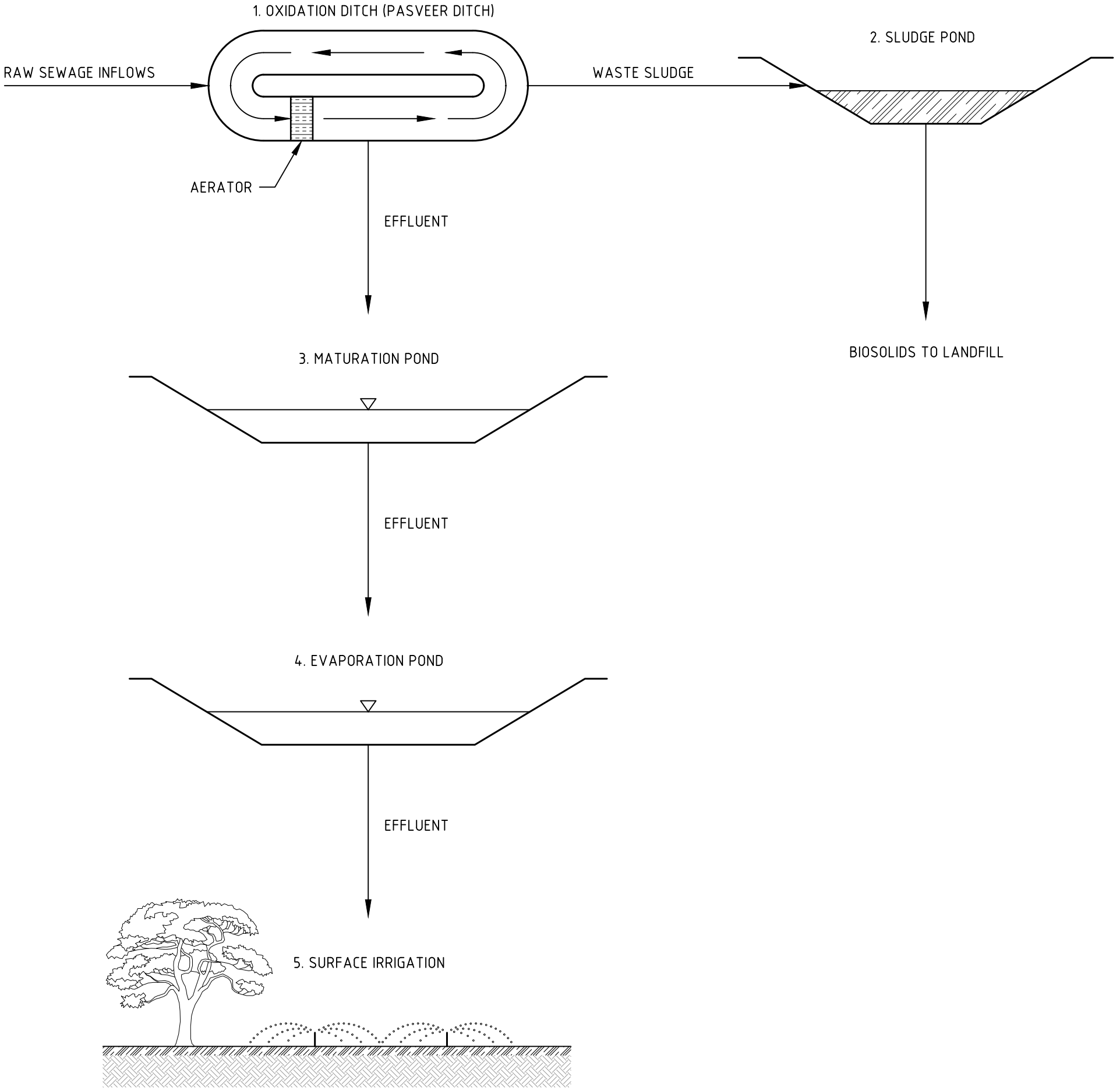
KALKITE STP

SEWAGE TREATMENT PLANT LAYOUT DIAGRAM

WESTLAKE PUNNETT

0 50 100 150 200m

SCALE 1:2000 (A1), 1:4000 (A3)



NORTH

KALKITE STP

TREATMENT PROCESS DIAGRAM

WESTLAKE PUNNETT



NORTH

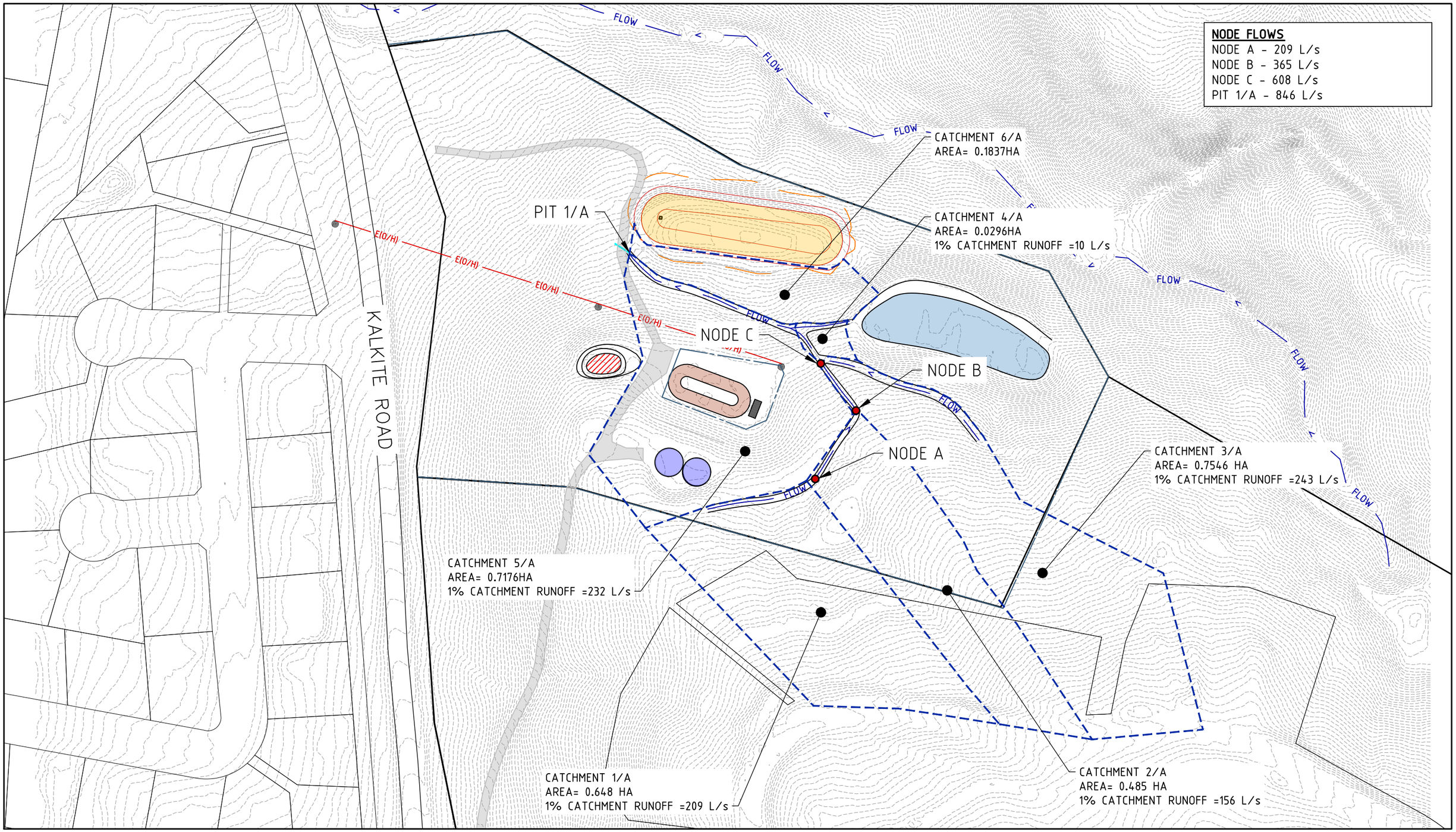
KALKITE STP

SEWAGE TREATMENT PLANT FINAL LAYOUT DIAGRAM

WESTLAKE PUNNETT

0 50 100 150 200m

SCALE 1:2000 (A1), 1:4000 (A3)



NORTH

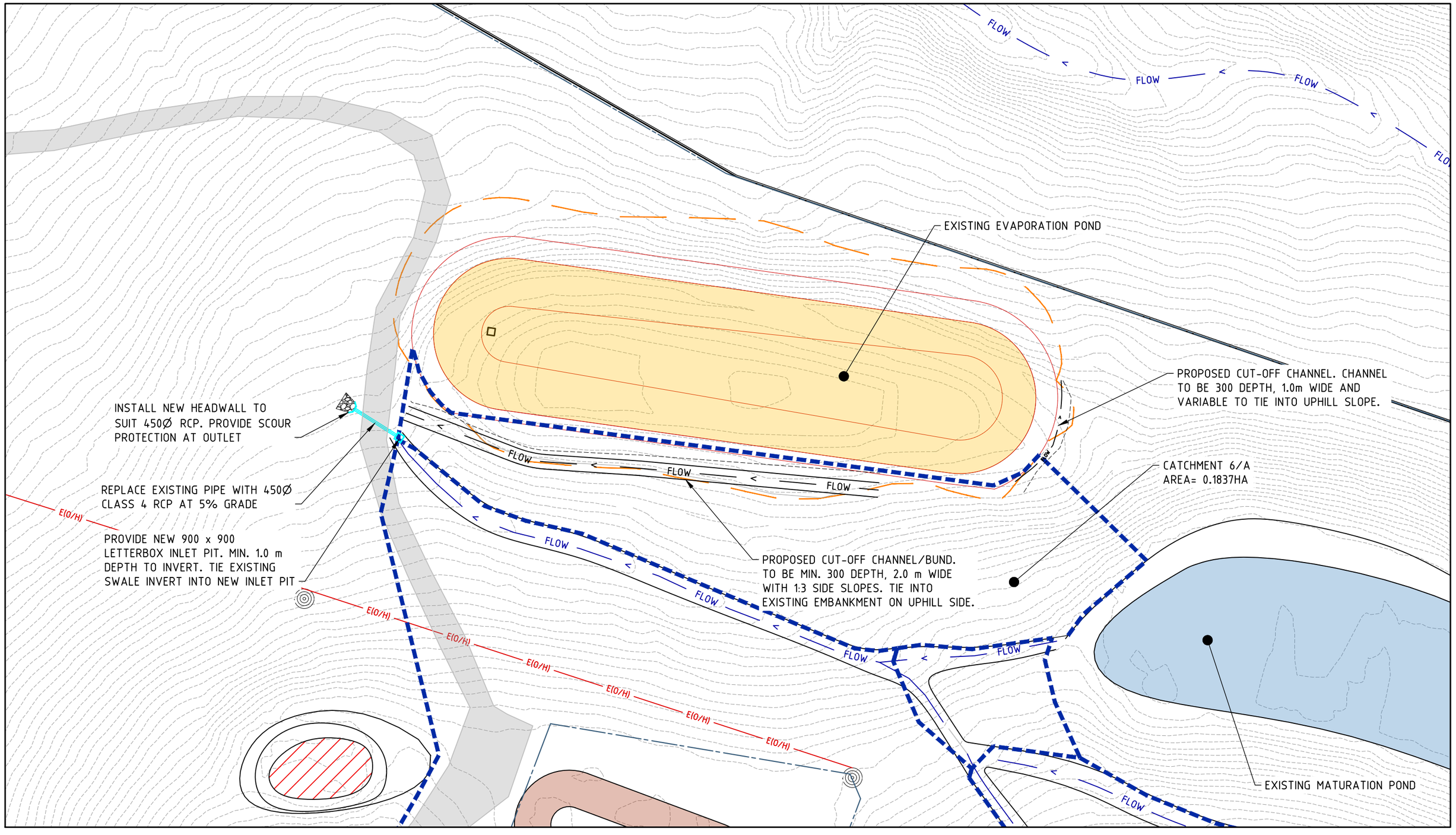
STORMWATER CATCHMENTS PLAN

KALKITE SEWERAGE TREATMENT PLANT

WESTLAKE PUNNETT

0 50 100 150m

SCALE 1:1500 (A1), 1:3000 (A3)



NORTH

STORMWATER MANAGEMENT PLAN

KALKITE SEWERAGE TREATMENT PLANT

WESTLAKE PUNNETT

0 10 20 30 40 50m

SCALE 1:500 (A1), 1:1000 (A3)

Appendix E: Ecology mapping data

Molonglo
Conservation Consulting

geoADAPT

GrassRoots
Environmental

Molonglo
CONSERVATION GROUP

SNOWY MONARO BIODIVERSITY STUDY

15 December 2019





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SNOWY MONARO BIODIVERSITY STUDY

Report prepared for Snowy Monaro Regional Council

15 December 2019

About Molonglo Consulting

The Molonglo Consulting team is skilled in ecology, soil science, land planning, biodiversity assessment, erosion control, Aboriginal cultural land management, environmental and agricultural economics, project management and community engagement. Our strength is in bringing all of these skills together—our focus is Inter-connected Landscape Management.

We also have strong community roots, as a regional coordinator of local Landcare and Park Care groups. The environmental outcomes we achieve are embedded in community stewardship. This facilitates long-term follow-up management of projects.

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The authors acknowledge the contribution of a number of third parties, as noted in this report.

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Molonglo CONSERVATION GROUP

geoADAPT

GrassRoots Environmental

Executive Summary

Background and Scope

The Snowy Monaro Regional Council (SMRC) area is diverse in biodiversity, demographics, industry and employment. Activities associated with European settlement such as clearing, urban development, forestry and agriculture have impacted on the biodiversity values of the region, which face further pressure going forward, in particular from population growth and climate change. Development certainty and conservation outcomes are best achieved by effective regional strategic planning rather than planning at the site-scale or development application stage (DECCW, 2010). The preparation of a new land use strategy and eventually a new Local Environmental Plan necessitated by the merger of three former Council areas presents an opportunity to re-evaluate approaches to rural and urban land use in this region. This has been outlined in the *Snowy Monaro Region Planning and Land Use Discussion Paper 2019* and forms the context for this biodiversity assessment. The Discussion Paper was released for comment for two months in early 2019 and received numerous submissions in response.

To address pressures on biodiversity and to best protect the values of the region, the SMRC is adopting an evidence-based approach towards land use planning. To facilitate this, the SMRC requires an understanding of the biodiversity values of the region to assist in future planning and decision making. The Snowy Monaro region is characterised by diverse landscapes, with multiple national parks and nature reserves covering approximately one-third of the Snowy Monaro Local Government Area (LGA). The rural lands of the LGA contain areas of nationally significant Natural Temperate Grassland, Monaro Tableland Cool Temperate Grassy Woodland, and other Endangered Ecological Communities (EECs), along with regionally significant biodiversity corridors as identified in the *South East and Tablelands Regional Plan 2036*.

The SMRC recognises that the LGA contains all four types of Environmental Protection Zones (EPZs 1-4) although they could be more readily applied in areas of significant environmental value than they are currently. A strong evidence base is required in order to justify amendments to Local Environmental Plans, particularly around townships where some of the land may be suitable for development to support future population growth.

The purpose of this study is to provide a broad-scale environmental evaluation of lands within the SMRC area which will inform recommendations on the utilisation of EPZs and the constraints for potential development based on regional and local environmental and biodiversity values, noting that an assessment of social and economic considerations is outside the scope of this report. The study also looks at potential climate change impacts on biodiversity values and evaluates the opportunities for agroforestry in the form of regenerative agriculture. In spite of development and land use pressures, the region maintains a very high level of biodiversity, a large proportion of which is protected in national parks, nature reserves and state forests (covering almost one-third of the region). Of equal importance are the biodiversity values on private lands which, although protected by legislation, need to be managed appropriately.

Analysing and Mapping Biodiversity Values

Criteria for the biodiversity assessment were selected in line with Clause 7.3(3) of the *Biodiversity Conservation Regulation 2017* to ensure that the values outlined in the report related to the NSW Government's Biodiversity Values Map. The Biodiversity Values Map is one of the triggers for determining whether the NSW Biodiversity Offset Scheme (BOS) applies to a clearing or development proposal. In addition to listed EECs and threatened species, there are a number of additional sensitive areas included for protection such as wetlands, Koala habitat, RAMSAR sites, protected riparian land, high value groundcover, old growth forest, rainforest, areas of outstanding biodiversity values, and any other land that the Minister for the Environment deems appropriate for inclusion.

For the purpose of this study and to ensure a comprehensive assessment was undertaken, these values were compiled, along with additional criteria including geoheritage, Aboriginal heritage and other constraints on development to create the assessment criteria shown in the summary table below. Each of these criteria are made up of numerous sub-criteria, which are also summarised in the table. Biodiversity values documented in

the assessment criteria represent a mix of available (surveyed) map products, distributional model predictions and field sightings. Over 40 layers of data were included in the spatial analyses that inform this report. Unfortunately, the full distributions of vegetation types, threatened species and Endangered Ecological Communities are poorly described for the region and some were not available for this assessment and report. For example, a project is currently underway by the NSW Government to map vegetation types across South East NSW using a consistent classification schema, but the data were not available for inclusion in this assessment and report. The data layers compiled and analysed have been provided to Snowy Monaro Regional Council as a comprehensive 'datapack'.

Criteria 1 Conservation Areas	National parks and nature reserves (Criteria_1a), state forests (Criteria_1b), scenic protection areas (Criteria_1c), as well as Crown reserves, conservation agreements and biobanking agreements (Criteria_1d). Note that Crown reserves include Travelling Stock Reserves (TSRs), which are often areas of high biodiversity containing significant environmental values.
Criteria 2 Native Vegetation	Rainforest and old growth forests (Criteria_2a); sensitive regulated lands (Criteria_2b); vulnerable regulated lands (Criteria_2c); vegetation maps for Bombala (Criteria_2d & 2j), Cooma (Criteria_2e), South Coast (Criteria_2g), Snowy River (Criteria_2h) and the Snowy Monaro (Criteria_2i); as well as candidate native grasslands (Criteria_2f). A significant omission was the newly listed EEC, the Werrima/Monaro EEC, as the spatial layer for this was unavailable.
Criteria 3 Threatened Entities	EPI terrestrial biodiversity (Criteria_3a); threatened entities of the South East Tablelands (Criteria_3b); sub-regional threatened species model predictions by Steve Priday (Criteria_3c, Criteria_3e, Criteria_3g); sub-regional Endangered Ecological Community model predictions by Steve Priday (Criteria_3d, Criteria_3f, Criteria_3h); biometric model predictions of vegetation types (Criteria_3i); freshwater threatened species distributions (Criteria_3j); Koala population surveys (Criteria_3k); and threatened species sightings (Criteria_3l, Criteria_3m, Criteria_3n).
Criteria 4 Freshwater Features	Bogs and fens (Criteria_4a); drinking water catchments (Criteria_4b); groundwater vulnerability (Criteria_4c); riparian lands and watercourses (Criteria_4d); significant wetlands of NSW (Criteria_4e); vulnerable protected riparian lands (Criteria_4f); wetlands of national significance (Criteria_4g); and Ramsar wetlands of international significance (Criteria_4h).
Criteria 5 Geological Heritage	Karst formations (Criteria_5a) and information from a national registry (which is not mapped due to coarse georeferencing) on type localities and fossil sites, etc. Unfortunately, spatially explicit information on geological heritage values is generally lacking for the region, with the exception of a map layer identifying karst formations near Michelago and Smiths Road.
Criteria 6 Aboriginal Heritage	Documents known, significant Indigenous areas and items (Criteria_6a).
Criteria 7 Other Constraints on Development	Coal seam gas exclusion areas (Criteria_7a); flood prone areas (Criteria_7b); landslide risk areas (Criteria_7c); strategic agricultural lands (Criteria_7d); and local flood risks for Bombala (Criteria_7e) and Cooma (Criteria_7f).

The process of synthesising the information relating to the range of conservation values included in this assessment was a difficult task. There were many different layers of information, none of which covered any one entire area or theme. Therefore, for some areas, the assessment has relied on modelled data which have been identified as such. Ground-truthing has been undertaken for key areas of interest for this report, as outlined in the scope for this study. However, it should be noted that there remain significant data gaps, particularly for certain vegetation communities such as native grasslands. Field surveys and data confirmation should form a key priority for any area proposed for land use or zoning changes.

The Snowy Monaro region has 18 listed Endangered Ecological Communities (six of which are of national importance) and over 200 threatened species, some of which are only found in the Snowy Monaro region. One EEC of particular note is the Snowy River Catchment (listed under NSW Fisheries legislation), which is unusual

in that it protects all of the values in the catchment rather than being a single vegetation community type (as is typical of other EEC listings). Although all threatened species bear equal importance in terms of being afforded protection and appropriate management, one species of particular note in the Snowy Monaro Shire is the Koala. The Koala population is significant for the conservation of Koalas across NSW and is highly valued by the community.

Other high conservation or environmental values that were included in the 'datapack' and spatially projected include native vegetation, wetlands and rivers, areas of geological importance, Aboriginal Heritage and other constraints on development such as landslide risk, important agricultural lands, coal seam gas exclusion and flood prone areas.

Numerous detailed maps have been provided with this report as part of the 'datapack'. In addition to production of maps for all criteria, the location of biodiversity corridors and their values were of interest to the SMRC. The corridors were mapped based upon known, mapped and predicted biodiversity values, as well as visual inspection of aerial imagery. Biodiversity corridors in the region are extensive, so for mapping and analysis as part of this assessment, the existing mapping polygons of the biodiversity corridors were aggregated into four zones, referred to throughout as 'West' 'North East', 'Central East' and 'South East'.

Future Urban Expansion Areas and Zoning

The standard instrument for Local Environmental Plans (LEPs) contains four Environment Protection Zones specifically for land where the primary focus is the conservation and/or management of environmental values. These zones provide for varying levels of environmental protection from zone E1 to E4 (NSW Government, 2009). This report makes recommendations on zoning only in the context of environmental and biodiversity values and does not make reference to other planning instruments or the social and political overlay. It is noted that there are a number of different viewpoints from stakeholders and the community working and living in the Shire, as evidenced by the variety of submissions to the *Snowy Monaro Region Planning and Land Use Discussion Paper 2019* (the 'Discussion Paper') which need to be taken into account as part of the planning and decision-making process.

Biodiversity values around key townships (nominated by the Snowy Monaro Regional Council) were investigated using existing spatial information in addition to ground-truthing of some areas where data were not previously available or confirmed. Given the extensive spatial data gaps that remain unconfirmed, only the areas of interest to the SMRC for potential future growth have been investigated on-ground as part of this study in line with available resources. The areas investigated include the townships of Berridale, Michelago, Smiths Road, Bombala and Cooma, and Smiths Road. The Crackenback / eastern approach to Kosciuszko National Park (SMRC, 2019) was also identified in the report scope; however, given the size of the area, the high biodiversity values indicated on the map, and the resources available, this area was only assessed based on existing biodiversity mapping. Note that Jindabyne was omitted from the study because land use planning is addressed in the *'Go Jindabyne' Masterplan*. Other town centres which were not specifically nominated for investigation but have been included in the High Environmental Value (HEV) map layer for the entire region are part of the 'datapack' for this report provided to the SMRC to inform zoning re-evaluation.

Recommendations for future urban-scale expansion is based on a decision-making dichotomy that first looks at whether there are environmental constraints on development for any given site. If the HEV mapping identifies constraints, the nature of these is investigated in more detail to determine whether a site involves Matters of National Environmental Significance (MNES), what are those values, and what are the potential threats to those values. If there are no environmental constraints identified, then rezoning can potentially be undertaken with respect to the economic and social considerations ascertained by Council. Also included for each town centre is a table that lists all of the value criteria (and their respective area in hectares) found within each SMRC area of interest. Specific zonal lot data were not provided for Smiths Road or the Crackenback / Eastern approach to Kosciuszko National Park, but these areas have been mapped and assessed for their values at a more generalised scale.

Analysis of the study areas of interest determined a variety of high value environmental entities according to the data, including in many areas that are currently RU1 (Primary Production) or R5 (Large Lot Residential) and would be suitable for Environmental zoning (E3 or E4). On the other hand, there is scope for rezoning in favour of development in some areas where environmental values were found to be relatively low and therefore these areas would be suitable as rural zoning or could be considered for industrial zoning. The table below provides a summary of the level of environmental values for each study area. The assignment of environmental value is based on the mapping, ground truthing and inventory of environmental values. Most were found to contain EECs and / or threatened species, and therefore are automatically assigned a high value. Condition of each EEC was also noted but, for the purposes of this report, does not have bearing on the assignment of values due to legislation that needs to be considered for all MNES. However, the condition of MNES does provide insight into what was verified on site. A very high values rating means that a site contains several MNES or large areas of one or more. A medium value means that few values were observed or mapped however there were still some values present.

Area of Interest (SMRC)	**Current Zone**	**Environmental Values**
East Polo Flat	RU1 Primary Production	High
Four Mile Zone	RU5 Village R5 Large Lot Residential	Very High
Cooma South	RU1 Primary Production	Very High
Michelago East	RU1 Primary Production	Very High
Michelago North	RU1 Primary Production	Very High
Michelago South West	RU1 Primary Production	Medium
Berridale Industrial	R5 Large Lot Residential	High
Berridale South	R5 Large Lot Residential	High
Berridale West	RU5 Village R5 Large Lot Residential	Very High
Bombala East	RU1 Primary Production	High
Bombala South 1	RU1 Primary Production	High
Bombala South 2	RU1 Primary Production	High
Bombala West	RU1 Primary Production RU5 Village R5 Large Lot Residential	High
Smith's Road – no specific zonal information provided. Whole area has high biodiversity values.	E3 Environmental Management	Very High
Eastern Approach to the Snowy Mountains / Crackenback Drive - no specific zonal Information provided.	E3 Environmental Management	Very high

Climate Impact on Biodiversity in the Snowy Monaro Shire

Climate change forecasting for the Australian Alps and Southern Tablelands predicts that the weather in the long term will become warmer (an increase of around 1.5–2.5°C). The area will experience a substantial increase in summer rainfall of between 20–50%. Significantly for the Snowy Monaro, winter rainfall is likely to decrease significantly which means a decrease in snowfall. This will be below the observed variability in winter rainfall in the 20th Century, particularly in the Alps and Southern Ranges. Spring and Autumn will be slightly wetter than, or close to, average in the Central Tablelands and 5% to 20% drier in the south. Compared with the long-term seasonal variability, rainfall in Spring and Autumn are generally within the ranges observed in the 1900 to 2000 period. Autumn is generally at the drier end of the observed range and Spring is at the moderate to wetter end. These changes have the potential for profound impacts on species that are already struggling to survive.

A report generated from the NSW Climate Refugia website, and provided in this report, summarises the predicted climate change impacts on local threatened species for 2030 and 2070. We also investigated the NSW Threatened Species Vulnerability Database to convey threatened species vulnerability as a function of existing threats and species traits. It should be noted that the NSW DPIE climate change impact assessments were not available for inclusion in the spatial layers for this study, so the project team required alternative modelling of impacts. We used the NSW Climate Refugia Portal to detail specific potential climate change impacts. As such, we are unable to predict shorter term climate change impacts, particularly in relation to future development recommendations as was the initial intent through projections mapping. It is therefore strongly recommended that any townships that include the species and vegetation communities highlighted in the report are significant to the state-wide protection of these species into the future and need to be managed accordingly.

Information has been provided in the report also on the detailed predicted impacts of climate change on ecosystems in the region based on work undertaken by Macquarie University in 2016, as well as detailed changes to climate predicted for the Snowy Monaro using NARCLIM. These data were averaged across 10 000 points in the Snowy Monaro Shire boundary and cover precipitation, temperature range and seasonality. These predicted impacts are significant and have implications for management not only of individual species, but also of entire ecosystems into the future in the face of a changing climate.

Potential for Regenerative Agroforestry

Agroforestry in the Snowy Monaro LGA in the context of this report focuses on the planting of native vegetation on degraded agricultural lands for regenerative farming, carbon sequestration, stewardship and potentially small-scale timber production. It represents only a small part of this study and is a starting point to consider whether this is feasible into the future in the face of a changing climate. The inclusion of agroforestry in this study stems from modelling work undertaken by the Australian National University Centre for Excellence in Plant Energy Biology. The ANU researchers have put forward a theoretical model that underpins a proposed pilot project to set up agroforestry trials. It must be noted nevertheless that this proposal has not been investigated in any detail and a lot more work will be required for its implementation. Native vegetation re-establishment which is sympathetic to the natural environment also can provide benefits to soil health, groundwater infiltration, habitat, biodiversity, water quality, carbon sequestration, and shelter for domestic stock.

The associated map layer developed for this report shows the areas that have the *potential* for agroforestry based on rural land-use zoning, tree cover (current and pre-1750), environmental values and other criteria. This provides a first step towards identifying areas that may be suitable for regenerative agroforestry upon which to base a more detailed study. According to estimations from this mapping, around 15% of the Snowy Monaro Shire has potential for agroforestry based entirely on the land-use criteria outlined above. However, social and economic constraints would need to be investigated. Predictions from research (Lynda et al., 2015) into carbon sequestration for the Southern Tablelands of NSW down to Tasmania predict a range of between

3.3 and 8 tons / ha sequestered per year from mixed native plantings. The actual amount of carbon sequestered depends on a range of factors such as planting density, plot shape, soils, and growth rates, in association with climatic conditions. Similarly, there are opportunities for biodiversity credits through the Biodiversity Conservation Trust's Biodiversity Offsets Program, where developers meet their offset obligations by paying into a Biodiversity Conservation Fund, and opportunities to protect native vegetation in perpetuity. Practitioners who are experienced with revegetation in the Monaro region have found that tree growth is slower than comparable revegetation efforts in other parts of the Southern Tablelands. However, if all the important vegetation establishment guidelines are adhered to, revegetation can be successful. This report provides a starting point for further investigations into the potential for regenerative agroforestry.

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1 Introduction

1.1 Background

The Snowy Monaro Regional Council (SMRC) area is diverse in biodiversity, demographics, industry and employment. Activities associated with European settlement such as clearing, urban development, forestry and agriculture have impacted on the biodiversity values of the region, which face further pressure going forward, in particular from population growth and climate change. Development certainty and conservation outcomes are best achieved by effective regional strategic planning rather than planning at the site-scale or development application stage (DECCW, 2010). The preparation of a new land-use strategy and eventually a new Local Environmental Plan necessitated by the merger of three former Council areas presents an opportunity to re-evaluate approaches to rural and urban land use in this region. This has been outlined in the *Snowy Monaro Region Planning and Land Use Discussion Paper 2019* and forms the context for this biodiversity assessment. The Discussion Paper was released for comment for two months in early 2019 and received numerous submissions in response.

To address pressures on biodiversity and to best protect the values of the region, the SMRC is adopting an evidence-based approach towards land-use planning. To facilitate this, the SMRC requires an understanding of the biodiversity values of the region to assist in future planning and decision making. The Snowy Monaro region is characterised by diverse landscapes, with multiple national parks and nature reserves covering approximately one-third of the Snowy Monaro Local Government Area (LGA). The rural lands of the LGA contain areas of nationally significant Natural Temperate Grassland, Monaro Tableland Cool Temperate Grassy Woodland, and other Endangered Ecological Communities, along with regionally significant biodiversity corridors as identified in the *South East and Tablelands Regional Plan 2036*.

The SMRC recognises that the LGA contains all four types of Environmental Protection Zones (EPZs), although they could be more readily applied in areas of significant environmental value than they are currently. The four EPZs are:

- E1 – National park and Nature Reserve
- E2 – Environmental Conservation
- E3 – Environmental Management
- E4 – Environmental Living.

The SMRC recognises that EPZs have been utilised inconsistently by the three separate former Councils and that there is a need for a consistent approach in the application of these zones for future planning. A strong evidence base is required in order to justify amendments to Local Environmental Plans, particularly around townships where some of the land may be suitable for development in the face of future population growth.

Significant information and data gaps were identified by the SMRC (and comments submitted in response to the *Planning and Land Use Discussion Paper 2019*) with regard to the identification of biodiversity constraints around many of the regional settlements, particularly Berridale, Bombala, Cooma and Michelago. It is anticipated that these areas are likely to experience modest to rapid growth over the next 20 years. Significant biodiversity corridors that have not been included in the comprehensive *'Go Jindabyne' Masterplan* require further investigation.

1.2 Purpose of the Study

The purpose of this study is to provide a broad-scale environmental analysis of lands within the SMRC area which will inform recommendations on the utilisation of EPZs and the constraints for potential development based entirely on environmental and biodiversity values, noting that an assessment of social and economic considerations is outside the scope of this report. The study also looks at potential climate change impacts on biodiversity values and evaluates the opportunities for agroforestry in the form of regenerative agriculture.

1.3 Scope of the Report

A detailed scope of the report is outlined in Table 1 as per the tender documentation. To summarise, the report provides a combination of reviewed literature from many sources, combined with the compilation of over 40 spatial data layers to determine and map the biodiversity values of the Snowy Monaro Shire.

Table 1 Report Scope and Study Methodology

Component	Section of the Report
Compilation of spatial data layers • Sourcing of relevant information including maps and spatial layers	Section 4
Desktop review of regional environmental Information • A thorough investigation of literature and spatial layers reviewed from a variety of sources, including (but not limited to): ○ Snowy Monaro Regional Council ○ NSW Office of Environment and Heritage ○ the SEED database ○ South East Local Land Services ○ Landcare ○ Australian National University ○ subject matter experts ○ individuals with local knowledge	Section 2 Section 5
Desktop and background analysis of biodiversity values in the Snowy Monaro LGA • Local biodiversity significance (as per the parameters set out for Matters of National Environmental Significance in relevant legislation including the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and the NSW *Biodiversity Conservation Act 2016*) • Gap analysis to identify the areas where on-ground biodiversity surveys and / or on-ground truthing of spatial data was required for the purposes of this report	Section 2 Section 3 Section 4 Section 5
Investigation of all regionally significant biodiversity corridors in the *South East and Tablelands Regional Plan* Identification of clear boundaries of the corridors and provision of recommendations on use of EPZs in these areas: • Mapping and spatial analysis, which informed data-deficient gaps • Emphasis on federally listed Matters of National Environmental Significance (MNES) • Mapping with clear boundaries as per those that have been mapped by OEH for biodiversity corridors and local EPZs	Section 4
Biodiversity values, threats and constraints in and around major centres in the Snowy Monaro Shire • Analysis and identification of biodiversity values and associated threats in and around the townships of Berridale, Michelago, Smiths Road, Bombala and Cooma townships, and the Crackenback / eastern approach to Kosciuszko National Park. Includes the development of consistent and representative biodiversity value maps for the region to enable an assessment of the biodiversity constraints around these key townships • Recommendations developed for future land suitability for urban-scale expansions including regarding appropriate EPZs on the basis of biodiversity constraints	Section 5
Analysis of the emerging impact of climate change on the biodiversity values of the Snowy Monaro Region • Impact assessment of future climate change scenarios on regional biodiversity based on NSW OEH predicted changes	Section 6

• Synthesis of potential biodiversity impacts from climate change taking into consideration EPZ classifications and future development recommendations for key townships in the short-, medium- and long-term • Provision of guidance on how future development may proceed and how future climate and proposed developments may impact on local biodiversity values	
Literature review to investigate potential benefits of agroforestry and carbon drawdown on Snowy Monaro rural land • Investigation of rural areas that are potentially suited to agroforestry with a focus on native forestry that could be an option to rehabilitate degraded lands and improve biodiversity (e.g. in dieback areas) • Investigation of how agroforestry may contribute to a draw-down of carbon across the region • Production of coarse agroforestry suitability maps and analysis of the amount of carbon sequestration potential	Section 7
Update of Snowy Monaro Regional Council's vegetation and biodiversity spatial data • Compile all spatial biodiversity data in the environmental study (i.e. shapefiles, rasters, tables, etc) into a 'datapack' compatible with standard GIS software packages (i.e. ArcGIS, QGIS) • All datasets in the 'datapack' tagged with metadata to guide interpretation by the Council and ensure appropriate use	Section 4

1.4 Project Team

The project team was coordinated by Dr Jasmyn Lynch from Molonglo Consulting (MCG) with Dr Jason MacKenzie, Principal of geoADAPT, leading all spatial analyses and mapping, and creating the 'datapack' submitted to Council; Lori Gould, Principal of GrassRoots Environmental, undertaking the literature and desktop review and drafting of the report; and Lesley Peden (MCG) completing the ground-truthing field work.

1.5 Client

The client is the Snowy Monaro Regional Council (SMRC) based at 81 Commissioner Street, Cooma, NSW. The project manager within the SMRC is Alexanda Adkins, Senior Strategic Land Use Planner.

1.6 Limitations

This biodiversity assessment is based upon best available evidence at the time of preparation (i.e. documents and spatial data) augmented by targeted field assessments within selected study areas. There were significant gaps in spatial data (i.e. vegetation mapping coverage / classification, threatened species distributions, etc). As such, the data considered include a mix of validated mapping, distributional modelling and incidental presence-only species sightings. Similarly, known locations of the most critically endangered species (i.e. Category 1; NSW) were not available given the sensitivities associated with illegal collection. Consistent classification of vegetation types across the region was not available for use in this study, although it is understood that the NSW Government has provided Council with Plant Community Type mapping for the region. Similarly, draft mapping of the recently listed Critically Endangered Ecological Community (CEEC) Werriwa/Monaro Grasslands was not available for analysis or inclusion in report maps. Ground-truthing for most data layers was minimal. These limitations need to be recognised when using the data and interpreting the study recommendations.

1.7 Acknowledgements

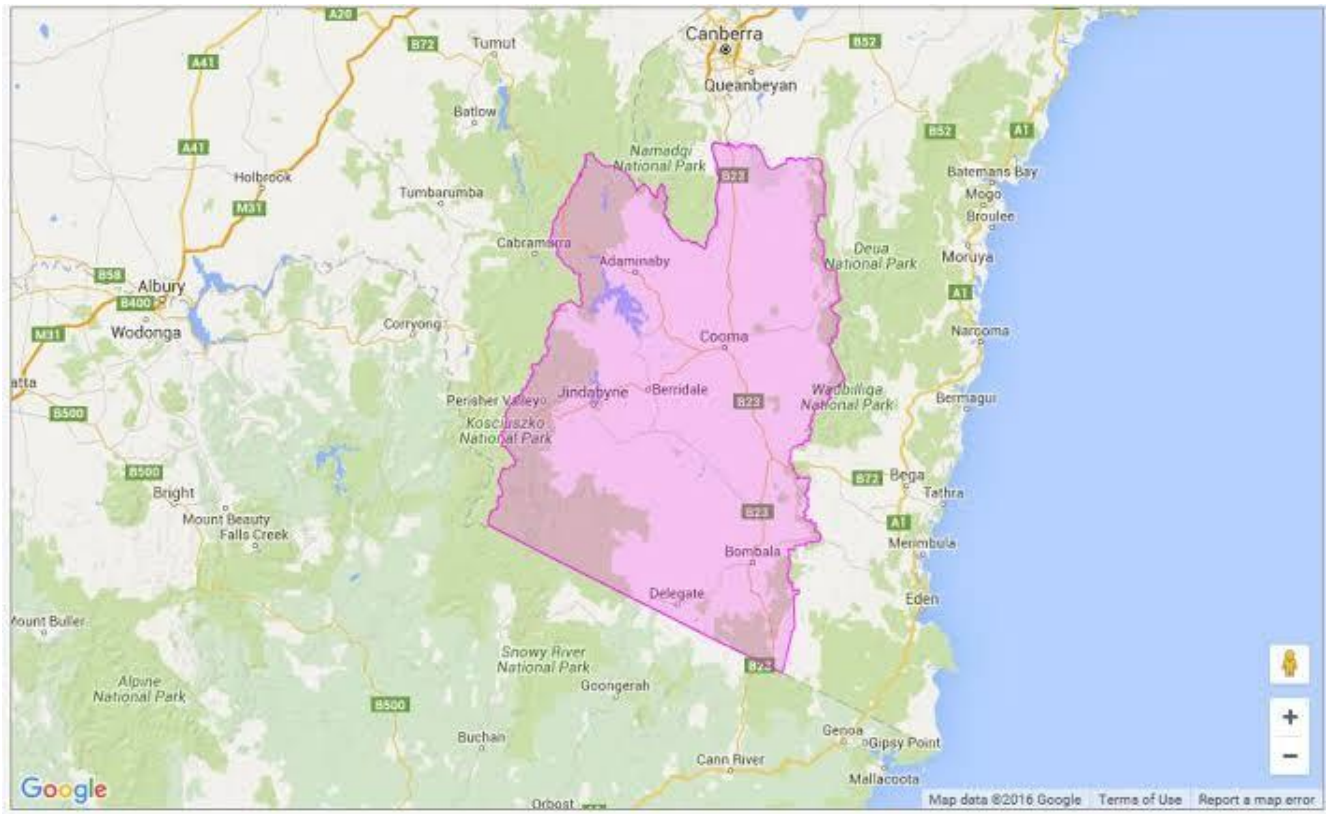
We would like to acknowledge the following people: Joanna Clarke (SMRC) for cadastral data, threatened species sightings and regional biodiversity model predictions; Mallory Barnes (NSW DPIE) for vegetation and wetland mapping; Tobi Edmonds (NSW Biodiversity Conservation Trust) for HEV criteria; Dr John Baumgartner

(Melbourne University) and Dr Linda Beaumont (Macquarie University) for climate refugia modelling of species; Karen Danaher (NSW Fisheries) for data on freshwater threatened species; Fiona Woods (Commonwealth Department of Energy and Environment) for data on Matters of National Environmental Significance; Dr Armstrong Osborne (University of Sydney) for data on geological heritage in the region; Professor Justin Borevitz and team from the ANU Centre of Excellence in Plant Energy Biology for meeting with the study team and providing their input into the potential for agroforestry in the Snowy Monaro Shire; Lauren Van Dyke from the Upper Snowy Landcare Network for sharing Information on the regional revegetation experience; Antia Brademann from the Upper Murrumbidgee Demo Reach, and Graham Fifield from Greening Australia, both for fielding questions on revegetation success across the Snowy Monaro.

2 Regional Overview

The Snowy Monaro Regional Shire is a Local Government Area (LGA) which spans 15 158 km^2, located in New South Wales (NSW) to the south of the Australian Capital Territory (ACT) (SMRC, 2019). It stretches from the ACT border in the north to the Victorian border in the south, and from the top of the South Coast escarpment in the east to the top of Mount Kosciuszko in the west.

Figure 1 Snowy Monaro Shire Location (SMRC, 2019)



The Snowy Monaro Region is a unique region with many opportunities for different types of land use and development. The local planning framework for the region must balance this opportunity with the need to preserve the environment for which the region is famous (SMRC, 2019). The region has a population of 20 655 people (ABS ERP, 2017 cited by SMRC, 2019) which is projected to reach 21 550 people by 2036 (Department of Planning and Environment, 2018). This represents a conservative population growth of around 0.2% a year, which is fairly consistent with growth over the past 10 years (SMRC, 2019).

The Aboriginal tribe Ngarigo (or Narego) has occupied the greater Monaro district for some 15 000 years. It is believed that the tribe consisted of several hundred people whose language was different, although not entirely dissimilar, to that of their neighbours, particularly those to the west known as the Walgalu. Some other tribes considered the Ngarigo and the Walgalu to be one people. There are many sites throughout the Cooma-Monaro Shire where evidence of Aboriginal cultural connections can be found, such as Aboriginal place names that have continued to be used after European settlement. The Aboriginal people of the region were heavily impacted by European settlement through disputes over land and from exotic diseases (Plowman, 2007). A similar story occurred with the Ngunnawal people to the north, who used to trade and come together for ceremony with other regional Aboriginal peoples.

Upon arrival in the 1800s, European settlers appreciated the largely treeless plain and pastures for stock grazing and instigated an agricultural industry centred around sheep and cattle grazing. After a history of squatting and the more formalised ‘land selection’, the introduction of a Land Act gave people security to

undertake improvements to the land. The township of Cooma was established in 1849, along with other villages and regional centres across the Snowy Monaro Shire. Gold was discovered in 1859 and commercial mining for gold, copper and silver continued in many parts of the Snowy Monaro until 1927 (Plowman, 2007).

The Snowy Mountains Hydro-Electricity Scheme was approved in 1949 and Cooma selected as the headquarters for the Scheme's planning and development. The decision rapidly transformed the quiet rural town with a population of 2000 into a major centre of 10 000 people. Families, with their different traditions and languages, came from all over the world, often from places affected by World War II. Two-thirds of the Snowy Scheme's workers were immigrants. The Snowy Scheme brought prosperity to the town and the region generally with the demand for services and goods. It confirmed Cooma as the commercial centre of the Monaro (Plowman, 2007). In the late 1960s, the Snowy Mountains Hydro-Electricity Authority created Lake Jindabyne, and in the process drowned the old town. A new town was created primarily to provide accommodation for the men working on the Snowy Scheme but has become more recently an important service area for tourism (in particular the skiing and mountain-biking recreation industries).

In addition to agriculture and tourism, another major land use in the south-eastern region of the SMRC area is pine plantation forestry around Bombala. Apart from wood production, these forests are popular destinations for camping, mountain-biking, four-wheel driving, trail biking, fossicking and more. They also support a valuable industry producing timber for Australian homes and businesses and thousands of jobs. Of the 220 000 hectares of plantation managed by the Forestry Corporation, 33 000 hectares of Radiata pine plantations are in the Bombala area (Forestry Corporation, 2015). Today, most (95%) of the gross value of agricultural production on the Monaro comes from wool ($27.5 million p.a.), beef (24.9 million p.a.) and lamb ($19.8 million p.a.) production (NSW Government, 2017). The type of agriculture is determined largely by soils, pastures and topography which also affect stock carrying capacity. Grazing occurs on a mixture of native pastures, introduced exotic pastures and in many cases invasive grasses, such as African love grass, which has taken over parts of the region. There is some cropping and horticulture, but this is very restricted to pockets of suitable soils. However, since the 1970s, there has been a steady decline in terms of trade and production (SMRC, 2019).

The Snowy Mountains region is a significant tourism destination that attracts large numbers of visitors each year for recreation activities and to explore the rich history and diverse landscapes year-round (Tourism Snowy Mountains, 2016). This accounts for 27% of the economic contribution to the whole Southern Tablelands region and amounts to $500m p.a. (NSW Government, 2017).

Production and development over the past 220 years has led to changes in the natural ecosystems and biodiversity due to clearing, altered drainage, introduction of weeds and feral animals, and urban development and infrastructure. However, the region still maintains a large number of national parks, nature reserves and state forests, as well as significant natural values outside the reserve system on private land. According to a comprehensive summary compiled as part of a submission to the Rural Land Use Discussion Paper by Upper Snowy Landcare Network (2019), approximately 17% of the land area was naturally treeless prior to European settlement due to the basaltic soils. The remainder is predicted to have been covered in dense forests on the mountain slopes with sparser woodland on the tableland areas. Since the 1800s, about half of the treed areas has been cleared, increasing the area of grassland from 17% to 42%. Changes in woody vegetation between 1988 and 2010, as assessed by satellite imagery, show that 27.8 km^2 of the remaining vegetation outside national parks has been cleared. This has been mainly in state forests (20 km^2) with the remainder in areas classified either as an Endangered Ecological Community (EEC) or as habitat for threatened species. In addition to the threat from rural and urban clearing, the main EEC in the Region (the Snow Gum–Ribbon Gum–Candlebark Grassy Woodland) is at risk due to severe dieback in approximately 20% of the non-reserved areas for reasons that are not entirely clear (Ross & Brack, 2015). Therefore, the conservation of remaining areas of important ecological communities is of extremely high importance.

The present-day landscape is changing due to population growth, with a growing number of rural residential landholders commuting from Canberra to locations such as Michelago and Bredbo or choosing a 'tree change' and a move away from busy cities. This brings with it a mixture of advantages and disadvantages. Some tree changers do so with an appreciation of nature that potentially results in less grazing and higher levels of environmental restoration. In other cases, residents move primarily for recreational space which may result in more clearing and high-pressure activities such as from horses, trailbikes, introduced garden species, and so on. Higher density settlement also requires management of rubbish and sewage, for example in the case of localities such as Smiths Road and Michelago. However, denser settlement may also result in smaller block sizes that are more manageable for weed control and other land management activities. Such changes in land use create a need for periodic re-evaluation of zoning in order to protect local environmental values and to best manage these landscapes for the future as outlined in the SMRC's *Planning and Land Use Discussion Paper 2019*.

3 Conservation Policies and Legislation

Biodiversity conservation in the Snowy Monaro LGA is underpinned by a range of local, state and federal policies, legislation and associated regulatory criteria, with the key aspects summarised below.

3.1 *Australia's Biodiversity Conservation Strategy 2010-2030*

Australia's Biodiversity Conservation Strategy 2010-2030 (the Strategy) was released in 2010 as the guiding framework for governments to conserve our national biodiversity to 2030. It provides an overview of the state of Australia's biodiversity and outlines national priorities for conservation. The Strategy aims to coordinate efforts at a national level across all sectors to sustainably manage biological resources in a way that meets current needs and ensures long-term resilience, health and viability.

Note that this document is currently under review and the revised document called *Australia's Strategy for Nature 2018-2030: Australia's Biodiversity Conservation Strategy and Action Inventory* has closed for comment and is awaiting sign-off by state and federal Ministers (DoEE, 2019). The revised Strategy's aim is to improve the ability for governments to drive change in biodiversity management priorities and to better align with Australia's international biodiversity commitments (DoEE, 2019).

The following principles underpin the implementation of the goals and objectives in this Strategy and provide a useful guide to the broader aims of biodiversity conservation.

- Individual actions, both big and small, can make a difference.
- Collaborative decision-making, alignment of effort and partnerships contribute to effective policy-making.
- Effective nature management relies on continuous research and innovation.
- Sharing data and Information contributes to evidence-based and cost-effective actions.
- The culture, values, knowledge, innovations and practices of Aboriginal and Torres Strait Islander people are valued and respected, and should be incorporated, where appropriate, in nature management and conservation.
- Sustainable use of nature must meet the needs of today without compromising the needs of future generations.
- Lack of full scientific certainty should not be used as a reason for postponing a measure to prevent degradation of the environment where there are threats of serious or irreversible environmental damage.
- Using an ecosystem-based approach, integrated management of land, water and living resources can be achieved.
- Accounting for nature in all decision-making significantly enhances biodiversity conservation.
- Nature does not abide by legal tenure boundaries and therefore management responses must also cut across ownership.

3.2 Biodiversity Conservation Legislation

***Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act; Commonwealth)**

The objectives of the EPBC Act are to:

- provide for the protection of the environment, especially Matters of National Environmental Significance
- conserve Australian biodiversity
- provide a streamlined national environmental assessment and approvals process
- enhance the protection and management of important natural and cultural places

- control the international movement of plants and animals (wildlife), wildlife specimens and products made or derived from wildlife
- promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources
- recognise the role of Indigenous people in the conservation and ecologically sustainable use of Australia's biodiversity
- promote the use of Indigenous peoples' knowledge of biodiversity with the involvement of, and in cooperation with, the owners of the knowledge.

Biodiversity Conservation Act 2016 **(BC Act; NSW)**

The purpose of this Act is to maintain a healthy, productive and resilient environment for the greatest well-being of the community, now and into the future, consistent with the principles of ecologically sustainable development. In particular, the BC Act aims to:

- conserve biodiversity at bioregional and State scales
- maintain the diversity and quality of ecosystems and enhance their capacity to adapt to change and provide for the needs of future generations
- improve, share and use knowledge, including local and traditional Aboriginal ecological knowledge, about biodiversity conservation
- support biodiversity conservation in the context of a changing climate
- support collation and sharing of data, and monitoring and reporting on the status of biodiversity and the effectiveness of conservation actions
- assess the extinction risk of species and ecological communities, and identify key threatening processes, through an independent and rigorous scientific process
- regulate human interactions with wildlife by applying a risk-based approach
- support conservation and threat abatement action to slow the rate of biodiversity loss and conserve threatened species and ecological communities in nature
- support and guide prioritised and strategic investment in biodiversity conservation
- encourage and enable landholders to enter into voluntary agreements over land for the conservation of biodiversity
- establish a framework to avoid, minimise and offset the impacts of proposed development and land-use change on biodiversity
- establish a scientific method for assessing the likely impacts on biodiversity values of proposed development and land-use change, for calculating measures to offset those impacts and for assessing improvements in biodiversity values
- establish market-based conservation mechanisms through which the biodiversity impacts of development and land-use change can be offset at landscape- and site-scales
- support public consultation and participation in biodiversity conservation and decision-making about biodiversity conservation
- make expert advice and knowledge available to assist the Minister in the administration of this Act.

Development can still occur but is subject to a biodiversity offsets scheme.

National Parks and Wildlife Act 1974 **(NPW Act; NSW)**

The objects of the NPW Act include the conservation of nature, including but not limited to the conservation of:

- habitat, ecosystems and ecosystem processes
- biological diversity at the community, species and genetic levels
- landforms of significance, including geological features and processes
- landscapes and natural features of significance including wilderness and wild rivers.

The NPW Act also aims to conserve objects, places or features (including biological diversity) of cultural value within the landscape, including, but not limited to:

- places, objects and features of significance to Aboriginal people
- places of social value to the people of NSW
- places of historic, architectural or scientific significance.

These are to be achieved by applying the principles of ecologically sustainable development and are not restricted to those lands reserved under the NPW Act, but throughout the landscape.

Biodiversity Certification

One of the key mechanisms to give effect to this renewed focus on landscape-scale strategic planning is the opportunity for biodiversity certification to be conferred on an area of land. Under the provisions of Part 7AA of the TSC Act, the NSW Minister for Climate Change and the Environment has the ability to confer biodiversity certification if the Minister is satisfied that the package of measures contained in a biodiversity certification strategy will lead to the overall improvement or maintenance of biodiversity values, including threatened species and communities. The primary effect of granting certification in that any project under Part 3A, any development under Part 4, or any activity under Part 5 of the EPA Act is taken to be a development that is not likely to significantly affect threatened species, populations, ecological communities or their habitats. Similarly, the *Native Vegetation Act 2003* (NV Act) does not apply to biodiversity certified land. Applications for biodiversity certification are made by a planning authority.

***Local Land Services Act 2013* (NSW)**

The purpose of this Act is to establish a statutory corporation (known as Local Land Services) with responsibility for management and delivery of local land services in the social, economic and environmental interests of the State in accordance with any State priorities for local land services.

***Environmental Planning and Assessment Act 1979* (EPA Act; NSW)**

The EPA Act is the primary legislation governing land use in NSW. It governs the proper management and conservation of natural and artificial resources (i.e. agricultural land, natural areas, forests, minerals, water, urban areas) to promote the social and economic welfare of the community and a better environment. It includes:

- the promotion and coordination of the orderly and economic use and development of land
- the protection of the environment, including the protection and conservation of native animals and plants, including threatened species, populations and ecological communities and their habitats
- ecologically sustainable development.

The *Environmental Planning and Assessment Amendment Act 2005* facilitated the modernisation and standardisation of LEPs across NSW. Subsequently, on 31 March 2006, a standard instrument for LEPs was gazetted, prescribing a standard form and content of a principal LEP. All new LEPs are to be prepared in accordance with this standard.

The Department of Planning has developed a series of regional strategies to guide residential and employment-related development until 2031.

SEPP 44 (NSW)

State Environmental Planning Policies (SEPPs) are planning controls put in place by the NSW Government. They deal with issues considered to have state significance. SEPPs are 'environmental planning instruments' (EPIs) under the NSW *Environmental Planning & Assessment Act 1979* and are taken into consideration in assessment of all development applications. Of particular note in the SMRC area is the population of Koalas that is protected under this Act. There is an associated Koala Management Plan pertaining to this legislation. It

should be noted that only one species (*E. viminalis*) of the food tree species suitable for the Snowy Monaro population of Koalas is listed under SEPP 44. Table 2 illustrates this.

Table 2 Preferred Tree Species in Numeralla Koala Survey, April 1999 (Allen & Pietsch, 1999 cited by Bertram, 2015)

Species Name	Common Name	Percentage Use
E. dives	Broad-leaf Peppermint	7.8%
E. viminalis	Ribbon Gum / Manna Gum	13%
E. pauciflora	Snow Gum	18.75%
E. rossii	Scribbly Gum	16%
E. rubida	Candlebark	33%

***Fisheries Management Act 1994* (FM Act; NSW)**

The objects of the *Fisheries Management Act 1994* are to conserve, develop and share the fishery resources of NSW for the benefit of present and future generations.

In particular, the objectives of the FM Act include to:

- conserve fish stocks and protect key fish habitats
- conserve threatened species, populations and ecological communities of fish and marine vegetation
- promote ecologically sustainable development, including the conservation of biological diversity
- promote viable commercial fishing and aquaculture industries
- promote quality recreational fishing opportunities
- appropriately share fisheries resources among users of those resources
- provide social and economic benefits for the wider community of NSW.

To meet these objectives, Part 7 of the FM Act outlines legislative provisions to protect fish habitat and Part 7A outlines threatened aquatic species legislation. The Part 7 provisions are commonly triggered by the 'integrated development' process under the EPA Act. However, there are other activities which may not require development consent but may require a permit from Industry and Investment NSW which administers the FM Act and associated Regulations.

***Crown Lands Act 1989* (CL Act; NSW)**

The CL Act and its Regulation (2006) are the principal legislation in the management of Crown lands and provide important requirements and guidance for suitability assessment, including environmental values.

3.3 Biodiversity Conservation Regulation Criteria

In addition to Endangered Ecological Communities (EECs) and threatened species listed under the BC Act, there are a number of additional sensitive areas that meet criteria under the Clause 7.3(3) of the *Biodiversity Conservation Regulation 2017.* This Regulation describes in clause 7.3(3) the types of land that the Head of the Environment Agency can include on the NSW Biodiversity Values (BV) Map. The BV Map identifies areas of high biodiversity values that are sensitive to impacts, which is one of the triggers for determining whether the Biodiversity Offset Scheme (BOS) applies to a clearing or development proposal. The BV Map has been prepared by the Office of Environment and Heritage (OEH), now the Department of Planning, Industry and the Environment (DPIE). It includes a range of mapping layers which are maintained by agencies and councils. The inclusion of these layers on the BV map requires the approval of the Chief Executive of OEH or delegate.

The land types that can be included on the Biodiversity Values Map are:

- Coastal wetlands and littoral rainforest mapped under the State Environmental Planning Policy (Coastal Management) 2018 (Coastal Management SEPP)

- Core Koala habitat identified in a plan of management under State Environmental Planning Policy No. 44 – Koala Habitat Protection (SEPP 44)
- Declared Ramsar wetlands listed under the *Environment Protection and Biodiversity Conservation Act 1999*
- Land containing threatened species or threatened ecological communities identified as potential serious and irreversible impacts (SAII) under section 6.5 of the BC Act
- Protected riparian land
- High conservation value grasslands or groundcover
- Old growth forest identified in mapping developed in relation to the *National Forest Policy Statement* but excluding areas not meeting the criteria published jointly by the Minister for the Environment and the Minister for Primary Industries
- Rainforest identified in mapping developed in relation to the *National Forest Policy Statement* but excluding areas not meeting the criteria published jointly by the Minister for the Environment and the Minister for Primary Industries
- Declared areas of Outstanding Biodiversity Value
- Council nominated areas with connectivity or threatened species habitat that the Minister for the Environment considers will conserve biodiversity at bioregional or state scale
- Any other land that, in the opinion of the Environment Agency Head, is of sufficient biodiversity value to be included.

As these criteria have been developed by the NSW Government primarily to assist in undertaking assessments for clearing and development proposals, it was appropriate to use them to inform this report as the criteria to determine the biodiversity values of the SMRC area. Mapping data were aligned with these criteria to create a map of High Environmental Values. This process is described further in Section 4.3.

4 Criteria for Biodiversity Assessment

4.1 Assessment Criteria

Following the precautionary principle, the biodiversity values summarised in this study represent a complete inventory of the best available evidence available at the time of this assessment. A total of 40 spatial datasets, representing a mix of regional biodiversity values, as well as other constraints on development, were compiled and reformatted into the seven Assessment Criteria categories, as follows:

- Criteria 1 Areas Protected for Conservation
- Criteria 2 Native Vegetation of High Conservation Value
- Criteria 3 Threatened Entities (species or communities)
- Criteria 4 Wetlands, Rivers, Estuaries and Coastal Features
- Criteria 5 Areas of Geological Significance
- Criteria 6 Aboriginal Heritage
- Criteria 7 Other Constraints on Development.

The Criteria were designed to be consistent with the NSW Government mapping of High Environmental Values for the South East Tablelands. A detailed description of the Criteria guidelines is provided in the document *Developing Maps for High Environmental Value for Strategic Planning* (OEH, 2015).

In this study, we extend upon the South East Tablelands assessment criteria by including Aboriginal Heritage (Criteria 6) and other constraints on Development (i.e. floods, landslide risk and so on) (Criteria 7), both of which are sourced from NSW Environmental Planning Instruments. Throughout the report, the term High Environmental Value (HEV) refers to areas of environmental significance in accordance with the criteria for Biodiversity Conservation Regulation outlined in Section 3.3 from Clause 7.3(3) of the *Biodiversity Conservation Regulation 2017*. Appendix A lists the sub-criteria contributing to each of the criteria in detail. For example, multiple sources of vegetation mapping, distribution model predictions and threatened species sightings contribute to Criteria 3 – Threatened Entities. It should be noted that the criteria are provided in the spatial 'datapack' (see Section 4.2). The data layers are provided individually (e.g. Criteria1a_Reserves, Criteria1b_StateForests, Criteria1c_ScenicProtection, Criteria1d_CrownReservesConservationAgreements, etc) and pooled by broad category (e.g. Criteria1_HEV_ConservationAreas, etc).

To create the criteria layers described above, source data layer fields were mutated and/or renamed, then exported as shapefiles in R (R Core Team, 2019) using the `sf` (Pebesma et al., 2018) and `dplyr` (Wickham et al., 2019) packages. All datasets provided are locally projected to "GDA 94 / MGA zone 55" (EPSG: 28355) and clipped to the Snowy Monaro LGA boundary to simplify spatial analyses and cartography. Metadata (ISO 19139 format) were tagged to all source data (directly from providers where possible), as well as derived products in ArcGIS Desktop 10.7.1 (ESRI, 2019). Given that the metadata may not be readable in QGIS, metadata for all source and derivative spatial data are also provided as *.xml in the spatial 'datapack'. A look up table (LUT) documenting the layer name, data provider and URL links for accessing each dataset is tabled in Appendix G (LUT_SMES_DataSources). Details on how specific source data layers were converted into criteria layers (i.e. field mapping of source and criteria attributes) are provided in Appendix A. Additional look up tables (LUTs) in the spatial 'datapack' include: all threatened species (LUT_ThreatenedSpecies), all Endangered Ecological Communities (LUT_EndangeredCommunities), and all threatening processes (LUT_ThreateningProcesses) occurring in the region.

Biodiversity values documented in the assessment criteria described above represent a mix of available (surveyed) map products, distributional model predictions and field sightings. Unfortunately, the full distributions of vegetation types, threatened species and Endangered Ecological Communities are poorly described for the region. A project is currently underway by the NSW Government to map vegetation types

across South East NSW using a consistent classification schema; however, the data were not available for inclusion in this assessment and report.

4.1.1 Conservation Areas

Criteria 1, focusing on conservation areas, distinguishes the following sub-criteria: national parks and nature reserves (Criteria_1a), state forests (Criteria_1b), scenic protection areas (Criteria_1c), as well as Crown reserves, conservation agreements and biobanking agreements (Criteria_1d). National Parks and nature reserves were sourced from the Commonwealth Collaborative Australian Protected Areas Database 2018. The NSW Government provided State Forests, scenic protection areas (via Environmental Planning Instruments), as well as private land conservation agreements (via High Environmental Values for South East Tablelands; Tobi Edmonds, pers. comm.). Note that Crown reserves include Travelling Stock Reserves (TSRs), which are often areas of high biodiversity containing significant environmental values which need to be carefully managed.

4.1.2 Native Vegetation

Criteria 2, focusing on native vegetation of significance to conservation, distinguishes the following sub-criteria: rainforest and old growth forests (Criteria_2a); sensitive regulated lands (Criteria_2b); vulnerable regulated lands (Criteria_2c); vegetation maps for Bombala (Criteria_2d & 2j), Cooma (Criteria_2e), South Coast (Criteria_2g), Snowy River (Criteria_2h) and the Snowy Monaro (Criteria_2i); as well as candidate native grasslands from the Koala Habitat Information Base (Criteria_2f). Rainforests and old growth forests were filtered from High Environmental Values for South East Tablelands (Tobi Edmonds, pers. comm.). Sensitive and Vulnerable Regulated Lands from the Native Vegetation Regulatory Map were provided by NSW DPIE via data license agreement. Local and regional vegetation maps were provided by the SMRC and the NSW DPIE.

The vegetation mapping available for this study is split into coverages based on former Local Government Area (LGA) boundaries (i.e. Snowy River, Cooma-Monaro and Bombala) with significant gaps in coverage, and no consistent classification schema. For example, vegetation types mapped for different sub-regions (i.e. former Local Government Areas) do not use the same terminology. The process of translating vegetation types into threatened entities (i.e. Endangered Ecological Communities) is described in Section 4.

Similar to the lack of a standardised vegetation classification schema for the region, there was no clear guidance available on the conservation status of mapped vegetation types (i.e. a means to infer which vegetation types are Endangered Ecological Communities, etc). Therefore, to the best of our ability, EECs have been interpreted using the vegetation type descriptions documented in mapped and modelled products. A full inventory of Endangered Ecological Communities occurring in the region is provided in Appendix B. Designation of vegetation types to EECs varies in terms of our lower level of confidence. We note that some coastal vegetation types are mapped as small polygons in the far eastern margin of the SMRC boundary (i.e. from South Coast EEC maps). We suspect that very little (if any) of these community types are likely to occur in the Snowy Monaro Shire, but they are included in the list in Appendix B just in case. Appendix C shows the assignment of vegetation types to EECs based on descriptions.

Another layer, the 'Native Vegetation Extent Raster', developed as part of the Koala Habitat Information Base, has been filtered and included to complement mapping of the EEC Natural Temperate Grasslands. The purpose of this layer was originally to help discriminate native tree cover as potential Koala habitat; however, in undertaking this exercise, grasslands were also mapped. As such, this information was fed into the spatial layer 'Candidate Native Grasslands' which combines a range of grassland mapping sources. This dataset is provided in the spatial 'datapack', although it is likely that the 'Candidate Native Grasslands' data layer over-estimates the extent of existing Natural Temperate Grasslands (NTG), and therefore may be superseded by draft mapping of the Werrima/Monaro EEC, which was unavailable for this study.

4.1.3 Threatened Entities

Criteria 3, focusing on threatened entities, distinguishes the following sub-criteria: EPI terrestrial biodiversity (Criteria_3a); threatened entities of the South East Tablelands (Criteria_3b); sub-regional threatened species model predictions by Steve Priday (Criteria_3c, Criteria_3e, Criteria_3g); sub-regional endangered ecological community model predictions by Steve Priday (Criteria_3d, Criteria_3f, Criteria_3h); biometric model predictions of vegetation types (Criteria_3i); freshwater threatened species distributions (Criteria_3j); Koala population surveys (Criteria_3k); and threatened species sightings (Criteria_3l, Criteria_3m, Criteria_3n).

Regional distributions of threatened entities (individual threatened species and Endangered Ecological Communities) is generally poor for this region. As such, criteria in the spatial 'datapack' include any evidence of mapped, modelled or known threatened species or Endangered Ecological Communities. EPI terrestrial biodiversity was provided by NSW DPIE. Threatened entities were filtered from High Environmental Values for South East Tablelands (Tobi Edmonds, pers. comm.). Model predictions for threatened species and EECs were provided by the SMRC. Data on Koala surveys were provided by the NSW Biodiversity Conservation Trust. Biometric vegetation mapping was produced by South East Local Land Services. Freshwater threatened species distributions were provided by NSW Fisheries.

Threatened Species Sightings

There were two main sources of information for threatened species records (i.e. presence-only occurrence data): BioNet and the Atlas of Living Australia. The BioNet Atlas of NSW (BioNet) is the repository for biodiversity data products managed by the NSW Department of Planning, Industry and Environment (NSW DPIE; formerly OEH). BioNet aims to improve biodiversity outcomes by enabling the community and government to proactively manage and enhance biodiversity in NSW through comprehensive, credible and robust information (http://www.bionet.nsw.gov.au/). In addition, the Atlas of Living Australia (ALA) is a collaborative, digital, open infrastructure that collates Australian biodiversity data from multiple sources, making it accessible and reusable. The ALA is hosted by the CSIRO. Both of these databases are useful platforms to undertake searches on areas of interest or for certain species (https://www.ala.org.au/).

Prior to consideration in this study, all threatened species data were cleansed to ensure maximal locational accuracy. For example, any point records provided in the datapack, mapped in figures and/or reported in zonal statistics, were first filtered by year (2000 to present), locational uncertainty (100 m or less) and georeferenced precision (i.e. 3 or more decimals for latitudes/longitudes). The records were then converted to buffered polygons (100 m) to more accurately represent potential locations of each species. Biodiversity sightings for sensitive species in Snowy Monaro LGA were queried in BioNet by the Snowy Monaro Regional Council. Records were then cleansed for positional uncertainty <= 100 m, georef precision <= 100 m, sightings = human observations) and projected (to EPSG:28355). Due to differences in positional accuracy, records dated after widespread use of GPS in the field (i.e. year=2000) are distinguished in a separate layer from those based upon less precise georeferencing methods (i.e. year < 2000). We suggest caution should be exercised when interpreting the positional accuracy of older records (despite attribution).

It is important to note that the accuracy of threatened species locations derived from BioNet varies by sensitivity category, as described in Table 3. This is important contextual Information because the data sensitivity reflects the accuracy of the threatened species locations in the spatial data. According to DPIE (2019), some threatened species are highly threatened by exploitation and other threats, therefore location data were not provided for this assessment (i.e. for Category 1 species). Therefore, these species are listed in the report (Appendix D) but were not mapped. Locations of Category 2 species were provided under a data license agreement and were mapped as part of this assessment. Category 3 species are publicly available and also were mapped.

A comprehensive list of threatened species found in the region is provided in Appendix D. The list derived from BioNet appears to be more comprehensive than for the ALA for reasons unknown, and therefore was the basis

for Appendix D. Notably, aquatic fauna were largely missing from both lists, so the list presented was modified to include threatened freshwater species curated by NSW Fisheries.

For environmental assessment purposes, presence-only occurrence data is not an adequate surrogate for systematic field surveys, which need to be carried out independently to confirm where listed species are likely to occur (DPIE, 2019). For example, sighting records are useful for indicating areas where species are expected to occur and have been found; however, these records should not be confused with systematic data on species distributions because an absence of sightings in an area does not provide Information about the absence of a species. There may be other locations where the species occurs that have not been included in surveys.

Table 3 Sensitivity Categories relating to the Availability of Threatened Species Data

Category 1	Species of high biological significance, for which no records will be provided at all. The reason for non-disclosure is that the species is highly threatened by exploitation/disease or other identifiable threats, and even general locality information may threaten the taxon
Category 2	Species considered to be at serious risk from threats such as disturbance or exploitation. For species in this category, geographic coordinates of sightings will be supplied 'denatured', in order to generalise the locality. Exceptions to this rule may be granted to some government agencies, or for certain research purposes
Category 3	Species considered to be at medium to high risk of threats such as disturbance or exploitation. For species in this category, coordinates will be supplied at 'as held' accuracy to licensed clients but will otherwise be supplied 'denatured'. The term 'as-held' refers to coordinate details as supplied to OEH for entry into the Atlas database. As-held records do not necessarily equate to exact locational details and must be interpreted with reference to their geographic accuracy. Some records, for example, are only accurate to one kilometre

Biodiversity Model Predictions (Species and Communities)

Predictive modelling of threatened species and Endangered Ecological Communities has been previously undertaken by PCP Consulting (Priday, 2011) to fill notable gaps in distribution data for the former Cooma-Monaro and Snowy River LGAs. Models were not developed for the former Bombala LGA, therefore regional coverage for the Snowy Monaro Shire is not complete. A detailed methodology of the modelling approach undertaken is provided in Priday (2011). The Priday model predictions include a mix of Endangered Ecological Communities (n=8), threatened flora (n=6) and threatened fauna (n=14). Predictions for the threatened species were derived using only (outdated) vegetation and topography and are not ground-truthed. While these data represent an important complement to biodiversity value mapping in the region, we suggest they only be treated as guides, as they may significantly over- and/or under-estimate actual threatened species distributions. The Priday (2011) modelling layers are included in the spatial 'datapack' with this report.

A planning framework employed by Priday (2011) synthesises area-based predictions into four 'categories':

- Category A: Public lands known to contain EECs and/or habitat for threatened species. This category includes all national parks and nature reserves within Snowy River Shire and a number of travelling stock reserves.
- Category B1: Areas considered to have a moderately high to high likelihood of containing EECs or core threatened species habitat, based on predictive modelling.
- Category B2: Areas considered to have a moderate likelihood of containing EECs or core threatened species habitat, based on predictive modelling.
- Category C: Areas considered least likely, based on the information available, to contain EECs or core habitat for threatened species.

For Criteria provided in the spatial 'datapack', 'high probability' predictions of EECs were filtered and specifically attributed by EEC (i.e. Natural Temperate Grasslands, Box Gum Woodland, etc) as sub-criteria representing the former Cooma-Monaro LGA (Criteria_3c), the Yaouk district (Criteria_3f) and the former Snowy River LGA (Criteria_3h). Due to time constraints, and a lack of standards in how threatened species were labelled across the Priday datasets (i.e. some codes were based on common names, while other codes were based on scientific names, etc), high probability predictions of threatened species are generically attributed as 'Threatened Species Prediction' in the spatial 'datapack' criteria. Source data are provided which end users can query to identify which species are predicted to occur in any given polygon. Only high probability predictions (i.e. 'Predicted – 1' values) were considered in the spatial layers for this report.

4.1.4 Freshwater Features

Criteria 4, focusing on freshwater features, distinguishes the following sub-criteria: bogs and fens (Criteria_4a), drinking water catchments (Criteria_4b), groundwater vulnerability (Criteria_4c), riparian lands and watercourses (Criteria_4d), significant wetlands to NSW (Criteria_4e), vulnerable protected riparian lands (Criteria_4f), wetlands of national significance (Criteria_4g) and Ramsar wetlands of international significance (Criteria_4h). Data on bogs and fens were provided by the NSW DPIE (Mallory Barnes, pers. comm.). NSW Government Environmental Planning Instruments document drinking water catchments, groundwater vulnerability, riparian lands and watercourses, as well as significant wetlands for NSW. Vulnerable protected riparian lands were sourced from the NSW DPIE. Nationally significant wetlands and internationally significant Ramsar wetlands were sourced from the Commonwealth Directory of Important Wetlands in Australia (DIWA) Spatial Database.

4.1.5 Geological Heritage

Criteria 5, focusing on geological heritage, documents karst formations (Criteria_5a) but also includes additional information from a national registry (which is not mapped due to coarse georeferencing) on type localities and fossil sites, etc.

Information on karst formations was sourced from the NSW DPIE Environmental Planning Instruments (i.e. 'Local Provisions'). Additional data were extracted from the archived National Estate GeoHeritage dataset. The GeoHeritage dataset provides coarsely georeferenced locations (i.e. point data) from published scientific papers, existing inventory studies, published geological maps, geological map explanatory notes and 1:100 000 scale topographic maps. The dataset was developed as part of the National Estate assessment for the NSW Comprehensive Regional Assessment (CRA) process. The database provides a listing of geoheritage place names, place types, relevant Register of the National Estate criteria, geoheritage units, references (data source), the page number in a reference, eastings, northings, latitude, longitude, size class, data status (data quality) and fragility. This is an archived dataset owned by the Australian Government, under the NSW Regional Forest Agreements (RFA) Data Agreement of 31 March 2000.

Unfortunately, spatially explicit information on geological heritage values is generally lacking for the region, despite a range of published values, with the exception of a map layer identifying karst formations near Michelago and Smiths Road. We suggest geological heritage be considered in any EIS process due to the potential national significance of geoheritage within the Snowy Monaro region.

4.1.6 Aboriginal Heritage

Criteria 6, focusing on Aboriginal heritage, documents known, significant Indigenous areas and items (Criteria_6a). These data were sourced from the NSW DPIE Environmental Planning Instruments.

Council has many data and knowledge gaps in understanding of Aboriginal cultural heritage across the snowy Monaro Region and an independent study by suitably qualified consultant will be required to ascertain aboriginal heritage significance across the region. Therefore Criteria 6 is referred to Heritage in the Maps.

4.1.7 Other Constraints on Development

Criteria 7, focusing on other constraints on development, distinguishes: coal seam gas exclusion areas (Criteria_7a), flood prone areas (Criteria_7b), landslide risk areas (Criteria_7c), strategic agricultural lands (Criteria_7d) and local flood risks for Bombala (Criteria_7e) and Cooma (Criteria_7f). The data on coal seam gas exclusion areas, flood prone areas, landslide risk and strategic agricultural lands were sourced from the NSW DPIE Environmental Planning Instruments. Data on local flood prone areas were sourced from the SMRC.

4.2 Spatial 'datapack' of source and derived data layers

A spatial 'datapack' accompanies this report which includes a copy of all authoritative source data used for this assessment as well as new spatial data products derived for analysing and visualising biodiversity values and other constraints on development. The spatial data formats in the 'datapack' include both shape files and rasters (for use in QGIS) as well as file geodatabases (for use in ArcGIS). Authoritative spatial data were provided from the following sources: the NSW Government's Department of Planning, Industry and Environment (DPIE), the CSIRO, the Atlas of Living Australia (ALA), the Commonwealth Department of Environment and Energy (DoEE), Macquarie University and the Snowy Monaro Regional Council (SMRC).

In addition to the criteria derived from the individual data layers, the NSW Biodiversity Values Map has been included as its own layer, as the key combined layer used by NSW Government and community to determine values in a given area. The Biodiversity Values Map (BV Map) identifies land with high biodiversity value that is particularly sensitive to impacts from development and clearing. The BV Map is one of the triggers for determining whether the Biodiversity Offset Scheme (BOS) applies to a clearing or development proposal. The BV Map has been prepared by the Office of Environment and Heritage (OEH) under Part 7 of the *Biodiversity Conservation Act 2016* (BC Act). A range of mapping layers are included in the BV map. These mapping layers have been developed and are maintained by a range of agencies and councils. The inclusion of these layers on the BV map requires the approval of the Chief Executive of OEH or delegate. The BV Map shows areas that have been added in the last 90 days as the BOS does not apply to development proposals lodged within this time period. Areas that no longer meet one of the criteria for being included on the BV map will also be removed in map updates. It is planned to update the BV Map quarterly. However, users of the BV Map are strongly encouraged to visit the BMAT website and BMAT Tool viewer regularly to be up-to-date with the latest version and other related information. The spatial data for this version are available from the Web Service (see link below). The latest version of the BV map can be viewed in the Biodiversity Values Map and Threshold (BMAT) Tool (see URL link below). More information on the BV map is available at - https://www.environment.nsw.gov.au/biodiversity/biodiversity-values-map.htm.

Ground Validation data (for Endangered Ecological Communities, threatened species and vegetation types) is intended as a coarse indication of ecological values within survey areas. The data include some (but likely not all) threatened species in areas surveyed. In some cases, field surveys conducted by ecologists were restricted to looking 'over the fence' due to lack of access to individual properties where landholders did not agree to a site inspection or were not able to be contacted in a timely manner. This was facilitated by the SMRC as well as local ecologists. For detailed, precise mapping of ecological community boundaries, structured field surveys using rigorous experimental designs should be employed. Field surveys were conducted by Molonglo Consulting, in consultation with Grass Roots Environmental, then digitisation of field surveys was conducted by geoADAPT. Ground verification of areas of interest should be undertaken in a systematic way using the Biodiversity Assessment Method and Groundcover assessment methodology in consultation with the DPIE (formerly OEH), NSW Government.

4.3 Caveats

We note that while maps are provided to help visualise values and constraints (by region, by corridor and by townships), the appropriate spatial data layers provided as part of the supplied 'datapack' need to be viewed for specific local details. For example, many values and constraints are masked by overlays of other

values/constraints in the maps, therefore interrogation of the data is required to identify the specific values occurring at a particular location. In addition to maps of all study areas (i.e. region, corridors, townships), lists of all values and constraints identified in the spatial data are tabled with associated hectare coverages in the 'datapack'. In general, we did not attempt to verify the accuracy of spatial data provided to us by regional authorities, aside from very targeted field surveys in a few investigation areas (see Section 7.3).

The process of synthesising the information relating to the range of conservation values included in this assessment was a difficult task. There were many different layers of information, none of which covered any one entire area or theme. Therefore, for some areas, the assessment has relied on modelled data which have been identified as such. Ground-truthing has been undertaken for key areas of interest for this report, as outlined in the scope for this study. However, it should be noted that there remain significant area gaps, particularly for certain vegetation communities such as native grasslands. Field surveys and data confirmation should form a key priority for any area proposed for land use or zoning changes. A number of submissions to the *Snowy Monaro Region Planning and Land Use Discussion Paper 2019* also highlighted this point.

5 Regional Biodiversity Assessment

Biodiversity in the Snowy Monaro Shire is highly diverse, and very significant to achieving conservation objectives in NSW. A summary of regional biodiversity values adapted from the SMRC *Planning and Land Use Discussion Paper 2019* and the Upper Snowy Landcare Network submission to the Paper for the Snowy Monaro Shire region has been included as it provides a good summary to capture the diverse suite of values. This is also substantiated in the spatial data and literature review. The area:

- contains many endangered or threatened species and ecological communities, especially within its woodland areas; e.g. Koalas, Snow Gum–Ribbon Gum–Candlebark Grassy Woodland, Tableland Clay Grassy Woodlands, Wirrewa/Monaro Grasslands
- contains and adjoins large areas of high biodiversity conservation value lands, including national parks and nature reserves
- is crossed by biodiversity corridors connecting the South East and Tablelands areas
- despite extensive land clearing, contains a large amount of extant native vegetation, albeit in a fragmented state
- contains many significant rivers and waterways that have unique biodiversity within their aquatic and riparian communities, and which form the headwaters of Australia's major river systems
- has a substantial amount of previously productive RU1-zoned land (Primary Production) which is now degraded by weeds and erosion and therefore no longer classifies as 'the most productive agricultural land'
- contains substantial areas of state forest which are undergoing significant amounts of clearing
- is in demand from 'tree-changers' who wish to own a piece of rural land for its landscape value but not necessarily earn a living from it
- has stunning, iconic scenery which is valued by the region's many tourists and its residents.

Of all the values in the Shire, natural entities protected under federal and NSW legislation are of the utmost importance in terms of land management planning and development. This includes all Matters of National Environmental Significance (MNES) and those that are protected under state legislation and include Endangered Ecological Communities (EEC's) and threatened species. Another important consideration is the connectivity of vegetation to support the survival and dispersal of species, irrespective of whether they are threatened or not. Therefore, these three categories have been prioritised as key criteria for this report as a measure of High Environmental Value and constraints on development.

5.1 Endangered Ecological Communities

The Snowy Monaro region has 18 Endangered Ecological Communities (EEC's) listed under NSW legislation, of which six are listed as nationally important and also protected under federal legislation. Table 4 shows regional EECs exported from BioNet, with the additional Snowy River EEC sourced from DPI Fisheries. Table 5 shows EECs exported from the nationally administered Protected Matters Search tool. Communities are listed as 'V' for Vulnerable, 'E' for Endangered and 'CE' for Critically Endangered in both tables. However, the classification schema and naming of vegetation communities differs between the state and federal agencies that oversee listings and therefore these lists have been deliberately kept separate. In some cases, names may differ between lists, although those that align have been identified - the rows in the table refer to the equivalent community. Note that for the NSW list, several EECs occur at the very eastern margins of the Snowy Monaro Shire as the list aligns with the South East IBRA region mapping which extends outside the Snowy Monaro Shire. These EECs are identified with a single star and mostly relate to coastal communities. They were left in the table in the interests of being thorough. Of particular note is the Snowy River EEC, which encompasses an entire catchment and all of its values rather than being restricted to a particular community type. It differs from the other EECs as it is protected under NSW Fisheries legislation.

Table 4 Snowy Monaro Endangered Ecological Communities (EECs) based on the NSW Government's BioNet

Community	Status NSW	Status EPBC
Araluen Scarp Grassy Forest in the South East Corner Bioregion	E	
Bangalay Sand Forest of the Sydney Basin and South East Corner bioregions*	E	
Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions*	E	V
Dry Rainforest of the South East Forests in the South East Corner Bioregion	E	
Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions*	E	
Lowland Grassy Woodland in the South East Corner Bioregion***	E	CE
Monaro Tableland Cool Temperate Grassy Woodland in the South Eastern Highlands Bioregion***	CE	
Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps bioregions***	E	E
Natural Temperate Grassland of the South Eastern Highlands***		CE
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions*	E	
Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	E	E
Tableland Basalt Forest in the Sydney Basin and South Eastern Highlands Bioregions	E	
Themeda grassland on seacliffs and coastal headlands in the NSW North Coast, Sydney Basin and South East Corner Bioregions***	E	
Werriwa Tablelands Cool Temperate Grassy Woodland in the South Eastern Highlands and South East Corner Bioregions***	CE	
White Box Yellow Box Blakely's Red Gum Woodland***	E	CE
Windswept Feldmark in the Australian Alps Bioregion	CE	
Tablelands Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland in the South Eastern Highlands, Sydney Basin, South East Corner and NSW South Western Slopes Bioregions**	EEC Final Determination	Not listed
The aquatic ecological community of the Snowy River catchment - includes all native fish and aquatic invertebrates within all rivers, creeks and streams of the Snowy River catchment. The listing includes the river-bed channels inundated by the artificial impoundments of Jindabyne, Eucumbene, Island Bend and Guthega dams, but excludes the ecological communities that have developed in the waters of these impoundments.	E	
* Mainly coastal communities outside Snowy Monaro Shire. Left in as they may adjoin parts of the Shire. ** This vegetation community is not yet listed under NSW or Federal legislation, but the NSW Threatened Species Scientific Committee has made a final determination to list it as EEC. *** Aligns with SPRAT EEC listed communities in Table 4.		

Table 5 Snowy Monaro Endangered Ecological Communities (EECs) based on Commonwealth Protected Matters Report

Community	Status EPBC
Alpine Sphagnum Bogs and Associated Fen	E
Lowland Grassy Woodland in the South East Corner Bioregion	CE
Natural Temperate Grassland of the South Eastern Highlands	CE
Temperate Highland Peat Swamps on Sandstone	E
Upland Wetlands of the New England Tablelands and the Monaro Plateau (South Eastern Highlands Bioregion)	E
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	CE

5.2 Threatened Species

There are more than 200 threatened species identified in the Snowy Monaro Region. These are listed in Appendix D and represent a very diverse range of animals and plants, some of which face particularly unique challenges in association with the Snowy Mountains and the effects of climate change. This is covered in detail in Section 8.

Threatened species all bear equal importance in terms of being afforded protection and appropriate management, but one of particular note in the Snowy Monaro Shire is the Koala which is significant to the conservation of Koalas across NSW.

5.2.1 Snowy Monaro Koala Population

The population of Koalas in the Snowy Monaro Shire is protected under State Environmental Planning Policy No. 44 (SEPP 44) which outlines controls to better protect Koala habitat while ensuring consistent assessment of development applications.

As per Table 2 from Section 3.2, four of the five important food tree species for Koalas have been omitted from SEPP 44 – i.e. all except *Eucalyptus viminalis* (Ribbon Gum). This is important in the context of potential future development, as the additional currently unlisted food tree species need to be afforded the same level of protection. The population of Koalas is not only protected under appropriate legislation but is extremely important to the community.

A specific Koala Plan of Management has been developed for the Snowy Monaro Shire by Martin and Phillips (2015) and contains detailed information on the management of the population, including the important species of food trees, habitat requirements and threats to the species. There is also advice and positive opportunities for private landholders, Councils and managers of Crown lands to collaborate to conserve Koala habitat. This entails appropriate land-use planning (and zoning) as well as a potential Koala credits scheme for private landholders enabling them to be supported to undertake activities such as fencing, reduction of fire risk, weed management, protection of remnant vegetation and revegetation (Martin & Phillips, 2015).

Koala habitat has been included as a specific mapping layer in this report (along with associated spatial data) and has also been incorporated into the High Environmental Values mapping layer under Criteria 3k [Threatened Species Populations/Koala].

Unique to the Cooma-Monaro Shire, bark chewing by Koalas was confirmed from UV camera footage during the survey work undertaken for the purposes of the Draft Habitat Study, with *E. mannifera* recorded as the target species.

5.3 Other Biodiversity Values

As mentioned in section 4, a range of criteria were spatially analysed in addition to EECs and threatened species. These included high conservation value native vegetation, wetlands and rivers, areas of geological importance, Aboriginal heritage and other constraints on development such as landslide risk, important agricultural lands, coal seam gas exclusion and flood prone areas.

5.4 Mapping Layers

As outlined in Section 4, a series of data layers have been produced incorporating the region's biodiversity values by criteria shown in Figures 2-8. These can be investigated in greater detail via the spatial data layer provided in the datapack. Many values overlay one another when presented in single map form.

Figure 2 Regional Biodiversity Values and Development Constraints in the Snowy Monaro – All Criteria Combined.

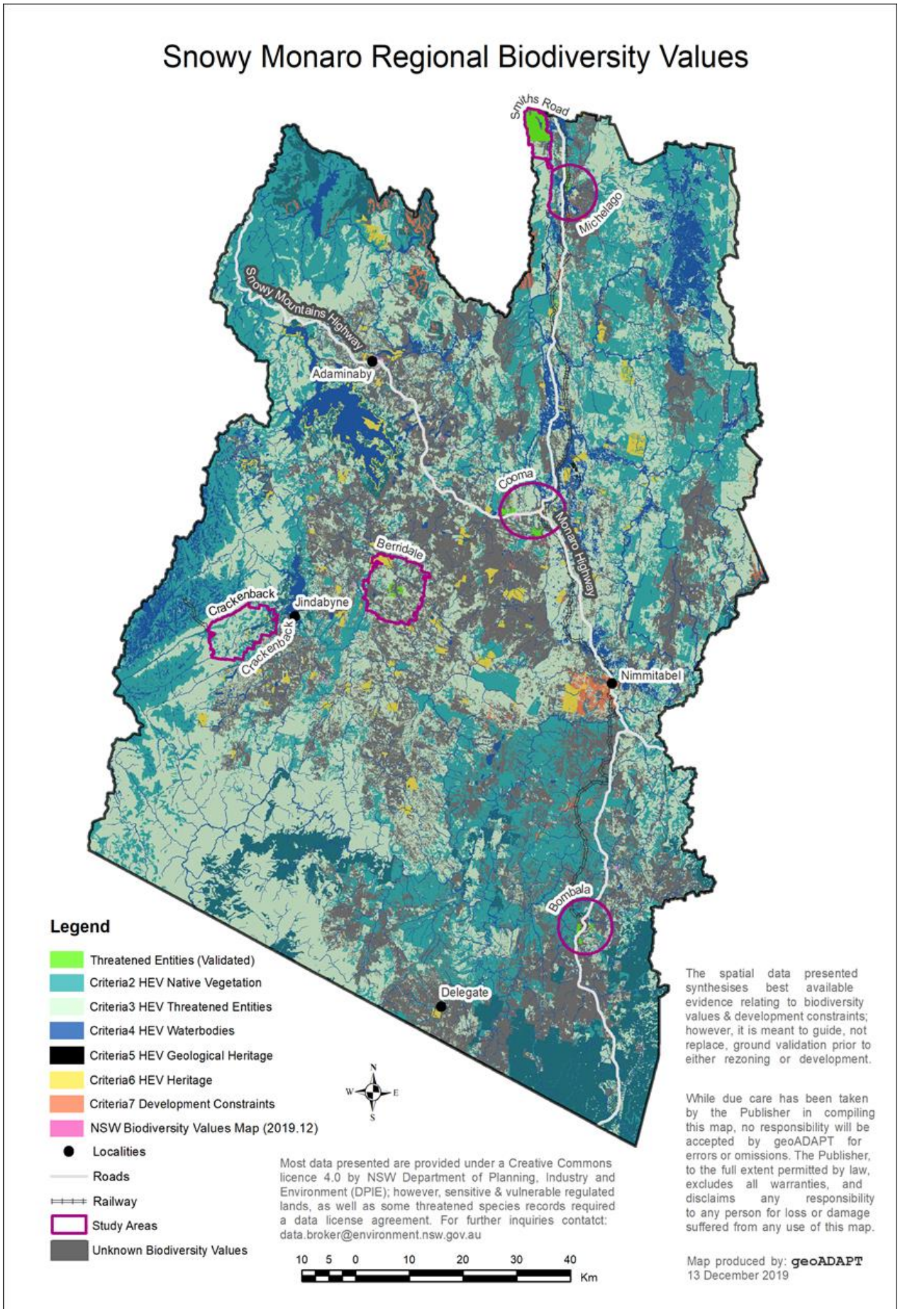


Figure 3 Conservation Areas (Criteria 1) in the Snowy Monaro

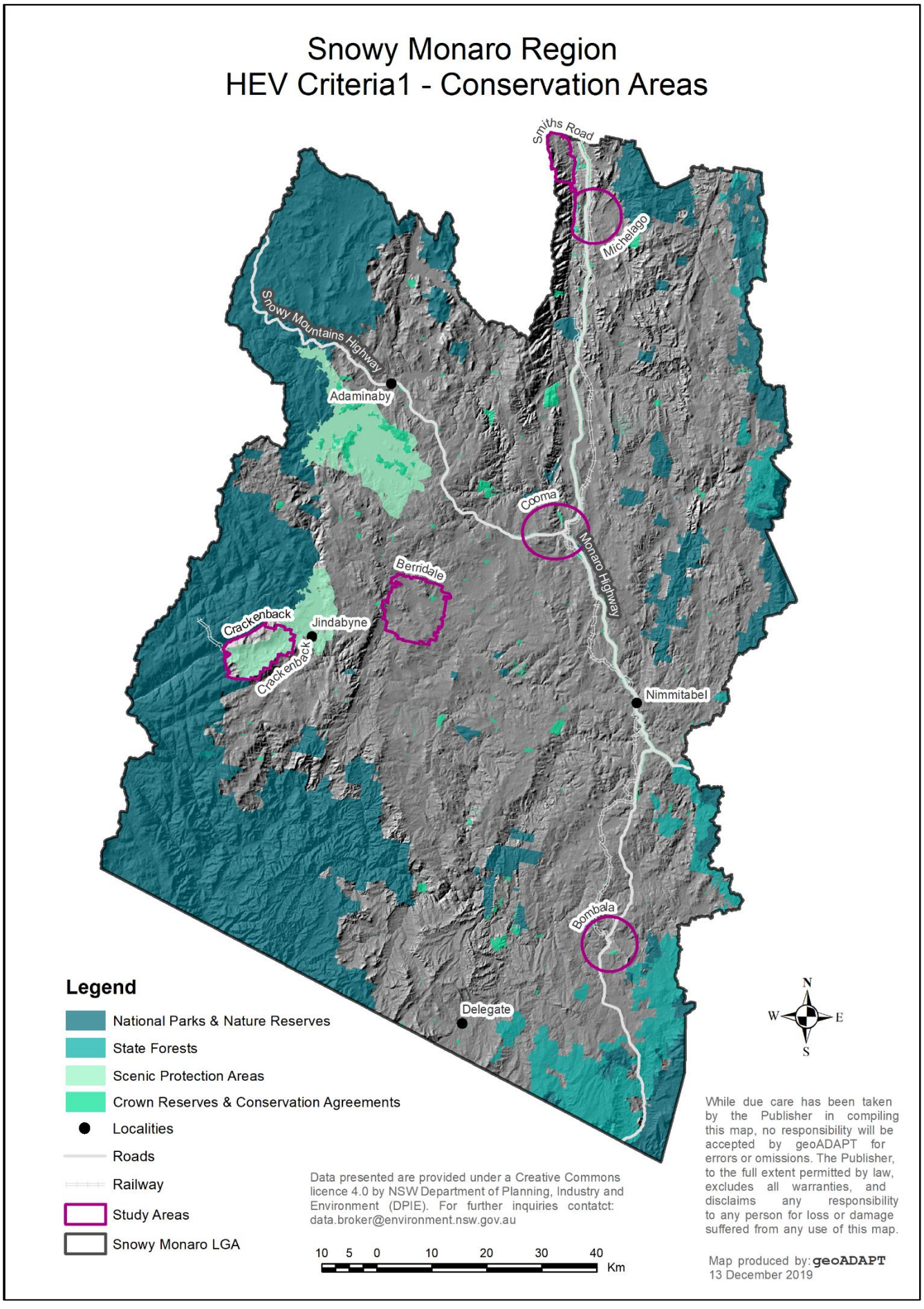


Figure 4 Significant Native Vegetation (Criteria 2) in the Snowy Monaro

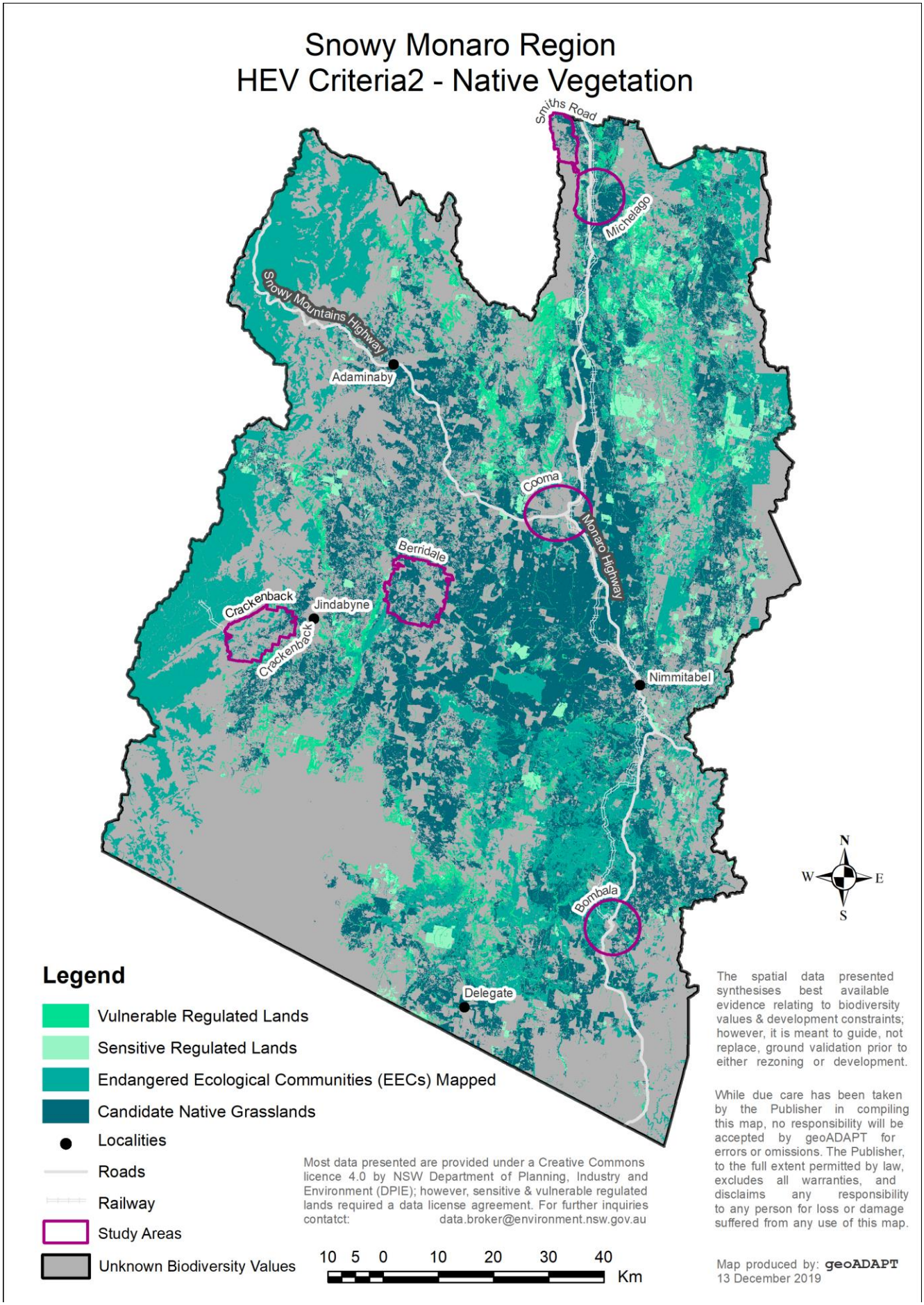


Figure 5 Threatened Entities (Criteria 3) in the Snowy Monaro

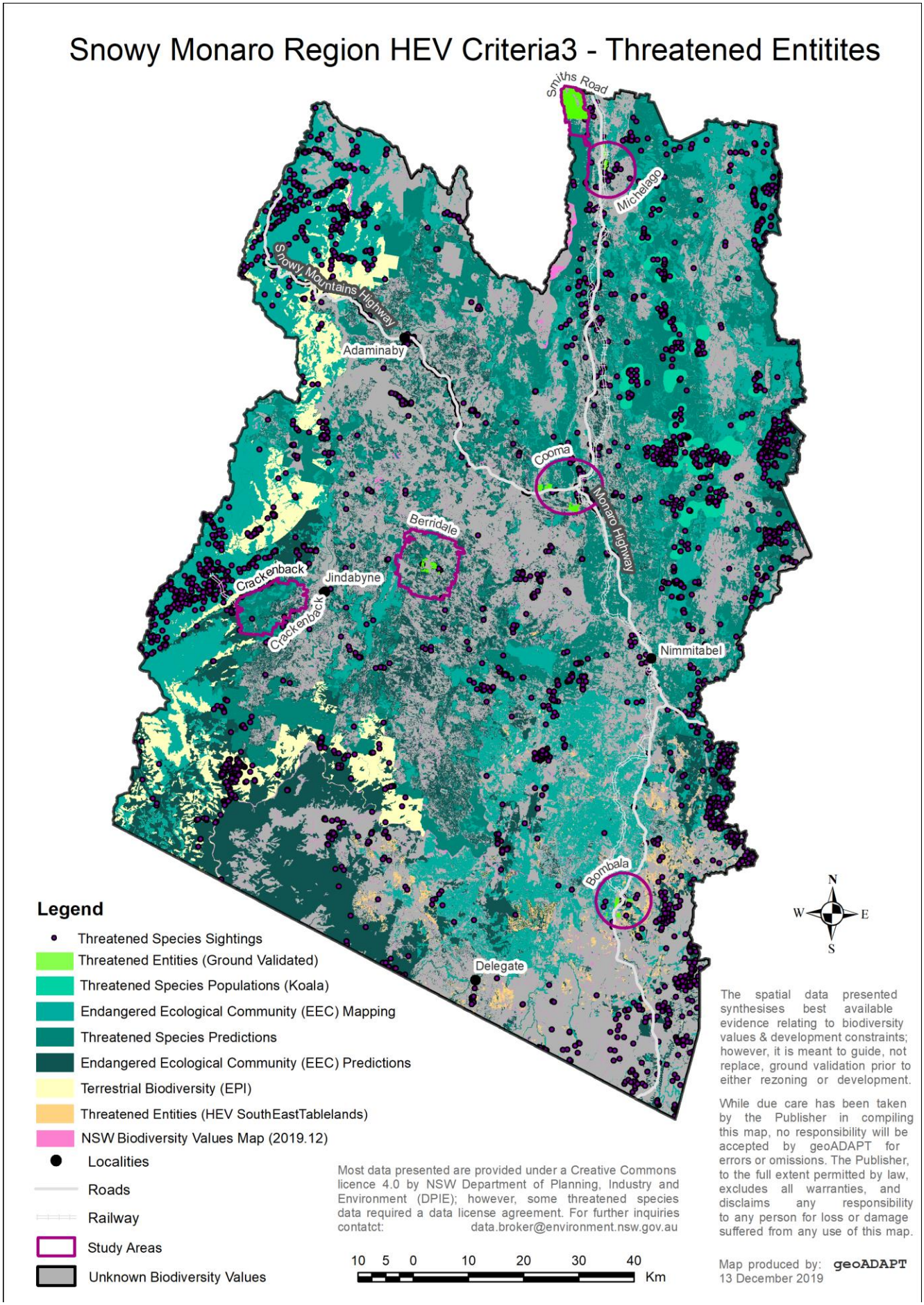


Figure 6 Freshwater Values (Criteria 4) in the Snowy Monaro

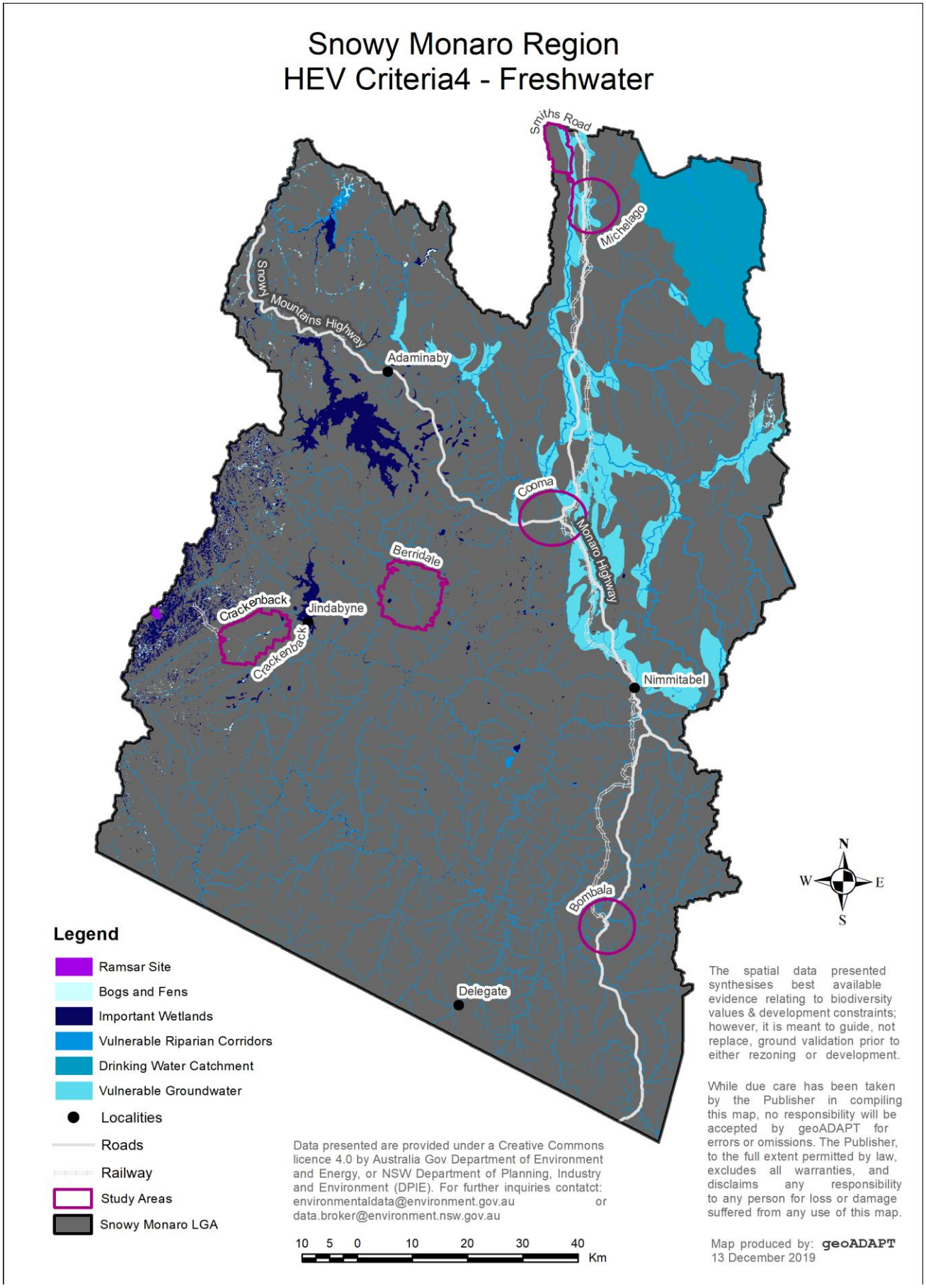


Figure 7 Geological Heritage (Criteria 5) in the Snowy Monaro

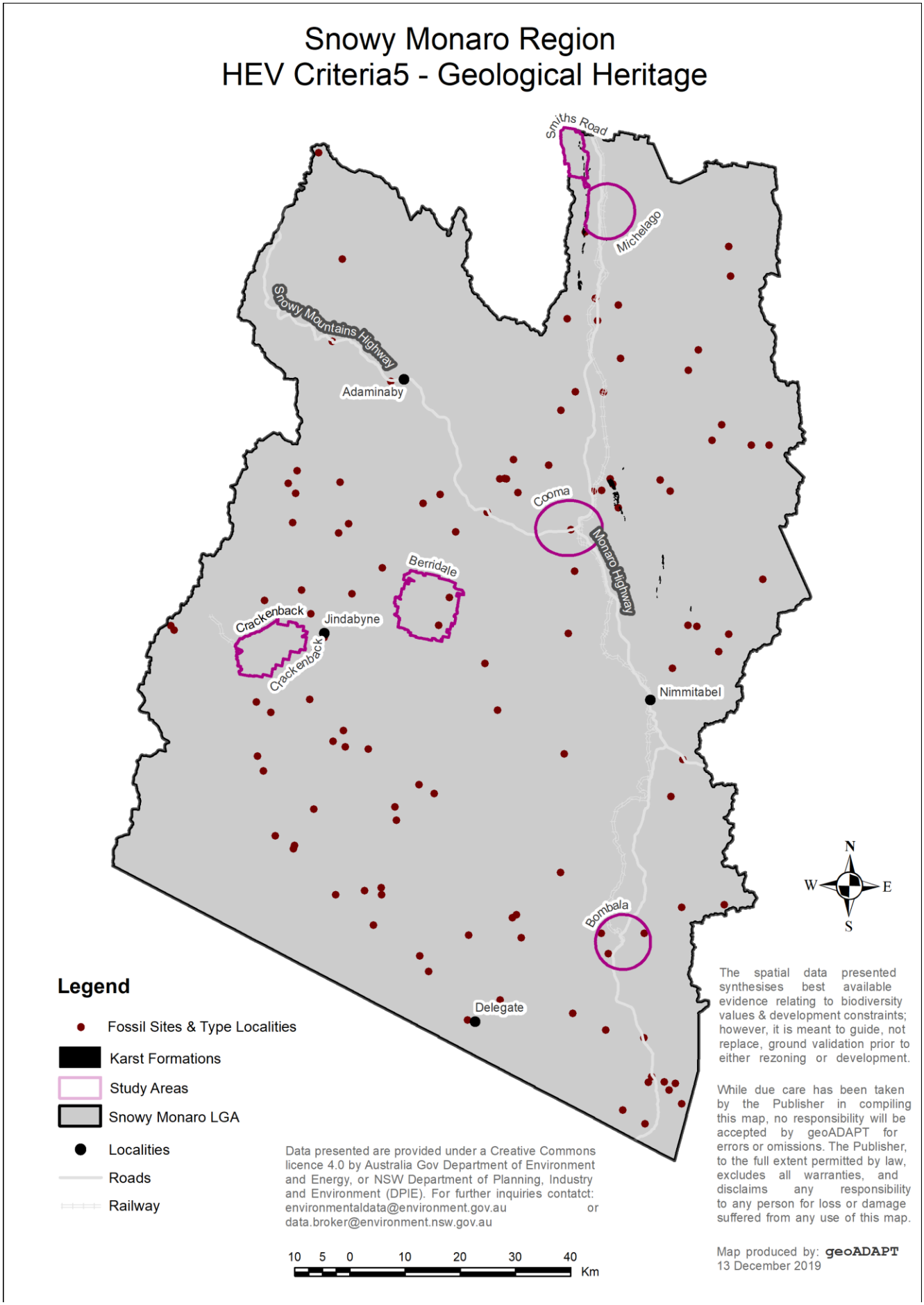


Figure 8 Aboriginal Heritage Values (Criteria 6) in the Snowy Monaro

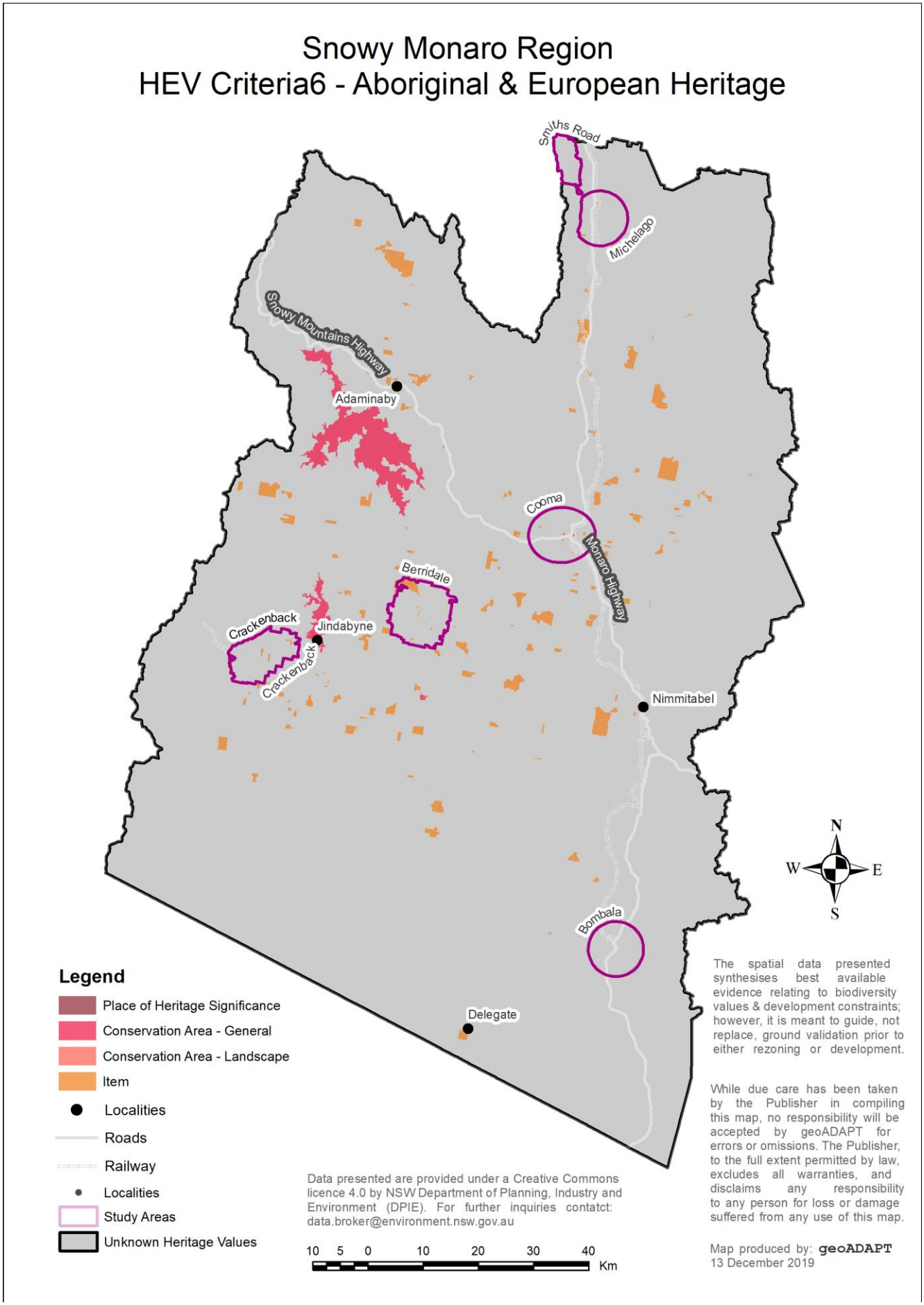
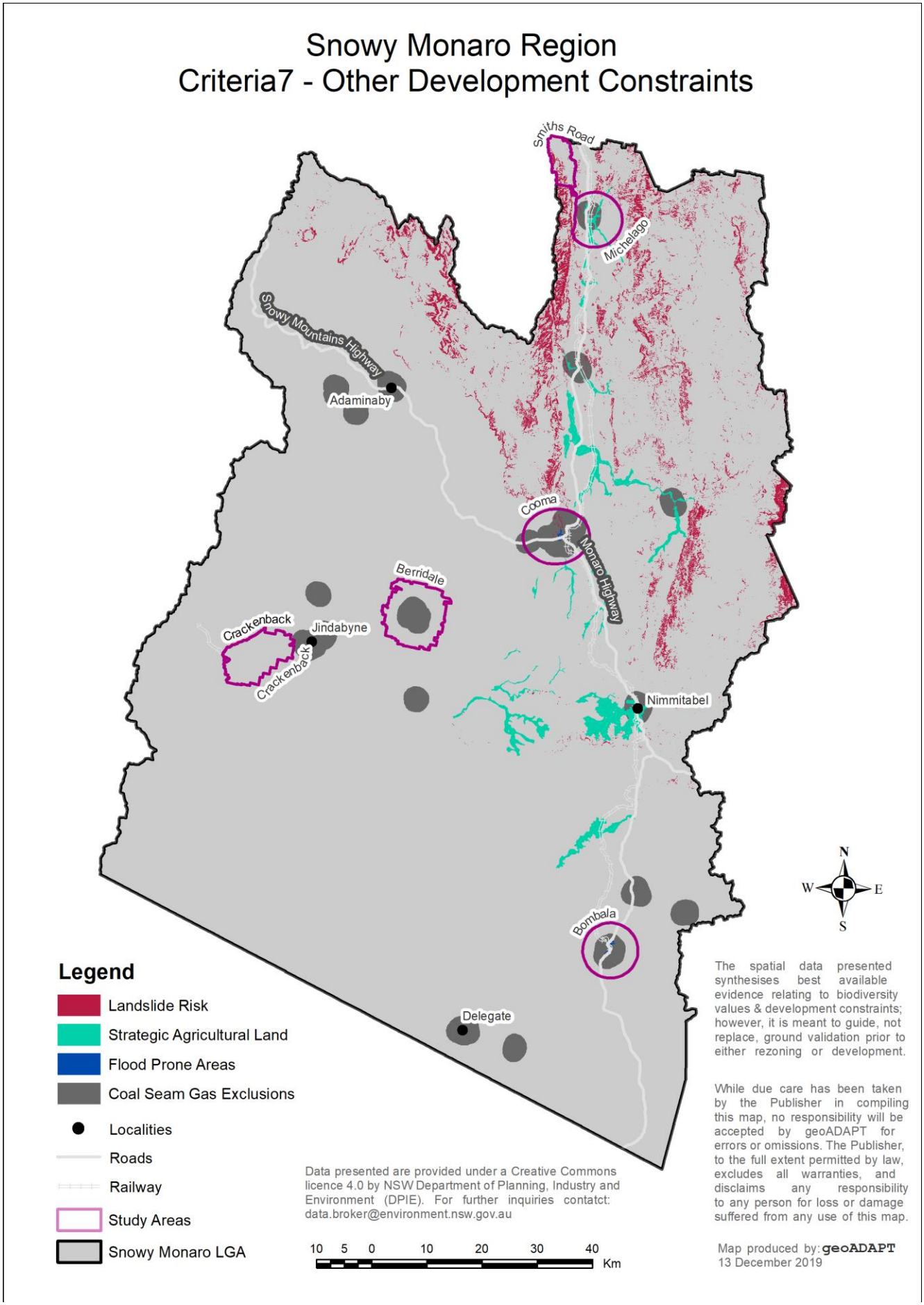


Figure 9 Other Development Constraints (Criteria 7) in the Snowy Monaro



5.5 Biodiversity Corridors

This section focuses on the biodiversity values and development constraints within regional biodiversity corridors. These corridors were first introduced in the *South East and Tablelands Regional Plan 2036* which is the regional planning blueprint for the next two decades. It reflects community and stakeholder aspirations and opportunities for balanced growth, while protecting the region's natural environment (NSW Government, 2017). The boundaries of these proposed corridors were developed through extensive stakeholder consultation by the NSW Government (2017).

The locations of the corridors were mapped based upon known, mapped and predicted biodiversity values, as well as visual inspection of aerial imagery. Biodiversity corridors in the region are extensive, so for mapping and analysis as part of this assessment, the existing mapping polygons of the biodiversity corridors were aggregated into four zones, referred to throughout as 'West' 'North East', 'Central East' and 'South East'. The locations and extent of each corridor are shown in Figure 10, whereas biodiversity values and constraints to development are shown in Figures 11 (for 'West'), Figure 12 (for 'North East'), Figure 13 (for 'Central East') and Figure 14 (for 'South East'). Given the difficulties in visualising all values and constraints on a single map, inventories (i.e. lists) of all values and constraints are provided in Appendix E. They are also provided in the 'datapack' (ZonalStats_RegionsCorridorsTownships.xls).

Figure 10 Location of Regional Biodiversity Corridors

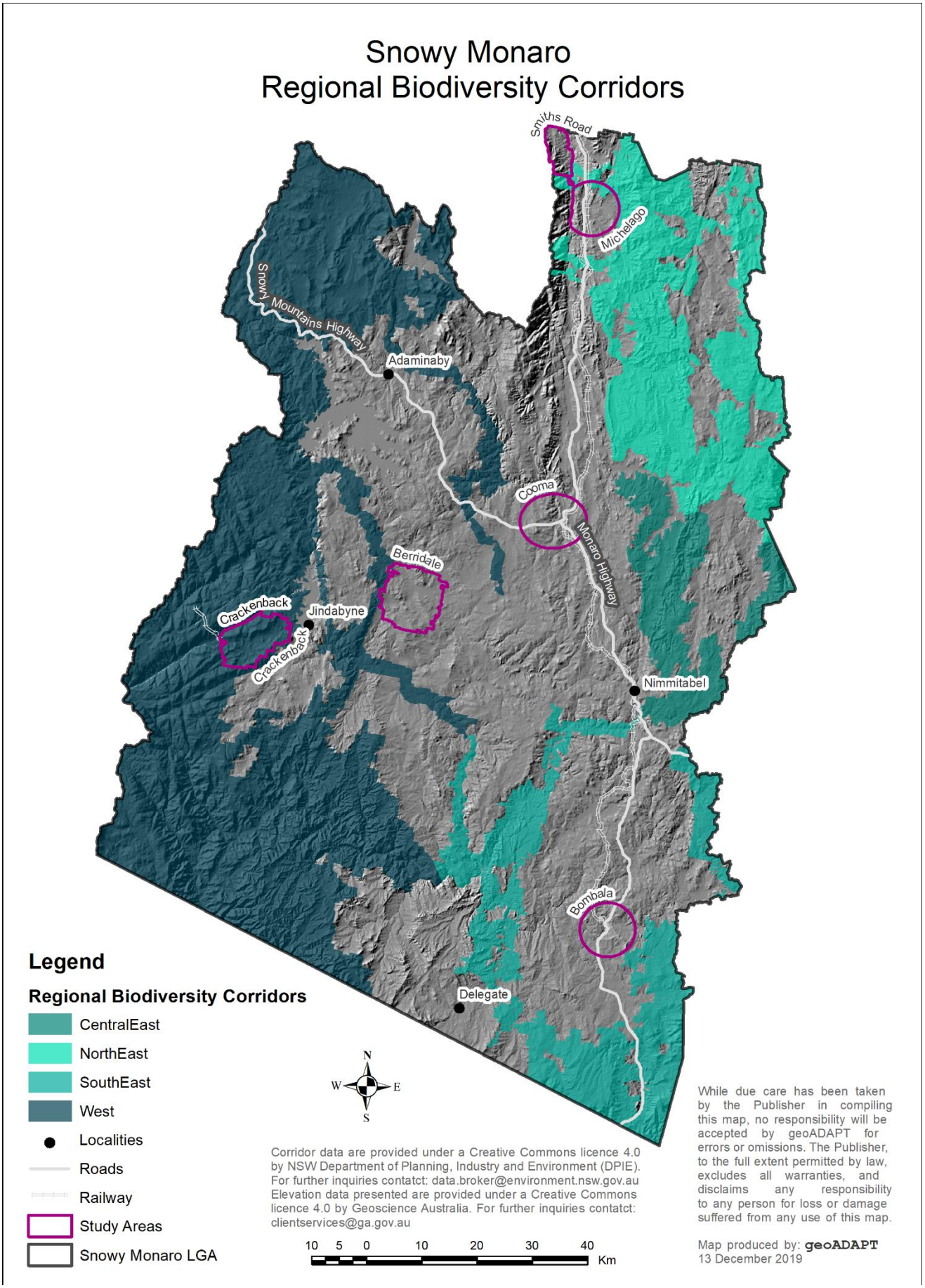


Figure 11 Biodiversity Values and Development Constraints in the 'West' Biodiversity Corridor

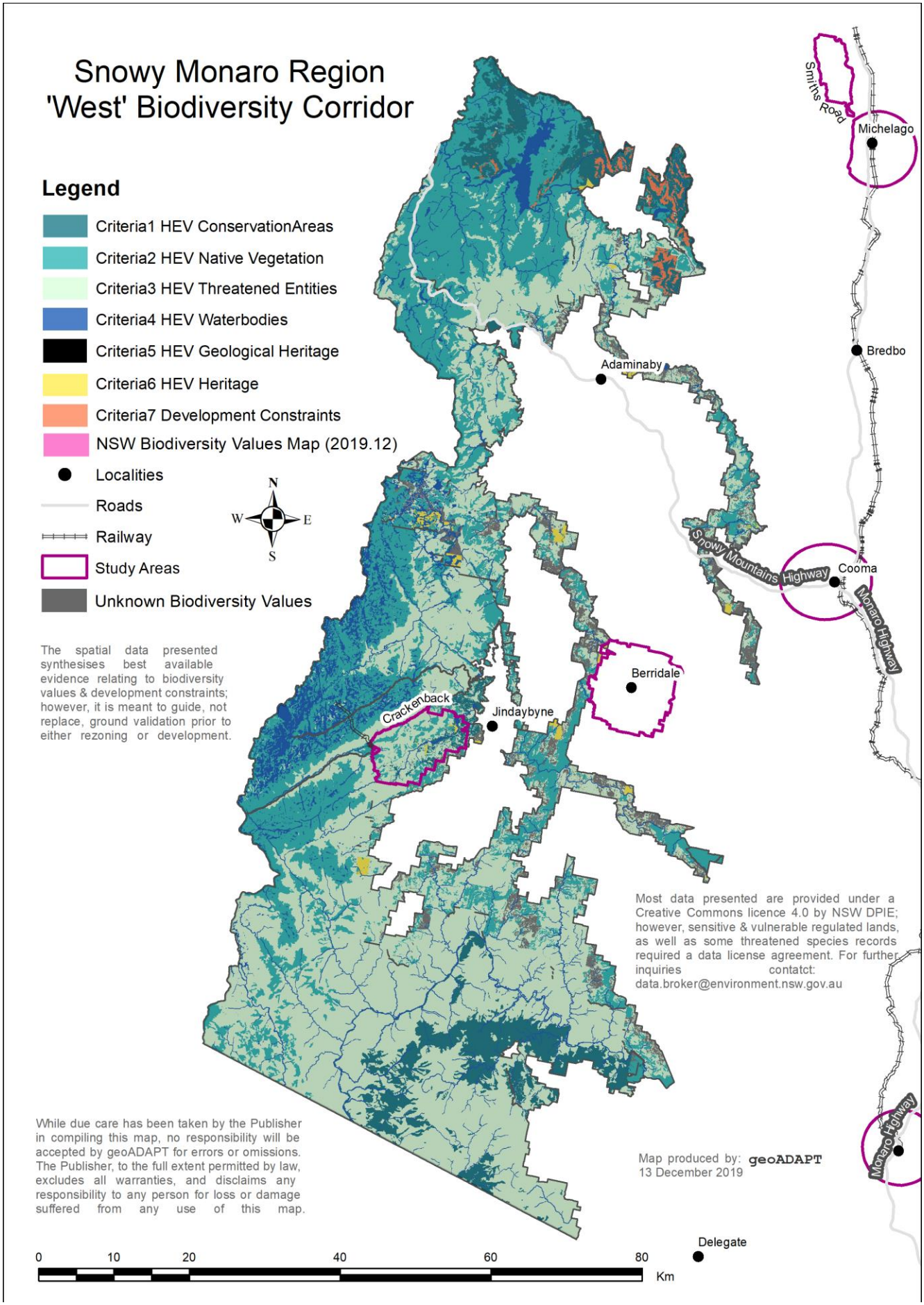


Figure 12 Biodiversity Values and Development Constraints in the 'North East' Biodiversity Corridor

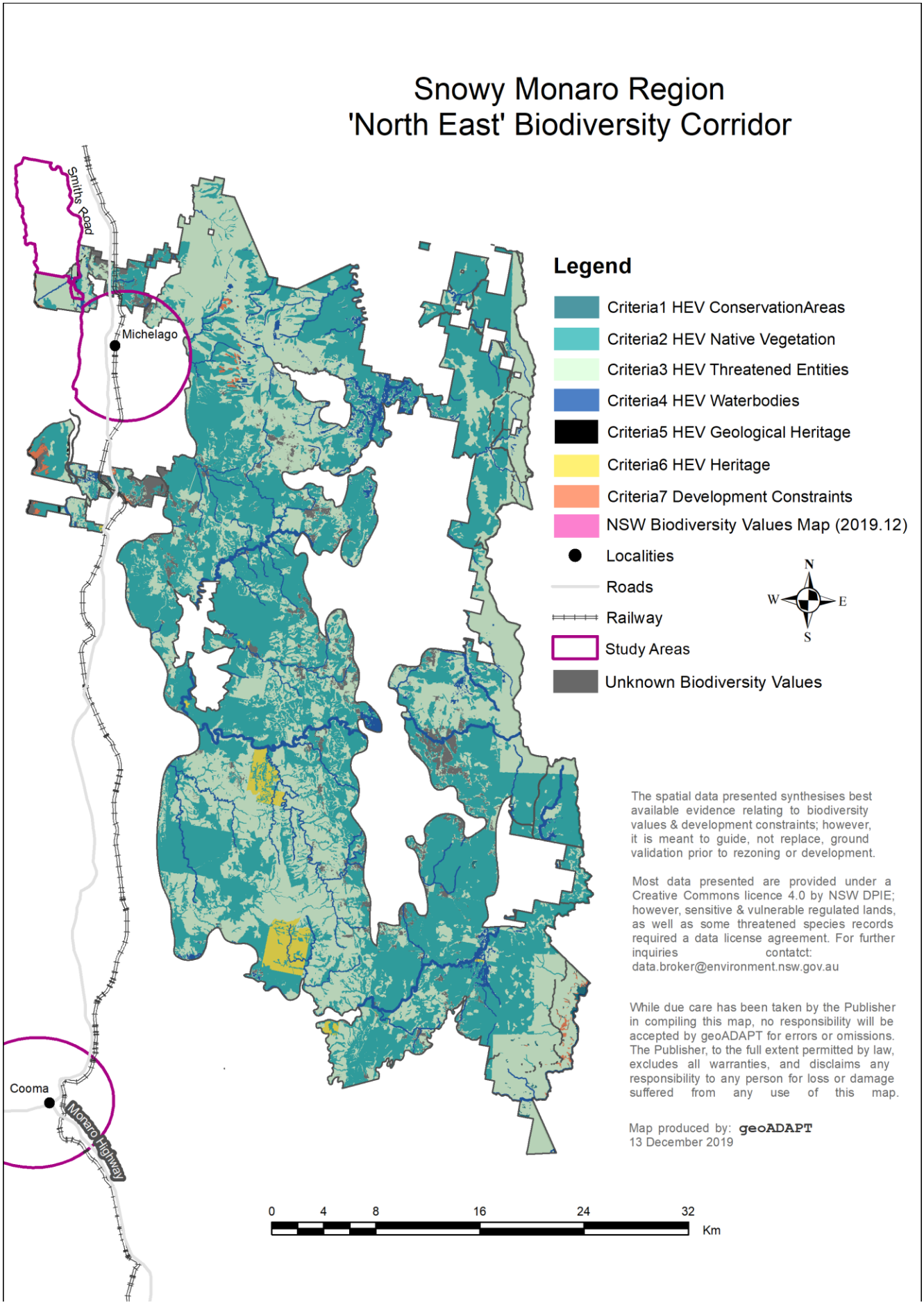


Figure 13 Biodiversity Values and Development Constraints in the 'Central East' Biodiversity Corridor

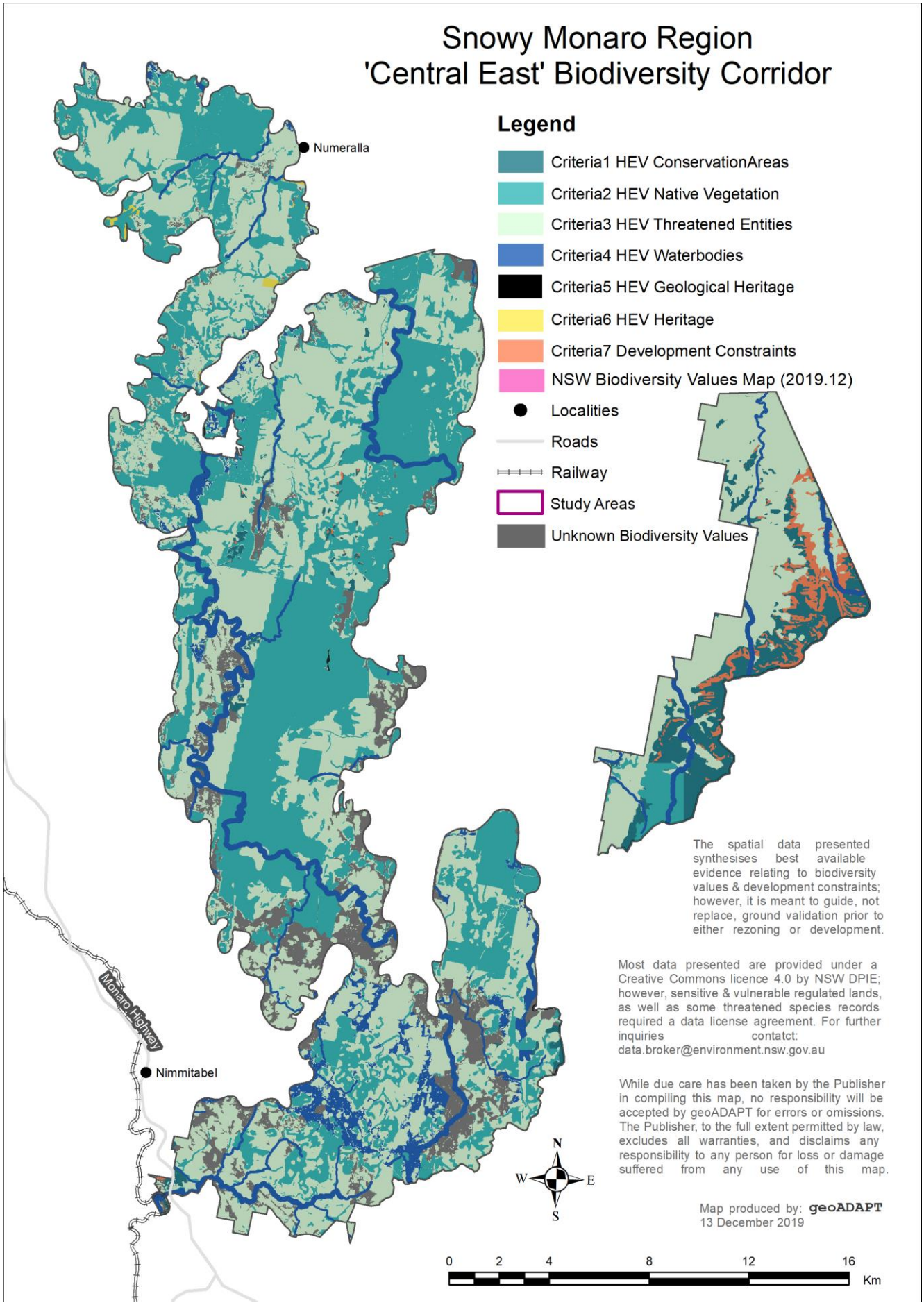
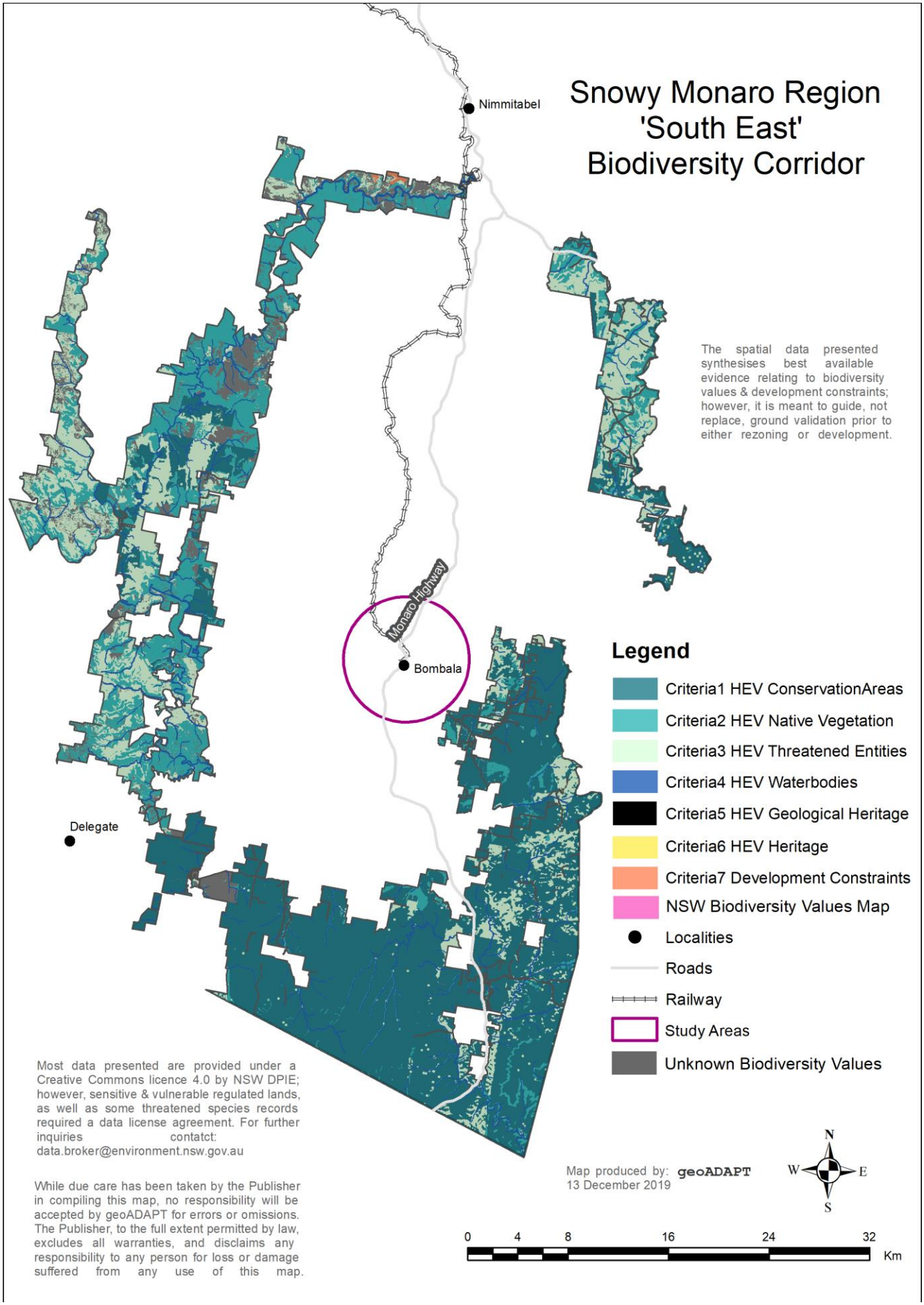


Figure 14 Biodiversity Values and Development Constraints in the 'South East' Biodiversity Corridor



6 Future Urban Expansion Areas and Zoning

6.1 Environmental Planning Zones

The standard instrument for Local Environmental Plans (LEPs) contains four environment protection zones specifically for land where the primary focus is the conservation and management of environmental values. The zones provide for varying levels of environmental protection from zone E1 to E4 (NSW Government, 2009).

According to the *South East and Tablelands Regional Plan 2036*, these zones are not utilised enough and should be applied to a greater extent in regional planning (NSW Government, 2017). However, the allocation of zone designations must be based on consistency and evidence-based planning in order to justify changes to existing zoning (SMRC, 2019).

Another important consideration relating to zoning is the use of Environmental Protection Zones (EPZs). There is a perception that EPZs may constrain growth and development, but this is not often the case. It is important to consider the natural environment when it comes to zoning as it can prevent inappropriate activities in areas of high biodiversity value. For example, appropriate consideration of environmental values can prevent residents and developers from unwittingly purchasing blocks or applying to conduct an activity that is subsequently disallowed under State or Federal legislation and policies (SMRC, 2019).

Environmental Protection Zones vary quite significantly. For example, Zone E2 – Environmental Conservation, is designed for areas of high significance and focused mainly on protecting the environmental values of the land. On the other end of the spectrum, Zone E4 – Environmental Living is focused more on providing rural residential lots which take advantage of the natural setting and landscape. Table 6 outlines these categories.

Table 6 Definition of Environmental Planning Zones

E1	National Parks and Nature Reserves	This zone is for existing national parks, nature reserves and conservation areas and new areas proposed for reservation that have been identified and agreed by the NSW Government
E2	Environmental Conservation	This zone is for areas with high ecological, scientific, cultural or aesthetic values outside national parks and nature reserves. The zone provides the highest level of protection, management and restoration for such lands whilst allowing uses compatible with those values. It is anticipated that many councils will generally have limited areas displaying the characteristics suitable for the application of the E2 zone. Areas where a broader range of uses is required (whilst retaining environmental protection) may be more appropriately zoned E3 – Environmental Management
E3	Environmental Management	This zone is for land where there are special ecological, scientific, cultural or aesthetic attributes or environmental hazards/processes that require careful consideration/management and for uses compatible with these values
E4	Environmental Living	This zone is for land with special environmental or scenic values and accommodates low impact residential development. As with the E3 zone, any development is to be well located and designed so that it does not have an adverse effect on the environmental qualities of the land

In accordance with NSW planning legislation, zoning should distinguish carefully between the E4 – Environmental Living zone, the RU4 – Rural Small Holdings and R5 – Large Lot Residential zones to address environmental, agricultural and residential land capabilities respectively. If there are few environmental considerations, then R5 may be the appropriate zone. Where environmental capabilities are the primary concern on land that may be zoned R5 – Large Lot Residential, RU4 – Rural Small Holdings or E4 – Environmental Living, preference should be given to the E4 zone.

Local environmental provisions may be applied where zone provisions need to be augmented in order to ensure that special environmental features are considered. For example, rural land that is still principally utilised for agriculture, but which contains environmentally sensitive areas, may be zoned RU1 or RU2 and the environmental sensitivities managed through a local provision and associated map (NSW Government, 2009).

This report makes comment on the environmental and biodiversity value and does not make reference to other planning instruments or the social and political overlay. It is noted that there are a number of different viewpoints from stakeholders and the community working and living in the Shire, as evidenced by the variety of submissions to the *Snowy Monaro Region Planning and Land Use Discussion Paper 2019* (the 'Discussion Paper') which need to be taken into account as part of the regional planning and decision-making process.

6.2 Biodiversity Values, Threats and Constraints in Study Areas

Biodiversity values around key townships (nominated by the Snowy Monaro Regional Council) were investigated using existing spatial information in addition to ground-truthing of areas where data were not previously available or confirmed. Input from various agencies and community groups was also considered via submissions to the Discussion Paper as contextual Information. As mentioned earlier, this report focusses only on the environmental and biodiversity values in relation to zoning and not stakeholder input which will be addressed through Council planning processes.

A number of the submissions to the Land Use Discussion Paper confirmed that mapped biodiversity layers are not 'ground-verified', even though they may be mapped as High Environmental Value (HEV). This is particularly true for the grassland areas where the noxious weed African Love Grass may appear similar to a patch of the EEC Natural Temperate Grassland from remotely sensed data, the primary means of mapping grasslands in the region. A particular area of concern raised by both the community and the SMRC was the land between Cooma and Canberra which has a mosaic of African Love Grass, pasture grasses (native and exotic) and Natural Temperate Grassland. Ideally, a dedicated study should be carried out to determine the nature of these treeless areas but was beyond the scope of this assessment and report. In addition to this, as outlined in Section 4.1.3, threatened species locations are also not often precise in order to protect entities from disturbance. This has been considered by the use of buffers around indicative mapped locations.

Given the extensive spatial data gaps that remain unconfirmed and the available resources, only the areas of interest to the SMRC for potential future growth have been investigated on-ground as part of this study. These areas include Berridale, Michelago, Smiths Road, Bombala, and Cooma townships. The Crackenback / eastern approach to Kosciuszko National Park (SMRC, 2019) was also identified in the report scope, but this, in addition to Jindabyne, is being addressed in the *'Go Jindabyne' Masterplan*. The ground-truthing determined that most of the areas of interest that were investigated contain Matters of Environmental Significance (MNES) in varying condition, which needs to be taken into account for future planning. While the condition of these has been noted, they are still MNES and need to be managed accordingly.

Other town centres that were not specifically nominated for investigation but have been included in the HEV map layer include Nimmitabel, Numeralla, Bredbo, Kalkite, Cathcart, Dalgety, Bibbenluke, Adaminaby and Delegate. Bombala Rail Line and the Snowy Mountains Airport are also covered by this map layer. All of these areas have important natural values associated with them but are less likely to be areas of high future growth than the towns nominated for this assessment. Changes to zoning for future development would need on-ground investigation to supplement the mapping data. The HCV spatial layer provided to the SMRC as part of the 'datapack' for this report can inform zoning re-evaluation.

Submissions received from circulation of the *Rural Land Use Discussion Paper 2019* by the SMRC included a number of comments in relation to land-use changes from a general perspective as well as specific comments relating to certain locations. These comments were consulted to inform this report but have not been specifically incorporated, as it is more appropriate for Council to consider this input as another overlay to the biodiversity mapping and recommendations.

One strong theme that came through in the submissions was the strong support for localised planning based on environmental values. This planning needs to consider potential land-use activities; for example, rural residential areas with intact bushland represent a major source of vegetation removal in the Southern Tablelands due to high clearing rates and there are broader impacts associated with subdivision, small-scale agricultural activities, unstable soils, dieback, pest plants and animals, and domestic animals (OEH, 2019). The impact of land management activities often extends further afield than the designated blocks, which is another consideration when providing recommendations for urban-scale expansion and appropriate EPZs; for example, domestic animals, run-off, impacts on ground water, etc. On the other hand, smaller lot sizes may be easier to manage for weeds and other environmental threats.

The initial study scope of this assessment included development of recommendations for the utilisation of EPZs over the next 5 years, 5-10 years and 10-20 years. However, the timeframe of 10-20 years could be considered relatively short term in the context of land-use planning changes, urban expansion and other development. In this regard, the timing of changes to land-use zoning is more related to priority (urgency) rather than in relation to specific (and arbitrary) timeframes; that is, short term (high priority), medium term (moderate priority), and longer term (low priority). The information provided in this report can be considered as relevant for at least the next ten years unless ground-truthing or new mapping alters the spatial information that informs planning.

6.3 Future Urban Expansion Study Areas

For each study area (i.e. township), biodiversity mapping has been undertaken along with associated ground-truthing to further inform the mapping. This is particularly relevant for areas where mapping is based entirely on modelled data rather than collected data. The methodology for producing the High Environmental Value (HEV) maps can be found in Section 4.

Recommendations for future urban-scale expansion is based on a decision-making dichotomy which first looks at whether there are environmental constraints on development for any given site. If the HEV mapping identifies constraints, the nature of these is investigated in more detail to determine whether a site involves Matters of National Environmental Significance (MNES), what are those values, and what are the potential threats to those values. Key threatening processes are listed under State and federal legislation in association with EECs and threatened species. These have been included as a mapping layer and in the associated Look Up Table (LUT) as part of the 'datapack' provided with this report. If there are no environmental constraints identified, then rezoning can potentially be undertaken with respect to the economic and social overlays and considerations as determined by Council.

It should be noted that the maps presented herein are for display purposes, as they contain seven criteria layers (one layer per criteria) and each one obscures the view of those beneath them. The 'datapack' provided to Council enables each layer to be thoroughly investigated individually or collectively as required.

Also included for each town centre is a table that lists all the value criteria (and their respective area in hectares) found within each SMRC area of interest. To date, specific zonal lot data have not been provided for Smiths Road or the Crackenback / Eastern approach to Kosciuszko National Park, but these areas have been mapped and assessed for their values at a more generalised scale. These tables provide an indication of all the values that are associated with the area in question, and it should be noted that there is some overlap where various criteria layers are captured. For example, for grasslands there may be mapped EECs, modelled EECs or a combination of criteria indicating an EEC. This reflects the number of data layers and the need to include all of them for the most comprehensive coverage to indicate High Environmental Values for an area. On the other hand, some areas have only one layer available indicating a particular criterion, and if it wasn't included that value would not be captured for a particular site.

The assignment of environmental values was based on the mapping, ground-truthing and inventory of environmental values. Most were found to contain EECs and / or threatened species, and therefore are

automatically assigned a high value. Condition for each EEC was also noted but, for the purposes of this report, does not have bearing on the assignment of values due to legislation that needs to be considered for all MNES. However, the condition of MNES does provide some insight into what occurs on site. A 'very high' rating means that a site contains several MNES or large areas of one or more. A medium value means that few values were observed or mapped but there were still some values present.

Criteria 8 shows the area (in hectares) of MNES in the ground-verified data layer and is denoted by (GV). They have been assigned a condition score in addition to the mapping data, and even in the case of a medium condition score, they are still MNES and need to be considered accordingly in relation to rezoning. None of the sites were free of any environmental values and therefore a medium rating was the lowest rating assigned. It is recommended that this information is used as a preliminary guide and that detailed assessment is undertaken in relation to rezoning or future development.

6.3.1 Cooma

The SMRC *Planning and Land Use Discussion Paper* acknowledges that the landscape around Cooma constrains it from growing in terms of terrain and environmental values (SMRC, 2019). Urban expansion to the north, south and west (to a lesser extent) is constrained by the terrain being steep and heavily vegetated. For the last ten years, growth to the north along Mittagang Road has been favoured by Council as it has been viable in terms of provision of services and is relatively unconstrained by the landscape. However, an Endangered Ecological Community (EEC) is limiting growth further north. In 2018, the NSW Government has included this area and its surrounds on the Biodiversity Value Map. This requires that any development on this land go through a biodiversity assessment process with an accredited assessor which may or may not be cost prohibitive and may discourage further development in this direction (SMRC, 2019).

In terms of industrial development (according to the Discussion paper), the most logical place to provide additional industrial land is to the east of Polo Flat. This would assist in consolidation of Polo Flat as a key employment and service hub for Cooma and would limit any future land-use conflict between industrial and residential land. According to DPIE (2019), expansion of Polo Flat to the east would need to consider threatened species such as the Grassland Earless Dragon, the Pink Tail Worm Lizard, and the Striped Legless Lizard. The area is also close to Kuma Nature Reserve (DPIE, 2019).

Environmental values in the areas of interest around Cooma are shown in Figure 15 and specifically listed in Table 7. Note that all three areas of interest contain one or more Matters of National Environmental Significance, particularly Cooma South which has several high values.

Figure 15 Biodiversity Values and Development Constraints around Cooma

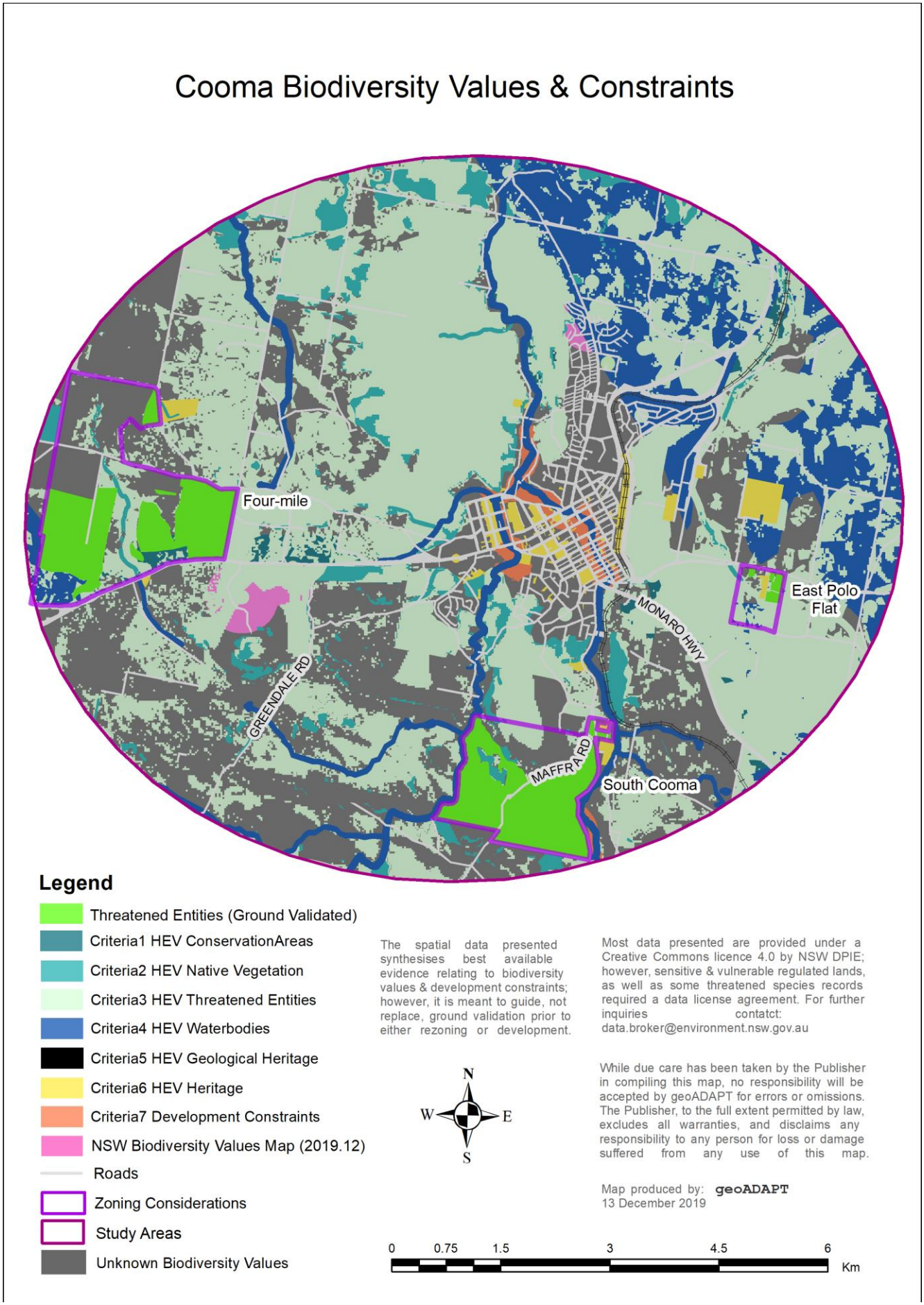


Table 7 HEV Criteria Values and Zoning in Cooma Investigation Areas

Lot Name	Criteria	Description	Hectares
East Polo Flat	CRIT_4c	Groundwater Vulnerability	22
	CRIT_6a	Heritage	3
Current Zone: R1	CRIT_2a	Riparian vegetation of rivers	0
	CRIT_2f	Candidate Native Grasslands	2
Environmental Values:	CRIT_3a	EPI Terrestrial Biodiversity	1
High	CRIT_3b	NSW HEV Criteria 2.1, 2.2, 2.3 and 3.2 combined	1
	CRIT_3c	Threatened Species Prediction (Priday)	37
	CRIT_3d	EEC_NTG	1
	CRIT_3i	Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory	4
	CRIT_3j	Southern Pygmy Perch	7
	CRIT_8b (GV)	Natural Temperate Grassland and Themeda Grassland (low condition)	9
Four Mile Zone	CRIT_1c	Scenic Protection	94
Current Zones:	CRIT_4c	Groundwater Vulnerability	55
RU5 Village	CRIT_2a	Riparian vegetation of rivers	12
RU1 Primary Production	CRIT_2e	Ribbon Gum Mountain Gum Snow Gum Grassy Woodland / Forest	0
R5 Large Lot Residential	CRIT_2f	Candidate Native Grasslands	160
Environmental Values:	CRIT_2i	Ribbon Gum Mountain Gum Snow Gum Grassy Woodland / Forest	0
Very High	CRIT_3a	EPI Terrestrial Biodiversity	29
	CRIT_3b	NSW HEV Criteria 2.1, 2.2, 2.3 and 3.2 combined	29
	CRIT_3c	Threatened Species Prediction (Priday)	217
	CRIT_3d	EEC_SnowGum	29
	CRIT_3i	Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory	123
	CRIT_8b (GV)	Natural Temperate Grassland and Themeda Grassland (low condition)	28
	CRIT_8b (GV)	Ribbon Gum Mountain Gum Snow Gum Grassy Woodland / Forest (low – moderate condition)	196
Cooma South	CRIT_4d	Riparian Lands and Watercourses	3
	CRIT_4f	Vulnerable Protected Riparian Lands	7
Current Zone: RU1	CRIT_6a	Heritage	2
	CRIT_7d	Riparian vegetation of rivers	2
Environmental Values:	CRIT_2a	Vulnerable Regulated Lands	4
Very High	CRIT_2c	Candidate Native Grasslands	72
	CRIT_2f	Natural Temperate Grassland and Themeda Grassland	17
	CRIT_2i	Ribbon Gum Mountain Gum Snow Gum Grassy Woodland / Forest	19
	CRIT_3a	EPI Terrestrial Biodiversity	39
	CRIT_3b	NSW HEV Criteria 2.1, 2.2, 2.3 and 3.2 combined	38
	CRIT_3c	Threatened Species Prediction (Priday)	17
	CRIT_3h	EEC_TGW_Predicted1	0
	CRIT_3h	Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory	22 38
	CRIT_3i	Swainsona sericea	1
	CRIT_3o	Protected Riparian Land	1
	CRIT_8a (GV)	Natural Temperate Grassland and Themeda Grassland	46
	CRIT_8b (GV)	Ribbon Gum Grassy Woodland / Forest (low condition)	14
	CRIT_8b (GV)	Ribbon Gum Mountain Gum Snow Gum Grassy Woodland / Forest (low to moderate condition)	165

For extra detail on the Matters of National Environmental Significance, refer to Appendix H Cooma SPRAT.

6.3.2 Michelago

According to the SMRC *Planning and Land Use Discussion Paper*, the landscape surrounding Michelago contains a number of areas with impressive views and mediocre agricultural potential, but nevertheless relatively high residual land values. It may be appropriate to re-orient the land uses around Michelago away from a primarily agricultural direction. This would include consideration as to whether or not existing minimum lot sizes should be reduced and more rural lifestyle blocks encouraged. Critical to this occurring in an orderly fashion would be the preservation of the general appearance of the landscape in the area. This landscape is also known to support various threatened species which must be protected from the impacts of existing and new development (SMRC, 2019).

The village core of Michelago is zoned RU5 - Village with a minimum lot size of 1800 m^2. Michelago is currently not serviced, with no reticulated water or sewerage. As such, larger lots are required for houses to provide their own water catchment, storage and septic facilities. The existing village zone is very flexible and provides for a range of uses but, as the village expands into a town, the presence of some business uses within residential areas may in the long term be counterproductive in terms of residential amenity and attracting new residents (SMRC, 2019). This is largely a social consideration but provides some context for the purposes of this report.

Environmental values in the areas of interest around Michelago are shown in Figure 16 and specifically listed in Table 8.

Figure 16 Biodiversity Values and Development Constraints around Michelago

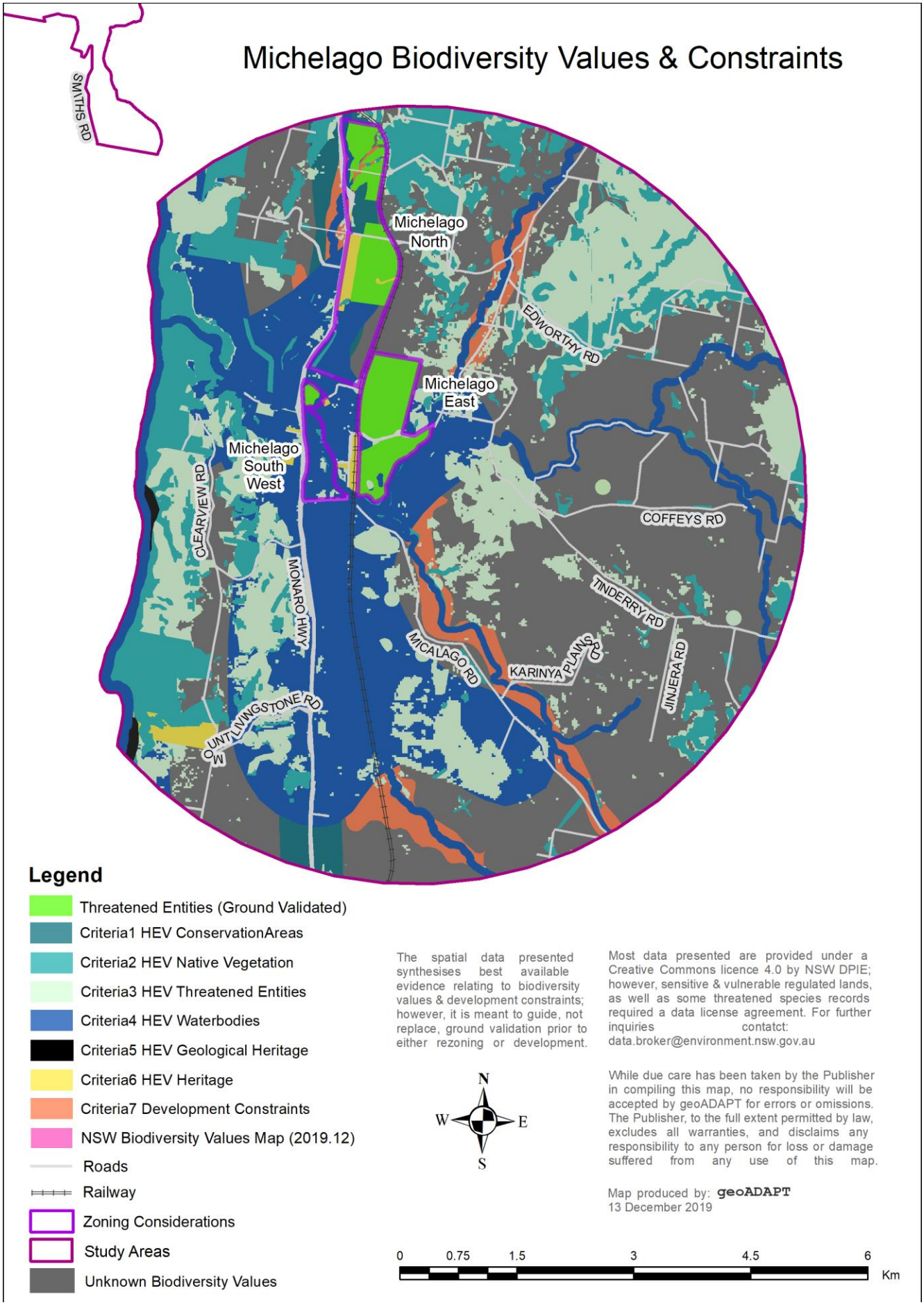


Table 8 HEV Criteria Values and Zoning in Michelago Investigation Areas

Lot Name	Criteria	Description	Hectares
Michelago East	CRIT_4c	Groundwater Vulnerability	117
	CRIT_4d	Riparian Lands	3
Current Zone:	CRIT_4f	Vulnerable Protected Riparian Lands	4
RU1	CRIT_7c	Landslide Risk	1
	CRIT_7d	Strategic Agricultural Land Map	11
Environmental	CRIT_2a	Riparian vegetation of rivers	1
Values: Very	CRIT_2b	Sensitive Regulated Lands	2
High	CRIT_2c	Vulnerable Regulated Lands	2
	CRIT_2f	Candidate Native Grasslands	147
	CRIT_3a	EPI Terrestrial Biodiversity	16
	CRIT_3b	NSW HEV Criteria 2.1, 2.2, 2.3 and 3.2 combined	16
	CRIT_3c	Threatened Species Prediction (Priday)	17
	CRIT_3d	EEC_NTG	16
	CRIT_3i	Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory	19
	CRIT_3l	Dodonaea procumbens	13
	CRIT_3l	Rutidosis leptorhynchoides	11
	CRIT_3m	Dillwynia glaucula	12
	CRIT_3m	Dodonaea procumbens	15
	CRIT_3m	Rutidosis leptorrhynchoides	4
	CRIT_3m	Stagonopleura guttata	3
	CRIT_3m	Swainsona sericea	4
	CRIT_3o	Dillwynia glaucula	30
	CRIT_8a	Protected Riparian Land	1
	CRIT_8b	Natural Temperate Grassland and Themeda Grassland (Low, Mod and high condition in variable patches)	144
	CRIT_8c	Michelago Parrot Pea	7
Michelago	CRIT_1c	Scenic Protection	127
North	CRIT_4c	Groundwater Vulnerability	94
	CRIT_4f	Vulnerable Protected Riparian Lands	10
Current Zone:	CRIT_6a	Heritage	59
RU1	CRIT_7d	Strategic Agricultural Land Map	16
	CRIT_2a	Riparian vegetation of rivers	2
Environmental	CRIT_2c	Vulnerable Regulated Lands	5
Values: Very	CRIT_2e	Lowland Grassy Woodland	2
High	CRIT_2e	Natural Temperate Grassland and Themeda Grassland	7
	CRIT_2f	Candidate Native Grasslands	23
	CRIT_2i	Lowland Grassy Woodland	2
	CRIT_2i	Natural Temperate Grassland and Themeda Grassland	7
	CRIT_3a	EPI Terrestrial Biodiversity	2
	CRIT_3b	NSW HEV Criteria 2.1, 2.2, 2.3 and 3.2 combined	1
	CRIT_3c	Threatened Species Prediction (Priday)	3
	CRIT_3d	EEC_BoxGum	0
	CRIT_3d	EEC_NTG	2
	CRIT_3i	Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory	6
	CRIT_3l	Rutidosis leptorhynchoides	1
	CRIT_3m	Rutidosis leptorrhynchoides	1
	CRIT_8a (GV)	Protected Riparian Land	5
	CRIT_8b (GV)	Box Gum Woodland (moderate condition)	14
	CRIT_8b (GV)	Natural Temperate Grassland and Themeda Grassland (low to moderate condition)	68
	CRIT_8c (GV)	Pink Tail Worm Lizard Potential Habitat (Low Condition)	9
Michelago	CRIT_1c	Scenic Protection	41
South West	CRIT_4c	Groundwater Vulnerability	43
	CRIT_4d	Riparian Lands	6

Current Zone: RU1 Environmental Values: Medium	CRIT_4f	Vulnerable Protected Riparian Lands	6
	CRIT_7d	Strategic Agricultural Land Map	24
	CRIT_2a	Riparian vegetation of rivers	4
	CRIT_2c	Vulnerable Regulated Lands	3
	CRIT_3a	EPI Terrestrial Biodiversity	4
	CRIT_3b	NSW HEV Criteria 2.1, 2.2, 2.3 and 3.2 combined	3
	CRIT_3c	Threatened Species Prediction (Priday)	4
	CRIT_3d	EEC_NTG	4
	CRIT_3i	Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory	5
	CRIT_8a (GV)	Protected Riparian Land	3
	CRIT_8b (GV)	Natural Temperate Grassland and Themeda Grassland (moderate condition)	4

For extra detail on the Matters of National Environmental Significance, refer to Appendix I Michelago SPRAT.

6.3.3 Berridale

According to the SMRC *Planning and Land Use Discussion Paper,* there are considerable natural values around the Berridale area. This includes several Matters of National Environmental Significance in the area such as Natural Temperate Grasslands (NTG) and Snow Gum Grassy Woodlands. The area of nominated NTG requires ground-truthing as the data underpinning this are modelled predictions of NTG distribution.

An option being considered for a new regional industrial area is around the Berridale area. Being located between Cooma and Jindabyne makes Berridale well positioned to service both of the larger towns (SMRC, 2019), particularly if the new industrial area is sited on the northern side of town near the waste-water treatment plant. The township of Berridale is currently surrounded on all sides by a zoning of R5 - Large lot residential.

Environmental values in the areas of interest around Berridale are shown in Figure 17 and specifically listed in Table 9.

Figure 17 Biodiversity Values and Development Constraints around Berridale

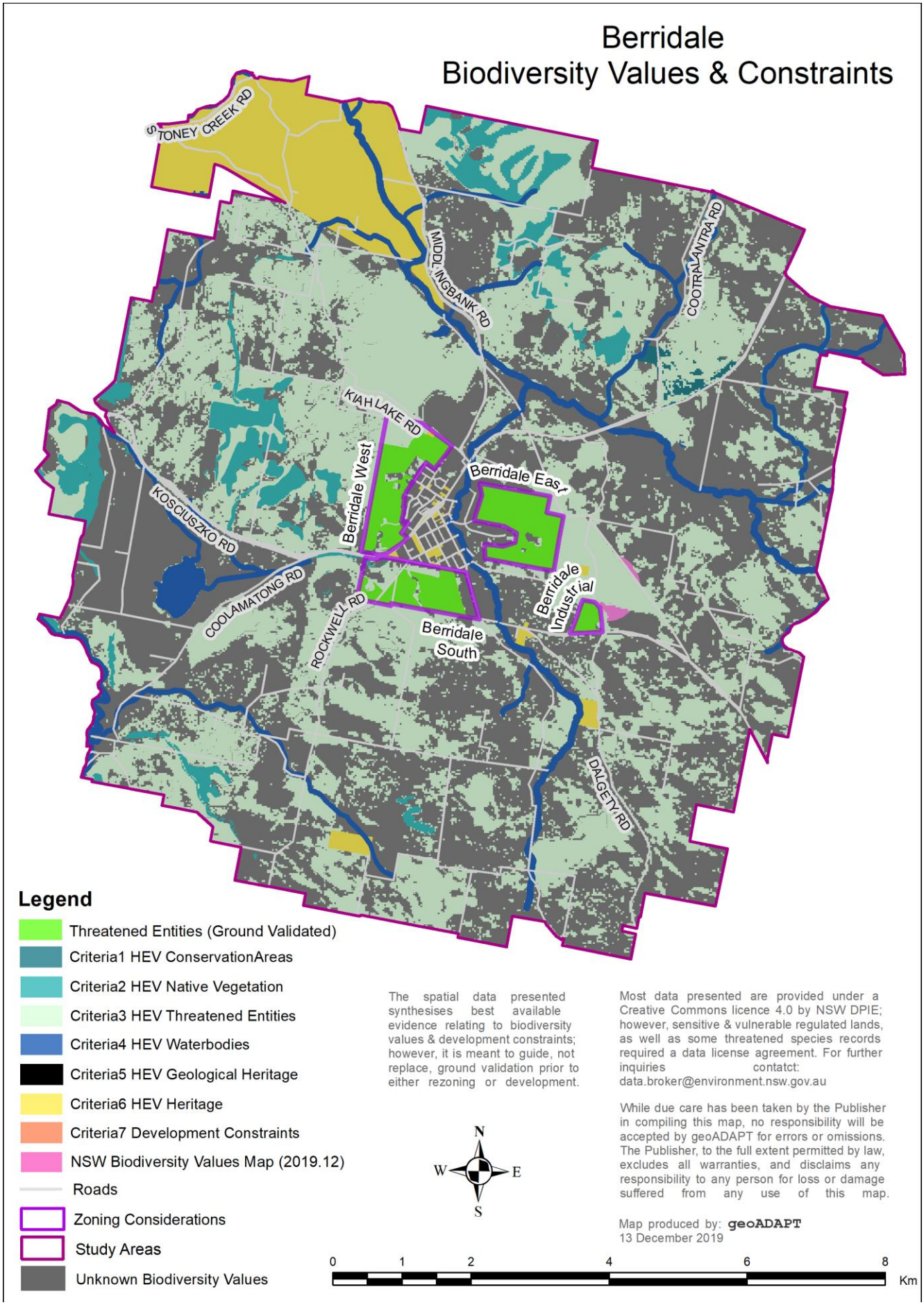


Table 9 HEV Criteria Values and Zoning in Berridale Investigation Areas

Lot Name	Criteria	Description	Hectares
Berridale Industrial Current Zone: R5 Environmental Values: High	CRIT_2f CRIT_3a CRIT_3b CRIT_3h CRIT_3h CRIT_3i CRIT_8a (GV) CRIT_8b (GV)	Candidate Native Grasslands EPI Terrestrial Biodiversity NSW HEV Criteria 2.1, 2.2, 2.3 and 3.2 combined EEC_NTG_Predicted1 EEC_TGW_Predicted1 Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory Threatened species or communities with potential for serious and irreversible impacts Ribbon Gum Mountain Gum Snow Gum Grassy Woodland / Forest (moderate condition)	7 1 1 0 1 5 6 15
Berridale South Current Zone: R5 Environmental Values: High	CRIT_2a CRIT_2f CRIT_3a CRIT_3b CRIT_3g CRIT_3h CRIT_3h CRIT_3i CRIT_8b (GV)	Riparian vegetation of rivers Candidate Native Grasslands EPI Terrestrial Biodiversity NSW HEV Criteria 2.1, 2.2, 2.3 and 3.2 combined Threatened Species Prediction (Priday) EEC_NTG_Predicted1 EEC_TGW_Predicted1 Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory Natural Temperate Grassland and Themeda Grassland (low, moderate and high condition in varying patches)	1 70 10 9 4 3 3 64 62
Berridale West Current Zones: RU5 and R5 Environmental Values: Very High	CRIT_6a CRIT_2a CRIT_2f CRIT_3a CRIT_3b CRIT_3g CRIT_3h CRIT_3h CRIT_3i CRIT_3l CRIT_8b (GV) CRIT_8b (GV)	Heritage Riparian vegetation of rivers Candidate Native Grasslands EPI Terrestrial Biodiversity NSW HEV Criteria 2.1, 2.2, 2.3 and 3.2 combined Threatened Species Prediction (Priday) EEC_NTG_Predicted1 EEC_TGW_Predicted1 Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory Calotis glandulosa Natural Temperate Grassland and Themeda Grassland (low, moderate and high condition in varying patches) Ribbon Gum Mountain Gum Snow Gum Grassy Woodland / Forest (low- moderate condition)	7 0 78 67 67 27 59 1 38 3 80 8
Berridale East Current Zone: R5 Environmental Values: High	CRIT_2f CRIT_3a CRIT_3b CRIT_3g CRIT_3h CRIT_3h CRIT_3i CRIT_8b (GV) CRIT_8b (GV)	Candidate Native Grasslands EPI Terrestrial Biodiversity NSW HEV Criteria 2.1, 2.2, 2.3 and 3.2 combined Threatened Species Prediction (Priday) EEC_NTG_Predicted1 EEC_TGW_Predicted1 Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory Natural Temperate Grassland and Themeda Grassland (low – moderate condition) Ribbon Gum Mountain Gum Snow Gum Grassy Woodland / Forest (low condition)	70 17 17 2 0 16 37 80 21

For extra detail on the Matters of National Environmental Significance, refer to Appendix J - Berridale SPRAT.

6.3.4 Bombala

Bombala has very limited industrial land and providing more industrial land could encourage more development and create more employment in the area. Dongwha Timbers could benefit from being zoned industrial and the land around it could be suited for industrial development to complement the timber mill. Parsonage Creek has been included on the NSW Biodiversity Values Map and needs on-ground assessment (SMRC, 2019).

Environmental values in the areas of interest around Berridale are shown in Figure 18 and specifically listed in Table 10.

Figure 18 Biodiversity Values and Development Constraints around Bombala

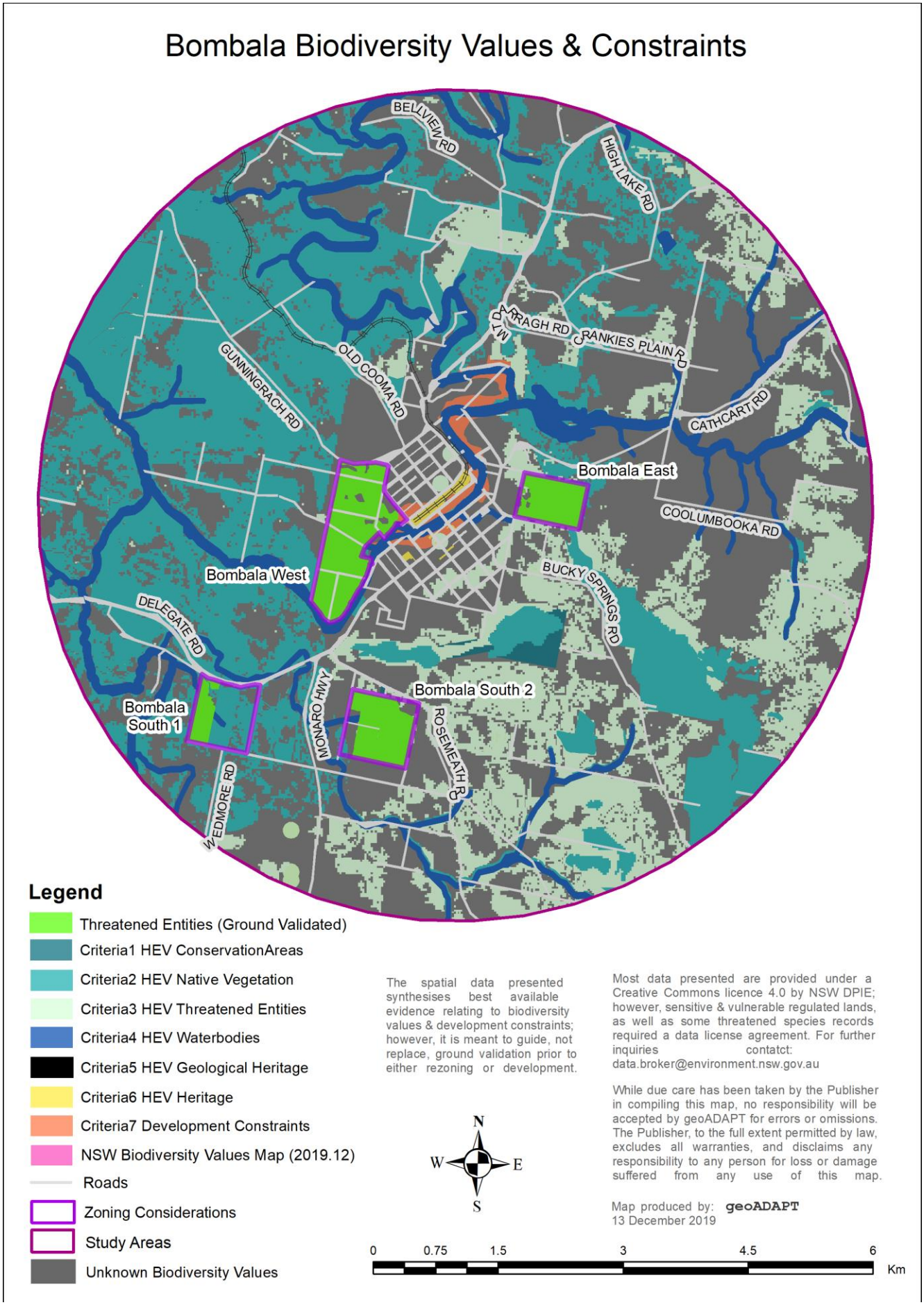


Table 10 HEV Criteria Values and Zoning in Bombala Investigation Areas

Lot Name	Criteria	Description	Hectares
Bombala East	CRIT_2f	Candidate Native Grasslands	10
	CRIT_2j	Secondary Grassland - Snowgum Derived	6
Current Zone: RU1	CRIT_3a	EPI Terrestrial Biodiversity	6
	CRIT_3b	NSW HEV Criteria 2.1, 2.2, 2.3 and 3.2 combined	9
Environmental Values: High	CRIT_3i	Tablelands Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland in the South Eastern Highlands, Sydney Basin, South East Corner and NSW South Western Slopes Bioregions	20
	CRIT_8b (GV)	Natural Temperate Grassland and Themeda Grassland (low to moderate condition)	14
	CRIT_8b (GV)	Ribbon Gum Mountain Gum Snow Gum Grassy Woodland / Forest (moderate condition)	27
Bombala South 1	CRIT_4d	Riparian Lands and Watercourses	4
	CRIT_2d	Natural Temperate Grassland and Themeda Grassland	14
Current Zone: RU1	CRIT_2d	Ribbon Gum Mountain Gum Snow Gum Grassy Woodland / Forest	4
Environmental Values: High	CRIT_2f	Candidate Native Grasslands	29
	CRIT_2i	Natural Temperate Grassland and Themeda Grassland	14
	CRIT_2i	Ribbon Gum Mountain Gum Snow Gum Grassy Woodland / Forest	4
	CRIT_2j	Natural Temperate Grasslands	19
	CRIT_2j	Secondary Grassland - Snowgum Derived	6
	CRIT_3a	EPI Terrestrial Biodiversity	25
	CRIT_3b	NSW HEV Criteria 2.1, 2.2, 2.3 and 3.2 combined	25
	CRIT_8b (GV)	Natural Temperate Grassland and Themeda Grassland (low condition)	17
Bombala South 2	CRIT_4d	Riparian Lands and Watercourses	4
	CRIT_2a	Riparian vegetation of rivers	2
Current Zone: RU1	CRIT_2j	Natural Temperate Grasslands	2
	CRIT_3a	EPI Terrestrial Biodiversity	2
Environmental Values: High	CRIT_3b	NSW HEV Criteria 2.1, 2.2, 2.3 and 3.2 combined	29
	CRIT_3i	Tablelands Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland in the South Eastern Highlands, Sydney Basin, South East Corner and NSW South Western Slopes Bioregions	1
	CRIT_8b (GV)	Natural Temperate Grassland and Themeda Grassland (low to moderate condition)	51
	CRIT_8b (GV)	Ribbon Gum Grassy Woodland / Forest (low condition)	2
Bombala West	CRIT_4d	Riparian Lands and Watercourses	5
	CRIT_4f	Vulnerable Protected Riparian Lands	5
Current Zones: R1,	CRIT_7b	Flood Prone Land Map	5
RU1, R5	CRIT_2a	Riparian vegetation of rivers	1
	CRIT_2c	Vulnerable Regulated Lands	1
Environmental Values:	CRIT_2f	Candidate Native Grasslands	54
HIgh	CRIT_2j	Secondary Grassland - Snowgum Derived	23
	CRIT_3a	EPI Terrestrial Biodiversity	23
	CRIT_3b	NSW HEV Criteria 2.1, 2.2, 2.3 and 3.2 combined	28
	CRIT_3i	Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory	3
	CRIT_8a (GV)	Protected Riparian Land	1
	CRIT_8b (GV)	Natural Temperate Grassland and Themeda Grassland (low condition)	73
	CRIT_8b (GV)	Ribbon Gum Grassy Woodland / Forest (low to moderate condition)	34

For extra detail on the Matters of National Environmental Significance, refer to Appendix K - Bombala SPRAT.

6.3.5 Smiths Road

According to the *Planning and Land Use Discussion Paper* (SMRC, 2019), the expansion of Smiths Road is generally supported but with a caveat that a regional growth strategy is required for the area to address protection of biodiversity, transport, waste and community services which are at present partially reliant on ACT services. All the land within the Smiths Road area is currently zoned E3 - Environmental Management under the provisions of the *Cooma-Monaro Local Environmental Plan 2013*. The current zoning is generally in line with the previous zoning under the former *Yarrowlumla Local Environmental Plan 2002*.

The area could support a mixture of E3 - Environmental Management and E4 - Environmental Living (which is essentially rural residential). However, rezoning of the area from 80 ha lots to 15 ha lots may have consequences for biodiversity, and therefore it is necessary to ensure the associated impacts are minimal. The benefit of rezoning revolves around social outcomes and having a larger population for services (SMRC, 2019). Under present planning controls, there is little potential for further development in the area. A minimum lot size of 80 ha for a new subdivision or dwelling house has rendered very limited opportunities for such development to occur. However, whilst there continues to be a large disparity between the economics of development in the area and the existing planning controls, there will continue to be agitation for further development to be permitted (SMRC, 2019).

The HEV mapping supports the high level of environmental values, with a high number of biodiversity values in the Smiths Road area, in addition to the Murrumbidgee River as a water supply catchment area. Although lot size could be reduced in terms of the environmental values on-site, there are implications associated with a population increase whereby activities impact on environmental values further afield. The area to the north of Smiths Road was investigated for its potential to rezone from E3 to E4 as part of this report. E4 zoning could be considered where environmental values are at the lower end of the scale.

Figure 19 Biodiversity Values and Development Constraints around Smiths Road

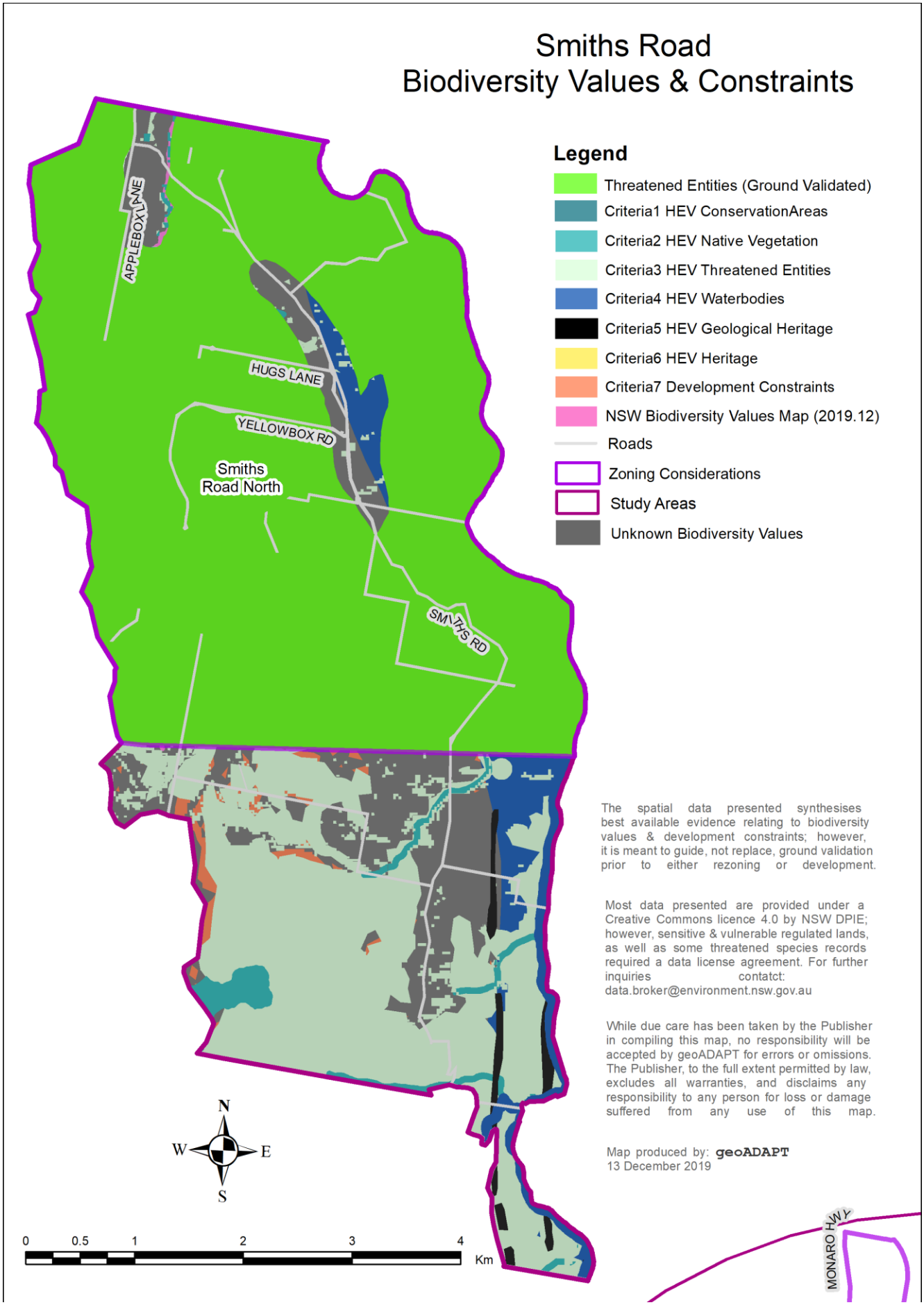


Table 11 HEV Criteria Values and Zoning in Smiths Road North Investigation Areas

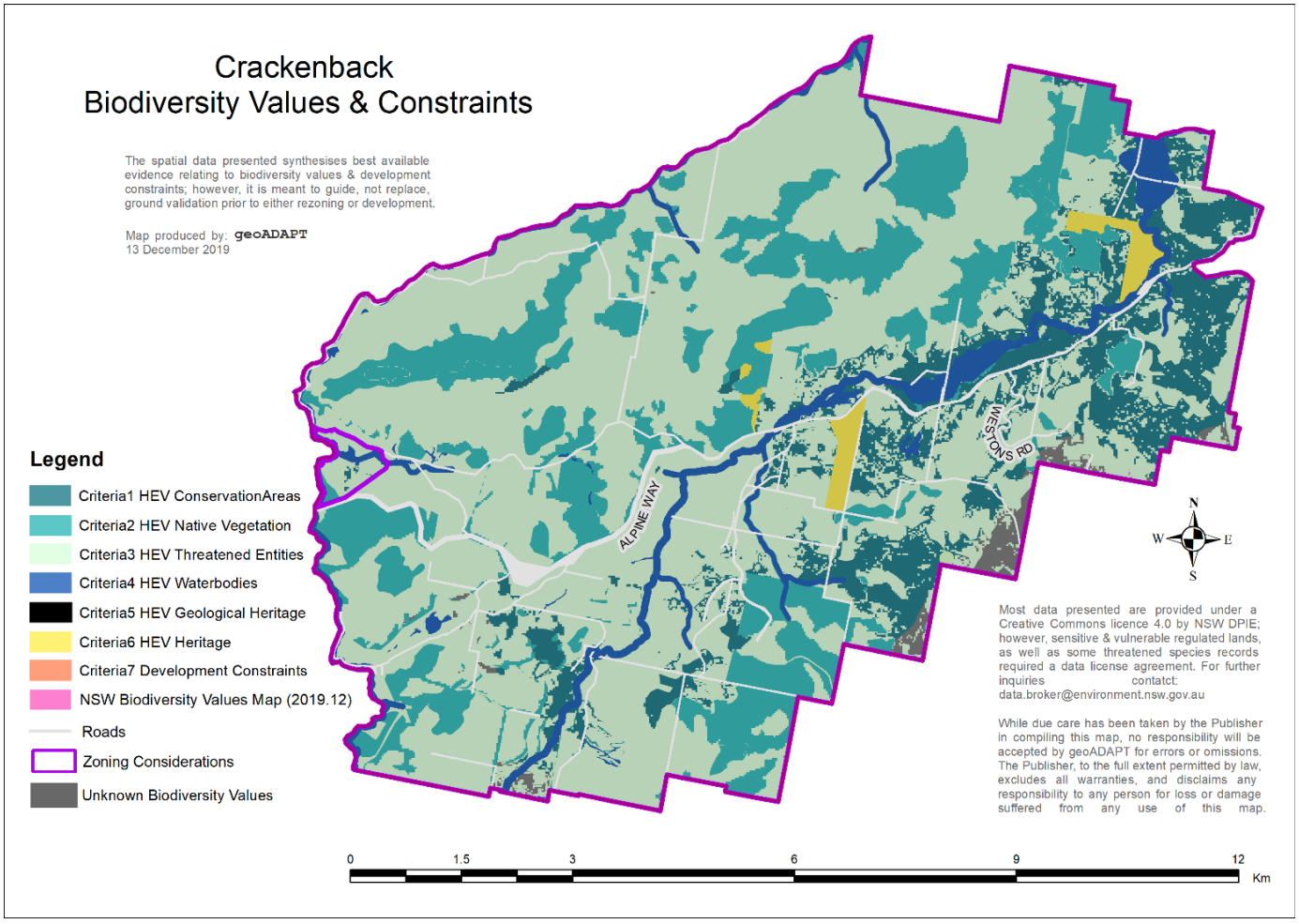
Lot Name	Criteria	Description	Hectares
Bombala East Current Zone: RU1 Environmental Values: Very High	CRIT_4c	Groundwater Vulnerability	672
	CRIT_4d	Riparian Lands	99
	CRIT_4f	Vulnerable Protected Riparian Lands	49
	CRIT_5a	Natural Resources Karst	15
	CRIT_7c	Landslide Risk	282
	CRIT_2a	Riparian vegetation of rivers	72
	CRIT_2e	Box Gum Woodland	13
	CRIT_2e	River Flat Eucalypt forest on Coastal Floodplain	10
	CRIT_2f	Candidate Native Grasslands	904
	CRIT_2i	Box Gum Woodland	13
	CRIT_2i	River Flat Eucalypt forest on Coastal Floodplain	10
	CRIT_3a	EPI Terrestrial Biodiversity	10
	CRIT_3b	NSW HEV Criteria 2.1, 2.2, 2.3 and 3.2 combined	9
	CRIT_3c	Threatened Species Prediction (Priday)	462
	CRIT_3d	EEC_BoxGum	10
	CRIT_3i	Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory	90
	CRIT_3j	Macquarie Perch	10
	CRIT_3j	Murray Crayfish	30
	CRIT_3j	Trout Cod	10
	CRIT_3o	Swainsona sericea	3
	CRIT_8a (GV)	Protected Riparian Land	49
	CRIT_8b (GV)	Box Gum Woodland (low, moderate and high condition in varying patches)	2116

For extra detail on the Matters of National Environmental Significance, refer to Appendix L - Smiths Road SPRAT.

6.3.6 Eastern Approach to the Snowy Mountains / Crackenback Drive

The Eastern approach to the Snowy Mountains / Crackenback Drive was not specifically ground-truthed as part of this report due to the considerable resources required to do so being beyond the scope of this assessment. However, the DEM modelling shows that there are a very high number of environmental values in this area. Any downgrading of the E3 zoning to SP3 (as discussed in the SMRC *Planning and Land Use Discussion Paper* 2019) would need to be thoroughly justified and based on a detailed assessment of the area. As the mapping layers are available for the entire Snowy Monaro Shire, on-ground truthing should be relatively straightforward (albeit time consuming). Based on the mapping, this area should continue to be afforded a high level of protection through zoning. This area has recently been included as part of the *'Go Jindabyne' Master Plan* and therefore no longer a priority for this report. Figure 20 shows the DEM model of values for Crackenback Drive and the eastern approach to the Snowy Mountains.

Figure 20 Biodiversity Values and Development Constraints around Crackenback (DEM Model)



6.4 Summary of Zoning and Environmental Values in Areas of Interest

Table 12 Summary of Areas of Interest, Current Zoning and Environmental Values

Area of Interest (SMRC)	Current Zone	Environmental Values
East Polo Flat	RU1 Primary Production	High
Four Mile Zone	RU5 Village R5 Large Lot Residential	Very High
Cooma South	RU1 Primary Production	Very High
Michelago East	RU1 Primary Production	Very High
Michelago North	RU1 Primary Production	Very High
Michelago South West	RU1 Primary Production	Medium
Berridale Industrial	R5 Large Lot Residential	High
Berridale South	R5 Large Lot Residential	High
Berridale West	RU5 Village R5 Large Lot Residential	Very High
Bombala East	RU1 Primary Production	High
Bombala South 1	RU1 Primary Production	High
Bombala South 2	RU1 Primary Production	High
Bombala West	RU1 Primary Production RU5 Village R5 Large Lot Residential	High
Smith's Road – no specific zonal Information provided. Whole area has high biodiversity values.	E3 Environmental Management	Very High
Eastern Approach to the Snowy Mountains / Crackenback Drive - no specific zonal Information provided.	E3 Environmental Management	Very high

Assessment Rating Definitions

- Low: No MNES (Matters of Environmental Significance)
- Medium: Some biodiversity values – small areas of low quality MNES
- High: Several biodiversity values present, including MNES
- Very High: Many biodiversity values including MNES

7 Climate Impact Assessment on Biodiversity Values

Humans are profoundly changing climate and impacting biodiversity around the world. Substantial changes in ecological processes are already visible, including climate change impacts on genes, species and ecosystems (Scheffers et al., 2016). Up to half of all known species may already have altered distributions in response to recent changes in climate (Pecl et al., 2017), and impacts on threatened species are expected to be severe (Pacifici et al., 2017). The planet is undergoing a sixth mass extinction event and so urgent action is required to avoid grave consequences globally for human wellbeing (Diaz et al., 2019).

Recognition that climate change is posing a significant threat to global biodiversity has resulted in the development of government policies and strategies incorporating climate change adaptation into conservation actions. Many of the suggested strategies are not targeted towards specific species and operate at broad spatial scales (i.e. landscape or continental). They aim to maximise the adaptive capacity and resilience of multiple species and include a wide range of management actions. Examples include increasing the area of land within reserve systems, using predictions of future climates and species distributions to guide selection of new protected areas, protecting likely climate refugia, conserving the full range of environmental heterogeneity and habitat diversity within reserve systems, improving connectivity between protected areas, improving the condition of land outside protected areas to improve conservation value, managing existing broad-scale threats such as land clearing and weed invasion, and managing for maintenance of ecosystem services and function rather than species composition (Macquarie University, 2016 citing many sources).

Climate change forecasting for the Australian Alps and Southern Tablelands predict that the weather will be warmer (an increase of around 1.5–2.5°C). The area will experience a substantial increase in Summer rainfall of between 20–50%. Significantly for the Snowy Monaro, Winter rainfall is likely to decrease significantly which means a decrease in snowfall. This will be below the observed variability in Winter rainfall in the 20th Century, particularly in the Alps and Southern Ranges. Spring and Autumn will be slightly wetter than, or close to, average in the Central Tablelands and 5% to 20% drier in the south. Compared with the long-term seasonal variability, rainfall in Spring and Autumn are generally within the ranges observed in the 1900 to 2000 period. Autumn is generally at the drier end of the observed range and Spring is at the moderate to wetter end (Table 13).

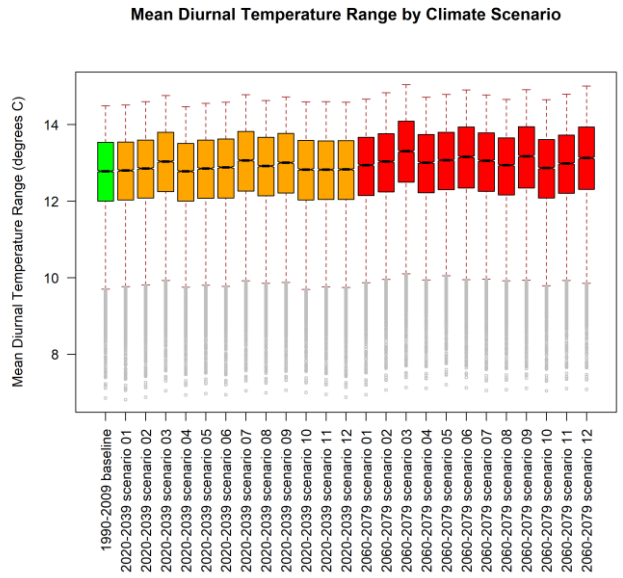
Table 13 Temperature and Rainfall Summary for the Alps and Southern and Central Tablelands of NSW (2050 A2 Scenario)

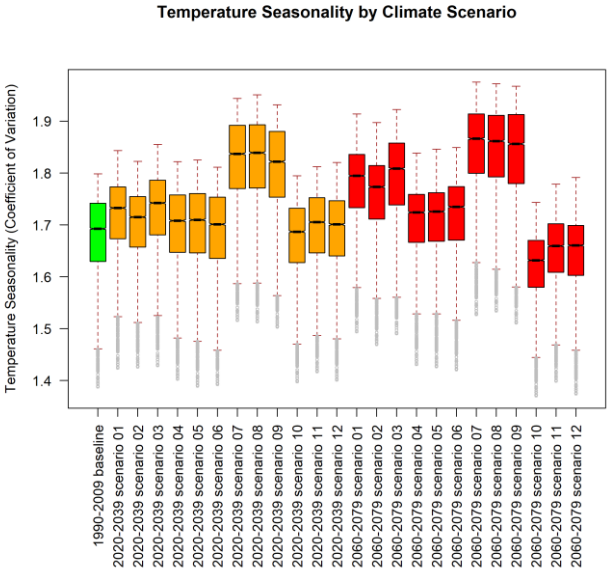
Season	Minimum Temperature	Maximum Temperature	Precipitation
Spring	1.5–2.5°C warmer (warmer in the east)	2–2.5°C warmer	5–20% increase in the Central and Southern Tablelands No change in the ACT Region 5%–20% decline in the Alps and Monaro
Summer	1.5–2°C warmer	1.5–2°C warmer	20–50% increase in summer rainfall
Autumn	1–2.5°C warmer (warmer in the east)	2 –2.5°C warmer No change in the Central and Southern Tablelands	5–20% decrease from the ACT south, including in the Alps and Monaro
Winter	2–2.5°C warmer	1–2.5°C warmer	10–20% decrease in Central Tablelands and eastern Monaro. 20%–50% decrease in Southern Tablelands, Alps and Monaro

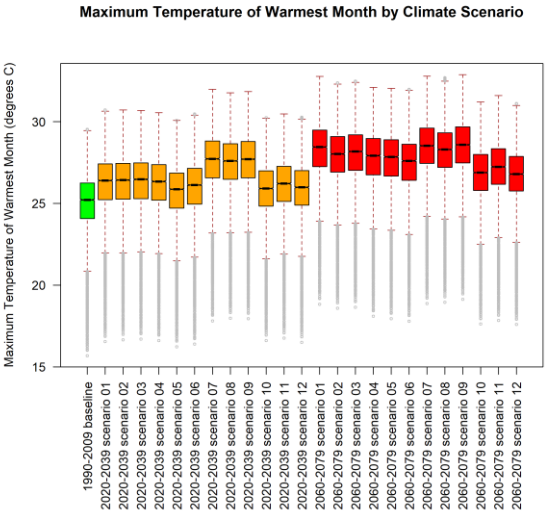
It should be noted that the NSW DPIE climate change impact assessments were not available for inclusion in the spatial layers for this study, so the project team required alternative modelling of impacts. We used the NSW Climate Refugia Portal to detail specific potential climate change impacts. The NSW Climate Refugia

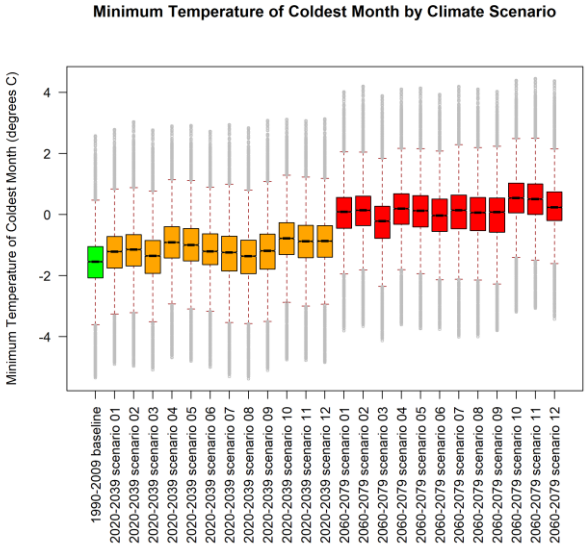
portal (which produced the results captured in Table 13) considers twelve plausible future climate change scenarios based upon the NARCliM project. Figure 21 (a-g) shows a) Mean Diurnal Temperature Range, b) Temperature Seasonality, c) Maximum Temperature (hottest month), d) Minimum Temperature (coldest month), e) Precipitation (wettest month), f) Precipitation (driest month) and g) Precipitation Seasonality.

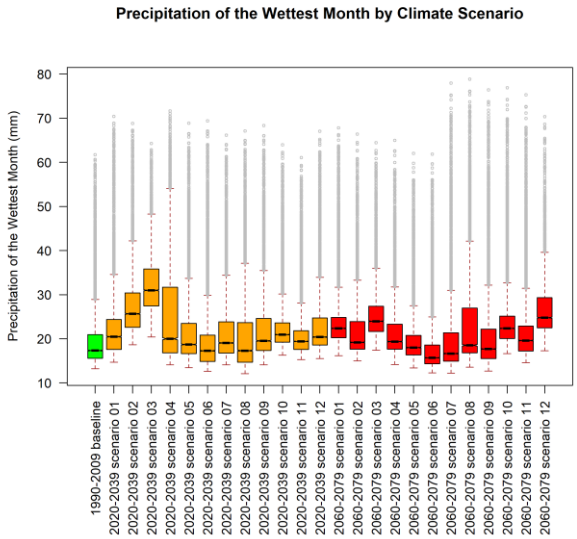
Figure 21 (a-g) Climate Change Scenarios for Temperature and Precipitation

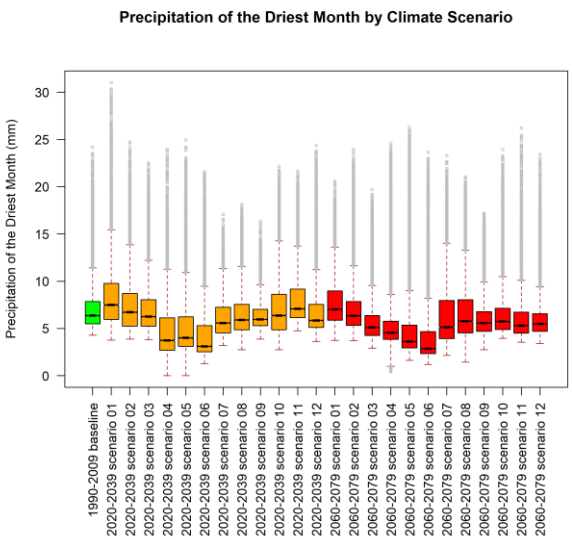


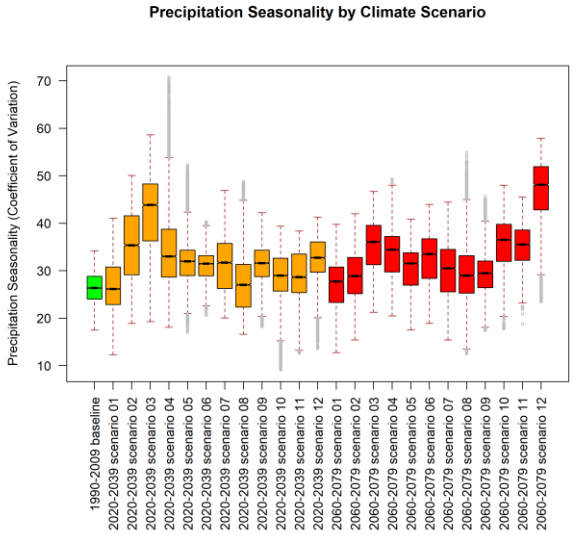












The online tool allows users to explore scenario and consensus-based impacts for individual species by decade (i.e. 2010-2070). The results presented are based on a consensus (i.e. agreement) across 12 scenarios. The species highlighted are those for which the Snowy Monaro region is the most important for their survival and future planning needs to consider the presence of these and potential impacts on these species. All of these species are incorporated into the HEV mapping for this report and are listed in Table 14.

To help biodiversity adapt to climate change in the Snowy Monaro region, the NSW Government has funded research to identify and appropriately manage areas where targeted species are likely to persist under climate change (i.e. biodiversity refugia). Publicly available distribution models provide a foundation for identifying local biodiversity refugia under plausible future climate scenarios. These models assess potential climate change impacts for threatened species under near-future (2020-2039) and far-future (2060-2079) climate scenarios proposed by the NSW and ACT Regional Climate Modelling (NARCliM) project (Evans et al., 2014). Table 1 highlights some of the changes expected for vegetation communities

A report generated from the website, and provided below, summarises the predicted climate change impacts on local threatened species for 2030 and 2070. We also investigated the NSW Threatened Species Vulnerability Database to convey threatened species vulnerability as a function of existing threats and species

traits. However, it does mean that we are unable to predict shorter term climate change impacts, particularly in relation to future development recommendations as was the initial intent through projections mapping.

As we are generalising climate impacts across the region, we were unable to consider climate change impacts in relation to EPZ classifications and town-based predictions, other than in relation to the species listed in the NSW Climate Refugia portal shown in Table 14, and the ecological communities in Table 15. The modelling was at a 1 km resolution whereas townships are roughly ~25 km^2. Therefore, it is not appropriate to apply the model predictions at lot-scale to infer climate change impacts. It is recommended that any townships that include the species and vegetation communities highlighted in Tables 14 and 15 are significant to the state-wide protection of these species into the future. Available data were not suitable for highlighting which species occur in each township (small scale) as the data often were denatured (spatially imprecise) or unavailable for such sensitive species. Ultimately, field validation in areas where these species are suspected to occur will be paramount for regional planning. Any future development proposals that identify the presence of green highlighted species should consider those occurrences as highly significant biodiversity values / constraints on development.

7.1 Climate Change Impact - Species

Table 14 Projected Climate Refugia for Snowy Monaro Threatened Species (sourced from http://nswclimaterefugia.net/). Highlighted Species indicate that the Snowy Monaro is important for survival of the species as a whole. Locations with these species are particularly important for the overall protection of the species

Scientific Name	Common Name	Type	Saving Our Species Management Stream	NSW Status	Present in region?	Current suitable habitat (km2)	Current suitable habitat (%)	2030 Future Projected Refugia (%)	2070 Future Projected Refugia (%)	2030 Regional Contribution to Future Projected Refugia (%)	2070 Regional Contribution to Future Projected Refugia (%)
Heleioporus australiacus	Giant Burrowing Frog	Amphibian	Landscape	Vulnerable	Yes	166	1	0	0	Low (0-10%)	Low (0-10%)
Litoria aurea	Green and Golden Bell Frog	Amphibian	Site	Endangered	Yes	23	0	0	0	Low (0-10%)	Low (0-10%)
Litoria castanea	Yellow-spotted Tree Frog	Amphibian	Site	Critically Endangered	Yes	9206	61	47	47	Moderate (10-50%)	High (50-90%)
Pseudophryne pengilleyi	Northern Corroboree Frog	Amphibian	Site	Critically Endangered	No	100	1	0	0	Low (0-10%)	None (Local Populations Lost?)
Falsistrellus tasmaniensis	Eastern False Pipistrelle	Bat	Landscape	Vulnerable	Yes	12289	81	56	35	Moderate (10-50%)	Moderate (10-50%)
Anthochaera phrygia	Regent Honeyeater	Bird	Site	Critically Endangered	Yes	9013	59	32	32	Low (0-10%)	Low (0-10%)
Callocephalon fimbriatum	Gang-gang Cockatoo	Bird	Landscape	Vulnerable	Yes	15145	100	94	71	Moderate (10-50%)	Moderate (10-50%)
Calyptorhynchus lathami	Glossy Black-Cockatoo	Bird	Landscape	Vulnerable	Yes	60	0	0	0	Low (0-10%)	Low (0-10%)
Chthonicola sagittata	Speckled Warbler	Bird	Landscape	Vulnerable	Yes	5305	35	17	17	Low (0-10%)	Low (0-10%)
Daphoenositta chrysoptera	Varied Sittella	Bird	Landscape	Vulnerable	Yes	12544	83	74	74	Low (0-10%)	Low (0-10%)
Falco subniger	Black Falcon	Bird	Landscape	Vulnerable	Yes	2972	20	1	1	Low (0-10%)	Low (0-10%)

Glossopsitta pusilla	Little Lorikeet	Bird	Landscape	Vulnerable	Yes	2743	18	18	18	Low (0-10%)	Low (0-10%)
Grantiella picta	Painted Honeyeater	Bird	Landscape	Vulnerable	Yes	3643	24	19	19	Low (0-10%)	Low (0-10%)
Hieraaetus morphnoides	Little Eagle	Bird	Landscape	Vulnerable	Yes	10504	69	29	28	Low (0-10%)	Low (0-10%)
Neophema pulchella	Turquoise Parrot	Bird	Landscape	Vulnerable	Yes	971	6	4	4	Low (0-10%)	Low (0-10%)
Ninox strenua	Powerful Owl	Bird	Landscape	Vulnerable	Yes	9563	63	17	7	Low (0-10%)	Low (0-10%)
Oxyura australis	Blue-billed Duck	Bird	Landscape	Vulnerable	Yes	2129	14	0	0	Low (0-10%)	Low (0-10%)
Pachycephala olivacea	Olive Whistler	Bird	Landscape	Vulnerable	Yes	8317	55	18	13	Moderate (10-50%)	Moderate (10-50%)
Petroica boodang	Scarlet Robin	Bird	Landscape	Vulnerable	Yes	14378	95	89	88	Moderate (10-50%)	Moderate (10-50%)
Petroica phoenicea	Flame Robin	Bird	Landscape	Vulnerable	Yes	15157	100	84	56	Moderate (10-50%)	Moderate (10-50%)
Stagonopleura guttata	Diamond Firetail	Bird	Landscape	Vulnerable	Yes	12948	85	61	61	Low (0-10%)	Low (0-10%)
Stictonetta naevosa	Freckled Duck	Bird	Landscape	Vulnerable	Yes	171	1	0	0	Low (0-10%)	Low (0-10%)
Tyto novaehollandiae	Masked Owl	Bird	Landscape	Vulnerable	Yes	4133	27	2	0	Low (0-10%)	None (Local Populations Lost?)
Tyto tenebricosa	Sooty Owl	Bird	Landscape	Vulnerable	Yes	1070	7	0	0	Low (0-10%)	None (Local Populations Lost?)
Calotis glandulosa	Mauve Burr-daisy	Flora	Site	Vulnerable	Yes	9564	63	36	7	Very High (90-100%)	Very High (90-100%)
Carex raleighii	Raleigh Sedge	Flora	Site	Endangered	Yes	5783	38	7	2	High (50-90%)	High (50-90%)
Commersonia prostrata	Dwarf Kerrawang	Flora	Site	Endangered	No	1012	7	0	0	Low (0-10%)	Moderate (10-50%)
Dampiera fusca	Kydra Dampiera	Flora	Site	Endangered	Yes	6086	40	4	0	Very High (90-100%)	None (Species Extinct?)

Dillwynia glaucula	Michelago Parrot-pea	Flora	Site	Endangered	Yes	3778	25	0	0	Very High (90-100%)	Very High (90-100%)
Discaria nitida	Leafy Anchor Plant	Flora	Site	Vulnerable	Yes	6545	43	2	0	Very High (90-100%)	None (Species Extinct?)
Diuris pedunculata	Small Snake Orchid	Flora	Site	Endangered	Yes	12154	80	54	39	Moderate (10-50%)	High (50-90%)
Dodonaea procumbens	Creeping Hop-bush	Flora	Site	Vulnerable	Yes	6490	43	24	21	Very High (90-100%)	Very High (90-100%)
Eucalyptus aggregata	Black Gum	Flora	Site	Vulnerable	Yes	6551	43	2	1	Moderate (10-50%)	Moderate (10-50%)
Euphrasia scabra	Rough Eyebright	Flora	Site	Endangered	Yes*	4189	28	0	0	Very High (90-100%)	Very High (90-100%)
Hibbertia sp. Bankstown	Hibbertia sp. Bankstown	Flora	Site	Critically Endangered	No	1907	13	0	0	Low (0-10%)	Low (0-10%)
Pomaderris cotoneaster	Cotoneaster Pomaderris	Flora	Site	Endangered	Yes	1553	10	1	1	Low (0-10%)	Low (0-10%)
Rutidosis leiolepis	Monaro Golden Daisy	Flora	Site	Vulnerable	Yes	4370	29	21	10	Very High (90-100%)	Very High (90-100%)
Eucalyptus pulverulenta	Silver-leafed Gum	Mallee	Site	Vulnerable	Yes	6404	42	3	3	High (50-90%)	High (50-90%)
Eucalyptus saxatilis	Suggan Buggan Mallee	Mallee	Site	Endangered	Yes	1512	10	1	0	Very High (90-100%)	Very High (90-100%)
Burramys parvus	Mountain Pygmy-possum	Marsupial	Site	Endangered	Yes	848	6	1	0	High (50-90%)	Moderate (10-50%)
Cercartetus nanus	Eastern Pygmy-possum	Marsupial	Landscape	Vulnerable	Yes	3629	24	16	13	Moderate (10-50%)	Moderate (10-50%)
Dasyurus maculatus	Spotted-tailed Quoll	Marsupial	Landscape	Vulnerable	Yes	14438	95	76	49	Moderate (10-50%)	Moderate (10-50%)
Petaurus australis australis	Yellow-bellied Glider	Marsupial	Landscape	Vulnerable	Yes	4814	32	1	0	Low (0-10%)	Low (0-10%)

Potorous tridactylus	Long-nosed Potoroo	Marsupial	Site	Vulnerable	Yes	52	0	0	0	Low (0-10%)	Low (0-10%)
Aprasia parapulchella	Pink-tailed Legless Lizard	Reptile	Landscape	Vulnerable	Yes	5507	36	3	2	Low (0-10%)	Moderate (10-50%)
Tympanocryptis pinguicolla	Grassland Earless Dragon	Reptile	Site	Endangered	Yes	10899	72	3	0	Very High (90-100%)	None (Species Extinct?)
Varanus rosenbergi	Rosenberg's Goanna	Reptile	Landscape	Vulnerable	Yes	1125	7	0	0	Moderate (10-50%)	Moderate (10-50%)

7.2 Climate Change Impacts – Region

Table 15 Summary of Impacts by Ecosystem: Alps and Southern Tablelands Regions (adapted from Macquarie University, 2016)

Ecosystem	Community	Main Reason	Major Impacts
Wet Sclerophyll Forest	Southern Tablelands and Escarpment	Major impacts likely from increased fire frequency	*Increased fire frequency:* • Increased fuel load in wetter years because of increased summer rainfall: - increased fire risk in drier years • Alpine ash communities are highly sensitive to fire: - change in species composition and structure - increased shrubbiness; loss of alpine ash - fire-resistant species favoured • Increased potential for hazard-reduction burns in Southern Tablelands forests • Loss of refugia in southern escarpment forests • Implications for hollow-bearing trees and resource availability for fauna *Increased temperatures:* • may increase the length of the growth season • may exceed the temperatures required for seed germination • alpine ash are potentially buffered by their location on south-facing slopes *Shift in seasonality of moisture availability, with increased summer rainfall and less winter rainfall:* • potentially advantageous, as the forests are currently winter-growth limited
Grassy Woodlands	Subalpine, grassy	Impacts will vary depending on the community. Major impacts will be as a result of predicted changes in	*Change in seasonality of rainfall/moisture availability, with increased summer rainfall and decreased winter rainfall:* • impacts on plant species composition (grasses and weeds) - C4 plants favoured over C3 plants • less spring growth, with loss of geophytic species

	woodlands, tableland clay	seasonality of rainfall and increased fire frequency	• increased shrubbiness:
			  - change in habitat suitability for fauna species
			  - decreased species diversity
			• change in timing of flowering events:
			  - affects resource availability (insects, pollen/nectar)
			  - change in the timing of breeding cycles of autumn- winter- and spring-breeding fauna
			Decreased annual rainfall:
			• decreased recruitment and increased patch deaths of trees because of drought:
			  - increased susceptibility to disease and insect attack
			• possible decreases in grazing viability
			• increased salinity
			Increased fire frequency:
			• impacts in subalpine rather than lowland woodlands
			Increased temperatures:
			• increase in abundance of species currently limited by cold:
			  - more weed/feral species
			• increase in grazing in colder areas

Dry sclerophyll forests		Major impacts from increased aridity and decreased annual rainfall likely	*Increasing aridity, with decreased annual rainfall and increasing temperatures:*
			• shift in vegetation structure and perhaps species composition, overstorey and ground cover:
			  - increased shrubbiness due to increased moisture stress on grasses
			  - decreased productivity, with loss of diversity
			  - effects on the fauna present
			• reduced frequency, extent and duration of flowering events:
			  - flow-on to resource availability to fauna
			  - reduced winter rainfall affecting winter- and spring-breeding species
			  - increased summer rainfall, possibly leading to increased disease prevalence
			Increased fire frequency and intensity:
			• adds to changes in understorey composition and structure from increasing aridity
			• potential for increased hazard-reduction burning, with consequent loss of productivity

Heathlands	Sydney montane, southern montane	Major impacts predicted from increased fire frequency	*Increased fire frequency:*
			• inter-fire frequency affects colonization by fauna species:
			  - a longer frequency is required by eastern bristlebirds (*Dasyornis brachypterus*)
			  - a mosaic of fire regime is required for maximum species diversity
			• effect on species composition (obligate seeders versus resprouters)
			  - species that require fire for regeneration may prosper
			Decreased overall moisture availability:

			• physiological tolerances may be exceeded: - moisture-dependent species may decline • possible decreases in diversity

Grasslands		Predicted changes in rainfall seasonality will impact on productivity and threatened species	*Decreased annual rainfall and change in the seasonality of moisture availability—in particular, with drier winters and springs and wetter summers*
			• general decrease in productivity
			• decrease in spring annual growth, especially in the south of the region (both exotic and native species affected)
			• short-term changes in species composition, with a shift from winter-growing C3 grasses to summer-growing C4 grasses:
			  - increase in abundance of summer weeds
			  - management implications (grazing regimes, use of fertilisers)
			• likely heavy impacts on already threatened specialist grassland fauna:
			  - decreased cover, leading to increased predation
			  - reduced productivity: less invertebrate activity because of dry conditions
			  - change in species composition, with implications for resource availability
			• increased erosion
			• loss of snowgrass (*Poa labillardieri*) grasslands along drainage lines:
			  - definite decline in productivity
			  - increased weed invasion
			• the drier environment may favour the spread of calicivirus in European rabbits (*Oryctolagus cuniculus*) and disfavour the spread of myxomatosis
			• possible conversion to agricultural land and grasslands not representative of this community
			Increased temperatures:
			• increased length of the growing season
			• if combined with increased CO2 levels, may lead to increased shrubbiness

Alpine complex	Grasslands above 1110m altitude	Likely to be highly changed in terms of species composition and ecological function due to decreased annual precipitation	*Decreased annual precipitation (in particular, winter snow cover):*
			• loss of the insulation properties of snow over winter and exposure to more extreme temperatures and frosts:
			  - frost-kills in plants
			  - exposure of over-wintering fauna [e.g. mountain pygmy-possum (*Burramys parvus*) to temperatures below physiological thresholds
			  - increase in exposure to feral predators (currently limited by the presence of snow) (e.g. cats)
			• increase in abundance of fauna currently limited by snow
			• increased erosion through frost exposure:
			  - changes in invertebrate activity and nutrient cycling, with loss of organic matter in soils
			  - increased soil temperatures caused by a reduction in snow cover combined with warmer temperatures
			• loss or simplification of water-dependent communities (short alpine herbfields, alpine fjaeldmarks, bogs and fens):

			- southern corroboree frogs (*Pseudophryne corroboree*) require winter precipitation in sphagnum bogs for egg survival - loss of organic matter from humic soils through combined effects of decreased moisture and increased temperatures - flow-on effects to downstream plant communities *Increased temperatures:* • animals may be able to reach higher altitudes that are currently cold-limited: - increase in fauna diversity - increase in number of species able to over-winter - increased grazing pressure from native and feral herbivores [e.g. deer, pigs (*Sus scrofa*), kangaroos] - reduced species diversity and endemism - increased weed invasion • decreased summer germination of herbaceous seeds • increased shrubbiness due to combination of increased temperatures with drier conditions • vegetation thickening at the upper treeline (but this may still be restricted by extreme events such as frosts) • change in migration patterns of Bogong moths (*Agrotis infusa*): - effect on resource availability to fauna (e.g. mountain pygmy possum, foxes) - shift in predation focus if moths are not available - altitudinal change • impacts on sphagnum (bleaching/crisping) - a component of the ecosystem very important for water regulation and fauna habitat • shortened spring breeding season for fauna • increased potential for plant and animal pathogen dispersal *Increased fire frequency because of the drier, warmer environment:* • fire is currently only an infrequent component of the ecosystem, so some major changes are expected • increased peat and organic soil fires • changes in species composition: - fewer obligate seeders (e.g. *Sphagnum* spp.) - some species may flourish after fire, but they are still used to only infrequent fires - consequences for broad-toothed rat and mountain pygmy possum
Freshwater wetlands	Montane lakes, bogs and fens	Decreases in productivity and changes in species composition are expected due to projected decreased moisture availability	*Decreased annual moisture availability, with a major decrease in winter rainfall and slight increase in summer rainfall:* • decreased productivity and species diversity • loss of resources for fauna: - loss of winter rainfall will be detrimental to winter- and spring-breeding fauna species • changes in species composition: - incursions by plant species less able to tolerate wet conditions - loss of endemic wet-adapted plants

			• gradient of less annual rainfall to more annual rainfall from west to east - western bogs and fens will be more heavily affected by drying than eastern ones • possible increases in fire frequency with drier conditions • increase in weed abundance • increased erosion

Forested wetlands		Decreased annual rainfall is likely to affect flood events resulting in reduced productivity and recruitment of some species	*Decreased annual rainfall, with a gradient of more rainfall to less rainfall from north to south:*
			• decreased snow cover and thus decreased melt flows
			• fewer flooding events owing to river regulation and water extraction, with a loss of ephemeral nature:
			  - decreased casuarina and river red gum recruitment
			  - increased tree death from water stress
			  - decreased shrub component
			• decreased productivity:
			  - decline in riparian vegetation (thinner riparian band)
			  - decline in resource availability for fauna in major dispersal corridor networks
			• decreased water quality
			• changes in flow paths due to loss of riverbank vegetation (stream widening and changes in course):
			  - increased erosivity
			Increased temperatures:
			• warmer water temperatures, with lower oxygen levels
			• impacts on aquatic fauna
			• increased potential for algal blooms
			Changes in seasonality of rainfall (decreased winter rainfall and increased summer rainfall):
			• increased invasion potential for summer-growing weed species [e.g. willows (*Salix* spp.), blackberries (*Rubus* spp.), aided by decreased shading because of loss of overstorey through moisture stress

8 Potential for Regenerative Agroforestry

Agroforestry in the Snowy Monaro in the context of this report focuses on the planting of native vegetation on degraded agricultural lands for regenerative farming, carbon sequestration and small-scale timber production. Broad scale forestry in the absence of associated infrastructure and services, and the potential impacts on biodiversity and agriculture would need its own investigation although this has not been identified as a priority by Council or anyone else. The only major forestry currently occurring in the region is the softwood pine industry operating around the Bombala which may be considered for expansion if there is sufficient suitable land to do so.

Agroforestry could potentially include long-term plans for harvesting of timber; however, depending on the direction of future governance, these areas are likely to be more valuable for carbon sequestration and biodiversity credits in the face of climate change. Also, in the absence of a timber industry and the costs associated with the transport and processing of hardwood, it is likely that any removal of timber would be at a small scale and would potentially service a niche market.

There is nevertheless merit in investigating the potential for regenerative native agroforestry where multiple benefits can be realised. The Australian National University Centre for Excellence in Plant Energy Biology (Justin Borevitz, pers. comm. 2019) is exploring this issue and has put forward a theoretical model which underpins a proposed pilot project that entails setting up a trial of 10 x 100 ha native tree plots (Eucalypts) augmented with the use of basalt soils for fertilizer and biochar production. He estimates that initial set-up costs would be approximately $1 million per property with a pay back of 10 years (ANU, 2019). However, this research is based purely on modelling and on-ground studies are yet to be established (Justin Borevitz, pers. comm.; Borevitz et al., 2019).

Predictions of tree cover are based on https://bastinjf_climate.users.earthengine.app/view/potential-tree-cover which is very limited when dealing with important treeless values such as Natural Temperate Grasslands as it just predicts tree cover at a global scale. Natural Temperate Grasslands (NTG) are a nationally significant Endangered Ecological Community that should NOT be planted with trees. It is hoped (but unclear) that the distribution of Natural Temperate Grasslands is sufficiently well represented by other mapped and modelled spatial data products included in the study to inform the potential location for agroforestry but it can never fully replace assessment on-ground as part of detailed planning.

Practitioners who are experienced with revegetation in the Monaro region have found that tree growth is slower than comparable revegetation efforts in other parts of the Southern Tablelands, but that, if all the important vegetation establishment guidelines are adhered to and sites are chosen that are not compacted or heavily degraded, then a high level of success can be realised (USLC, 2019). This information has been sourced form a recent summit hosted by the Upper Snowy Landcare Network (2019) of industry participants involved in large-scale tree planting across the Snowy Monaro. The summit included presentations by people with extensive experience in preparing sites, planting large numbers of trees and shrubs, and subsequently maintaining these rehabilitation areas. A common challenge for tree and shrub planting across the Snowy Monaro is extreme climate including frosts, extended drought periods, strong winds, short growing season and naturally poorer quality soils, exacerbated by various detrimental land-use practices over the past 150 years. Other challenges for successful plant survival include various pests including increasing pressure from deer.

Many vegetation communities, particularly *Eucalyptus viminalis* (Ribbon Gum) communities, have been facing extreme levels of dieback thought to be influenced by climate change (Ross & Brack, 2015). Over the past four years, along with partners including Greening Australia and a range of funders, suppliers, contractors and volunteers, USLN has installed 17 x 1 ha-sized biodiversity plots in response to the dramatic tree dieback on the Monaro in an area the size of the ACT. To try to alleviate the damage, the USLN has planted native trees and shrubs in densities of 1000 stems per hectare, often in the most disturbed or highly degraded areas and they plan to plant a further 11 000 trees and shrubs over the next three years. Greening Australia is

augmenting this program with eight provenance trials to test the viability of out-of-area species and sub-species of *Eucalyptus viminalis*. The results of this study and success rate of this project is of particular importance if consideration is to be given to large-scale regenerative agroforestry on the Monaro. It also highlights the importance of species selection in the face of climate change which predicts the region will increase in temperature by about 1.5–2.5°C by 2050. Section 7 has more Information on climate change.

Carbon sequestration is likely to augment and perhaps even drive agroforestry in time. Government determined methodology for carbon plantings states that trees must be permanently planted under current legislation and carbon sequestration is calculated on a minimum 30-year project (Australian Government, 2015). If trees are harvested in the future, then this is likely to affect the positive effects of carbon so the purpose of the plantings would need to be clear from the start. Predictions from research (Lynda et al., 2015) into carbon sequestration in the Southern Tablelands of NSW down to Tasmania are for between 3.3 and 8 tons / ha / sequestered per year from mixed native plantings. The actual amount of carbon sequestered depends on a range of factors such as planting density, plot shape, soils and growth rates in association with climatic conditions. It should be noted that research has also shown that the National Carbon Accounting Tool (FULLCAM model), which is used to estimate carbon, tends to underestimate carbon sequestration for permanent plantings (CSIRO, 2013). Nevertheless, it is the approved tool used by the Australian Government so proposed carbon sequestration plantings must adhere to this tool and the requirements of the approved methodology set out for mixed native plantings (Australian Government, 2015).

The mapping undertaken as part of this study and report shows areas that are likely to be suitable for regenerative agroforestry. The methodology for the derivation of these layers is outlined in detail in Section 4. Figure 21 shows the areas that are potentially suited to agroforestry. Around 15% of the Snowy Monaro Shire could be considered for agroforestry on the basis of this spatial data. In actual land area terms, this equates to approximately 200 000 ha of the total 1.5 million ha. Assuming calculations of a range of between 3–8 tC /ha/year, potential carbon sequestration could be in the range of 600 000 to 1.6 million t C per year. The reality of this amount of land being revegetated in its entirety is extremely unlikely due to practicalities; however, the potential for agroforestry plantings for carbon sequestration is feasible.

Another opportunity in relation to regeneration of land (irrespective of whether the focus is on agroforestry) is the NSW Government's Biodiversity Conservation Trust's 'Biodiversity Offsets Program', which is responsible for securing biodiversity offsets when developers choose to meet their offset obligation by paying into the Biodiversity Conservation Fund. Offsets are secured by buying biodiversity credits from landholders who have existing biodiversity stewardship agreements (BSAs) or BioBanking Agreements or by working with landowners to establish new BSAs that will generate credits that the BCT can then purchase at an agreed price. The Biodiversity Offsets Program will initially use three delivery mechanisms to secure biodiversity credits needed to meet developer offset obligations (Biodiversity Conservation Trust, 2019):

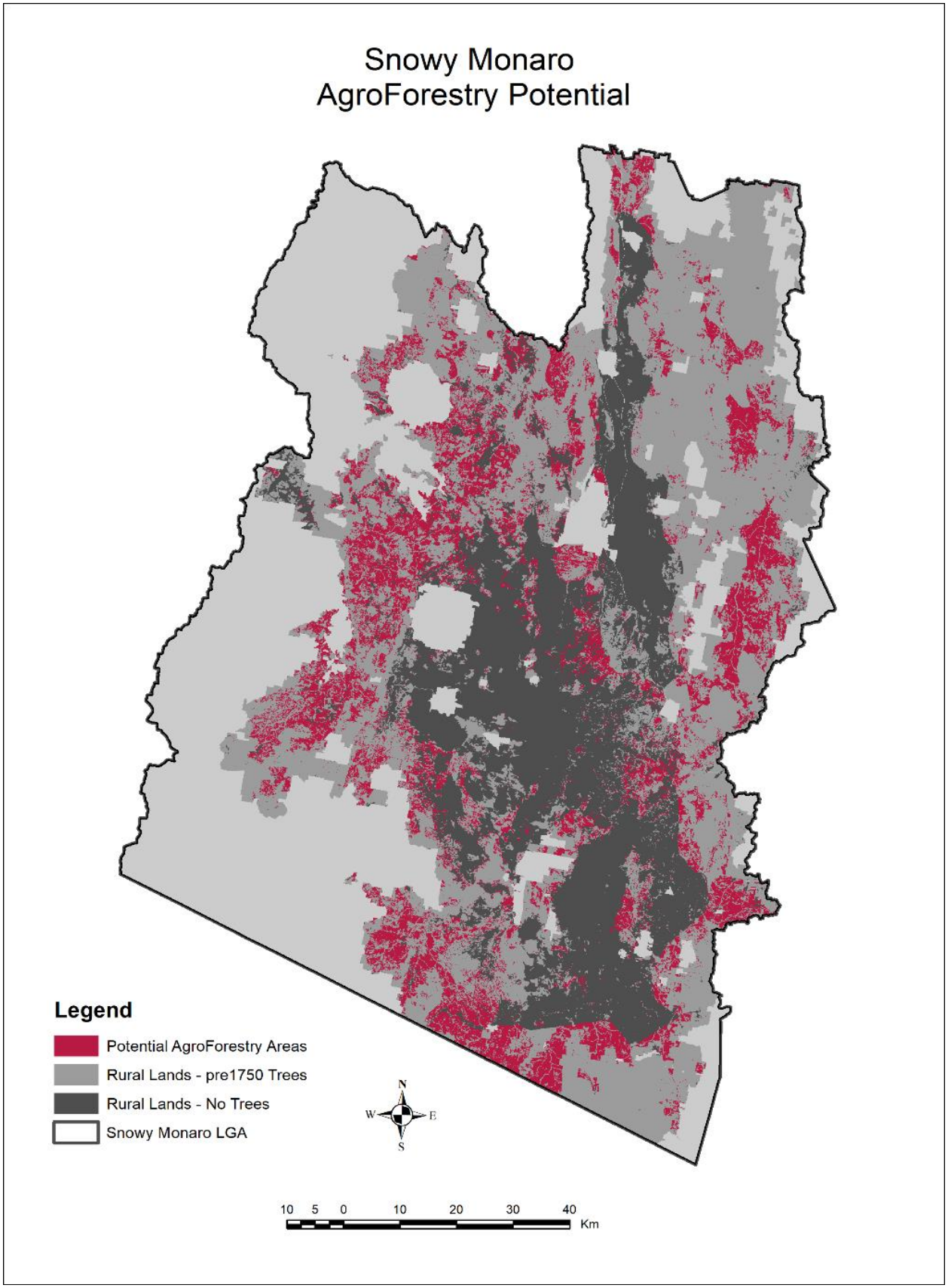
- Biodiversity credits tenders – selling credits through a tender process
- Biodiversity credits fixed price offers – selling credits via a fixed price offer (first come first serve)
- The BCT's Revolving Fund – purchase of property to which a conservation agreement is applied before resale.

Alternatively, landholders can access a conservation grants scheme whereby the BCT may identify and fund high-priority investment options or may invite tenders to supply conservation projects. This is generally carried out in relation to voluntary conservation areas and / or Land for Wildlife certification.

Implemented appropriately, agroforestry may provide opportunities for multiple benefits as part of mixed farming enterprises. For example, native vegetation reestablishment which is sympathetic to the natural environment can provide benefits to soil health, infiltration, habitat, biodiversity, water quality, carbon sequestration and shelter for domestic stock. Consideration would need to be given to the long-term plans for harvesting of timber if this is the aim, but many of these areas are likely to be more valuable for carbon

sequestration and biodiversity credits, depending on the future opportunities around carbon trading. Planning will require on-ground surveys, and evaluation of local ecological parameters, drainage, species selection, end products, constraints, economics, and the social implications as well as the context of climate change projections.

Figure 22 Potentially Suitable Areas for Agroforestry in the Snowy Monaro Shire



9 Conclusions

The Snowy Monaro region is an area that possesses many diverse natural values and includes significant components of every criteria assessed (in alignment with the *NSW Biodiversity Conservation Regulation 2017*). This includes many Endangered Ecological Communities, including the listing of the whole Snowy River catchment, over 200 threatened species (including an important Koala population), wetlands and riparian lands, important geological and groundwater systems, and Aboriginal history and ongoing cultural connections. Whilst many of these assets are represented in national parks and nature reserves, most of the diversity occurs on private lands. These same lands support industry, production and agriculture.

Whether the land use is tourism, farming, forestry, lifestyle or conservation, maintaining and improving biodiversity is one of the key priorities to ensuring a sustainable future and critical for protecting land, air and water for future sustainability. Pressures such as declining terms of trade for agriculture, population growth, changed land use, and climate change all contribute to increasing pressures and a loss of biodiversity. However, managed carefully and underpinned by sound regional strategic planning, the impacts of these pressures can be reduced.

The merging of three Councils has provided the Snowy Monaro Regional Council with the opportunity to prioritise the environment (and biodiversity) as a key consideration of planning, which enables re-evaluation of land use ensuring an evidence-based approach. Much of the land currently falls into very broad zoning categories (i.e. rural) with minimal use of the environmental land-use zoning (EPZ) instruments. In particular, the lands surrounding town centres are an obvious target for development as population increases and knowing which areas may be suitable for development based on their biodiversity values reduces the risk of environmental impacts while ensuring that development can proceed.

A sound understanding of the resource base through the integration of spatial analysis, mapping, review of literature and stakeholder engagement offers a strong platform upon which decisions can be made for land zoning based on the understanding and protection of biodiversity values as a key priority. Social and economic overlays can then be incorporated through consultation and other analyses. This approach also enables a fresh look at the management and development of land in an environmentally sensitive way and enables consideration of alternative land use in some areas in the face of a warming climate and population growth.

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Appendix A Criteria Mapping Layers

Criterion	Criteria Geodatabase Layer	Criteria Shapefile	Licensed Data	Input Data Layer	Purpose	Criteria FieldSource	Description Field Source	CRIT Field Name	Description Field Name	Data Source
Criteria_1a	SnowyMonaro_EnvironmentalStudy.gdb/Criteria1_HEV_ConservationAreas/Criteria_1a_Reserves	Criteria_1a_Reserves.shp		ConservationAreas_Reserves	Nature Reserves	TYPE	NAME	CRIT_1a	CRIT_1a	NSW Department of Planning, Industry and Environment
Criteria_1b	SnowyMonaro_EnvironmentalStudy.gdb/Criteria1_HEV_ConservationAreas/Criteria_1b_StateForests	Criteria_1b_StateForests.shp		ConservationAreas_StateForests	State Forests	{State Forest}	TAG_VALUE	CRIT_1b	CRIT_1b	NSW Department of Planning, Industry and Environment
Criteria_1c	SnowyMonaro_EnvironmentalStudy.gdb/Criteria1_HEV_ConservationAreas/Criteria_1c_ScenicProtection	Criteria_1c_ScenicProtection.shp		EPI_Scenic_Protection	Scenic Protection Areas	MAP_NAME	LAY_NAME	CRIT_1c	CRIT_1c	NSW Department of Planning, Industry and Environment
Criteria_1d	SnowyMonaro_EnvironmentalStudy.gdb/Criteria1_HEV_ConservationAreas/Criteria_1d_CrownReservesConservationAgreements	Criteria_1d_CrownReservesConservationAgreements.shp		HEV_ConservationAreas_CrownReservesAgreements	Crown Reserves, Conservation Agreements	{OtherProtectedAreas}	CONCAT	CRIT_1d	CRIT_1d	NSW Department of Planning, Industry and Environment
Criteria_2a	SnowyMonaro_EnvironmentalStudy.gdb/Criteria2_HEV_NativeVegetation/Criteria_2a_HighValueVegetation_HEVSouthEastTablelands	Criteria_2a_HighValueVegetation_HEVSouthEastTablelands.shp		HEV_NativeVegetation	High Value Native Vegetation	{HighValueVegetation}	CONCAT	CRIT_2a	CRIT_2a	NSW Department of Planning, Industry and Environment
Criteria_2b	SnowyMonaro_EnvironmentalStudy.gdb/Criteria2_HEV_NativeVegetation/Criteria_2b_SensitiveRegulatedLands	Criteria_2b_SensitiveRegulatedLands.shp	Yes	RegulatedLands_Sensitive	Sensitve Regulated Lands (Native Vegetation)	{Native Vegetation Regulations}	{Sensitive Regulated Lands}	CRIT_2b	CRIT_2b	NSW Department of Planning, Industry and Environment
Criteria_2c	SnowyMonaro_EnvironmentalStudy.gdb/Criteria2_HEV_NativeVegetation/Criteria_2c_VulnerableRegulatedLands	Criteria_2c_VulnerableRegulatedLands.shp	Yes	RegulatedLands_Vulnerable	Vulnerable Regulated Lands (Native Vegetation)	{Native Vegetation Regulations}	{Vulnerable Regulated Lands}	CRIT_2c	CRIT_2c	NSW Department of Planning, Industry and Environment
Criteria_2d	SnowyMonaro_EnvironmentalStudy.gdb/Criteria2_HEV_NativeVegetation/Criteria_2d_VegetationMap_PossibleEECs_OEH_Bombala	Criteria_2d_VegetationMap_PossibleEECs_OEH_Bombala.shp		VegetationMap_OEH_Bombala_possibleEECs	Endangered Ecological Communities (mapped)	{Endangered Ecological Communities (mapping)}	EEC_Name	CRIT_2d	CRIT_2d	NSW Department of Planning, Industry and Environment

Criteria_2e	SnowyMonaro_EnvironmentalStudy.gdb/Criteria2_HEV_NativeVegetation/Criteria_2e_VegetationMap_PossibleEECs_OEH_Cooma	Criteria_2e_VegetationMap_PossibleEECs_OEH_Cooma.shp		VegetationMap_OEH_Cooma_possibleEECs	Endangered Ecological Communities (mapped)	{Endangered Ecological Communities (mapping)}	EEC_Name	CRIT_2e	CRIT_2e	NSW Department of Planning, Industry and Environment
Criteria_2f	SnowyMonaro_EnvironmentalStudy.gdb/Criteria2_HEV_NativeVegetation/Criteria_2f_NativeVegExtent_CandidateGrasslands	Criteria_2f_NativeVegExtent_CandidateGrasslands.shp		VegetationMap_OEH_NativeVegExtent 2017	Candidate Native Grasslands	{Native Vegetation Extent 07}	{Candidate Native Grassland}	CRIT_2f	CRIT_2f	NSW Department of Planning, Industry and Environment
Criteria_2g	SnowyMonaro_EnvironmentalStudy.gdb/Criteria2_HEV_NativeVegetation/Criteria_2g_VegetationMap_PossibleEECs_OEH_SouthCoast	Criteria_2g_VegetationMap_PossibleEECs_OEH_SouthCoast.shp		VegetationMap_OEH_ShoalhaveEuroboddallaBega_EECs	Endangered Ecological Communities (mapped)	{Endangered Ecological Communities (mapping)}	EEC_Name	CRIT_2g	CRIT_2g	NSW Department of Planning, Industry and Environment
Criteria_2h	SnowyMonaro_EnvironmentalStudy.gdb/Criteria2_HEV_NativeVegetation/Criteria_2h_VegetationMap_PossibleEECs_OEH_Snowy	Criteria_2h_VegetationMap_PossibleEECs_OEH_Snowy.shp		VegetationMap_OEH_Snowy_possibleEECs	Endangered Ecological Communities (mapped)	{Endangered Ecological Communities (mapping)}	EEC_Name	CRIT_2h	CRIT_2h	NSW Department of Planning, Industry and Environment
Criteria_2i	SnowyMonaro_EnvironmentalStudy.gdb/Criteria2_HEV_NativeVegetation/Criteria_2i_VegetationMap_PossibleEECs_OEH_SnowyMonaro	Criteria_2i_VegetationMap_PossibleEECs_OEH_SnowyMonaro.shp		VegetationMap_OEH_SnowyMonaro_possibleEECs	Endangered Ecological Communities (mapped)	{Endangered Ecological Communities (mapping)}	EEC_Name	CRIT_2i	CRIT_2i	NSW Department of Planning, Industry and Environment
Criteria_2j	SnowyMonaro_EnvironmentalStudy.gdb/Criteria2_HEV_NativeVegetation/Criteria_2j_VegetationMap_PossibleEECs_SMRC_Bombala	Criteria_2j_VegetationMap_PossibleEECs_SMRC_Bombala.shp		VegetationMap_SMRC_Bombala_possibleEECs	Endangered Ecological Communities (mapped)	{Endangered Ecological Communities (mapping)}	EEC	CRIT_2j	CRIT_2j	NSW Department of Planning, Industry and Environment
Criteria_3a	SnowyMonaro_EnvironmentalStudy.gdb/Criteria3_HEV_ThreatenedEntities/Criteria_3a_EPI_TerrestrialBiodiversity	Criteria_3a_EPI_TerrestrialBiodiversity.shp		EPI_Terrestrial_Biodiversity	Threatened Entities (species or communities)	{Threatened Entities}	{EPI Terrestrial Biodiversity}	CRIT_3a	CRIT_3a	NSW Department of Planning, Industry and Environment
Criteria_3b	SnowyMonaro_EnvironmentalStudy.gdb/Criteria3_HEV_ThreatenedEntities/Criteria_3b_ThreatenedEntities_HEVSouthEastTablelands	Criteria_3b_ThreatenedEntities_HEVSouthEastTablelands.shp		HEV_ThreatenedEntities	Threatened Entities (species or communities)	{Threatened Entities}	CONCAT	CRIT_3b	CRIT_3b	NSW Department of Planning, Industry and Environment
Criteria_3c	SnowyMonaro_EnvironmentalStudy.gdb/Criteria3_HEV_ThreatenedEntities/Criteria_3c_ThreatenedSpeci	Criteria_3c_ThreatenedSpeciesPredictions_PridayCooma.shp		ThreatenedEntityPredictions_Priday_Coma_NatVeg07	Threatened Species Predictions	{Threatened Species Predictions}	CONCAT	CRIT_3c	CRIT_3c	Snowy Monaro Regional Council

	esPredictions_PridayCooma									
Criteria_3d	SnowyMonaro_EnvironmentalStudy.gdb/Criteria3_HEV_ThreatenedEntities/Criteria_3d_EndangeredCommunityPredictions_PridayCooma	Criteria_3d_EndangeredCommunityPredictions_PridayCooma.shp		ThreatenedEntityPredictions_Priday_Coma_NatVeg07_EEChigh	Endangered Ecological Communities (predictions)	{Endangered Ecological Communities (predictions)}	EEC_merge	CRIT_3d	CRIT_3d	Snowy Monaro Regional Council
Criteria_3e	SnowyMonaro_EnvironmentalStudy.gdb/Criteria3_HEV_ThreatenedEntities/Criteria_3e_ThreatenedSpeciesPredictions_PridayYaouk	Criteria_3e_ThreatenedSpeciesPredictions_PridayYaouk.shp		ThreatenedEntityPredictions_Priday_Coma_NatVegYaoukJune09	Threatened Species Predictions	{Threatened Species Predictions}	CONCAT	CRIT_3e	CRIT_3e	Snowy Monaro Regional Council
Criteria_3f	SnowyMonaro_EnvironmentalStudy.gdb/Criteria3_HEV_ThreatenedEntities/Criteria_3f_EndangeredCommunityPredictions_PridayYaouk	Criteria_3f_EndangeredCommunityPredictions_PridayYaouk.shp		ThreatenedEntityPredictions_Priday_Coma_NatVegYaoukJune09_EEChigh	Endangered Ecological Communities (predictions)	{Endangered Ecological Communities (predictions)}	EEC_merge	CRIT_3f	CRIT_3f	Snowy Monaro Regional Council
Criteria_3g	SnowyMonaro_EnvironmentalStudy.gdb/Criteria3_HEV_ThreatenedEntities/Criteria_3g_ThreatenedSpeciesPredictions_PridaySnowy	Criteria_3g_ThreatenedSpeciesPredictions_PridaySnowy.shp		ThreatenedEntityPredictions_Priday_Snowy_PlanningTEEedits_241012	Threatened Entity Predictions (species & communities)	{Threatened Species Predictions}	CONCAT	CRIT_3g	CRIT_3g	Snowy Monaro Regional Council
Criteria_3h	SnowyMonaro_EnvironmentalStudy.gdb/Criteria3_HEV_ThreatenedEntities/Criteria_3h_EndangeredCommunityPredictions_PridaySnowy	Criteria_3h_EndangeredCommunityPredictions_PridaySnowy.shp		ThreatenedEntityPredictions_Priday_Snowy_PlanningTEEedits_241012	Endangered Ecological Communities (predictions)	{Endangered Ecological Communities (predictions)}	EECmerge	CRIT_3h	CRIT_3h	Snowy Monaro Regional Council
Criteria_3i	SnowyMonaro_EnvironmentalStudy.gdb/Criteria3_HEV_ThreatenedEntities/Criteria_3i_EndangeredCommunityPredictions_SELLSBiometric	Criteria_3i_EndangeredCommunityPredictions_SELLSBiometric.shp		ThreatenedEntityPredictions_SELLS_Biometric_2014_E_4211_EECTEChigh	Endangered Ecological Communities (predictions)	{Endangered Ecological Communities (predictions)}	CONCAT	CRIT_3i	CRIT_3i	Snowy Monaro Regional Council
Criteria_3j	SnowyMonaro_EnvironmentalStudy.gdb/Criteria3_HEV_ThreatenedEntities/Criteria_3j_ThreatenedSpeciesPredictions_Freshwater_buffer50m	Criteria_3j_ThreatenedSpeciesPredictions_Freshwater_buffer50m.shp		ThreatenedSpecies__Freshwater	Freshwater Threatened Species Mapping	{Threatened Freshwater Species}	Species	CRIT_3j	CRIT_3j	NSW Department of Planning, Industry and Environment
Criteria_3k	SnowyMonaro_EnvironmentalStudy.gdb/Criteria3_HEV_ThreatenedEntities/Criteria_3k_ThreatenedSpeciesPopulations_Koala	Criteria_3k_ThreatenedSpeciesPopulations_Koala.shp		ThreatenedSpecies_KoalaPlanOfManagement_Cooma	Threatened Species Plan of Management	{Threatened Species PoM Boundary}	{Koala}	CRIT_3k	CRIT_3k	NSW Department of Planning, Industry and Environment

Criteria_3l	SnowyMonaro_EnvironmentalStudy.gdb/Criteria3_HEV_ThreatenedEntities/Criteria_3l_ThreatenedSpeciesSightings_ALA_buffer100m	Criteria_3l_ThreatenedSpeciesSightings_ALA_buffer100m.shp		ThreatenedSpeciesSightings_ALA_Buffer100m	Threatened Species Sightings (buffered 100m)	{Threatened Species Sightings}	Species	CRIT_3l	CRIT_3l	NSW Department of Planning, Industry and Environment
Criteria_3m	SnowyMonaro_EnvironmentalStudy.gdb/Criteria3_HEV_ThreatenedEntities/Criteria_3m_ThreatenedSpeciesSightings_BioNet_buffer100m	Criteria_3m_ThreatenedSpeciesSightings_BioNet_buffer100m.shp		ThreatenedSpeciesSightings_BioNet_Buffer100m	Threatened Species Sightings (buffered 100m)	{Threatened Species Sightings}	Scientific	CRIT_3m	CRIT_3m	NSW Department of Planning, Industry and Environment
Criteria_3n	SnowyMonaro_EnvironmentalStudy.gdb/Criteria3_HEV_ThreatenedEntities/Criteria_3n_ThreatenedSpeciesSightings_BioNet_buffer100m	Criteria_3n_ThreatenedSpeciesSightings_BioNet_buffer100m.shp	Yes	ThreatenedSpeciesSightings_BioNet_buffer100m_LICENSE	Threatened Species Sightings (buffered 100m)	{Threatened Species Sightings}	Scientific	CRIT_3n	CRIT_3n	NSW Department of Planning, Industry and Environment
Criteria_4a	SnowyMonaro_EnvironmentalStudy.gdb/Criteria4_HEV_WetlandsRivers/Criteria_4a_BogsAndFens_SnowyMountains	Criteria_4a_BogsAndFens_SnowyMountains.shp		BogsAndFens_SnowyMountains	Bogs and Fens	{Bogs and Fens}	Bog_name	CRIT_4a	CRIT_4a	NSW Department of Planning, Industry and Environment
Criteria_4b	SnowyMonaro_EnvironmentalStudy.gdb/Criteria4_HEV_WetlandsRivers/Criteria_4b_EPI_DrinkingWaterCatchments	Criteria_4b_EPI_DrinkingWaterCatchments.shp		EPI_Drinking_Water_Catchments	EPI Drinking Water Catchment	MAP_NAME	LAY_CLASS	CRIT_4b	CRIT_4b	NSW Department of Planning, Industry and Environment
Criteria_4c	SnowyMonaro_EnvironmentalStudy.gdb/Criteria4_HEV_WetlandsRivers/Criteria_4c_EPI_GroundwaterVulnerability	Criteria_4c_EPI_GroundwaterVulnerability.shp		EPI_Groundwater_Vulnerability	Vulnerable Groundwater	MAP_NAME	LAY_CLASS	CRIT_4c	CRIT_4c	NSW Department of Planning, Industry and Environment
Criteria_4d	SnowyMonaro_EnvironmentalStudy.gdb/Criteria4_HEV_WetlandsRivers/Criteria_4d_EPI_RiparianLandsWatercourses	Criteria_4d_EPI_RiparianLandsWatercourses.shp		EPI_Riparian_Lands_Watercourses	EPI Riparian Lands and Watercourse	MAP_NAME	LAY_CLASS	CRIT_4d	CRIT_4d	NSW Department of Planning, Industry and Environment
Criteria_4e	SnowyMonaro_EnvironmentalStudy.gdb/Criteria4_HEV_WetlandsRivers/Criteria_4e_EPI_Wetlands	Criteria_4e_EPI_Wetlands.shp		EPI_Wetlands	EPI Wetlands	MAP_NAME	LAY_CLASS	CRIT_4e	CRIT_4e	NSW Department of Planning, Industry and Environment
Criteria_4f	SnowyMonaro_EnvironmentalStudy.gdb/Criteria4_HEV_WetlandsRivers/Criteria_4f_VulnerableLands_ProtectedRiparian_buffer50m	Criteria_4f_VulnerableLands_ProtectedRiparian_buffer50m.shp		VulnerableLands_ProtectedRiparian	Vulnerable Protected Riparian Lands	{Vulnerable Protected Riparian Lands}	HYDRONAME	CRIT_4f	CRIT_4f	NSW Department of Planning, Industry and Environment
Criteria_4g	SnowyMonaro_EnvironmentalStudy.gdb/Criteria4_H	Criteria_4g_Wetlands_Important.shp		Wetlands_Important	Important Wetlands	{Important Wetlands}	SPECIFIC_N	CRIT_4g	CRIT_4g	NSW Department of Planning,

	EV_WetlandsRivers/Criteria_4g_Wetlands_Important									Industry and Environment
Criteria_4h	SnowyMonaro_EnvironmentalStudy.gdb/Criteria4_HEV_WetlandsRivers/Criteria_4h_Wetlands_RamsarSites	Criteria_4h_Wetlands_RamsarSites.shp		Wetlands_Ramsar	Ramsar Sites	{RAMSAR Site}	RAMSAR_NAM	CRIT_4h	CRIT_4h	Australian Department of Environment and Energy)
Criteria_5	SnowyMonaro_EnvironmentalStudy.gdb/Criteria5_HEV_GeoHeritage/Criteria_5a_EPI_LocalProvisions_GeologicalHeritage	Criteria_5a_EPI_Local Provisions_GeologicalHeritage.shp		EPI_Local_Provisions	Geological Heritage (Karst Formations)	MAP_NAME	LAY_CLASS	CRIT_5	CRIT_5	Australian Department of Environment and Energy)
Criteria_6	SnowyMonaro_EnvironmentalStudy.gdb/Criteria6_HEV_AboriginalHeritage/Criteria_6a_EPI_AboriginalHeritage	Criteria_6a_EPI_AboriginalHeritage.shp		EPI_Aboriginal_Heritage	Aboriginal Heritage	LAY_NAME	LAY_CLASS	CRIT_6	CRIT_6	NSW Department of Planning, Industry and Environment
Criteria_7a	SnowyMonaro_EnvironmentalStudy.gdb/Criteria7_ConstraintsToDevelopment/Criteria_7a_EPI_CSGexclusions	Criteria_7a_EPI_CSGexclusions.shp		EPI_CSG_Exclusions	Coal Seam Gas Exclusions	MAP_NAME	LAY_CLASS	CRIT_7a	CRIT_7a	NSW Department of Planning, Industry and Environment
Criteria_7b	SnowyMonaro_EnvironmentalStudy.gdb/Criteria7_ConstraintsToDevelopment/Criteria_7b_EPI_Flood	Criteria_7b_EPI_Flood.shp		EPI_Flood	Risk of Floods	MAP_NAME	LAY_CLASS	CRIT_7b	CRIT_7b	NSW Department of Planning, Industry and Environment
Criteria_7c	SnowyMonaro_EnvironmentalStudy.gdb/Criteria7_ConstraintsToDevelopment/Criteria_7c_LandslideRisk	Criteria_7c_Landslide Risk.shp		EPI_Landslide_Risk	Risk of Landslides	MAP_NAME	LAY_CLASS	CRIT_7c	CRIT_7c	NSW Department of Planning, Industry and Environment
Criteria_7d	SnowyMonaro_EnvironmentalStudy.gdb/Criteria7_ConstraintsToDevelopment/Criteria_7d_StrategicAgriculturalLand	Criteria_7d_StrategicAgriculturalLand.shp		EPI_Strategic_Agricultural_Land	Strategic Agricultural Lands	MAP_NAME	LAY_CLASS	CRIT_7d	CRIT_7d	NSW Department of Planning, Industry and Environment
Criteria_7e	SnowyMonaro_EnvironmentalStudy.gdb/Criteria7_ConstraintsToDevelopment/Criteria_7e_FloodRisk1in100yr_Bombala	Criteria_7e_FloodRisk 1in100yr_Bombala.shp		Flood_1in100yr_Bombala_poly	Risk of Floods	{Flood Prone Land}	{Flood Prone Area}	CRIT_7e	CRIT_7e	Snowy Monaro Regional Council
Criteria_7f	SnowyMonaro_EnvironmentalStudy.gdb/Criteria7_ConstraintsToDevelopment/Criteria_7f_FloodRiskPMF_Cooma	Criteria_7f_FloodRiskPMF_Cooma.shp		Flood_AreaPMF_Cooma	Risk of Floods	{Flood Prone Land}	{Flood Prone Area}	CRIT_7f	CRIT_7f	Snowy Monaro Regional Council

Appendix B Endangered Ecological Communities Snowy Monaro

Community	Status NSW	Status EPBC
Araluen Scarp Grassy Forest in the South East Corner Bioregion	E	
Bangalay Sand Forest of the Sydney Basin and South East Corner bioregions*	E	
Coastal Saltmarsh in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions*	E	V
Dry Rainforest of the South East Forests in the South East Corner Bioregion	E	
Freshwater Wetlands on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions*	E	
Lowland Grassy Woodland in the South East Corner Bioregion	E	CE
Monaro Tableland Cool Temperate Grassy Woodland in the South Eastern Highlands Bioregion	CE	
Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps bioregions	E	E
Natural Temperate Grassland of the South Eastern Highlands		CE
River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions*	E	
Swamp Oak Floodplain Forest of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	E	E
Tableland Basalt Forest in the Sydney Basin and South Eastern Highlands Bioregions	E	
Themeda grassland on seacliffs and coastal headlands in the NSW North Coast, Sydney Basin and South East Corner Bioregions	E	
Werriwa Tablelands Cool Temperate Grassy Woodland in the South Eastern Highlands and South East Corner Bioregions	CE	
White Box Yellow Box Blakely's Red Gum Woodland	E	CE
Windswept Feldmark in the Australian Alps Bioregion	CE	
Tablelands Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland in the South Eastern Highlands, Sydney Basin, South East Corner and NSW South Western Slopes Bioregions**	EEC Final Determination	Not listed
The aquatic ecological community of the Snowy River catchment - includes all native fish and aquatic invertebrates within all rivers, creeks and streams of the Snowy River catchment. The listing includes the river-bed channels inundated by the artificial impoundments of Jindabyne, Eucumbene, Island Bend and Guthega dams, but excludes the ecological communities that have developed in the waters of these impoundments.	E	
E = Endangered		
CE = Critically Endangered		

Appendix C Assignment of Endangered Ecological Communities based on Vegetation Type

Vegetation Types	EEC	EEC Community Name	Confidence
Acacia Scrub			
Alpine Heath/Grassland complex (2)	X	Montane Peatlands of the Australian Alps / Alpine Bogs	High
Basalt Wet Herb Forest	X	Tableland Basalt Forest	Moderate
Coastal Dry Shrub Forest	X	Bangalay Sand Forest - very coastal	Very low
Coastal Foredune Scrub	X	Coastal Saltmarsh	Very low
Coastal Range Dry Shrub Forest	X	Bangalay Sand Forest - very coastal	Very low
Coastal Warm Temperate RF			
Cool Montane Wet Forest			
Cool Temperate Rainforest	X	Dry Rainforest of SE Forests	Moderate
Dry Foothill Forest			
Eastern Rainshadow Woodland (24)			
Eastern Tableland Moist Woodland on high altitude (7)	X	Ribbon Gum Mountain Gum Snow Gum Grassy Woodland / Forest	High
Eastern Tablelands Dry Forest / Woodland (21)			
Eastern Tablelands Dry Woodland (20)			
Escarpment Dry Grass Forest	X	Araluen Scarp Grassy Forest	Moderate
Flats Wet Herb Forest			
Foothills Dry Shrub Forest			
Genoa Dry Shrub Forest			
High Mountain Wet Layered Forest			
Hinterland Dry Grass Forest			
Hinterland Heath			
Hinterland Warm Temperate RF			
Hinterland Wet Fern Forest			
Hinterland Wet Shrub Forest			
Inland Intermediate Shrub Forest			
Kydra Flats Grass Forest			
Less than 100ha			
Moist Foothill Forest	X	Lowland Grassy Woodland	Low
Monaro Basalt Grass Woodland	X	Ribbon Gum Mountain Gum Snow Gum Grassy Woodland / Forest	Low
Monaro Dry Grass Forest	X	Ribbon Gum Mountain Gum Snow Gum Grassy Woodland / Forest	Low
Monaro Grassland	X	Natural Temperate Grassland and Themeda Grassland	High
Montane Forests (15)			
Montane Heath	X	Windswept Feldmark of the Australian Alps region	Low
Montane Moist Forests (16)			
Montane/Tableland Moist Woodland (12)			
Mountain Dry Shrub Forest			

Mountain Intermediate Shrub Forest			
Mountain Rock Scrub			
Mountain Sandstone Shrub Forest			
Mountain Wet Fern Forest			
Mountain Wet Herb Forest			
Mountain Wet Layered Forest			
Mt Nadgee Heath			
Nalbaugh Dry Grass Forest			
Natural Temperate Grassland	X	Natural Temperate Grassland and Themeda Grassland	High
Northern Riparian Scrub			
Numeralla Dry Shrub Woodland			
Sandstone Dry Shrub Forest			
Slopes and Tablelands Moist Grasslands (27)		Natural Temperate Grassland and Themeda Grassland	Moderate
Slopes and Western Tablelands Dry Woodland (22)			
Southern Escarpment Wet Forests (9)			
Southern Riparian Scrub	X	River Flat Eucalypt forest on Coastal Floodplain	Moderate
Sub-Alpine Bog	X	Montane Peatlands of the Australian Alps	High
Subalpine Dry Shrub Forest			
Sub-alpine Woodlands	X	Ribbon Gum Mountain Gum Snow Gum Grassy Woodland / Forest	Moderate
Sub-Alpine Woodlands (18)	X	Ribbon Gum Mountain Gum Snow Gum Grassy Woodland / Forest	Moderate
Swamp Forest	X	Swamp Oak Floodplains	Low
Tableland and Montane Dry Shrubby Woodland (5)			
Tableland Casuarina Heath (3)			
Tableland Dry Shrub Forest			
Tableland Dry Shrublands (5a)			
Tableland Dry Woodlands (5b)	X	Lowland Grassy Woodland	Very low
Tableland Moist Forests (8a)	X	Dry Rainforest of SE Forest	Moderate
Tableland Wet/Moist Forests (8)	X	Dry Rainforest of SE Forest	Moderate
Tablelands and Slopes Box-Gum Woodland (19)	X	Box Gum Woodland	High
Tablelands Riparian Woodlands (26)	X	River Flat Eucalypt forest on Coastal Floodplain	Low
Tallaganda Wet Forest			
Tantawangalo Wet Shrub Forest			
Unvegetated			
Upper Shoalhaven Montane Heath	X	Windswept Feldmark of the Australian Alps region	Moderate
Wadbilliga Dry Shrub Forest			
Wadbilliga Heath Forest			
Wallagaraugh Dry Grass Forest			
Water			

Appendix D Threatened Species (BioNet and DPI Fisheries)

Note: DPI Fisheries Information do not have number of records specified.

Key
CE / E4A = Critically Endangered
E / E1 = Endangered
V = Vulnerable
K = Known
P = Protected (NSW)
C, J, K in association with listings = CAMBA, JAMBA, RoKAMBA (protected under international agreements)
Numerals in association with listings = sensitivity category in relation to data availability. 1 = data not available for mapping, 2 = mapped with permission from DPIE, 3 = mapped and publicly available.

Scientific Name	Common Name	Status NSW	Status EPBC	Records
Frogs				
Mixophyes balbus	Stuttering Frog	E1,P,2	V	1
Pseudophryne corroboree	Southern Corroboree Frog	E4A,P,2	CE	27
Pseudophryne pengilleyi	Northern Corroboree Frog	E4A,P,2	CE	K
Heleioporus australiacus	Giant Burrowing Frog	V,P	V	4
Litoria aurea	Green and Golden Bell Frog	E1,P	V	4
Litoria booroolongensis	Booroolong Frog	E1,P	E	4
Litoria castanea	Yellow-spotted Tree Frog	E4A,P	E	3
Litoria littlejohni	Littlejohn's Tree Frog	V,P	V	K
Litoria raniformis	Southern Bell Frog	E1,P	V	2
Litoria spenceri	Spotted Tree Frog	E4A,P	E	K
Litoria verreauxii alpina	Alpine Tree Frog	E1,P	V	245
Birds				
Callocephalon fimbriatum	Gang-gang Cockatoo	V,P,3		770
Glossopsitta porphyrocephala	Purple-crowned Lorikeet	V,P,3		P
Lathamus discolor	Swift Parrot	E1,P,3	CE	K
Lophoictinia isura	Square-tailed Kite	V,P,3		5
Neophema chrysogaster	Orange-bellied Parrot	E4A,P,3	CE	1
Neophema pulchella	Turquoise Parrot	V,P,3		10
Ninox connivens	Barking Owl	V,P,3		3
Ninox strenua	Powerful Owl	V,P,3		141
Pandion cristatus	Eastern Osprey	V,P,3		K
Pezoporus wallicus wallicus	Eastern Ground Parrot	V,P,3		K
Polytelis swainsonii	Superb Parrot	V,P,3	V	2
Tyto novaehollandiae	Masked Owl	V,P,3		24
Tyto tenebricosa	Sooty Owl	V,P,3		21
Calyptorhynchus lathami	Glossy Black-Cockatoo	V,P,2		12
Dasyornis brachypterus	Eastern Bristlebird	E1,P,2	E	K
Actitis hypoleucos	Common Sandpiper	P	C,J,K	1
Anthochaera phrygia	Regent Honeyeater	E4A,P	CE	2
Apus pacificus	Fork-tailed Swift	P	C,J,K	3
Ardea ibis	Cattle Egret	P	C,J	4

Ardenna tenuirostris	Short-tailed Shearwater	P	J,K	1
Artamus cyanopterus cyanopterus	Dusky Woodswallow	V,P		209
Botaurus poiciloptilus	Australasian Bittern	E1,P	E	K
Burhinus grallarius	Bush Stone-curlew	E1,P		K
Calamanthus fuliginosus	Striated Fieldwren	E1,P		K
Calidris alba	Sanderling	V,P	C,J,K	K
Calidris canutus	Red Knot	P	E,C,J,K	K
Calidris ferruginea	Curlew Sandpiper	E1,P	CE,C,J,K	K
Calidris ruficollis	Red-necked Stint	P	C,J,K	1
Calyptorhynchus lathami	Glossy Black-Cockatoo	V,P,2		
Chthonicola sagittata	Speckled Warbler	V,P		39
Circus assimilis	Spotted Harrier	V,P		10
Climacteris picumnus victoriae	Brown Treecreeper (eastern subspecies)	V,P		119
Daphoenositta chrysoptera	Varied Sittella	V,P		67
Ephippiorhynchus asiaticus	Black-necked Stork	E1,P		K
Epthianura albifrons	White-fronted Chat	V,P		11
Esacus magnirostris	Beach Stone-curlew	E4A,P		K
Falco subniger	Black Falcon	V,P		3
Gallinago hardwickii	Latham's Snipe	P	C,J,K	84
Glossopsitta pusilla	Little Lorikeet	V,P		3
Grantiella picta	Painted Honeyeater	V,P	V	K
Haematopus fuliginosus	Sooty Oystercatcher	V,P		K
Haematopus longirostris	Pied Oystercatcher	E1,P		K
Haliaeetus leucogaster	White-bellied Sea-Eagle	V,P	C	19
Hieraaetus morphnoides	Little Eagle	V,P		30
Hirundapus caudacutus	White-throated Needletail	P	C,J,K	73
Irediparra gallinacea	Comb-crested Jacana	V,P		K
Ixobrychus flavicollis	Black Bittern	V,P		K
Limosa lapponica baueri	Bar-tailed Godwit (baueri)	P	V,C,J,K	K
Limosa limosa	Black-tailed Godwit	V,P	C,J,K	K
Melanodryas cucullata cucullata	Hooded Robin (south-eastern form)	V,P		72
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subspecies)	V,P		1
Merops ornatus	Rainbow Bee-eater	P	J	28
Numenius madagascariensis	Eastern Curlew	P	CE,C,J,K	K
Oxyura australis	Blue-billed Duck	V,P		9
Pachycephala olivacea	Olive Whistler	V,P		181
Petroica boodang	Scarlet Robin	V,P		349
Petroica phoenicea	Flame Robin	V,P		666
Petroica rodinogaster	Pink Robin	V,P		20
Plegadis falcinellus	Glossy Ibis	P	C	1
Ptilinopus superbus	Superb Fruit-Dove	V,P		K
Rostratula australis	Australian Painted Snipe	E1,P	E	1
Stagonopleura guttata	Diamond Firetail	V,P		106
Sternula albifrons	Little Tern	E1,P	C,J,K	K

Stictonetta naevosa	Freckled Duck	V,P		4
Fish (Source: DPI Fisheries)				
Gadopsis marmoratus	River Black Fish	E (pop)	E (pop)	
Galaxias tantangara	Stocky Galaxias	CE	CE	1
Maccullochella macquariensis	Trout Cod	E	E	
Macquaria australasica	Macquarie Perch	E	E	
Nannoperca australis	Southern Pygmy Perch	E	Pending	
Crayfish				
Euastacus armatus	Murray Crayfish	V	Pending	
Insects				
Austropetalia tonyana	Alpine Redspot Dragonfly	V		5
Petalura gigantea	Giant Dragonfly	E1		K
Synemon plana	Golden Sun Moth	E1	CE	K
Mammals				
Burramys parvus	Mountain Pygmy-possum	E1,P	E	298
Cercartetus nanus	Eastern Pygmy-possum	V,P		24
Chalinolobus dwyeri	Large-eared Pied Bat	V,P	V	K
Dasyurus maculatus	Spotted-tailed Quoll	V,P	E	455
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V,P		60
Isoodon obesulus obesulus	Southern Brown Bandicoot (eastern)	E1,P	E	4
Mastacomys fuscus	Broad-toothed Rat	V,P	V	304
Micronomus norfolkensis	Eastern Coastal Free-tailed Bat	V,P		K
Miniopterus orianae oceanensis	Large Bent-winged Bat	V		53
Myotis macropus	Southern Myotis	V,P		15
Petauroides volans	Greater Glider population in the Eurobodalla local government area	E2,P	V	K
Petauroides volans	Greater Glider	P	V	575
Petaurus australis	Yellow-bellied Glider	V,P		139
Petaurus norfolcensis	Squirrel Glider	V,P		11
Petrogale penicillata	Brush-tailed Rock-wallaby	E1,P	V	1
Phascogale tapoatafa	Brush-tailed Phascogale	V,P		K
Phascolarctos cinereus	Koala	V,P	V	628
Phoniscus papuensis	Golden-tipped Bat	V,P		K
Potorous longipes	Long-footed Potoroo	E4A,P	E	4
Potorous tridactylus	Long-nosed Potoroo	V,P	V	7
Pseudomys fumeus	Smoky Mouse	E4A,P	E	1
Pteropus poliocephalus	Grey-headed Flying-fox	V,P	V	10
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V,P		1
Scoteanax rueppellii	Greater Broad-nosed Bat	V,P		6
Sminthopsis leucopus	White-footed Dunnart	V,P		3

Reptiles				
Aprasia parapulchella	Pink-tailed Legless Lizard	V,P	V	5
Cyclodomorphus praealtus	Alpine She-oak Skink	E1,P	E	72
Delma impar	Striped Legless Lizard	V,P	V	31
Hoplocephalus bungaroides	Broad-headed Snake	E1,P,2	V	P
Liopholis guthega	Guthega Skink	E1,P	E	319
Suta flagellum	Little Whip Snake	V,P		20
Tympanocryptis pinguicolla	Grassland Earless Dragon	E1,P	E	133
Varanus rosenbergi	Rosenberg's Goanna	V,P		10
Flora				
Acacia constablei	Narrabarba Wattle	V	V	K
Acacia georgensis	Bega Wattle	V	V	K
Ammobium craspedioides	Yass Daisy	V	V	K
Argyrotegium nitidulum	Shining Cudweed	V	V	9
Astrotricha sp. Wallagaraugh	Merimbula Star-hair	E1		K
Baloskion longipes	Dense Cord-rush	V	V	K
Boronia deanei	Deane's Boronia	V,P	V	K
Bossiaea bombayensis	Bombay Bossiaea	V		K
Bossiaea oligosperma	Few-seeded Bossiaea	V	V	P
Caladenia concolor	Crimson Spider Orchid	E1,P,2	V	P
Caladenia montana	Mountain Spider Orchid	V,P,2		P
Caladenia tessellata	Thick Lip Spider Orchid	E1,P,2	V	P
Calotis glandulosa	Mauve Burr-daisy	V	V	281
Calotis pubescens	Max Mueller's Burr-daisy	E1		25
Carex archeri	Archer's Carex	E1		2
Carex raleighii	Raleigh Sedge	E1		10
Commersonia prostrata	Dwarf Kerrawang	E1	E	K
Correa baeuerlenii	Chef's Cap Correa	V	V	K
Correa lawrenceana var. *genoensis*	Genoa River Correa	E1	E	9
Cryptostylis hunteriana	Leafless Tongue Orchid	V,P,2	V	K
Dampiera fusca	Kydra Dampiera	E1		103
Dillwynia glaucula	Michelago Parrot-pea	E1		17
Dillwynia tenuifolia		V		1
Discaria nitida	Leafy Anchor Plant	V		38
Distichlis distichophylla	Australian Saltgrass	E1		K
Diuris aequalis	Buttercup Doubletail	E1,P,2	V	K
Diuris ochroma	Pale Golden Moths	E1,P,2	V	61
Diuris ochroma	Pale Golden Moths	E1,P,2	V	
Dodonaea procumbens	Creeping Hop-bush	V	V	83
Eriocaulon australasicum	Austral Pipewort	E1	E	P
Eucalyptus aggregata	Black Gum	V	V	24
Eucalyptus imlayensis	Imlay Mallee	E4A,3	E	K
Eucalyptus kartzoffiana	Araluen Gum	V	V	1
Eucalyptus parvula	Small-leaved Gum	E1	V	197

Eucalyptus pulverulenta	Silver-leafed Gum	V	V	83
Eucalyptus saxatilis	Suggan Buggan Mallee	E1		18
Euphrasia collina subsp. *muelleri*	Mueller's Eyebright	E1	E	P
Euphrasia scabra	Rough Eyebright	E1,3		94
Galium australe	Tangled Bedstraw	E1		K
Genoplesium rhyoliticum	Rhyolite Midge Orchid	E1,P,2	E	K
Genoplesium vernale	East Lynne Midge Orchid	V,P,2	V	K
Gentiana baeuerlenii	Baeuerlen's Gentian	E1	E	2
Gentiana bredboensis	Bredbo Gentian	E4A,2	V	6
Gentiana bredboensis	Bredbo Gentian	E4A,2	V	
Glycine latrobeana		E4A	V	7
Grevillea acanthifolia subsp. *paludosa*	Bog Grevillea	E1	E	K
Grevillea iaspicula	Wee Jasper Grevillea	E4A,2	E	K
Haloragis exalata subsp. *exalata*	Square Raspwort	V	V	K
Irenepharsus magicus	Elusive Cress	E1		P
Leionema ralstonii	Ralston's Leionema	V	V	K
Lepidium hyssopifolium	Aromatic Peppercress	E1	E	2
Leptospermum thompsonii	Monga Tea Tree	V	V	K
Leucochrysum albicans var. *tricolor*	Hoary Sunray		E	151
Lysimachia vulgaris var. *davurica*	Yellow Loosestrife	E1,3		K
Mixophyes balbus	Stuttering Frog	E1,P,2	V	
Monotaxis macrophylla	Large-leafed Monotaxis	E1		K
Monotoca rotundifolia	Trailing Monotoca	E1		6
Nematolepis rhytidophylla	Nalbaugh Nematolepis	V	V	K
Pelargonium sp. *striatellum*	Omeo Storksbill	E1	E	9
Persicaria elatior	Tall Knotweed	V	V	K
Plinthanthesis rodwayi	Budawangs Wallaby Grass	E4A	V	K
Pomaderris bodalla	Bodalla Pomaderris	V		K
Pomaderris cotoneaster	Cotoneaster Pomaderris	E1	E	3
Pomaderris elachophylla	Lacy Pomaderris	E1		27
Pomaderris gilmourii var. *cana*	Grey Deua Pomaderris	V	V	K
Pomaderris pallida	Pale Pomaderris	V	V	77
Pomaderris parrisiae	Parris' Pomaderris	V	V	4
Prasophyllum bagoense		E4A,P,2	CE	K
Prasophyllum canaliculatum	Summer Leek Orchid	E4A,P,2		
Prasophyllum innubum	Brandy Marys Leek Orchid	E4A,P,2	CE	K
Prasophyllum keltonii	Kelton's Leek Orchid	E4A,P,2	CE	K
Prasophyllum petilum	Tarengo Leek Orchid	E1,P,2	E	
Prasophyllum retroflexum	Kiandra Leek Orchid	V,P,2	V	
Prasophyllum sp. Majors Creek	Majors Creek Leek Orchid	E4A,P,2		
Pseudanthus ovalifolius	Oval-leafed Pseudanthus	E1		P
Pterostylis alpina	Mountain Greenhood	V,P,2		1
Pterostylis foliata	Slender Greenhood	V,P,2		K

Pterostylis oreophila	Blue-tongued Greenhood	E4A,P,2	CE	4
Pterostylis oreophila	Blue-tongued Greenhood	E4A,P,2	CE	
Pultenaea parrisiae	Parris' Bush-pea	V	V	24
Pultenaea pedunculata	Matted Bush-pea	E1		K
Ranunculus anemoneus	Anemone Buttercup	V	V	169
Rutidosis leiolepis	Monaro Golden Daisy	V	V	50
Rutidosis leptorrhynchoides	Button Wrinklewort	E1	E	6
Rytidosperma pumilum	Feldmark Grass	V	V	6
Rytidosperma vickeryae	Perisher Wallaby-grass	E1		16
Senecio garlandii	Woolly Ragwort	V		P
Senecio macrocarpus			V	K
Senecio spathulatus	Coast Groundsel	E1		K
Swainsona recta	Small Purple-pea	E1	E	11
Swainsona sericea	Silky Swainson-pea	V		216
Thelymitra alpicola		V,P,2		K
Thelymitra atronitida	Black-hooded Sun Orchid	E4A,P,2		K
Thesium australe	Austral Toadflax	V	V	15
Viola cleistogamoides	Hidden Violet	E1,3		K
Westringia davidii	David's Westringia	V	V	K
Westringia kydrensis	Kydra Westringia	E1	E	59
Wilsonia backhousei	Narrow-leafed Wilsonia	V		K
Wilsonia rotundifolia	Round-leafed Wilsonia	E1		K
Xerochrysum palustre	Swamp Everlasting		V	99
Zieria adenophora	Araluen Zieria	E4A,2	E	K
Zieria buxijugum	Box Range Zieria	E4A,2	E	K
Zieria citriodora	Lemon Zieria	E1	V	6
Zieria formosa	Shapely Zieria	E4A,2	E	K
Zieria parrisiae	Parris' Zieria	E4A,2	CE	K
Zieria tuberculata	Warty Zieria	V	V	K

Appendix E Inventories for Biodiversity Corridors

CRITERIA_ID_Value	Snowy Monaro LGA	Biodiversity Corridor "West"	Biodiversity Corridor "South East"	Biodiversity Corridor "North East"	Biodiversity Corridor "Central East"	Berridale	Bombala	Cooma	Crackenback	Michelago	Smiths Road
CRIT_1a_Conservation Reserve	1472										
CRIT_1a_Flora Reserve	497			497							
CRIT_1a_Heritage River	3			1	2						
CRIT_1a_National Park	378160	20459	7109	19985	330587				3		
CRIT_1a_Nature Reserve	47341	15069	8709	10397	10736			128			
CRIT_1a_Protected Area	3558	699		360	2489						
CRIT_1a_Reference Area	2										
CRIT_1a_Remote and Natural Area - Schedule 6, National Parks Act	3				3						
CRIT_1a_State Conservation Area	6517	2291	4214								
CRIT_1a_Wilderness Zone	68			10	58						
CRIT_1b_State Forest	66144	10135	463	50368	2809						
CRIT_1c_Scenic Protection	10866	335	103	289				462		788	
CRIT_1c_Scenic Protection Areas	49030				12245				6447		
CRIT_1d_Biobanking agreement	665			468							
CRIT_1d_Conservation agreement	4385	905	27		569					860	
CRIT_1d_Crown Reserves	9329	324	83	881	1155	70	115	176			
CRIT_1d_Declared Wilderness	1				0						
CRIT_1d_NPWS Estate	2	0			2						

CRIT_1d_NPWS Vested	158	107			0		0				
CRIT_1d_Quidong NR (acquired not gazetted)	180			0							
CRIT_1d_Registered Property Agreement	20				20						
CRIT_2a_Old Growth	36397	14872	3609	439	5388	123	47		497	108	22
CRIT_2a_Rainforest	4		0								
CRIT_2a_Riparian vegetation of rivers	35963	4556	1117	3496	4008	258	268	160	221	344	143
CRIT_2b_Sensitive Regulated Lands	58475	21228	4094	1569	6402	4	83	10	0	1046	
CRIT_2c_Vulnerable Regulated Lands	88698	16332	2593	6270	17328	0	332	56	0	1353	
CRIT_2d_Bangalay Sand Forest - very coastal	456			456							
CRIT_2d_Box Gum Woodland	2										
CRIT_2d_Dry Rainforest of SE Forests	63			63							
CRIT_2d_Lowland Grassy Woodland	1134			549	21		6				
CRIT_2d_Montane Peatlands of the Australian Alps	6474			6014			2				
CRIT_2d_Natural Temperate Grassland and Themeda Grassland	3769			1112	9		69				
CRIT_2d_Ribbon Gum Mountain Gum Snow Gum Grassy Woodland / Forest	6427			3431			312				
CRIT_2d_River Flat Eucalypt forest on Coastal Floodplain	69			57							
CRIT_2d_Swamp Oak Floodplains	315			298							
CRIT_2d_Tableland Basalt Forest	3971			2208							
CRIT_2d_Windswept Feldmark of the Australian Alps region	1165			817			108				
CRIT_2e_Araluen Scarp Grassy Forest	202	17	42								
CRIT_2e_Bangalay Sand Forest - very coastal	115		6	12							
CRIT_2e_Box Gum Woodland	31				0						13
CRIT_2e_Coastal Saltmarsh	2										
CRIT_2e_Dry Rainforest of SE Forest	35153	30015	2281		119						
CRIT_2e_Lowland Grassy Woodland	26883	11717	59		1576					396	
CRIT_2e_Montane Peatlands of the Australian Alps	183		51	72							
CRIT_2e_Montane Peatlands of the Australian Alps / Alpine Bogs	9018	473			8493						
CRIT_2e_Natural Temperate Grassland and Themeda Grassland	5155	10	6		311			32		34	

CRIT_2e_Ribbon Gum Mountain Gum Snow Gum Grassy Woodland / Forest	33458	8223	8022	160	6458			218			
CRIT_2e_River Flat Eucalypt forest on Coastal Floodplain	156	33								25	46
CRIT_2e_Tableland Basalt Forest	4134		2757	468							
CRIT_2e_Windswept Feldmark of the Australian Alps region	1323	32	1287								
CRIT_2f_Candidate Native Grasslands	446959	4472	3557	11969	40493	4703	3576	2777	1262	3867	1020
CRIT_2g_Tablelands Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland in the South Eastern Highlands, Sydney Basin, South East Corner and NSW South Western Slopes Bioregions	0										
CRIT_2h_Box Gum Woodland	8				6						
CRIT_2h_Dry Rainforest of SE Forest	7428				7428						
CRIT_2h_Lowland Grassy Woodland	18589			622	13684	30			1488		
CRIT_2h_Montane Peatlands of the Australian Alps / Alpine Bogs	46734				46564				1		
CRIT_2h_Natural Temperate Grassland and Themeda Grassland	1906			100	523	17		33	37		
CRIT_2h_Ribbon Gum Mountain Gum Snow Gum Grassy Woodland / Forest	71490			340	66873	299		82			
CRIT_2i_Araluen Scarp Grassy Forest	202	17	42								
CRIT_2i_Bangalay Sand Forest - very coastal	571		6	468							
CRIT_2i_Box Gum Woodland	40				6						13
CRIT_2i_Coastal Saltmarsh	2										
CRIT_2i_Dry Rainforest of SE Forest	42581	30015	2281		7547						
CRIT_2i_Dry Rainforest of SE Forests	63			63							
CRIT_2i_Lowland Grassy Woodland	46605	11717	59	1171	15280	30	6		1488	396	
CRIT_2i_Montane Peatlands of the Australian Alps	6657		51	6086			2				
CRIT_2i_Montane Peatlands of the Australian Alps / Alpine Bogs	55753	473			55056				1		
CRIT_2i_Natural Temperate Grassland and Themeda Grassland	10830	10	6	1212	843	17	69	65	37	34	
CRIT_2i_Ribbon Gum Mountain Gum Snow Gum Grassy Woodland / Forest	111375	8223	8022	3931	73331	299	312	300			

CRIT_2i_River Flat Eucalypt forest on Coastal Floodplain	226	33		57						25	46
CRIT_2i_Swamp Oak Floodplains	315			298							
CRIT_2i_Tableland Basalt Forest	8105		2757	2676							
CRIT_2i_Windswept Feldmark of the Australian Alps region	2488	32	1287	817			108				
CRIT_2i_Araluen Scarp Grassy Forest	202	17	42								
CRIT_2i_Bangalay Sand Forest - very coastal	571		6	468							
CRIT_2i_Box Gum Woodland	40				6						13
CRIT_2i_Coastal Saltmarsh	2										
CRIT_2i_Dry Rainforest of SE Forest	42581	30015	2281		7547						
CRIT_2i_Dry Rainforest of SE Forests	63			63							
CRIT_2i_Lowland Grassy Woodland	46605	11717	59	1171	15280	30	6		1488	396	
CRIT_2i_Montane Peatlands of the Australian Alps	6657		51	6086			2				
CRIT_2i_Montane Peatlands of the Australian Alps / Alpine Bogs	55753	473			55056				1		
CRIT_2i_Natural Temperate Grassland and Themeda Grassland	10830	10	6	1212	843	17	69	65	37	34	
CRIT_2i_Ribbon Gum Mountain Gum Snow Gum Grassy Woodland / Forest	111375	8223	8022	3931	73331	299	312	300			
CRIT_2i_River Flat Eucalypt forest on Coastal Floodplain	226	33		57						25	46
CRIT_2i_Swamp Oak Floodplains	315			298							
CRIT_2i_Tableland Basalt Forest	8105		2757	2676							
CRIT_2i_Windswept Feldmark of the Australian Alps region	2488	32	1287	817			108				
CRIT_2j_Box Gum Woodland	5747			2147	494						
CRIT_2j_Mitchell	5836			3301							
CRIT_2j_Natural Temperate Grasslands	22196			2168			424				
CRIT_2j_Secondary Grassland - Box Gum Derived	469			12							
CRIT_2j_Secondary Grassland - Snowgum Derived	39367			3821	4		1804				
CRIT_2j_Snowgum Woodland	2279			877							
CRIT_2j_Sub-alpine Bog	69			0			6				

CRIT_2j_Threatened species habitat	204						6				
CRIT_3a_EPI Terrestrial Biodiversity	591965	37958	24881	19378	312286	3135	2248	2193	6540	551	26
CRIT_3b_NSW HEV Criteria 2.1, 2.2, 2.3 and 3.2 combined	330946	45108	16224	17847	62840	2910	2957	1652	5396	517	20
CRIT_3c_Threatened Species Prediction (Priday)	304948	126321	40382	2704	1034			3849		2780	1273
CRIT_3d_EEC_BoxGum	677	257								109	10
CRIT_3d_EEC_MountainSwamp	49		6								
CRIT_3d_EEC_NTG	15540	1	3	388	0			410		102	
CRIT_3d_EEC_SnowGum	80538	21237	22172	314	738			947		320	13
CRIT_3e_Threatened Species Prediction (Priday)	14327				4920						
CRIT_3f_EEC_MountainSwamp	678				78						
CRIT_3f_EEC_NTG	462				73						
CRIT_3f_EEC_SnowGum	3643				1230						
CRIT_3g_Threatened Species Prediction (Priday)	101864			5333	62647	1167		175	5627		
CRIT_3h_EEC_MPS_Predicted1	194				190				139		
CRIT_3h_EEC_NTG_Predicted1	14588			5	1258	906		104	56		
CRIT_3h_EEC_TGW_Predicted1	66072			2248	19291	1622		303	2292		
CRIT_3h_EEC_UPWET_Predicted1	653				2	49					
CRIT_3i_Lowland Grassy Woodland in the South East Corner Bioregion	2844			2363							
CRIT_3i_Lowland Rainforest in the NSW North Coast and Sydney Basin Bioregions	18	18									
CRIT_3i_Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps bioregions	31230	980	256	5689	21889				63	50	
CRIT_3i_Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory	109585	2508	535	4465	6410	2588	614	1595	379	478	130
CRIT_3i_River-Flat Eucalypt Forest on Coastal Floodplains of the New South Wales North Coast, Sydney Basin and South East Corner Bioregions	79	6		57							

CRIT_3i_Robertson Basalt Tall Open Forest in the Sydney Basin Bioregion	439			439							
CRIT_3i_Tableland Basalt Forest in the Sydney Basin and South Eastern Highlands Bioregions	111261	15625	5526	7208	63054	0	20		3258		
CRIT_3i_Tablelands Snow Gum, Black Sallee, Candlebark and Ribbon Gum Grassy Woodland in the South Eastern Highlands, Sydney Basin, South East Corner and NSW South Western Slopes Bioregions	91857	1762	11584	15322	29026	1	561		2179		
CRIT_3i_White Box Yellow Box Blakelys Red Gum Woodland	43057	3718		1489	34907					308	
CRIT_3j_Alpine Redspot Dragonfly	7791				7673				83		
CRIT_3j_Macquarie Perch	3610	315			1356					170	20
CRIT_3j_Murray Crayfish	2091	266								511	59
CRIT_3j_River Blackfish	2771			426	501				17		
CRIT_3j_Southern Pygmy Perch	2331	446	134					77			
CRIT_3j_Stocky Galaxias	42				42						
CRIT_3j_Trout Cod	1092	89								170	20
CRIT_3k_Koala Populations	22094	14672	6208								
CRIT_3l_Aprasia parapulchella	13										
CRIT_3l_Argyrotegium nitidulum	19				19						
CRIT_3l_Burramys parvus	3677				3677						
CRIT_3l_Calotis glandulosa	3383				606	9		321			
CRIT_3l_Cyclodomorphus praealtus	41				41						
CRIT_3l_Delma impar	56			8	3			5			
CRIT_3l_Diuris lanceolata	3			3							
CRIT_3l_Dodonaea procumbens	382		2	27			3			35	
CRIT_3l_Eucalyptus aggregata	122	92									
CRIT_3l_Eucalyptus nicholii	12										
CRIT_3l_Eucalyptus parvula	1601			74							
CRIT_3l_Eucalyptus pulverulenta	31	19									
CRIT_3l_Glycine latrobeana	49				49						
CRIT_3l_Heleioporus australiacus	5			5							
CRIT_3l_Liopholis guthega	3789				3672						
CRIT_3l_Litoria raniformis	6				6						

CRIT_3l_Pelargonium Striatellum	5										
CRIT_3l_Petauroides volans	2729	1241		1377	6						
CRIT_3l_Pomaderris pallida	1121	116	190		22					689	9
CRIT_3l_Pomaderris parrisiae	26		26								
CRIT_3l_Pseudomys fumeus	3				3						
CRIT_3l_Pteropus poliocephalus	17						14	3			
CRIT_3l_Pterostylis chlorogramma	3										
CRIT_3l_Pultenaea parrisiae	211		61	148							
CRIT_3l_Ranunculus anemoneus	469				469						
CRIT_3l_Rutidosis leiolepis	196				77						
CRIT_3l_Rutidosis leptorhynchoides	44									13	
CRIT_3l_Rytidosperma pumilum	3				3						
CRIT_3l_Swainsona recta	69										
CRIT_3l_Thelymitra cyanapicata	3		3								
CRIT_3l_Thesium australe	43			6							
CRIT_3l_Tympanocryptis pinguicolla	793			35							
CRIT_3l_Westringia kydrensis	940		470	470							
CRIT_3l_Xerochrysum palustre	5794	28	8	5637	29						
CRIT_3l_Zieria citriodora	15	4	10								
CRIT_3m_Aprasia parapulchella	13										
CRIT_3m_Argyrotegium nitidulum	16				16						
CRIT_3m_Artamus cyanopterus cyanopterus	238	3	28	42	68			6	1	9	
CRIT_3m_Burramys parvus	4283				4283						
CRIT_3m_Callocephalon fimbriatum	1521	849	35	138	319		3	9	3		
CRIT_3m_Calotis glandulosa	2993				546	6		255			
CRIT_3m_Calotis pubescens	78				78						
CRIT_3m_Calyptorhynchus lathami	3		3								
CRIT_3m_Carex raleighii	22				22						
CRIT_3m_Cercartetus nanus	44	13	6		25						
CRIT_3m_Chthonicola sagittata	63	6	5	27	6						
CRIT_3m_Circus assimilis	9										
CRIT_3m_Climacteris picumnus victoriae	162	5	14	29	35		3	3			

CRIT_3m_Correa lawrenceana var. genoensis	22			22							
CRIT_3m_Cyclodomorphus praealtus	258				258						
CRIT_3m_Dampiera fusca	309	6	62	234							
CRIT_3m_Daphoenositta chrysoptera	91	13	13	35	16						
CRIT_3m_Dasyurus maculatus	1239	434	19	8	759						
CRIT_3m_Delma impar	54			8	3			6			
CRIT_3m_Dillwynia glaucula	25	3	10							12	
CRIT_3m_Discaria nitida	38				38						
CRIT_3m_Diuris ochroma	211				50						
CRIT_3m_Dodonaea procumbens	268		2	15			3			34	
CRIT_3m_Eucalyptus aggregata	126	94						3			
CRIT_3m_Eucalyptus parvula	1866	1	60	276							
CRIT_3m_Eucalyptus pulverulenta	122	25		85							
CRIT_3m_Eucalyptus saxatilis	25				23						
CRIT_3m_Euphrasia scabra	2637			2610							
CRIT_3m_Falco subniger	3										
CRIT_3m_Falsistrellus tasmaniensis	507	9		0	484						
CRIT_3m_Gentiana bredboensis	6										
CRIT_3m_Glycine latrobeana	49				49						
CRIT_3m_Haliaeetus leucogaster	30			5	4					13	
CRIT_3m_Heleioporus australiacus	3			3							
CRIT_3m_Hieraaetus morphnoides	40		6		9						
CRIT_3m_Isoodon obesulus obesulus	9			9							
CRIT_3m_Lepidium hyssopifolium	3										
CRIT_3m_Leucochrysum albicans var. tricolor	523	3	0	11	20			60		3	
CRIT_3m_Liopholis guthega	4959				4853						
CRIT_3m_Litoria verreauxii alpina	815				813						
CRIT_3m_Mastacomys fuscus	1068				1036						
CRIT_3m_Melanodryas cucullata cucullata	74		3	6	6						
CRIT_3m_Melithreptus gularis gularis	3										
CRIT_3m_Miniopterus orianae oceanensis	87		3	3	24						
CRIT_3m_Monotoca rotundifolia	16	1	13								

CRIT_3m_Myotis macropus	6				3						
CRIT_3m_Neophema pulchella	16		9		3						
CRIT_3m_Ninox connivens	3				3						
CRIT_3m_Ninox strenua	136	43		66	10						
CRIT_3m_Pachycephala olivacea	343	80	3	26	234				4		
CRIT_3m_Pelargonium sp. Striatellum	21										
CRIT_3m_Petauroides volans	3163	1050	18	2002	6						
CRIT_3m_Petaurus australis	287	3		245	19						
CRIT_3m_Petaurus norfolcensis	3										
CRIT_3m_Petroica boodang	630	41	33	258	96			3	0		
CRIT_3m_Petroica phoenicea	1331	56	19	89	918				6		
CRIT_3m_Petroica rodinogaster	32	3	3		25				0		
CRIT_3m_Phascolarctos cinereus	1243	683	501		50						
CRIT_3m_Polytelis swainsonii	3	3									
CRIT_3m_Pomaderris cotoneaster	4			4							
CRIT_3m_Pomaderris elachophylla	75		3	45							
CRIT_3m_Pomaderris pallida	1116	105	181		54					676	
CRIT_3m_Pomaderris parrisiae	25		25								
CRIT_3m_Potorous tridactylus	13	3		9							
CRIT_3m_Prasophyllum canaliculatum	287			287							
CRIT_3m_Prasophyllum petilum	44										
CRIT_3m_Prasophyllum retroflexum	9				9						
CRIT_3m_Pseudomys fumeus	3				3						
CRIT_3m_Pteropus poliocephalus	17						14	3			
CRIT_3m_Pterostylis alpina	3				3						
CRIT_3m_Pterostylis oreophila	3				3						
CRIT_3m_Pultenaea parrisiae	211		61	148							
CRIT_3m_Ranunculus anemoneus	703				701						
CRIT_3m_Rutidosis leiolepis	191				73			6			
CRIT_3m_Rutidosis leptorrhynchoides	28									6	
CRIT_3m_Rytidosperma pumilum	3				3						
CRIT_3m_Rytidosperma vickeryae	69				65						

CRIT_3m_Saccolaimus flaviventris	3				3						
CRIT_3m_Scoteanax rueppellii	3			3							
CRIT_3m_Sminthopsis leucopus	6			6							
CRIT_3m_Stagonopleura guttata	95	3	3	9	18		3	3	4	13	
CRIT_3m_Stictonetta naevosa	10				3						
CRIT_3m_Suta flagellum	22							6			
CRIT_3m_Swainsona recta	66										
CRIT_3m_Swainsona sericea	624	13	3	9	9	3		22		23	3
CRIT_3m_Thesium australe	49			6							
CRIT_3m_Tympanocryptis pinguicolla	752			34							
CRIT_3m_Tyto novaehollandiae	25	3		16	3						
CRIT_3m_Tyto tenebricosa	36	6		30							
CRIT_3m_Varanus rosenbergi	10	3									
CRIT_3m_Westringia kydrensis	912	6	474	432							
CRIT_3m_Xerochrysum palustre	3205	21	8	3098	27						
CRIT_3n_Calyptorhynchus lathami	3		3								
CRIT_3n_Diuris ochroma	1250				50						
CRIT_3n_Gentiana bredboensis	6										
CRIT_3n_Prasophyllum canaliculatum	4359			4359							
CRIT_3n_Prasophyllum petilum	44										
CRIT_3n_Prasophyllum retroflexum	13				13						
CRIT_3n_Pterostylis alpina	3				3						
CRIT_3n_Pterostylis oreophila	3				3						
CRIT_3o_Artamus cyanopterus cyanopterus	100	3	1	31	28		3				
CRIT_3o_Burramys parvus	1609				1609						
CRIT_3o_Callocephalon fimbriatum	495	58	26	100	256		9				
CRIT_3o_Calotis glandulosa	224				6			3			
CRIT_3o_Calyptorhynchus lathami	13				13						
CRIT_3o_Carex raleighii	4				3						
CRIT_3o_Cercartetus nanus	16	3			10	2			6		
CRIT_3o_Chthonicola sagittata	14				12						
CRIT_3o_Circus assimilis	3										

CRIT_3o_Climacteris picumnus victoriae	61	1	3		42						
CRIT_3o_Correa lawrenceana var. genoensis	6			6							
CRIT_3o_Cyclodomorphus praealtus	63				54						
CRIT_3o_Dampiera fusca	23		23								
CRIT_3o_Daphoenositta chrysoptera	73	6		25	19						
CRIT_3o_Dasyurus maculatus	90	46		3	32		3				
CRIT_3o_Delma impar	6										
CRIT_3o_Dillwynia glaucula	42		3							33	
CRIT_3o_Discaria nitida	50				43				2		
CRIT_3o_Dodonaea procumbens	142			1							
CRIT_3o_Epthianura albifrons	9				3		6				
CRIT_3o_Eucalyptus aggregata	13	3									
CRIT_3o_Eucalyptus parvula	60	1	3								
CRIT_3o_Eucalyptus pulverulenta	66	35	3	22	3						
CRIT_3o_Eucalyptus saxatilis	22				22						
CRIT_3o_Euphrasia scabra	5			5							
CRIT_3o_Falsistrellus tasmaniensis	201	13	19	28	139						
CRIT_3o_Glossopsitta pusilla	3				2						
CRIT_3o_Haliaeetus leucogaster	9		3		3						
CRIT_3o_Heleioporus australiacus	6			6							
CRIT_3o_Hieraaetus morphnoides	19				6		3				
CRIT_3o_Isoodon obesulus obesulus	3			3							
CRIT_3o_Leucochrysum albicans var. tricolor	177							9			
CRIT_3o_Liopholis guthega	501				418						
CRIT_3o_Litoria booroolongensis	9			6							
CRIT_3o_Litoria raniformis	6			3							
CRIT_3o_Litoria verreauxii alpina	6				3						
CRIT_3o_Lophoictinia isura	3										
CRIT_3o_Mastacomys fuscus	727				725						
CRIT_3o_Melanodryas cucullata cucullata	23			6	7						
CRIT_3o_Miniopterus orianae oceanensis	60	9	3	3	44						
CRIT_3o_Myotis macropus	41			6	35						

CRIT_3o_Neophema chrysogaster	4				4						
CRIT_3o_Neophema pulchella	3										
CRIT_3o_Ninox strenua	195	3	17	162	3						
CRIT_3o_Oxyura australis	20										
CRIT_3o_Pachycephala olivacea	335	12		12	311						
CRIT_3o_Petauroides volans	1310	101	67	1123							
CRIT_3o_Petaurus australis	150	64	3	79							
CRIT_3o_Petaurus norfolcensis	34	27		6							
CRIT_3o_Petroica boodang	187	3	3	59	70		6				
CRIT_3o_Petroica phoenicea	1719	59	5	63	1517		3				
CRIT_3o_Petroica rodinogaster	19				16						
CRIT_3o_Phascolarctos cinereus	164	60	29	13	21		3				
CRIT_3o_Pomaderris cotoneaster	6			6							
CRIT_3o_Pomaderris elachophylla	36	3		15							
CRIT_3o_Pomaderris pallida	15	5	6								
CRIT_3o_Pomaderris parrisiae	3		3								
CRIT_3o_Potorous longipes	15			15							
CRIT_3o_Potorous tridactylus	9			9							
CRIT_3o_Pteropus poliocephalus	3						3				
CRIT_3o_Pultenaea parrisiae	17		17								
CRIT_3o_Ranunculus anemoneus	181				181						
CRIT_3o_Rutidosis leiolepis	80				14			16			
CRIT_3o_Scoteanax rueppellii	16			15							
CRIT_3o_Stagonopleura guttata	69			6	3		3				
CRIT_3o_Suta flagellum	6										
CRIT_3o_Swainsona recta	3										
CRIT_3o_Swainsona sericea	354	4			3	6		9			3
CRIT_3o_Tympanocryptis pinguicolla	166										
CRIT_3o_Tyto novaehollandiae	27			20	6						
CRIT_3o_Tyto tenebricosa	40	27		11							
CRIT_3o_Zieria citriodora	13	6	3								
CRIT_4a_Bogs and Fens	5152	120			4335				62		

CRIT_4b_Drinking Water Catchment Map	51958	29181									
CRIT_4b_Sydney Drinking Water Catchment Map	164	155									
CRIT_4c_Groundwater Vulnerability	84300	8435	9397		671			2154		3429	971
CRIT_4d_Riparian Lands	32806	6161	2936	387	3631			177		1253	182
CRIT_4d_Riparian Lands and Watercourses	69690	0		6205	21417	466	592	135	334		
CRIT_4e_Wetlands	46337			73	24572	52		2	166		
CRIT_4f_Vulnerable Protected Riparian Lands	56418	4069	1956	4353	16396	247	376	269	352	1146	104
CRIT_4g_Important Wetlands	919	67		2	241	1					
CRIT_4h_Ramsar Site	741				741						
CRIT_5a_Natural Resources Karst	568	105	23							44	58
CRIT_5a_Natural Resources Land	0	0									
CRIT_5a_Original Holdings Land	1										
CRIT_6a_Heritage	44693	2477	140	0	4349	681	12	172	182	114	
CRIT_7b_Flood Prone Land Map	124						124				
CRIT_7c_Landslide Risk	41102	17029	5835	158	4191			89		356	625
CRIT_7d_Strategic Agricultural Land Map	18998	64	28	114	30			11		883	
CRIT_7f_Flood Prone Land	130							130			
CRIT_8a_Identified Old Growth Forest	36319	14817	3559	423	5299	123	47		496	442	22
CRIT_8a_Identified Rainforest	121	53	40	25							
CRIT_8a_Land identified by Environment Agency Head	7623				7562						
CRIT_8a_Protected Riparian Land	42842	2680	978	3036	16244	0	216	46	196	717	71
CRIT_8a_Ramsar Wetlands	679				679						
CRIT_8a_Threatened species or communities with potential for serious and irreversible impacts	6590				184	79		635			
CRIT_8b_Box Gum Woodland	2129	2								14	2116
CRIT_8b_Natural Temperate Grassland and Themeda Grassland	676	0				223	156	82		216	
CRIT_8b_Ribbon Gum Grassy Woodland / Forest	49						35	14			
CRIT_8b_Ribbon Gum Mountain Gum Snow Gum Grassy Woodland / Forest	431					44	27	361			

CRIT_8b_Snow Gum Grassy Woodland / Forest	0						0				
CRIT_8c_Michelago Parrot Pea	7									7	
CRIT_8c_Pink Tail Worm Lizard Potential Habitat - Low Condition	9									9	
CRIT_8a_Identified Old Growth Forest	36319	14817	3559	423	5299	123	47		496	442	22
CRIT_8a_Identified Rainforest	121	53	40	25							
CRIT_8a_Land identified by Environment Agency Head	7623				7562						
CRIT_8a_Protected Riparian Land	42842	2680	978	3036	16244	0	216	46	196	717	71
CRIT_8a_Ramsar Wetlands	679				679						

Appendix F Document Review Bibliography

Note: The following documents were reviewed but not necessarily referenced in the report. The full list is presented here as they were considered as part of the literature review process and provided important Information underpinning the biodiversity assessment, which focuses on environmental values in the Snowy Monaro Shire. The social and economic overlay is not considered in the report but it is important contextual Information and highlights the value placed on biodiversity by stakeholders and the community.

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Submission Snowy Monaro Region Planning and Land Use Discussion Paper 2019 – Smith's Rd Community
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Appendix G SMES Data Sources

Spatial Dataset	URL	Data Source	NOTES
Biodiversity Predictions (by Steve Priday)		Snowy Monaro Regional Council	
Digital Cadastral Database (AdministraveBoundary, Localities, Lots, Roads, Railway, RiverCorridors, Suburbs)		Snowy Monaro Regional Council	
Digital Topographic Database (Waterbodies, DrainageLines, Roads)		Snowy Monaro Regional Council	
Study Areas (Future Urban Expansion)		Snowy Monaro Regional Council	
Vegetation Mapping (for former Bombala, CoomaMonaro, Snowy LGAs)		Snowy Monaro Regional Council	
High Environmental Values of the South East Tablelands Planning Region	https://datasets.seed.nsw.gov.au/dataset/south-east-tablelands-high-environmental-value-hev-	NSW Government, Department of Primary Industries (SEED Portal)	
Native Vegetation of the Cooma-Monaro Shire. VIS_ID 4064	https://datasets.seed.nsw.gov.au/dataset/native-vegetation-of-the-cooma-monaro-shire-vis_id-4064a0a1c	NSW Government, Department of Primary Industries (SEED Portal)	
NSW Administrative Boundaries	https://datasets.seed.nsw.gov.au/dataset/nsw-administrative-boundaries	NSW Government, Department of Primary Industries (SEED Portal)	WMS only
NSW Biodiversity Strategy 2010-2015 Priorities	https://datasets.seed.nsw.gov.au/dataset/nsw-biodiversity-strategy-2010-2015-prioritiesd86bc	NSW Government, Department of Primary Industries (SEED Portal)	
NSW BioNet Indicative Threatened Ecological Community, Population and Species Distributions	https://datasets.seed.nsw.gov.au/dataset/nsw-bionet-indicative-threatened-ecological-community-population-and-species-distributions49c07	NSW Government, Department of Primary Industries (SEED Portal)	
NSW Bionet Threatened Biodiversity Profile Data Collection	https://datasets.seed.nsw.gov.au/dataset/nsw-bionet-threatened-entity-profile-data-collection8f027	NSW Government, Department of Primary Industries (SEED Portal)	
NSW Environmental Planning Instruments	contact the SEED Data Broker via data.broker@environment.nsw.gov.au	NSW Government, Department of Primary Industries (SEED Portal)	SEED layers split; contact data broker for full set
NSW Hydrography	https://datasets.seed.nsw.gov.au/dataset/nsw-hydrography	NSW Government, Department of Primary Industries (SEED Portal)	
NSW Koala Habitat Information Base	https://datasets.seed.nsw.gov.au/dataset/koala-habitat-Information-base	NSW Government, Department of Primary Industries (SEED Portal)	
NSW Land and Soil Capability Mapping	https://datasets.seed.nsw.gov.au/dataset/land-and-soil-capability-mapping-for-nsw4bc12	NSW Government, Department of Primary Industries (SEED Portal)	
NSW National Parks and Wildlife Service (NPWS) Estate	https://datasets.seed.nsw.gov.au/dataset/nsw-national-parks-and-wildlife-service-npws-estate3f9e7	NSW Government, Department of Primary Industries (SEED Portal)	

NSW Regulated Rivers	https://datasets.seed.nsw.gov.au/dataset/regulated-rivers	NSW Government, Department of Primary Industries (SEED Portal)	
NSW State Forest	https://datasets.seed.nsw.gov.au/dataset/state-forest	NSW Government, Department of Primary Industries (SEED Portal)	
NSW Threatened Species & Communities	http://www.nswthreatenedspecies.net/	NSW Government, Department of Primary Industries (SEED Portal)	Generating Lists (Threatened entities)
NSW Vulnerable Lands - Special Category	https://datasets.seed.nsw.gov.au/dataset/vulnerable-land-special-category414af	NSW Government, Department of Primary Industries (SEED Portal)	
NSW Vulnerable Lands - Steep or Highly Erodible	https://datasets.seed.nsw.gov.au/dataset/vulnerable-land-steep-or-highly-erodiblefefeb	NSW Government, Department of Primary Industries (SEED Portal)	
NSW Wild River Catchments	https://datasets.seed.nsw.gov.au/dataset/nsw-wild-river-catchments06e59	NSW Government, Department of Primary Industries (SEED Portal)	
NSW Wild Rivers	https://datasets.seed.nsw.gov.au/dataset/nsw-wild-rivers501e0	NSW Government, Department of Primary Industries (SEED Portal)	
NVR Map - Vulnerable Regulated Land	contact the SEED Data Broker via data.broker@environment.nsw.gov.au	NSW Government, Department of Primary Industries (SEED Portal)	
South East Local Land Services Biometric vegetation map, 2014. VIS_ID 4211	https://datasets.seed.nsw.gov.au/dataset/south-east-local-land-services-biometric-vegetation-map-2014-vis_id-4211	NSW Government, Department of Primary Industries (SEED Portal)	
Southeast and Tablelands Regional Plan Corridors	https://datasets.seed.nsw.gov.au/dataset/http-webmap-environment-nsw-gov-au-planninghtml5viewer-viewer-seat-corridors	NSW Government, Department of Primary Industries (SEED Portal)	
Vulnerability of threatened species and ecological communities to climate change in NSW	https://datasets.seed.nsw.gov.au/dataset/vulnerability-of-threatened-species-and-ecological-communities-to-climate-change-in-nsw	NSW Government, Department of Primary Industries (SEED Portal)	Climate Vulnerability Assessment - Species traits
Werriwa/Monaro CEEC advisory layer	https://www.lmbc.nsw.gov.au/Maps/index.html?viewer=NVRmap	NSW Government, Department of Primary Industries (SEED Portal)	New CEEC (spatial data can be viewed, but not downloaded)
NSW Freshwater Threatened Species Distributions	https://webmap.industry.nsw.gov.au/Html5Viewer/index.html?viewer=Fisheries_Data_Portal	NSW Government, Department of Primary Industries (Fisheries)	contact NSW Fisheries for file geodatabase of all freshwater threatened species
NSW Freshwater Threatened Species Distributions	https://www.dpi.nsw.gov.au/fishing/species-protection/threatened-species-distributions-in-nsw/freshwater-threatened-species-distribution-maps	NSW Government, Department of Primary Industries (Fisheries)	KMZ online; contact Fisheries for .shp/.gdb

Biodiversity sightings for listed species in Snowy Monaro	register for login access to BioNet Atlas via https://www.environment.nsw.gov.au/atlaspublicapp/Registration.aspx	NSW Government, Department of Primary Industries (BioNet Atlas)	
Climate Refugia NSW	http://nswclimaterefugia.net/	NSW Government, AdaptNSW (Macquarie University)	Climate Impact Assessment - ID refugia
Climate-ready revegatation: A guide for natural resource managers. Version 2	https://www.mq.edu.au/research/research-centres-groups-and-facilities/secure-planet/centres/biodiversity-node/documents/Climate-Reveg-Guide-v2-2018.pdf	NSW Government, AdaptNSW (Macquarie University)	
AdaptNSW	https://climatechange.environment.nsw.gov.au/	NSW Government, AdaptNSW	climate projections, climate impacts, educational resources etc
Hydrologically Enforced Digital Elevation Model (DEM-H)	https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/72759	Geoscience Australia	
Biodiversity sightings for listed species in Snowy Monaro	https://doi.org/10.26197/5da6bc4a20065	CSIRO (Atlas of Living Australia)	
Helping Biodiversity Adapt: Supporting climate adaptation planning using a community-level modelling approach	https://adaptnrm.csiro.au/wp-content/uploads/2015/06/AdaptNRM_M4_BiodiversityAdaption_screen.pdf	CSIRO (AdaptNRM)	Strategic guidance with data & maps
The Biodiversity Adaptation Toolbox	https://adaptnrm.csiro.au/biodiversity-options/the-biodiversity-adaptation-toolbox/	CSIRO (AdaptNRM)	Strategic principles, goals and actions for managing biodiversity under climate change
Australia - Ecological Communities of National Environmental Significance Database (Public Grids)	https://www.environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7B184A3793-2526-48F4-A268-5406A2BE85BC%7D	Australian Government, Department of Environment and Energy	
Australia - Species of National Environmental Significance Database	https://www.environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7B163F2377-7849-4109-9752-D37DA873CE49%7D	Australian Government, Department of Environment and Energy	
Collaborative Australian Protected Areas Database (CAPAD) 2018 - Terrestrial	http://www.environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7B4448CACD-9DA8-43D1-A48F-48149FD5FCFD%7D	Australian Government, Department of Environment and Energy	
Directory of Important Wetlands in Australia (DIWA) Spatial Database	https://www.environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7BED248FC1-7237-4A74-91AC-2DA3FC277E0A%7D	Australian Government, Department of Environment and Energy	

National Vegetation Information System (NVIS) Version 5.1 - AUSTRALIA - Estimated Pre-1750 Vegetation	http://environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7BB26A2C5D-5964-4EE4-BA29-8DAA7C90ABA2%7D	Australian Government, Department of Environment and Energy	
National Vegetation Information System (NVIS) Version 5.1 - AUSTRALIA - Extant Vegetation	http://environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7Bab942d6d-9efd-4cf2-bec7-4c1521b83803%7D	Australian Government, Department of Environment and Energy	
National Vegetation Information System (NVIS) Version 5.1 Lookup Table - Australia - Extant and Estimated Pre-1750 Vegetation Types	http://environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7BA46EB156-5065-485A-9413-919AA4A60097%7D	Australian Government, Department of Environment and Energy	
National Vegetation Information System (NVIS) Version 5.1 Lookup Table - Australia - Extant and Estimated Pre-1750 Vegetation Types Flat File	http://environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7BBB53C501-C51B-4974-9FBF-F4EEBE50D291%7D	Australian Government, Department of Environment and Energy	
NSW - CRA/RFA - Forests - All Regions - National Estate - Geoheritage Places	https://www.environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7B4B909C13-3528-495F-A95E-94326EB7308A%7D	Australian Government, Department of Environment and Energy	
Protected Matters Search Tool	http://www.environment.gov.au/epbc/protected-matters-search-tool	Australian Government, Department of Environment and Energy	Generating Lists (MNES)

Appendices H – L Attachments from SPRAT Searches

The following Appendices have been supplied with the report as pdf Attachments. They are the results of SPRAT searches for Matters of National Environmental Significance (MNES) in the respective township areas.

APPENDIX H: SPRAT COOMA

APPENDIX I: SPRAT MICHELAGO

APPENDIX J: SPRAT BERRIDALE

APPENDIX K: SPRAT BOMBALA

APPENDIX L: SMITHS ROAD

Appendix F:
Kalkite Road Safety Review

Member of the Surbana Jurong Group

Technical Memorandum

Memo No.	01	**Date of Issue**	21 December 2023
Subject	Kalkite Road Preliminary Road Safety Review	**Discipline**	Roads and Highways
Project Title	Kalkite Infrastructure Study	**Project No.**	3002881
Document No.	-	**Revision**	02
Author	Oliver Emary, Doug Tonge		
Reviewed by	Ian Obrien	**Approved by**	Oliver Emary
Prepared for	Snowy Monaro Regional Council	**Attention to**	Gina McConkey
Attachments	None		

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3. Safety Review....8

4. Kalkite Access....25

5. Recommendations....27

1. Introduction

1.1 Project Objectives

An Infrastructure Study of Kalkite in the Snowy Monaro Regional Council (SMRC) area has been developed to assess the infrastructure required to facilitate the additional development in the township. The anticipated growth of Kalkite is being delivered primarily through two major developments either planned or underway. A Planning Proposal has been lodged to rezone land from RU1 Primary Production to RU5 Village and C4 Environmental Living and would deliver 220 lots to Kalkite. An approved subdivision located east of Kalkite would provide an additional 43 lots. The Snowy Monaro Draft Settlement Strategy 2022 (the Draft Settlement Strategy) notes that whilst Kalkite is not incorporated within the Snowy Mountains SAP, approximately 10% of growth is expected to occur outside of Jindabyne in smaller villages such as Kalkite.

The Infrastructure Study provides analysis and recommendations in consideration of the expected population growth to ensure that infrastructure is of sufficient capacity to meet the demands of future residents. With increasing development interest in Kalkite, there is a need to understand the capacity of essential infrastructure and plan for augmentation to provide certainty and confidence for the sustainable development of the town. The Infrastructure Assessment considers:

1. The future possible road network for Kalkite's growth areas and transport implications of the development
2. Required infrastructure network upgrades to service the additional demand anticipated by development across electricity, potable water supply, sewer, and stormwater.
3. Consideration of road safety of Kalkite Road.

This Technical Memorandum aims to address the requirements of Item 3 above.

This Memorandum is confidential and is intended for the addressee only. If you have received this Memorandum in error, please contact the sender.

1.2 Project Location and Key Features

The township of Kalkite is located in the SMRC Local Government Area (LGA) approximately 21km southeast of Jindabyne and 56km southwest of Cooma along the eastern shore of Lake Jindabyne. Primary access to Kalkite is provided by Kalkite Road which is a two-lane sealed road connecting to Kosciuszko Road (via Eucumbene Road) which runs in a north-south direction approximately 5km east of the township. The location of Kalkite shown in orange in Figure 1.

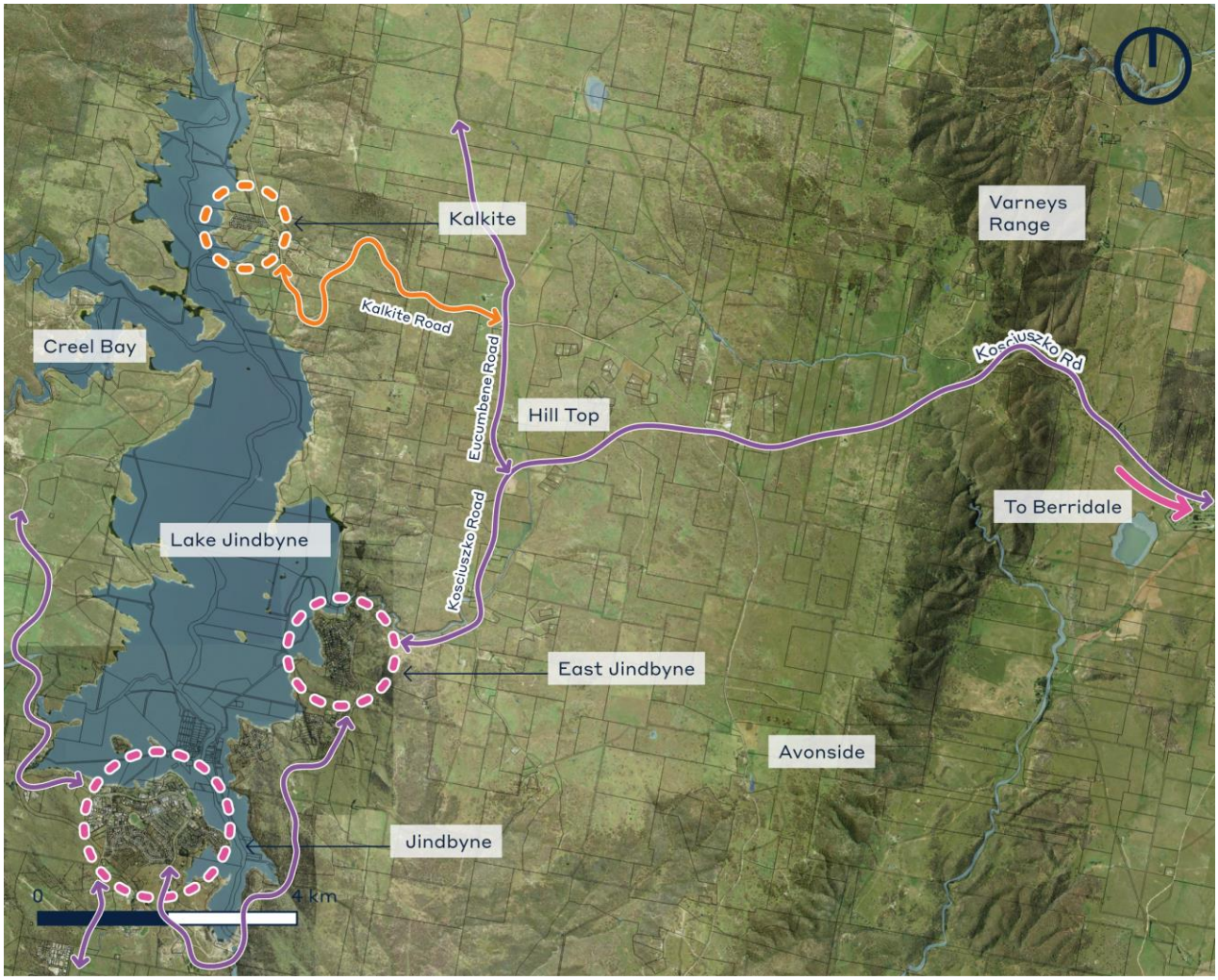


Figure 1 | Kalkite Locality Plan

The village of Kalkite is relatively small and primarily consists of single and two storey residential dwellings with some tourist accommodation. There are currently no commercial or retail land uses within the township and residents rely heavily on the services provided in Jindabyne

1.3 Technical Memorandum Scope and Objectives

A component of the broader Infrastructure Study is to conduct a review of Kalkite Road between the township of Kalkite and Eucumbene Road through a broad lens of safety, contemporary and compliant road design. Whilst Kalkite Road extends north beyond the township of Kalkite, the focus of this assessment is the 6 km link between Kalkite and Eucumbene Road. This Technical Memorandum documents a Preliminary Route Safety Review (PRSR) of this part of Kalkite Road. The scope and objectives of the PRSR include:

- Undertake a desktop review and qualitative field observations of Kalkite Road
- Development of an overview of the physical attributes and general condition of Kalkite Road, including:
  - Typical cross section
  - Horizontal and vertical geometry
  - Sight lines
  - Roadside hazards
  - Direct accesses
  - Roadside furniture
  - Pavement Condition
  - Kalkite Road / Eucumbene Road intersection
- Consider design standards and guidelines relevant to Kalkite Road, and the degree to which the observed features of Kalkite Road comply with these documents
- Consider access to the township of Kalkite in the context of the proposed development
- Identify recommendations for potential future upgrades to Kalkite Road to improve the safety of the road corridor, and likely future assessments that will be required to validate the need and scope of these upgrades.

The PRSR documented in this technical memorandum is intended to represent the basis for future feasibility studies into upgrades along Kaklite Road and identify objectives for any design development work that will be required subsequent to the Infrastructure Study of Kalkite.

2. Overview and Methodology

2.1 Route Safety Review

A Route Safety Review is an investigation intended to identify existing safety concerns within a road corridor and provide recommendations to improve the safety performance of the route. The Preliminary Route Safety Review for Kalkite Road presented here is based on the model applied to numerous regional highway corridors by Transport for NSW (TfNSW), noting it has been adapted to the needs of the Kalkite Infrastructure Study in several ways including:

- Whilst there are numerous safety deficiencies noted on the route, Kalkite Road does not have a substantial crash history. This is considered likely a result of the very low traffic volumes on the road. As such, the route safety review aims to anticipate parts of the corridor that are likely to perform poorly from a safety perspective if and when volumes on the route increase significantly.
- Given the early stage of the development lifecycle that the Infrastructure Review lies; the limited availability of information; the scale of the route (traffic volumes, hierarchy, and length); and the fact that the review is seeking to forecast safety performance rather than assessing existing performance, the Kalkite Road PRSR is necessarily preliminary in nature and does not carry out the level of detailed analysis undertaken by TfNSW for larger and more significant corridors.

The approach used for route safety reviews aims to recommend road safety treatments that are known to be effective and can be implemented without major engineering works. The PRSR for Kalkite Road has been developed to examine and report on various road safety issues including:

- Current crash performance and how it may evolve with significant increases in traffic volumes
- General road conditions along the route and road safety issues identified at specific sites including those raised by the community
- Facilities, including intersection treatments, safety barriers, signage, line marking and direct accesses.
- The appropriateness of current speed limits and speed zones

2.2 Route Investigated

This PRSR considers a portion of Kalkite Road between Eucumbene Road and the Kalkite village. The route is approximately 6 km long and connects Kalkite to the broader road network via Kosciuszko Road through either Eucumbene Road (a two way sealed carriageway) or Hilltop Road (unsealed). Kalkite Road is the only road connection for the village to the broader transport network and navigates a route through relatively steep mountainous terrain utilising highly curvilinear geometry and steep grades. The Kalkite Road route assessed in this PRSR is indicated in Figure 2, which also includes a slope analysis that demonstrates mountainous topography of the corridor.

Kalkite Road has a current posted speed limit of 80 km/h over most of its length that reduces to 60 km/h on approach to the residential village zone of the corridor. It is a two-way single sealed carriageway that generally adopts a 6m wide cross section. The corridor currently experiences very low traffic volumes, although these volumes are forecast to increase by over 400% over the coming 20 years, albeit these forecast volumes are also considered relatively low and well below the capacity of the road and its intersections.

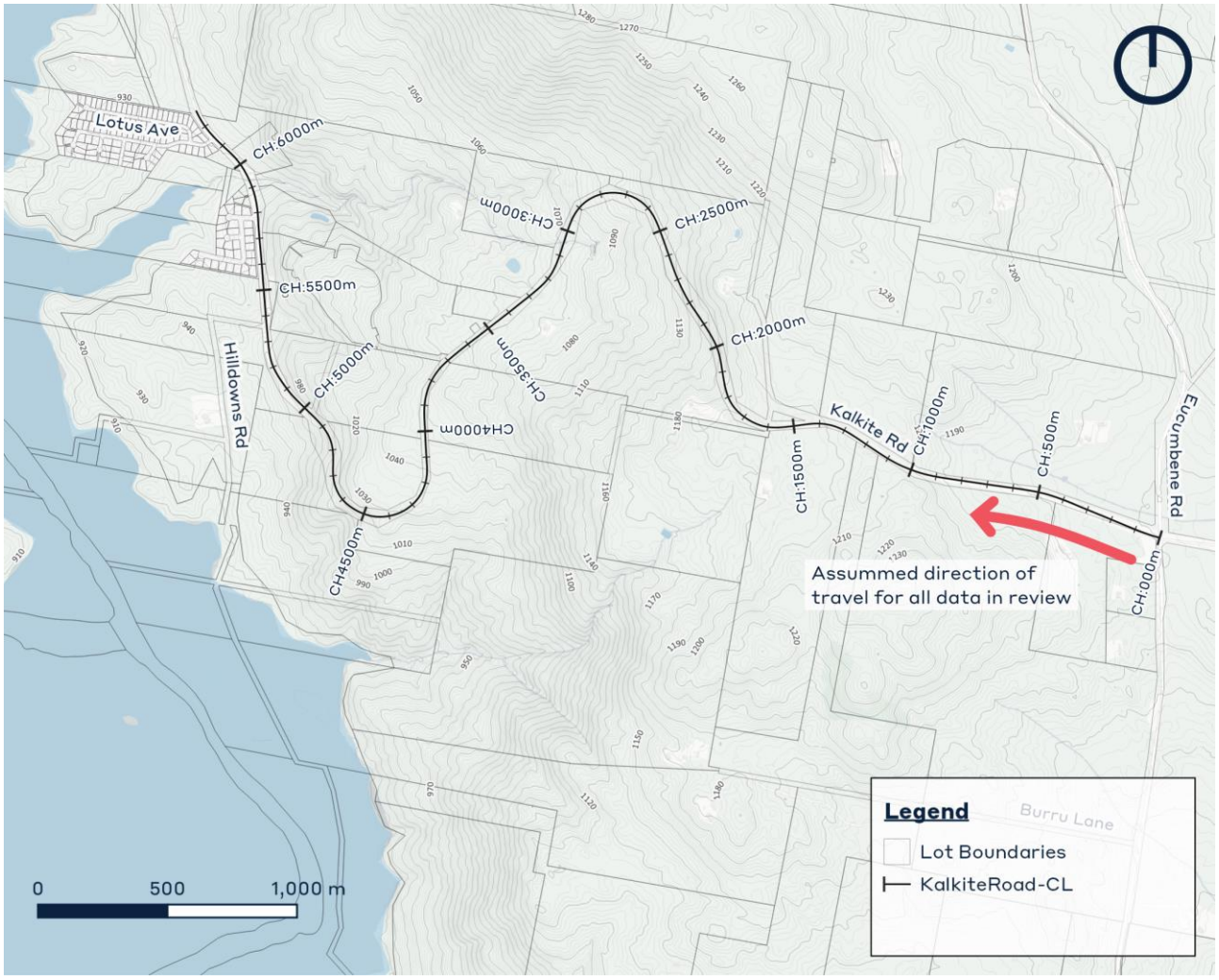


Figure 2: Overview of Kalkite Road with contours (10m)

2.3 Traffic

A demand analysis for the Kalkite road corridor has been undertaken and is documented in the Kalkite Infrastructure Study. This analysis notes that 2023 traffic surveys indicate that Kalkite Road currently conveys 529 vehicle movements per day (vpd) in both directions. Classification of these movements is not available so it is unclear what proportion of these movements are by heavy or commercial vehicles. In terms of public transport, the Kalkite Infrastructure Study notes that there is currently one general local bus service and two school bus services that use the route.

As future developments and increased population in Kalkite eventuate, the Infrastructure Study forecasts that trips on the route will increase to 2,350 trips per day (both directions).

2.4 Assessment Methodology

2.4.1 Overview

The PRSR investigates various safety considerations across several components of the road corridor. These components include:

- Intersections
- Kalkite Road mainline (geometry, sightlines, signage and delineation, and road condition)
- Roadside objects and features
- Direct property accesses

The review process is primarily a desktop exercise based on available information, with limited field validation. It aims to identify safety deficiencies on the route when considered against current design guidelines, and provide practical recommendations to improve the safety of the route including suggestions for upgrade priorities. In the absence of

traffic survey data, the operating speed of the corridor has been assumed to be 90 km/h which is 10 km/h above the posted speed in accordance with the approach outlined in the GRD Part 3.

2.4.2 Crash History

To provide context and an appreciation of the crash performance of the route, a review of the crash history of Kalkite Road has been undertaken. This review considered TfNSW crash data over a five-year period to 2022.

2.4.3 Kalkite Road Geometry

The Kalkite Road mainline geometry has been assessed for its compliance with the Austroads Guide to Road Design Part 3 – Geometric Design (GRD Part 3). This assessment involved review of aerial imagery and comparison of road geometry data gathered through an automated vehicle mounted survey undertaken by the Australian Road Research Board in February 2019 provided by SMRC (ARRB 2019) and GRD Part 3 to investigate areas of non-compliance with this guideline in addition limited qualitative field observations. This assessment considered:

- Horizontal alignment (curvature)
- Vertical alignment (grades and curvature)
- Cross section configuration (carriageway / lane widths, shoulders, verges, crossfalls)
- Sightlines (broad commentary based on qualitative field observations, as distinct from measured sight distances based on topographic survey or digital terrain models)

It is noted that Council also has road design guidelines but it is understood that these documents are intended for application to subdivision road networks rather than link roads such as Kalkite Road and as such these Council documents have not been considered in the assessment.

2.4.4 Roadside Hazards

Qualitative commentary on observed roadside hazards has been provided in the PRSR. The roadside hazards considered include:

- Drainage structures
- Roadside objects
- Power poles
- Steep batter slopes

Existing protection measures of hazards such as safety barriers have also been considered in the assessment.

2.4.5 Pavement Condition

It is noted that the condition of the Kalkite Road route is highly variable. A combination of qualitative field observations and interpretation of surveyed International Roughness Index measurements (ARRB 2019) have been considered to provide commentary on the pavement condition of the route and its implications for safety.

2.4.6 Property Accesses

Direct property accesses onto Kalkite Road have been identified through field observation with a brief description of the access and relevant safety considerations provided.

2.4.7 Signage and Delineation

Broad commentary on existing signage and delineation / line marking in the context of AS 1742 requirements based on field observations has been provided, including where it is likely to be deficient in communicating road safety hazards to road users.

2.4.8 Intersections

The layout and dimensions of the three main intersections on Kalkite Road (Eucumbene Road, Gardenia Court and Lotus Avenue) were reviewed in the context of the increased traffic flows resulting from the development of Kalkite. The likely design vehicle for the intersection, sightlines, and signage and delineation were also considered in the assessment.

2.4.9 Recommendations

Based on the assessment of existing conditions on the route, and their compliance with current design guidelines, a collection of recommendations have been generated in this PRSR. Acknowledging that it is unlikely to be practical for Council to fully upgrade Kalkite Road to be consistent with current relevant guidelines and standards in the foreseeable future, the recommendations identify potential priorities to improve safety on the route. These recommendations are based on the following:

- Engineering judgement and experience
- Road features considered to constitute the most significant safety risk to road users on the route in the context of the proposed development of Kalkite
- Guidance provided in the following Austroads documents:
  - AGRS07-21 – Guide to Road Safety Part 7 – Road Safety Strategy and Management
  - AP-R449-14 – Methods for Reducing Speeds on Rural Roads
  - AP-R691-23 – Managing Regional Road Safety Priorities

2.5 Limitations

The PRSR is a preliminary review of safety on the Kalkite Road corridor, based on desktop data generated by others and limited field observation undertaken between July 2023 and November 2023. As such it is the subject of several limitations, including:

- All geometric commentary / findings are based on the ARRB 2019 vehicle mounted survey data. Topographic survey of the route has not been undertaken as part of this of this safety review exercise and it is noted that appropriateness of the commentary provided here is reliant upon the accuracy of this externally provided data. It is further noted that this data is now dated and elements of it may no longer be applicable or may have changed.
- Similarly, the accuracy of other desktop data provided by or obtained from external sources such as aerial imagery, Snowy Monaro Regional Council (SMRC) etc has not been verified and may be subject to error.
- Field observations are qualitative only. Whilst general commentary about site observations has been provided, site measurements or surveys have not been taken and as such the accuracy of observations has not been verified.
- No assessment of underground utilities has been undertaken.

It should be noted that the PRSR is high level in nature and is not intended to fulfill the function of a formal Road Safety Audit or Safe Systems Assessment. To this end, this PRSR does not purport to be a thorough identification of all road safety issues on the Kalkite Road corridor, and there may be additional road safety issues on the route that have not been identified in this Technical Memorandum. It is recommended that validation of identified safety issues documented in the PRSR be undertaken prior to commencement of any works.

3. Safety Review

3.1 Crash History

Whilst the crash history of a corridor is not necessarily a predictor of future vehicle accidents, it can be used as an indicator understand the general safety of a route. As such, a review of crashes for the five years between 2018-2022 has been undertaken as part of the PRSR for Kalkite Road. Despite numerous identified safety issues on the route (refer below), there has only been one crash in the corridor in the five years to 2022. The location of this crash is indicated in orange in Figure 3 which occurred during daylight hours in 2018 and was a single vehicle, non-casualty run off road crash on the bend just after CH 3000m.

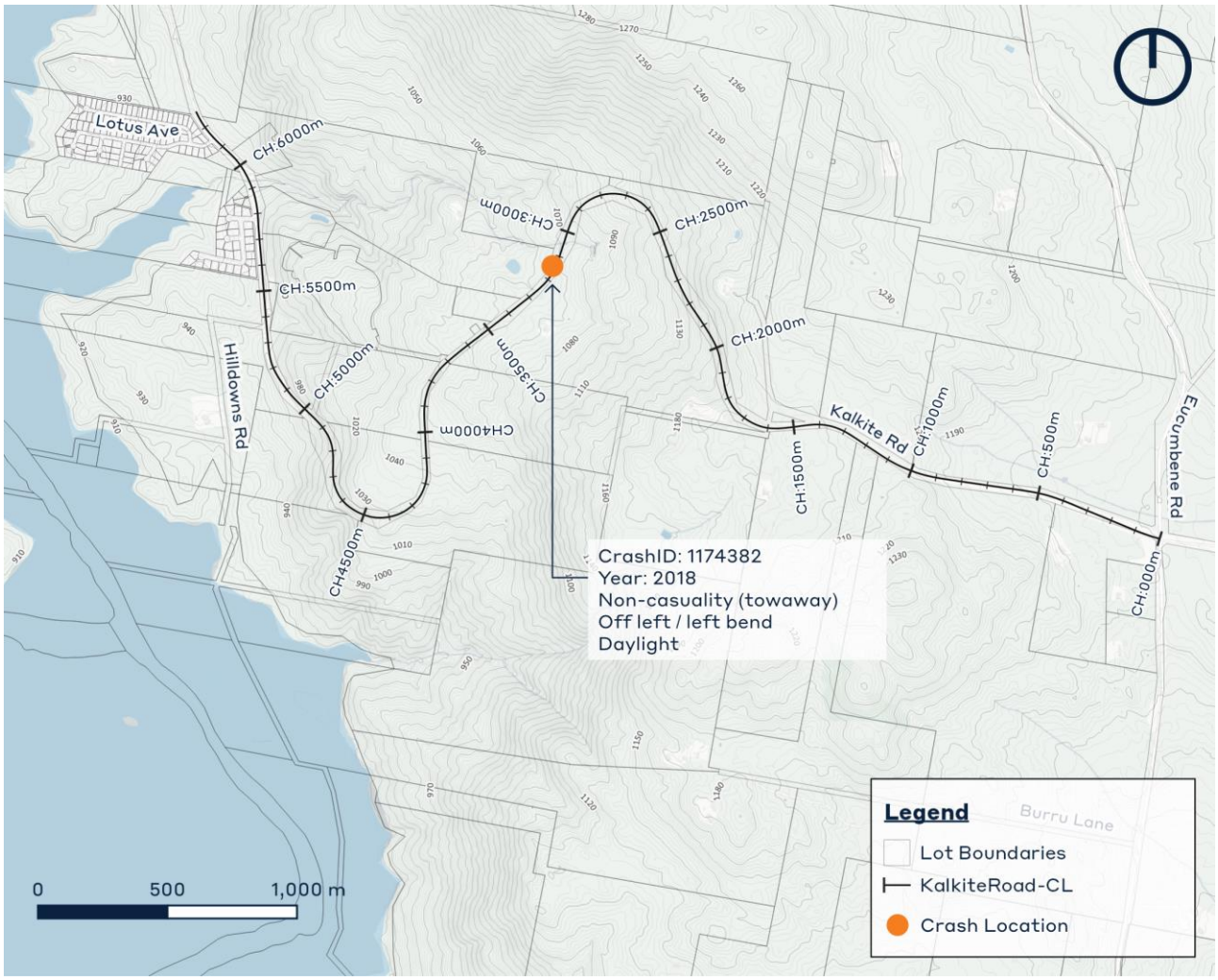


Figure 3: Crash location on Kalkite Road, 2018-2022 (NSW Centre for Road Safety LGA Crash Map – retrieved 31 October 2023)

Given the safety concerns noted with the existing corridor discussed below, this relatively good crash performance is considered more likely to be a function of the low number of vehicle movements on Kalkite Road rather than the inherent quality of the route. With the expected increase in movements resulting from the development of the Kalkite village it is anticipate that without improvements to the road the annual crash rate on the route will increase as there will be more trips on corridor (increased exposure), and more interaction between vehicles (increased likelihood of crashes).

3.2 Kalkite Road Cross Section

3.2.1 Desirable Cross Section

Austroads GRD Part 3 provides guidance on appropriate cross section elements for rural roads in Australia. Key features of these requirements include:

- **Lane width** – 3.1-3.5m lane width for carriageways with 500-1000 vpd (3.5m for 1000-3000 vpd)
- **Shoulder width** - 1.5m (0.5 m sealed) for carriageways with 500-1000 vpd (2.0m incl. 1.0 m sealed for 1000-3000 vpd)
- **Crossfall** – 3% desirable, 7% maximum for 70-89 km/h, 10% maximum for speeds less than 70 km/h (noting that this 10% maximum is highly undesirable for vehicles with high centres of mass)
- **Verge width** – 1.0m min to allow guidepost installation, 1.5 m if safety barrier is required, and >1.0m where batter rounding is required
- **Turn lane width** – 3.0m min (GRD Part 4A)

3.2.2 Existing Cross Section

Much of the existing Kalkite Road route is estimated to have a standard 6.0m wide rural road profile (ie 2 x 3.0 m lanes), noting that there are areas along its length where the road widens to allow for a turning lane (refer Figure 5). The typical cross section of Kalkite Road between Eucumbene Road and Lotus Avenue (CH 6150) is depicted in Figure 5, and Table 1 provides commentary on compliance with the GRD.



Figure 4 | Overview of typical cross sections and road batter slopes

Table 1 | Lane width summary

Chainage (m)	Cross section(m)	Observations & Compliance with GRD Part 3
CH0m-CH6150m	6.0m (Profile 1)	3.0 m lanes marginally deficient for current volumes, substantially deficient for development volumes
CH3630m-CH3760m	Up to 13m (Profile 2)	Includes right turn lane to Three Rivers Estate. Approx 3.0 m wide through lanes (deficient) and 2.7 m wide turn lane. It is also noted that the turn lane length is insufficient for full deceleration off the mainline

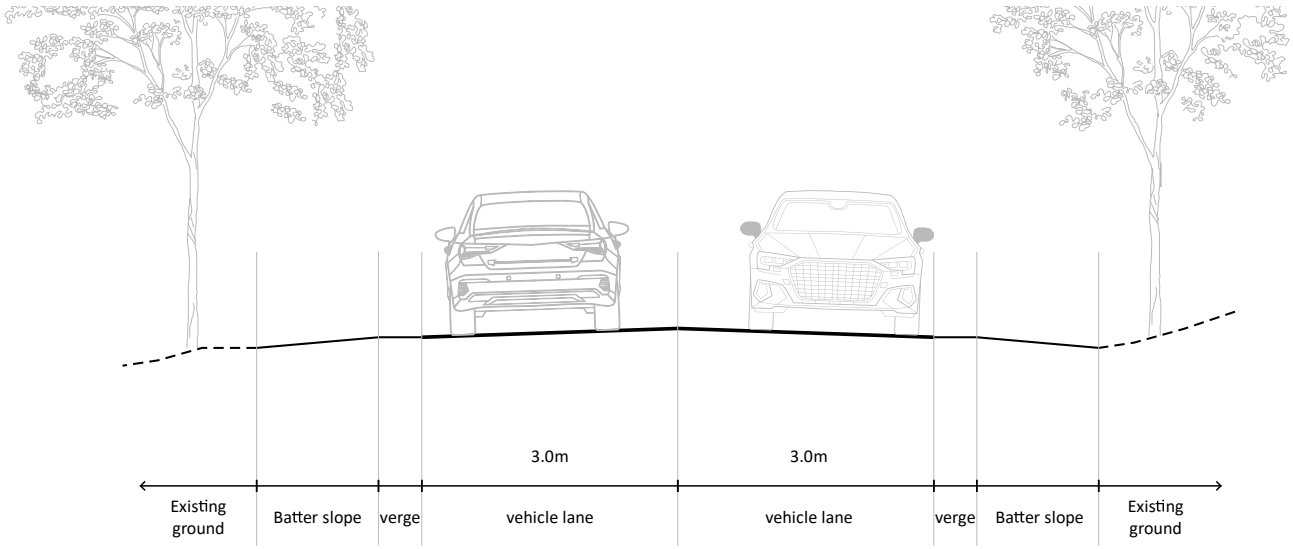


Figure 5 |Typical cross section

Given the current guidance on cross section requirements, the existing Kalkite Road route has several areas of non-compliance relating the cross section, including:

- **Lane Widths** – As noted in Table 1, lane widths are generally non-compliant and will become increasingly so as volumes on the route increase. This deficiency is exacerbated by the fact that there is no lane line marking provided for most of the route, and as such mainline lanes are not delineated (discussed in greater detail in Section 0). Substandard lane widths reduce the latitude for drivers to remain within their lane, increasing the risk of head on collision or run off road crashes. They also reduce the margin for drivers to initiate cornering prior to a curve, although this risk is likely mitigated to a degree as the original design of the road appears to have used spiral curves.
- **Shoulder width** – There is no sealed shoulder throughout the route. Furthermore, whilst there is grassed verge for parts of the route, there is no formal unsealed shoulder on the route either, noting the placement of guideposts in close proximity to the pavement. As such, this element of the cross section also is not compliant with current guidelines. The safety risks associated with the absence of shoulder is exacerbated by the absence of edge lines and the fact that pavement edge has broken away in numerous locations. The absence of shoulders, combined with substandard lane widths significantly compromises road safety as it increases the risk of run off road and loss of control accidents as drivers have minimal margin for error to avoid their left wheel path leaving the paved surface.
- **Crossfall** – Whilst the route generally meets the minimum crossfall requirements (excluding curve transitions), it is frequently non-compliant with maximum crossfall values. The ARRB 2019 data indicates that approximately 22% of the route exceeds the 7% threshold for the current posted speed limit of 80 km/h, and 14 % of the route exceeds the maximum 10% crossfall requirement (to a maximum of 13%) if the speed regime was reduced to less than 60 km/h. Acknowledging that the road elevation ranges from between 915-1,200m, it is noted that the GRD recommends a maximum superelevation of 6% where the road is subject to snow and ice. Offsetting some of this risk to a degree, is that fact that the road is likely to experience minimal heavy vehicle volumes that have a high centre of mass, although this will increase with the development of Kalkite, particularly during construction phase. Notwithstanding, it is noted that a minimum of 22% of the route, and potentially more, is non-compliant with current guidance of road crossfalls which presents an additional safety risk for road users.

- **Verge width** – Information on verge width was not available for this assessment, however qualitative visual inspection of the route indicated that there are areas on the corridor where the recommended minimums for verge width are not achieved. Deficient verge widths compromise safety as they fail to provide sufficient space for errant vehicle recovery; batter rounding, and to accommodate street furniture and signage.
- **Curve widening** – Curve widening is recommended in the GRD on small radius curves to accommodate the tracking of heavy vehicles. The smallest radius curve recorded on the route is 150m, with several examples of 180m radius curves. The GRD recommends widening of 0.4m and 0.3m per lane for a 19 m semi trailer and a rigid bus respectively for these radii curves. As noted above, lane widths on the route are generally consistent at 3.0m, and as such there is a safety risk on the route at small radius curves. This is mitigated to a degree by the likely small volume of bus and heavy vehicle movements on the corridor, noting that volumes will increase with the development of Kalkite, particularly during construction phase.

Whilst not investigated in this analysis, it is considered unlikely that sheet flow on the pavement surface will be a safety issue as cross falls are generally high and longitudinal grades are also high, meaning that zones of superelevation transition (that necessarily contain a zone of zero crossfall) are likely to have a residual slope and by extension acceptable drainage.

3.3 Kalkite Road Alignment

Road geometry plays a critical role in ensuring the safety of a road corridor. Deficient horizontal or vertical road alignment (or a combination of both) can create unsafe driving conditions and lead to road accidents. The GRD Part 3 provides guidance on appropriate road geometry for routes such as Kalkite Road, and has been used as a basis to assess whether the existing geometry of the road complies with current guidelines and good design practice. The following summarises the general degree of compliance of the Kalkite Road alignment with the requirements of the GRD Part 3 for various the geometric components of the road.

3.3.1 Horizontal alignment

Kalkite Road between Eucumbene Road and the Kalkite Village adopts a highly curvilinear alignment in response to the mountainous terrain of the corridor. It has numerous small-radius curves, many of which are considered substandard in the context of current design guidelines. It is further noted that any safety risks created by deficient horizontal geometry on Kalkite Road will be exacerbated by proposed developments in Kalkite and the associated expected increase in traffic volumes on the route.

To understand current compliance of Kalkite Road's horizontal geometry, and by extension the safety implications of development proposed in Kalkite, this PRSR has reviewed the horizontal curves on the route. Figure 6 indicates the horizontal curves that exist on the route that were identified in the ARRB 2019 data.

These curves were then assessed against GRD Part 3 requirements (the appropriateness of which are affected by longitudinal grade) to see if they were compliant with side friction requirements (ie appropriate to retain traction whilst cornering), and if not the degree to which they were deficient. Table 2 summarises the finding of this assessment. As can be seen, most of the horizontal curves on the route depart from the requirements of GRD Part 3 to a degree with many curves being significantly substandard for the assumed 90 km/h operating speed. Furthermore, it is noted that tight horizontal curves can also compromise sight distance (discussed in more detail in Section 3.7).

Furthermore, it is noted that there appears to be three examples of compound curves on the route. Compound curves occur when two different radii curves are used sequentially (ie have a common tangent point) and increase the risk of crashes as a change in steering lock is required mid-curve which may not be perceived by the driver resulting in lane departure and/or loss of control. The existence of these compound curves further compromises road safety in these three locations.

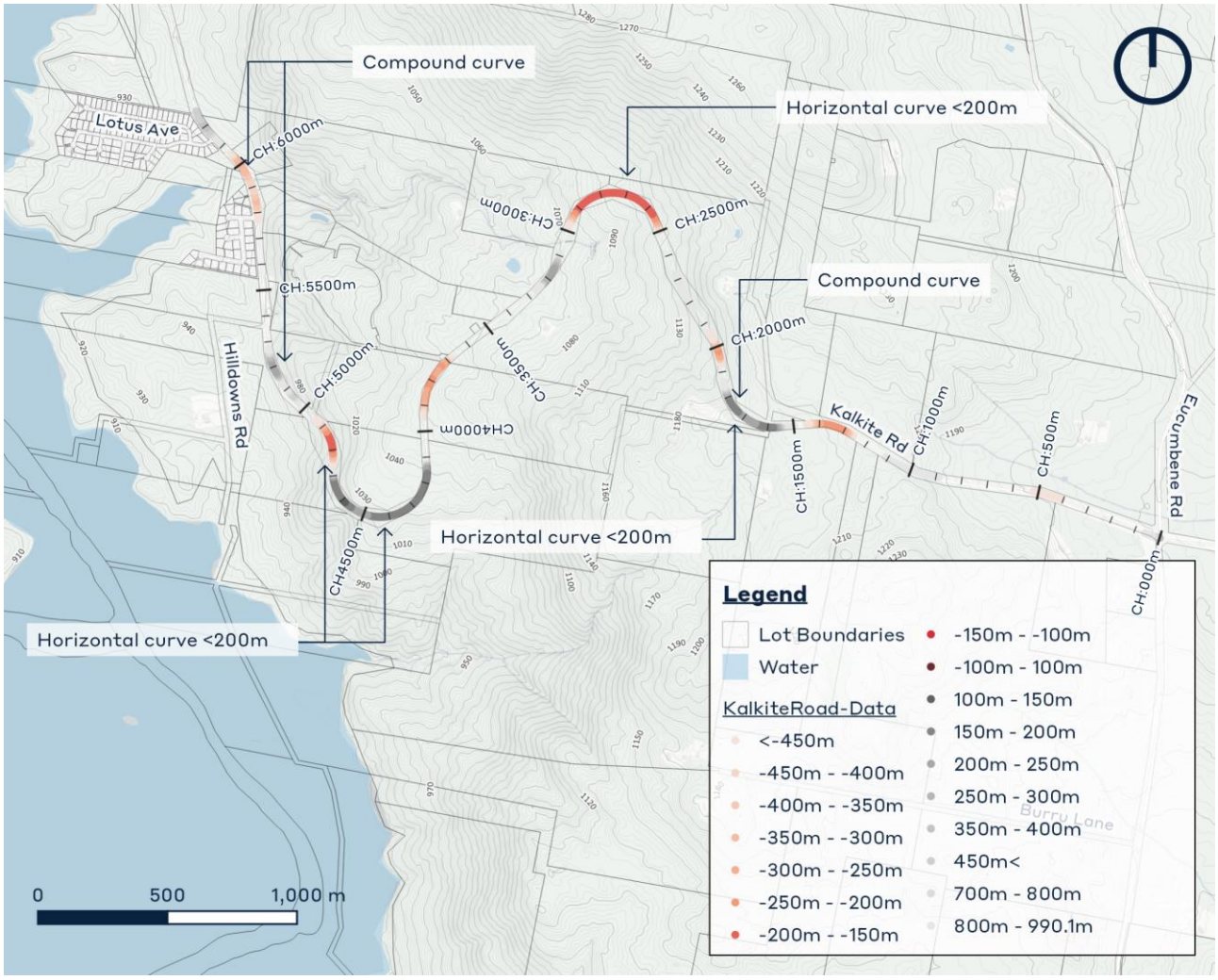


Figure 6 | Overview of horizontal curves along Kalkite Road (Grey (+ve) values denote right hand turn – Orange (-ve) values denote left hand turn)

Table 2 | Horizontal Alignment Summary

Approx. Chainage (m)	Approx. Horizontal Curve Radius (m)	Approx. Crossfall	Approx. Average Grade	Compliance with GRD Part 3	Comment
CH 450m – 500m	550m	5.0%	3.0%	Complies	
CH 900m – 1100m	500m	4.5%	7.0%	Complies	
CH 1250m – 1450m	200m	12.0%	3.5%	Moderate departure	
CH 1550m – 1700m	180m	7.0%	4.0%	Major deficiency	Compound curve
CH 1700m – 1850m	150m	10.5%	7.5%	Major deficiency	
CH 1950m – 2050m	230m	9.0%	10.0%	Major deficiency	
CH 2150m – 2250m	480m	2.0%	8.5%	Complies	
CH 2270m – 2330m	600m	0.5%	6.0%	Complies	
CH 2500m – 3000m	180m	11.0%	10.5%	Major deficiency	
CH3100m – 3250m	220m	8.0%	4.0%	Major deficiency	
CH3700m – 3950m	220m	7.0%	2.0%	Major deficiency	
CH4150m – 4700m	180m	10.5%	8.0%	Major deficiency	
CH4750m – 4950m	180m	10.0%	10.0%	Major deficiency	
CH5050m – 5130m	400m	3.5%	8.5%	Major deficiency	Compound curve
CH5130m – 5280m	220m	6.5%	6.0%	Major deficiency	

Approx. Chainage (m)	Approx. Horizontal Curve Radius (m)	Approx. Crossfall	Approx. Average Grade	Compliance with GRD Part 3	Comment
CH5780m – 5920m	380m	7.0%	8.0%	Moderate departure	Compound curve
CH5920m – 6070m	300m	6.5%	4.0%	Moderate departure	
CH6100m – 6350m	360m	6.0%	2.5%	Complies	

3.3.2 Vertical Alignment

As noted above, the route navigates mountainous terrain, utilising relatively steep grades to negotiate the descent from the Eucumbene Road intersection to the Kalkite township. The GRD Part 3 recommends maximum grades of 6 – 9% for roads with operating speeds between 80-100 km/h, however it does acknowledge that there are circumstances when steeper grades are acceptable, several of which are appliable to the Kalkite Road route. These include:

- Comparatively short sections of steeper grade which can lead to significant cost savings
- Difficult terrain in which general maximum grades are not practical
- Where absolute numbers of heavy vehicles are generally low
- Less important local roads where the costs or impact of achieving higher standards are difficult to justify.

A summary of the grades on the route were assessed using the ARRB 2019 data are indicated in Figure 7. There are three locations (CH 1950m – 2050m, CH 2500m – 3000m and CH4750m – 4950m) where the average grade exceeds the 9% threshold, constituting approximately 20% of the route, with a maximum grade of 12.7%. Whilst shallower grades are desirable, noting the constraints of the terrain and acknowledging the acceptable exceptions identified in the GRD, the grades contained on the Kalkite Road in and of themselves are not considered a significant safety hazard. However steep grades that are coincident with small radius horizontal curves can be hazardous. This safety concern is considered in the analysis of horizontal curves documented in Section 3.3.1.

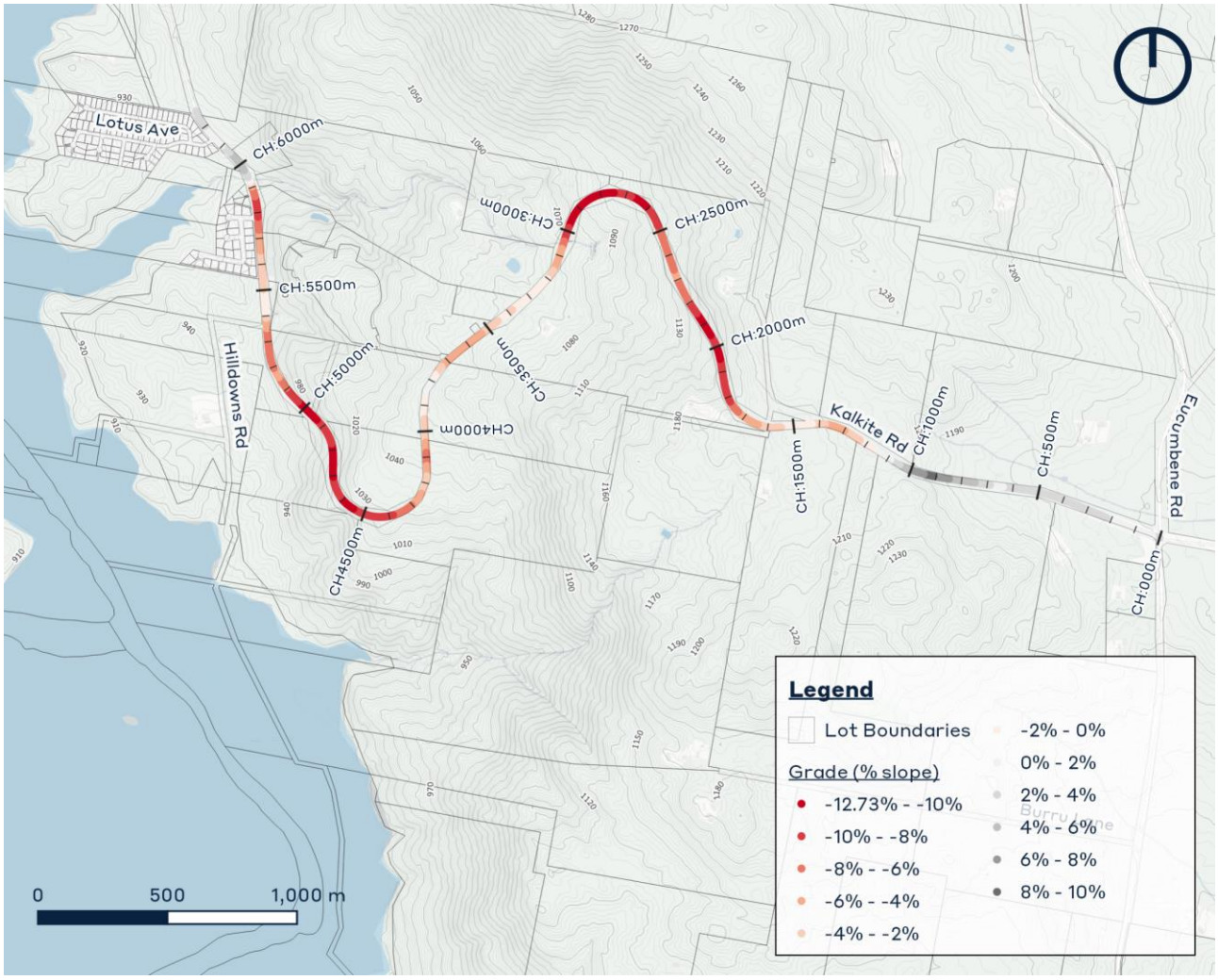


Figure 7 | Overview of Kalkite Road Grade

Vertical curves can also have safety implications as they can compromise sight lines and affect journey comfort. The GRD provides guidance on acceptable vertical curve values to achieve appropriate sight lines as a function of operating speed. Figure 8 depicts the location of vertical curve radii on the route (positive values denote sag / negative denotes crest) and Table 3 provides a summary of vertical curves on the route and discussion on their compliance with the GRD Part 3 assuming a 2.0 second reaction time for crest curves and headlight criteria for sag curves, although it is noted that this can be relaxed to a 1.5 second reaction time in some circumstances. It is further noted that safety concerns can be exacerbated when vertical curves conceal horizontal curves.

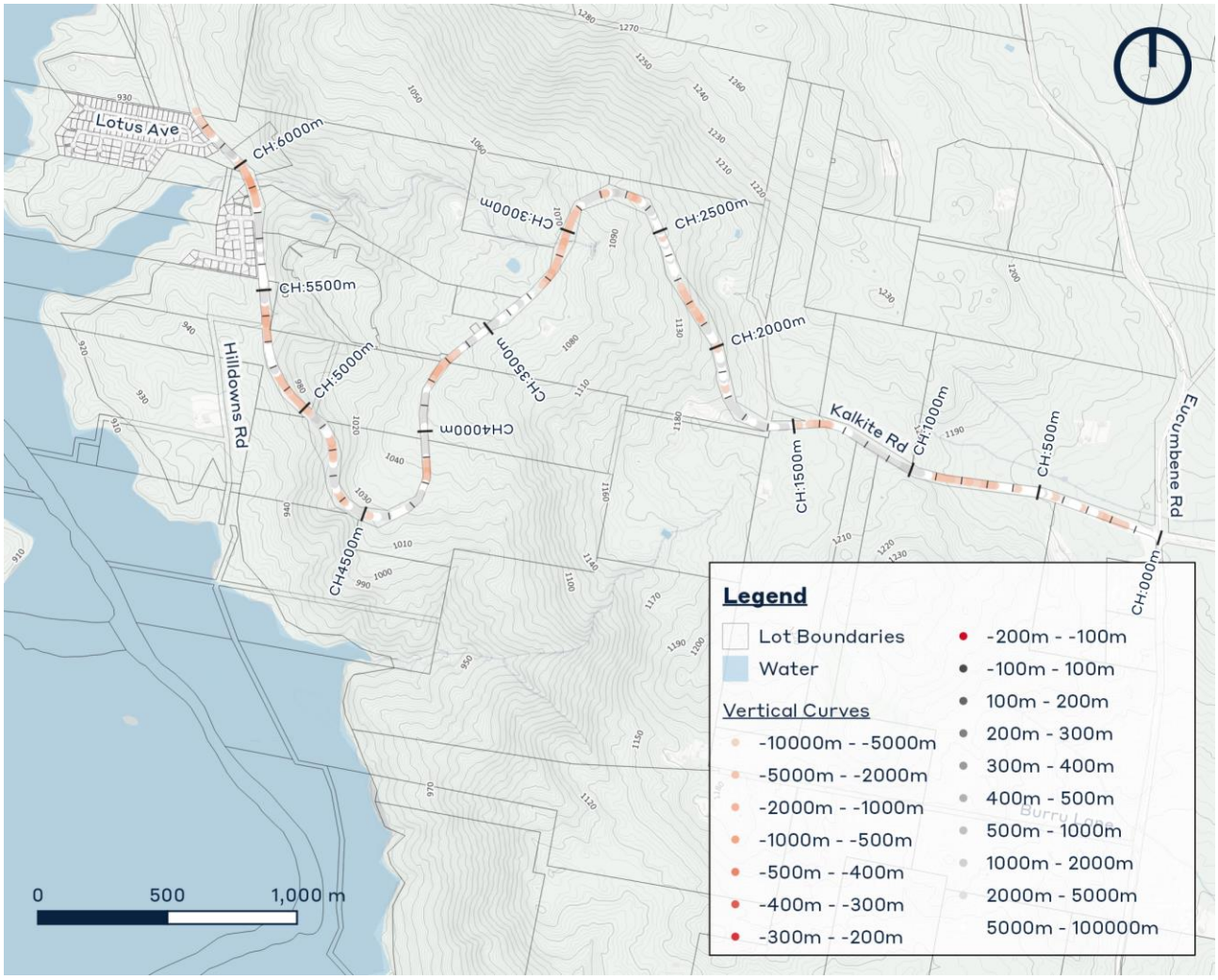


Figure 8 | Overview of vertical curves along Kalkite Road

As can be seen in Table 3, the ARRB 2019 data suggest that there are numerous substandard crest curves on the route which impede stopping sight distance on the corridor and compromise road safety. However, it is noted that crest curve arc length (which is difficult to ascertain with confidence from the data) also affects sight distance, and further analysis based on survey may find that stopping sight distance is actually achieved at some of these crest curve sites. Sag curves on the route are generally compliant with the headlight criteria outlined in GRD Part 3.

Table 3 | Vertical curve summary

Chainage (m)	Approximate Vertical Curve Radius (m)	Compliance with GRD Part 3
CH100m – 250m	7500m (crest)	Complies
CH700m – 900m	4300m (crest)	Complies
CH900m – 1100m	2100m (sag)	Complies
CH1100m – 1300m	3400m (sag)	Complies
CH1350m – 1450m	2600m (crest)	Major deficiency
CH1500m – 1650m	4100m (sag)	Complies
CH1700m – 1800m	2800m (sag)	Complies
CH2100m – 2300m	3500m (crest)	Moderate departure*
CH2500m – 2600m	2800m (sag)	Complies
CH2600m – 2700m	2300m (crest)	Major deficiency
CH 2700m – 2800m	2300m (sag)	Complies
CH2800m – 2900m	3600m (sag)	Complies
CH2900m – 3100m	2600m (crest)	Major deficiency

Chainage (m)	Approximate Vertical Curve Radius (m)	Compliance with GRD Part 3
CH3100m – 3200m	2800m (crest)	Major deficiency
CH3450m – 3550m	3500m (sag)	Complies
CH3700m – 3800m	2100m (crest)	Major deficiency
CH3950m – 4100m	4000m (sag)	Complies
CH4100m – 4200m	2200m (crest)	Major deficiency
CH4250m – 4350m	2900m (sag)	Complies
CH4450m-4600m	5600m (crest)	Complies
CH4600m -4650m	3600m (crest)	Complies
CH4650m – 4750m	3500m (sag)	Complies
CH4750m – 4850m	2600m (crest)	Major deficiency
CH4900m – 5000m	2200m (sag)	Complies
CH5000m – 5200m	3000m (crest)	Major deficiency
CH5200m – 5250m	4000m (sag)	Complies
CH5350m – 5450m	2200m (crest)	Major deficiency
CH5450m -5500m	2500m (sag)	Complies
CH5650m -5800m	2900m (sag)	Complies
CH5850m -6000m	1300m (crest)	Moderate departure
CH6050m-6100m	1900m (sag)	Complies
CH6150m-6250m	3500m (crest)	Complies

* Moderate departure considered acceptable as it provides appropriate sight distance assuming a 1.5 second reaction time which is likely appropriate given that drivers can be expected to be alert on this route.

3.4 Roadside Hazards

3.4.1 Road batter slopes

Kalkite Road is situated in mountainous topography and as a result there are numerous examples of fill batter slopes adjacent to the carriageway. Depending on slope and height, fill batter slopes can be a safety hazard for road users as they can cause loss of control and roll-over for errant vehicles.

Table 4 and Figure 9 summarise notable identified cut/fill batter slopes on the route that were identified using topography data sourced from https://elevation.fsdf.org.au/. The assessment estimates approximate fill batter slope and location, noting that these are generally the longer sections of substantial edge batter slopes in the corridor and that there are many more shorter lengths of steep (greater than 4H:1V) and unprotected batter drops in close proximity to the carriageway edge also present on the Kalkite Road route.

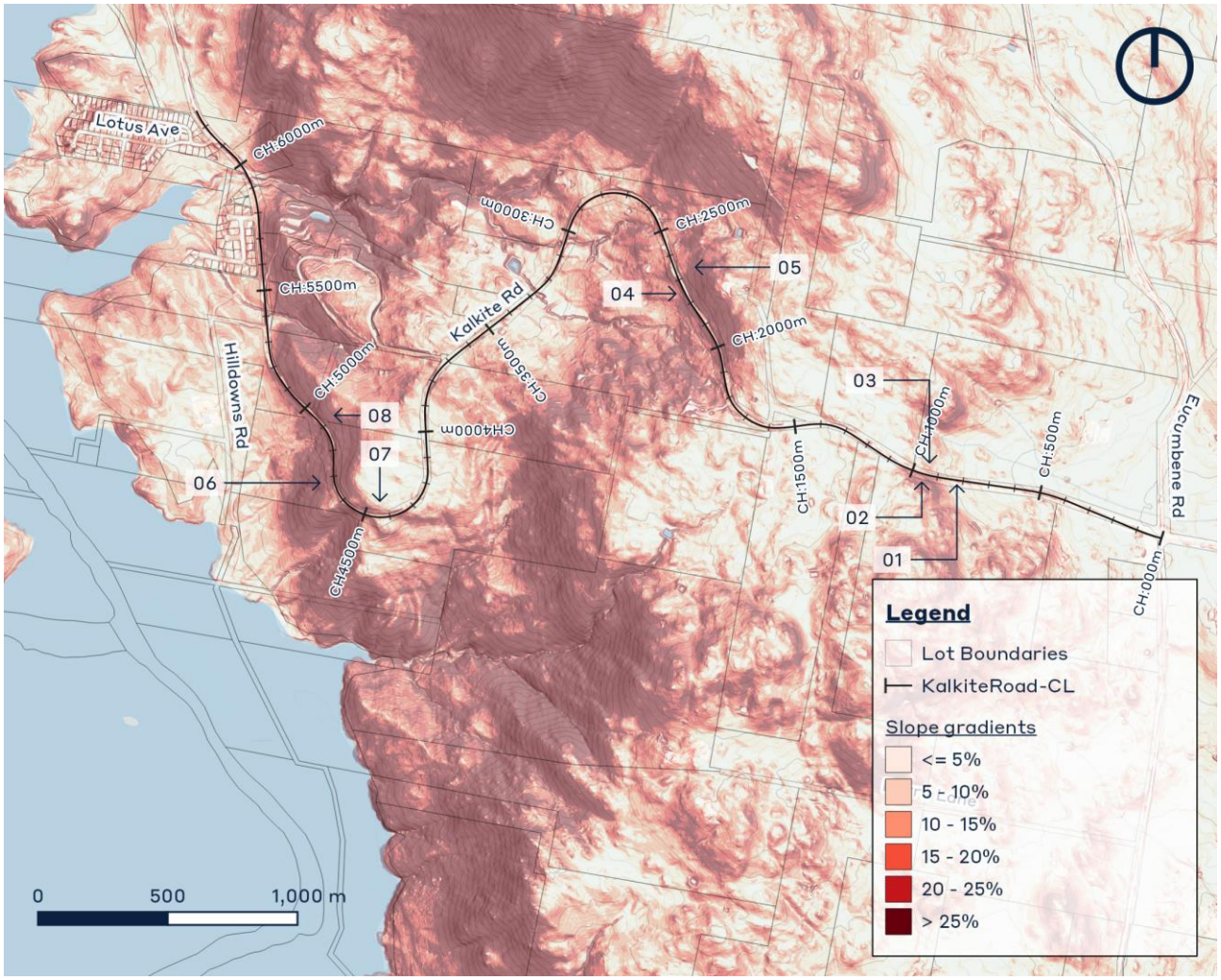


Figure 9 |Overview Kalkite Road slope analysis and batter slopes

Table 4 | Road Batter Slope Summary

Chainage (m)	ID	Average Slope % (approximate)	Observations
CH780 – 890	01	22-29%	Westbound - 8m offset
CH890 – 1070	02	20% (40% at roadside)	Westbound - 6m offset
CH800 – 900	03	10 - 15%	Eastbound - 6.5m offset
CH2000 – 2300	04	20 - 35% (70% at roadside)	Westbound - 5.3m offset
CH2030 – 2300	05	30% - 42%	Eastbound - 4.9m offset
CH4470 – 4900	06	30% - 40% (50% at roadside)	Westbound - 2m offset
CH4350 – 4620	07	27% - 38%	Eastbound - 7.3m offset
CH4900 – 5100	08	26% - 35% (70% at roadside)	Eastbound - 9m offset

3.4.2 Drainage structures

Drainage structures under and adjacent to roadways can be a hazard as associated headwalls can either create vertical drops and the risk of vehicle rollover or provide a non-frangible face that vehicles can impact. Several drainage structures have been identified on the route through a combination of aerial imagery, ARRB 2019 data and field observations. Figure 10 indicates the location of known drainage structures on the route, and Table 5 provides discussion on the nature of these structures.

The assessment indicates that whilst the many of drainage structures are longitudinal culverts under property driveways that do not pose significant safety risk to road users as they are sufficiently set back from the carriageway edge, although there are a few in close proximity to the carriageway that pose a safety risk. In addition, there are several examples of transverse drainage culverts that have associated high vertical drops close to the carriageway edge that are unprotected and represent a significant safety risk on the route. Images of major culvert hazards are provided in Figure 11 to Figure 14.

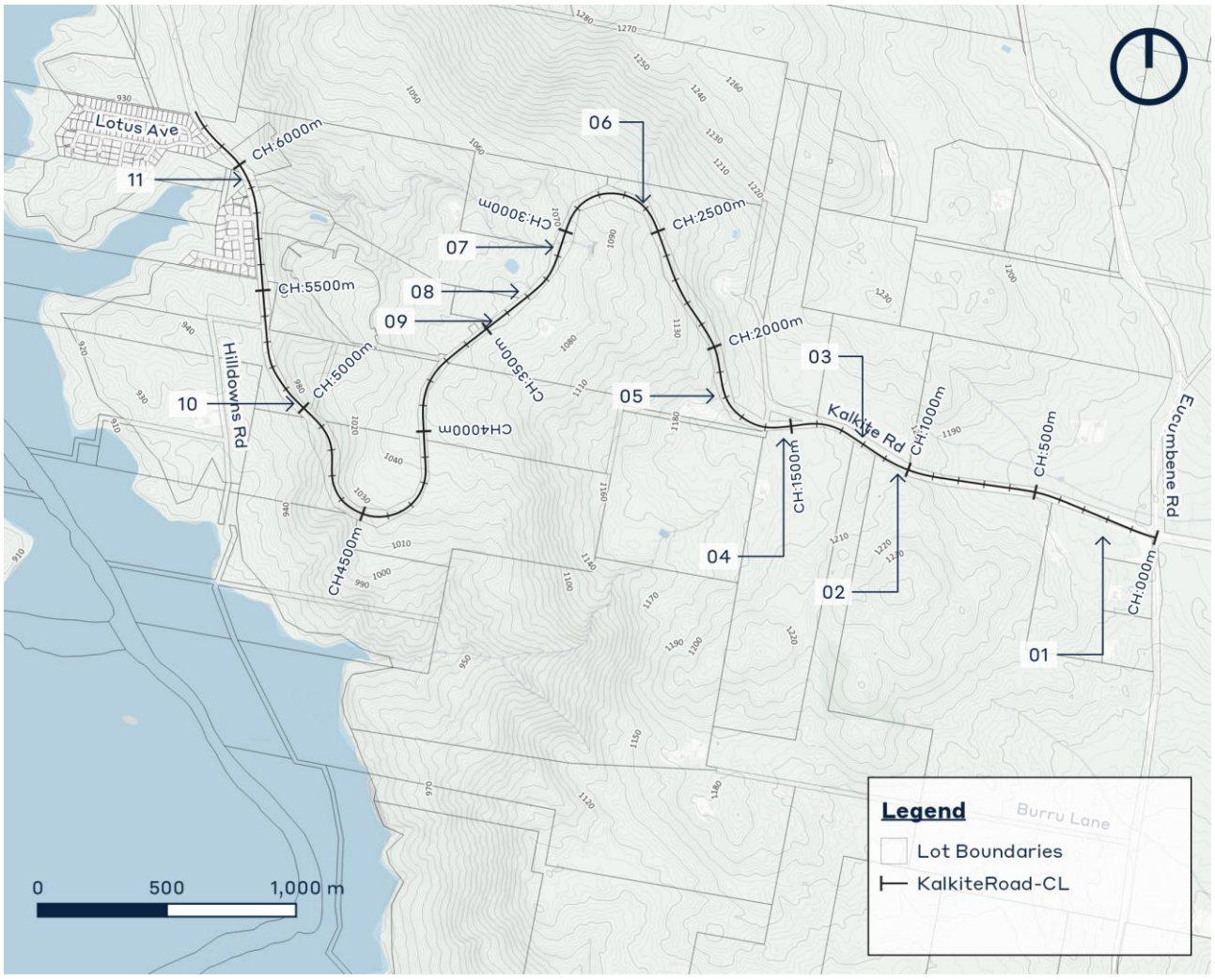


Figure 10 | Drainage structure locations

Table 5 | Drainage structure summary

Chainage (m)	ID	Description	Discussion
CH240	01	Longitudinal driveway culvert - westbound	Low headwall in clear zone - minor hazard
CH600	02	Transverse culvert crossing under road (minor)	Headwall creates vertical drop near carriageway edge
CH1050	03	Longitudinal driveway culvert - westbound	Low headwall in clear zone - minor hazard
CH1550	04	Transverse culvert crossing under road (minor)	Headwall creates vertical drop near carriageway edge
CH2500	05	Large transverse culvert crossing under road	Headwall creates large vertical drop near carriageway edge
CH2620	06	Longitudinal driveway culvert - eastbound	Low headwall in clear zone - minor hazard

Chainage (m)	ID	Description	Discussion
CH3150	07	Midsize transverse culvert crossing under road	Headwall creates large drop near carriageway edge
CH3200	08	Longitudinal driveway culvert - eastbound	Low headwall in clear zone - minor hazard
CH3300	09	Large transverse culvert crossing under road	Headwall creates very large vertical drop near road edge
CH3420	10	Longitudinal driveway culvert - westbound	Low headwall in clear zone - minor hazard
CH5400	11	Large transverse culvert crossing under road	Very high and steep drop in close proximity to the road
CH5900	12	Large triple transverse culvert under road	High vertical drop in very close proximity to the road
CH6100	13	Transverse culvert crossing under road	Headwall creates vertical drop near carriageway edge



Figure 11 | Culvert ID 05 – Large culvert with unprotected vertical drop in very close proximity to the road edge – CH 2500

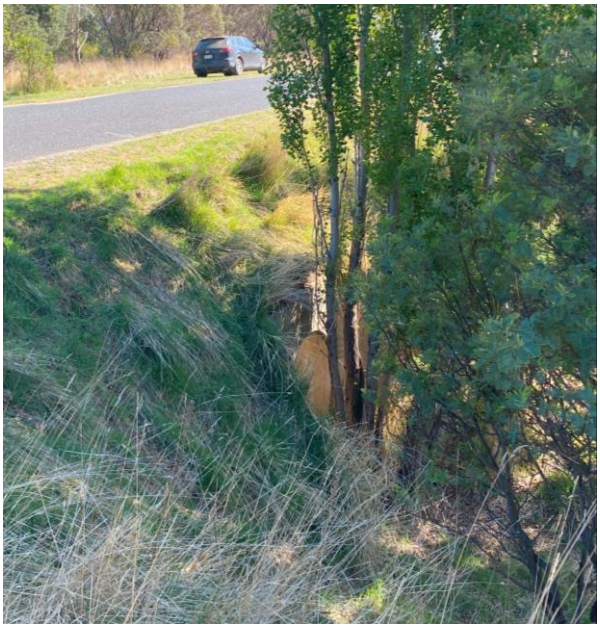


Figure 12 | Culvert ID 09 – Large culvert with high unprotected vertical drop in very close proximity to the road edge – CH 3300



Figure 13 | Culvert ID 11 – Large culvert with high unprotected vertical drop in very close proximity to the road edge – CH 5400



Figure 14 | Culvert ID 12 – Large triple culvert with unprotected vertical drop in very close proximity to the road edge – CH 5900

3.4.3 Roadside objects

There are numerous unprotected roadside objects throughout the route in both directions of travel. Many of these objects are a safety hazard for errant vehicles that leave the carriageway, particularly in locations where they are on the outside of curves. These hazards include:

- **Trees** – There are numerous trees within the clearzone in both directions along the route. Whilst many of these trees are relatively small and likely frangible, there are also many substantial trees in close proximity to the carriageway, are unprotected by safety barrier and pose a substantial safety hazard for errant vehicles.
- **Rocks** – There are several unprotected large independent boulders within the clearzone along the route, in addition to protruding outcrops in cut batters in a number of locations that have the potential to snag an errant vehicle
- **Power poles** – There are several power poles in the westbound verge in close proximity to the carriageway on approach and withing the Kalkite township between CH5200 – 5800.

3.4.4 Roadside furniture

There is minimal road furniture present on the route. Guideposts have been used to provide an appreciation of road geometry at night, particuarly on curves. It is noted however that their provision is somewhat sporadic and frequently not consistent with the requirements of AS 1742.2 in terms of post spacing. Furthermore, many of the guideposts were observed to be damaged or bent with reflectors not oriented towards oncoming drivers.

There is one length of W-Beam safety barrier on the route between CH4420 – 5080 on the outside of the curve protecting a steep batter indicated in Figure 15. The condition of this safety barrier has not been assessed.

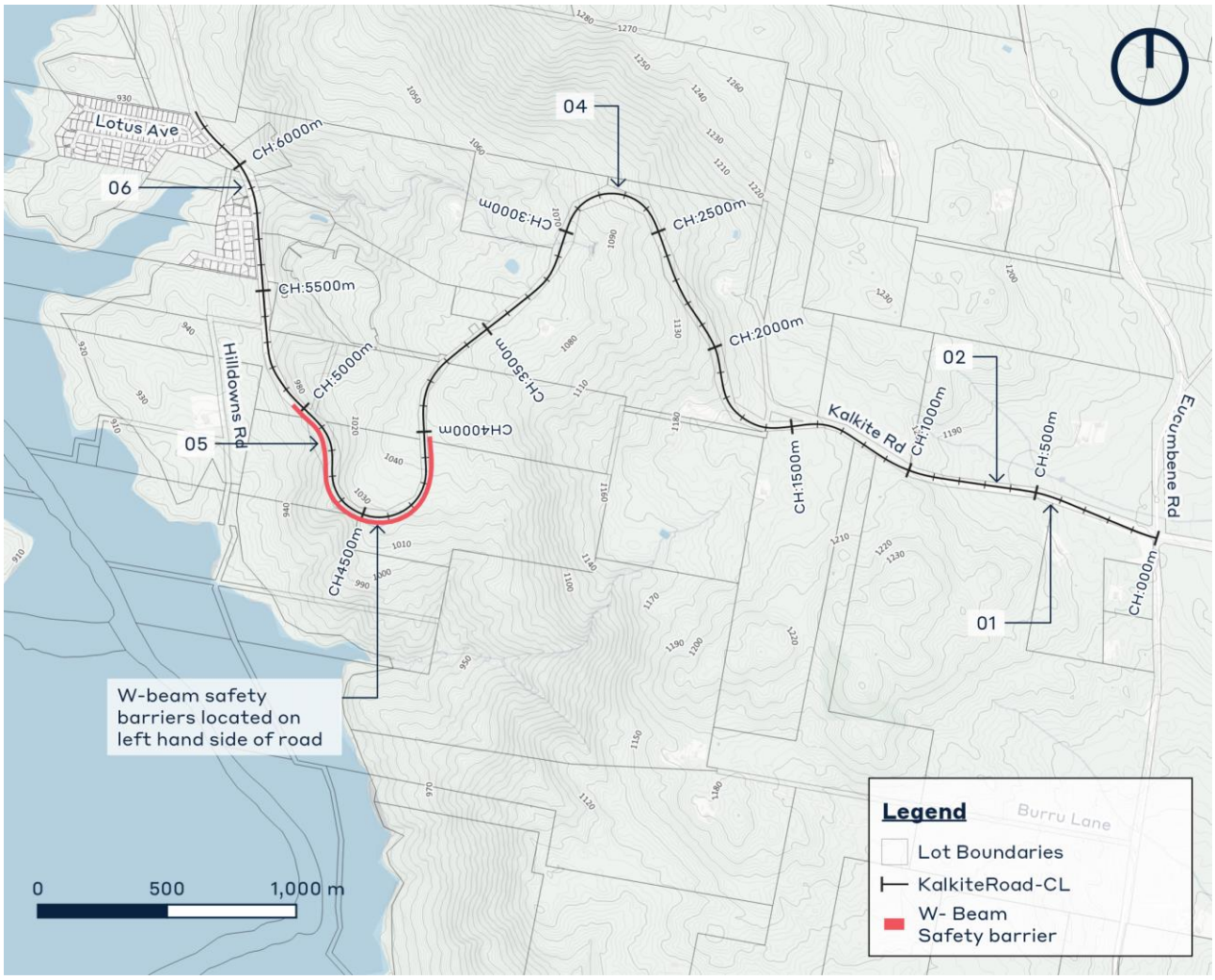


Figure 15 | Overview of roadside furniture and pavements

3.5 Pavements

Whilst this PRSR is not intended to be a review of pavement condition or an asset management exercise, it is noted that defective pavements can pose a safety hazard for road users. The International Roughness Index data recorded by ARRB 2019 suggested that the pavement surface condition on the Kalkite Road route at the time was predominantly satisfactory, indicating that 61% could be classified as Very Good; 22% Good; 14% Fair; and only 2% poor in accordance with the National Association of Australian State Road Authorities classification framework.

However, it is noted that localised pavement defects were observed during field validation activities. In addition to the pavement edge failures described above, several defect sites were identified as summarised in Table 6, with locations depicted in Figure 15, noting that this is not intended to be a comprehensive inventory of all pavement defects on the route.

Table 6 | Localised pavement defects (to be read with figure 15)

Chainage (m)	ID	Observations
CH420-CH425	01	Depression in the pavement
CH650-CH680	02	Potholes/depression on the pavement
CH1370-CH1390	03	Potholes/depression on the pavement
CH2710-CH2730	04	Uneven surface
CH4810-CH4840	05	Potholes/depression on the pavement
CH5920-CH5950	06	Potholes/depression on the pavement

3.6 Direct Property Accesses

There are numerous direct private property accesses onto Kalkite Road. Accesses that join collector roads can create safety issues as they:

- Can require vehicles to prop and hold in through lanes as they wait for a gap to turn right into the property access, creating a risk of rear end crashes
- May have deficient sight lines, resulting in vehicles entering the mainline from the property access unsafely, again resulting in the risk of collision

While these are unlikely to be significant safety concerns with the very low volumes that are currently use Kalkite Road, they will increasingly become a safety issue as the proposed development generates higher volumes on the corridor into the future.

Sightlines at these access locations are important as they help allow road users to make appropriate decisions on when it is safe to enter the through carriageway or slow on approach to a vehicle waiting to enter a property. The site of each property access is summarised in Table 7, inclusive of some qualitative discussion on safe intersection site distances at each site based on visual observations, noting that there is insufficient information available to accurately quantify actual site distances.

Table 7 | Private property access locations

Chainage (m)	Description	Observations*
CH230	Westbound – unsealed driveway	Appears likely to achieve appropriate sight distance from both directions.
CH700	Westbound – unsealed driveway	Appears likely to achieve appropriate sight distance from both directions.
CH1190	Eastbound – 1 x unsealed driveway	Sight distance appears marginal in both directions
CH1560-1600	Westbound – 2 x unsealed driveways	Both driveways - easterly sight distance appears compliant, however westerly sight distances appear sub standard
CH1600-1620	Eastbound – 2 x unsealed driveways	Appears unlikely to achieve required sight distance from either direction.
CH1720	Westbound – 1 x unsealed driveway	Appears unlikely to achieve required sight distance from either direction.
CH1800	Westbound – 1 x unsealed driveway	Appears likely to achieve appropriate sight to the north, but not east.

Chainage (m)	Description	Observations*
CH2830	Eastbound – 1 x unsealed driveway	Appears unlikely to achieve required sight distance from either direction.
CH3300	Eastbound – 1 x unsealed driveway	Appears likely to achieve appropriate sight from the south, but not north.
CH3320	Westbound – 1 x unsealed driveway	Appears likely to achieve appropriate sight distance from both directions.
CH3700	Eastbound – 1 sealed access lane	Assess to Three Rivers estate – sight distance may be substandard from the north due to a short crest curve, although appears likely to be acceptable (albeit marginal) from the southern approach. It is noted that the turn slots at the access appear to be substandard in terms of length.
CH4400	Westbound – 1 x unsealed driveway	Appears unlikely to achieve required sight distance from either direction.
CH5350	Westbound – Hilldowns Road	Appears likely to achieve appropriate sight distance from both directions.
CH5500	Eastbound – 1 x unsealed driveway	Appears likely to achieve appropriate sight distance from both directions.
CH5800	Eastbound – 1 x unsealed driveway	Appears likely to achieve appropriate sight distance from both directions.
CH5840	Westbound – 1 x unsealed driveway	Appears likely to achieve appropriate sight distance from both directions.
CH5940	Westbound – 1 x unsealed driveway	Appears likely to achieve appropriate sight distance from both directions.

* based on utilisation for Extended Design Domain consistent with the requirements of GRD Part 4A.

3.7 Sight lines

There was insufficient information available to undertake a quantitative analysis of sight lines along the route. Notwithstanding, it is clear from visual field observations that there is a failure to achieve stopping sight distance requirements articulated in the GRD Part 3 Section 5 in many locations along the route. There are several causes of these sight distance deficiencies, including:

- **Cut Batter slopes** – there are numerous locations where horizontal curves are located within cuttings. In many of these locations, cut batter faces impede sight lines through the curve
- **Vegetation** – vegetation on the inside of horizontal curves compromises sight distance in several locations.
- **Crests** – there are numerous vertical crest curves that impede stopping sight distance on the route (refer Section 3.3.2)

Notwithstanding that it is typical to experience sight distance issues on curvilinear road alignment in mountainous terrain, it is noted that compromised sight distances have significant implications for road user safety. Substandard sight distance decreases the time that drivers have to react to hazards including oncoming, turning, stopped or slowing vehicles; to vulnerable road users, wildlife and to appreciate upcoming road geometry. This in turn significant increases the risk of crashes, which is exacerbated by the absence of lane line marking.

3.8 Signage and Delineation

As noted above, there is no linemarking or raised pavement markers present on the route that delineate road geometry or lane extents. Whilst guideposts have been used in some locations, their use is inconsistent and the general absence of lane delineation significantly increases the risk of run off road and head on accidents.

There are several signage categories present on the route, including:

- **Regulatory signage** – The use of threshold and repeater speed limit signage appears clear and appropriate.
- **Warning signage** – The application of warning signage appears inconsistent and does not communicate many of the geometric deficiencies that exist on the route such as steep grades, or substandard horizontal or vertical curvature. Insufficient warning signage increases the risk that drivers will approach deficient geometry at inappropriate speed.
- **Guide signage** – there is no guide signage on the route. However, given that Kalkite is the only destination that can be accessed on the route this is considered appropriate.

3.9 Intersections

3.9.1 Kalkite Road / Eucumbene Road Intersection

The existing intersection is a four leg priority controlled intersection. Three of the legs (Eucumbene Road and Kalkite Road) are sealed and the Hilltop Road approach is unsealed. Signage and line marking at the intersection is broadly appropriate (although the Kalkite Give Way threshold has a large setback), and stopping sight distances appear appropriate in three directions although may be deficient on the southern leg (refer Figure 18 and Figure 19). Approach sight distance on Kalkite Road to the intersection appears likely to be compliant.

It is noted however that there is insufficient pavement width on Eucumbene Road to allow vehicles to pass southbound right turning vehicles into Kalkite Road, requiring vehicles to pass on the unsealed shoulder / verge. It is further noted that gravel from Hilltop Road tends to be tracked into the intersection, reducing friction coefficients through the intersection.

Notwithstanding the general compliance of the intersection with current guidelines, Austroads Guide to Traffic Management (AGTM) Part 6 notes that priority controlled four leg intersections are considered undesirable, and that staggered T intersections are the preferred treatment due to the high crash rates for minor road through movements that four-leg intersection tend to generate. Supporting this, the intersection has minimal visual cues to alert drivers of the upcoming intersection from the Kalkite Road approach, and as Eucumbene Road is not conspicuous there is a risk that drivers may not perceive the intersection refer Figure 17, increasing the risk of crashes. Given the anticipated volumes at the intersection, and the warrants outlined in AGTM Part 6, it appears unlikely that the provision of turn lanes will be required.



Figure 16 | Aerial overview of Kalkite Road / Eucumbene Road Intersection

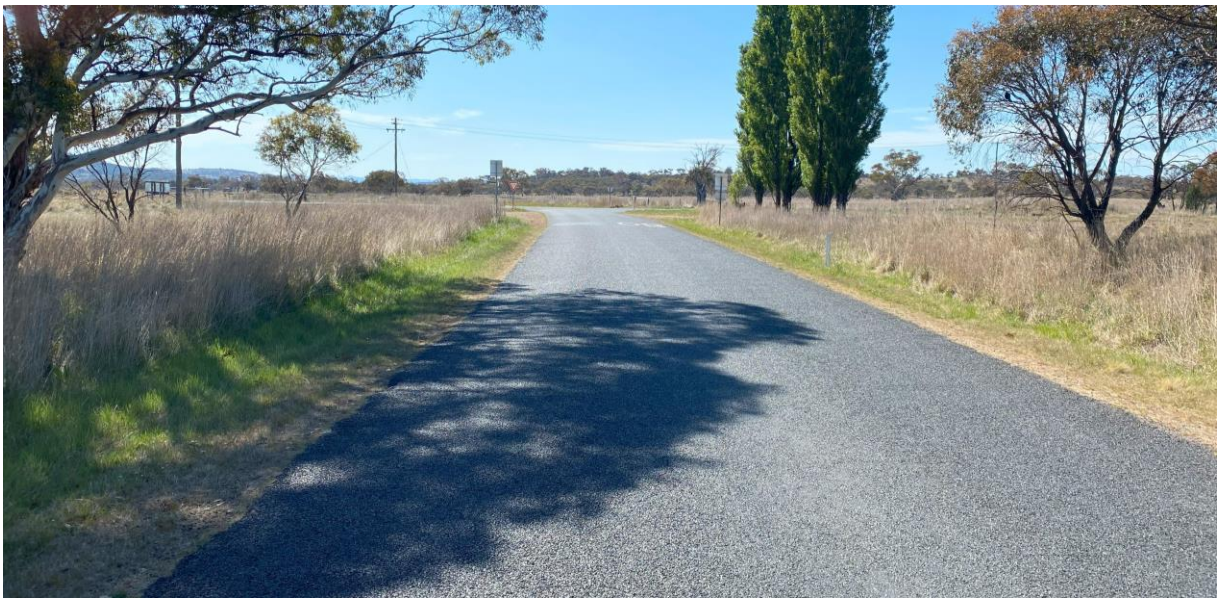


Figure 17 | Kalkite Rd / Eucumbene Rd intersection – eastbound approach



Figure 18 | Kalkite Rd / Eucumbene Rd intersection – sightlines to south



Figure 19 | Kalkite Rd / Eucumbene Rd intersection – sightlines to north

3.9.2 Gardenia Court Intersection

The Gardenia Court intersection is T intersection (Kalkite Road being the major leg) providing access to residential properties. It is priority controlled by a give way sign, however does not have threshold line marking. Safe intersection sight distance appears good in both directions, and intersection geometry appears appropriate.

3.9.3 Lotus Avenue Intersection

The Lotus Avenue intersection is also T intersection with Kalkite Road as the major leg, and provides access to residential properties. It is priority controlled by a give way sign, however does not have threshold line marking. Safe intersection sight distance appears to be achieved to the north, however is potentially deficient to the south.

4. Kalkite Access

4.1 Background

Kalkite Road is the only road access to the township of Kalkite. The lack of alternative road connections for Kalkite compromises network redundancy, which has implications for maintenance operations, emergency access and egress to the township, emergency response (particularly bushfire response) and community safety more broadly. Whilst this is currently an issue for the village, risks will be exacerbated with the increased population considered for the future and worsening of likelihood and severity of bushfire risk associated with changing climate.

There is a risk that emergency service providers such as the NSW Rural Fire Service will challenge further development in Kalkite due its potential for severance and isolation from the broader transport network during emergencies. By way of example, the Planning for Bush Fire Protection guidelines published in 2019 by the NSW Rural Fire Services states that:

> *Strategic planning should provide for the exclusion of inappropriate development in bush fire prone areas where the development is likely to be difficult to evacuate during a bush fire due to its siting in the landscape, **access limitations**, fire history and/or size and scale;*

As such, management of the risks associated with the singular access to Kalkite is likely to require increasing attention and focus into the future. Potential approaches could include:

- Development of a second access
- Improve the robustness and resilience of the Kalkite Road route and the township
- Alternative emergency egress / access arrangements

4.2 Second Kalkite Access

Ideally any further development of Kalkite would be accompanied by the establishment of a second access to the village. However, the local topography, environment and property ownership create significant challenges to the development of a second access.

A potential option for this access may be an extension of Kalkite Road to the north, using a combination of both an existing road gazettal and a route through existing private property to loop back onto Eucumbene Road. Such an access would require either property acquisition or formal agreement to a Right of Way with the property owner/s, and would require construction of a road of appropriate standard (ie minimum cross sectional dimensions, geometric, drainage and pavement requirements). The feasibility of such a road in terms of environmental impacts and cost implications would also require confirmation. It is noted that there may also be other, more appropriate alternative routes for a second access.

The establishment of a formal second access to Kalkite would substantially improve network redundancy and is considered likely to provide a significant mitigation for emergency access / egress concerns relating to increased population in Kalkite. However, the feasibility or appropriateness of a second access is to be confirmed. If a second access is found not to be viable, there may be other approaches that could contribute to the management of these safety risks. The appropriateness of these approaches outlined below would require close consultation with emergency service providers and validation.

Resilience of Kalkite Road and Township

A potential alternative to a second access (or to complement it) and subject to consultation and support of the relevant emergency service providers, would be to improve the resilience of the existing Kalkite Road route such that it remains operational either through a bushfire event, or soon thereafter. These improvements could include:

- General enhancements such as improved cross section, geometry, delineation and pavement condition
- Vegetation removal to a specified setback from the road edge

This improvement in the access route resilience could be accompanied by enhancements in the Kalkite township itself, including:

- Supplementation of existing bushfire response infrastructure and equipment
- Vegetation management and regular fuel reduction activities
- Ensuring robust communication infrastructure is in place to allow comprehensive and reliable communication is facilitated during emergencies
- Enhanced development requirements for new dwellings

4.3 Alternative Access Arrangements

As another alternative should a second access be impractical, consideration could also be given to the potential for alternative forms of transport access to Kalkite, namely via Lake Jindabyne. Whilst impractical to evacuate large populations, such access could be utilised to provide emergency medical retrieval or transfer of supplies should the township become isolated. Such an approach would likely require establishment of water infrastructure (wharves etc) to facilitate access from the lake. Again, close consultation with emergency services would be required to understand the appropriateness of this solution.

5. Recommendations

5.1 Conclusions

The PRSR has identified several safety concerns on the Kalkite Road corridor that present various degrees of risk to road users. Whilst the identified safety issues have not generated a poor crash history on the route in the past 5 years, this is considered likely a product of the low volumes in the corridor more so than the standard of the road. The identified safety risks include:

- Substandard road cross section - lane widths, shoulders, verge and cross fall not complying with current design standards
- Substandard road geometry - vertical and horizontal alignment not complying with current standards
- Unprotected roadside hazards - non-fragile objects, vertical drops and steep batters
- Deficient sight lines
- Inadequate warning signage

There are several likely reasons for these deficiencies, primary amongst them is that designers at the time of the road's development needed to make value judgements and use a pragmatic approach to the deal with the challenging topography that the route navigates, which necessitated design compromises.

Notwithstanding, typical of many rural roads, particularly those in mountainous areas, Kalkite Road in many respects does not meet current design standards. As such, and in the context of an anticipated growth in demand on the route, there are opportunities to improve safety for users of the corridor.

5.2 Recommendations

Given that upgrading Kalkite Road to current design standards is highly likely to be both cost prohibitive and economically unviable, a suite of recommended improvements are proposed that are intended to improve safety on the route in a financially sustainable way. The improvement recommendations provided have been informed by approaches identified in the following guidelines:

- Austroads Guide to Road Safety Part 7: Road Safety Strategy and Management (AGRS07-21)
- Austroads Practical Approaches for Managing Regional Road Safety Priorities (AP-R691-23)
- Austroads Methods for Reducing Speeds on Rural Roads – Compendium of Good Practice (AP-R449-14)
- National View on Regional and Remote Road Safety (AP-R603-19)

It is suggested that these recommendations be part of a long term programme of works for Kalkite Road, responding to growth in traffic volumes over time and in observed changes to crash patterns. The recommendations include five broad categories:

Recommendation 1 – Signage

Provision of enhanced signage is a relatively low cost and effective way to improve safety performance. It is recommended that a review of existing signage and improvement opportunities be undertaken, which is expected to consider the following signage types observed in AP-R449-14 to be effective in improving safety:

- Advanced warning signage with speed advisory warnings (there appears to be scope to improve the existing warning signage on the route)
- Chevron Alignment Markers for small radius curves, particularly those with high safety risks
- Vehicle activated warning signage (active signage) if static signage is considered unlikely (or found) to be effective
- Guidepost repair and installation in accordance with current design standards

Recommendation 2 - Cross Section Improvements

It is recommended that a program of carriageway widening be undertaken along the route to improve the cross section of Kalkite Road, coordinated with rehabilitation works of edge damage as it occurs. There are two primary cross-sectional improvements recommended:

- *Provision of 3.5 m lane widths* – Whilst accurate lane widths are still to be confirmed, it appears that overall carriageway width on the route is approximately 6.0 m (3.0 m lanes) or less. Widening to a minimum lane width of 3.5 m where it can be readily achieved within the existing formation (and 3.1 m as a minimum consistent with the GRD) combined with shoulder sealing and lane delineation (refer below) will reduce the likelihood of head on and run-off-road crashes. Provision of 3.5 m lane widths should be considered where the existing road formation allows or where the road formation is easily adapted (potentially CH 0-1300 m), and areas of high risk (such as tight radius bends) should be prioritised.
- *Provision of 0.5 m minimum sealed shoulders* – The addition of 0.5 m shoulders will aid recovery for errant vehicles, reduce the incidence of loss of vehicle control, and compensate for the lack of curve widening provided on the route. Shoulder sealing will also reduce the instance of pavement edge damage and requisite maintenance activities. AP-R691-23 notes that shoulder sealing is an effective treatment for reducing lane departure crashes.

Where the existing formation and topographical constraints do not allow substantial carriageway widening it is recommended that provision of 0.5 m shoulders be prioritised over 3.5m lanes (ie a minimum treatment should target 3.1 m lanes and 0.5 m shoulders). It is recommended that pavement rehabilitation be undertaken in defect areas as part of cross section improvement works.

Recommendation 3 – Protection / Removal of Roadside Hazards

Austroads (AP-R691-23) identifies safety barriers as a highly effective safety solution to reduce the severity of run-off-road accidents. Given the nature of many of the identified safety issues (including substandard horizontal geometry and numerous roadside hazards) it is recommended that a programme of safety barrier installation be undertaken, targeting highest risk areas. Recommended installation sites include:

- Zones on the route that have steep batters, including those adjacent to residential dwellings
- Locations of vertical drops in close proximity to the carriageway edge, particularly transverse culvert headwall sites
- Instances of non-frangible hazards eg large diameter trees, boulders and power poles in close proximity to the carriageway, noting that removal of isolated hazards may be preferable to short lengths of barrier

In addition to barriers, consideration could be given to alternative methods of managing the risks associated with roadside hazards, including:

- Make the runoff areas as traversable as possible, including the removal of any non frangible hazards within the clear zone. This will also help with sight distances and crash severity.
- Replace longitudinal headwalls with trafficable headwall, reducing crash severity

Recommendation 4 – Delineation

Currently lanes including carriageway edges are not delineated on the entire Kalkite Road route. It is recommended that in conjunction with the proposed cross section improvements describe above, lane delineation line marking (primarily centre in addition to edge lines wherever possible) in addition to raised pavement markers (Raised Reflective Pavement Markers) be provided for the entirety of the route. Lane delineation will assist in reducing the likelihood of head-on and run-off-road crashes, in addition to being critical to supporting in-vehicle technologies such as driver assistance devices (eg lane departure management systems) and vehicle autonomy. As noted in AP-R449-14, the use of narrow lanes (the perception of which is created by lane delineation) reduces operating speeds which in turn reduces crash likelihood and severity.

It is preferable to undertake cross sections improvements prior to the provision of lane delineation along Kalkite Road prior to ensure appropriate lane widths are defined. However there may be some safety benefits in providing lane delineation in zones of substandard geometry prior to cross section improvements.

It is also recommended that delineation on approach to Eucumbene / Kalkite Road intersection be enhanced in all directions (potentially including a splitter island on the Kalkite Road approach) to enhance the legibility of the intersection.

Recommendation 5 – Revised Speed Regime

Many of the horizontal curves on the route between CH 1500 – 5300 m are deficient either in terms of side friction, sight lines, or both, for the current posted and expected operating speed. Similarly, there are several vertical crest curves that appear likely to provide deficient sight distance for the existing operating speed. It is therefore recommended that investigation of speed limit reduction be undertaken for the route from CH1400 onwards to 60

km/h (or potentially 70 km/h if compliance is considered unlikely to be achieved), noting that NSW guidance on speed zoning will require consideration. It is noted that revising posted speeds may attract community opposition, and extensive consultation will be required. Enforcement activities should be considered on the route to encourage compliance.

If it is found that the Eucumbene / Kalkite Road intersection develops a significant crash history as traffic volumes grow in response the further development in Kalkite, consideration could be given to a reconfiguration of the intersection, including:

- Staggered T
- General enhancements (signage, line marking, splitter islands etc)
- Extension of seal on Hilltop Road to reduce tracking of gravel into the intersection throat,
- Widening of intersection throat for right turning vehicles to be passed by through vehicles

Appendix G: Project Consultation Meeting Minutes

Member of the Surbana Jurong Group

Project Meeting Minutes

Meeting Name	Discussion for Transport and Stormwater		
Project Name	Berridale and Kalkite Infrastructure Studies		
Location	MS Teams		
Date	30 May 2023	**Time Zone**	AEST
Start Time	10:30am	**Finish Time**	11:30am
Minutes by	Melissa Everett	**Checked by**	Oliver Emary

Record of Discussion

1.0 Welcome, Introduction of Attendees, Apologies & Meeting Agenda	
Invitees	[AA] Alexanda Adkins – SMRC [OE] Oliver Emary – SMEC [ME] Melissa Everett – SMEC [JE] Josh Everett – SMEC [SC] Shefali Chakrabarty - SMEC [GS] Gary Shakespeare – SMRC [ZC] Zachary Crombie-Brown - SMRC
In Attendance	[AA] Alexanda Adkins – SMRC [GS] Gary Shakespeare – SMRC [OE] Oliver Emary – SMEC [ME] Melissa Everett – SMEC [SC] Shefali Chakrabarty - SMEC
Apologies	[JE] Josh Everett – SMEC [ZC] Zachary Crombie-Brown - SMRC

2.0	**Project General**	**Date**
2.1	[ITEM] - The objective of the meeting is for the attendees to discuss the following elements for the Road network and Stormwater network at Berridale and Kalkite. • Observations and thoughts on existing network conditions • Key concerns with network • Future considerations for the network • How can the SMEC commission – 'Infrastructure studies' support the work currently being undertaken	

3.0	Berridale	Date
	General	

3.1	[ITEM] - Road Network
	• Existing conditions
	  • The majority of the township's road network is sealed and in reasonable condition
	  • An observation provided by SMRC is that the recent demographic changes in Berridale has resulted in changes in traffic flows with more commuting traffic seen traveling to Jindabyne and Cooma.
	• Key Concerns
	  • Seasonal growth in population and traffic volumes
	  • Interface between council and state roads --> design standards
	  • Speed concerns --> 50km/hr on Jindabyne Road --> rejected to TfNSW
	  • Community would like to explore speed limit reductions	

3.2	[ITEM] - Stormwater
	• Existing conditions
	  • The stormwater in Berridale is reliant on the overland flow and is connected to two existing creeks, Myack Creek and Wullwye Creek
	  • It has limited stormwater infrastructure and is mostly kerb and gutters
	• Key Concerns
	  • The interface with Jindabyne Road and the management of discharge / dissipating from the following streets:
	  o Mackey Street
	  o Myack Street
	  o Boundary Street
	  • Any infrastructure works in Berridale will have to be undertaken either through grant funding or a stormwater levy.
	• Thoughts for the Future
	  • Consider SW harvesting based on Footprint 2015
	  • Incorporate a stormwater levy (in the past this hasn't been supported by the Council)
	• Infrastructure studies outcomes
	  • Include the outcomes of the FRMSP into the strategy
	  • Infrastructure Studies to reference all the available studies
	  • Recommendations for 'upgrades' and further studies
	  • Flavour of costs would be preferable
	  • Possibly speak to disaster resilience - flood, fire in report	

4.0	Kalkite	Date
	General	

4.1	[ITEM] – Road Network
	• Existing conditions
	  • The majority of the roads in Kalkite are steep, narrow and the pavement condition is variable.
	  • It was discussed that the vegetation and speed has affected the roads within the town.
	  • There is no line marking on the roads which is an existing concern.
	• Key Concerns
	  • The second access is necessary however would be very difficult (environment).	

4.2	[ITEM] – Stormwater
	• Existing conditions
	  • Limited information available and no studies
	  • Relying on council for insight
	  • There is push back from developers
	• Key Concerns
	  • There are two different engineering standards making it hard to enforce on developers.
	• Thoughts for the Future
	  • Councils' intention is for developers to build the infrastructure required and then vest into Council
	• Infrastructure studies outcome
	  • Mainly focus' on a new development. Council to confirm whether other existing areas are to be considered
	  • Specific DCP conditions for Kalkite
	  • Recommendations for 'upgrades' and further studies
	  • Flavour of costs would be preferable
	  • Possibly speak to disaster resilience – flood, fire in report	

>> Legend <<

[ITEM] – statement or element for information only

[**ACTION**] – action requiring attention

[**INSTR**] – Instruction for execution made by project client

[CLOSED] – actioned item

Member of the Surbana Jurong Group

Project Meeting Minutes

Meeting Name	Discussion for Planning and Environment		
Project Name	Berridale and Kalkite Infrastructure Studies		
Location	MS Teams		
Date	31 May 2023	**Time Zone**	AEST
Start Time	1.00pm	**Finish Time**	2.00pm
Minutes by	Melissa Everett	**Checked by**	Oliver Emary

Record of Discussion

1.0 Welcome, Introduction of Attendees, Apologies & Meeting Agenda	
Invitees	[AA] Alexanda Adkins – SMRC [OE] Oliver Emary – SMEC [ME] Melissa Everett – SMEC [TC] Thomas Carberry – SMEC [RC] Rebecca Carman – SMEC [HV] Hans Van Rijnberk – SMEC [JG] John Gargett – SMRC [TA] Tanveer Ahmad – SMRC [VG] Volker Georgi - SMRC
In Attendance	AA] Alexanda Adkins – SMRC [OE] Oliver Emary – SMEC [ME] Melissa Everett – SMEC [RC] Rebecca Carman – SMEC [HV] Hans Van Rijnberk – SMEC [JG] John Gargett – SMRC [VG] Volker Georgi - SMRC
Apologies	[TA] Tanveer Ahmad – SMRC

2.0	Project General	Date
2.1	[ITEM] - The objective of the meeting is for the attendees to discuss the following elements for Planning and Environment factors in Berridale and Kalkite. • Observations and thoughts on existing network conditions • Key concerns with network • Future considerations for the network • How can the SMEC commission – 'Infrastructure studies' support the work currently being undertaken	

3.0	Berridale	Date
	General	

3.1	[ITEM] - Existing conditions
	• The emphasis is on Kosciusko Road
	• The existing DAs for Berridale are for the following:
	  • Hoskins Street
	  • Komparo Drive
	  • Brown Street
	• The Stormwater / DAs are to be managed on a site-by-site basis. Some of the sites have already started.	

3.2	[ACTION] – The Data pack has been provided for the Snowy Monaro Biodiversity study – SMEC to add to the input register.	
3.3	[ACTION] - AA to provide GIS data from the map in the Snowy Monaro Biodiversity study report.	
3.4	[ACTION] – The ecology information has been provided for Berridale. SMEC to add to input register.	
3.4	[ITEM] - Question - Township structure plan: Updated structure plan already provided.	
3.5	[ITEM] – Berridale has thirteen access points into the township.	
3.6	[ACTION] – OE to provide the DCP provisions for Berridale to AA.	
3.7	[ITEM] - Key Concerns • Lack of stormwater / flood prone causes concern • Infrastructure constraints • Subdivisions and impacts they will have • Small upgrade to Mackey Street / Jindabyne Road • Key concerns to be addressed individually	

4.0	Kalkite	Date
	General	
4.1	[ITEM] – Existing conditions • The need to update Kalkite road • The secondary access needs to be considered broadly. There is a need to review opportunities to update Kalkite Road • Determine parameters for future studies • The township has a need for a second access for the future • Capacity of existing infrastructure – limiting factor Thoughts for the Future • The second access to be provided.	
4.2	[ACTION] – AA to provide OE with a copy of the Three Rivers Biodiversity Report.	

>> Legend <<

[ITEM] – statement or element for information only

[**ACTION**] – action requiring attention

[**INSTR**] – Instruction for execution made by project client

[CLOSED] – actioned item

Member of the Surbana Jurong Group

Project Meeting Minutes

Meeting Name	Discussion for Water and Sewer		
Project Name	Berridale and Kalkite Infrastructure Studies		
Location	MS Teams		
Date	1 June 2023	**Time Zone**	AEST
Start Time	12.30pm	**Finish Time**	1.30pm
Minutes by	Melissa Everett	**Checked by**	Oliver Emary

Record of Discussion

1.0 Welcome, Introduction of Attendees, Apologies & Meeting Agenda	
Invitees	[AA] Alexanda Adkins – SMRC [OE] Oliver Emary – SMEC [ME] Melissa Everett – SMEC [MA] Muhammad AMJAD – SMEC [AE] Anahita EFTEKHAR – SMEC [MF] Mark FITZPATRICK – SMEC [CW] Chris Witney – SMRC [HS] Harry Sahota – SMRC [AS] Andrew Scharkie – SMRC [AA] Alexanda Adkins – SMRC
In Attendance	AA] Alexanda Adkins – SMRC [OE] Oliver Emary – SMEC [ME] Melissa Everett – SMEC [MA] Muhammad AMJAD – SMEC [MF] Mark FITZPATRICK – SMEC [AS] Andrew Scharkie – SMRC – background [HS] Harry Sahota – SMRC – sewer at Berridale - leads [CW] Chris Witney – SMRC – are the lead – water ways team
Apologies	[AE] Anahita EFTEKHAR – SMEC

2.0	Project General	Date
2.1	[ITEM] - The objective of the meeting is for the attendees to discuss the following elements for Water and Sewer in Berridale and Kalkite. • Observations and thoughts on existing network conditions • Key concerns with network • Future considerations for the network • How can the SMEC commission – 'Infrastructure studies' support the work currently being undertaken	

3.0	Berridale	Date
	General	
3.1	[ITEM] – Existing conditions - Sewer • Reaching capacity at the treatment plant • Sewer network at capacity • Developments are in planning phase • Models for new trunk on Western side	
3.2	[ITEM] – The developers for Berridale are working with the council on individual developments within the town. SMRC needs to look at a whole town approach, looking at the broader piece of the work, including the future growth area for development. There is an urgency to service southern developments.	
3.3	[ACTION] – AA to provide SMEC with the waste area draft data.	
3.4	[ITEM] - Water • Proposed renewals for the water network for Berridale • Hydraulics report (moving PRV) • There are future plans on the western side of Berridale • Scope renewal/section 68 work • The active model can be accessed if needed. [ITEM] - Thoughts for the Future • The future growth has a 20-year timeframe	

4.0	Kalkite	Date
	General	
4.1	[ITEM] – Existing conditions – Water • Operating very poorly, rising mains, gravity mains, huge pressure points, chlorination is an issue. The Hydraulic report captures those issues. • Capacity and reservoirs should operate at night • Reservoirs might need to be used through the day [ITEM] – Key Concerns • Operational issues for growth sites	

4.2 [ITEM] – Existing conditions – Sewer

- Sewer report – Issues with evaporation pond
- Looking at different options
- The sewer plant for Kalkite is at the top of the town. It has a simple setup, not sure of the capacity
- Two reservoirs: Irrigation water, ???

[ITEM] – Key Concerns

- Heavy rainfall causes issues which causes stormwater to go into the plant.

[ITEM] – Thoughts for the Future

- Received grant money for an options study, this is being looked at (based on the Recommendations study)

[ITEM] OE – Proposed Infrastructure study has varying levels of detail – overall can help out with recommendations

>> Legend <<

[ITEM] – statement or element for information only

[**ACTION**] – action requiring attention

[**INSTR**] – Instruction for execution made by project client

[CLOSED] – actioned item

Member of the Surbana Jurong Group

Project Meeting Minutes

Meeting Name	Discussion for TfNSW & SMRC		
Project Name	Berridale and Kalkite Infrastructure Studies		
Location	MS Teams		
Date	8 June 2023	**Time Zone**	AEST
Start Time	1.00pm	**Finish Time**	2.00pm
Minutes by	Melissa Everett	**Checked by**	Oliver Emary

Record of Discussion

1.0 Welcome, Introduction of Attendees, Apologies & Meeting Agenda	
Invitees	[AA] Alexanda Adkins – SMRC [OE] Oliver Emary – SMEC [JE] Josh Everett – SMEC [ME] Melissa Everett – SMEC [ER] Elira Reynolds – TfNSW [MM] Maurice Morgan - TfNSW
In Attendance	[AA] Alexanda Adkins – SMRC [OE] Oliver Emary – SMEC [JE] Josh Everett – SMEC [ME] Melissa Everett – SMEC [ER] Elira Reynolds – TfNSW [MM] Maurice Morgan - TfNSW
Apologies	

2.0	**Project General**	**Date**
2.1	[ITEM] - SMRC received funding from a housing development fund. They decided to do Berridale and Kalkite studies to identify infrastructure gaps required to deliver housing. Transport and access study, along with Kalkite Road upgrade road study. Mostly compliance review against TfNSW requirements to identify upgrades needed to support development. Stakeholder engagement, this session, to understand requirements. Come back in a month or two to discuss options and recommendations.	

3.0	Berridale	Date
3.1	[ITEM] - Any current constraints/concerns?	
	Jindabyne Road runs through centre of Berridale. In more recent times, has become a pinch point in terms of facilitating growth and managing traffic flows.	
	MM: Do not want to increase access points to the road. Main route to snowfields. Flow must remain uninhibited as possible. Any expansion to Berridale must not impact on flow. Other constraints include water/sewer/topo/road network.	
	ER: Land on southern fringe likely to proceed (without TfNSW review). Have commented on northern development. Aware that council want to develop. Would prefer consolidated access. Consider upgrades to existing intersections.	
	AA: Five recently approved subdivisions on the north, likely to soak up most of the short-term growth. Land release area to the west, constrained by elevation (water service). Setting up DCP showing road connection plans. Jindabyne Road through Berridale is a heritage item (trees). Identified FUA south if Boundary Street (not zoned for residential, no planning proposals yet).	
	MM: Southern and Northern developments do not appear to need extra connections. Western development might justify extra connection.	
	ER: dealing with upgrade to Mackay intersection (WAD team) (mostly line marking and shoulder widening). Might be able to upgrade existing intersection north of Boundary St to accommodate.	
	MM: Scope? Looking at infrastructure to the development or within? OE: Both. ER: important to identify some kind of indicative internal road network. TfNSW happy to provide feedback/advice. Need to be bus capable and allow for active transport. Need to move decision-making points away from state roads.	

4.0	Kalkite	Date
4.1	[ITEM] MM: Kalkite is remote from state road network, so little comment from TfNSW. Only interested in intersections on Kosciusko Road. Responsible for speed limits but has not had a review for a long time (AA: reduced from 100 to 80 recently). Increases to population/residential development may change classification of road and trigger review. Will do review if warranted or triggered by crash history. May need to consider road design to enforce speed change, rather than just change the sign. What about single access point to Kalkite? ER: have been talking to TfNSW about the proposed 280-lot development. TfNSW feel that Hilltop Road will be used by residents. Need works on the intersection minimum channelised right turn + auxiliary left turn. Eucumbene Road intersection is problematic in terms of future development. TfNSW will be attending site to attend. Single access accepted by TfNSW if capacity can be demonstrated. RFS may not accept. MM: scope? Current development or others? AA: 200+32, no others known. Happy to assist with discussions around layouts, bus, service vehicles etc, but really only concerned about intersections on Kosciusko Rd. AA: updated documents received from proponent but may need some changes (excludes any contribution to state road upgrades). Seemed to be lacking detail. Contact ER in the first instance if we have any questions. ER+MM to be in Cooma mid-July, may be an opportunity to meet up.	

>> Legend <<

[ITEM] – statement or element for information only

[**ACTION**] – action requiring attention

[**INSTR**] – Instruction for execution made by project client

[CLOSED] – actioned item

Member of the Surbana Jurong Group

Project Progress Meeting Minutes

Meeting Name	Discussion with Essential Energy		
Project Name	Berridale and Kalkite Infrastructure Studies		
Location	MS Teams		
Date	19 July 2023	**Time Zone**	AEST
Start Time	11:00am	**Finish Time**	12:00pm
Minutes by	Melissa Everett	**Checked by**	Oliver Emary

Record of Discussion

1.0 Attendees, Apologies & Meeting Agenda	
Invitees	[OE] Oliver Emary – SMEC [ME] Melissa Everett – SMEC [GM] Gina McConkey – SMRC [AW] Andrew Wykes – Essential Energy [JB] Joe Barry – Essential Energy
In Attendance	[OE] Oliver Emary – SMEC [ME] Melissa Everett – SMEC [GM] Gina McConkey – SMRC [AW] Andrew Wykes – Essential Energy [JB] Joe Barry – Essential Energy
Apologies	

2.0	**Project General**	**Date**

2.1	[ITEM] Essential Energy presented an overview of the network in the proximity of Berridale and Kalkite:
	• The growth in the Berridale and Kalkite area will be supplied from the Jindabyne East Zone sub which consists of 2 x 8/10 MVA transformers.
	• The sub has capacity for 6 feeders in total, currently there are 2 connected.
	  • JYE3B2- Supplies Kalkite and Berridale
	  • JYE3B3 – Supplies East Jindabyne and Tyrolean
	• As the growth occurs on each feeder the developer is contributing to maintain adequate voltage levels both in Berridale town and the Kalkite area with re-conductoring on the feeders.
	• As growth continues the plan is to split JYE3B2 into 2 separate feeders, 1 dedicated to Berridale and the 2nd dedicated to Kalkite with interties for reliability and maintenance purposes.
	• The Western rural feeder out of Cooma (COO3B7) also has a limited capacity to supply the Berridale township, we are looking to boost this capacity soon which will again assist with reliability and growth within Berridale town.
	• The existing combined Peak load fed of the 2 East Jindabyne feeders is 5.3MVA.

2.2	[ITEM] EE discussed that Berridale and Kalkite are on the same feeder, but it was discussed that there is a plan for both to have their own feeder.
2.3	[ITEM] Future Projections for Kalkite – EE received applications for 214 lots. They will need to build a new feeder to support the new lots.
2.4	[ITEM] - EE confirmed that they have not seen any additional planning proposals from developers in Kalkite [ITEM] – SMRC and this project will be in further contact about communicating these future possible developments in Kalkite.
2.6	[ITEM] It was discussed that EE need to be included in conversations earlier, so they have the insight on what is happening.
2.7	[ITEM] GM mentioned to attendees that Berridale LEP is being revised – currently in draft. This will change minimum lot sizes in Berridale - the lots will change from 1000m^2 to 700 m^2. The intention is to encourage infill development within the township.
2.8	[ITEM] EE discussed that subdivisions and dual occupancies are an ongoing concern for planning capacity in the network.
2.9	[ITEM] - EE are looking at projected forecasts for 5 - 10 years.
2.10	[ITEM] - SMRC have a planning horizon of 20 years and a budget horizon of 10 years.
2.11	[ITEM] – SMEC to continue working with EE to provide an overview of the current network, along with planned future and possible future upgrades for Berridale and Kalkite.

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[ITEM] – statement or element for information only

[**ACTION**] – action requiring attention

[**INSTR**] – Instruction for execution made by project client

[CLOSED] – actioned item

Member of the Surbana Jurong Group

Project Progress Meeting Minutes

Meeting Name	Discussion with Rural Fire Service		
Project Name	Berridale and Kalkite Infrastructure Studies		
Location	MS Teams		
Date	18 August 2023	**Time Zone**	AEST
Start Time	10:30am	**Finish Time**	11:30am
Minutes by	Oliver Emary	**Checked by**	Josh Everett

Record of Discussion

1.0 Attendees, Apologies & Meeting Agenda	
Invitees	[OE] Oliver Emary – SMEC [JE] Josh Everett – SMEC [GM] Gina McConkey – SMRC [JD] Jim Darrant – RFS [MD] Martha Dotter - RFS
In Attendance	[OE] Oliver Emary – SMEC [JE] Josh Everett – SMEC [JD] Jim Darrant – RFS [MD] Martha Dotter - RFS
Apologies	[GM] Gina McConkey – SMRC

2.0	**Project General**	**Date**
2.1	[ITEM] – SMEC provided a brief overview of project and its objectives - Project is looking to develop a series of infrastructure upgrade recommendations that will assist in facilitating growth in Berridale and Kalkite over the next 20 years.	
2.2	[ITEM] – The aim of these conversation is to introduce the project to representatives from RFS and through conversation, have the project gain further insight into the parameters influencing emergency services in Berridale and Kalkite	
2.3	[ITEM] - Planning for Bushfire Protection (pg 35) includes strategic planning to be referenced in recommendations for bushfire planning	
	Berridale	
2.4	[ITEM] – Winter and summer seasons create constant stream of vehicle traffic along Kosciuszko Road / Jindabyne Road.	
2.5	[ITEM] – RFS would welcome any upgrades to existing road connections onto Kosciuszko Road / Jindabyne Road that improves safety and the flow of traffic.	
2.6	[ITEM] – Berridale RFS station recently upgraded (<5yrs). Is able to accommodate projected population growth.	

2.7	[ITEM] – Future development areas on western flank are adjacent to grasslands. A clear fuel load management strategy will need to be established. The vegetation easement will need to re-established along a new border to allow access.
2.8	[ITEM] - Berridale is RFS protection zone, so RFS attend all fires and general emergencies etc.
2.9	[ITEM] – While not in the scope of this study, future peak loads on existing intersections should consider emergency access.
	Kalkite
2.10	[ITEM] - Kalkite village is problematic from an emergency access point-of-view. It has one substandard access point that has poor pavement condition, visibility and grades.
2.11	[ITEM] - Development needs to consider resident evacuation, appliance access
2.12	[ITEM] – The Council planned population (>1,000) would justify a stronger RFS presence in Kalkite, but emergency would always require additional appliances from Berridale (or elsewhere). Existing RFS site wouldn't be suitable in the long term.
2.13	[ITEM] - Given the significant access constraints (one lane, through bushfire risk zone), access will be critiqued carefully at DA stage.
2.14	[ITEM] - Hilltop Road is a dirt road. Additional traffic likely to use this to get to Cooma. Access route for emergency vehicles from the north. May require paving.

>> Legend <<

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[CLOSED] – actioned item