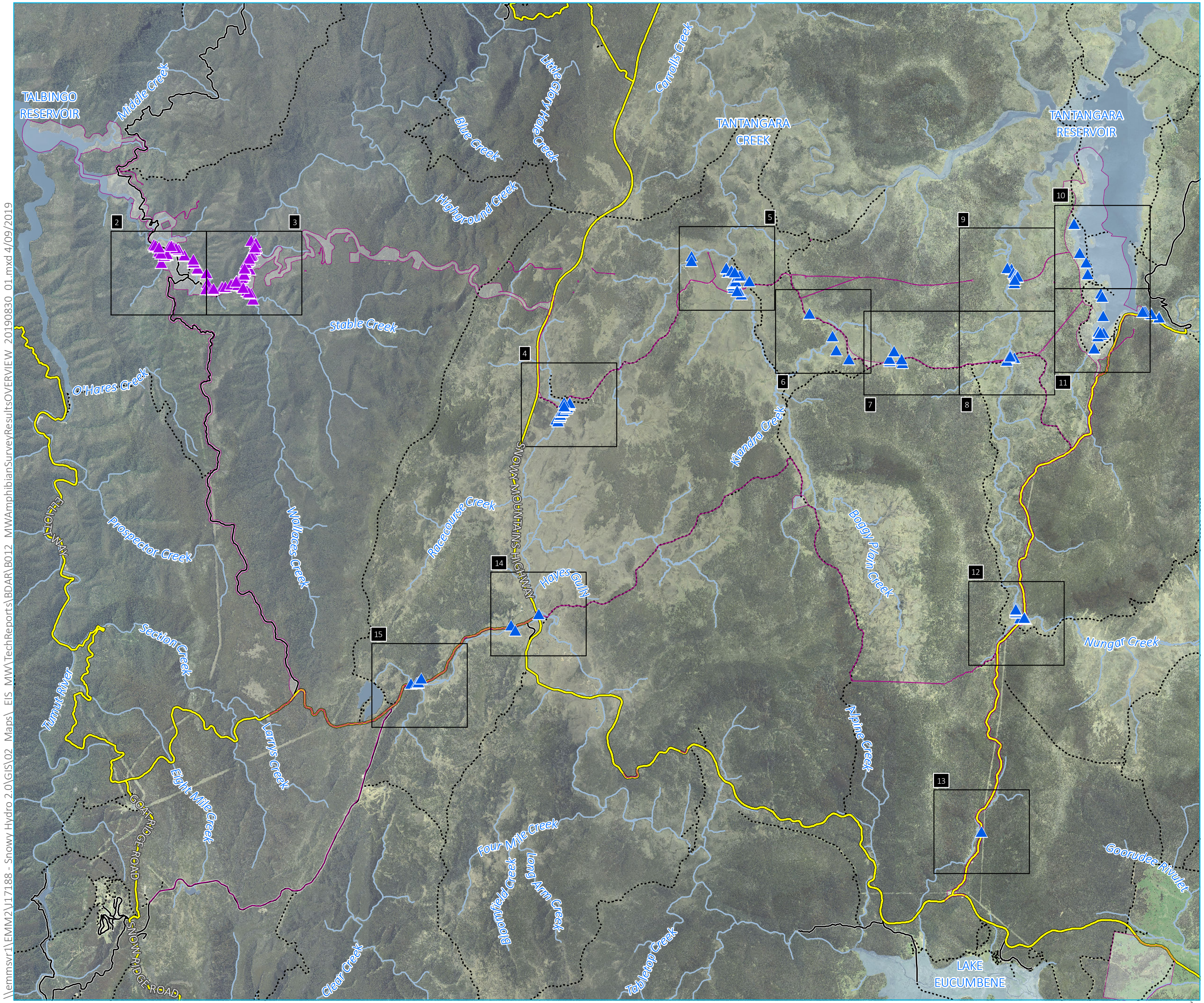


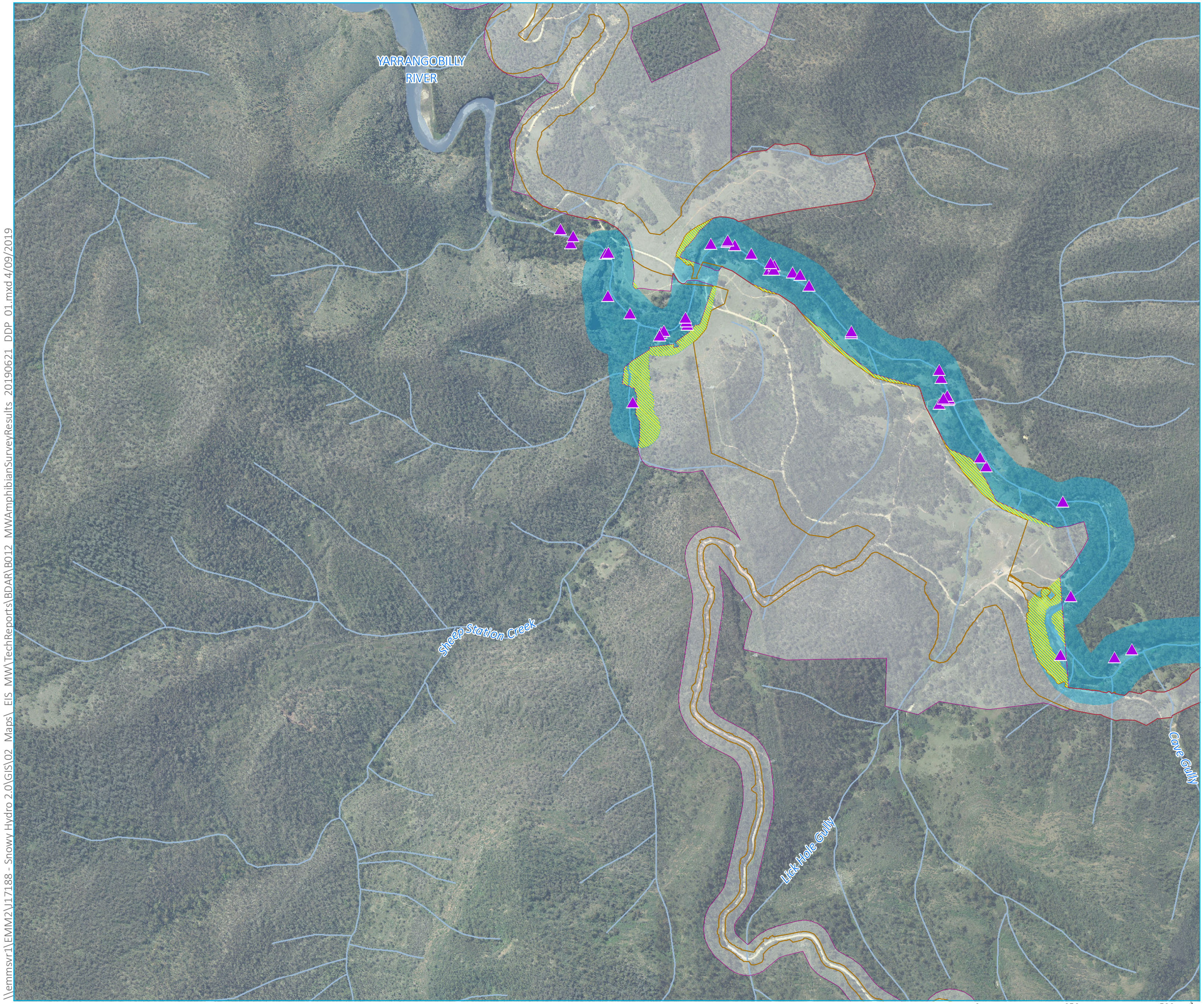
\\emmsvr1\EMM2\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_MW\TechReports\BDAR\B012_MWAmphibianSurveyResultsOVERVIEW_20190830_01.mxd 4/09/2019

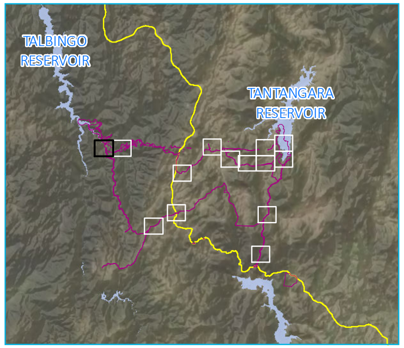
Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

KEY
- Watercourse / drainage line
- Main road
- Local road
- Vehicular track
- Amphibian survey grid index
- Main Works disturbance footprint
- Waterbody
- Alpine Tree Frog (123)
- Booroolong Frog (110)

Amphibian survey results - overview

Snowy 2.0
Biodiversity Assessment Report
Main Works
Figure 6.10.1





KEY

- Watercourse / drainage line
- Waterbody
- Main Works disturbance footprint
- Approved footprint
- Booroolong Frog species polygon
- Booroolong Frog species habitat
- Booroolong Frog (44)

Amphibian survey results

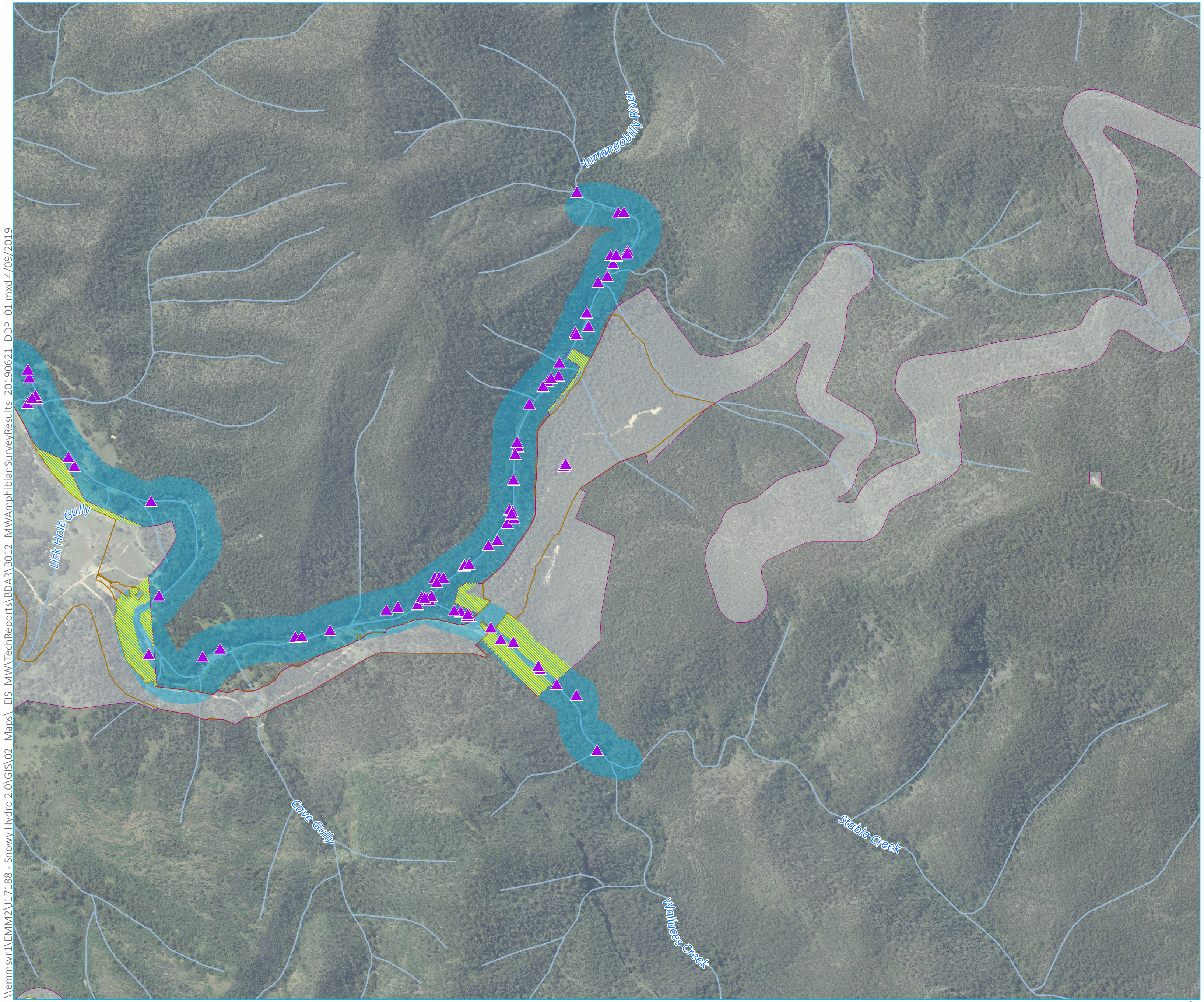
Snowy 2.0
Biodiversity Assessment Report
Main Works
Figure 6.10.2

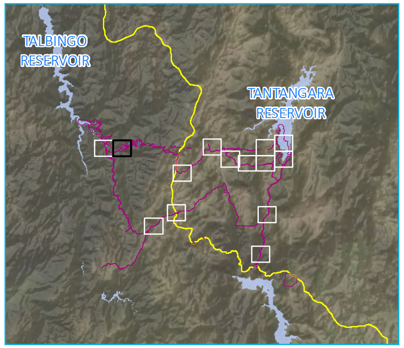
Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

\\emmsvr1\EMM2\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_MW\TechReports\BDAR\B012_MWAmphibianSurveyResults_20190621_DDP_01.mxd 4/09/2019

snowy 2.0

EMM creating opportunities





KEY

- Watercourse / drainage line
- Main Works disturbance footprint
- Approved footprint
- Booroolong Frog species polygon
- Booroolong Frog species habitat
- Booroolong Frog (82)

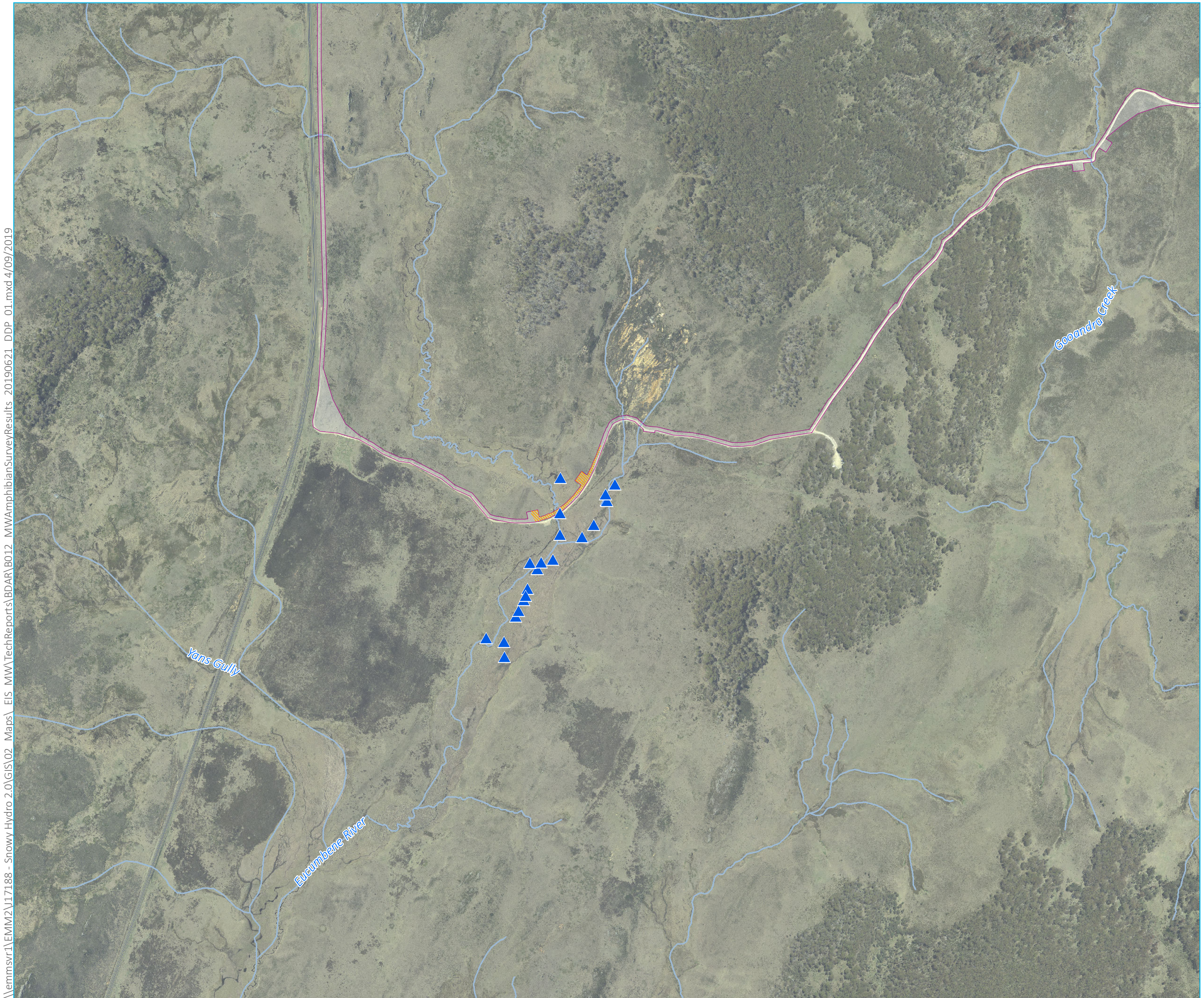
Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

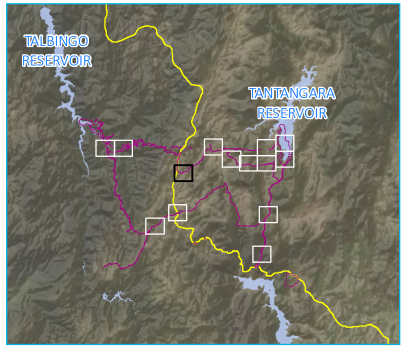
0 250 500 m
GDA 1994 MGA Zone 55
N

\\emmsvr1\EMM2\J17188 - Snowy Hydro 2.0\GIS\02_Maps\EIS_MW\TechReports\BDAR\B012_MWAmphibianSurveyResults_20190621_DDP_01.mxd 4/09/2019

Amphibian survey results

Snowy 2.0
Biodiversity Assessment Report
Main Works
Figure 6.10.3





KEY

- Watercourse / drainage line
- Main Works disturbance footprint
- Alpine Tree Frog species polygon
- Alpine Tree Frog (21)

Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

0 250 500 m

GDA 1994 MGA Zone 55

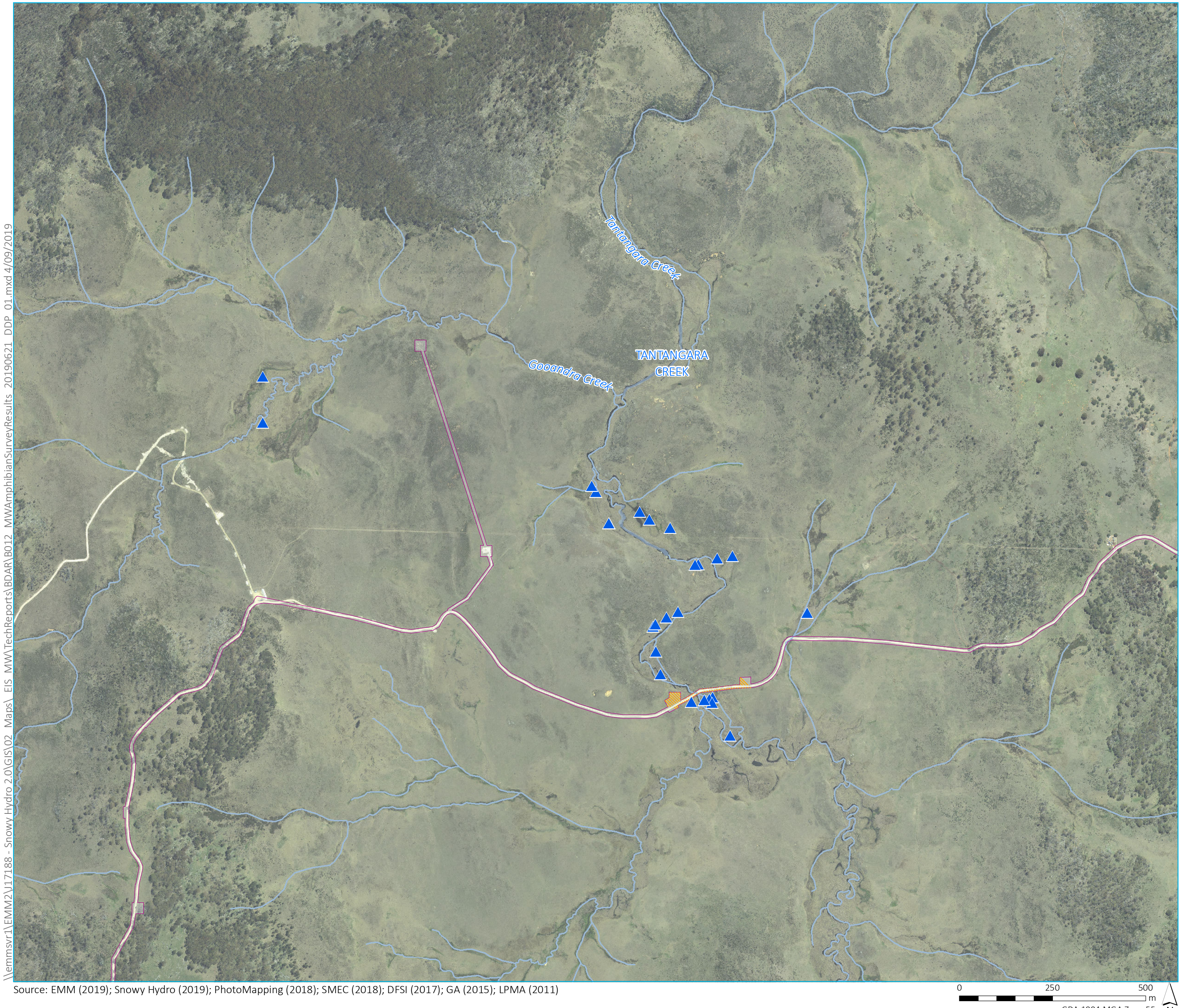
N

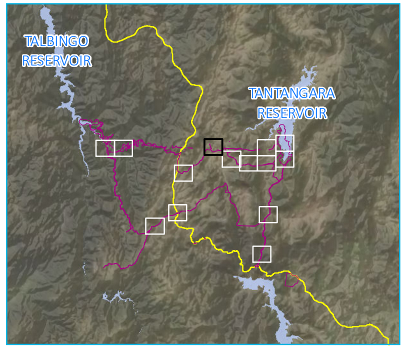
Amphibian survey results

Snowy 2.0
Biodiversity Assessment Report
Main Works
Figure 6.10.4

snowy 2.0

EMM creating opportunities





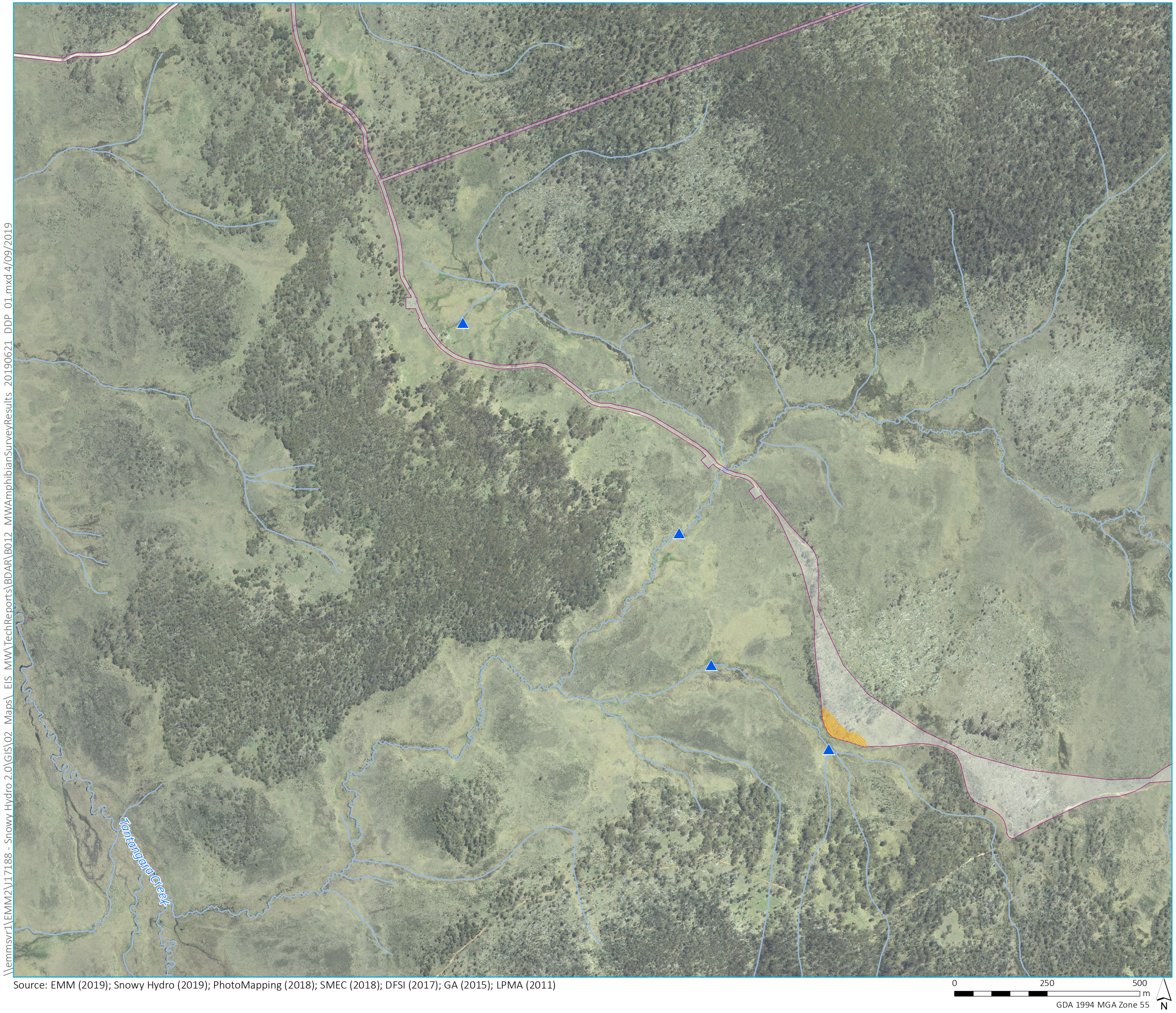
KEY
- Watercourse / drainage line
- Waterbody
- Main Works disturbance footprint
- Alpine Tree Frog species polygon
- Alpine Tree Frog (26)

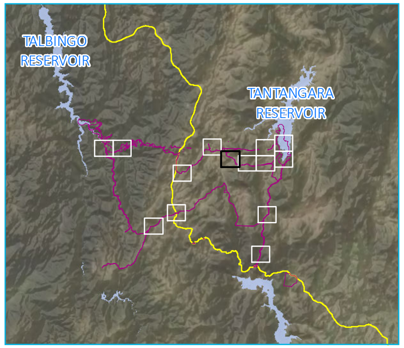
Amphibian survey results

Snowy 2.0
Biodiversity Assessment Report
Main Works
Figure 6.10.5

Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

\\emmsvr1\EMM2\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_MW\TechReports\BDAR\B012_MWAmphibianSurveyResults_20190621_DDP_01.mxd 4/09/2019





KEY
- Watercourse / drainage line
- Main Works disturbance footprint
- Alpine Tree Frog species polygon
- Alpine Tree Frog (4)

Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

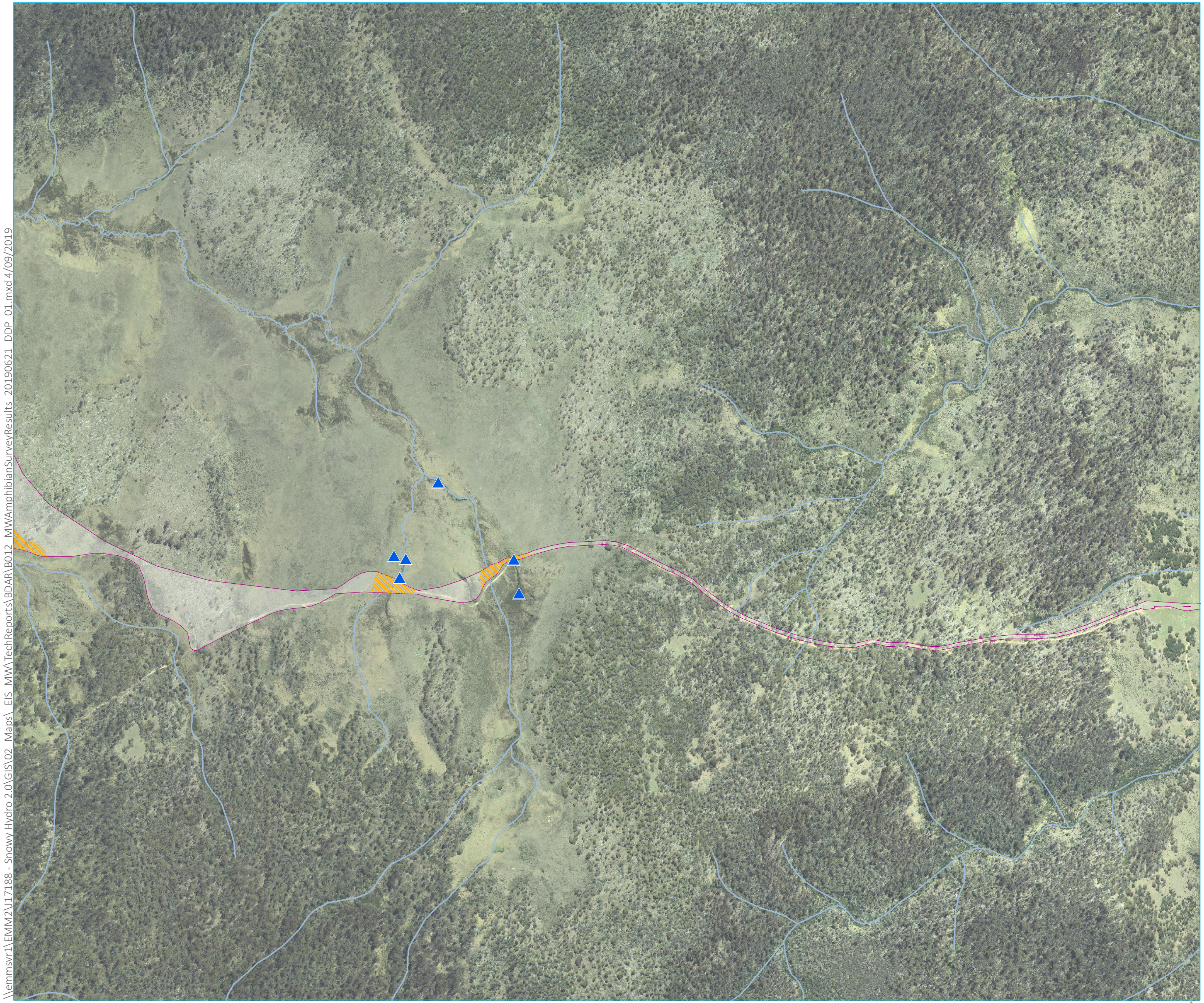
\\emmsvr1\EMM2\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_MW\TechReports\BDAR\B012_MWAmphibianSurveyResults_20190621_DDP_01.mxd 4/09/2019

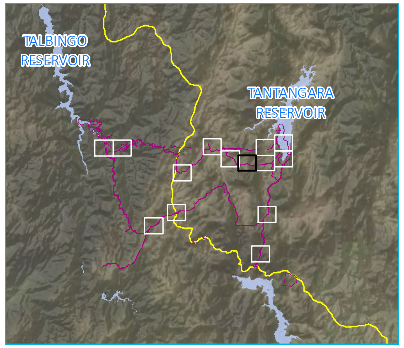
Amphibian survey results

Snowy 2.0
Biodiversity Assessment Report
Main Works
Figure 6.10.6

snowy 2.0

EMM creating opportunities





KEY

- Watercourse / drainage line
- Main Works disturbance footprint
- Alpine Tree Frog species polygon
- Alpine Tree Frog (7)

Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

0 250 500 m

GDA 1994 MGA Zone 55

N

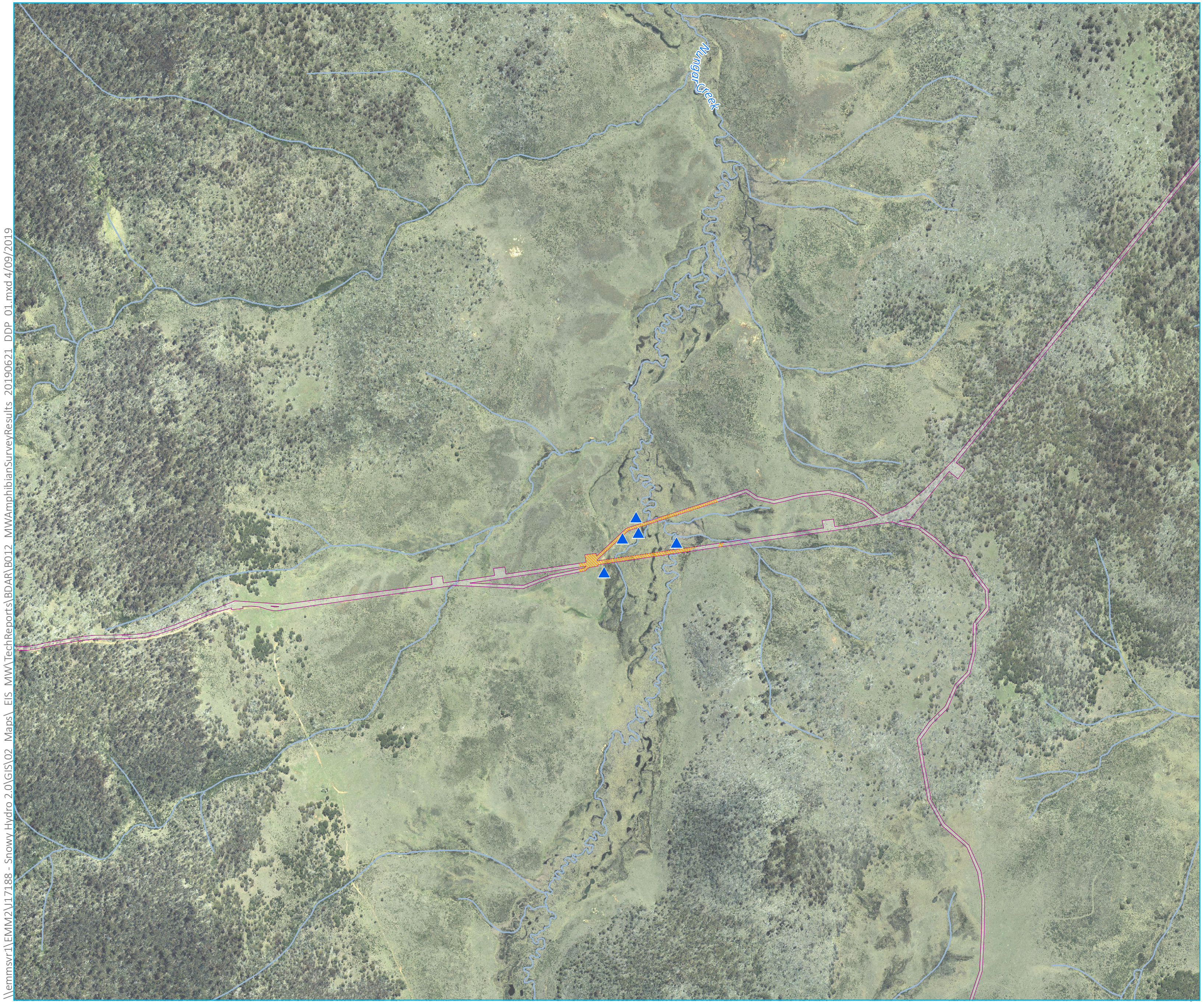
\\emmsvr1\EMM2\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_MW\TechReports\BDAR\B012_MWAmphibianSurveyResults_20190621_DDP_01.mxd 4/09/2019

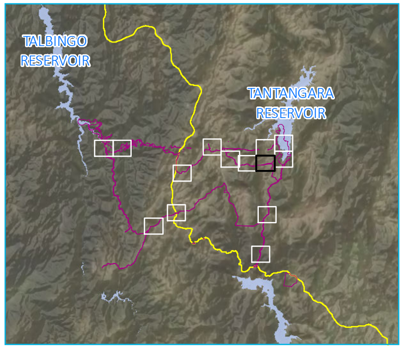
Amphibian survey results

Snowy 2.0
Biodiversity Assessment Report
Main Works
Figure 6.10.7

snowy 2.0

EMM creating opportunities





KEY

- Watercourse / drainage line
- Main Works disturbance footprint
- Alpine Tree Frog species polygon
- Alpine Tree Frog (5)

Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

0 250 500 m

N

GDA 1994 MGA Zone 55

Amphibian survey results

Snowy 2.0
Biodiversity Assessment Report
Main Works
Figure 6.10.8

snowy 2.0

EMM creating opportunities

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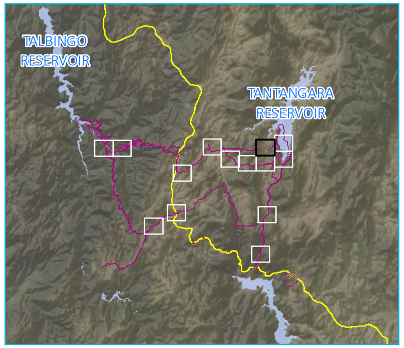


KEY

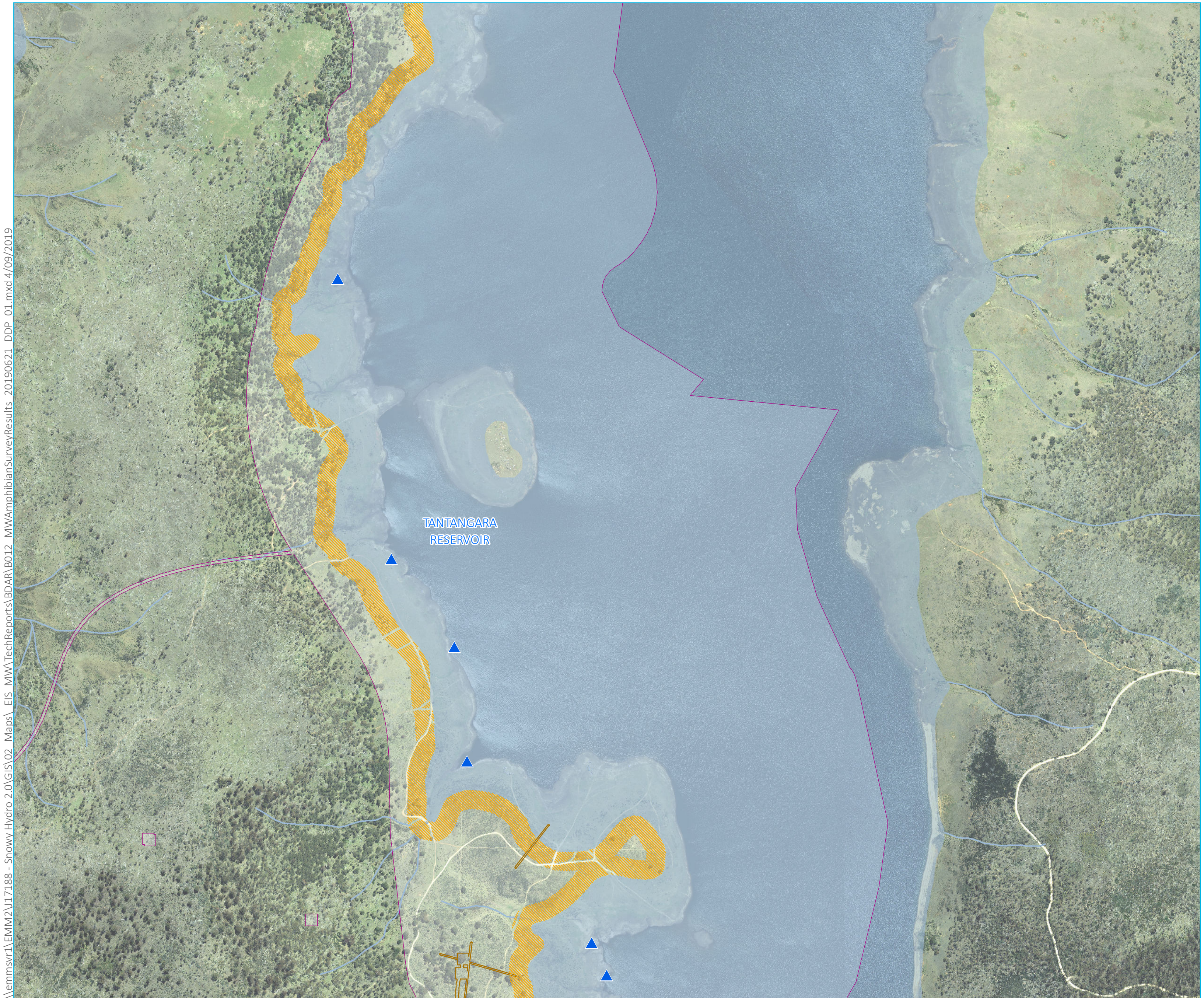
- Watercourse / drainage line
- Waterbody
- Main Works disturbance footprint
- Alpine Tree Frog species polygon
- ▲ Alpine Tree Frog (13)

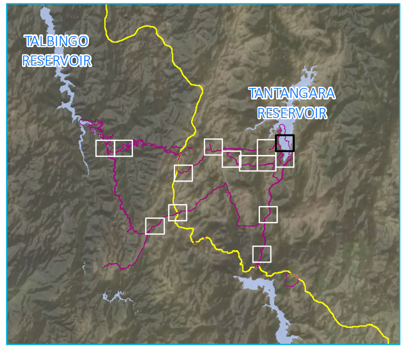
Amphibian survey results

Snowy 2.0
Biodiversity Assessment Report
Main Works
Figure 6.10.9

Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

\\emmsvr1\EMM2\J17188_Snowy Hydro 2.0\GIS\02_Maps_EIS_MW\TechReports\BDAR\B012_MWAmphibianSurveyResults_20190621_DDP_01.mxd 4/09/2019





KEY
- Watercourse / drainage line
- Waterbody
- Main Works disturbance footprint
- Approved footprint
- Alpine Tree Frog species polygon
- Alpine Tree Frog (6)

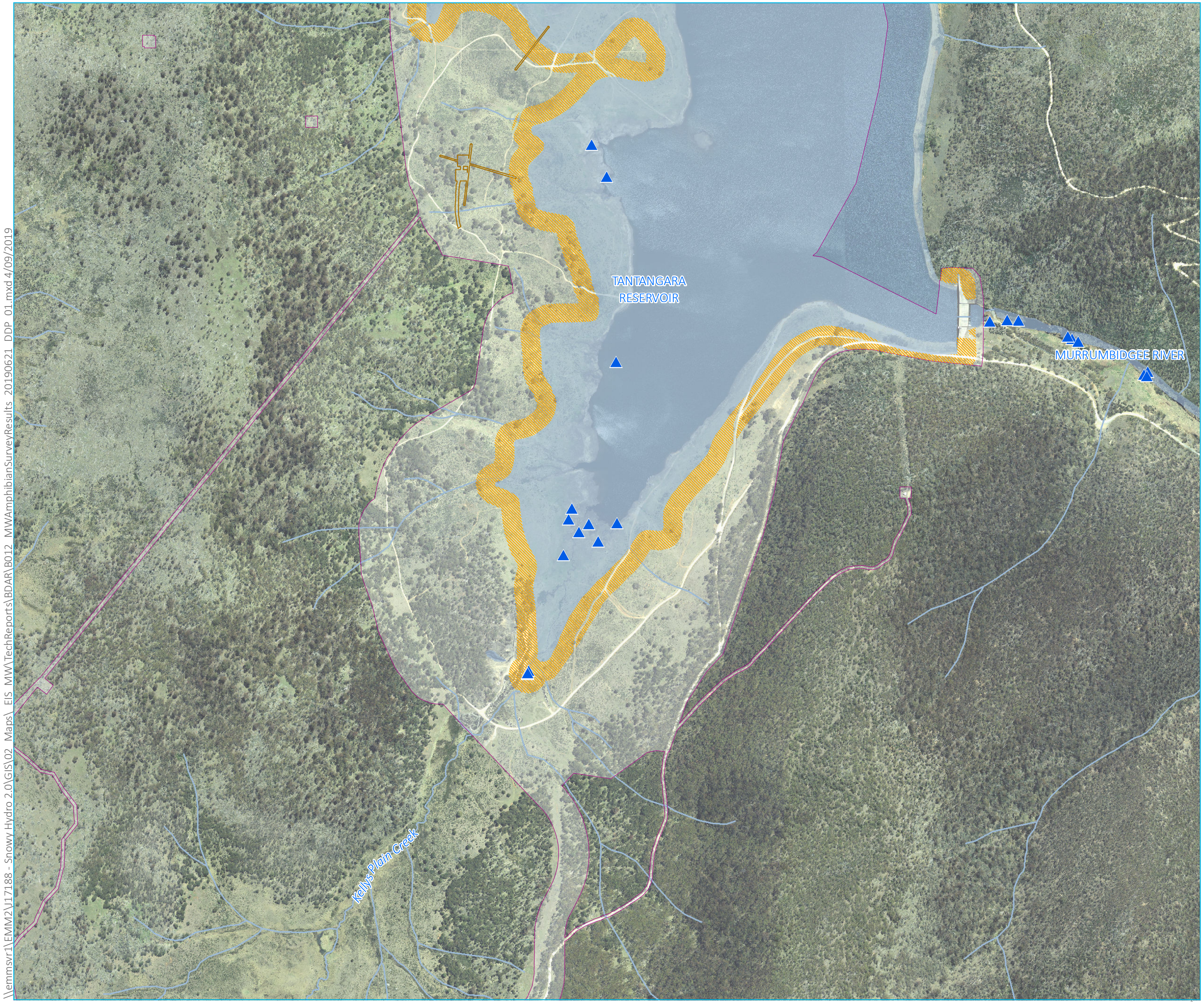
Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

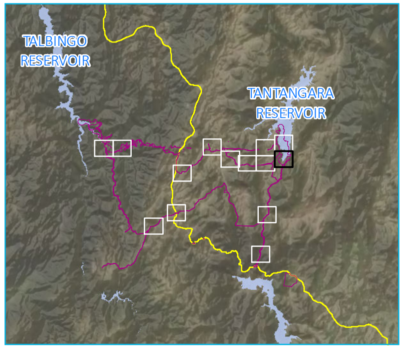
0 250 500 m
GDA 1994 MGA Zone 55
N

\\emmsvr1\EMM2\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_MW\TechReports\BDAR\B012_MWAmphibianSurveyResults_20190621_DDP_01.mxd 4/09/2019

Amphibian survey results

Snowy 2.0
Biodiversity Assessment Report
Main Works
Figure 6.10.10





KEY

- Watercourse / drainage line
- Waterbody
- Main Works disturbance footprint
- Approved footprint
- Alpine Tree Frog species polygon
- Alpine Tree Frog (22)

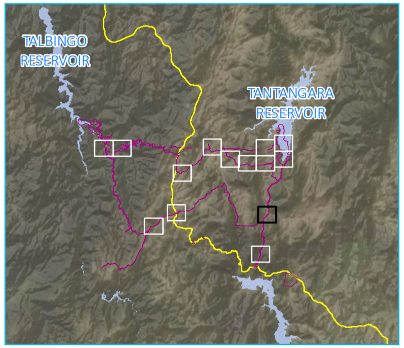
Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

\\emmsvr1\EMM2\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_MW\TechReports\BDAR\B012_MWAmphibianSurveyResults_20190621_DDP_01.mxd 4/09/2019

Amphibian survey results

Snowy 2.0
Biodiversity Assessment Report
Main Works
Figure 6.10.11

snowy 2.0
EMM creating opportunities



KEY

- Watercourse / drainage line
- Main Works disturbance footprint
- Alpine Tree Frog species polygon
- Alpine Tree Frog (13)

Amphibian survey results

Snowy 2.0
Biodiversity Assessment Report
Main Works
Figure 6.10.12

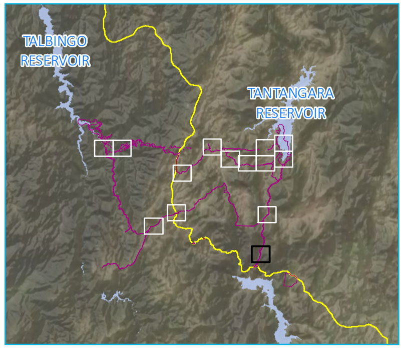
Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

0 250 500 m
GDA 1994 MGA Zone 55
N

snowy 2.0

EMM creating opportunities

\\emmsvr1\EMM2\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_MWTechReports\BDAR\B012_MWAmphibianSurveyResults_20190621_DDP_01.mxd 4/09/2019



KEY

- Watercourse / drainage line
- Main Works disturbance footprint
- Alpine Tree Frog (1)

Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

0 250 500 m

GDA 1994 MGA Zone 55

N

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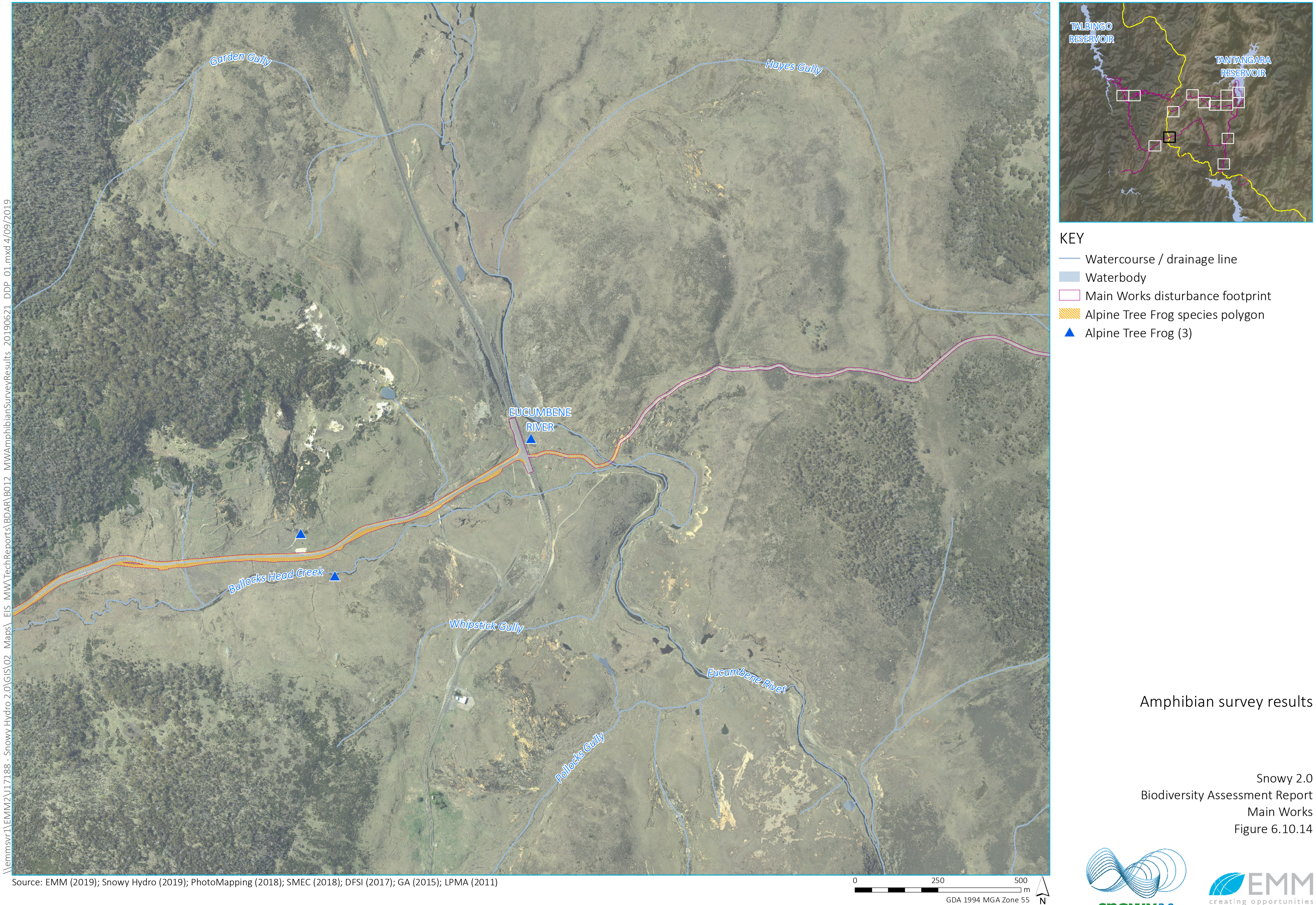
Amphibian survey results

Snowy 2.0
Biodiversity Assessment Report
Main Works
Figure 6.10.13

snowy 2.0

EMM creating opportunities



Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

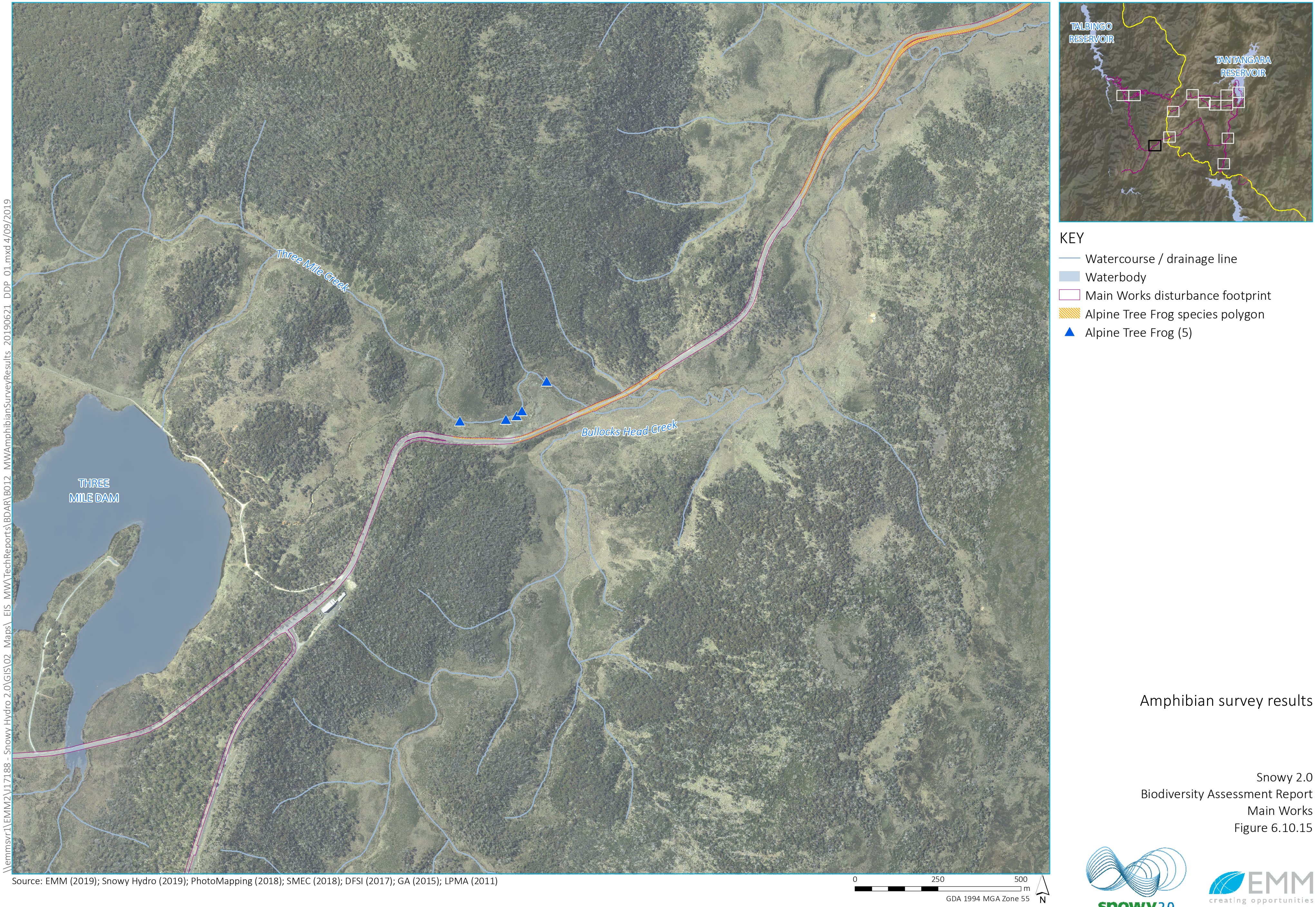
KEY

- Watercourse / drainage line
- Waterbody
- Main Works disturbance footprint
- Alpine Tree Frog species polygon
- Alpine Tree Frog (3)

Amphibian survey results

Snowy 2.0
Biodiversity Assessment Report
Main Works
Figure 6.10.14

\\emmsvr1\EMM2\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_MW\TechReports\BDAR\B012_MWAmphibianSurveyResults_20190621_DDP_01.mxd 4/09/2019



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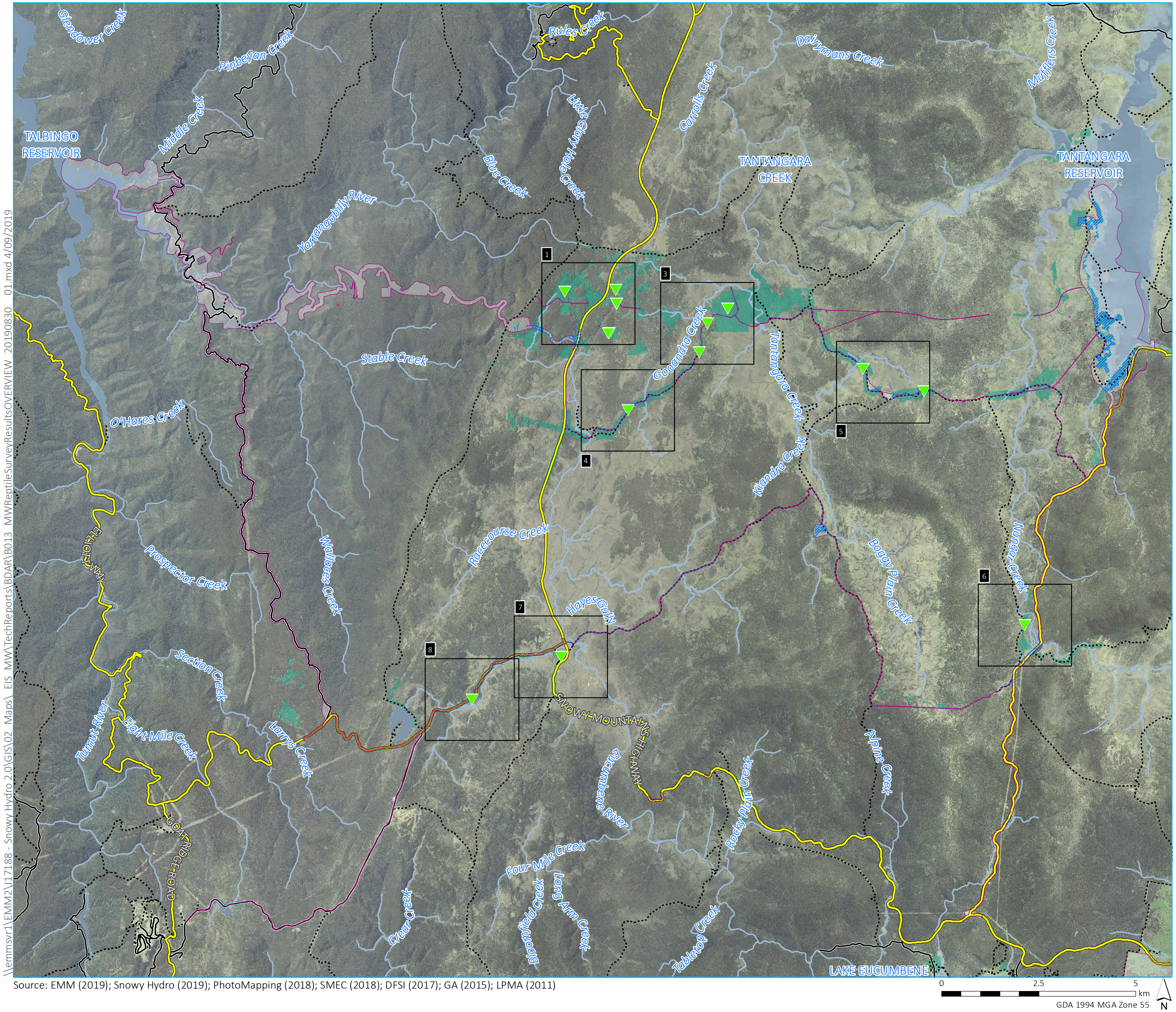
Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

KEY

- Watercourse / drainage line
- Waterbody
- Main Works disturbance footprint
- Alpine Tree Frog species polygon
- Alpine Tree Frog (5)

Amphibian survey results

Snowy 2.0
Biodiversity Assessment Report
Main Works
Figure 6.10.15



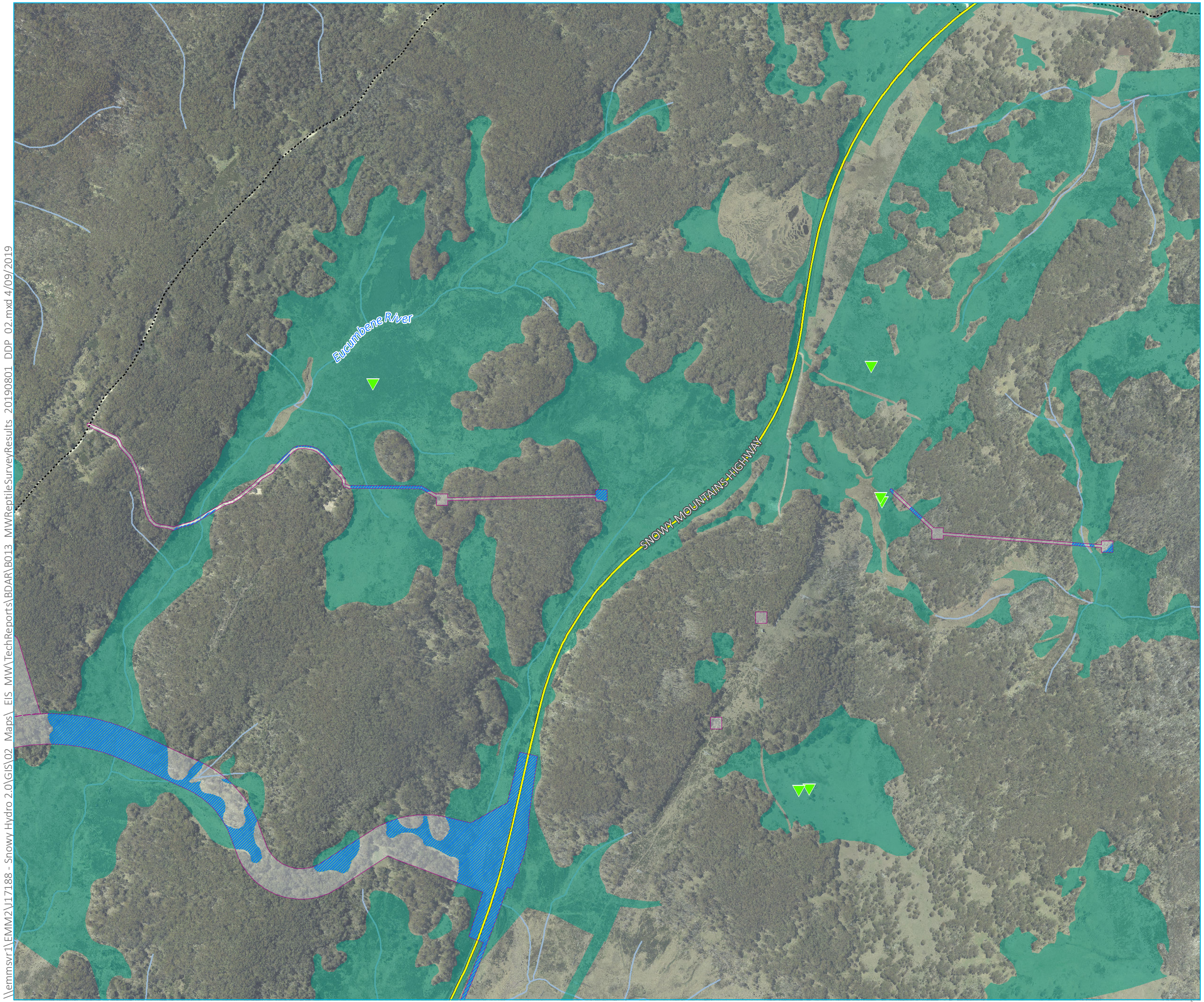
Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

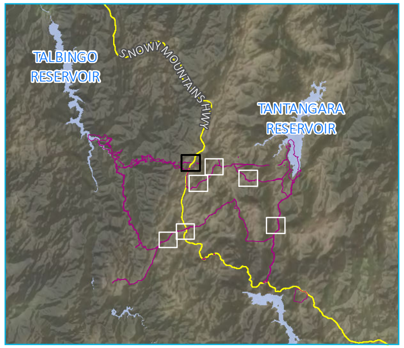
KEY
- Watercourse / drainage line
- Main road
- Local road
- Vehicular track
- Main Works disturbance footprint
- Waterbody
- Alpine She-oak Skink survey grid index
- Alpine She-oak Skink species polygon
- Alpine She-oak Skink species habitat
- Alpine She-oak Skink (16)

Reptile survey results
- overview

Snowy 2.0
Biodiversity development assessment
Main Works
Figure 6.11.1

\\emmsvr1\EMM2\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_MW\TechReports\BDAR\B013_MWReptileSurveyResultsOVERVIEW_20190830_01.mxd 4/09/2019





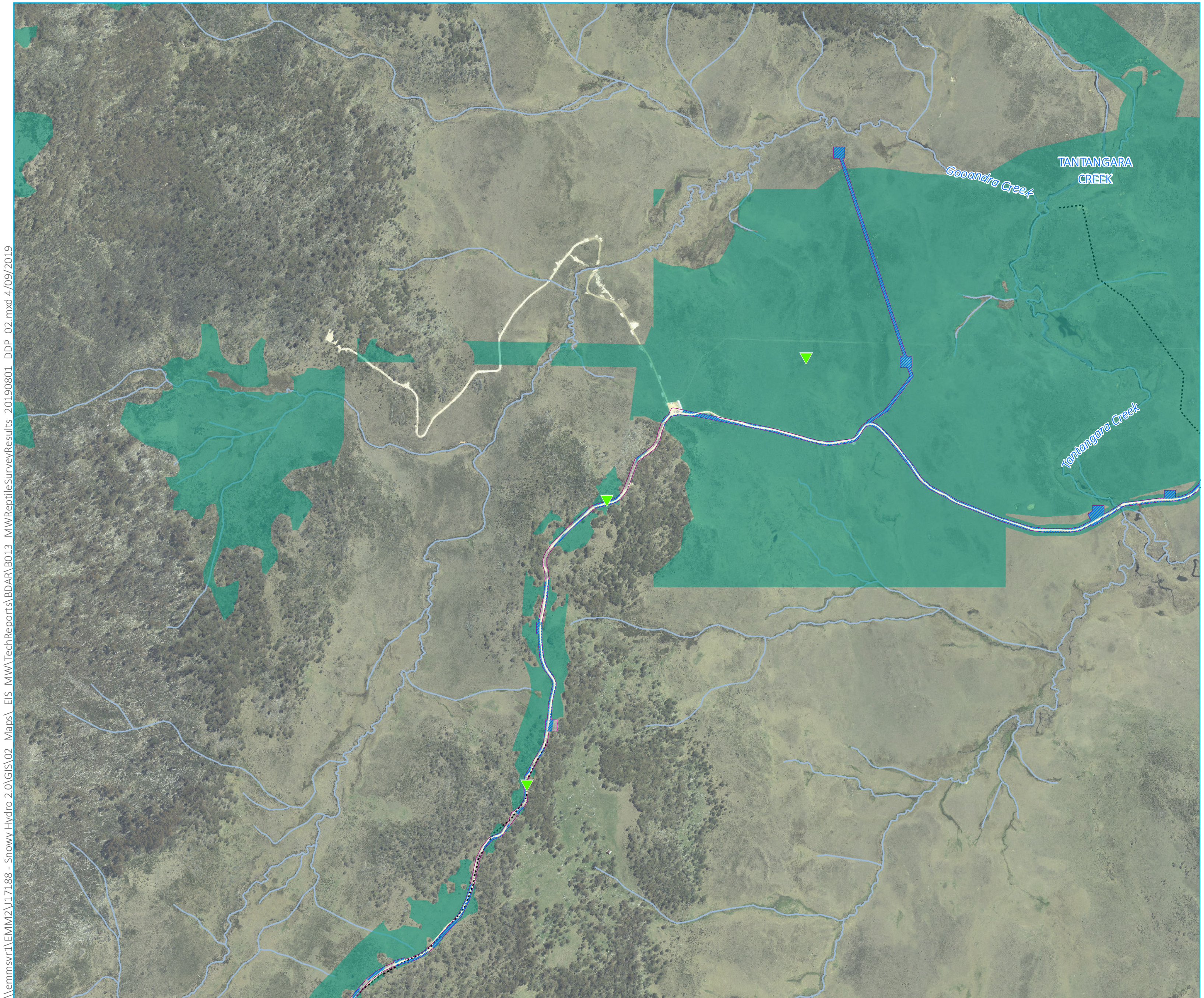
KEY

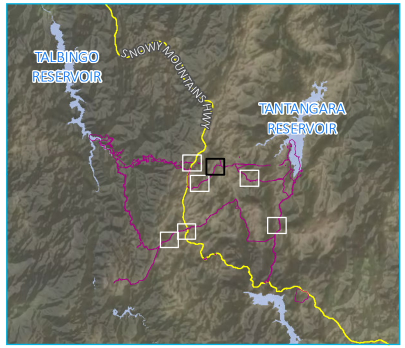
- Watercourse / drainage line
- Main road
- Vehicular track
- Main Works disturbance footprint
- Alpine She-oak Skink species polygon
- Alpine She-oak Skink species habitat
- Alpine She-oak Skink

Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

Reptile survey results

Snowy 2.0
Biodiversity development assessment
Main Works
Figure 6.11.1





KEY

- Watercourse / drainage line
- Vehicular track
- Waterbody
- Main Works disturbance footprint
- Alpine She-oak Skink species polygon
- Alpine She-oak Skink species habitat
- Alpine She-oak Skink

Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

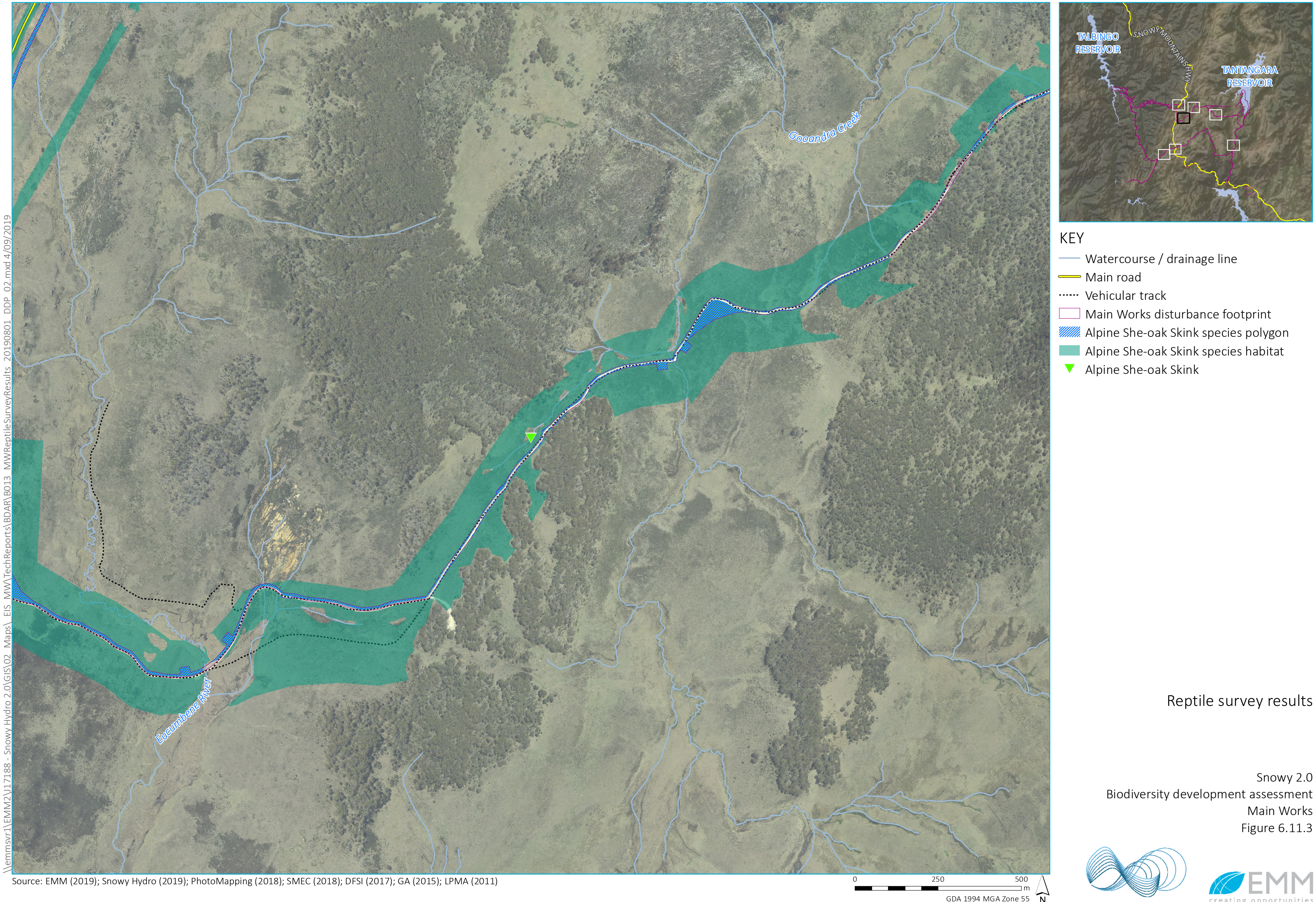
0 250 500 m

GDA 1994 MGA Zone 55

N

Reptile survey results

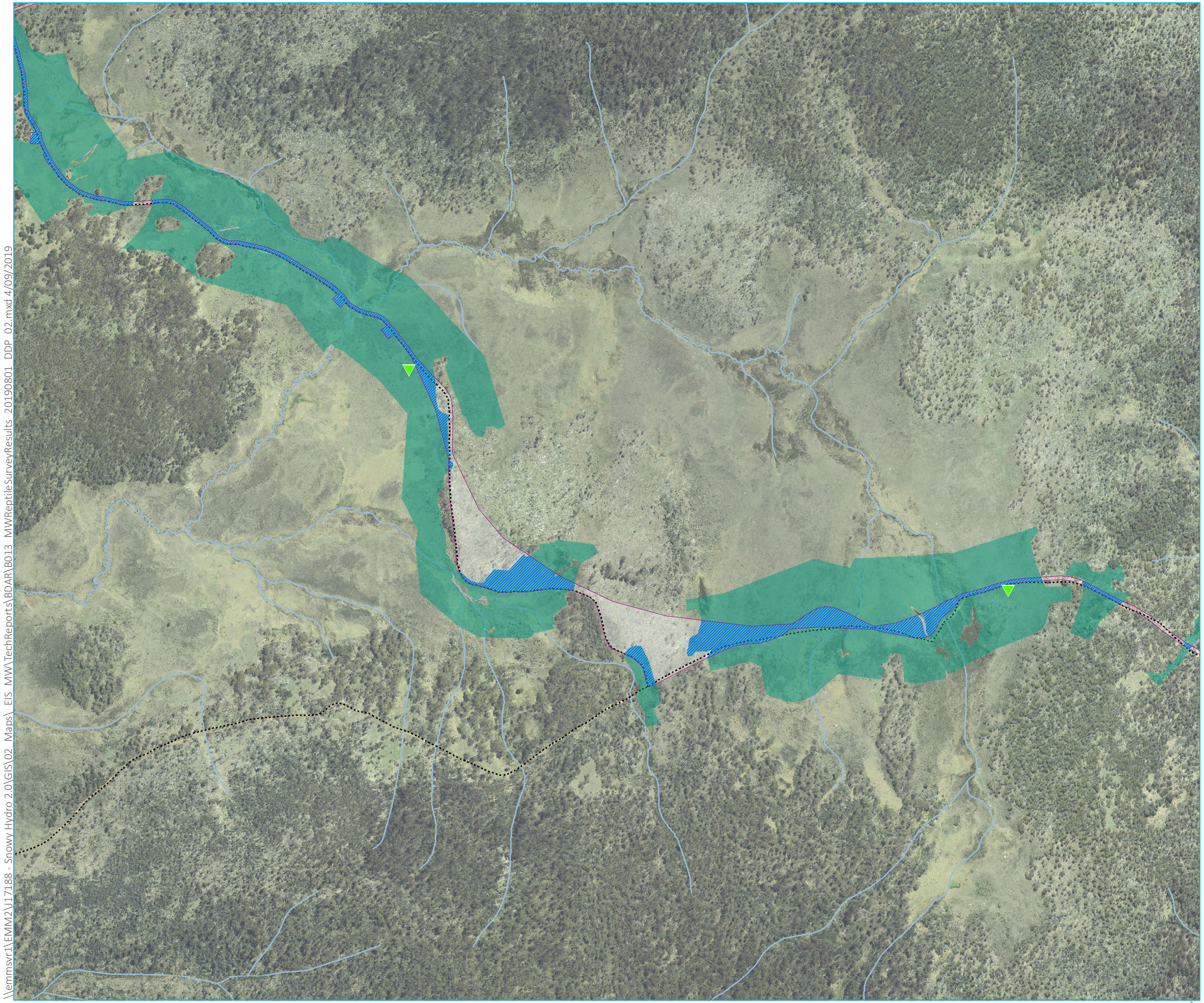
Snowy 2.0
Biodiversity development assessment
Main Works
Figure 6.11.2

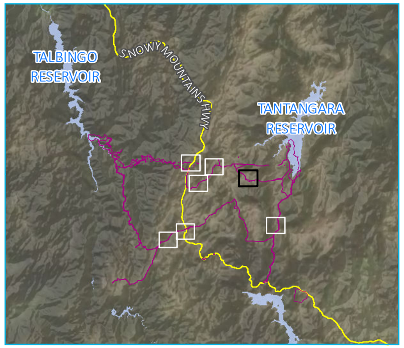


Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

Reptile survey results

Snowy 2.0
Biodiversity development assessment
Main Works
Figure 6.11.3





KEY

- Watercourse / drainage line
- Vehicular track
- Main Works disturbance footprint
- Alpine She-oak Skink species polygon
- Alpine She-oak Skink species habitat
- Alpine She-oak Skink

\\emmsvr1\EMM2\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_MW\TechReports\BDAR\B013_MWReptileSurveyResults_20190801_DDP_02.mxd 4/09/2019

Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

0 250 500 m

GDA 1994 MGA Zone 55

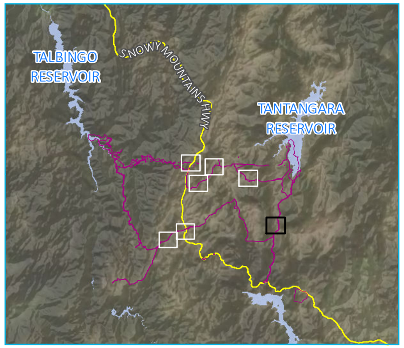
N

Reptile survey results

Snowy 2.0
Biodiversity development assessment
Main Works
Figure 6.11.4

snowy 2.0

EMM creating opportunities



KEY

- Watercourse / drainage line
- Main road
- Vehicular track
- Main Works disturbance footprint
- Alpine She-oak Skink species polygon
- Alpine She-oak Skink species habitat
- Alpine She-oak Skink

Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

0 250 500 m

GDA 1994 MGA Zone 55

N

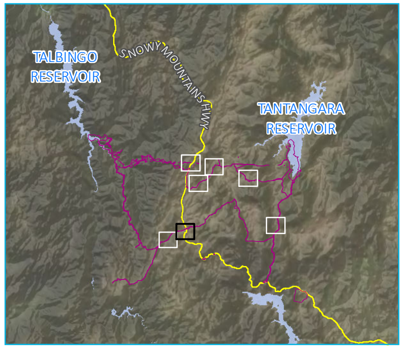
Reptile survey results

Snowy 2.0
Biodiversity development assessment
Main Works
Figure 6.11.5

snowy 2.0

EMM creating opportunities

\\emmsvr1\EMM2\J17188 - Snowy Hydro 2.0\GIS\02 Maps\ EIS MW\TechReports\BDAR\B013 MWReptileSurveyResults 20190801 DDP 02.mxd 4/09/2019



KEY

- Watercourse / drainage line
- Main road
- Local road
- Vehicular track
- Waterbody
- Main Works disturbance footprint
- Alpine She-oak Skink species polygon
- Alpine She-oak Skink species habitat
- Alpine She-oak Skink

Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

0 250 500 m

GDA 1994 MGA Zone 55

N

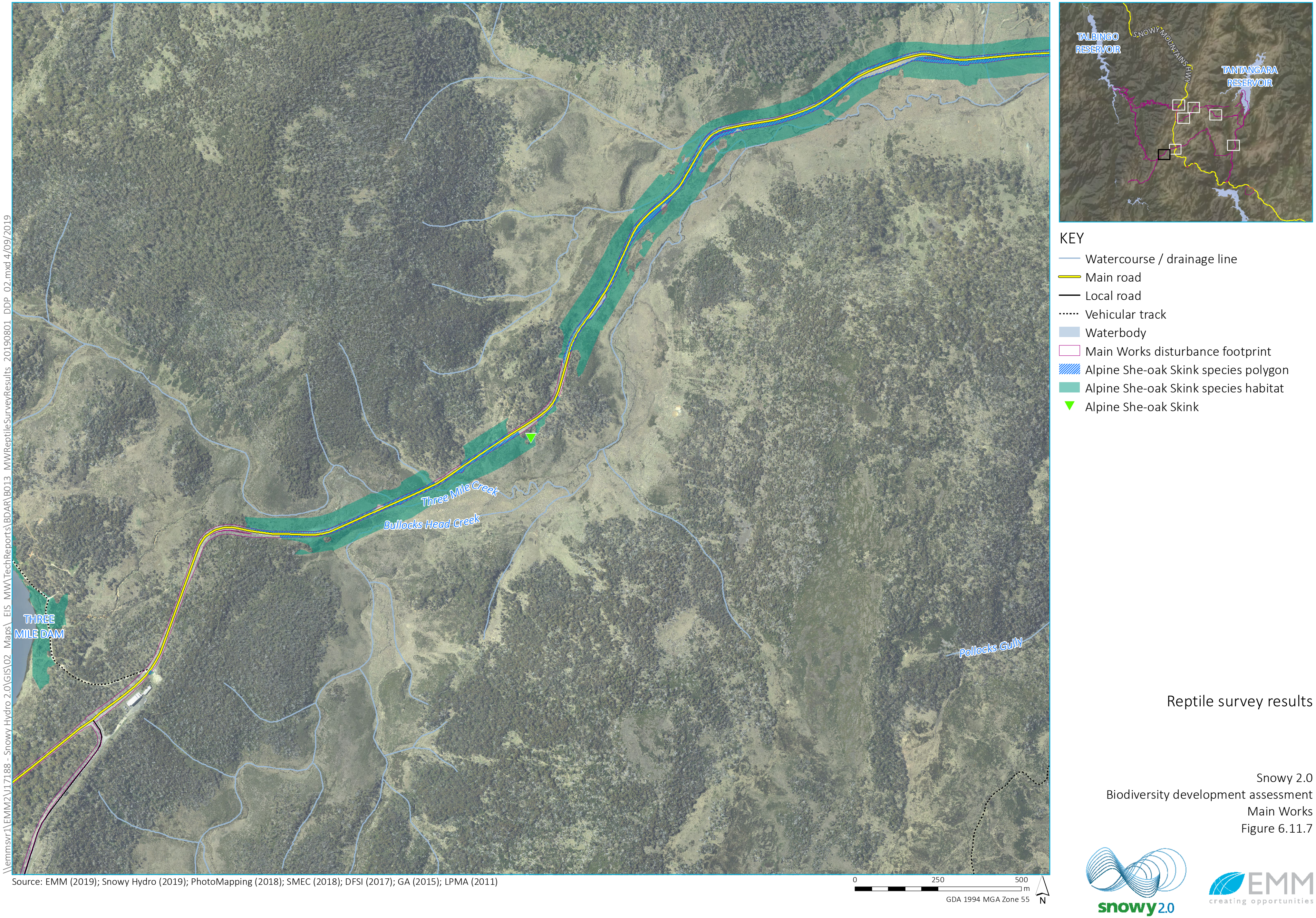
\\emmsvr1\EMM2\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_MW\TechReports\BDAR\B013_MWReptileSurveyResults_20190801_DDP_02.mxd 4/09/2019

Reptile survey results

Snowy 2.0
Biodiversity development assessment
Main Works
Figure 6.11.6

snowy 2.0

EMM creating opportunities



\\emmsvr1\EMM2\J17188 - Snowy Hydro 2.0\GIS\02_Maps_EIS_MW\TechReports\BDAR\B013_MWReptileSurveyResults_20190801_DDP_02.mxd 4/09/2019

Source: EMM (2019); Snowy Hydro (2019); PhotoMapping (2018); SMEC (2018); DFSI (2017); GA (2015); LPMA (2011)

KEY

- Watercourse / drainage line
- Main road
- Local road
- Vehicular track
- Waterbody
- Main Works disturbance footprint
- Alpine She-oak Skink species polygon
- Alpine She-oak Skink species habitat
- Alpine She-oak Skink

Reptile survey results

Snowy 2.0
Biodiversity development assessment
Main Works
Figure 6.11.7

6.3.5 Species credit species

A list of candidate species credit species predicted to occur within the Main Works disturbance footprint, along with an assessment of whether the species will be impacted by Main Works, is provided within Table 6.22.

Based on targeted surveys, the following species will be impacted:

- Clover Glycine – 2.01 ha;
- Kiandra Leek Orchid – 1.67 ha;
- Leafy Anchor Plant – 17 individuals;
- Mauve Burr-daisy – 16.55 ha;
- Raleigh Sedge – 0.38 ha;
- Slender Greenhood – 0.18 ha;
- *Thelymitra alpicola* – 0.04 ha;
- Gang-gang Cockatoo (breeding habitat only) – 5.42 ha;
- Broad-toothed rat – 30.23 ha;
- Eastern Pygmy-possum – 552.94 ha;
- Smoky Mouse – 174.63 ha;
- Booroolong Frog – 9.85 ha;
- Alpine Tree Frog – 48.87 ha; and
- Alpine She-oak Skink – 133.83 ha.

These species will require offsets in accordance with the BAM (OEH 2017a). Species polygons across the survey area are shown in Figure 6.1 to Figure 6.11.

Table 6.22 Species credit species, habitat suitability and targeted survey results

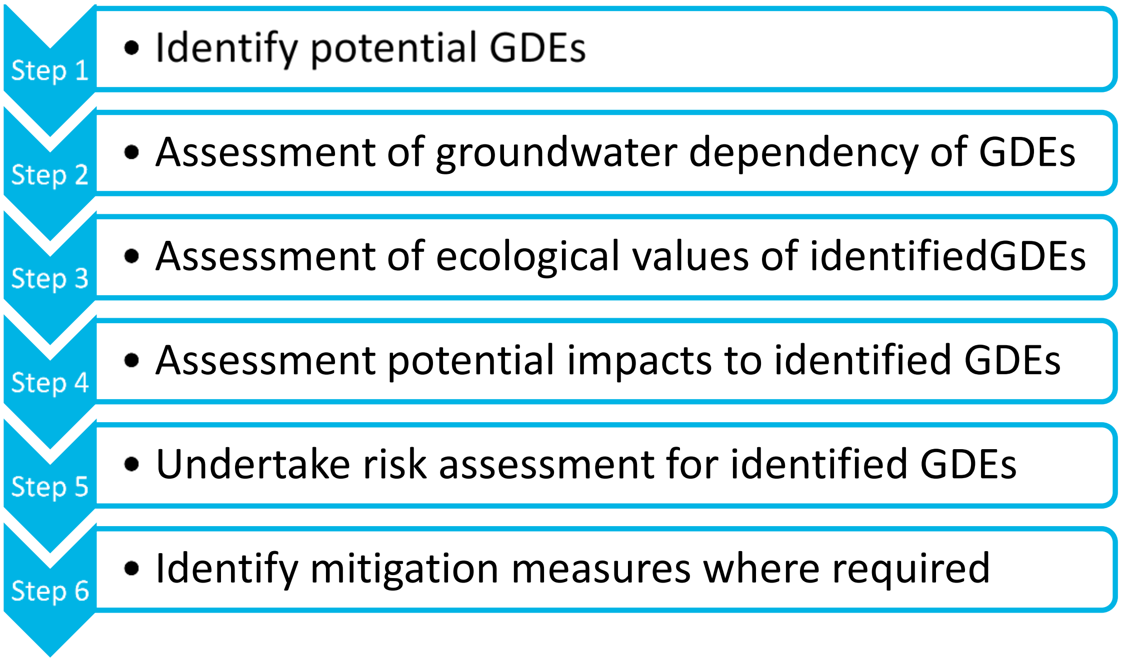
Scientific name	Common name	Biodiversity risk weighting	Habitat present within the Main Works disturbance footprint	Recorded during field surveys	Impacted by development	Justification
Flora						
Calotis glandulosa	Mauve Burr-daisy	3.00	Yes	Yes	Yes	
Carex raleighii	Raleigh Sedge	3.00	Yes	Yes	Yes	
Discaria nitida	Leafy Anchor Plant	2.00	Yes	Yes	Yes	
Glycine latrobeana	Clover Glycine	3.00	Yes	Yes	Yes	
Pomaderris cotoneaster	Cotoneaster Pomaderris	2.00	Yes	No	No	Not recorded during targeted surveys.
Prasophyllum retroflexum	Kiandra Leek Orchid	3.00	Yes	Yes	Yes	
Pterostylis foliata	Slender Greenhood	1.00	Yes	Yes	Yes	
Thesium australe	Austral Toadflax	1.50	Yes	No	No	Not recorded during targeted surveys.
Thelymitra alpicola	-	1.50	Yes	Yes	Yes	
Fauna						
Callocephalon fimbriatum	Gang-gang Cockatoo (Breeding)	2.00	Yes	Yes	Yes	
Cercartetus nanus	Eastern Pygmy-possum	2.00	Yes	Yes	Yes	
Cyclodomorphus praealtus	Alpine She-oak Skink	2.00	Yes	Yes	Yes	
Litoria booroolongensis	Booroolong Frog	2.00	Yes	Yes	Yes	
Litoria verreauxii alpina	Alpine Tree Frog	2.00	Yes	Yes	Yes	
Mastacomys fuscus	Broad-toothed Rat	2.00	Yes	Yes	Yes	
Myotis macropus	Southern Myotis	2.00	Yes	No	No	Not recorded during targeted surveys.
Ninox connivens	Barking Owl (Breeding)	2.00	Yes	No	No	Not recorded during targeted surveys.

Table 6.22 Species credit species, habitat suitability and targeted survey results

Scientific name	Common name	Biodiversity risk weighting	Habitat present within the Main Works disturbance footprint	Recorded during field surveys	Impacted by development	Justification
Ninox strenua	Powerful Owl (Breeding)	2.00	Yes	No	No	Although a dead animal was recorded during surveys, no evidence of nesting was observed.
Petaurus norfolcensis	Squirrel Glider	2.00	Yes	No	No	Not recorded during targeted surveys.
Petroica rodinogaster	Pink Robin	2.00	Yes	No	No	Not recorded during targeted surveys.
Phascogale tapoatafa	Brush-tailed Phascogale	2.00	Yes.	No	No	Not recorded during targeted surveys.
Phascolarctos cinereus	Koala (Breeding)	2.00	Yes	No	No	Not recorded during targeted surveys.
Pseudomys fumeus	Smoky Mouse	3.00	Yes	Yes	Yes	
Pseudophryne pengilleyi	Northern Corroboree Frog	3.00	Yes	No	No	Not recorded during targeted surveys.
Tyto novaehollandiae	Masked Owl (Breeding)	2.00	Yes	Yes	Yes	

7 Groundwater-dependent ecosystems

A groundwater-dependent ecosystem (GDE) risk assessment has been completed in accordance with the NSW Government *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (Serov et al. 2012). This assessment follows the process detailed below:



7.1 Identification of potential GDEs

Ecosystems that could rely on either the surface or subsurface expression of groundwater within or surrounding the project area are those associated with:

- creeks and rivers across the project area where groundwater is discharging and provides baseflow;
- shallow (perched) and deeper regional groundwater systems; and
- springs associated with the steep escarpment in the transition between the Gooandra Volcanics and Ravine Beds geological formations.

GDEs considered in this assessment included:

- subsurface ecosystems such as:
  - karst and caves;
  - subsurface phreatic aquifer ecosystems;
  - baseflow stream hyporheic ecosystems;

- surface ecosystems such as:
  - groundwater-dependent wetlands;
  - baseflow streams (surface water ecosystems); and
  - groundwater-dependent terrestrial ecosystems (phreatophytes).

GDEs were classified into three categories according to their increasing dependence on groundwater:

- non-dependent;
- facultative:
  - opportunistic;
  - proportional;
  - highly dependent; and
- entirely dependent/obligate.

7.1.1 Subsurface GDEs

A stygofauna assessment was undertaken by Macquarie University (2019, Annexure F).

Stygofauna sampling was undertaken at 16 sites located within 2 km of the proposed pipeline (Figure 7.1). These include existing monitoring bores accessing fractured rock aquifers (subsurface phreatic aquifer ecosystems – 11 sites) at various depths, as well as colluvial aquifers associated with the alpine bogs and fens (baseflow stream hyporheic ecosystems – 5 sites).

Sampling was undertaken by pumping water from groundwater bores, with 100 L of water collected or 2 hours of pumping (whichever came first). For groundwater bores in which pumps were not installed, groundwater was sampled by dragging plankton nets (50 µm mesh) through the water to collect any fauna, or by lowering a bailer into the bore to collect 10 L of water. All samples collected were sieved through a 50 µm mesh sieve. The contents of the sieve were carefully transferred to sample jars and preserved in 100% undenatured ethanol.

Preserved samples were analysed in the laboratory and all invertebrates removed, identified and enumerated. All specimens collected were identified to the lowest practicable level using morphological traits and keys. Each specimen was classified based on the likelihood of it being an obligate groundwater organism. eDNA (environmental DNA) analysis of groundwater samples was also undertaken on groundwater collected from 11 groundwater bores (ie. not including piezometers in alpine bogs and fens).

The objective of the stygofauna assessment was to determine the presence or absence of stygofauna in aquifers and alpine bogs and fens. A complete description of the assessment method is provided in Macquarie University (2019, Annexure F).

7.1.2 Surface GDEs

Access to the groundwater is dependent on several factors with the core factor being the depth to the water table. As terrestrial vegetation communities are composed of a range of vegetation types, with a range of rooting depths and strategies there is a relationship between groundwater depth and the types and composition of the vegetation that can access it (Serov 2013).

Considerations in evaluating surface ecosystems and their potential dependency on groundwater included:

- association with groundwater levels across the region;
- the physiology of plant species that occur in that community and their likely dependence on water availability;
- a PCTs location in the landscape; and
- if the rooting depth of vegetation would be able to take up groundwater based on likely depth of the aquifer and soil characteristics.

To identify groundwater-dependent terrestrial ecosystems (phreatophytes), an analysis was undertaken documenting the association of the PCTs found within the project area with groundwater levels as modelled by the regional numerical groundwater flow model, referred to as SH4.0 (EMM 2019b). Groundwater levels across the project area are shown in Figure 7.2.

An intersection was undertaken in ArcGIS between PCTs mapped as a part of this assessment against groundwater levels in the following categories:

- 0 - 0.5 mbgl;
- 0.5 - 2 mbgl;
- 2 - 5 mbgl;
- 5 - 20 mbgl; and
- >20 mbgl.

The percentage of each PCT within these bands was determined, and the criteria listed in Table 7.1 was applied to provide an initial determination of the dependence of PCTs within the project area on groundwater. Ecological knowledge of the PCTs, along with knowledge of the floristics of each PCT were applied to confirm the results of this initial analysis, with some PCT amended based on this additional layer of assessment.

Table 7.1 Criteria used for determining groundwater dependence on PCTs

Dependence on groundwater	Criteria
Entirely/obligate	More than 50% of the PCT is mapped in areas with groundwater at 0.5 mbgl or less, or more than 75% of the PCT is mapped in areas with groundwater at 2 mbgl or less.
Facultative - high	More than 50% of the PCT is mapped in areas with groundwater at 2 mbgl or less, and more than 75% of the PCT is mapped in areas with groundwater at 5 mbgl or less.
Facultative - proportional	More than 75% of the PCT is mapped in areas with groundwater at 5 mbgl or less, but less than 50% of the PCT is mapped in areas with groundwater at 2 mbgl or less.
Facultative - opportunistic	More than 50% of the PCT is mapped in areas with groundwater at 5 mbgl or less, but less than 75% of the PCT is mapped in areas with groundwater at 5 mbgl and/or less than 50% of the PCT is mapped in areas with groundwater at 2 mbgl.
Non-dependent	Evenly distributed across groundwater levels, with generally less than 50% of the PCT mapped in areas with groundwater at 5 mbgl or less.

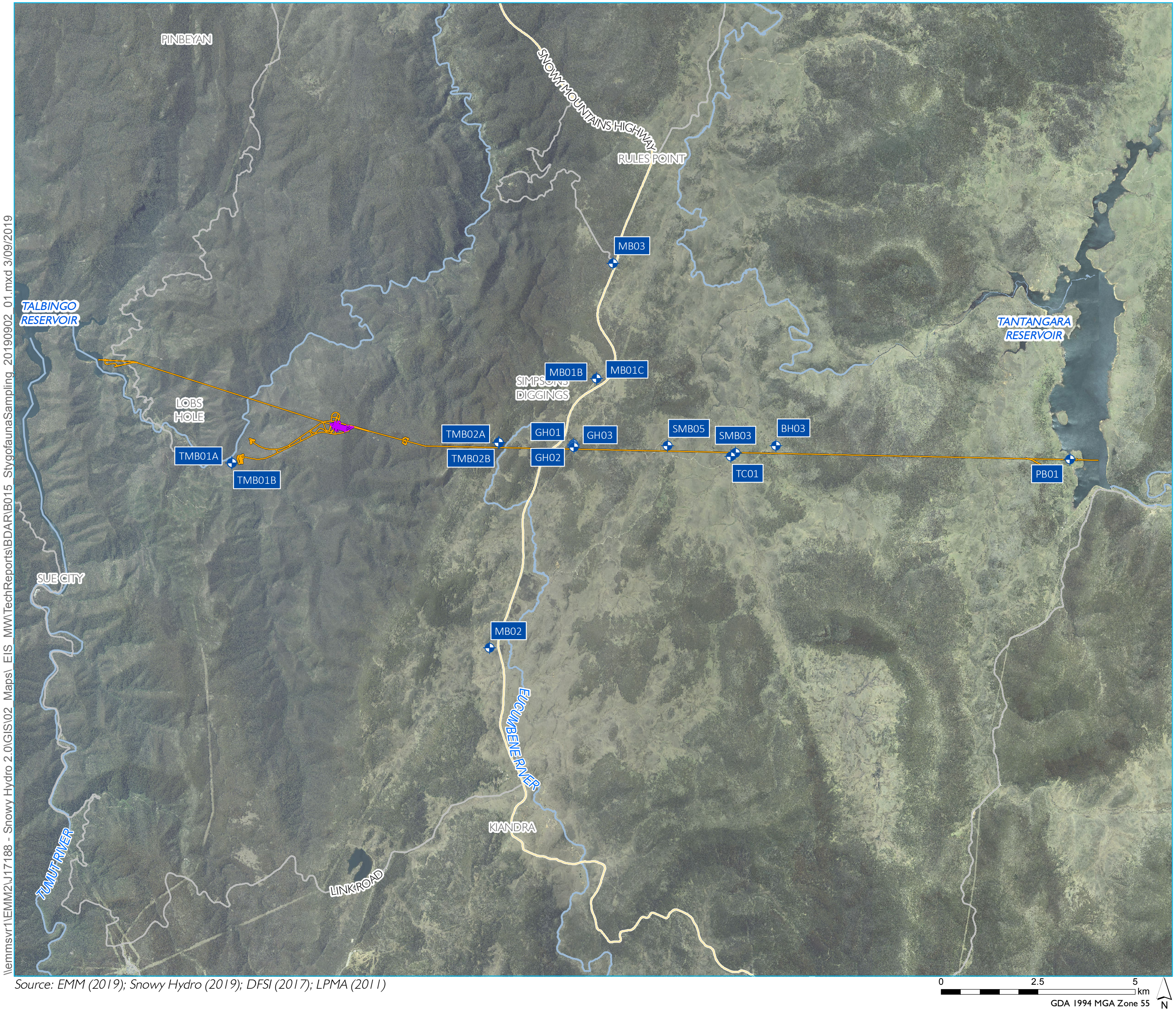
To identify potential groundwater-dependent riparian vegetation associated with baseflow streams, a field assessment was undertaken. The objective of the survey was to identify where groundwater expresses itself at the surface. Water Resources Engineers from EMM traversed each major drainage line and associated tributaries to identify the highest groundwater seep in each drainage line. Once identified, the location was tagged in Collector and categorised as follows (note the terminology can be updated):

- Type 1 – Contact/hillslope springs: springs displaying visible flow, typically on hillslopes. These were generally found in the upstream sections of more defined tributaries and occasionally in low lying areas.

- Type 2 – Lowland seeps: visible seeps into sediment storage (ie floodplains). These were typically found in low-lying areas adjacent to large watercourses and tributaries.

- Type 3 – Alpine bogs: boggy, wet ground, typically in depressions in the landscape. The most common discharge type across the survey area and generally occurred in the upstream section of smaller tributaries.

Surveys were undertaken in February and March 2019. Vegetation downslope of these points was deemed to have potential to be reliant on the surface expression of groundwater, and thus deemed to be groundwater-dependent riparian vegetation. It should be noted that in many instances the vegetation downslope of each of these points where groundwater expresses itself at the surface is indistinguishable from surrounding vegetation. In some instances, there was a small expression of mesic or hydric vegetation, such as *Sphagnum* sp. or *Leptospermum* sp.



Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011)

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KEY

Existing environment

- Main road
- Local road
- Watercourse

Snowy 2.0 operational elements

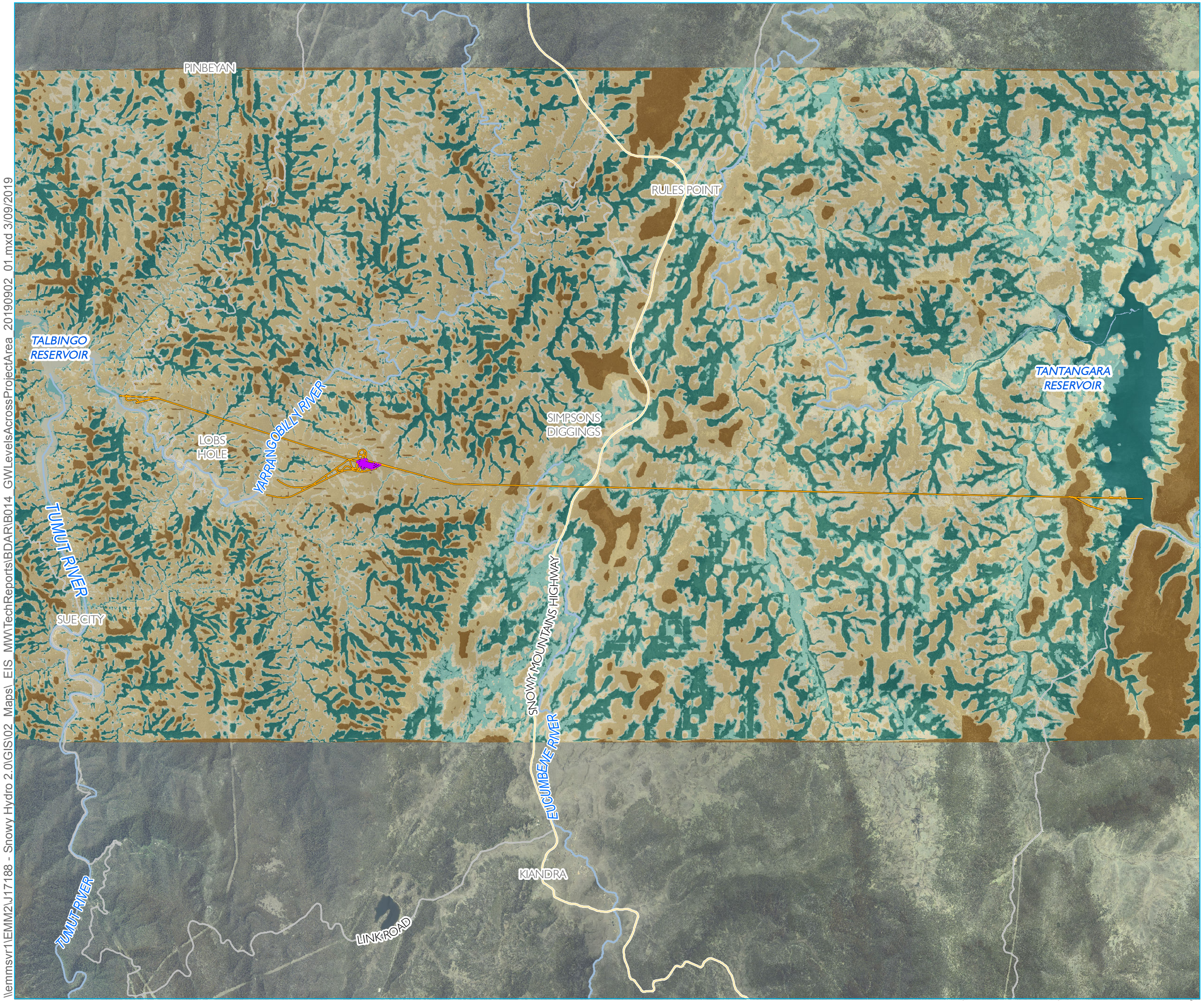
- Tunnels, portals, intakes, shafts
- Power station
- Stygofauna sampling location

Stygofauna sampling locations

Snowy 2.0
Biodiversity development assessment report
Main Works
Figure 7.1

snowy 2.0

EMM creating opportunities



KEY

Existing environment
- Main road
- Local road
- Watercourse

Snowy 2.0 operational elements
- Tunnels, portals, intakes, shafts
- Power station

Groundwater levels (m)
- 0 - 0.5
- 0.5 - 2.0
- 2.0 - 5.0
- 5.0 - 20
- > 20

Groundwater levels across the project area

Snowy 2.0
Bidiversity development assessment report
Main Works
Figure 7.2

Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011)

0 2.5 5 km
GDA 1994 MGA Zone 55
N

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7.2 Potential GDEs

7.2.1 Subsurface GDEs

A total of five specimens from two families, likely to be obligate stygofauna representatives, were collected from one of the 11 fractured rock sites (TMB02A) and two of the five Alpine bog and fen sites (GH01, GH02); a further 80 specimens from five groups, with potential to be obligate stygofauna representatives, were collected from four of the 11 fractured rock sites (TMB02A, MB01C, PB01 and SMB03) and four of the five Alpine bog and fen sites (GH01, GH02, GH03 and TC01) (Table 7.2). The family Parastenocarididae is a group of copepods in the order Harpacticoida, which display affinities with groundwater existence (Cottarelli et al. 2010). The family Canthocamptidae is also a group of copepods in the order Harpacticoida; however, representatives may comprise surface or groundwater taxa from freshwater or marine habitats (Pesce 2007). The specimens collected from the two Alpine bog and fen sites have the potential to be surface aquatic taxa, although Macquarie University (2019) indicated that they had the morphological traits typical of stygobiotic species, including lack of eyes and pigmentation and enhanced sensory appendages, and are likely to be obligate groundwater species. Parastenocarididae was unique to the fractured rock aquifers of the Gooandra Volcanics, while Canthocamptidae and Ostracoda were unique to the alpine bogs and fens.

The remaining specimens collected (Table 7.2) comprised representatives from Oligochaeta (Subclass), Acarina (Subclass), Ostracoda (Class), Rotifera (Phylum) and Nematoda (Phylum), with the oligochaetes, acari, rotifers and nematodes common to both aquifers. While the oligochaetes, rotifers and nematodes have the potential to be stygobiotic, it is considered difficult to determine their affinity with groundwater due to the wide variety of habitats in which they occur (Macquarie University 2019). Similarly, acari and ostracod taxa have stygobiotic potential; however, their taxonomy was not resolved (Macquarie University 2019).

Locations where likely and potential stygofauna species were recorded are shown in Table 7.2.

Table 7.2 Abundance of potential stygofauna specimens recorded

Species	Fractured rock aquifers sites				Alpine bog and fen sites			
	TMB02A	MB01C	PB01	SMB03	GH01	GH02	GH03	TC01
Stygofauna species								
Parastenocarididae sp.	2							
Canthocamptidae sp.					2	1		
Potential stygofauna species								
Oligochaeta sp.			1			1		
Acarina sp.			1		1	1		1
Ostracoda sp.					1	3		
Rotifera sp.		1		1			1	
Nematoda sp.	52	1	2		4	7	1	

The remaining specimens were either not considered to be stygobiotic (Hypogastruridae, Sminthuridae), or were too damaged to identify (Copepoda nauplii).

Limited stygofauna studies have been undertaken within fractured rock aquifers of the region, thus there is limited data for comparison. The stygofauna found in the aquifers in the Snowy 2.0 Project area are similar to those encountered in other fractured rock systems in NSW.

7.2.2 Surface GDEs

Twenty-one PCTs have been recorded within the GW model domain. A review of the Groundwater Dependent Ecosystems Atlas (BOM 2019) identified the majority of PCTs as having a low-high GDE potential. Two PCTs were identified as having a moderate-high (PCT 285) and high GDE potential (PCT 637):

- PCT 285 – Broad-leaved Sally grass – sedge woodland on valley flats and swamps in the NSW South Western Slopes Bioregion and adjoining South Eastern Highlands Bioregion; and
- PCT 637 – Alpine and sub-alpine peatlands, damp herbfields and fens, South Eastern Highlands Bioregion and Australian Alps Bioregion.

Analysis of the distribution of PCTs in relation to the simulated regional groundwater levels indicated several PCTs are strongly associated with shallow groundwater (Table 7.3).

Table 7.3 PCTs within the project area, association with simulated groundwater levels and derived GW dependence

Row Labels	0-0.5 mbgl	0.5-2 mbgl	2-5 mbgl	5-20 mbgl	>20 mbgl	Total to 2 mbgl	Total to 5 mbgl	GW dependency
PCT 765 - Carex - Juncus sedgeland/wet grassland of the South Eastern Highlands Bioregion	17%	81%	2%	0%	0%	98%	100%	Entirely / obligate
PCT 1225 - Sub-alpine grasslands of valley floors, southern South Eastern Highlands Bioregion and Australian Alps Bioregion	50%	46%	4%	0%	0%	96%	100%	Entirely / obligate
PCT 637 - Alpine and sub-alpine peatlands, damp herbfields and fens, South Eastern Highlands Bioregion and Australian Alps Bioregion	69%	16%	12%	2%	0%	86%	98%	Entirely / obligate
PCT 285 - Broad-leaved Sally grass - sedge woodland on valley flats and swamps in the NSW South Western Slopes Bioregion and adjoining South Eastern Highlands Bioregion	11%	14%	67%	8%	0%	25%	92%	Facultative - proportional
PCT 302 - Riparian Blakely's Red Gum - Broad-leaved Sally woodland - tea-tree - bottlebrush - wattle shrubland wetland of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion	4%	16%	69%	11%	0%	20%	89%	Facultative - proportional
PCT 299 - Riparian Ribbon Gum - Robertsons Peppermint - Apple Box riverine very tall open forest of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion	27%	19%	35%	19%	0%	46%	81%	Facultative - proportional
PCT 679 - Black Sallee - Snow Gum low woodland of montane valleys, South Eastern Highlands Bioregion and Australian Alps Bioregion	58%	11%	26%	5%	0%	69%	95%	Facultative - opportunistic
PCT 303 - Black Sally grassy low woodland in valleys in the upper slopes sub-region of the NSW South Western Slopes Bioregion and western South Eastern Highlands Bioregion	32%	18%	30%	19%	1%	50%	80%	Facultative - opportunistic

Table 7.3 PCTs within the project area, association with simulated groundwater levels and derived GW dependence

Row Labels	0-0.5 mbgl	0.5-2 mbgl	2-5 mbgl	5-20 mbgl	>20 mbgl	Total to 2 mbgl	Total to 5 mbgl	GW dependency
PCT 300 - Ribbon Gum - Narrow-leaved (Robertsons) Peppermint montane fern - grass tall open forest on deep clay loam soils in the upper NSW South Western Slopes Bioregion and western Kosciuszko escarpment	17%	8%	27%	40%	8%	25%	52%	Facultative - opportunistic
PCT 952 - Mountain Gum - Narrow-leaved Peppermint - Snow Gum dry shrubby open forest on undulating tablelands, southern South Eastern Highlands Bioregion	1%	5%	21%	60%	13%	6%	27%	Non-dependent
PCT 953 - Mountain Gum - Snow Gum - Broad-leaved Peppermint shrubby open forest of montane ranges, South Eastern Highlands Bioregion and Australian Alps Bioregion	2%	2%	12%	78%	6%	4%	16%	Non-dependent
PCT 999 - Norton's Box - Broad-leaved Peppermint open forest on footslopes, central and southern South Eastern Highlands Bioregion	3%	2%	20%	75%	1%	5%	24%	Non-dependent
PCT 1191 - Snow Gum - Candle Bark woodland on broad valley flats of the tablelands and slopes, South Eastern Highlands Bioregion	4%	6%	22%	67%	2%	10%	32%	Non-dependent
PCT 311 - Red Stringybark - Broad-leaved Peppermint - Nortons Box heath open forest of the upper slopes subregion in the NSW South Western Slopes Bioregion and adjoining South Eastern Highlands Bioregion	4%	3%	19%	72%	2%	8%	26%	Non-dependent
PCT 639 - Alpine Ash - Snow Gum shrubby tall open forest of montane areas, South Eastern Highlands Bioregion and Australian Alps Bioregion	5%	5%	14%	68%	7%	10%	24%	Non-dependent
PCT 644 - Alpine Snow Gum - Snow Gum shrubby woodland at intermediate altitudes in northern Kosciuszko NP, South Eastern Highlands Bioregion and Australian Alps Bioregion	5%	7%	25%	45%	18%	13%	38%	Non-dependent
PCT 729 - Broad-leaved Peppermint - Candlebark shrubby open forest of montane areas, southern South Eastern Highlands Bioregion and South East Corner Bioregion	8%	5%	28%	56%	2%	13%	41%	Non-dependent
PCT 296 - Brittle Gum - peppermint open forest of the Woomargama to Tumut region, NSW South Western Slopes Bioregion	10%	4%	23%	60%	3%	15%	37%	Non-dependent
PCT 1196 - Snow Gum - Mountain Gum shrubby open forest of montane areas, South Eastern Highlands Bioregion and Australian Alps Bioregion	14%	8%	19%	43%	17%	22%	41%	Non-dependent
PCT 1224 - Sub-alpine dry grasslands and heathlands of valley slopes, southern South Eastern Highlands Bioregion and Australian Alps Bioregion	20%	27%	35%	16%	1%	48%	82%	Non-dependent
PCT 643 - Alpine shrubland on scree, blockstreams and rocky sites of high altitude areas of Kosciuszko National Park, Australian Alps Bioregion	26%	8%	20%	46%	0%	34%	54%	Non-dependent

Three PCTs were identified as having an entirely/obligate dependence on groundwater (Figure 7.3):

- PCT 637 - Alpine and sub-alpine peatlands, damp herbfields and fens, South Eastern Highlands Bioregion and Australian Alps Bioregion;
- PCT 765 - Carex - Juncus sedgeland/wet grassland of the South Eastern Highlands Bioregion; and
- PCT 1225 - Sub-alpine grasslands of valley floors, southern South Eastern Highlands Bioregion and Australian Alps Bioregion.

These PCTs show strong associations with shallow groundwater (<2 mbgl), with 86%, 98% and 96% of the mapped extent of these PCTs occurring in areas of shallow groundwater. The floristic composition of these PCTs also show a number of mesic and hydric species which are not found outside of these shallow groundwater systems.

Three PCTs were identified as having a facultative proportional dependence on groundwater (Figure 7.3):

- PCT 285 - Broad-leaved Sally grass - sedge woodland on valley flats and swamps in the NSW South Western Slopes Bioregion and adjoining South Eastern Highlands Bioregion;
- PCT 299 - Riparian Ribbon Gum - Robertsons Peppermint - Apple Box riverine very tall open forest of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion; and
- PCT 302 - Riparian Blakely's Red Gum - Broad-leaved Sally woodland - tea-tree - bottlebrush - wattle shrubland wetland of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion.

Despite less than 50% of the community being mapped in areas of shallow groundwater (<2 mbgl), PCTs 285, 299 and 302 were deemed likely to have a facultative – proportional reliance on GW with 92%, 89% and 81% of these PCTs mapped in areas with groundwater at <5 mbgl, respectively. These PCTs occur in riparian zones and gullies where there is likely to be some near-surface expression of groundwater. In addition, the floristic composition of these communities supports a number of mesic species, as well as tree species that are likely to be accessing groundwater in unconsolidated alluvial and colluvial systems.

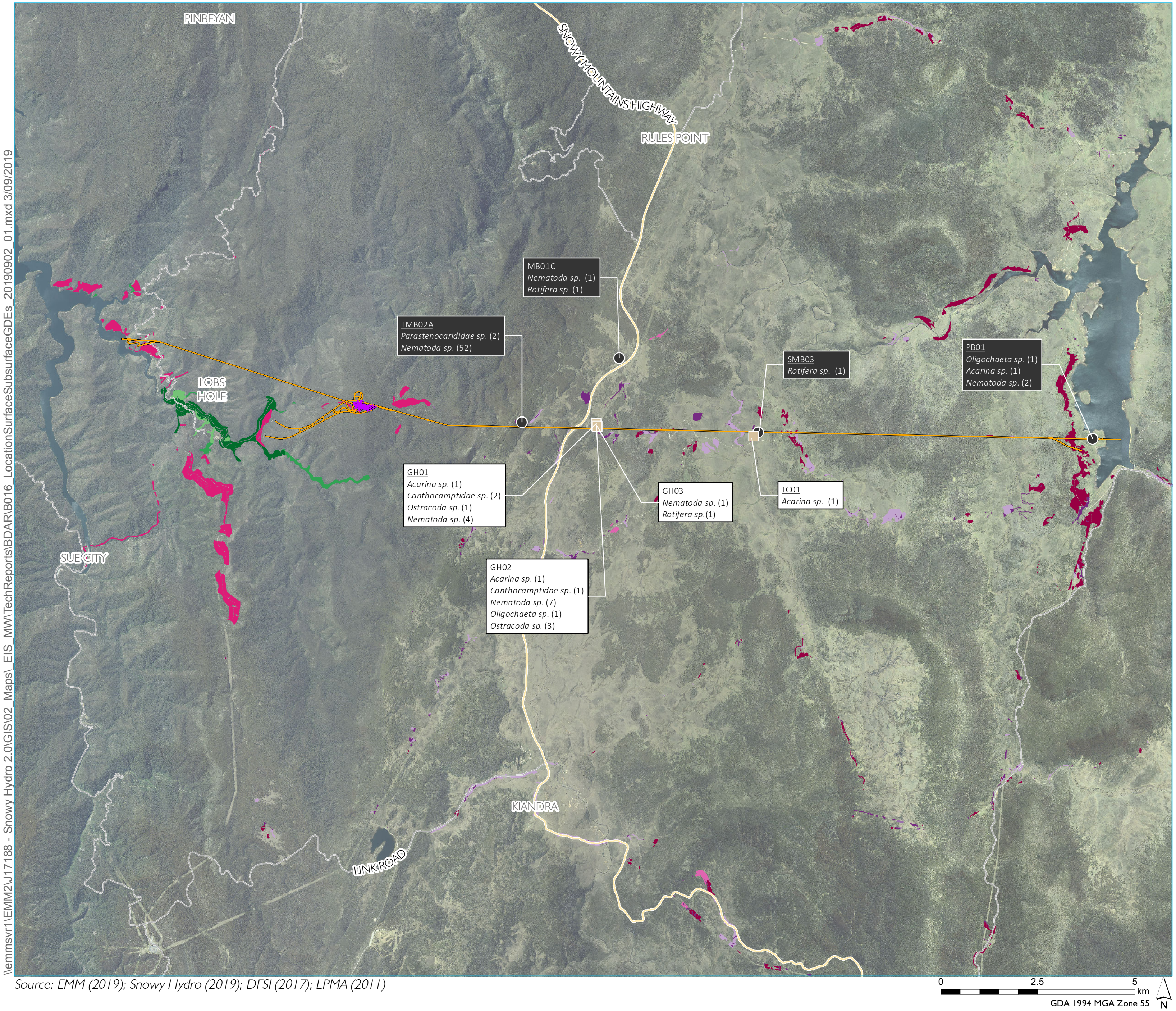
Three PCTs were identified as having a facultative – opportunistic dependence on groundwater (Figure 7.3):

- PCT 300 - Ribbon Gum - Narrow-leaved (Robertsons) Peppermint montane fern - grass tall open forest on deep clay loam soils in the upper NSW South Western Slopes Bioregion and western Kosciuszko escarpment;
- PCT 303 - Black Sally grassy low woodland in valleys in the upper slopes sub-region of the NSW South Western Slopes Bioregion and western South Eastern Highlands Bioregion; and
- PCT 679 - Black Sallee - Snow Gum low woodland of montane valleys, South Eastern Highlands Bioregion and Australian Alps Bioregion.

PCT 300 occurs along drainage lines on mid slopes across the project area. This PCT shows some association with groundwater at up to 5 mbgl (52%) but also occurs in areas of deeper groundwater. This PCT may be accessing intermittent groundwater during periods of prolonged drought. Despite being associated with shallow groundwater systems, PCTs 303 and 679 are largely derived by their landscape position, occurring on the edges of frost hollows where cold air depressions restrict growth to robust and cold air tolerant species such as Black Sallee. Any relationship with groundwater is coincidental and derived by landscape position. Despite this, a conservative assessment has been undertaken with these communities assumed to have a facultative – opportunistic dependence on groundwater.

The remaining communities were considered non-dependent on groundwater. Two non-dependent communities show some association with shallow to intermittent groundwater. PCT 643 occurs in basalt boulderfields derived from periglacial activity. There is no association between this community and groundwater levels, as the community is largely devoid of flora species. PCT 1224 is mapped in areas with intermittent groundwater levels (<5 mbgl). Despite this, the community is considered unlikely to be accessing groundwater for survival, with flora species likely to have shallow roots and the floristic composition of the community does not show any association with mesic or hydric species.

A conceptual diagram, showing the interaction of potential surface GDEs with the groundwater table, is shown in Figure 7.4.



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Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011)

KEY

BoreType
- Alpine bog and fen site
- Fractured rock aquifer site

Existing environment
- Main road
- Local road

Snowy 2.0 operational elements
- Tunnels, portals, intakes, shafts
- Power station

Entirely/obligate dependence
- PCT 637
- PCT 765
- PCT 1225

Facultative - opportunistic
- PCT 303
- PCT 300
- PCT 679

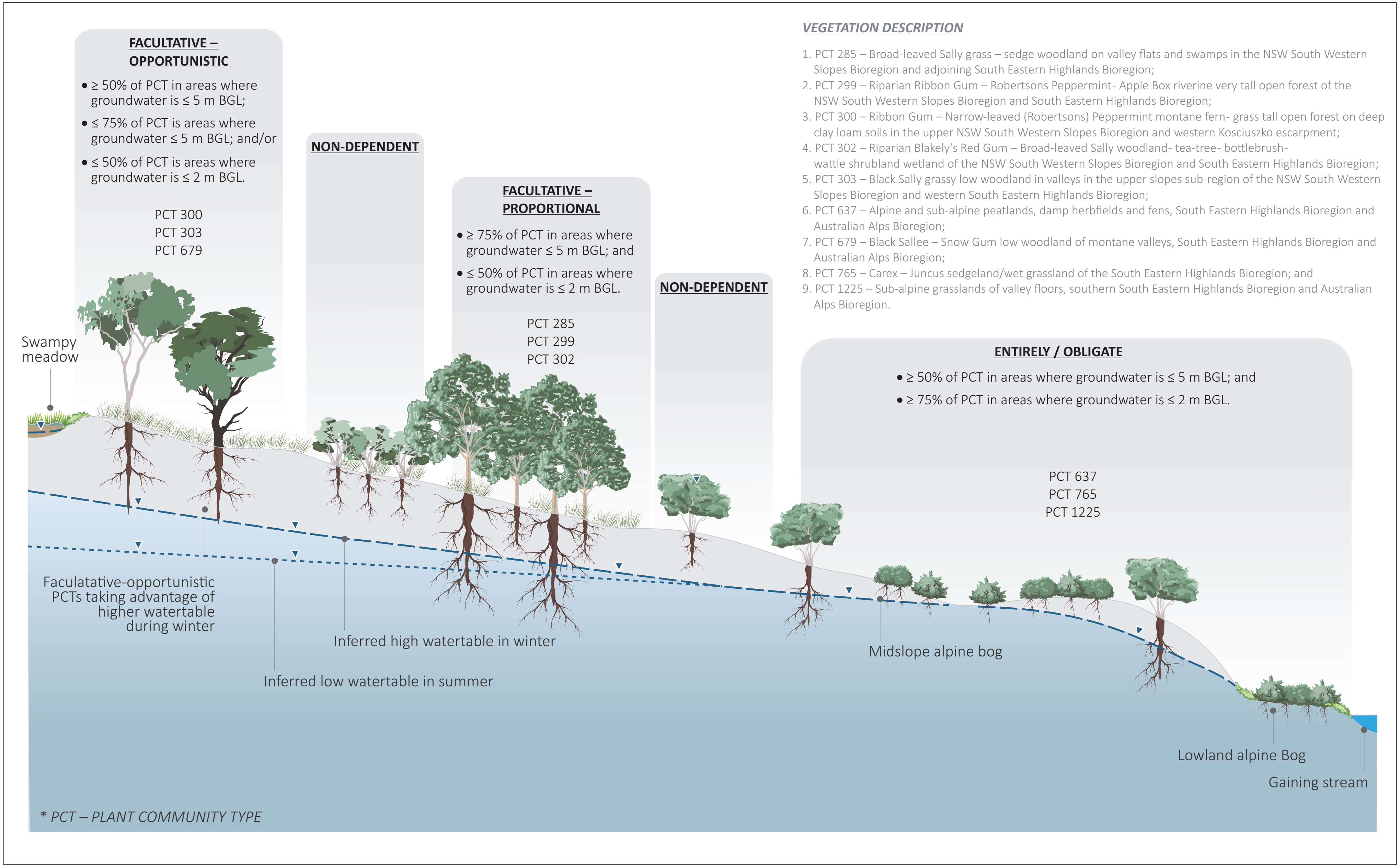
Facultative - proportional
- PCT 302
- PCT 299
- PCT 285

Location of surface GDEs and locations where likely and potential stygofauna species were recorded

Snowy 2.0
Biodiversity development assessment report
Main Works
Figure 7.3

snowy 2.0

EMM creating opportunities



Conceptual diagram for surface GDEs

Snowy 2.0
Environmental Impact Statement
Figure 7.4

7.3 Ecological values of identified GDEs

GDEs within the survey area are deemed to have high ecological value, based on their occurrence with KNP, good water quality and quantity parameters, and aquifer structure given limited disturbance, patch size criteria given high levels of connectivity, and delivery of ecosystem services.

7.4 Assessment of predicted groundwater impacts

Predicted impacts to identified GDEs have been determined in accordance with the guidelines in Serov *et al*. (2012). Impact assessment has largely been restricted to predicted impacts to water quantity and biological integrity of GDEs and associated aquifers, as the project is predicted to have negligible impacts on water quality or the geological integrity of any aquifer.

The groundwater model predicts groundwater drawdown of up to 50 m in some area (Figure 7.5). This has been used to predict impacts to subsurface and surface GDEs.

It is important to note that the groundwater model adopted a conservative approach of simulating all excavations as non-mitigated/controlled and predicts a base case worst scenario. Construction methods to increase tunnel stability, such as pre/post-grouting and segmental lining, which can also have the added benefit of reducing tunnel inflows, were not considered because the location and extent of methods were not known at the time of modelling. In this respect, the impact assessment below represents an overestimate of the impacts arising from the project.

7.4.1 Subsurface GDEs

The predicted impact to fractured rock aquifers will likely result in drawdown, reducing the extent of habitat available to stygofauna. It is likely that predicted impacts will be restricted to an area bounded by Tantangara Creek in the east and the boundary of the Gooandra Volcanics in the west. While survival of stygofauna in unsaturated zones is limited beyond 48 hours, drawdown of less than 20 m is considered unlikely to have a significant effect on many stygofauna species given the ability of these species to relocate within the saturated zone; drawdown of 5 m (for example) would be unlikely to have any significant effect.

As defined in Serov et al. (2012), stygofauna communities are considered to be at risk when considering predicted drawdown impacts. Only a small area (383 ha), greater than 20 m drawdown, is predicted to potentially impact these communities. However, if groundwater decline is slow or gradual in areas where predicted drawdown is greater than 20 m, it may present opportunities for stygofauna to migrate to saturated areas whilst drawdown is occurring.

7.4.2 Surface GDEs

To determine the predicted impacts to surface GDEs, the area of each GDE determined in Section 7.2.2 within the groundwater drawdown area (Figure 7.5) was determined. This data is presented in Table 7.4.

Table 7.4 Surface GDEs and the area of each GDE subject to drawdown

Row Labels	GW dependency	0.5–2 m	2-5 m	5-20 m	>20 m	Total
PCT 765 - Carex - Juncus sedgeland/wet grassland of the South Eastern Highlands Bioregion	Entirely / obligate	0	0	0	0	0
PCT 1225 - Sub-alpine grasslands of valley floors, southern South Eastern Highlands Bioregion and Australian Alps Bioregion	Entirely / obligate	6.09	2.48	1.01	0.78	10.37
PCT 637 - Alpine and sub-alpine peatlands, damp herbfields and fens, South Eastern Highlands Bioregion and Australian Alps Bioregion	Entirely / obligate	5.25	1.45	7.20	3.61	17.51
PCT 285 - Broad-leaved Sally grass - sedge woodland on valley flats and swamps in the NSW South Western Slopes Bioregion and adjoining South Eastern Highlands Bioregion	Facultative - proportional	0	0	0	0	0
PCT 302 - Riparian Blakely's Red Gum - Broad-leaved Sally woodland - tea-tree - bottlebrush - wattle shrubland wetland of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion	Facultative - proportional	0.28	0	0	0	0.28
PCT 299 - Riparian Ribbon Gum - Robertsons Peppermint - Apple Box riverine very tall open forest of the NSW South Western Slopes Bioregion and South Eastern Highlands Bioregion	Facultative - proportional	0.88	0.81	0.10	0.00	1.78
PCT 679 - Black Sallee - Snow Gum low woodland of montane valleys, South Eastern Highlands Bioregion and Australian Alps Bioregion	Facultative - opportunistic	0.10	0.10	0.01		0.21
PCT 303 - Black Sally grassy low woodland in valleys in the upper slopes sub-region of the NSW South Western Slopes Bioregion and western South Eastern Highlands Bioregion	Facultative - opportunistic	10.60	4.55	7.94	0.60	23.69
PCT 300 - Ribbon Gum - Narrow-leaved (Robertsons) Peppermint montane fern - grass tall open forest on deep clay loam soils in the upper NSW South Western Slopes Bioregion and western Kosciuszko escarpment	Facultative - opportunistic	2.74	0.03			2.77

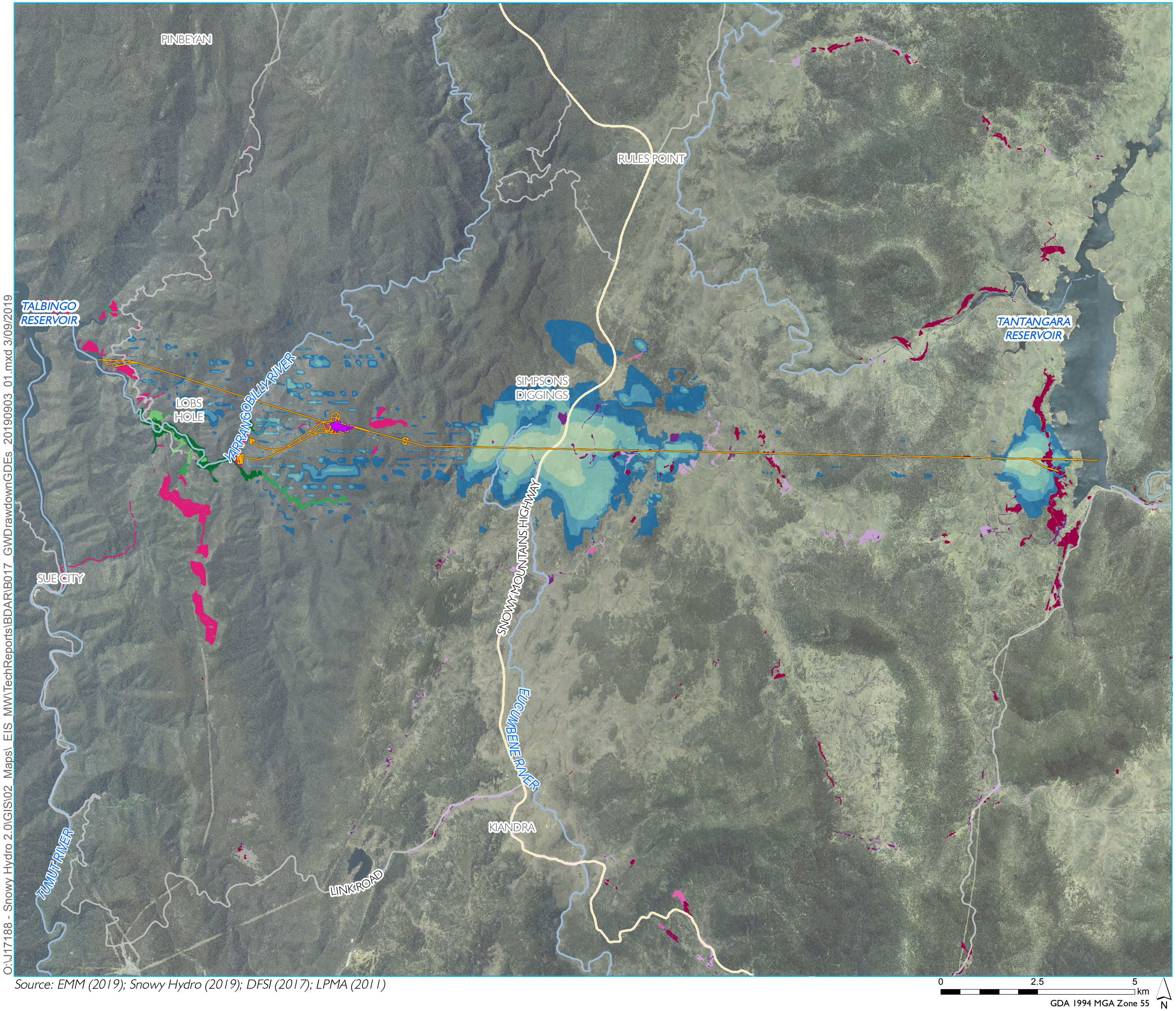
PCTs 765, 285, 302, 299, 679 and 300 will experience predicted impacts to less than 3 ha of the community, and/or will experience groundwater drawdown of less than 5 m. These GDEs are considered to be at a low risk of impacts.

PCT 303 will experience predicted impacts to 23.69 ha of the community, representing 6% of the 370 ha of the community mapped in the project area. In addition, 10.6 ha of this will experience drawdown of less than 2 m, and will be unlikely to have any noticeable effect on the ability of this community to access groundwater during periods of stress, and is therefore unlikely to result in any significant changes in the biological integrity of the GDE. It is predicted this GDE is at low risk of impact, as defined in Serov et al. (2012).

PCT 1225 will experience drawdown of >0.5 m to 10.37 ha of the community. Drawdown of more than 0.5 m may have some impact given the entirely/obligate dependence of this community on groundwater. While there is a high risk of predicted impact to some portion of the community, as defined in Serov et al. (2012), the predicted drawdown will impact on 6% of the 163 ha of this PCT mapped across the project area, and larger patches of the community will be maintained on major watercourses such as Tantangara Creek and Nungar Creek. Overall impacts to community are expected to be low.

PCT 637, aligned with the Alpine bogs and fens, will experience drawdown of >0.5 m to 17.51 ha of the community. This community is entirely/obligate dependence on groundwater and has a large number of hydric and mesic species that do not occur outside of this, or other allied communities. The 17.51 ha that will be subject to drawdown represents 25% of the mapped extent of the community across the project area, 0.2% of the mapped extent of the community in the Snowy Mountains (OEH 2012b) and 0.15% of the 11,100-ha mapped at a national scale (TSSC 2009). While there is a high risk of predicted impact to some portion of the community, as defined in Serov et al. (2012), the overall risk to the community and listed community is considered low.

Groundwater-dependent riparian vegetation, consisting of species adapted to mesic/hydric soils, are located along sections of creeks and waterways where groundwater is expressing at the surface. It is unlikely that drawdown of less than 5 m will impact on these areas, as some groundwater will continue to be expressed at the surface. In addition, not all groundwater will be diverted to regional aquifers, with an unknown proportion continuing to supply baseflow to these GDEs, maintaining biological integrity. Groundwater-dependent riparian vegetation is predicted to be at moderate risk of predicted impact due to groundwater drawdown.



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Source: EMM (2019); Snowy Hydro (2019); DFSI (2017); LPMA (2011)

KEY

Existing environment
- Main road
- Local road
- Watercourse

Snowy 2.0 operational elements
- Tunnels, portals, intakes, shafts
- Power station

Entirely/obligate dependence
- PCT 637
- PCT 765
- PCT 1225

Facultative - opportunistic
- PCT 303
- PCT 300
- PCT 679

Facultative - proportional
- PCT 302
- PCT 299
- PCT 285

Groundwater drawdown (m)
- 0.5 - 2
- 2 - 5
- 5 - 20
- > 20

Groundwater drawdown in relation to GDE's

Snowy 2.0
Biodiversity development assessment report
Main Works
Figure 7.5

snowy 2.0

EMM creating opportunities

7.5 Final risk assessment for identified GDEs

The GDE assessment, prepared in accordance with Serov et al. (2012), determined that all GDEs within the project area are considered as having high ecological value. Based on the ecological values of the GDEs present in the project area, and the predicted impacts arising from the project, the initial risk assessment has determined that some GDEs are at high risk of impact. However, these predicted impacts are considered an overestimate of the impacts arising from the project given the groundwater model was not able to be considered the effectiveness of pre-grouting the tunnel, which will be implemented during construction. This is likely to considerably reduce the drawdown arising from the project; however, the degree of reduction is unknown. In addition, only small areas of each GDE will be impacted.

Stygofauna communities are considered to be at high risk; however, given only a small area of habitat will be affected and the low species diversity found the overall predicted impact to stygofauna is predicted to be low.

Several PCTs are predicted to be at low risk of predicted impact (category A). This includes PCTs 765, 285, 302, 299, 679, 300 and 303. These areas will experience minimal to no drawdown and will not experience any changes in biological integrity.

Groundwater-dependent riparian vegetation is predicted to be at moderate risk of predicted impact, as the GDE will experience some drawdown, but some level of baseflow is expected to be maintained to large areas and the community will only experience minor changes in species composition.

The initial risk assessment identified that PCTs 1225 and 637 may be at high risk of predicted impact given the level of drawdown, the entirely/obligate dependence of these communities on groundwater and possible changes in species composition. However, these impacts will occur to a small portion of these communities at a local, NSW and national scale. Overall risk of impact is considered low.

The mitigation measures required by Serov et al. (2012) for GDEs at high risk include:

- protection of aquifer and GDE catchment / sub-catchments;
- monitoring to ensure no change to risk;
- mitigate impact and apply water sharing plan rules; and
- monitor effectiveness of mitigation strategy using appropriate indicators.

A monitoring program will be implemented to ensure actual impacts are within or less than predicted. If actual impacts are greater than predicted, adaptive management will be implemented. The monitoring program will be determined as a part of the Biodiversity and Groundwater Management Plans to be developed post-approval.