# Mount Buller Water Storage Project

# Hydrological and Ecological Monitoring and Adaptive Management Program

# Impact Year 2 Monitoring

DRAFT REPORT

Prepared for Mount Buller and Mount Stirling Alpine Resort Management Board

25 August 2021

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- Michael Goddard, Jane Kenny, John Muchan and Georgie Zacks (fieldwork, data analysis and/or reporting)
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# Summary


**Background**

From October 2019 to May 2020, the Mount Buller and Mount Stirling Alpine Resort Management Board (the RMB) constructed a 100-megalitre off-stream water storage and ancillary infrastructure (the project) on Mount Buller, within a 10.347-hectare Project Construction Footprint (PCF) between the summit and the village. As part of the project, the RMB is implementing an ongoing Hydrological and Ecological Monitoring and Adaptive Management Program (HEMAMP), with an objective of maintaining the extent and condition of Alpine Bogs that are downslope of the water storage.

Two years of baseline ecological monitoring data (Baseline Years 1 and 2 or BY1 and BY2) were collected as part of the HEMAMP in 2018 and 2019. This was followed by ecological monitoring during construction in 2020 (Impact Year 1 or IY1) and post-construction ecological monitoring 2021 (Impact Year 2 or IY2). This report summarises the results of ecological monitoring from Impact Year 2, compares the results with baseline data and assesses these results against the HEMAMP's performance criteria.

The HEMAMP's performance criteria are as follows:

- The 'extent' criterion – there will be no more than a 10% reduction in the total combined area of the impact sites, determined by on-ground or remote (aerial) monitoring and taking into account natural variation based on extent observations averaged across control sites.
- The 'composition' criterion – there will be no more than a 10% reduction in the total 'bog-dependent' native flora species richness of the impact sites, taking into account natural variation based on species richness observations averaged across control sites.
- The 'encroachment' criteria:
  - Atypical species – there will be no more than a 10% increase in the cover of 'non-bog-dependent' species within the impact sites, taking into account natural variation based on observations averaged across control sites.
  - Weeds – the total cover of weeds (naturalised exotic flora species) within the impact sites will not exceed 5%.
- The 'structure' criterion – there will be no more than a 10% reduction in the average cover of Peat Moss *Sphagnum* spp. within the impact sites, taking into account natural variation based on Peat Moss cover averaged across control sites.

### Results

| Criterion | Parameter | Threshold | Result* | Compliant? | Action Req'd? | Comments |
|---|---|---|---|---|---|---|
| **Extent** | Area of Alpine Bogs | -10.0% | -4.1% | Yes | Yes | Potential for future non-compliance. Greater relative reduction than IY1. Control weeds/deer and revegetate, focussing on areas of sediment. |
| **Composition** | Bog-dependent species richness | -10.0% | -9.5% | Yes | Yes | Potential for future non-compliance. One bog-dependent species was not detected at impact sites in IY2. Investigate further in IY3 and consider re-introduction. |
| **Encroachment by atypical species** | Cover of non-bog-dependent native flora | +10.0% | +4.9% | Yes | Yes | Potential for future non-compliance, although lower relative increase than IY1. Investigate possible hydrological changes. |
| **Encroachment by weeds** | Cover of weeds at impact sites | 5% | 8.1% | No | Yes | Non-compliant. Weed cover has increased since IY1. Control weeds/deer and revegetate, focussing on areas of sediment. |
| **Structure** | Cover of Peat Moss | -10.0% | +11.1% | Yes | No | Overall, Peat Moss cover and health is good. |

*Note: The result for cover of weeds is expressed as an absolute percentage cover. All other results are expressed as a relative change from the Baseline Mean (BM) to Impact Year 2 (IY2).

### Conclusion and recommendations

The following observations and conclusions were made from Impact Year 2 monitoring results:

- Some of the construction-related impacts on downslope Alpine Bogs observed in Impact Year 1 appear to have stabilised or been reversed. This includes mortality of Peat Moss and turbidity of surface water, both of which were at least partly attributable to sedimentation from the PCF.
- The full extent of some of the construction-related impacts on downslope Alpine Bogs observed in Impact Year 1 is more apparent in Impact Year 2, given that vegetation had one season in which to

respond. For example, localised mortality of some Alpine Bog vegetation was noted in Impact Year 2 as a result of the rocks and boulders that entered Alpine Bogs from the PCF in Impact Year 1.

- New impacts have occurred and are primarily associated with construction of the environmental watering system, which took place in late April and early May 2020, after Impact Year 1 monitoring finished. These new impacts include additional but more localised sedimentation in Bogs 4.2 and 11.2 and removal of approximately 8 square metres of Bog 4.2 along 16 metres of its south-eastern boundary (despite it being flagged off before construction). New impacts also include an increase in concentration of certain minerals in groundwater near control sites.
- Weeds continue to proliferate at impact sites, particularly in locations of sedimentation, despite weed control and revegetation efforts in Impact Year 1. Weed proliferation has contributed to the loss of the extent of Alpine Bogs at impact sites.

Ultimately, these new and pre-existing impacts have contributed to one non-compliance (encroachment by weeds) and one potential future non-compliances (extent of Alpine Bogs) in Impact Year 2. The impacts may have also contributed to two other potential future non-compliances (loss bog-dependent species richness and encroachment by non-bog-dependent species), although further investigation into these is needed.

Given that at least one of the HEMAMP's adaptive management triggers (deterioration of Alpine Bog condition) have been met, this report recommends that certain management actions be taken to reverse the observed trends. Recommended management actions are outlined in Section 4.5 of this report and include weed control, deer/rabbit control and revegetation that targets existing areas of sedimentation and the area of Alpine Bog that was removed during construction. Some of these management actions are already being implemented but will need increased efforts.

Further recommendations of this monitoring report are as follows:

1. The RMB must ensure that laboratory water quality analyses include all parameters required by the HEMAMP, such as total dissolved solids, which was missed at one groundwater monitoring bore on one occasion in IY2.
2. The RMB should re-instate BH09, which was inadvertently destroyed during construction of the environmental watering system.
3. Better management of the HEMAMP's hydrological datasets is required to ensure consistency and completeness of the HEMAMP's hydrological data from year to year. The RMB should maintain a centralised spreadsheet or database of all hydrological data, similar to the way in which it manages the HEMAMP's climatological datasets, to avoid misplacement of data and data corruption.
4. The RMB should ensure that flow sensors at Boggy Creek Weirs 1 and 2 are reliably installed, calibrated and provisioned with automated data loggers to minimise maintenance requirements, reduce the need for daily visits to record flow data and ultimately provide complete datasets for surface water flows through the Boggy Creek catchment, as required by the HEMAMP.
5. The RMB should ensure that groundwater depth sensors are calibrated and promptly re-installed in monitoring bores, together with their automated data loggers, to minimise gaps in groundwater depth datasets.
6. A pictorial guide to bryophyte species recorded at the Mount Buller and Mount Stirling would be useful to assist in consistent field identifications between monitoring years.
7. Consider amalgamating records of Mountain Baeckea *Baeckea utilis s.s.* and Subalpine Baeckea *Baeckea latifolia* under one taxon name (e.g. Mountain Baeckea *Baeckea utilis s.l.*) due to the difficulty in consistently distinguishing between the two species at Mount Buller and Mount Stirling.
8. The HEMAMP protocol for point intersection sampling along transects should be updated to make it clear that the 'vegetation' and 'litter' ground condition categories do not require plant material to be alive or dead, simply attached or detached (respectively).

9. The HEMAMP protocol for point intersection sampling along transects should be updated to include the new sub-categories for 'bare ground': 'bare ground (deer)', 'bare ground (sedimentation)' and 'bare ground (natural)'.
10. The RMB should install data loggers on water meters at the water storage drainage discharge points to monitor volumes of water being discharged from the water storage and from groundwater drainage under the water storage, as required by the HEMAMP.
11. Improvements are needed to the process by which water samples are labelled, handled and recorded in the field to avoid corruption of water quality data and improve traceability of laboratory results.
12. The accuracy of water quality laboratory analyses should be cross-checked as soon as possible (e.g. through analysis of relative percentage difference with duplicate samples) to detect and reconcile any errors as early as possible.
13. The Ecological Rehabilitation Plan (Biosis 2020) must continue to be implemented to prevent further movement of sediment, rocks and boulders from the PCF into Alpine Bogs. This will require regular and long-term monitoring, maintenance and (where required) addition of erosion controls (e.g. sediment barriers).
14. Efforts to control Sambar Deer *Cervus unicolor* at Mount Buller and Mount Stirling should continue, with the aim of preventing this species from further damaging Alpine Bogs.
15. The presence or absence of Silver Astelia *Astelia alpina* var. *novae-hollandiae* from impact sites (particularly Bogs 4.2 and 6) should be further investigated in Impact Year 3. If the presence of Silver Astelia is not detected, the RMB should consider re-introducing this species to these monitoring sites through revegetation.
16. Increased weed control should be undertaken at impact sites and along the aqueduct, prioritising areas of bare ground (particularly sedimentation). The following weed species should be targeted:
    - Milfoil *Achillea millefolium*
    - Brown-top Bent *Agrostis capillaris*
    - Sweet Vernal-grass *Anthoxanthum odoratum*
    - Spear Thistle *Cirsium vulgare*
    - Musk Monkey-flower *Erythranthe moschata*
    - Monkey Musk *Erythranthe guttata*
    - Manna Grass *Glyceria declinata*
    - Yorkshire Fog *Holcus lanatus*
    - Jointed Rush *Juncus articulatus* subsp. *articulatus*
    - Soft Rush *Juncus effusus* subsp. *effusus*
    - Sword Rush *Juncus ensifolius*
    - Apple *Malus pumila*
    - Creeping Buttercup *Ranunculus repens*
    - Blackberry *Rubus anglocandicans*.
17. The use of alternative weed control methods, such as heat, should continue to be trialled to expand the window of time during which weed control can occur, to minimise the risk to Alpine Bogs from herbicide application and to ultimately improve the management of weeds in Alpine Bogs.
18. Locations of mortality of vegetation surrounding Alpine Bogs should be re-visited again in future years to investigate possible causes and to track vegetation recovery or succession.

# 1. Introduction

## 1.1 Project background

Alpine Bogs are groundwater dependent ecosystems with a scattered distribution in alpine, sub-alpine and montane environments across the Australian Alps (DEWHA 2009; FFG Act Scientific Advisory Committee 2013). They are generally characterised by the presence of Peat Moss *Sphagnum* spp. and are particularly susceptible to climate change, given that they have a fragmented distribution and are already at their environmental tolerance limit (DEWHA 2009; Macdonald 2009). Approximately 3 hectares of Alpine Bog are known to exist at Mount Buller.

Alpine Bogs are listed as threatened ecological communities under Commonwealth and State legislation. The Alpine Sphagnum Bogs and Associated Fens (ASBAF) ecological community is listed as endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Alpine Bog Community is listed as threatened under the Victorian *Flora and Fauna Guarantee Act 1988* (FFG Act). Throughout this document, the term 'Alpine Bogs' refers to both ASBAF and the Alpine Bog Community.

In October 2019, the Mount Buller and Mount Stirling Alpine Resort Management Board (the RMB) started construction of a 100-megalitre off-stream water storage and ancillary infrastructure (the project) on Mount Buller between the summit and the village. Construction of the project finished in May 2020, although rehabilitation of the Project Construction Footprint (PCF) is ongoing. Most of the known Alpine Bog community at Mount Buller is located downslope of the PCF and the project has the potential to affect the hydrology of these Alpine Bogs (Biosis and GHD 2016).

In accordance with approvals for the project (EPBC Act Approval 2014/7303 and Planning Permit PA1600138), the RMB is implementing a Hydrological and Ecological Monitoring and Adaptive Management Program (HEMAMP), with the objective of maintaining the extent and condition of Alpine Bogs that are downslope of the proposed water storage (Biosis 2019). Those Alpine Bogs with catchment areas affected by the water storage are known as impact sites and are monitored annually as part of the HEMAMP. The annual monitoring also includes control sites, which are Alpine Bogs with catchment areas that are unaffected by the water storage.

The HEMAMP aims to meet the following performance criteria:

- The 'extent' criterion – there will be no more than a 10% reduction in the total combined area of the impact sites, determined by on-ground or remote (aerial) monitoring and taking into account natural variation based on extent observations averaged across control sites.
- The 'composition' criterion – there will be no more than a 10% reduction in the total 'bog-dependent' native flora species richness of the impact sites, taking into account natural variation based on species richness observations averaged across control sites.
- The 'encroachment' criteria:
  - Atypical species – there will be no more than a 10% increase in the cover of 'non-bog-dependent' species within the impact sites, taking into account natural variation based on observations averaged across control sites.
  - Weeds – the total cover of weeds (naturalised exotic flora species) within the impact sites will not exceed 5%.

- The 'structure' criterion – there will be no more than a 10% reduction in the average cover of Peat Moss within the impact sites, taking into account natural variation based on Peat Moss cover averaged across control sites.

## 1.2 Scope of this report

The HEMAMP outlines a monitoring and management regime for selected Alpine Bogs on Mount Buller and Mount Stirling (Figure 1). Between 2014 and 2018, the RMB, assisted by Biosis Pty Ltd (Biosis) and GHD Pty Ltd (GHD), established climatological and hydrological monitoring infrastructure and commenced collecting climate, groundwater and surface water observations as part of the HEMAMP. In January and February 2018, the RMB commissioned Biosis to establish the HEMAMP's ecological monitoring components and collect the first year of baseline ecological monitoring data. In total, two years of baseline (pre-construction) monitoring were undertaken (Baseline Years 1 and 2 or BY1 and BY2), one year of monitoring was completed during construction (Impact Year 1 or IY1) and one year of post-construction monitoring has been completed (Impact Year 2 or IY2).

This monitoring report:

- Provides a summary of the monitoring data collected in IY2.
- Compares data collected in IY2 with the baseline data collected over BY1 and BY2.
- Assesses these results against the HEMAMP's performance criteria and recommends appropriate management actions.

In order to remain adaptive, the HEMAMP will be updated as required and with approval from the Victorian Government Department of Environment, Land, Water and Planning (DELWP) and the Australian Government Department of Agriculture, Water and the Environment (DAWE). Numerous refinements were made to the HEMAMP protocol during the two baseline monitoring years. Recommendations for further refinements are made in this report and, along with management recommendations, are highlighted in text boxes as shown below.

| Recommendations |
| --- |
| All recommendations arising from IY2 monitoring are highlighted in this fashion throughout this monitoring report. |

# 2. Methods

Monitoring methods follow the HEMAMP protocol (Biosis 2019), except where explicitly noted. Mount Buller and Mount Stirling monitoring sites are shown on Figure 2 and Figure 3 respectively.

## 2.1 Monitoring effort, frequency and timing

HEMAMP monitoring years run from the start of June (winter) to the end of May (autumn) each year.

### 2.1.1 Ecological monitoring

The ecological monitoring components of the HEMAMP were established in January and February 2018 (BY1). Since 2018, Biosis has conducted ecological monitoring, with assistance from the RMB, at six impact sites and seven control sites (Table 1). Each year, transect monitoring has been undertaken from late January until mid-February, while mapping has been undertaken from late January until mid-March (Table 2). The timing and completeness of the ecological datasets are further outlines in Appendix 1.

Slight differences in timing of ecological monitoring (particularly the monitoring end date) are generally associated with weather conditions and the need to maintain consistency in the quality of the data (e.g. DGPS mapping under clear skies). Slight differences in the timing of ecological monitoring from year to year are unlikely to affect an assessment against the performance criteria.

**Table 1 Annual ecological monitoring effort as part of the HEMAMP**

| Monitoring effort | Impact sites | Control sites (Mt Buller:Mt Stirling) | Total |
|---|---|---|---|
| **Number of sites* (Alpine Bogs)** | 6 | 7<br>(4 : 3) | 13 |
| **Number of transects** | 24 | 23<br>(14 : 9) | 47 |
| **Average length of transect (m)** | 18.5 | 21.6<br>(22.3 : 20.4) | 20 |
| **Number of point intersections (20-cm intervals)** | 2196 | 2457<br>(1546 : 911) | 4653 |
| **Number of quadrats** | 87 | 101<br>(64 : 37) | 188 |
| **Number of photo points** | 48 | 46<br>(28 : 18) | 94 |

*Note: The data presented in this table relate to the sites at which line and belt transects have been established. Additional sites are mapped but not subject to monitoring with line and belt transects.

**Table 2 Timing of ecological monitoring**

| Monitoring year | Transect monitoring period | Mapping period |
|---|---|---|
| **Baseline Year 1** | 26 Jan 2018 to 9 Feb 2018 | 26 Jan 2018 to 9 Feb 2018 |
| **Baseline Year 2** | 29 Jan 2019 to 14 Feb 2019 | 29 Jan 2019 to 23 Feb 2019 |
| **Impact Year 1** | 28 Jan 2020 to 20 Feb 2020 | 30 Jan 2020 to 14 Mar 2020 |
| **Impact Year 2** | 25 Jan 2021 to 4 Feb 2021 | 2 Feb 2021 to 26 Feb 2021 |

### 2.1.2 Climatological monitoring

The climatological monitoring components of the HEMAMP rely on:

- An Australian Government Bureau of Meteorology (BoM) weather station at Mount Buller (Station Number 083024), which has been operational since 1948 and which captures climate data relevant to impact sites and control sites at Mount Buller (Figure 2; Table 3).
- An RMB weather station at Mount Stirling, which was re-installed in November 2018 and which captures climate data relevant to control sites at Mount Stirling (Figure 3; Table 3).
- Snow gauges maintained by Buller Ski Lifts at three locations on Mount Buller (Tirol Flat, Boggy Creek and Family Run), which are relevant to impact sites and control sites at Mount Buller (Figure 2; Table 3).

The weather stations contribute daily rainfall data to the HEMAMP. This includes daily rainfall measurements from Mount Buller from 1985 onwards (earlier measurements are less reliable) and daily rainfall measurements from Mount Stirling from November 2018 onwards. Natural and artificial snow depths are measured daily during winter each year, from the first to the last significant snowfall of the year (typically early June to early October). Snow depth data from May 2015 onwards has been collated as part of the HEMAMP.

The timing and completeness of the daily rainfall and daily snow depth datasets is outlined in Appendix 1. The Mount Buller daily rainfall dataset is more than 99% complete, the Mount Stirling daily rainfall dataset is more than 90% complete (since establishment in November 2018) and the Mount Buller daily snow depth dataset is 100% complete. While the rainfall and snow depth datasets are relatively complete, there may be multiple reasons for missing data. For example, BY1 climatological data for Mount Stirling is not available because the Mount Stirling weather station was installed midway through BY2. In addition, the Mount Stirling weather station relies on a solar panel, battery and data logger, all of which may fail unexpectedly (particularly after repeated exposure to extreme cold and snow, which is why data are often missing in winter).

**Table 3 Annual climatological monitoring effort as part of the HEMAMP**

| Monitoring sites | Impact sites | Mt Buller control sites | Mt Stirling control sites |
|---|---|---|---|
| **Weather stations** | BoM Mount Buller weather station* | BoM Mount Buller weather station* | RMB Mount Stirling weather station |
| **Snow gauges** | Tirol Flat, Boggy Creek and Family Run* | Tirol Flat, Boggy Creek and Family Run* | Not available |

*Note: The weather station and snow gauges at Mount Buller collect data across a broad catchment area, which does not allow for comparisons of precipitation at impact sites and control sites at Mount Buller.

### 2.1.3 Hydrological monitoring

Since February 2018, the RMB has collected surface water and groundwater data at Mount Buller as part of the HEMAMP. Data are collected from the following locations (Figure 2; Table 4):

- Surface water quality and flow data are collected from Boggy Creek Weir 1 Pickup 1, Boggy Creek Weir 1 Pickup 2 and Boggy Creek Weir 2.
  - Boggy Creek Weir 1 Pickup 1 is relevant to control sites at Mount Buller. The catchment area for Pickup 1 is the north-western slopes of Mount Buller and is thought to include Bog 4.1/5/7 (a control site).
  - Boggy Creek Weir 1 Pickup 2 is relevant to impact sites at Mount Buller. The catchment area for Pickup 2 is the central northern slopes of Mount Buller and is thought to include all impact sites.
  - Boggy Creek Weir 2 is relevant to impact sites and control sites at Mount Buller. It is downstream of the confluence of Boggy Creek Weir 1 Pickups 1 and 2 and therefore captures data for the broader Boggy Creek catchment, including all impact sites and control sites at Mount Buller.
- Groundwater quality and depth data are collected from boreholes BH06, BH09, BH16, BH17 and BH18.
  - BH09 and BH17 are relevant to impact sites at Mount Buller.
  - BH06, BH16 and BH18 are relevant to control sites at Mount Buller.

The RMB visits these sites in November and February each monitoring year to take water samples for quality analysis. Water quality readings are taken in the field and water samples are sent to a laboratory for more detailed analysis. Data loggers at surface water weirs and pickups record stage heights (surface water levels) every three seconds and data loggers at groundwater bores record groundwater depths every four hours. Data from surface water data loggers must be manually downloaded each day and converted to an average daily flow measurement. Data from groundwater data loggers are downloaded when water samples are taken from groundwater bores in November and February of each monitoring year.

**Table 4 Annual hydrological monitoring effort as part of the HEMAMP**

| Monitoring sites | Impact sites | Mt Buller control sites | Mt Stirling control sites |
|---|---|---|---|
| **Surface water weirs/pickups** | Weir 1 Pickup 2 and Weir 2* | Weir 1 Pickup 1 and Weir 2* | Not available |
| **Groundwater bores** | BH09 and BH17 | BH06, BH16 and BH18 | Not available |

*Note: Boggy Creek Weir 2 collects data for the broad Boggy Creek catchment, which includes impact sites and control sites at Mount Buller.

The surface water and groundwater quality datasets are mostly complete (Appendix 1). Water quality was not analysed in November 2017 (first half of BY1), analysis of Total Dissolved Solids (TDS) was missed at BH18 in February 2021 (second half of IY2) and BH09 was inadvertently destroyed during construction of the environmental watering system in April or May 2020, meaning that IY2 data is not available for this location. In addition, it appears that corruption of some water quality data may have occurred in water quality documents stored by the RMB in IY1 or IY2. Some of these documents include baseline water quality data that does not match the baseline data that was presented in the baseline monitoring report.

**Impact Year 2 – Recommendation 1**

The RMB must ensure that laboratory water quality analyses include all parameters required by the HEMAMP, such as total dissolved solids, which was missed at one groundwater monitoring bore on one occasion in IY2.

**Impact Year 2 – Recommendation 2**

The RMB should re-instate BH09, which was inadvertently destroyed during construction of the environmental watering system.

**Impact Year 2 – Recommendation 3**

Better management of the HEMAMP's hydrological datasets is required to ensure consistency and completeness of the HEMAMP's hydrological data from year to year. The RMB should maintain a centralised spreadsheet or database of all hydrological data, similar to the way in which it manages the HEMAMP's climatological datasets, to avoid misplacement of data and data corruption.

Unfortunately, most surface water flow and groundwater depth data are missing (Appendix 1). The surface water flow dataset is less than 10% complete (the dataset captures approximately one quarter of BY2) and the groundwater depth dataset is approximately 35% complete (with approximately 70% of baseline data available). There are multiple reasons for these incomplete datasets, including the following:

- Difficulties establishing and calibrating flow meters and data loggers at surface water monitoring sites hampered data collection early in the monitoring program (particularly in the first half of BY2). Issues such as blockages and short circuiting were common, resulting in patchy, unreliable and/or nonsensical data that could not be included in the dataset.
- The need to visit flow meters on a daily basis to manually download data severely limits the surface water flow dataset. This means that data are often missing for periods of RMB resourcing constraints, such as most weekends, periods of high bushfire threat and periods of COVID-19 restrictions.
- There appear to have been delays in calibrating and replacing or re-installing groundwater depth sensors in February of each baseline monitoring year, resulting in no groundwater depth data being captured in autumn of these years.
- Changeover of RMB staff responsible for hydrological monitoring is likely to have resulted in data being misplaced, lost or not captured.

The lack of surface water and groundwater data is currently a major limitation of the HEMAMP. The incompleteness of these datasets limits our knowledge and understanding of the environmental stimuli to which the Alpine Bogs may be responding and, in turn, limits the inferences that can be made about the way in which the Alpine Bogs are reacting to environmental change.

**Impact Year 2 – Recommendation 4**

The RMB should ensure that flow sensors at Boggy Creek Weirs 1 and 2 are reliably installed, calibrated and provisioned with automated data loggers to minimise maintenance requirements, reduce the need for daily visits to record flow data and ultimately provide complete datasets for surface water flows through the Boggy Creek catchment, as required by the HEMAMP.

**Impact Year 2 – Recommendation 5**

The RMB should ensure that groundwater depth sensors are calibrated and promptly re-installed in monitoring bores, together with their automated data loggers, to minimise gaps in groundwater depth datasets.

## 2.2 Species lists

The comprehensive list of all flora species observed at Alpine Bog monitoring sites is updated annually to reflect taxonomic name changes and to add any new observations, including incidental observations and observations made during transect monitoring. The full flora list is shown in Appendix 2 and uses Victorian Biodiversity Atlas (DELWP 2021) nomenclature.

The list of bog-dependent flora species used for assessing performance criteria is also presented in Appendix 2. This is a subset of species considered dependent on and characteristic of the Alpine Bogs at Mount Buller and Mount Stirling. The list draws heavily upon the diagnostic bog species outlined in the Diagnostic Key to Alpine Bogs (Appendix 3; DoE 2013) and the EPBC Act policy statement for Alpine Bogs (DEWHA 2009).

While the flora lists are comprehensive, there are a number of reasons why not all flora species will have been detected. For example, some flora species may not have been found or positively identified due to seasonal conditions, species dormancy and a lack of diagnostic material with which to identify specimens to species level.

A herbarium of plant samples, including most bryophyte species, is being maintained and will assist in refining the flora species list over time. Where possible, plant samples are not taken from near monitoring transects, rather than along transects, to minimise interference with monitoring along the same transects in future years. In IY2, a concerted effort was made to collect, photograph and identify all bryophytes (in this case, liverworts and mosses). Most bryophyte samples were identified to species level with the use of compound microscopes and various taxonomic keys, including Scott and Stone (1976), Scott (1988), Meagher and Fuhrer (2003) and Seppelt (2004).

The majority of bryophyte species identified in IY2 have never previously been recorded at Mount Buller or Mount Stirling. Some species are so rare or poorly studied that they have very few records from anywhere in Victoria (DELWP 2021). Since BY1, all bryophytes except for Peat Moss *Sphagnum cristatum* have been treated as non-bog-dependent species. This is partly because little is known about the habitat requirements of some of these bryophytes. It is likely that some of these species (particularly the rarer species with very few records from anywhere in Victoria) would be more appropriately considered bog-dependent. However, for the sake of consistency between monitoring years and assessment of performance criteria, we have retained the classification of non-bog-dependent for all bryophytes except Peat Moss.

**Impact Year 2 – Recommendation 6**

A pictorial guide to bryophyte species recorded at the Mount Buller and Mount Stirling would be useful to assist in consistent field identifications between monitoring years.

At many of the monitoring sites, there can be great difficulty distinguishing Mountain Baeckea *Baeckea utilis s.s.* and Subalpine Baeckea *Baeckea latifolia*. Mount Buller and Mount Stirling are two of only a small number of locations where Mountain Baeckea and Subalpine Baeckea co-occur. The two taxa were recognised as two varieties of a single species until Bean's (1997) taxonomic revision. Bean (1997) examined specimens from New South Wales and Victoria, including from the Boggy Creek area at Mount Buller where most monitoring sites are located, and noted several differences between the two taxa. These differences are summarised in Appendix 2 and are similar to (but not entirely consistent with) the differences noted by VicFlora (RBGV 2021).

Both Bean (1997) and VicFlora (RBGV 2021) provide taxonomic keys that distinguish the two species by leaf width and shape, although the VicFlora key allows for some overlap between the species. For example, a specimen with mostly elliptic leaves that are 2 to 3 millimetres wide could be either of the two species according to the VicFlora key (RBGV 2021). Indeed, VicFlora notes that it is often difficult to distinguish the two species.

So far, empirical observations and samples collected at Mount Buller and Mount Stirling suggest that it would be more appropriate to treat the two taxa as one species. There are often no reliable characteristics to distinguish the two taxa and specimens with intermediate characteristics are frequently observed. For example, a specimen may have leaves that are more characteristic of one species but the number of stamens per flower is more suggestive of the other species.

As a result, the distinction between Mountain Baeckea and Subalpine Baeckea at Mount Buller and Mount Stirling is often subjective and is likely to have been inconsistent between monitoring years at certain transects. Given that both species are considered to be bog-dependent and that the monitoring involves a robust number of replicates, any inconsistency in the identification of these taxa is unlikely to have influenced results to date. Nevertheless, care should be taken when assessing bog-dependent species richness to ensure that any changes have not been brought about by presence or absence of Mountain Baeckea or Subalpine Baeckea.

**Impact Year 2 – Recommendation 7**

Consider amalgamating records of Mountain Baeckea *Baeckea utilis s.s.* and Subalpine Baeckea *Baeckea latifolia* under one taxon name (e.g. Mountain Baeckea *Baeckea utilis s.l.*) due to the difficulty in consistently distinguishing between the two species at Mount Buller and Mount Stirling.

## 2.3 Monitoring parameters

Line transects, belt transects, photo points and on-ground mapping are used to collect data for the following ecological parameters in accordance with the HEMAMP:

- Bog extent:
  - Area of Alpine Bogs.
- Bog composition:

- Richness of bog-dependent flora.
- Cover of bog-dependent flora.

- Encroachment by weeds and other atypical species:
  - Cover of weeds.
  - Cover of non-bog-dependent flora.
- Bog structure:
  - Peat Moss *Sphagnum* spp. cover.

These parameters allow for the current extent and condition of the Alpine Bogs to be directly assessed against the HEMAMP's performance criteria.

Additional ecological parameters, such as the dimensions of the Alpine Bogs and cover of bare ground, are examined in this monitoring report to provide a more detailed analysis of the outcomes of Alpine Bog management at Mount Buller and Mount Stirling. Climatological and hydrological parameters are also discussed because they may provide explanations for ecological observations.

### 2.3.1 Line transects (point intersections)

Fixed transects are used as line transects to collect data that can be used to infer bog extent, bog composition, weed encroachment and bog structure. At each transect, a measuring tape is extended from the start peg (designated as 0 centimetres) to the end peg. A 5-millimetre diameter steel pin (approximately 1 metre long) is inserted vertically into the vegetation at 20-centimetre intervals along the tape. At each interval, the following observations are recorded:

- The ground condition at the base of the pin, categorised as follows:
  - Litter: detached plant material.
  - Vegetation: attached plant material (this category is used where the base of the pin rested on vegetation, such as the woody stem of a shrub or the rosette leaves of a herb, in which case the species to which the vegetation belongs is also recorded).
  - Rock: substrate comprising cobbles, boulders or bedrock i.e. anything with a particle size greater than 64 millimetres and therefore not easily erodible in an Alpine Bog context (EPA Victoria 2003).
  - Bare ground: substrate comprising silt, sand, gravel or pebbles i.e. anything with a particle size of 64 millimetres or less and therefore easily erodible in an Alpine Bog context (EPA Victoria 2003). In IY2, the type of bare ground was also recorded and attributed to one or more of the following categories to better understand the likely causes for bare ground:
    - Bare ground (deer): where the bare ground was probably linked to deer activity, evidenced by the presence of a deer wallow, track, print and/or scat.
    - Bare ground (sedimentation): where the substrate appeared to have originated from outside the bog (i.e. allochthonous) and was typically made up of inorganic fines such as clay – this category generally targeted sediment from the water storage project and could be determined by sight and feel (the clay-like consistency and colour of the sediment) and/or by tracing the source of the sediment uphill.
    - Bare ground (natural): attributed to all other instances of bare ground, typically where the substrate was a dark, organic-rich humus and/or peat.

- Water: running water (which is generally rare, except after rain) or a standing pool or puddle of water (which is generally more common).

- All species of flora touching the pin along any part of the pin's length. Note that only species in contact with the pin (not species above the pin) are recorded.
- The condition of each species touching the pin, categorised as follows:
  - Alive: where the plant that is touching the pin has living plant material, even if the material that is actually touching the pin is dead (living material is inferred by the presence of photosynthesising tissue i.e. 'green' tissue).
  - Dead: where all material belonging to the plant that is touching the pin is dead (inferred by a clear lack of photosynthesising tissue).

| Impact Year 2 – Recommendation 8 |
| --- |
| The HEMAMP protocol for point intersection sampling along transects should be updated to make it clear that the 'vegetation' and 'litter' ground condition categories do not require plant material to be alive or dead, simply attached or detached (respectively). |

| Impact Year 2 – Recommendation 9 |
| --- |
| The HEMAMP protocol for point intersection sampling along transects should be updated to include the new sub-categories for 'bare ground': 'bare ground (deer)', 'bare ground (sedimentation)' and 'bare ground (natural)'. |

At each line transect, the first point observation is made at a distance of 20 centimetres (0.2 metres) from the start peg. Point observations are made at 20-centimetre increments thereafter, moving towards the end of the transect, with the final observation being made at a point 20 centimetres from the end peg.

The types of species recorded (i.e. bog-dependent species or not) and the position at which they are recorded provides an indication of the extent of the Alpine Bog, by allowing the dimensions of the Alpine Bog to be estimated. Using the Diagnostic Key to Alpine Bogs (Appendix 3), the edge of the Alpine Bog is taken to be the point at which bog-dependent flora species richness is equal to non-bog-dependent flora species richness (similar to the on-ground boundary mapping, where the edge of the Alpine Bog is where bog-dependent flora no longer make up 50% of vegetative cover).

The frequency at which species are recorded provides an indication of the structure of the Alpine Bogs and any encroachment of atypical or weed species. It allows for the cover of bog-dependent species, non-bog-dependent species, weeds and Peat Moss to be estimated and assessed against the relevant performance criteria. The frequency at which various ground conditions or dead plant specimens are recorded may also give an early indication of potential floristic or structural changes occurring within the Alpine Bogs.

### 2.3.2 Belt transects (quadrats)

The fixed transects are used as belt transects to collect a comprehensive flora species list, estimate the species richness of bog-dependent flora and identify new atypical species that may be encroaching on the Alpine Bogs.

A 1x1 metre quadrat is placed at 4-metre intervals along each transect, starting and ending 4 metres from the ends of each transect. The centre of the quadrat is placed at the 4-metre interval mark. All flora species within the quadrat are recorded.

When combined with point intersection data, quadrat data provide a measure of the species richness of bog-dependent flora. Point intersection data capture the most dominant flora species. The inclusion of quadrat data increases the likelihood of detecting small or rare species, including any novel weed species that may need managing.

### 2.3.3 Photo points

The start and end pegs of each fixed transect are photo points from which photos are taken annually to allow for qualitative assessment of changes (if any) to the extent, composition, encroachment and structure of Alpine Bogs. The standard photo point requirements, including camera settings, are detailed in the HEMAMP protocol (Biosis 2019). Importantly, photos are labelled with a code that is a concatenation of the bog number (1, 2, 4.1, 4.2, 5, 6, 7, 8, 9, 10, 11.1, 11.2, 12, 13, S1, S2 or S3), transect letter (A, B, C, D or E) and peg position ('S' to denote 'start peg' or 'E' to denote 'end peg'). For example, the photo taken from the start peg of Transect C at Bog 8 is labelled '8CS'. All photo point photos since BY1 are collated in Appendix 4.

### 2.3.4 On-ground mapping

Each year, the boundary of each Alpine Bog (at impact and control sites) has been mapped on foot using a DGPS (Samsung Galaxy Tab A6 paired with a Trimble R1 GNSS receiver). In BY1 and BY2, this mapping was to an accuracy of 3 metres or better in most instances, but accuracy was reduced to up to 5 metres in some areas with an overhanging tree canopy, particularly at Mount Stirling. From IY1 onwards, improvements to DGPS technology (e.g. satellite availability and satellite-delivered correction services, particularly Trimble RTX) allowed for sub-2-metre accuracy in most instances (especially at Mount Buller sites) and generally no worse than 3-metre accuracy (e.g. at Mount Stirling sites with overhanging tree canopies). As much as possible, mapping is conducted under clear skies because cloud cover adversely affects DGPS accuracy.

Alpine Bogs are mapped using the Diagnostic Key to Alpine Bogs (Appendix 3), as follows:

- Using the Diagnostic Key to Alpine Bogs, it is first determined whether an Alpine Bog is present in the given area. Areas are considered to be Alpine Bog if one or more of the following criteria are met (Appendix 3):
  - Live, hummock-forming Peat Moss is present and abundant (at least 20% cover).
  - A peat substrate is present, Peat Moss is present but not abundant (less than 20% cover) and at least two bog-dependent flora species (diagnostic species) make up at least 50% of the cover of all other vegetation present.
  - A peat substrate is present, Peat Moss is absent but at least three bog-dependent flora species (diagnostic species) make up at least 50% of the vegetative cover.
- Once presence of an Alpine Bog is established, the boundary of the Alpine Bog is mapped at the point where bog-dependent flora are no longer dominant (i.e. bog-dependent flora no longer make up 50% of the vegetative cover).
- For the purpose of mapping Alpine Bog boundaries and determining the dominance of bog-dependent flora, the cover of Bidgee-widgee *Acaena novae-zelandiae,* Alpine Water-fern *Blechnum penna-marina* subsp. *alpina* and Tall Sedge *Carex appressa* are not included in total vegetation cover. These three species are regarded as 'neutral' when mapping Alpine Bog boundaries, although they are still considered to be non-bog-dependent for all other purposes. This approach is consistent with relevant policy documents (e.g. TSSC 2009 and DEWHA 2009), which indicate that these species are

typical of Alpine Bogs (although Bidgee-widgee is more typical of Tasmanian Alpine Bogs). The policy documents also explain that the fens component of the ecological community may be dominated by *Carex* sedges, which is why Sub-alpine Wet Sedgeland is recognised as an Ecological Vegetation Class that is synonymous with the community (TSSC 2009; DEWHA 2009).

On-ground mapping provides an opportunity to inspect the full extent of the Alpine Bogs and to note any management issues that may not have been detected by transect monitoring (e.g. sedimentation, weed invasion or deer activity). Mapping data and notes from previous years are made available in the field for comparison, so that the cause of any changes can be investigated on the ground and past observations (e.g. regarding sedimentation, weeds or deer) can be revisited.

#### 2.3.5 Rainfall and snow depth

Monthly and annual rainfalls are calculated from daily rainfall data from the Mount Buller and Mount Stirling weather stations. In the case of the well-established Mount Buller weather station, the long-term mean annual rainfall is calculated using monthly rainfall data from 1985 to present. The periods from June 1992 to May 1994 and June 2000 to May 2001 were not used for the purposes of calculating the long-term mean because most data are missing for these periods. A further 12 missing monthly rainfall values from 1991 to 2010 were estimated using the monthly average of the five years preceding and following the data gap. Daily rainfall data from Mount Buller and Mount Stirling have been strongly correlated in the past, meaning that the long-term mean annual rainfall provides some context for the annual rainfall observed at Mount Buller and Mount Stirling since BY1.

Daily snow depth data from Tirol Flat, Boggy Creek and Family Run snow gauges are used to calculate mean natural snow depth for Mount Buller. Mean natural snow depth data for Mount Buller from 1993 to present is used to calculate a long-term mean natural snow depth for each winter day, which provides some context for the mean natural snow depth observed in a given monitoring year. In particular, it provides context around the quantity, longevity and seasonality of snow in a given year e.g. whether snow arrived early or late and whether it lasted for more or less than the average snow season. Daily natural snowfall (mm) has been recorded since 2017 (BY1) and, along with artificial snow depth (from snowmaking), provides additional context for observations made at the Alpine Bog monitoring sites each year.

#### 2.3.6 Surface water quality and flow

The HEMAMP requires that surface water quality and flow monitoring take place at three locations in the Boggy Creek catchment (Boggy Creek Weir 1 Pickup 1, Boggy Creek Weir 1 Pickup 2 and Boggy Creek Weir 2; Table 4).

Surface water samples are taken in November and February each monitoring year for water quality analysis. Each sampling event consists of measuring field parameters (pH, electrical conductivity, oxidation-reduction potential and temperature) followed by sampling for laboratory analysis. Field parameters are measured using a calibrated YSI ProPlus water quality meter. Samples are collected in accordance with EPA Victoria (2009) sampling guidelines. Water samples are sent to NATA (National Association of Testing Authorities) accredited laboratories for analysis.

Field duplicates and field blank samples are collected as part of the QA/QC program. Relative Percentage Difference (RPD) between primary and duplicate samples is calculated to quantitatively assess the accuracy of the laboratory results. RPD is calculated as an absolute difference between the primary and duplicate samples, relative to the mean value of the two samples i.e. RPD = (Sample1 – Sample2) / (Sample1 + Sample2) / 2. (Standards Australia 2005). An RPD of less than 30% is preferable, but an RPD between 30% and 50% is generally considered acceptable, where the results are more than ten times the LoR (Standards Australia 2005).

For the purposes of data analysis (including calculating RPD), values that were below the Limit of Reporting (LoR) were substituted with a value equal to half of the LoR. For example, if the LoR for turbidity was 0.1 Nephelometric Turbidity Units (NTU) and the result for turbidity for a given sample was <0.1 NTU, this value was substituted with 0.05 NTU i.e. half the LoR.

In accordance with the HEMAMP protocol (Biosis and GHD 2017), laboratory analyses test surface water samples for the following:

- pH (field only)
- Electrical Conductivity (EC)
- Total Dissolved Solids (TDS)
- Nutrients (Total P and N)
- Major ions (Ca, Mg, Na, K, Cl, SO4, HCO3, CO3 and NO3)
- Turbidity
- Suspended Solids.

Where relevant, surface water quality is compared with ANZECC (2000) guidelines for 95% species protection and SEPP (2018) environmental water quality indicators for highland streams (above 1000 metres altitude).

A rectangular weir and water level sensor (Siemens LUT400) has been installed at each of the three surface water monitoring locations to measure surface water flow. The water level sensor records stage height every 3 seconds, which is converted to a flow measurement based on the geometry of the weir. These measurements are then used to estimate a daily average flow at each location, although the daily average flow must be recorded manually, which is one of the reasons for the incomplete surface water flow dataset (see Section 2.1 of this report).

As required by the HEMAMP, water meters have been added to the water storage drainage discharge points to monitor volumes of water discharged from the water storage and from groundwater de-watering under the water storage (Photo 1). Although water meters have been installed, the RMB does not yet regularly monitor the water volumes passing through these discharge points.

| **Impact Year 2 – Recommendation 10** |
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| The RMB should install data loggers on water meters at the water storage drainage discharge points to monitor volumes of water being discharged from the water storage and from groundwater drainage under the water storage, as required by the HEMAMP. |

### 2.3.7 Groundwater quality and depth

The HEMAMP requires that groundwater quality and depth monitoring take place at five bores in the Boggy Creek catchment (BH06, BH09, BH16, BH17 and BH18; Table 4).

Groundwater samples are taken in November and February each monitoring year for water quality analysis. For each sampling event, monitoring bores are purged of standing water (minimum of three casing volumes, where possible) prior to sampling using a dedicated, disposable bailer to eliminate cross contamination. Field water quality parameters (pH, electrical conductivity, oxidation-reduction potential and temperature) are measured during the sampling process using a calibrated YSI ProPlus water quality meter. Samples are collected in accordance with EPA Victoria (2000) sampling guidelines. Water samples were sent to NATA (National Association of Testing Authorities) accredited laboratories for analysis.

Field duplicates and field blank samples are collected as part of the QA/QC program. Relative Percentage Difference (RPD) between primary and duplicate samples is calculated to quantitatively assess the accuracy of the laboratory results. RPD is calculated as an absolute difference between the primary and duplicate samples, relative to the mean value of the two samples i.e. RPD = (Sample1 – Sample2) / (Sample1 + Sample2) / 2. (Standards Australia 2005). An RPD of less than 30% is preferable, but an RPD between 30% and 50% is generally considered acceptable, where the results are more than ten times the LoR (Standards Australia 2005).

For the purposes of data analysis (including calculating RPD), values that were below the Limit of Reporting (LoR) were substituted with a value equal to half of the LoR. For example, if the LoR for turbidity was 0.1 Nephelometric Turbidity Units (NTU) and the result for turbidity for a given sample was <0.1 NTU, this value was substituted with 0.05 NTU i.e. half the LoR.

In accordance with the HEMAMP protocol (Biosis and GHD 2017), groundwater samples are tested for the following:

- pH (field only)
- Electrical Conductivity (EC)
- Total Dissolved Solids (TDS)
- Nutrients (Total P, N).
- Major ions (Ca, Mg, Na, K, Cl, SO4, HCO3, CO3 and NO3).

Depth to water is measured manually using a Solinst Water Level Meter at the beginning of each monitoring event. For long-term groundwater depth monitoring, In-Situ LevelTROLL 400 water level loggers were installed in the monitoring bores. These level sensors are non-vented, meaning their measurements include atmospheric pressure. An In-Situ BaroTROLL 500 atmospheric pressure sensor was also installed in BH06 to provide data to correct water level readings for barometric pressure change. While these data loggers recorded groundwater depths throughout most of the baseline monitoring years (BY1 and BY2), no groundwater depth data is available for the period since construction began (IY1 and IY2), beyond the manual measurements taken during groundwater sampling events in November and February each monitoring year (see Section 2.1 of this report).

## 2.4 Data management

The following ecological and climatological datasets are being maintained for monitoring consistency and repeatability in future years:

- Herbarium of plant samples.
- An electronic data collection spreadsheet for transect monitoring.
- A spreadsheet of all observations from all transect monitoring conducted to date.
- Spatial dataset of Alpine Bog boundaries from each year, photo point locations and transect locations.
- Database of all photo points taken to date.

- A collection of on-ground observations (e.g. potential management issues) made while walking the Alpine Bog boundaries.
- A spreadsheet of all precipitation data from the Mount Buller BoM station, Mount Stirling weather station and snow gauges.

As noted in Section 2.1 of this report, it is likely that the incompleteness of the HEMAMP's hydrological datasets is partly due to data mismanagement. The RMB should maintain a centralised spreadsheet or database of all the HEMAMP's hydrological data, similar to the way in which the HEMAMP's ecological and climatological data is managed (see Recommendation 3 of this report). This would assist in ensuring consistency and completeness of the hydrological dataset, partly by highlighting the potential for missing or corrupted data to the individual responsible for collecting it.

As explained in the IY1 monitoring report, surface water samples from Weir 1 Pickups 1 and 2 were probably mislabelled in IY1 (November 2019 and February 2020), meaning that water quality results for Pickup 1 were actually the results for Pickup 2 and vice versa. The error was corrected by swapping the results for these two sites in IY1. Water quality results in IY2 suggest that the treatment of results in IY1 was justified. However, it appears that similar mislabelling errors may have occurred with duplicate samples used for the QA/QC process in IY2. This is discussed further in Section 3.6 of this report.

| **Impact Year 2 – Recommendation 11** |
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| Improvements are needed to the process by which water samples are labelled, handled and recorded in the field to avoid corruption of water quality data and improve traceability of laboratory results. |

| **Impact Year 2 – Recommendation 12** |
| --- |
| The accuracy of water quality laboratory analyses should be cross-checked as soon as possible (e.g. through analysis of relative percentage difference with duplicate samples) to detect and reconcile any errors as early as possible. |

In IY2, minor rounding errors were detected and corrected in baseline means that had been calculated for various ecological parameters. These errors only affected the fourth decimal place of values that were presented in reports and did not affect values maintained in the ecological dataset.

## 2.5 Data analysis

The ecological monitoring program follows a 'Beyond BACI' (Before-After-Control-Impact) design and data analysis has been set up accordingly (Underwood 1992 and 1994). Linear Mixed-effects Models (LMMs) and Analysis of Variance (ANOVA) were used to test the statistical significance of the effect of the period (before/after) and treatment (control/impact) on a given response variable (e.g. area of Alpine Bogs or cover of weeds).

LMMs were fitted using the 'lme4' package in the R statistical and graphical environment (R Development Core Team 2020) using the Restricted Maximum Likelihood (REML) method. The models were in the following form:

*Response ~ Period * Site Class + (1|Year) + (1|Sample)*

The various components of the models are explained as follows:

- Response:
  - The response variable is the ecological monitoring parameter of interest, such as the area of Alpine Bogs or cover of weeds, non-bog-dependent flora, bog-dependent flora or Peat Moss.
  - We are interested in detecting whether or not there has been a statistically significant change in the response variable at impact sites relative to control sites in the period after the impact commenced.
- Period and Site Class:
  - Period refers to the time before (i.e. BY1 and BY2) or after (i.e. IY1 and IY2) the potential impact commenced (i.e. before or after construction of the water storage started).
  - Site Class refers to the 'treatment' that the Alpine Bogs have received. The Alpine Bogs belong to one of two Site Classes – control sites or impact sites.
  - Period and Site Class are the fixed effects in the model. They are the BACI effect that we are monitoring.
- 1|Year and 1|Sample:
  - The model also includes Year (BY1, BY2, IY1 etc.) and Sample (Bog 1, Bog 2, Bog 4.1/5/7 etc.) as random effects (i.e. random temporal and spatial variables).
  - The Sample-to-Sample variation represents localised spatial variability within each Site Class (e.g. the variation between Bog 1 and Bog 2 represents some of the random effect within Control sites).
  - The Year-to-Year variation represents temporal variability that applies to all Samples, regardless of Site Class (i.e. the random temporal effect that applies equally to Control and Impact sites, causing the same fluctuations at both Site Classes from year-to-year).

We are interested in determining whether or not there is a statistically significant interaction between Period and Site Class (sometimes called a BA*CI interaction or BACI contrast). If the coefficient for the BA*CI interaction (i.e. the estimate of the BACI contrast) is statistically significant, it suggests that there is a significant difference in the response of control and impact sites to the impact. In other words, there is a statistically significant difference between the control and impact sites after the impact, compared with the control and impact sites before the impact.

The statistical significance of the BA*CI interaction (BACI contrast) was determined by two-way ANOVA using Type III Sums of Squares and the Kenward-Roger approximation for Degrees of Freedom (DF). Estimated Marginal Means (EMMs) provided an estimate of the BACI contrast and an indication of the variability or Standard Error (SE) in the dataset.

Examining SE is important and requires an ecological understanding of the dataset. If ANOVA suggests that the BA*CI interaction is not statistically significant, this may be because construction of the water storage has genuinely had no detectable effect on impact sites or it may be because the datasets are too variable (SE is too high) for an effect to be detectable.

Statistical tests were undertaken in the R statistical and graphical environment (R Development Core Team 2020) and a 5% statistical significance threshold ($\alpha = 0.05$). LMMs were fitted and ANOVA conducted using the 'lmerTest' package, while EMMs were computed and analysed using the 'emmeans' package.

# 3. Results

## 3.1 Bog extent

### 3.1.1 Area of Alpine Bogs

The area of each Alpine Bog was mapped using DGPS. The results of this mapping are summarised in Chart 1 and depicted in Figure 4 (raw results for each Alpine Bog are available in Appendix 5). The total combined area of all Alpine Bogs at impact sites was 1.3353 hectares in IY2, which is less than the baseline mean of 1.3666 hectares (a decrease of 0.0313 hectares or 2.3%). The total combined area of all Alpine Bogs at control sites was 2.1183 hectares in IY2, which is greater than the baseline mean of 2.0812 hectares (an increase of 0.0372 hectares or 1.8%). The relative change in the area of impact sites in IY2 was therefore a decrease of 4.1%, although this change was not statistically significant (BACI contrast = 0.0097; SE = 0.0099; F-statistic = 0.9455; numerator DF = 1; denominator DF = 35; P = 0.3375)

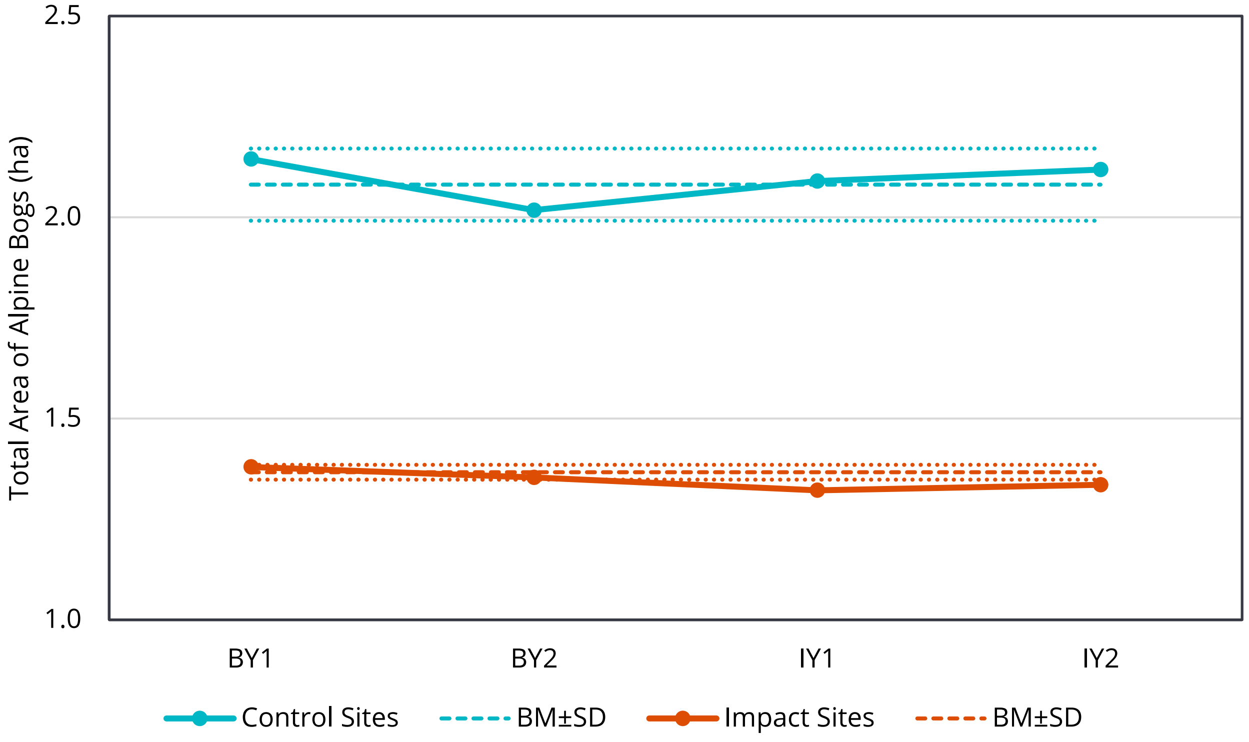


**Chart 1 Total area (hectares) of Alpine Bogs over time relative to the baseline mean ± one standard deviation (BM±SD)**

### 3.1.2 Dimensions of Alpine Bogs

The dimensions of each Alpine Bog were estimated using line transects and the Diagnostic Key to Alpine Bogs (Appendix 3). The results of these estimates are presented in Chart 2 (raw results for each Alpine Bog are available in Appendix 5). The sum of dimensions at impact sites was 354.2 metres in IY2, which is less than the baseline mean of 354.7 metres (a decrease of 0.5 metres or 0.1%). The sum of dimensions at control sites was 436.6 metres in IY2, which is less than the baseline mean of 438.8 metres (a decrease of 2.2 metres or 0.5%). The relative change in the dimensions of the impact sites was therefore an increase of 0.4%, although this change was not statistically significant (BACI contrast = -0.2050; SE = 0.5255; F-statistic = 0.1518; numerator DF = 1; denominator DF = 35; P =0.6991).

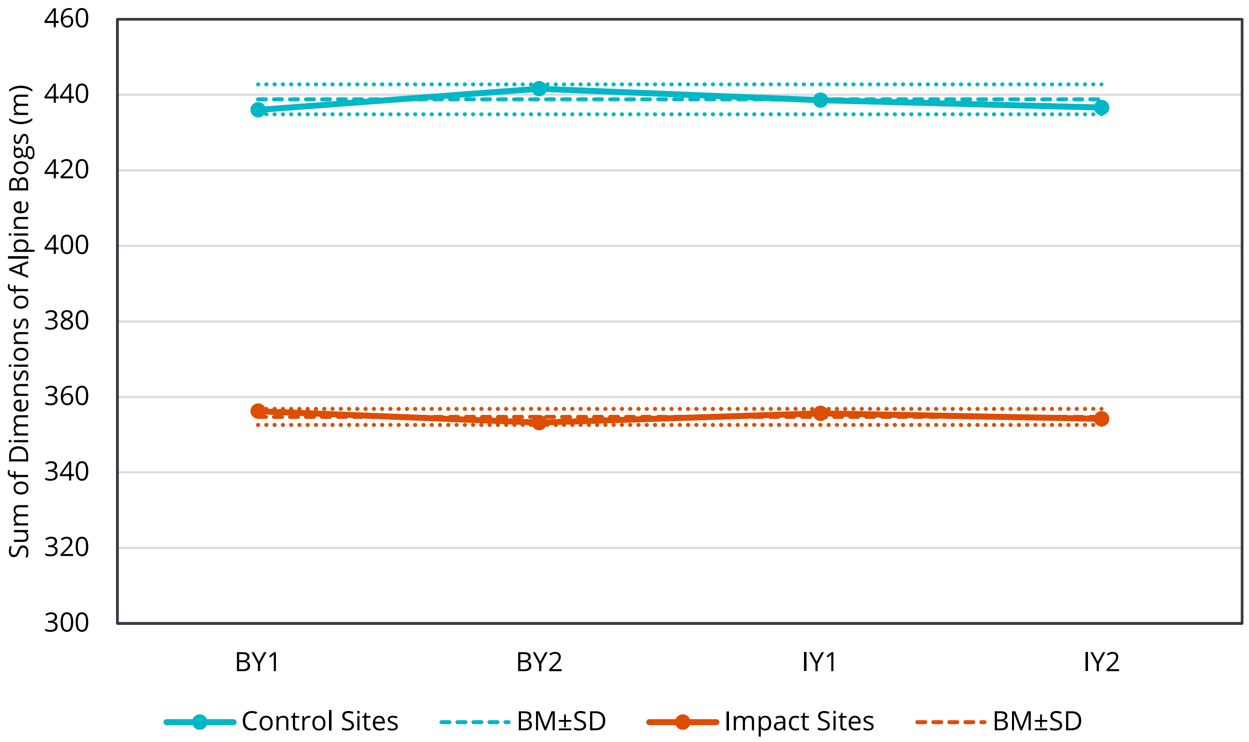


**Chart 2 Sum of dimensions (metres) of Alpine Bogs over time relative to the baseline mean ± one standard deviation (BM±SD)**

### 3.1.3 Bare ground

Line transects (point intersections) were also used to estimate the cover of bare ground. These estimates are displayed in Chart 3 (raw results for each Alpine Bog are available in Appendix 5). The cover of bare ground was again elevated at impact sites and control sites in IY2 relative to the baseline mean, although less elevated than in IY1. In IY2, the cover of bare ground was 4.6% at impact sites and 2.6% at control sites, compared with baseline mean covers of 1.0% and 0.5% respectively. The greater increase in bare ground at impact sites relative to control sites was not statistically significant (BACI contrast = -0.0019; SE = 0.0124; F-statistic = 0.0223; numerator DF = 1; denominator DF = 35; P = 0.8820).

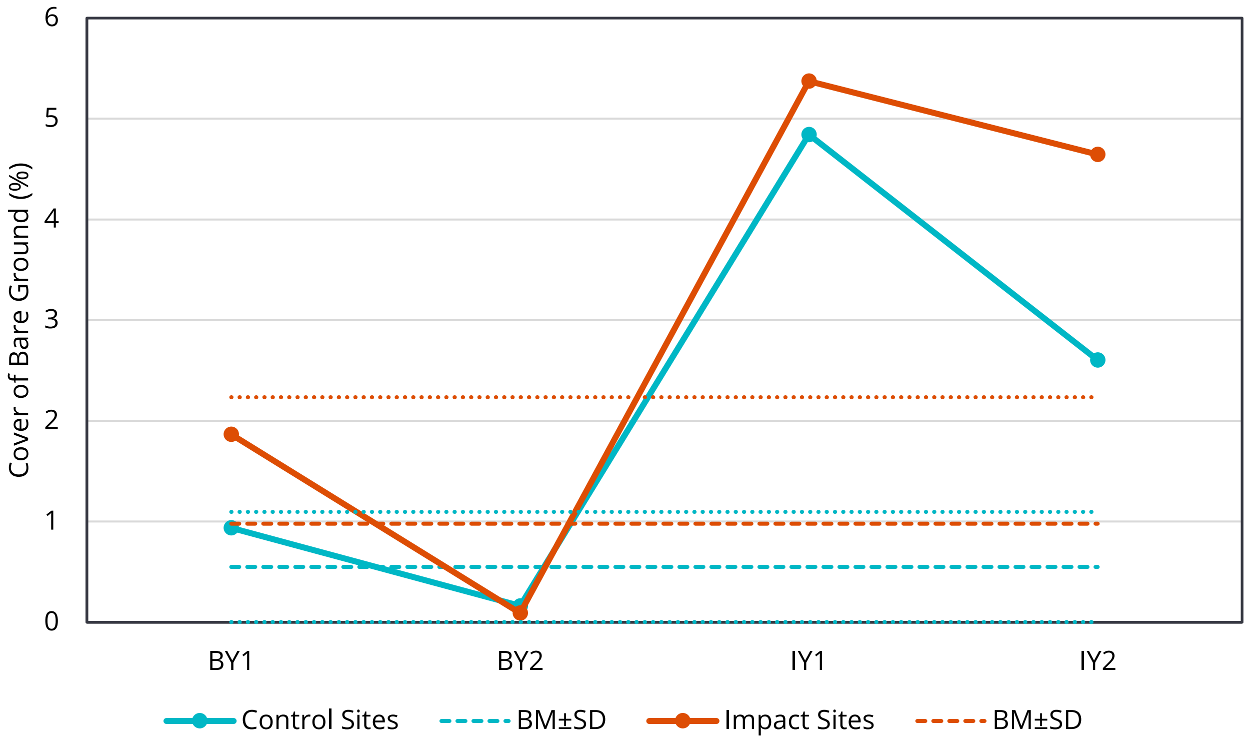


**Chart 3** **Percentage cover of bare ground at Alpine Bogs over time relative to the baseline mean ± one standard deviation (BM±SD)**

However, the causes of bare ground in IY2 differed markedly at impact sites compared with control sites, as shown in Chart 4. At impact sites, 72.5% of bare ground was attributed to sedimentation, while the remainder (27.5%) was considered natural (no bare ground was attributed to deer activity). At control sites, 67.2% of bare ground was considered natural, 32.8% was likely to have been caused by deer and no bare ground was attributed to sedimentation.

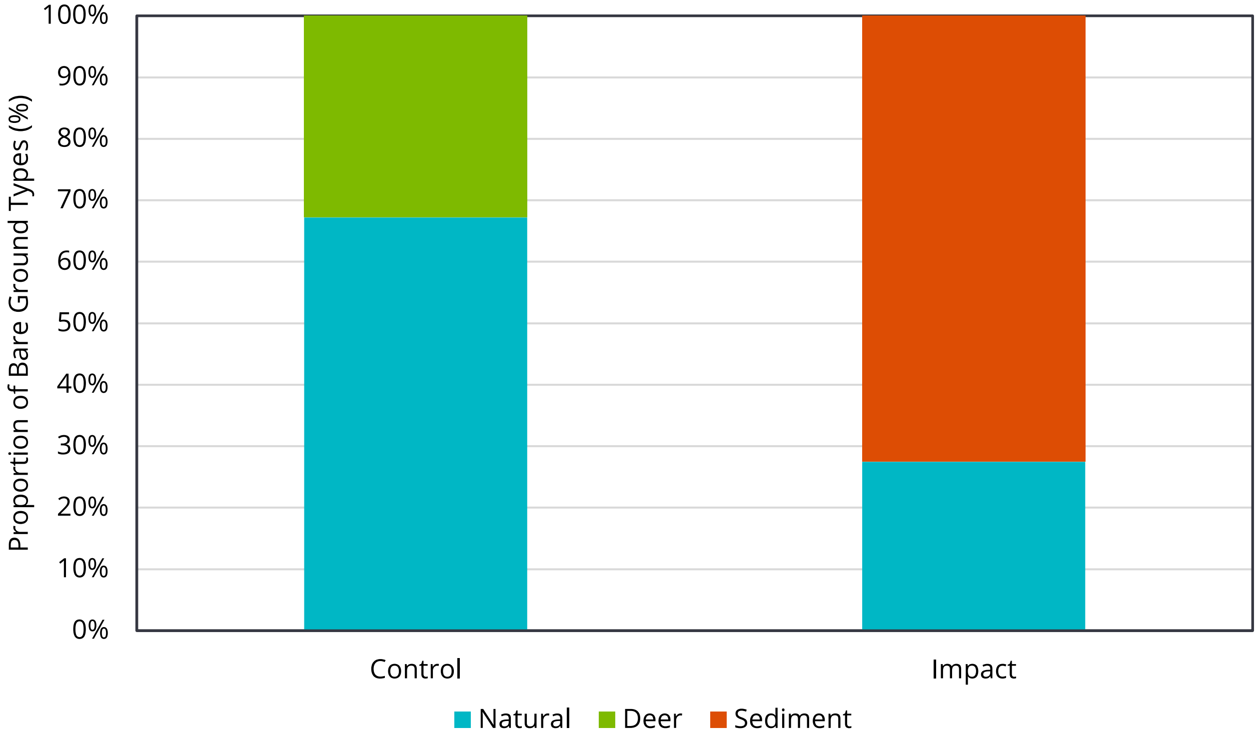


**Chart 4** **Types of bare ground recorded at control and impact sites as a proportion of all bare ground recorded at those sites**

## 3.2 Bog composition

### 3.2.1 Species richness

Using line transects (point intersections) and belt transects (quadrats), a total of twelve bog-dependent flora species have been recorded at impact and control sites since monitoring started (Appendix 2; Appendix 5). On average, baseline monitoring detected 10.5 bog-dependent species across all impact sites and 10.5 bog-dependent species across all control sites (Chart 5). In IY2, 10 bog-dependent flora species were recorded at impact sites (a 4.8% reduction in species richness from the baseline mean) and 11 bog-dependent flora species were recorded at control sites (a 4.8% increase in species richness from the baseline mean). The relative decrease in species richness at impact sites compared with control sites in IY2 was therefore 9.5%, although this change was not statistically significant (BACI contrast = 0.3571; SE = 0.4514; F-statistic = 0.6260; numerator DF = 1; denominator DF = 35; P = 0.4342).

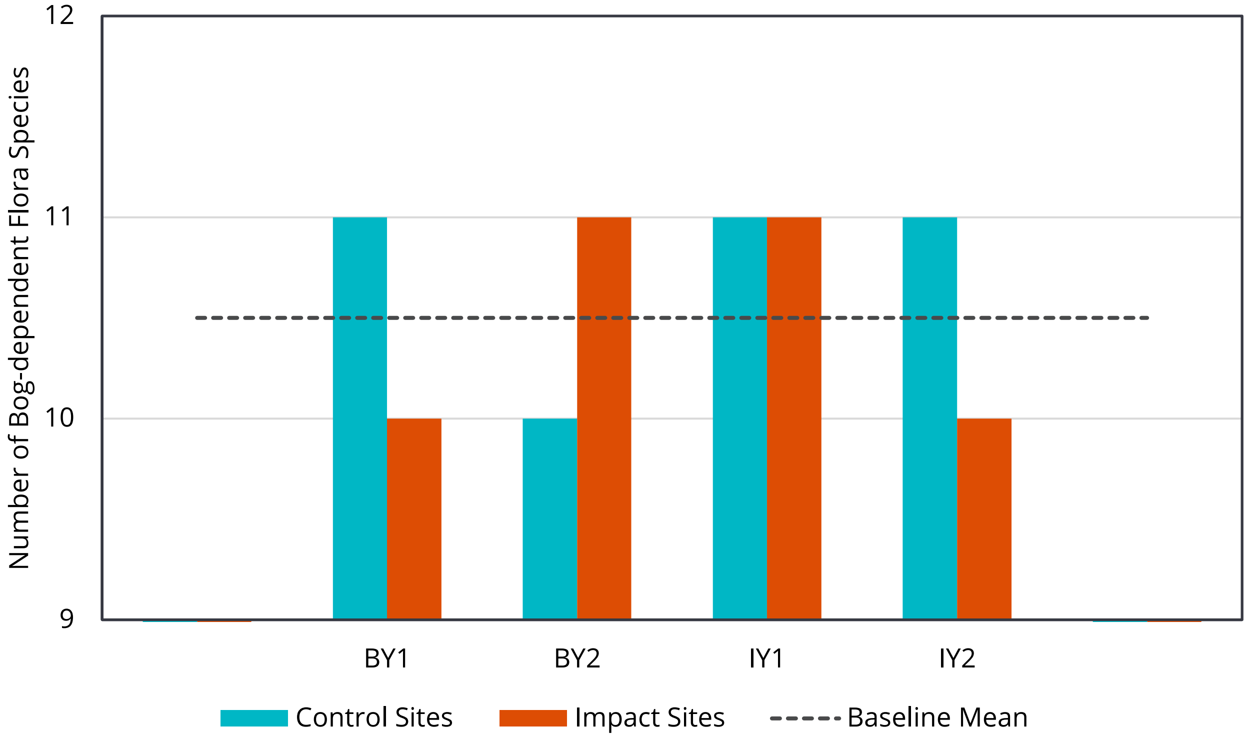


**Chart 5 Bog-dependent flora species richness at control and impact sites relative to the baseline mean**

### 3.2.2 Cover of bog-dependent flora

Line transects (point intersections) were also used to estimate the cover of bog-dependent flora species. Chart 6 shows these covers (raw results for each Alpine Bog are available in Appendix 5). The cover of bog-dependent flora species increased at impact sites from a baseline mean of 78.2% to 79.5% in IY2. The cover of bog-dependent flora species at control sites increased from a baseline mean of 87.9% to 88.9% in IY2. While the increase in cover of bog-dependent species was greater at impact sites relative to control sites, the increase was not statistically significant (BACI contrast = -0.0178; SE = 0.0102; F-statistic = 3.0534; numerator DF = 1; denominator DF = 35; P = 0.0893).

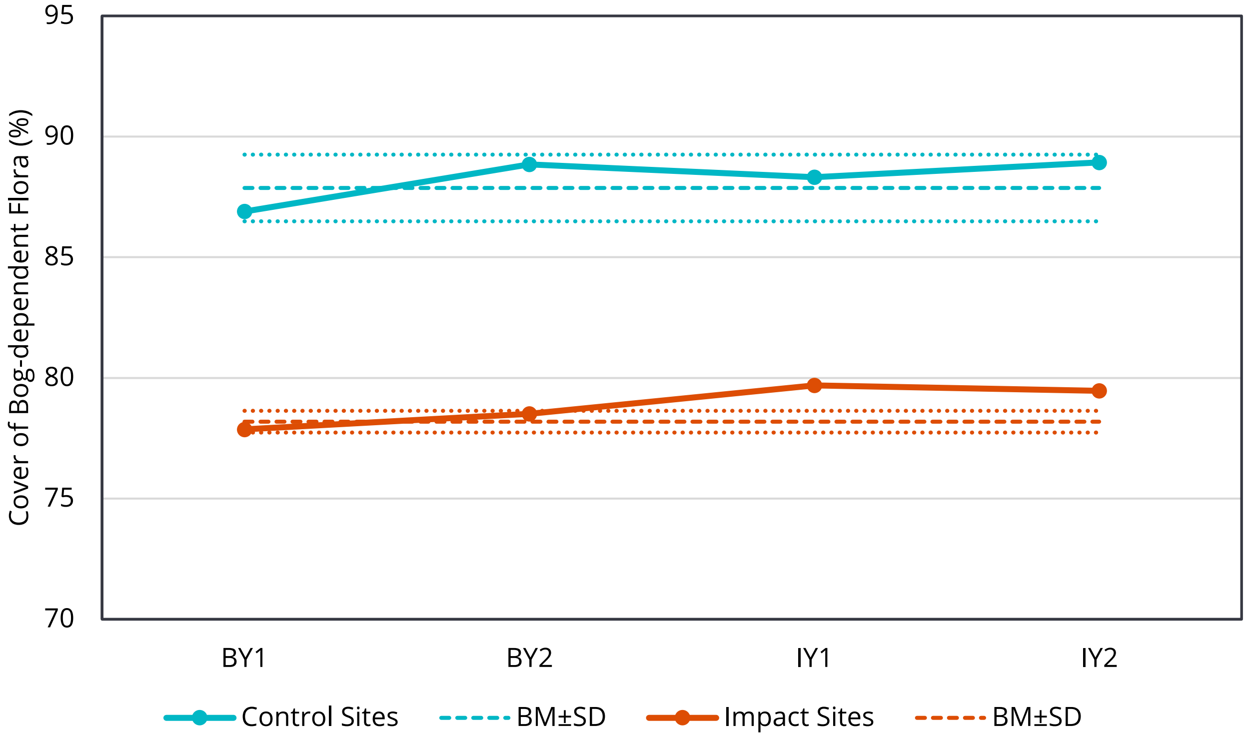


**Chart 6 Percentage cover of bog-dependent flora at Alpine Bogs over time relative to the baseline mean ± one standard deviation (BM±SD)**

## 3.3 Encroachment by weeds and other atypical species

Line transects (point intersections) were used to estimate the covers of native non-bog-dependent flora species and introduced flora species (weeds) at each Alpine Bog (Appendix 5).

### 3.3.1 Cover of native non-bog-dependent flora

The cover of native non-bog-dependent flora species is shown in Chart 7. The cover of native non-bog-dependent flora increased at impact sites from a baseline mean of 45.2% to 46.1% in IY2 and decreased at control sites from a baseline mean of 45.1% to 43.8% in IY2. This represents a relative increase of 4.9% in the cover of native non-bog-dependent flora species at impact sites relative to control sites in IY2. This relative increase was statistically significant (BACI contrast = -0.0306; SE = 0.0136; F-statistic = 5.0400; numerator DF = 1; denominator DF = 35; P = 0.0312).

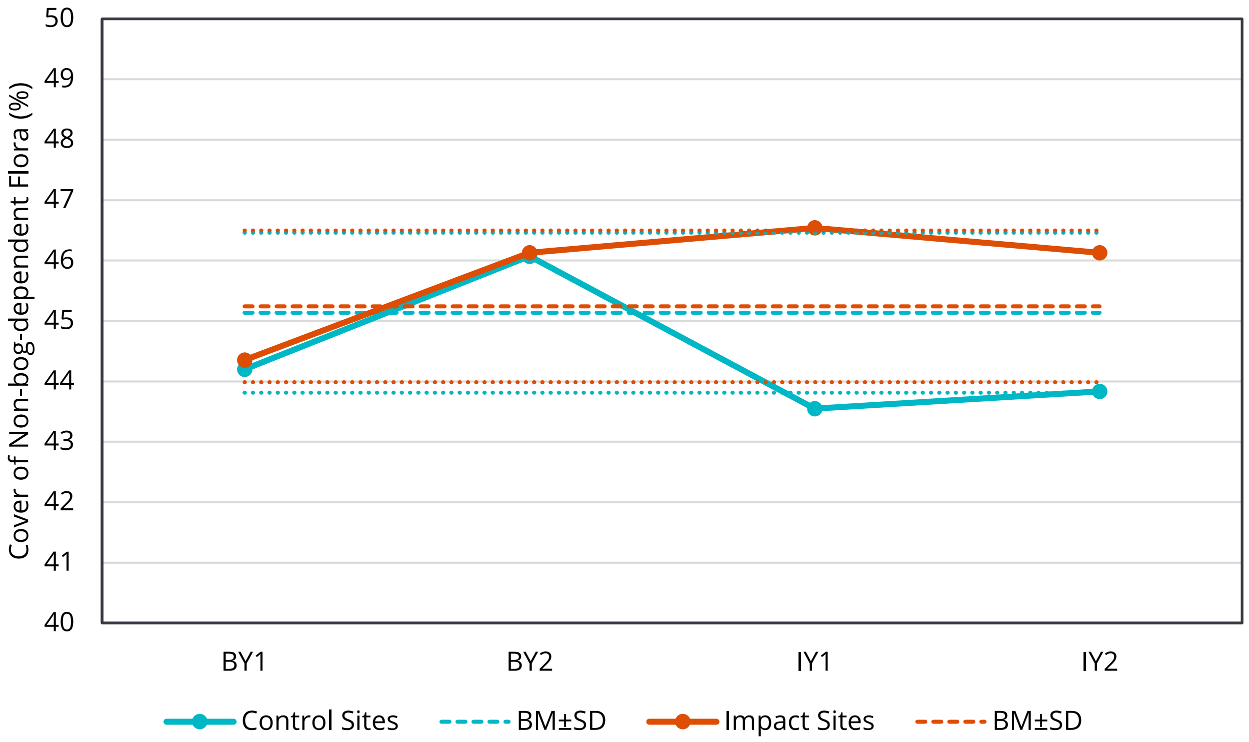


**Chart 7 Percentage cover of native non-bog-dependent flora at Alpine Bogs over time relative to the baseline mean ± one standard deviation (BM±SD)**

### 3.3.2 Cover of weeds

The cover of weeds is shown in Chart 8. The cover of weeds increased at impact sites from a baseline mean of 5.9% to 8.1% in IY2 and increased at control sites from a baseline mean of 4.3% to 4.9% in IY2. However, the greater increase in weed cover at impact sites relative to control sites was not statistically significant (BACI contrast = -0.0169; SE = 0.0098; F-statistic = 2.9713; numerator DF = 1; denominator DF = 35; P = 0.0936).

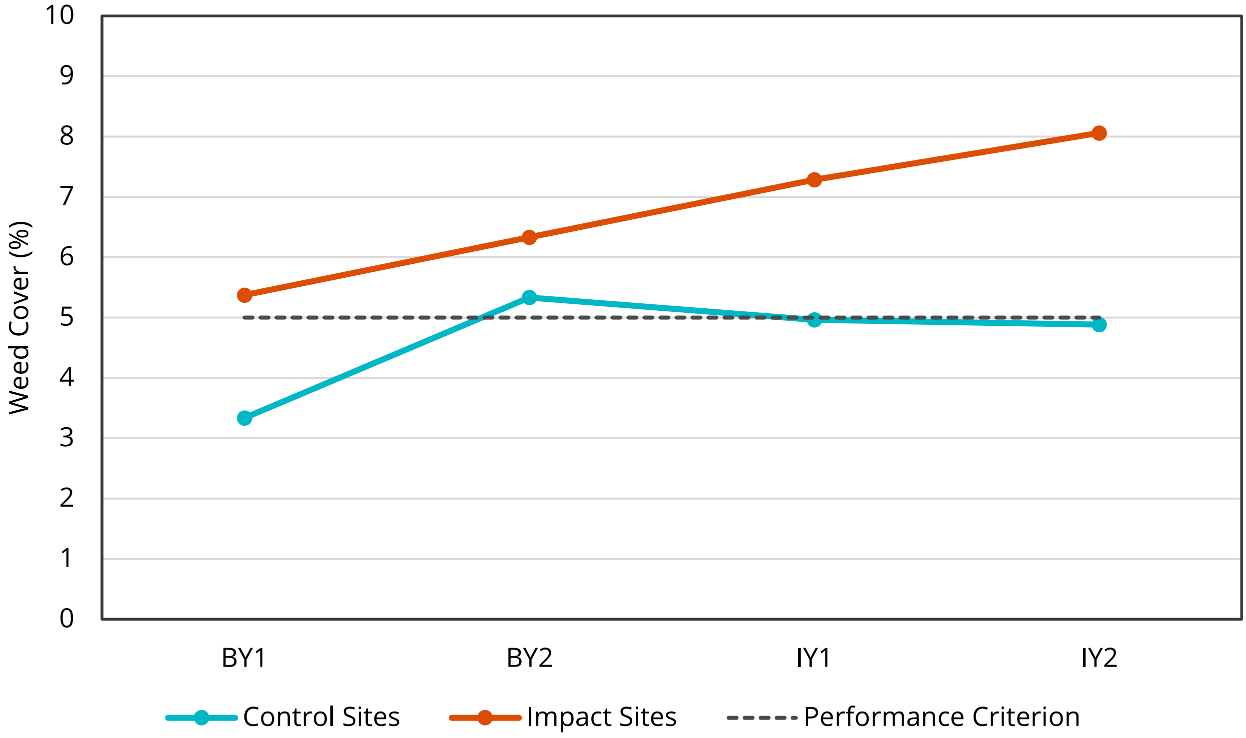


**Chart 8 Percentage weed cover at Alpine Bogs over time relative to the 5% performance criterion**

## 3.4 Bog structure

### 3.4.1 Cover of Peat Moss

Line transects (point intersections) were used to estimate the cover of Peat Moss *Sphagnum* spp. at impact sites and control sites. These estimates are displayed in Chart 9 (raw results for each Alpine Bog are available in Appendix 5). At impact sites, the cover of Peat Moss increased from a baseline mean of 5.4% to 6.0% in IY1 and remained at 6.0% in IY2. At control sites, the cover of Peat Moss in IY2 returned to the baseline mean of 16.4%, after dropping to 15.9% in IY1. The relative increase in Peat Moss cover at impact sites compared with control sites is not statistically significant (BACI contrast = -0.0157; SE = 0.0097; F-statistic = 2.5936; numerator DF = 1; denominator DF = 35; P = 0.1163).

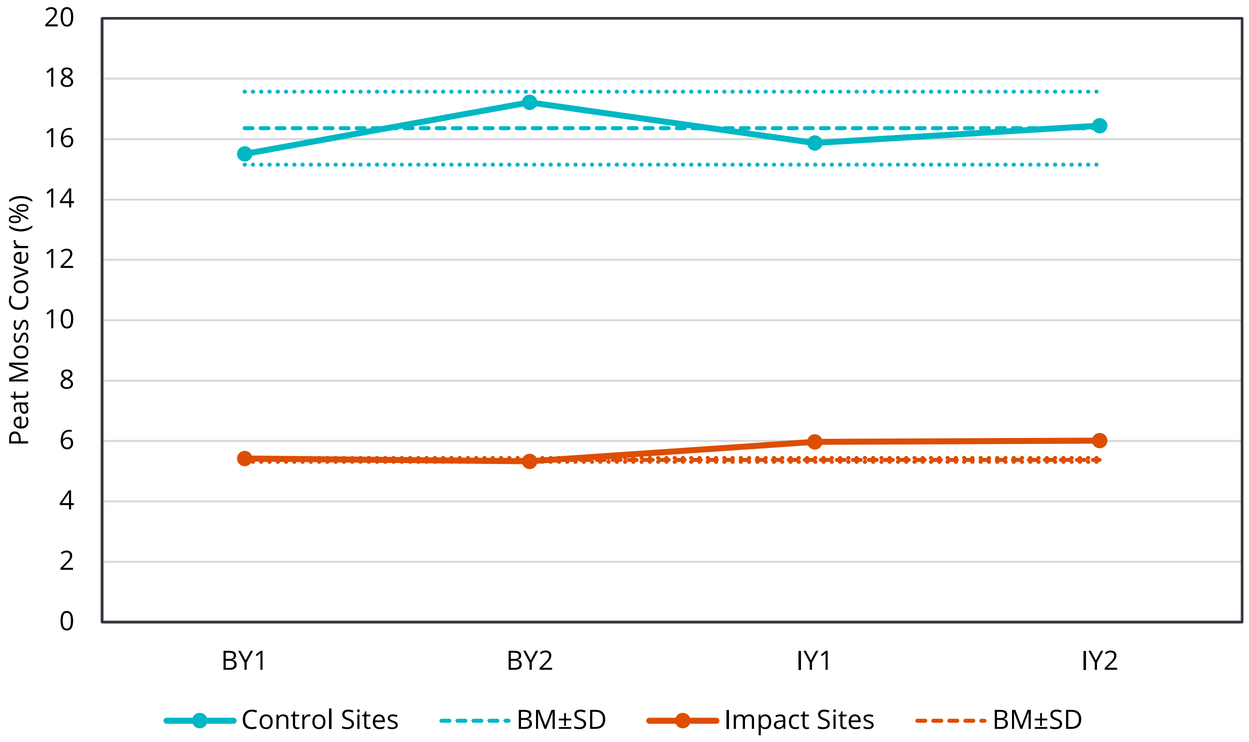


**Chart 9 Percentage cover of Peat Moss at Alpine Bogs over time relative to the baseline mean ± one standard deviation (BM±SD)**

### 3.4.2 Dead Peat Moss

It was a recommendation of IY1 monitoring that the proportion of dead Peat Moss be reviewed again in IY2 to examine whether a protracted decline in Peat Moss was occurring at impact sites. The proportion of dead Peat Moss at impact sites and control sites is shown in Chart 10. A substantial (albeit statistically insignificant) increase in dead Peat Moss was observed at impact sites in IY1, but the result was not repeated in IY2. At impact sites, the proportion of dead Peat Moss in IY2 was 2.5% and therefore slightly higher than the baseline mean of 2.2%. Changes in the proportion of dead Peat Moss at impact sites compared with control sites before and after construction have not been statistically significant (BACI contrast = -0.0041; SE = 0.0033; F-statistic = 1.4985; numerator DF = 1; denominator DF = 35; P = 0.2291).

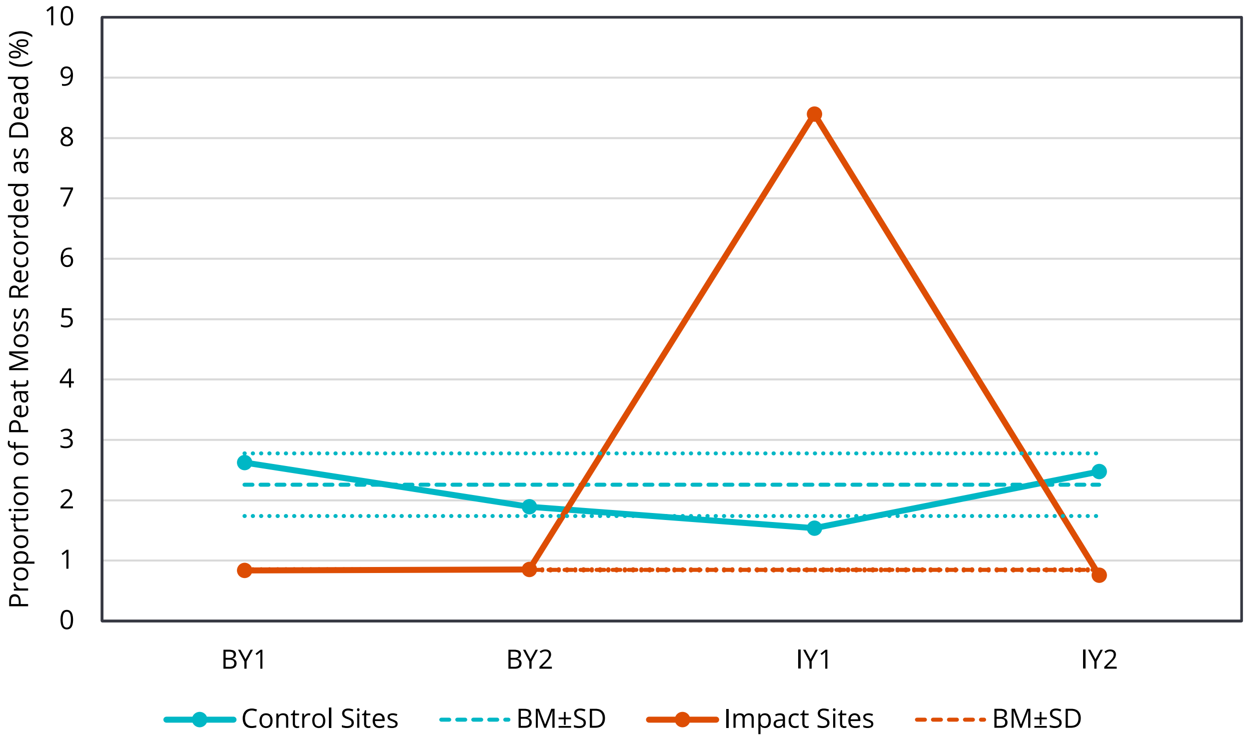


**Chart 10 Proportion of Peat Moss recorded as dead relative to the baseline mean ± one standard deviation (BM±SD)**

## 3.5 Climate

### 3.5.1 Rainfall

Daily rainfall data for Mount Buller and Mount Stirling were converted into monthly and annual rainfall figures, presented in Chart 11 and available in Appendix 6. Daily rainfall at Mount Buller and Mount Stirling is strongly correlated (Pearson's r = 0.8458; DF = 837; P < 0.0001) and major differences between the two datasets are typically associated with missing daily rainfall records from Mount Stirling (Chart 11; missing data are discussed in Section 2.1 of this report). Total annual rainfall at Mount Buller in IY2 was 1412.8 millimetres, 4.3% below the long-term mean annual rainfall of 1476.8 millimetres (1985 to present). Total annual rainfall at Mount Stirling in IY2 was 1253.8 millimetres, although this total probably would have been closer to the Mount Buller total if the Mount Stirling winter rainfall data were not incomplete. Regardless of missing data, rainfall at Mount  Buller and Mount Stirling did not appear to show any substantial divergence from each other or from the long-term mean.

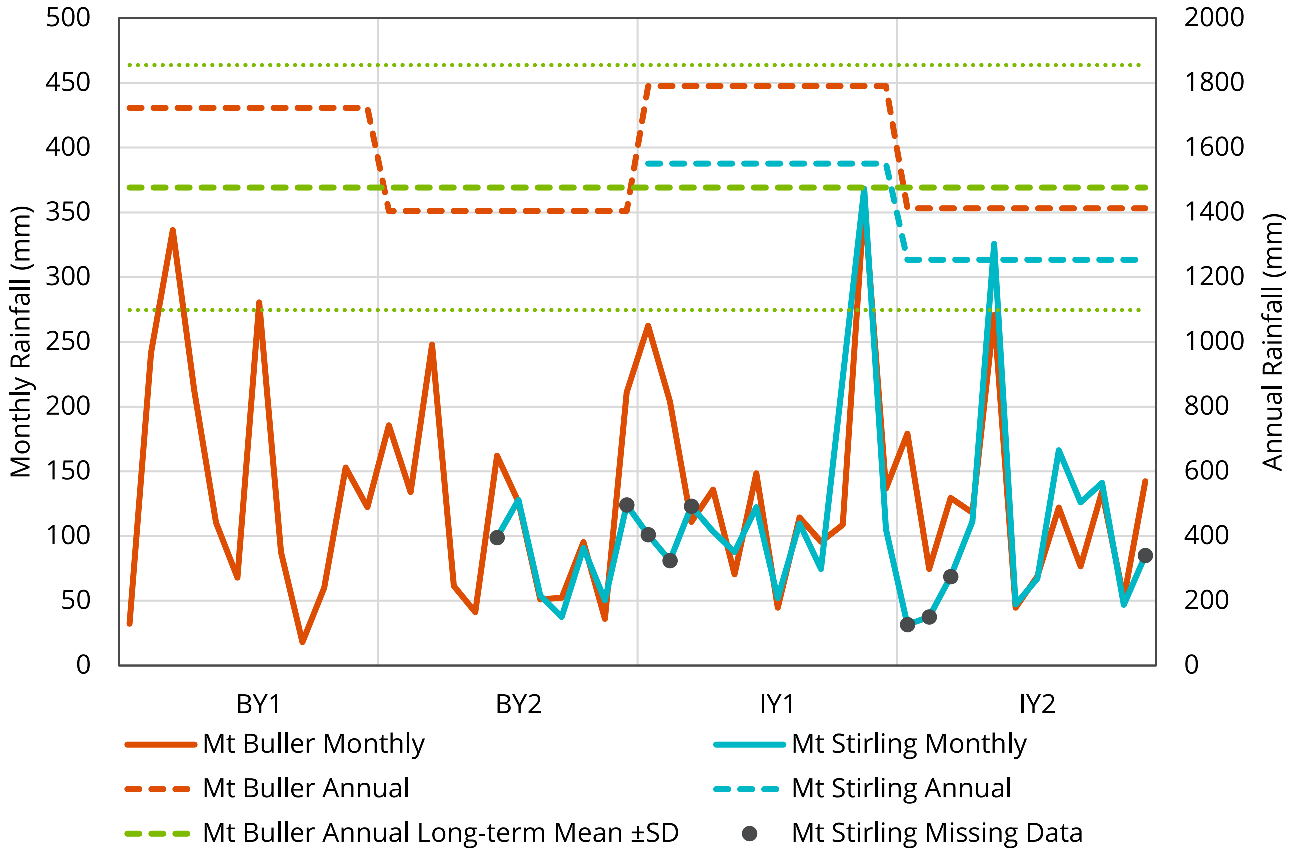


**Chart 11 Monthly and total annual rainfall at Mount Buller and Mount Stirling relative to long-term (1985 to present) annual rainfall at Mount Buller**

### 3.5.2 Snow depth

Daily snow depth data from Tirol Flat, Boggy Creek and Family Run snow gauges were used to calculate a mean daily natural snow depth for Mount Buller, which is plotted in Chart 12 along with daily artifical snow depth (from snowmaking) and the long-term mean daily natural snow depth (1993 to present). Monthly snow depth data are presented in Appendix 6. In IY2 (winter 2020), natural snow depth at Mount Buller was lower than the long-term mean daily natural snow depth for more than 97% of the winter (on all but three days) and the daily natural snow depth was on average 31.5 millimetres less than the long-term mean on any given day.

The below average snow depths in IY2 contrast with the greater than average snow depths recorded during baseline monitoring years and the relatively average snow depths recorded in IY1. In BY1 (winter 2017) and BY2 (winter 2018), natural snow depth at Mount Buller was higher than the long-term mean for approximately 75% and 85% of the winter respectively and was on average 26.6 and 31.7 millimetres greater than the long-term mean on any given day. In IY1 (winter 2019), natural snow depth at Mount Buller was lower than the long-term mean for approximately 59% of the winter and was on average 4.5 millimetres less than the long-term mean on any given day.

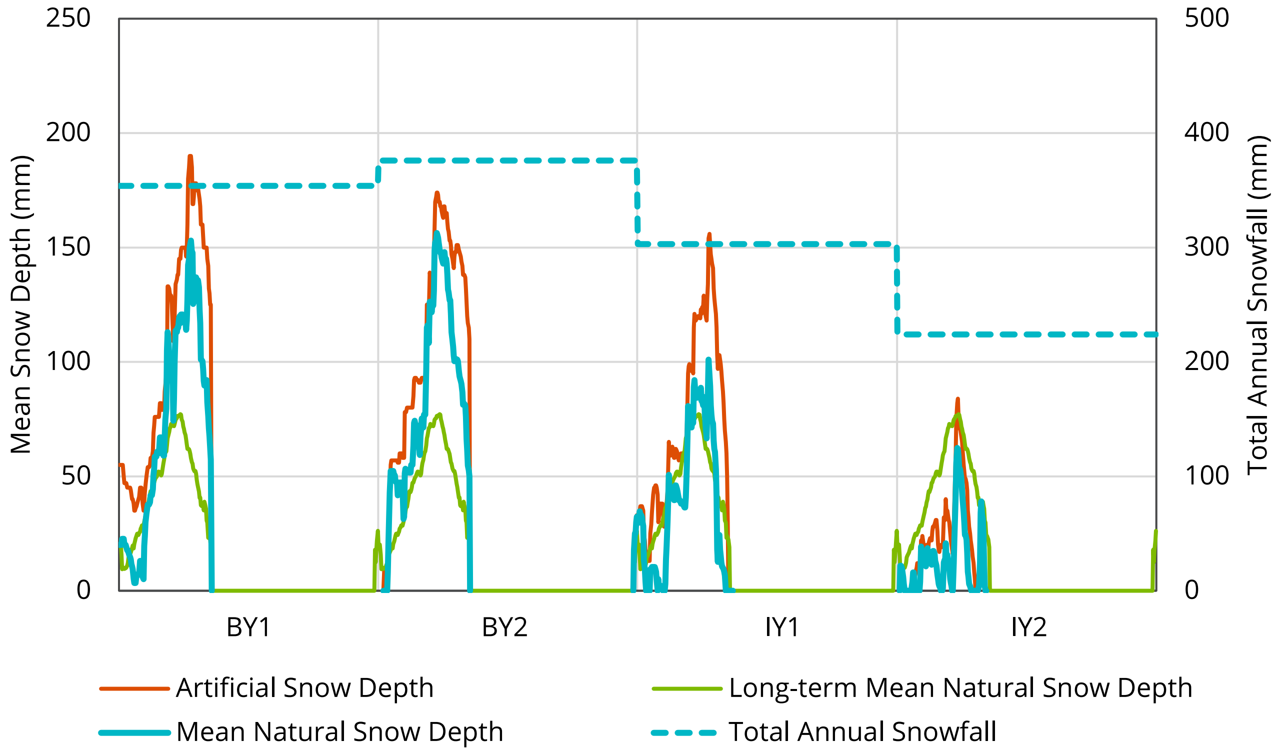


**Chart 12 Mean daily natural and artificial snow depths at Mount Buller relative to the long-term (1993 to present) mean daily natural snow depth and total annual snowfall**

## 3.6 Hydrology

### 3.6.1 Surface water quality

Field and laboratory results for surface water quality and RPD values for duplicate samples are summarised in Appendix 7. In IY2, most RPDs for surface water samples were below 50%, with a notable exception being Weir 1 Pickup 1 in February 2021 (IY2), where the duplicate sample differed considerably from the primary sample (Appendix 7). Strangely, the duplicate sample from Weir 1 Pickup 2 (rather than Weir 1 Pickup 1) better matches the primary sample for Weir 1 Pickup 1. This suggests that there may have been an error, such as a mislabelling error, with duplicate samples in February 2021. Indeed, the duplicate and primary samples for Weir 1 Pickup 2 in February 2021 (IY2) are identical in their water quality results (i.e. 0% RPD across all parameters), which also seems unlikely. Apart from Weir 1 Pickup 1 in February 2021, RPDs greater than 50% were mostly for parameters with values that were less than ten times the LoR (Standards Australia 2005).

Laboratory reports (including quality control certificates) are available in Appendix 8. Where relevant, surface water quality has been compared with ANZECC (2000) guidelines for 95% species protection and SEPP (2018) environmental water quality indicators for highland streams (above 1000 metres altitude).

#### pH

pH is measured in the field during sampling. In IY2, field pH for the three surface water monitoring sites was slightly acidic in spring (pH ranging from 5.52 to 5.79 in November 2020) and slightly alkaline in summer (pH ranging from 7.58 to 7.78 in February 2021). Surface water pH was therefore outside the pH 5.9 to 6.9 range specified in the SEPP (2018) guidelines (pH 5.9 to 6.9) for relatively unmodified highland streams. It appears that pH has become more variable at all surface water monitoring sites, including at Weir 1 Pickup 1 (the control site), since construction of the water storage began (Chart 13).

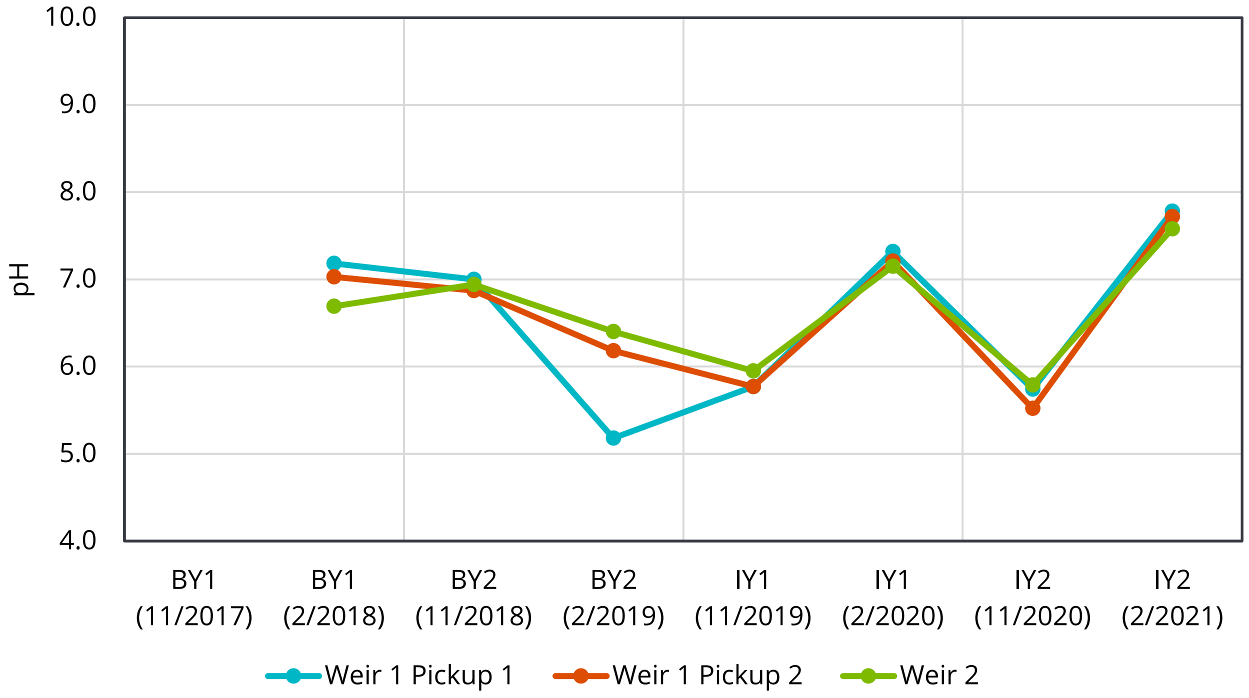


**Chart 13 pH at Boggy Creek Weir 1 (Pickups 1 and 2) and Weir 2 since BY1**

### Salinity (TDS and EC)

Field and laboratory data suggest that salinity of surface water was within ANZECC (2000) and SEPP (2018) guidelines at all surface water monitoring sites in IY2. Total Dissolved Solids (TDS) was below 30 mg/L and Electrical Conductivity (EC) was below 30 µS/cm (SEPP 2018). TDS ranged from 10 to 16 mg/L with a mean of 23 mg/L. EC at 25°C ranged from 19 to 27 µS/cm with a median of 23.2µS/cm (Appendix 7).

### Nutrients

Water quality results from IY2 suggest that nutrient levels in Boggy Creek have returned to preconstruction levels, after an increase in IY1 (Chart 14). Elevated concentrations of nitrogenous nutrients were detected at Weir 1 Pickup 2 (impact site) in IY1. Total nitrogen at Weir 1 Pickup 2 was 0.70 mg/L and 0.30 mg/L in spring (November 2019) and summer (February 2020) respectively, exceeding the SEPP (2018) guideline of 0.15 mg/L. While total nitrogen in Boggy Creek in IY2 averaged 0.15 mg/L across the monitoring sites in IY2 and dropped to 0.05 mg/L at Weir 1 Pickup 2 in November 2020, it was slightly elevated again at Weir 1 Pickup 2 in February 2021, reaching 0.30 mg/L (Chart 14). The increase in total nitrogen in summer may be the result of nutrient-laden sediment continuing to make its way downstream after breaching sediment controls in IY1.

Unfortunately, the LoR for total phosphorus is 0.05 mg/L, while the SEPP (2018) guideline is 0.02 mg/L. This makes it uncertain whether samples were indeed below the guidelines. All but one surface water sample in IY2 was at least below 0.05 mg/L of phosphorus. The exception was Weir 1 Pickup 1 (control site) in February 2021, which recorded 0.06 mg/L of phosphorus. However, the RPD of this sample's duplicate was very high at 169% (Appendix 7), suggesting that this result may have been erroneous (or that the sample and/or its duplicate were mislabeled).

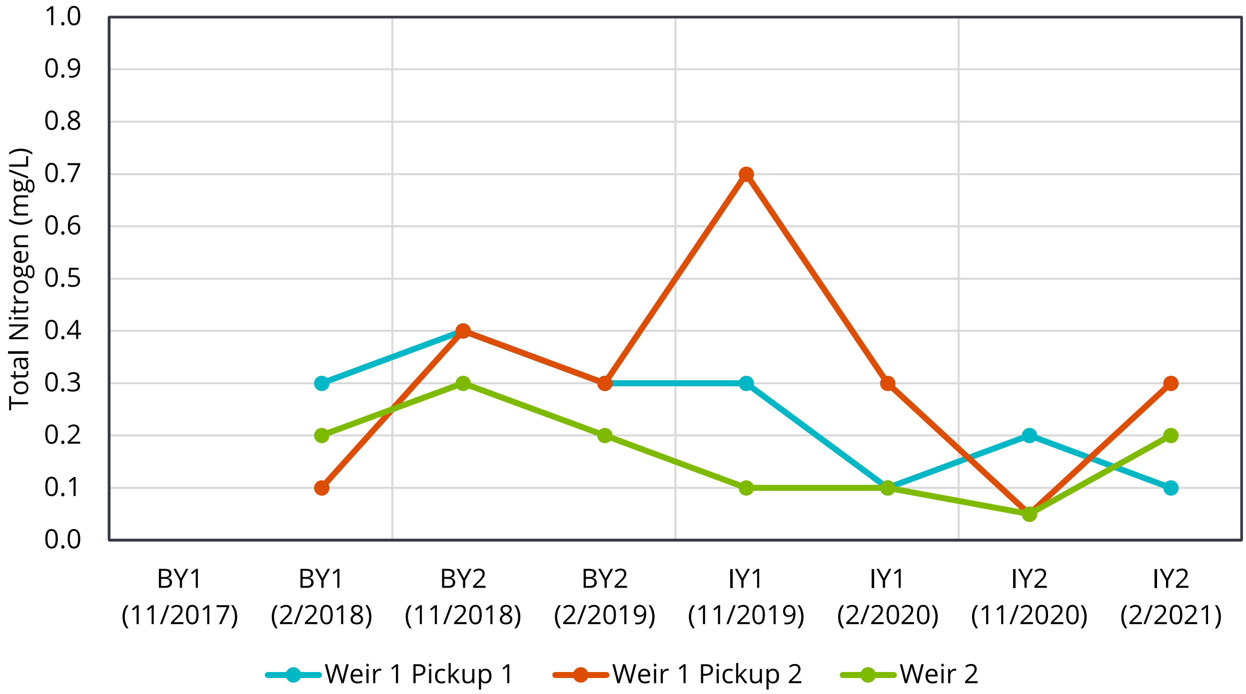


**Chart 14 Total nitrogen at Boggy Creek Weir 1 (Pickups 1 and 2) and Weir 2 since BY1**

### Major ions

The major ions (Ca, Mg, Na, K, Cl, SO4, HCO3, CO3 and NO3) were tested by external laboratory and the results are summarised in Appendix 7. Neither the ANZECC (2000) nor SEPP (2018) guidelines have specific quality indicators for major ions, so it is unsure if IY2 results are within the guidelines.

In February 2020 (IY1), there was an increase in concentration of sulphate at Weir 1 Pickup 2 (impact site), which was explained at the time as simply an increase in the LoR from 1 mg/L to 20 mg/L due to interferences in the sample matrix. There was a possibility that the increase may have been brought about by other means, such as mobilisation of acid sulphate soils by construction of the water storage (particularly as Weir 1 Pickup 2 is an impact site and interferences in the sample matrix were also responsible for an increase in the LoR for the duplicate sample). However, sulphate concentrations at Weir 1 Pickup 2 returned to baseline levels in IY2.

### Turbidity and suspended solids

Turbidity and suspended solids in Boggy Creek were below baseline levels in IY2, with turbidity ranging from 0.1 to 0.5 NTU (Chart 15) and suspended solids less than 2 mg/L at all sites. This was after a substantial increase in turbidity and suspended solids at impact sites (Weir 1 Pickup 2 and Weir 2) in IY1, most likely associated with sedimentation from the PCF making its way through the Alpine Bogs at the headwaters of Boggy Creek and into Boggy Creek itself. The increase in turbidity in IY1 exceeded the ANZECC (2000) and SEPP (2018) guideline value of 3 NTU. The return of turbidity and suspended solids to levels below baseline suggests that efforts to control erosion and sediment from the PCF have improved in IY2.

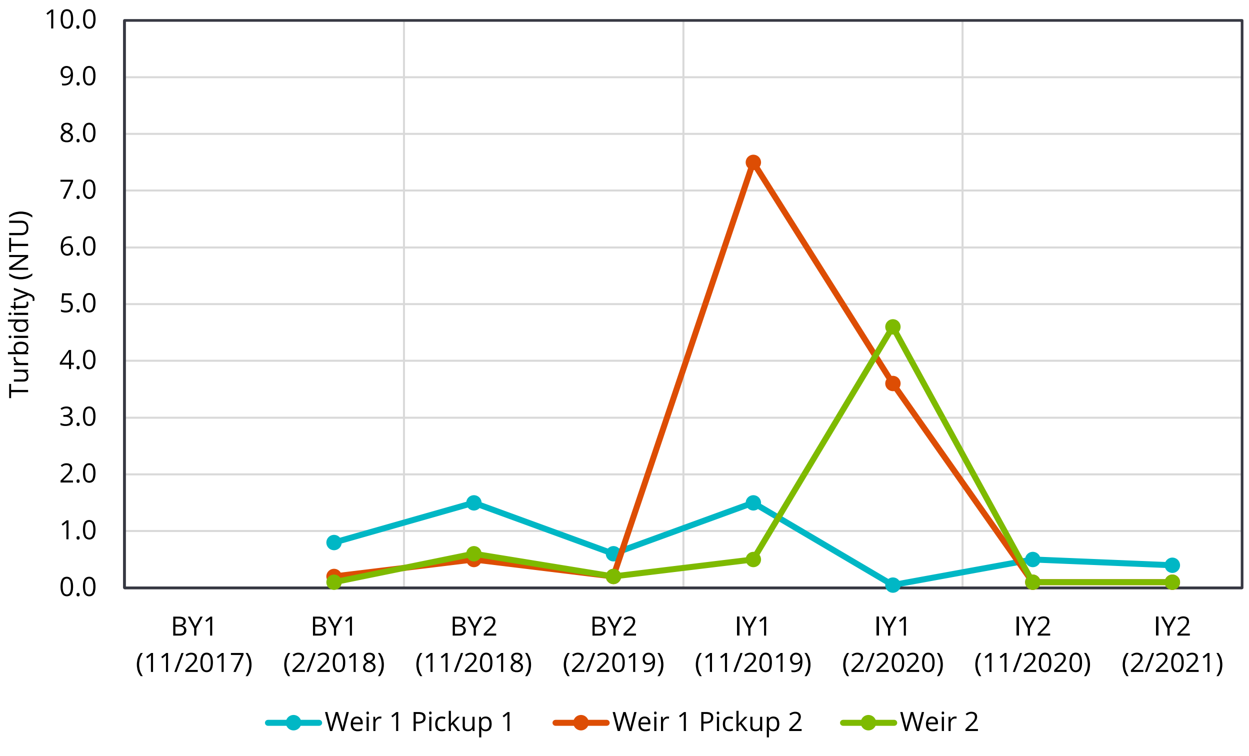


**Chart 15 Turbidity (Nephelometric Turbidity Unit or NTU) at Boggy Creek Weir 1 (Pickups 1 and 2) and Weir 2 since BY1**

### 3.6.2 Surface water flow

No surface water flow data were collected in IY2. Incomplete datasets are discussed in Section 2.1 of this report.

### 3.6.3 Groundwater quality

Field and laboratory analysis results for groundwater quality and RPD values for duplicate samples are summarised in Appendix 7. In IY2, most RPDs for groundwater samples were below 50% (Appendix 7). RPDs greater than 50% were mostly for parameters with values that were less than ten times the LoR (Standards Australia 2005). Laboratory reports (including quality control certificates) are available in Appendix 8. Where relevant, groundwater quality has been compared with ANZECC (2000) guidelines for 95% species protection and SEPP (2018) environmental water quality indicators for highland streams (above 1000 metres altitude).

In general, groundwater quality showed more change in IY2 than in previous years. In contrast, surface water quality showed some immediate changes in IY1 as a result of construction of the water storage. Given that groundwater flow is generally slower than surface water flow, it may be that there is a lag in any effect on groundwater quality.

#### pH

pH is measured in the field during sampling. In IY2, field pH for the four groundwater monitoring bores was acidic, with pH ranging from 3.9 to 6. The exception was BH17, near impact sites, which recorded a pH of 7.64 in spring (November 2020). The pH of groundwater in IY2 was therefore generally outside of the SEPP (2018) guidelines (pH 5.9 to 6.9) for relatively unmodified highland streams (note that these guidelines are for streams and not groundwater). Prior to IY2, groundwater pH was relatively consistent across monitoring bores in any given monitoring year (Chart 16). In IY2 (spring 2020), it appears that the remaining impact site (BH17) departed from the relatively consistent pH recorded at the control sites (BH06, BH16 and BH18).

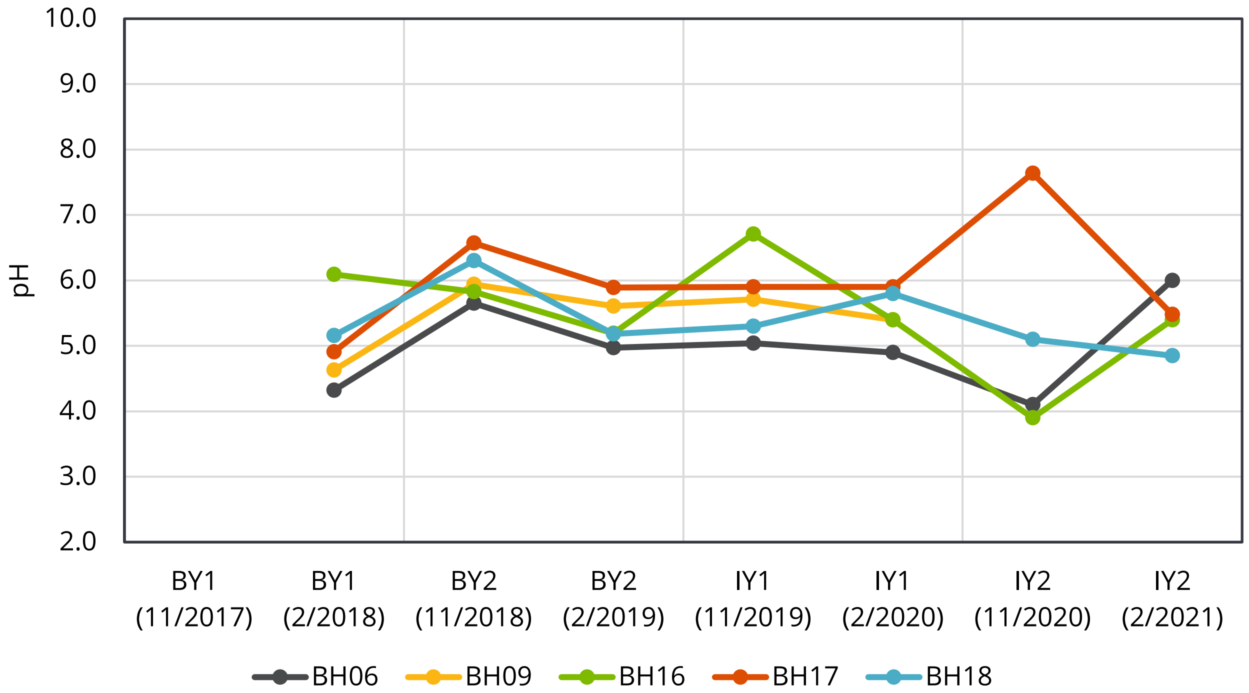


**Chart 16 pH at groundwater control bores (BH06, BH16 and BH18) and impact bores (BH09 and BH17) since BY1**

### Salinity (TDS and EC)

In terms of TDS and EC, field and laboratory data suggest that groundwater quality is high and falls within Segment A1 of the SEPP (2018) guidelines (0 to 600 mg/L TDS). In IY2, TDS within groundwater was less than 40 mg/L at all sites and EC was less than 60 µS/cm at all sites. As at IY2, there do not appear to be any trends emerging in groundwater salinity at any site.

### Nutrients

Elevated levels of nitrogen and phosphorus were detected across most groundwater bores again in IY2. All monitoring bores recorded total nitrogen concentrations in excess of the SEPP (2018) guideline of 0.15 mg/L. Total nitrogen ranged from 0.3 to 5.4 mg/L. Similarly, total phosphorus exceeded the SEPP (2018) guideline of 0.02 mg/L at most monitoring bores at some point in IY2, although this was difficult to ascertain at BH06 because the LoR was 0.05 mg/L. Importantly, as at IY2, there do not appear to be any trends emerging in groundwater nutrient levels when compared with baseline monitoring results.

### Major ions

The major ions (Ca, Mg, Na, K, Cl, SO4, HCO3, CO3 and NO3) were tested by external laboratory and the results are summarised in Appendix 7. Neither the ANZECC (2000) nor SEPP (2018) guidelines have specific quality indicators for major ions, so it is unsure if IY2 results are within the guidelines.

In November 2020 (first half of IY2), there was a considerable increase in the concentration of several major ions at several groundwater monitoring bores. In particular, concentrations of calcium (Chart 17), magnesium (Chart 18) and potassium (Chart 19) were up to ten times greater than baseline levels at BH18 and BH16 (both control sites). The effect was less pronounced at BH17 (the remaining impact site) and appears to be delayed by 6-12 months at BH06 (the control site furthest uphill; Figure 2).

It may be that breaking of ground (and, more specifically, granite) for construction of the water storage has increased the concentration of these minerals in the local groundwater and that groundwater has moved laterally (east and west) such that the elevated concentrations of these minerals is now detectable in monitoring bores closest to control sites (BH16 and BH18). This brings into question whether the Alpine Bogs that are designated as control sites at Mount Buller are truly control sites from a groundwater perspective. Given that Alpine Bogs are groundwater dependent ecosystems and that groundwater quality in bores closest to control sites appears to have been affected by the water storage construction, it is even more imperative that monitoring of groundwater depths resumes (refer to Recommendations 2 and 5 of this report).

### 3.6.4 Groundwater depth

Apart from manual depth measurements taken during sampling of groundwater for quality analysis in November 2020 and February 2021, daily groundwater depth data were not collected in IY2. Incomplete datasets are discussed in Section 2.1 of this report.

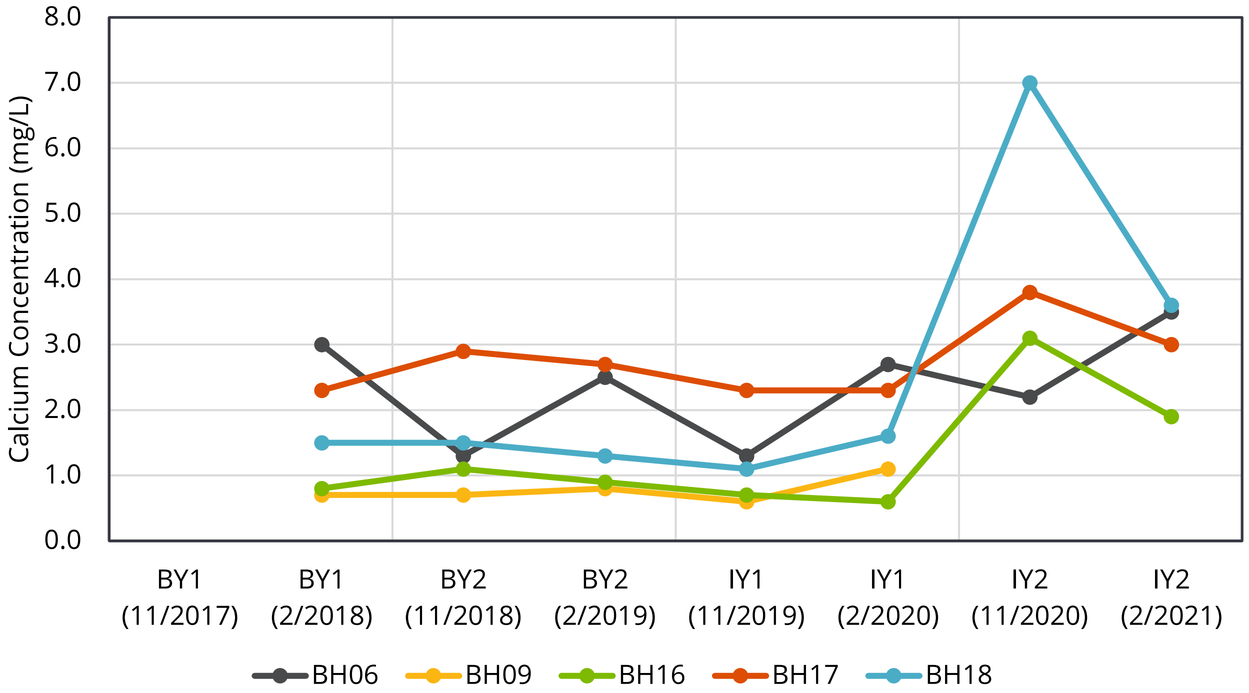


**Chart 17 Calcium concentration at groundwater control bores (BH06, BH16 and BH18) and impact bores (BH09 and BH17) since BY1**

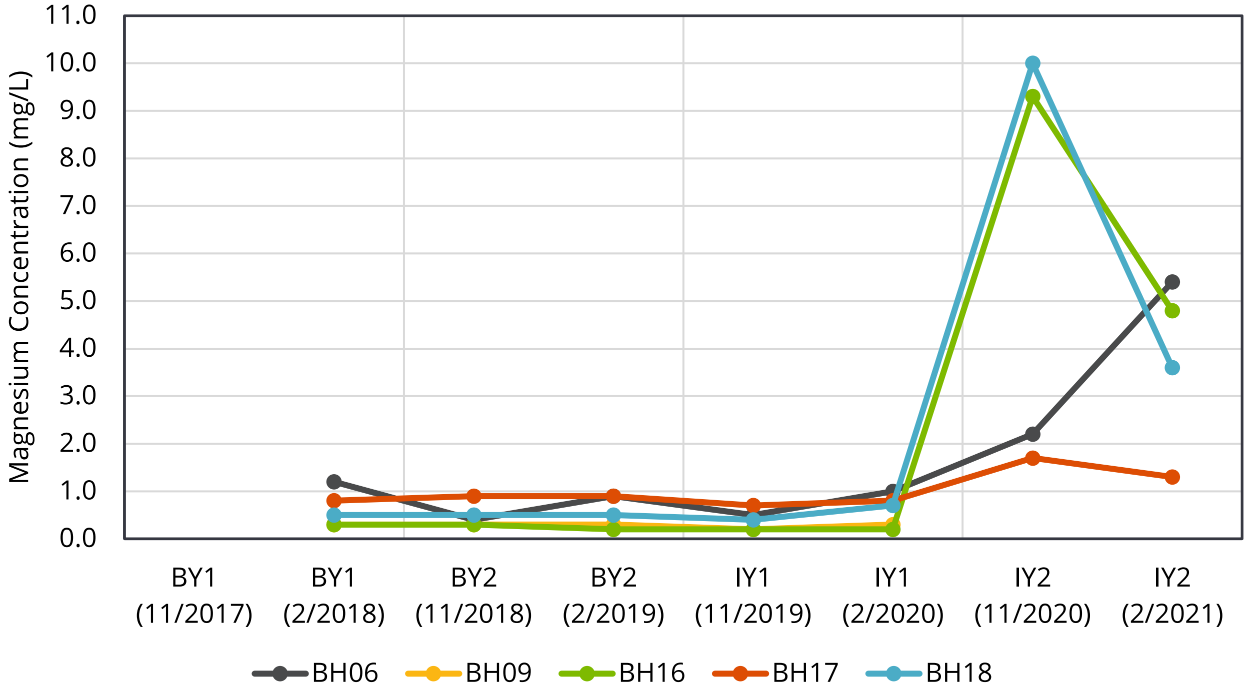


**Chart 18 Magnesium concentration at groundwater control bores (BH06, BH16 and BH18) and impact bores (BH09 and BH17) since BY1**

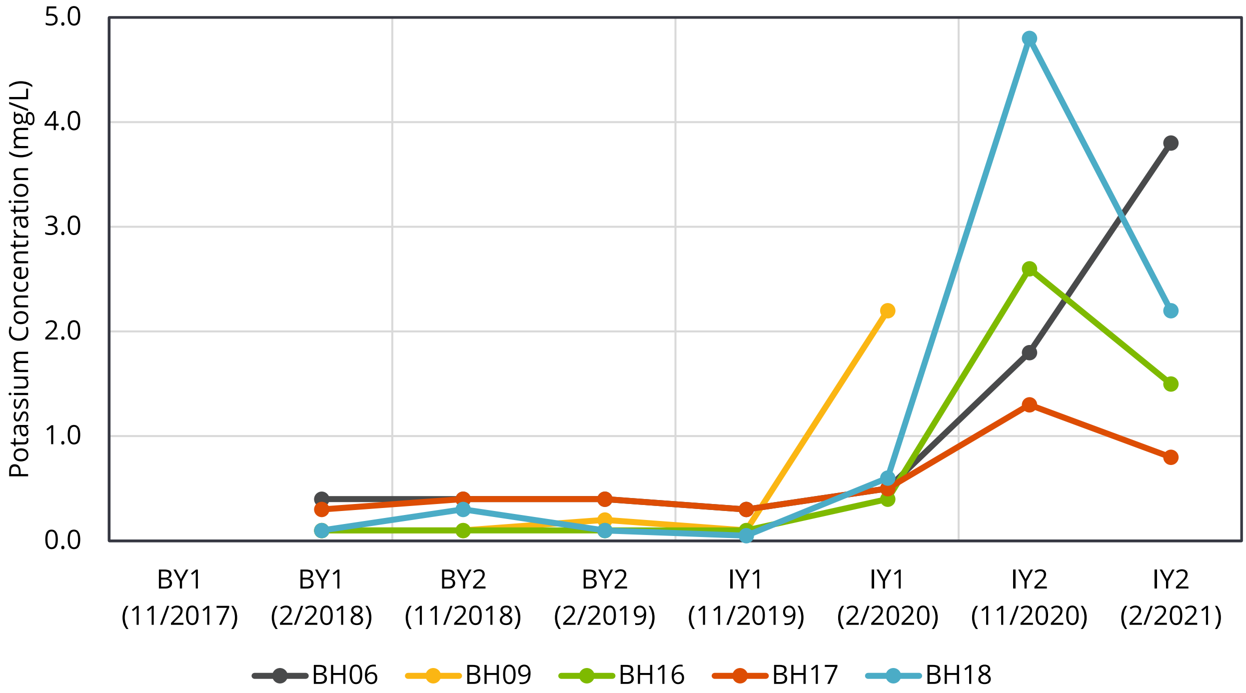


**Chart 19 Potassium concentration at groundwater control bores (BH06, BH16 and BH18) and impact bores (BH09 and BH17) since BY1**

### 3.7 Summary of monitoring results

Table 5 summarises the results of the HEMAMP IY2 monitoring in terms of the four performance criteria.

**Table 5 Summary of ecological monitoring results in Baseline Years 1 and 2 and Impact Year 1**

| Parameter | Site | Baseline Mean (BM) ±Standard Deviation | IY2 | Change (BM to IY2) | % Change (BM to IY2) |
|---|---|---|---|---|---|
| **Extent** | | | | | |
| **Area (ha)** | Impact sites | 1.3667 ±0.0185 | 1.3353 | -0.0313 | -2.3% |
| | Control sites | 2.0812 ±0.0897 | 2.1183 | +0.0371 | +1.8% |
| **Sum of dimensions (m)** | Impact sites | 354.7 ±2.1 | 354.2 | -0.5 | -0.1% |
| | Control sites | 438.8 ±4.0 | 436.6 | -2.2 | -0.5% |
| **Cover of bare ground (%)** | Impact sites | 1.0 ±1.3 | 4.6 | +3.6 | +360.0% |
| | Control sites | 0.6 ±0.5 | 2.6 | +2.1 | +372.7% |
| **Composition** | | | | | |
| **Bog-dependent species richness** | Impact sites | 10.5 ±0.7 | 10 | -0.5 | -4.8% |
| | Control sites | 10.5 ±0.7 | 11 | +0.5 | +4.8% |
| **Cover of bog-dependent flora (%)** | Impact sites | 78.2 ±0.4 | 79.5 | +1.3 | +1.7% |
| | Control sites | 87.9 ±1.3 | 88.9 | +1.1 | +1.2% |
| **Encroachment** | | | | | |
| **Cover of non-bog-dependent native flora (%)** | Impact sites | 45.2 ±1.2 | 46.1 | +0.9 | +2.0% |
| | Control sites | 45.1 ±1.3 | 43.8 | -1.3 | -2.9% |
| **Cover of weeds (%)** | Impact sites | 5.9 ±0.6 | 8.1 | +2.3 | +38.5% |
| | Control sites | 4.3 ±1.4 | 4.9 | +0.6 | +14.0% |
| **Structure** | | | | | |
| **Cover of Peat Moss (%)** | Impact sites | 5.4 ±0.1 | 6.0 | +0.7 | +12.1% |
| | Control sites | 16.4 ±1.2 | 16.4 | +0.0 | +0.3% |

# 4. Discussion

Construction of the water storage project started in October 2019, midway through IY1. Monitoring during IY1 detected that construction had caused noticeable impacts on several downslope Alpine Bogs at Mount Buller, particularly Bogs 4.2, 6, 11.2 and 12 (all impact sites). These impacts included the incursion of sediment, large rocks and boulders from the Project Construction Footprint (PCF) located upslope. At least seven large rocks and boulders were identified within impact sites in IY1 and widespread sedimentation was documented. Sedimentation and its effects were visible in parts of Alpine Bogs more than 200 metres downslope (e.g. Bog 6) and in surface water quality monitoring of Boggy Creek approximately 700 and 1400 metres downslope.

While the results of IY2 monitoring suggest that some of the potential impacts on downslope Alpine Bog communities (e.g. mortality of Peat Moss and turbidity of surface water) may have stabilised or been reversed, IY2 monitoring also detected further construction impacts that occurred after IY1 ecological monitoring finished in March 2020 (Figure 5). New impacts were primarily associated with construction of the environmental watering system in late April and early May 2020. New impacts included additional but more localised sedimentation in Bogs 4.2 and 11.2 (Photo 2) and removal of approximately 8 square metres of Bog 4.2 along 16 metres of its south-eastern boundary (Photo 3). This was despite the south-eastern boundary of Bog 4.2 being flagged off by an ecologist and environmental manager before construction.

Some of these additional impacts were first documented when Biosis (Michael Goddard, Senior Ecologist) visited the site in November 2020 (snow cover and COVID-19 restrictions meant that an earlier visit was not possible). At the time of the November 2020 visit, clear efforts were being made to implement the Ecological Rehabilitation Plan (ERP; Biosis 2020), including significant efforts to control erosion from the PCF (a response to permit and approval requirements and Recommendation 6 of the IY1 monitoring report). The RMB was repairing or replacing sediment fences where possible, adding organic coir logs at many locations, topping up mulch across the PCF and conducting some minor re-shaping of landforms within the PCF to slow run-off and minimise movement of sediment.

By the time IY2 ecological monitoring was conducted in January and February 2021, it appeared that further movement of sediment, rocks and boulders from the PCF was being successfully controlled. This was based on empirical observations, particularly during on-ground mapping, but also supported by results of transect and surface water (turbidity) monitoring. These results are discussed in more detail in the following sub-sections of this report.

## 4.1 Bog extent

### 4.1.1 Reduction in the area of impact sites

The performance criterion related to bog extent requires that there be no more than a 10% reduction in the total combined area of impact sites, relative to control sites. Further to this, Condition 2b of EPBC Act Approval 2014/7303 requires that there is no more than a 0.0900-hectare reduction in the total combined area of 'indirectly affected areas of Alpine Bog', relative to baseline monitoring and control sites. The approval defines 'indirectly affected areas of Alpine Bog' as Bogs 4.2, 6, 8, 9, 10, 11.2 and 12 (i.e. all impact sites except Bog 13).

The total area of impact sites decreased relative to control sites in IY2, but neither of the performance thresholds (10% or 0.0900-hectare reduction) were reached. The 'indirectly affected areas of Alpine Bog' decreased in area by 0.0311 hectares, relative to the baseline mean. Collectively, all impact sites recorded a 4.1% decrease in area relative to control sites in IY2, compared with the baseline mean. Since construction started, the relative area of impact sites appears to be on a downward trend. The relative area of impact sites was 3.7% below the baseline mean in IY1 and is now 4.1% below the baseline mean in IY2. Although the relative changes in bog extent in impact years have not been not statistically significant, the primary aim of monitoring is to assess results against the performance criteria (and over-reliance on statistical significance in the context of BACI monitoring should be avoided). The reduction in extent of impact sites in IY1 and IY2 point to potential protracted decline in bog extent at impact sites and future non-compliance.

Results from IY2 show that the collective area of impact sites decreased by 0.0313 hectares (2.3%) while the collective area of control sites increased by 0.0372 hectares (1.8%). The increase in area at control sites was at Mount Stirling, particularly Bog S3. The area of control sites at Mount Buller in IY2 was relatively stable, being 0.0070 hectares (0.6%) lower than the baseline mean and therefore within the range of variability recorded during baseline monitoring (Table 6). The reduction in area at impact sites in IY2 occurred at Bogs 4.2, 6 and 11.2, which recorded reductions in area of 0.0105 hectares (2.7%), 0.0250 hectares (3.7%) and 0.0074 hectares (6.4%) respectively.

**Table 6 Change in Alpine Bog area from baseline mean to Impact Year 2**

| Site | Area (ha) | | |
|---|---|---|---|
| | Baseline Mean (BM) ±Standard Deviation | Impact Year 2 | Change (BM to IY2) |
| **All Impact Sites** | **1.3666 ±0.0184** | **1.3353** | **-0.0313 (-2.3%)** |
| **All Control Sites** | **2.0812 ±0.0896** | **2.1183** | **+0.0372 (+1.8%)** |
| **Mount Buller Control Sites** | 1.1403 ±0.0360 | 1.1332 | -0.0070 (-0.6%) |
| **Mount Stirling Control Sites** | 0.9410 ±0.0536 | 0.9851 | +0.0442 (+4.7%) |

### 4.1.2 Potential causes for a reduction in area

The reduction in extent of Bogs 4.2, 6 and 11.2 is likely to be associated with impacts from construction of the water storage, including additional construction impacts that occurred in April and May 2020, after IY1 ecological monitoring took place. The following observations support this conclusion:

- Bogs 4.2 and 11.2 are the closest Alpine Bogs to the ground disturbance that took place for construction of the water storage and are therefore likely to have borne any direct impacts more severely than other Alpine Bogs. For example, approximately 8 square metres of Bog 4.2 was directly removed during construction of the environmental watering system in April and May. Similarly, boulders dislodged from the PCF and documented in IY1 appear to have subsequently caused the mortality of small areas of vegetation (each less than 1 square metre) in Bog 11.2 (compare Photo 4 and Photo 5). Cumulatively, these direct impacts will have contributed to loss of bog extent in IY2.
- Sedimentation is likely to be the major cause of a decrease in the extent of Bogs 4.2, 6 and 11.2. Sedimentation facilitates weed proliferation and consequent loss of bog extent (as documented in the IY1 monitoring report). Bogs 4.2, 6 and 11.2 are the Alpine Bogs at which most sedimentation was recorded during on-ground mapping and at which more than 85% of sedimentation was recorded during transect monitoring in IY2 (Figure 5; Appendix 5).

 

- Sediment has been deposited relatively widely across Bogs 4.2 and 11.2. Much of the sediment that washed through Bogs 4.2 and 11.2 was captured by the aqueduct, which defines the northern boundaries of Bogs 4.2 and 11.2 (Figure 2). This explains the contraction of Bogs 4.2 and 11.2 along their northern boundaries (Figure 4).
- The aqueduct, which discharges predominantly into Bog 6, appears to have had the effect of concentrating the impact of sedimentation from upslope onto Bog 6. As a result, the impact of sedimentation has been more localised but noticeably more intense in Bog 6, than in Bogs 4.2 or 11.2. The sediment layer in Bog 6 is still approximately 20 centimetres deep in parts. Weeds are proliferating through the sediment layer and contributing to fragmentation and contraction of Bog 6 (Photo 6).

#### 4.1.3 Reduction in bare ground

While there was an overall decrease in the area of impact sites in IY2, the total cover of bare ground (whether attributed to sediment, deer or natural causes) was actually less in IY2 than in IY1. This result was replicated across all impact sites except for Bog 11.2. Incidentally, weed cover was elevated at all impact sites in IY2, except for Bogs 11.2 and 12, where weed cover remained stable (no weeds have ever been recorded at Bog 11.2). It is possible that some of the observed reduction in bare ground at impact sites in IY2 may have been brought about by proliferation of weeds. Increasing weed cover is discussed further in Section 4.3.

It is also possible that the reduction in bare ground from IY1 to IY2 may have been brought about through a reduction in sedimentation at impact sites since IY1 monitoring, as a result of effective erosion control upslope and a natural washing out or covering of sediment from IY1. Unfortunately, bare ground was not categorised in IY1, which makes it difficult to compare the extent of sedimentation between IY1 and IY2. Nevertheless, observations and photos from on-ground mapping suggest that progress has been made in controlling sediment, allowing existing sediment to be washed out of Alpine Bogs and/or be covered by peat-forming species such as Peat Moss (compare Photo 7, Photo 8 and Photo 9, taken of the same location on the aqueduct before, during and after construction).

Although there are signs that implementation of the ERP has reduced sediment loads entering impact sites (e.g. as suggested by surface water turbidity and suspended solids returning to baseline levels in IY2), existing sediment will continue to be washed through the Alpine Bogs (Photo 10) and there will continue to be a risk that weeds become permanently established on new bare ground caused by sedimentation (resulting in a permanent loss of bog extent). In most cases, attempting to remove sediment and boulders from the Alpine Bogs cannot be easily achieved without causing further damage and disturbance to the Alpine Bogs. The ERP must continue to be implemented, focussing on controlling sediment and weeds. Weeds are discussed further in Section 4.3 of this report.

| Impact Year 2 – Recommendation 13 |
|---|
| The Ecological Rehabilitation Plan (Biosis 2020) must continue to be implemented to prevent further movement of sediment, rocks and boulders from the PCF into Alpine Bogs. This will require regular and long-term monitoring, maintenance and (where required) addition of erosion controls (e.g. sediment barriers). |

### 4.1.4 Deer activity

Activity of Sambar Deer *Cervus unicolor* is still evident at many Alpine Bogs, particularly control sites, where 32.8% of bare ground was attributed to deer activity in IY2. However, the following observations suggest that deer damage has not worsened at Mount Buller monitoring sites in IY2:

- A resting site for deer has been noted along the south-west boundary of Bog 4.2 (impact site) since BY1. Photos from IY1 and IY2 suggest that there has been no noticeable increase in deer activity or damage to vegetation at this location, except for burial of Spreading Rope-rush *Empodisma minus* below new sediment (compare Photo 11and Photo 12). This new sediment was presumably associated with construction of the environmental watering infrastructure approximately 15 metres upslope, which took place after the IY1 photo was taken.
- Transect 5A (control site) has passed through a relatively dry deer wallow since BY1. A comparison of Photo Point 5AE over the years suggests that there is very little change in deer activity at this location from IY1 to IY2 (Appendix 3). If anything, vegetation appears to be recovering in IY2.

Efforts to control deer at Mount Buller may be responsible for the apparent decrease in deer activity from IY1 to IY2. Alternatively, construction disturbance (e.g. noise) may have deterred deer from Mount Buller monitoring sites, resulting in less noticeable damage attributable to deer. Indeed, it appears that deer activity may have increased at Mount Stirling monitoring sites (all control sites), as supported by the following observations:

- Transect S3B is known to pass through a deer track and small wallow, obscured from view in photo points by tall shrubs. The cover of bare ground at Transect S3B increased from 7.9% in IY1 to 10.7% in IY2. In IY2, 25.9% of bare ground was attributed to deer activity. The increase in bare ground from IY1 to IY2 may be due to an increase in deer activity.
- In IY1, a deer wallow was recorded for the first time at the north-eastern edge of Bog S3, approximately 55 metres upslope from Transect S3B. The damage caused by deer at this location appears to have worsened in IY2 (compare Photo 13 and Photo 14).

Although there is some evidence to suggest that deer activity has not intensified further at Mount Buller in IY2, this may be temporary and the result of construction activity that has now ceased. Regardless, it was clear from IY2 monitoring that Sambar Deer continued to actively remove Alpine Bog vegetation and facilitate the spread of weeds at both Mount Buller and Mount Stirling. In response, the RMB removed 52 Sambar Deer from the Mount Buller and Mount Stirling alpine resorts in March and April 2021, after IY2 ecological monitoring (L. Perrin, RMB, pers. comm., 2 August 2021). This is the first time that Sambar Deer have been culled since monitoring began and it is anticipated that the recovery of vegetation will be noticeable in future monitoring years. Continued efforts to control deer will be required.

| Impact Year 2 – Recommendation 14 |
| --- |
| Efforts to control Sambar Deer *Cervus unicolor* at Mount Buller and Mount Stirling should continue, with the aim of preventing this species from further damaging Alpine Bogs. |

## 4.2 Bog composition

The performance criterion relating to the composition of the Alpine Bogs is expressed in terms of bog-dependent species richness (i.e. number of bog-dependent species). It requires that there be no more than a 10% reduction in the total bog-dependent native flora species richness of the impact sites, taking into account natural variation based on species richness observations averaged across control sites. The baseline mean bog-dependent species richness at impact sites and control sites was 10.5 species (10 to 11 bog-dependent species were recorded on average in the baseline monitoring years). This means that there would need to be a net loss of two bog-dependent species from impact sites relative to control sites for there to be greater than a 10% reduction in bog-dependent species richness.

In IY2, 10 bog-dependent species were recorded at impact sites and 11 bog-dependent species were recorded at control sites. The relative decrease in species richness at impact sites compared with control sites was therefore one species or 9.6%. This is close to the 10% threshold for non-compliance as specified in the performance criteria. The single bog-dependent species that was not detected at impact sites in IY2 was Silver Astelia *Astelia alpina* var. *novae-hollandiae*.

Since monitoring began, Silver Astelia has never been an abundant species. It has never been recorded at control sites and transect monitoring has only ever detected the species at two locations in Bogs 4.2 and 6. Silver Astelia was not recorded during transect monitoring in BY1 (it was only noted as an incidental observation near Transect 6E and in Bog 12). In BY2, Silver Astelia was recorded at two adjacent points along Transect 4.2B. In IY1, the species was recorded in one quadrat along Transect 6E. The distribution of Silver Astelia has therefore been highly localised since monitoring began and only ever detected by transect monitoring in Bogs 4.2 and 6.

Given the historically localised distribution of Silver Astelia at impact sites and the failure of transect monitoring to detect the species during one baseline monitoring year, the failure of transect monitoring to detect Silver Astelia in IY2 may simply be due to natural vegetation succession, seasonal conditions or observer error. However, it is important to note that Bogs 4.2 and 6 are two of the monitoring sites that are most affected by sedimentation (see discussion in Section 4.1 of this report). It could be that Silver Astelia has not been detected in IY2 because the species has been buried by sediment. Indeed, transect monitoring in IY2 recorded sedimentation within 40 centimetres of the locations at which Silver Astelia had previously been recorded (Silver Astelia was previously recorded at 13.8 and 14.0 metres along Transect 4.2B and in a quadrat at 8.0 metres along Transect 6E). If Silver Astelia is not detected again in Bogs 4.2 or 6 in Impact Year 3 (IY3), the RMB should consider re-introducing this species to these monitoring sites, perhaps during revegetation of bare ground created by sediment.

**Impact Year 2 – Recommendation 15**

The presence or absence of Silver Astelia *Astelia alpina* var. *novae-hollandiae* from impact sites (particularly Bogs 4.2 and 6) should be further investigated in Impact Year 3. If the presence of Silver Astelia is not detected, the RMB should consider re-introducing this species to these monitoring sites through revegetation.

## 4.3 Encroachment by weeds and other atypical species

### 4.3.1 Encroachment by weeds

In 2013/2014, Mount Buller's Alpine Bogs were recorded as having low (less than 5%) weed cover (Biosis and GHD 2016). As a result, the HEMAMP's performance criteria require that the total weed cover at impact sites does not exceed 5% (Biosis 2019). The total weed cover at impact sites has progressively increased from 5.4% in BY1 to 8.1% in IY2. In contrast, after an initial increase from 3.3% in BY1 to 5.3% in BY2, total weed cover at control sites appears to have since stabilised at 4.9-5.0% (Chart 8). While the difference in weed cover at impact sites relative to control sites is not statistically significant, it points towards a trend at impact sites that must be addressed.

Even before construction began, the criterion for maximum weed cover was already exceeded at impact sites. Limited weed management occurred at the Alpine Bogs during BY1 and BY2 to allow for a robust and representative baseline dataset to be collected. Weed control and targeted revegetation efforts were increased at all monitoring sites following IY1 monitoring. Nevertheless, while weed cover appears to have stabilised at control sites, it appears to be increasing at impact sites by almost 1% per year.

The continued increase in weed cover at impact sites, despite a stabilisation of weed cover at control sites, suggests that construction impacts may be hampering weed control efforts at impact sites. Since construction started, almost half of the increase in weed cover at impact sites has taken place at Bog 6, which is also one of the impact sites at which sedimentation has been most noticeable (see Section 4.1 of this report). Although deer activity has been observed to facilitate weed incursion, it is likely that sedimentation has been the major cause for the proliferation of weeds at impact sites.

Stoloniferous and rhizomatous weed species, such as Brown-top Bent *Agrostis capillaris* and Musk Monkey-flower *Erythranthe moschata*, are able to actively and rapidly grow through the sediment. Other weed species, such as Yorkshire Fog *Holcus lanatus*, Timothy Grass *Phleum pratense* and Soft Rush *Juncus effusus*, may or may not be stoloniferous or rhizomatous, but are tall enough to persist through the sediment, flower and set seed on the bare sediment layer below. In IY2, a novel rhizomatous weed, Manna Grass *Glyceria declinata*, was detected in Bog 6 at numerous locations affected by sediment. This species has not been previously recorded at monitoring sites. A large Manna Grass plant (covering 1-2 square metres) in the aqueduct is likely to have been the source plant for these new weed incursions (the plant is located upstream at the point at which the aqueduct passes through Sub-alpine Woodland, approximately 10 metres east-south-east of Bog 6).

Weed proliferation facilitated by sedimentation is one of the major reasons for the observed reduction in the extent of impact sites that has occurred since construction began. Areas that are now dominated by weeds no longer meet the definition of Alpine Bog vegetation as per the Diagnostic Key to Alpine Bogs (Appendix 3). It is therefore imperative that weed control efforts be increased at impact sites, focussing on areas of sedimentation. Without further weed control efforts, there is an increased risk that novel weed species may colonise the Alpine Bogs and that weed species may become permanently established on bare ground caused by sedimentation, resulting in a permanent reduction in the extent of Alpine Bogs.

**Impact Year 2 – Recommendation 16**

Increased weed control should be undertaken at impact sites and along the aqueduct, prioritising areas of bare ground (particularly sedimentation). The following weed species should be targeted:

- Milfoil *Achillea millefolium*
- Brown-top Bent *Agrostis capillaris*
- Sweet Vernal-grass *Anthoxanthum odoratum*
- Spear Thistle *Cirsium vulgare*
- Musk Monkey-flower *Erythranthe moschata*
- Monkey Musk *Erythranthe guttata*
- Manna Grass *Glyceria declinata*
- Yorkshire Fog *Holcus lanatus*
- Jointed Rush *Juncus articulatus* subsp. *articulatus*
- Soft Rush *Juncus effusus* subsp. *effusus*
- Sword Rush *Juncus ensifolius*
- Apple *Malus pumila*
- Creeping Buttercup *Ranunculus repens*
- Blackberry *Rubus anglocandicans*

**Impact Year 2 – Recommendation 17**

The use of alternative weed control methods, such as heat, should continue to be trialled to expand the window of time during which weed control can occur, to minimise the risk to Alpine Bogs from herbicide application and to ultimately improve the management of weeds in Alpine Bogs.

### 4.3.2 Encroachment by native non-bog-dependent species

The performance criterion for atypical species requires that there be no more than a 10% increase in the cover of non-bog-dependent species at impact sites, relative to control sites. A divergence of impact sites from control sites with respect to cover of non-bog-dependent species was detected in IY1 and has been maintained in IY2. When compared with the baseline mean, there has been a 2.1% increase in the cover of non-bog-dependent species at impact sites and a 2.8% reduction at control sites in IY2 (Chart 7). This represents a statistically significant 4.9% relative increase in the cover of non-bog-dependent species at impact sites in IY2 compared with the baseline mean.

There is a possibility that the increased focus on identifying bryophytes to species level in IY2 may have influenced results for non-bog-dependent species cover. While all bryophytes except for Peat Moss have consistently been classified as non-bog-dependent, the systematic approach to photographing, collecting and identifying bryophytes in IY2 may have meant that observers were more conscious of the presence of bryophytes. However, any difference in the cover of non-bog-dependent bryophytes across monitoring years has not been statistically significant (F statistic = 0.2356; DF = 3; P = 0.8710). The percentage cover of non-bog-dependent bryophyte cover at impact sites in IY2 (8.9%) was only 0.8% higher than the baseline mean percentage cover (8.1%) and actually decreased by 1.0% from IY1 to IY2. At control sites in IY2, the cover of non-bog-dependent bryophytes (21.8%) was 1.3% greater than the baseline mean (20.5%) but lower than the cover observed in BY2 (22.6%). The observed increase in non-bog-dependent species cover at impact sites relative to control sites in IY2 (and since construction began) has therefore not been driven by non-bog-dependent bryophytes.

The reason for the relative increase in non-bog-dependent species at impact sites is unclear, but the result appears to be driven by the same species that contributed to a similar result in IY1. The result has been driven largely by non-bog-dependent shrubs and graminoids, including:

- Alpine Rusty-pods *Hovea montana*
- Alpine Leionema *Leionema phylicifolium*
- Kerosene Bush *Ozothamnus cupressoides*
- Mountain Plum-pine *Podocarpus lawrencei*
- Alpine Podolobium *Podolobium alpestre*
- Snow Grasses *Poa* spp.

These species are typically found in vegetation surrounding Alpine Bogs, such as Alpine Grassy Heathland (EVC 1004) and Sub-alpine Woodland (EVC 32). The cover of these species has mostly increased at impacts sites but decreased or remained stable at control sites.

Importantly and unlike in IY1, changes in covers at control sites at Mount Buller are similar to the changes in covers observed at control sites at Mount Stirling and there does not appear to have been any recent divergence in rainfall across the two mountains. It may be that localised hydrological changes, such as a reduction in groundwater expression at impact sites, has contributed to an increase in the growth and cover of non-bog-dependent species (which tolerate drier conditions). Once again, this makes it imperative that monitoring of groundwater depths resumes at Mount Buller (see Recommendations 2 and 5 of this report).

### 4.3.3 Mortality of surrounding vegetation

During IY2 monitoring, we observed localised mortality of small areas (20 square metres or less) of Alpine Grassy Heathland downslope of the PCF, outside of Alpine Bogs but within 4 metres of Alpine Bog boundaries. Dieback of Alpine Rusty-pods *Hovea montana*, Alpine Leionema *Leionema phylicifolium* and Dusty Daisy-bush *Olearia phlogopappa* subsp. *flavescens* (all non-bog-dependent species) was observed in at least two locations near impact sites: one location approximately 3 metres south of Bog 10 and one location approximately 4 metres west of Bog 11.2 (Photo 15).

The cause of the observed dieback is uncertain. It may be natural senescence of vegetation, although this seems unlikely given the proximity to known construction impacts (e.g. sedimentation) and the fact that dieback of similar species and scale was not observed elsewhere. Areas of dieback typically had a thin layer of sediment deposited in the understorey, although other areas had also experienced similar sedimentation. It appeared that the dieback may have been due to upslope hydrological or landform changes delivering greater surface water to these areas.

Permanent waterlogging of soils may have caused localised mortality of non-bog-dependent vegetation in these small areas downslope of the PCF. These areas have been mapped and vegetation succession should be monitored in future years. If permanent, the change to surface water hydrology may result in nearby Alpine Bogs expanding to fill the void created by the death of non-bog-dependent vegetation. Alternatively, it may contribute to the contraction of nearby impact sites, such as Bog 11.2, if water is being diverted away from these sites.

| Impact Year 2 – Recommendation 18 |
| --- |
| Locations of mortality of vegetation surrounding Alpine Bogs should be re-visited again in future years to investigate possible causes and to track vegetation recovery or succession. |

## 4.4 Bog structure

The structure criterion requires that there be no more than a 10% reduction in the average cover of Peat Moss at impact sites, relative to control sites. The cover of Peat Moss has remained relatively stable at impact and control sites across monitoring years. As at IY2, there has been a small (0.6%) increase in Peat Moss cover at impact sites relative to control sites, compared with the baseline mean. The increase in Peat Moss cover has occurred at Bog 4.2 and 11.2, which are the two Alpine Bogs closest to the PCF and two of the Alpine Bogs that have been most impacted by sedimentation (Figure 5).

The small increase in Peat Moss cover at Bogs 4.2 and 11.2 reflects photos and observations from on-ground mapping, which suggest that Peat Moss is recovering from the sedimentation that has occurred at these sites (compare Photo 7, Photo 8 and Photo 9, taken of the same location on the aqueduct before, during and after construction). It appears that entry of new sediment into the Alpine Bogs is being controlled, allowing existing sediment to be washed out of Alpine Bogs and/or be covered by peat-forming species such as Peat Moss. In addition, the proportion of dead Peat Moss seems to have returned to baseline levels at impact sites, after a considerable increase in IY1 (Chart 10). This observation also suggests that Peat Moss is recovering at impact sites after a disturbance event in IY1.

## 4.5 Key observations at each monitoring site

Table 7 summarises the key observations made at each monitoring site in IY2 and indicates management actions that may be required.

**Table 7 Observations made at monitoring sites in IY1 and management priorities**

| Bog | Observations in IY1 | Priority |
|---|---|---|
| **Impact Sites** | | |
| **Bog 4.2** | Sediment has been deposited through the centre of this impact site (Figure 5), along the southern boundary (near the environmental watering system) and along the northern boundary (at the aqueduct). Areas of sedimentation should be monitored for establishing weeds and treated accordingly. Revegetation of sedimentation with suitable Alpine Bog plants should be considered where Alpine Bog vegetation is not recovering. The area of Bog 4.2 that was removed during construction (approx. 8 sq. m) should be revegetated with bog-dependent flora. Rabbit browsing damage (mainly on Spreading Rope-rush) was noted in IY2 in the vicinity of sedimentation along the southern boundary. Success of remediation works is likely to require rabbit control. | High priority for weed and rabbit control and revegetation. |
| **Bog 6** | Sedimentation is particularly evident in the south-west, west and centre of this site (Figure 5). Bog-dependent species have been buried and weeds (e.g. Musk Monkey-flower, Monkey Musk, Soft Rush, Brown-top Bent, Sweet Vernal-grass, Yorkshire Fog and, a novel weed, Manna Grass) are proliferating, resulting in fragmentation of the Alpine Bog. Deer activity is still evident, especially in the northern half. Urgent control of weeds and deer will be required to prevent weeds becoming permanently established. Bare ground should be revegetation with suitable Alpine Bog plants to minimise weed re-establishment. | High priority for weed and deer control and revegetation. |
| **Bog 8/9/10** | The covers of bare ground (due to sedimentation) and weeds (e.g. Brown-top Bent) have increased at this Alpine Bog complex since baseline monitoring, but the area of the Alpine Bog complex has so far remained stable. | Moderate priority for weed control. |
| **Bog 11.2 and 12** | These bogs are immediately upslope/downslope of each other and have similar management issues. The presence of sediment, rocks and boulders from the PCF is evident in these Alpine Bogs, causing loss of Alpine Bog vegetation (Photo 5) and a considerable increase in bare ground (e.g. no bare ground was recorded at Bog 11.2 during baseline monitoring, while the cover of bare ground due to sedimentation was 7.2% in IY2). Despite the increase in bare ground, weed cover has so far remained stable at these sites (e.g. no weeds have been recorded along transects at Bog 11.2). Bare ground should continue to be monitored to ensure that it is not colonised by weeds. | Moderate priority for weed control. |

| Bog | Observations in IY1 | Priority |
|---|---|---|
| **Bog 13** | Since BY1, this bog has been surrounded by predominantly introduced vegetation, particularly weedy grasses (e.g. Brown-top Bent and Sweet Vernal-grass). As at IY2, weed cover at this Alpine Bog appears to be increasing, although this is likely to be due to the very small size of the Alpine Bog and its isolation, rather than any impacts from construction. | Moderate priority for weed control. |
| **Control Sites** | | |
| **Bog 1** | The south-eastern corner of Bog 1 was noticeably dry in IY1 but appears to be wetter in IY2, with good growth from Candle Heath. Given that precipitation (rain and snowfall) decreased in IY2, this may reflect a resumption in discharge of water into this area from the water treatment hut 20 m south. Soft Rush is still present along the northern boundary of this site, along the edge of the Summer Nature Walk. | Moderate priority for weed control. |
| **Bog 2** | The eastern boundary of Bog 2, near Transect 2A, is subject to severe weed pressures due to historic disturbances to the east of this monitoring site. After an increase in IY1, the cover of most weed species (particularly Milfoil) along Transect 2A has returned to baseline levels in IY2, presumably due to weed control efforts. However, two previously unrecorded weed species (Cocksfoot and Field Pansy) were detected along Transect 2A in IY2 and may fill the void left by other weed species. Deer and rabbit activity was noted along the southern boundary of Bog 2 in IY2. | Moderate priority for weed control. |
| **Bog 4.1/5/7** | This Alpine Bog complex has been fragmented by weed proliferation along the aqueduct and north of the aqueduct. Some of this fragmentation has been reversed in IY2, possibly due to weed control and revegetation works. The main weeds of concern remain Sword Rush, Musk Monkey-flower, Soft Rush and Apple (Photo 16). While deer activity appears to have reduced, rabbit browsing (particularly on Spreading Rope-rush) appears to have worsened. | High priority for weed, deer and rabbit control. |
| **Bog 11.1** | Deer activity appears to have reduced at this control site, with Alpine Bog vegetation re-sprouting after browsing and trampling from deer. However, the western branch of this site remains fragmented by weeds (mainly Soft Rush) and the branch between Transects 11.1B and 11.1C is narrowing (and almost fragmented) due to proliferation of Jointed Rush. | High priority for weed and deer control. |

| Bog | Observations in IY1 | Priority |
|---|---|---|
| **Bog S1** | The north-western end of this Alpine Bog (near Transect S1A) remains dry, perhaps due to water flow becoming more channelised. The impact of deer and horses is still evident near Stirling Trail and deer impacts (wallowing and browsing) appear to be worsening. As a result, weedy grasses and Musk Monkey-flower are still abundant and the bog remains contracted at this end. Blocking of the main channel (e.g. with rice straw bales) may benefit some of this area and allow for recolonisation by bog-dependent species, although access by horses and deer would also need to be limited. Photo point peg S1AE was missing (possibly removed by deer) and replaced in IY2. Near the mid-point of this Alpine Bog, the southern boundary remains dynamic as Mountain Tea-tree continue to regenerate following the 2006-2007 fires and the Blackberry infestation that was treated in IY1 will need retreatment (Photo 17). | High priority for weed and deer control. |
| **Bog S2** | Although no weeds have ever been recorded by line (point) or belt (quadrat) transects at this monitoring site, incidental observations suggest that Musk Monkey-flower may be increasing in cover, particularly at the north-western end. Deer activity also appears to have increased in the Montane Riparian Thicket surrounding the Alpine Bog. | Moderate to high priority for weed and deer control. |
| **Bog S3** | Peat Moss at this control site appears very healthy, especially along the western boundary, despite disturbance caused by monitoring activity and falling Snow Gums. Weed cover at the southern edge of this Alpine Bog (along Transect S3C near Wombat Drop Track) has returned to baseline levels. In IY2, new and expanded deer wallows were noted and photographed outside the northern boundary of Bog S3 (Photo 13 and Photo 14) and more than 20% of bare ground recorded within Bog S3 was attributed to deer activity. | Moderate priority for deer control. |
| **Other Sites** | | |
| **Bog 3** | Soft Rush and Musk Monkey-flower are still present in Bog 3, particularly along its western side, resulting in the current size of the Alpine Bog still being less than its baseline mean. | Moderate priority for weed control. |

## 4.6 Triggers for adaptive management

The HEMAMP's triggers for adaptive management of impact sites are:

- A deterioration in Alpine Bog condition at impact sites relative to control sites, such that the performance criteria have not been met or are unlikely to be met in the next 12 months.
- A 50% reduction/decline in surface water flows at impact sites relative to control sites, over two consecutive years.
- A 50% reduction/decline in groundwater levels at impact sites relative to control sites, over two consecutive years.

The trigger relating to deterioration of Alpine Bog condition has been met. The weed criterion has been breached since baseline monitoring but appears to be worsening since construction of the water storage occurred. In addition, the extent (area) and composition (species richness) of impact sites relative to control sites appears to be in decline and there is a risk that these criteria may be breached in the next 12 months. Recommended management actions to address these trends are outlined in Section 4.5 of this report.

The triggers relating to surface water flows and groundwater levels cannot be assessed until regular monitoring of surface water flows and groundwater levels resumes (see Recommendations 2 to 5 of this report).

# 5. Conclusion and recommendations

Although hydrological monitoring is lacking, four years of ecological and climatological monitoring in accordance with the HEMAMP protocol have now been completed, including two years of baseline monitoring. The monitoring results allow for an assessment against the HEMAMP's performance criteria. Table 8 presents the results of the compliance assessment as at IY2.

**Table 8 Compliance with the HEMAMP performance criteria**

| Performance criterion | Compliant? | Action required? | Comments |
|---|---|---|---|
| **Extent** | | | |
| **No more than a 10% reduction in the total combined area of impact sites, relative to control sites.** | Yes | Yes | Potential for future non-compliance with a 4.1% reduction in the total combined area of impact sites, relative to control sites. Control weeds/deer and revegetate, focussing on areas of sediment. |
| **Composition** | | | |
| **No more than a 10% reduction in the total 'bog-dependent' native flora species richness of impact sites, relative to control sites.** | Yes | Yes | Potential for future non-compliance. One bog-dependent species was not detected at impact sites in IY2. Investigate further in IY3 and consider re-introducing the species through revegetation. |
| **Encroachment** | | | |
| **No more than a 10% increase in the cover of 'non-bog-dependent' species within impact sites, relative to control sites.** | Yes | Yes | Potential for future non-compliance with a relative 4.9% increase in cover of non-bog-dependent species at impact sites. Investigate possible hydrological changes and consider environmental watering. |
| **Weed cover not to exceed 5%.** | No | Yes | Weed cover at impact sites is 8.1% and increasing. Control weeds/deer and revegetate, focussing on areas of sediment. |
| **Structure** | | | |
| **No more than a 10% reduction in the average cover of Peat Moss within impact sites, relative to control sites.** | Yes | No | Average cover of Peat Moss within impact sites relative to control sites in IY2 is 11.1% higher than the baseline mean. Overall, Peat Moss cover and health is good. |

The recommendations of this monitoring report are as follows:

1. The RMB must ensure that laboratory water quality analyses include all parameters required by the HEMAMP, such as total dissolved solids, which was missed at one groundwater monitoring bore on one occasion in IY2.
2. The RMB should re-instate BH09, which was inadvertently destroyed during construction of the environmental watering system.
3. Better management of the HEMAMP's hydrological datasets is required to ensure consistency and completeness of the HEMAMP's hydrological data from year to year. The RMB should maintain a centralised spreadsheet or database of all hydrological data, similar to the way in which it manages the HEMAMP's climatological datasets, to avoid misplacement of data and data corruption.
4. The RMB should ensure that flow sensors at Boggy Creek Weirs 1 and 2 are reliably installed, calibrated and provisioned with automated data loggers to minimise maintenance requirements, reduce the need for daily visits to record flow data and ultimately provide complete datasets for surface water flows through the Boggy Creek catchment, as required by the HEMAMP.
5. The RMB should ensure that groundwater depth sensors are calibrated and promptly re-installed in monitoring bores, together with their automated data loggers, to minimise gaps in groundwater depth datasets.
6. A pictorial guide to bryophyte species recorded at the Mount Buller and Mount Stirling would be useful to assist in consistent field identifications between monitoring years.
7. Consider amalgamating records of Mountain Baeckea *Baeckea utilis s.s.* and Subalpine Baeckea *Baeckea latifolia* under one taxon name (e.g. Mountain Baeckea *Baeckea utilis s.l.*) due to the difficulty in consistently distinguishing between the two species at Mount Buller and Mount Stirling.
8. The HEMAMP protocol for point intersection sampling along transects should be updated to make it clear that the 'vegetation' and 'litter' ground condition categories do not require plant material to be alive or dead, simply attached or detached (respectively).
9. The HEMAMP protocol for point intersection sampling along transects should be updated to include the new sub-categories for 'bare ground': 'bare ground (deer)', 'bare ground (sedimentation)' and 'bare ground (natural)'.
10. The RMB should install data loggers on water meters at the water storage drainage discharge points to monitor volumes of water being discharged from the water storage and from groundwater drainage under the water storage, as required by the HEMAMP.
11. Improvements are needed to the process by which water samples are labelled, handled and recorded in the field to avoid corruption of water quality data and improve traceability of laboratory results.
12. The accuracy of water quality laboratory analyses should be cross-checked as soon as possible (e.g. through analysis of relative percentage difference with duplicate samples) to detect and reconcile any errors as early as possible.
13. The Ecological Rehabilitation Plan (Biosis 2020) must continue to be implemented to prevent further movement of sediment, rocks and boulders from the PCF into Alpine Bogs. This will require regular and long-term monitoring, maintenance and (where required) addition of erosion controls (e.g. sediment barriers).
14. Efforts to control Sambar Deer *Cervus unicolor* at Mount Buller and Mount Stirling should continue, with the aim of preventing this species from further damaging Alpine Bogs.
15. The presence or absence of Silver Astelia *Astelia alpina* var. *novae-hollandiae* from impact sites (particularly Bogs 4.2 and 6) should be further investigated in Impact Year 3. If the presence of Silver Astelia is not detected, the RMB should consider re-introducing this species to these monitoring sites through revegetation.

 

16. Increased weed control should be undertaken at impact sites and along the aqueduct, prioritising areas of bare ground (particularly sedimentation). The following weed species should be targeted:
    - Milfoil *Achillea millefolium*
    - Brown-top Bent *Agrostis capillaris*
    - Sweet Vernal-grass *Anthoxanthum odoratum*
    - Spear Thistle *Cirsium vulgare*
    - Musk Monkey-flower *Erythranthe moschata*
    - Monkey Musk *Erythranthe guttata*
    - Manna Grass *Glyceria declinata*
    - Yorkshire Fog *Holcus lanatus*
    - Jointed Rush *Juncus articulatus* subsp. *articulatus*
    - Soft Rush *Juncus effusus* subsp. *effusus*
    - Sword Rush *Juncus ensifolius*
    - Apple *Malus pumila*
    - Creeping Buttercup *Ranunculus repens*
    - Blackberry *Rubus anglocandicans*.
17. The use of alternative weed control methods, such as heat, should continue to be trialled to expand the window of time during which weed control can occur, to minimise the risk to Alpine Bogs from herbicide application and to ultimately improve the management of weeds in Alpine Bogs.
18. Locations of mortality of vegetation surrounding Alpine Bogs should be re-visited again in future years to investigate possible causes and to track vegetation recovery or succession.

# References


ANZECC 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment and Conservation Council, Canberra.

Bean A 1997. A Revision of *Baeckea* (Myrtaceae) in Eastern Australia, Malesia and South-East Asia. *Telopea*, vol. 7, pp. 245-268.

Biosis 2013. Mount Buller Ski Field: Vegetation Management Plan. Version 4. Report for Buller Ski Lifts. Authors: Steer R and Harvey A, Biosis Pty Ltd, Wangaratta. Project no. 10272.

Biosis 2019. Mount Buller Sustainable Water Security Project – Off-stream Storage: Hydrological and Ecological Monitoring and Adaptive Management Program. Report for Mount Buller and Mount Stirling Alpine Resort Management Board. Author: Goddard M, Biosis Pty Ltd, Melbourne. Project no. 29064.

Biosis 2020. Mount Buller Sustainable Water Security Project – Off-stream Storage: Ecological Rehabilitation Plan. Report for Mount Buller and Mount Stirling Alpine Resort Management Board. Authors: Goddard M and Harvey A, Biosis Pty Ltd, Melbourne. Project no. 29065.

Biosis and GHD 2016. Mount Buller Sustainable Water Security Project – Off-stream Storage: Flora and Fauna Assessment. Report for Mount Buller and Mount Stirling Alpine Resort Management Board.

DELWP 2021. Victorian Biodiversity Atlas. Victorian Government Department of Environment, Land, Water and Planning, Melbourne.

DEPI 2014. Advisory List of Rare or Threatened Plants in Victoria – 2014. Victorian Government Department of Environment and Primary Industries, Melbourne.

DEWHA 2009. Alpine Sphagnum Bogs and Associated Fens: A Nationally Threatened Ecological Community. *Environment Protection and Biodiversity Conservation Act 1999*: Policy Statement 3.16. Australian Government Department of the Environment, Water, Heritage and the Arts, Canberra.

DoE 2013. Key to the Listed Alpine *Sphagnum* Bogs and Associated Fens Ecological Community on the Australian Mainland. Australian Government Department of the Environment, Canberra.

DoE 2015. National Recovery Plan for the Alpine *Sphagnum* Bogs and Associated Fens: A Threatened Ecological Community Listed under the *Environment Protection and Biodiversity Conservation Act 1999*. Australian Government Department of the Environment, Canberra.

Elzinga C, Salzer D, Willoughby J and Gibbs J 2009. Monitoring Plant and Animal Populations: A Handbook for Field Biologists. John Wiley and Sons, Chichester.

EPA Victoria 2000. Groundwater Sampling Guidelines. Environmental Protection Authority Victoria, Melbourne.

EPA Victoria 2003. Guideline for Environmental Management: Rapid Bioassessment Methodology for Rivers and Streams. Environmental Protection Authority Victoria, Melbourne.

EPA Victoria 2009. Industrial Waste Resource Guidelines: Sampling and Analysis of Waters, Wastewaters, Soils and Wastes. Environmental Protection Authority Victoria, Melbourne.

FFG Act Scientific Advisory Committee 2013. *Flora and Fauna Guarantee Act 1988* – Threatened List. Characteristics of Threatened Communities. Department of Environment, Land, Water and Planning. Victorian Government, Melbourne.

GHD 2018. Water Storage Project Monitoring Review 2018. Report for Mount Buller and Mount Stirling Alpine Resort Management Board.

Macdonald T 2009. Technical Report 20. Sphagnum Bog Mapping and Recovery Plan. ACT Climate Change Strategy Action Plan 2007-2011. Project Report – Action 35. Territory and Municipal Services. Australian Capital Territory Government, Canberra.

Meagher D and Fuhrer B 2003. A Field Guide to the Mosses and Allied Plants of Southern Australia: Flora of Australia Supplementary Series Number 20. Australian Biological Resources Study, Canberra, and Field Naturalists Club of Victoria, Melbourne.

Quinn G and Keough M 2002. Experimental Design and Data Analysis for Biologists. Cambridge University Press: Cambridge.

R Development Core Team 2021. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna.

RBGV 2021. VicFlora: Online Flora of Victoria. Royal Botanic Gardens of Victoria, Melbourne.

Scott G 1988. Southern Australian Liverworts: Australian Flora and Fauna Series Number 2. Australian Biological Resources Study, Canberra.

Scott G and Stone I 1976. The Mosses of Southern Australia. Academic Press, London.

Seppelt R 2004. The Moss Flora of Macquarie Island. Australian Antarctic Division, Canberra.

SEPP 2018. State Environment Protection Policy (Waters). Victoria Government Gazette, Melbourne.

Standards Australia 2005. Australian Standard AS4482.1-2005: Guide to the Investigation and Sampling of Sites with Potentially Contaminated Soil. Part 1: Non-volatile and Semi-volatile Compounds. Standards Australia, Sydney.

TSSC 2009. Commonwealth Listing Advice on Alpine Sphagnum Bogs and Associated Fens: Advice to the Minister for the Environment, Heritage and the Arts from the Threatened Species Scientific Committee on Amendments to the List of Ecological Communities under the *Environment Protection and Biodiversity Conservation Act 1999*. Threatened Species Scientific Committee, Australian Government Department of the Environment, Water, Heritage and the Arts, Canberra.

Underwood A 1992. Beyond BACI: The Detection of Environmental Impacts on Populations in the Real, but Variable, World. *Journal of Experimental Marine Biology and Ecology*, vol. 161, pp. 145-178.

Underwood A 1994. On Beyond BACI: Sampling Designs that Might Reliably Detect Environmental Disturbances. *Ecological Applications*, vol. 4, pp. 3-15.

# Figures

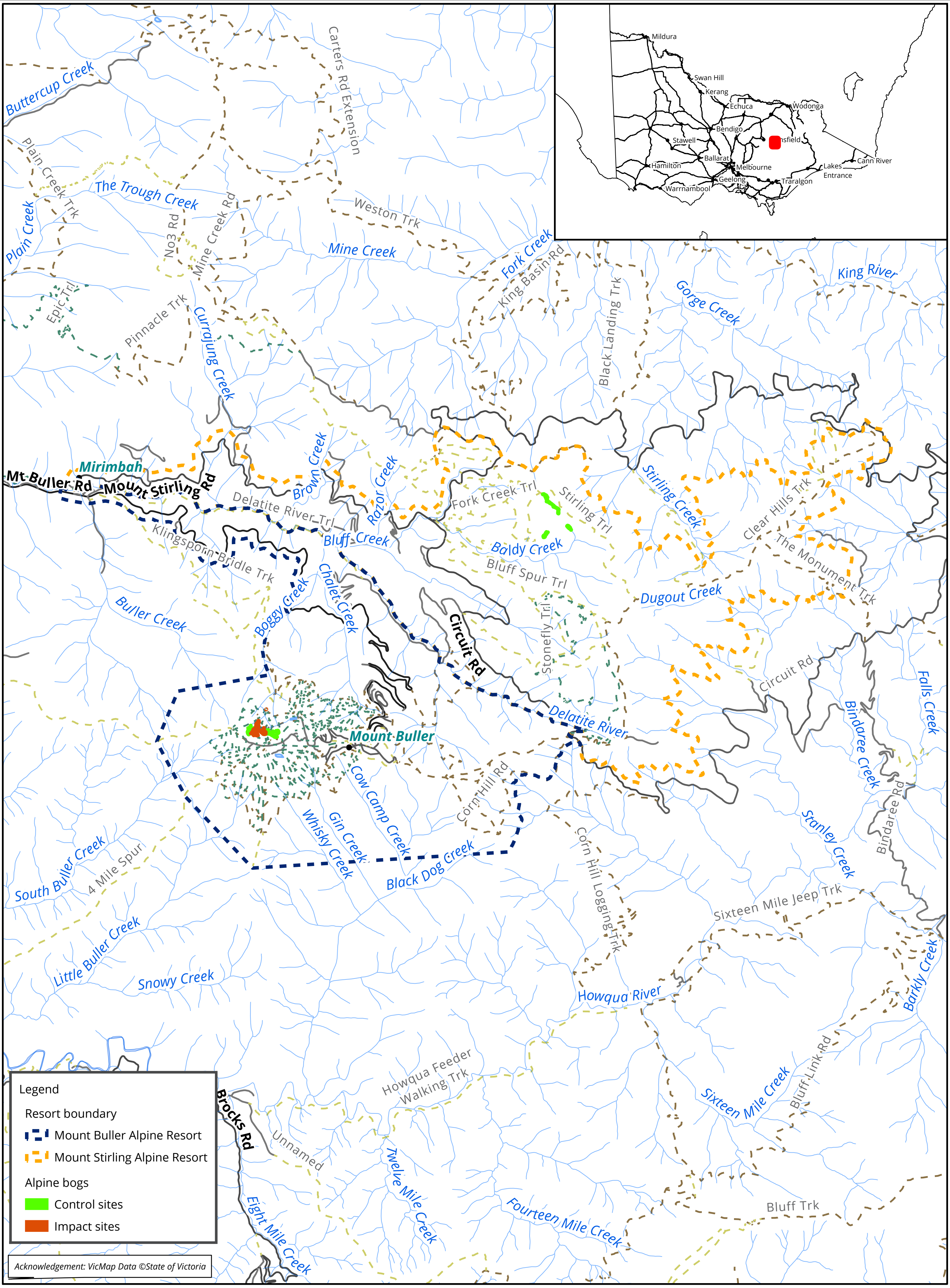


**Figure 1: Location of the Mount Buller and Mount Stirling Alpine Resorts, Victoria**

Biosis Pty Ltd
Albury, Ballarat, Melbourne,
Newcastle, Sydney, Wangaratta & Wollongong

Matter: 26702,
Date: 28 March 2018,
Checked by: MG, Drawn by: SSK, Last edited by: skumar
Location:P:\26700s\26702\Mapping\26702_Report Figures

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Metres
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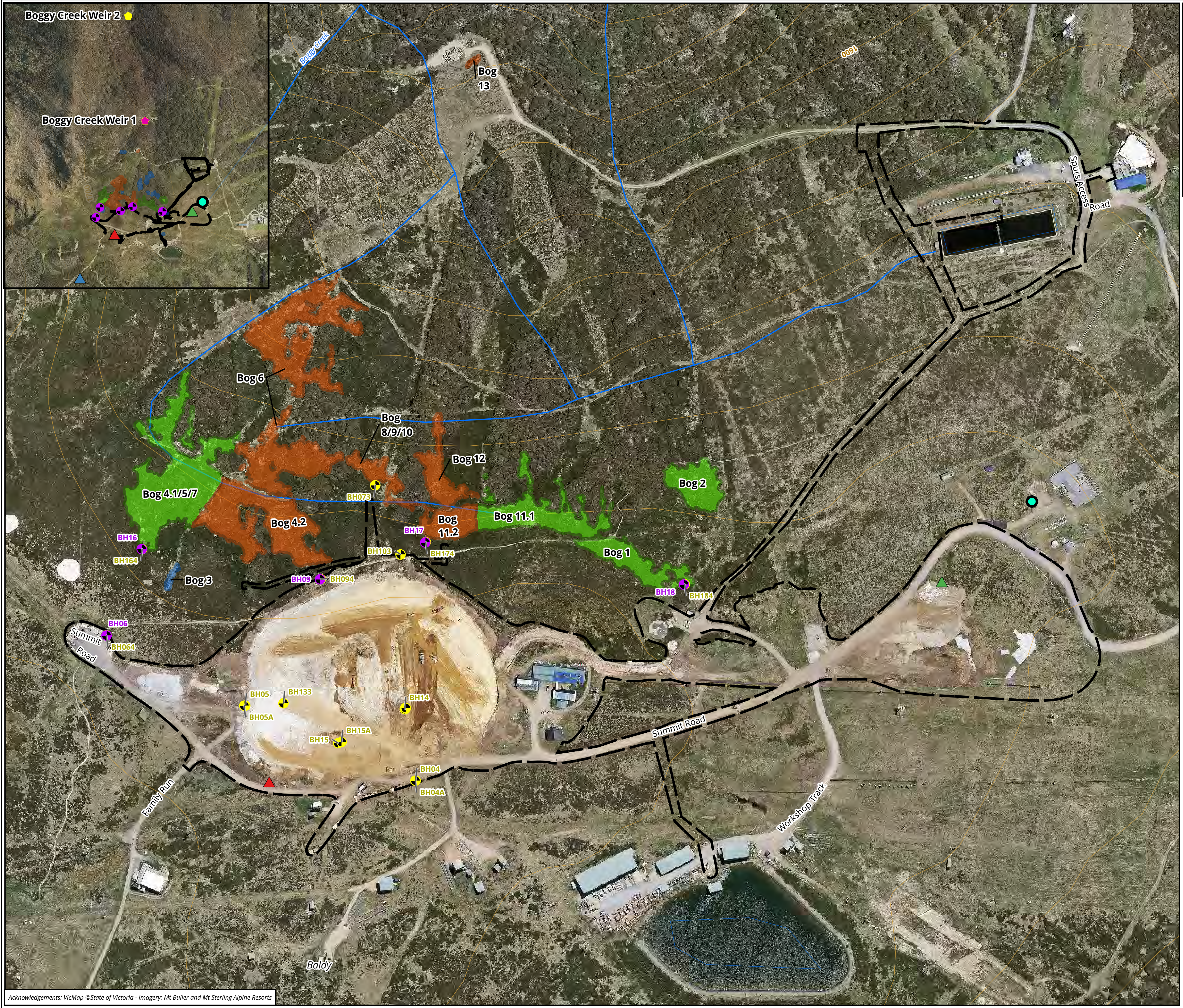


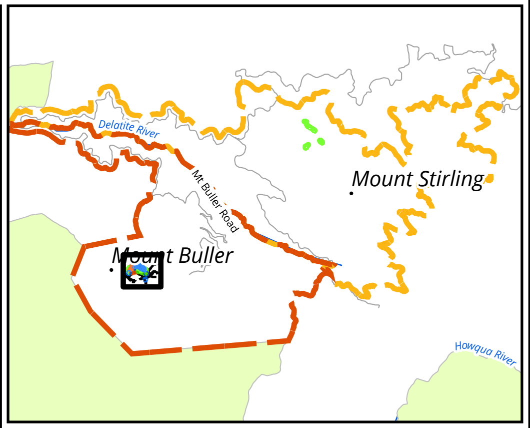


**Legend**

Project Construction Footprint

**Alpine Bogs**

- Control sites (2021)
- Impact sites (2021)
- Other sites (2021)
- Groundwater bore
- Other groundwater boreholes
- BoM Station
- Boggy Creek Snow Gauge
- Family Run Snow Gauge
- Tirol Snow Gauge

**Figure 2 Location of Alpine Bogs subject to monitoring at Mount Buller Alpine Resort**

0 20 40 60 80 100
Metres
Scale: 1:3,000 @ A3
*Coordinate System: GDA 1994 MGA Zone 55*

N

biosis.

Matter: 34410,
Date: 15 June 2021 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
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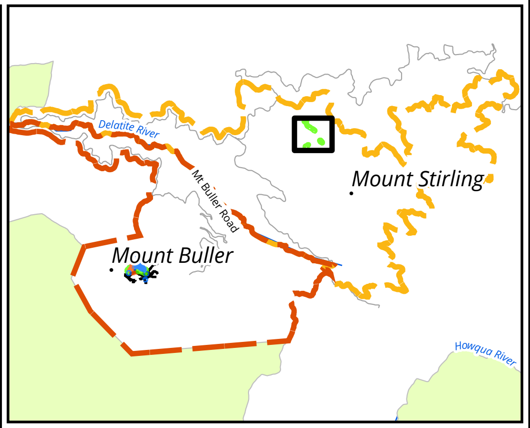


**Legend**

Mt Stirling weather station

**Alpine Bogs**

Control sites (2021)

**Figure 3 Location of Alpine Bogs subject to monitoring at Mount Stirling Alpine Resort**

0 20 40 60 80 100

Metres

Scale: 1:3,000 @ A3

*Coordinate System: GDA 1994 MGA Zone 55*

N

biosis.

Matter: 34410,
Date: 15 June 2021 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
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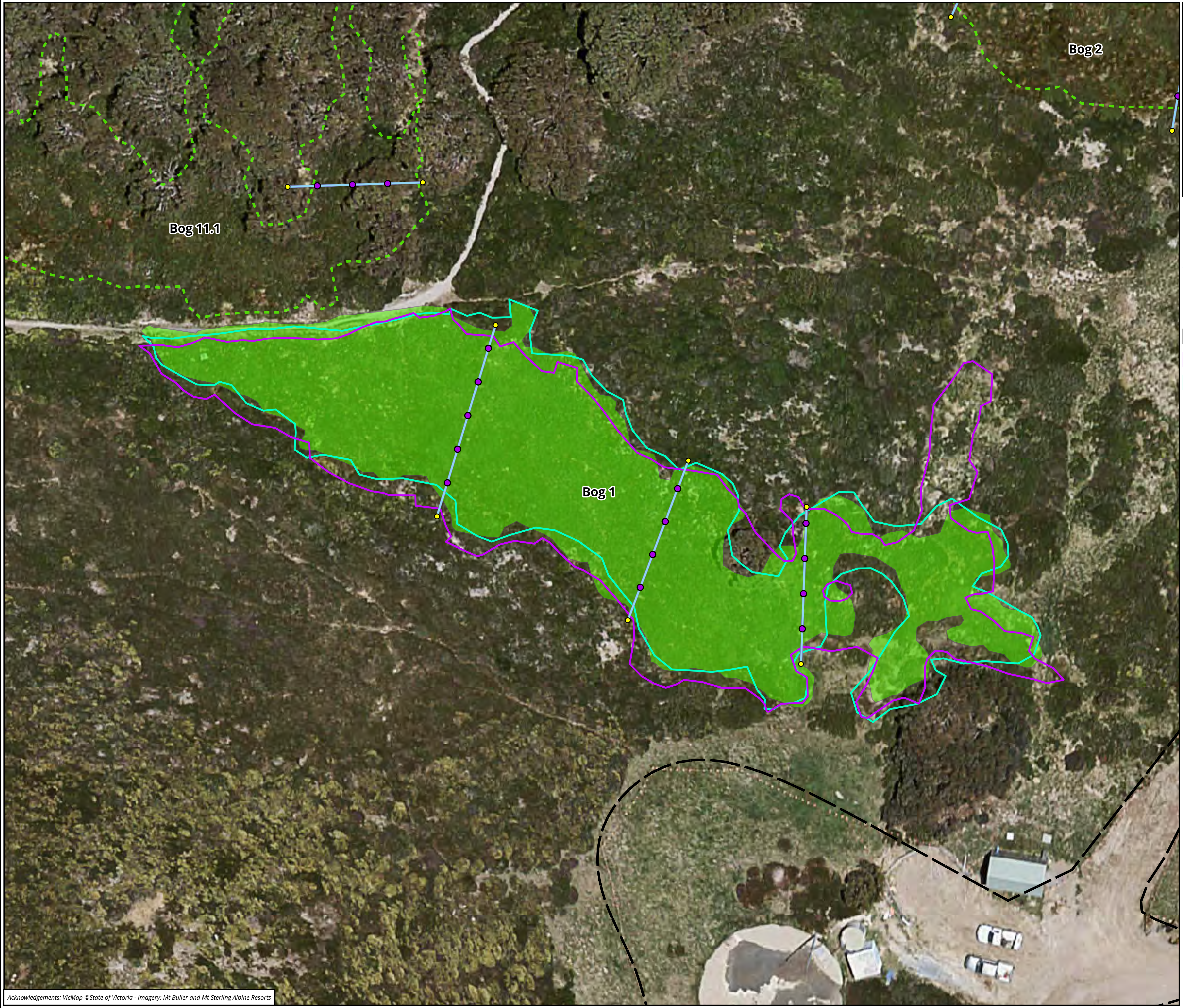


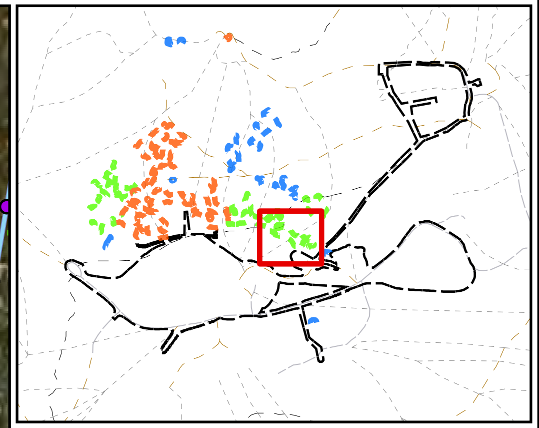

**Legend**

- Project Construction Footprint
- Transects
- Quadrats
- Photo points
- Control site (2021)
- Baseline year 1
- Baseline year 2

**Figure 4a: Bog 1 (control site)**

0 3 6 9 12 15

Metres

Scale: 1:400 @ A3

*Coordinate System: GDA 1994 MGA Zone 55*

N

biosis.

Matter: 34410,
Date: 15 June 2021 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
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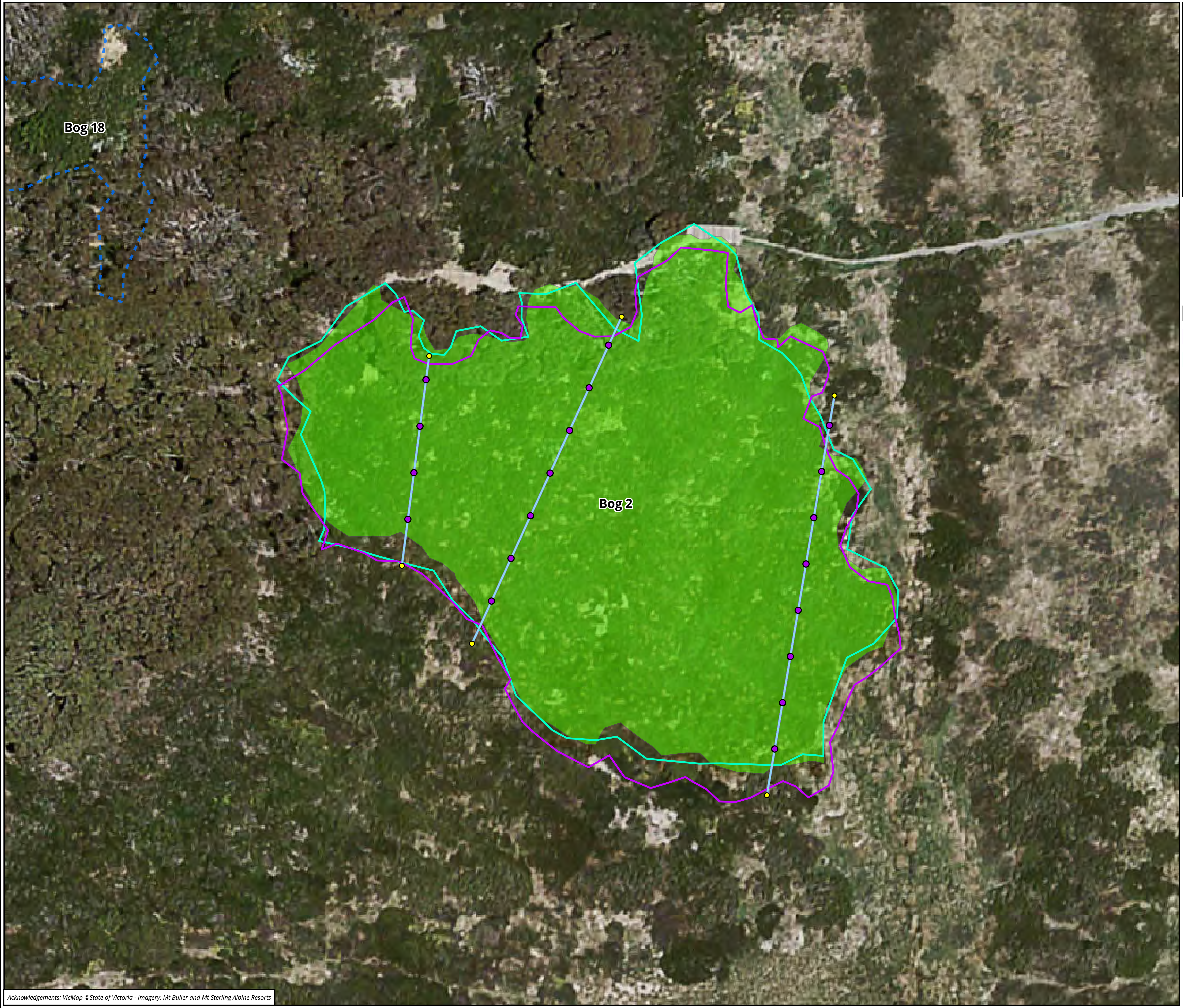


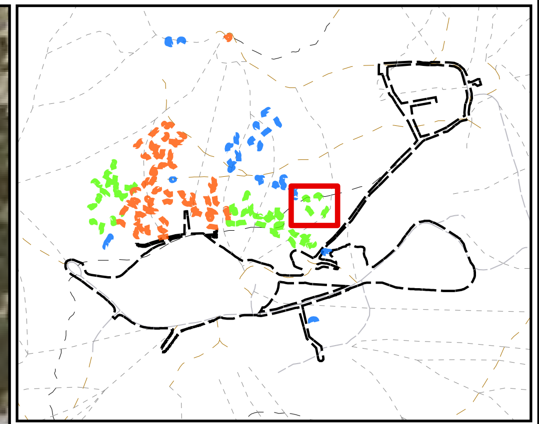

**Legend**

- Transects
- Quadrats
- Photo points
- Control site (2021)
- Baseline year 1
- Baseline year 2

**Figure 4: Bog 2 (control site)**

0 2 4 6 8 10
Metres
Scale: 1:300 @ A3
*Coordinate System: GDA 1994 MGA Zone 55*

N

biosis

Matter: 34410,
Date: 15 June 2021 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
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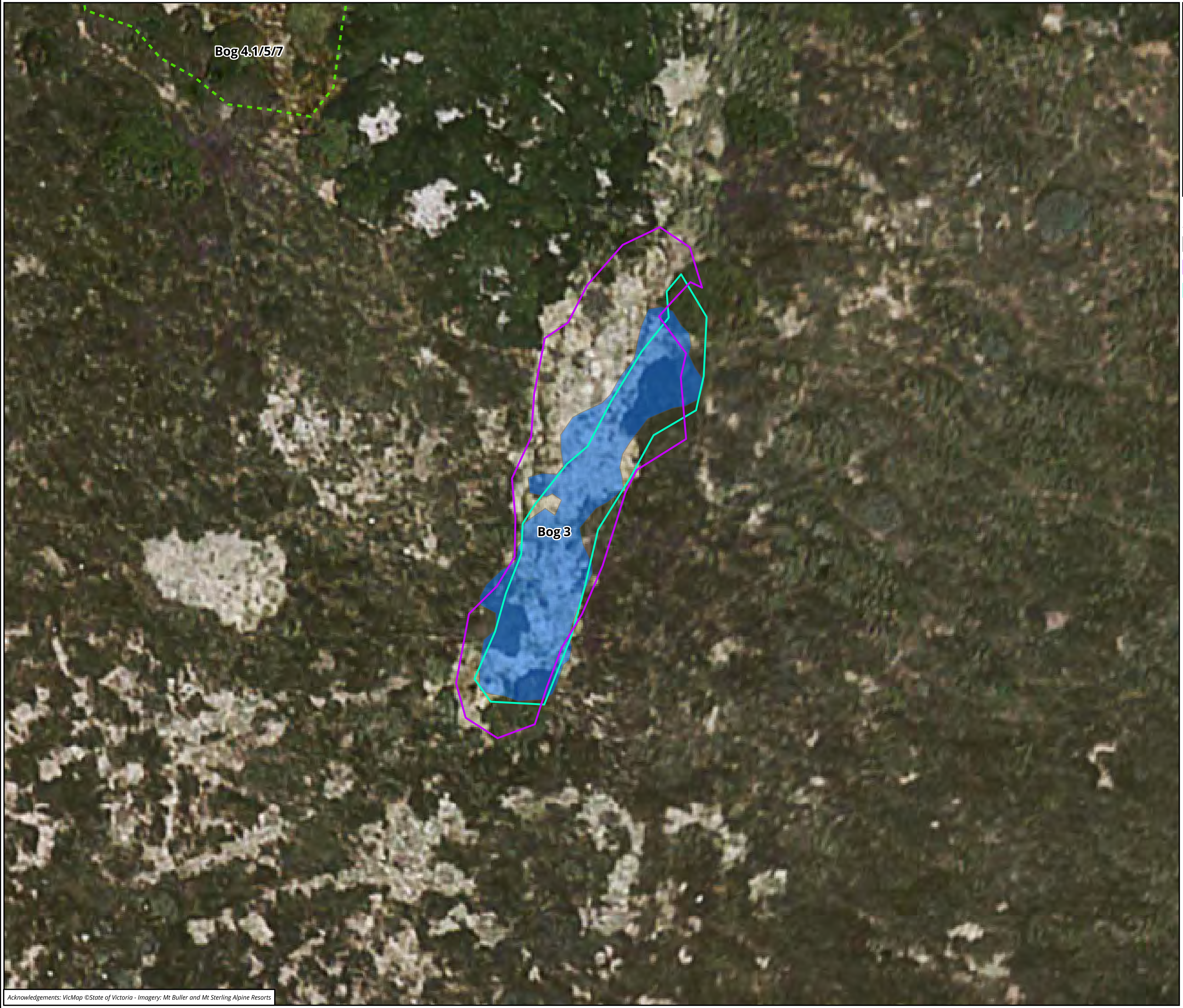
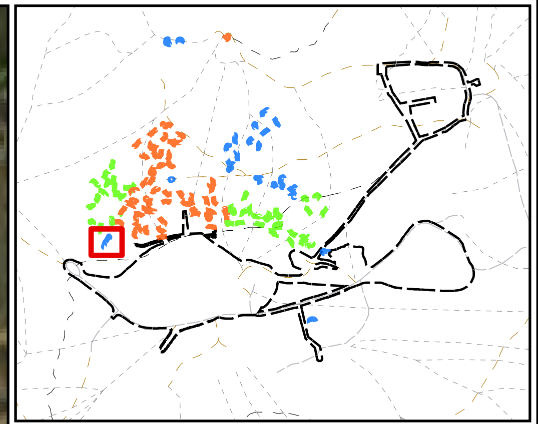
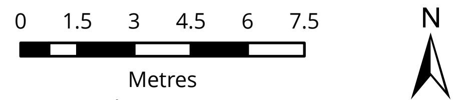


**Legend**

- Other site (2021)
- Baseline year 1
- Baseline year 2

**Figure 4: Bog 3 (other site)**

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Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
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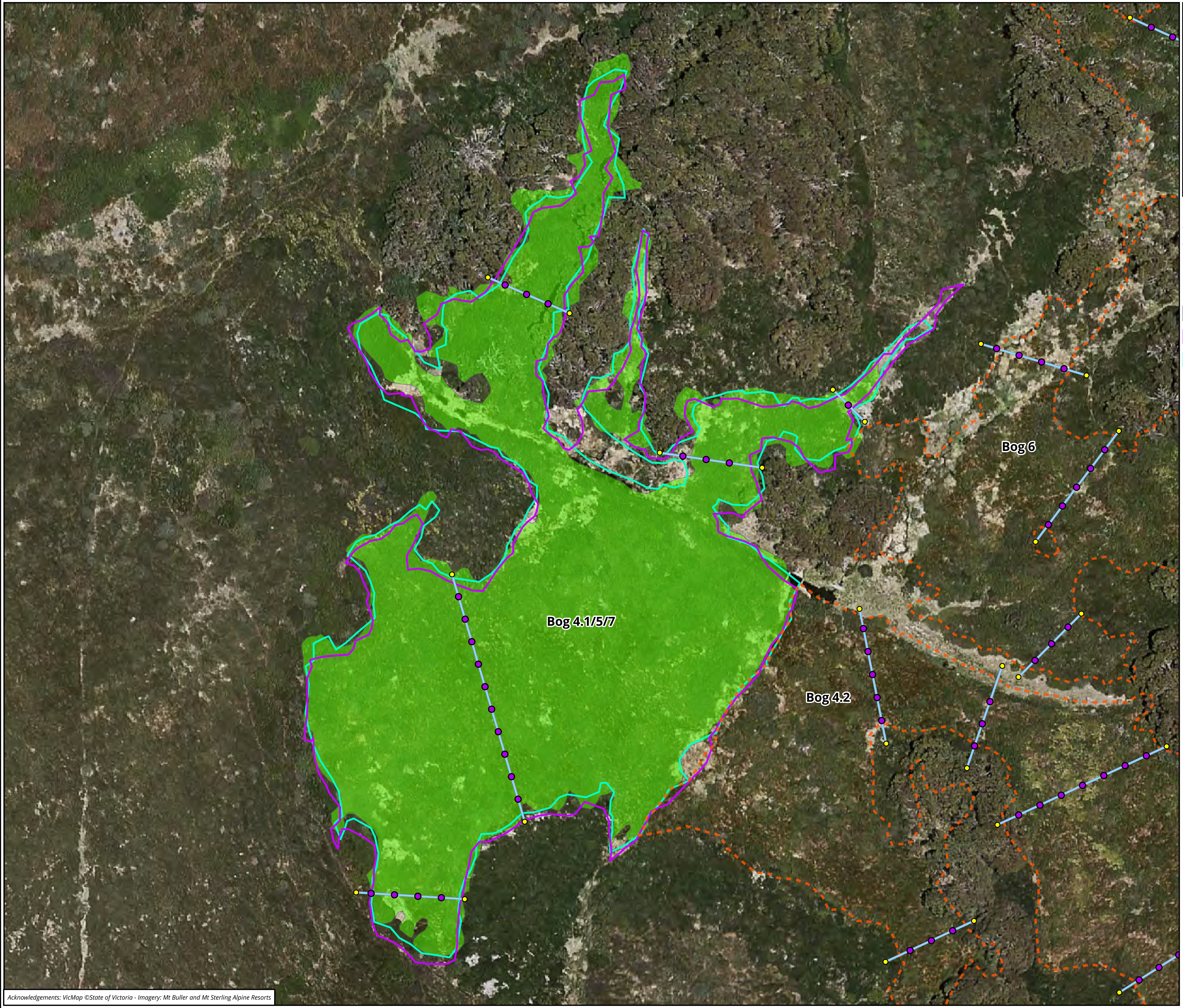


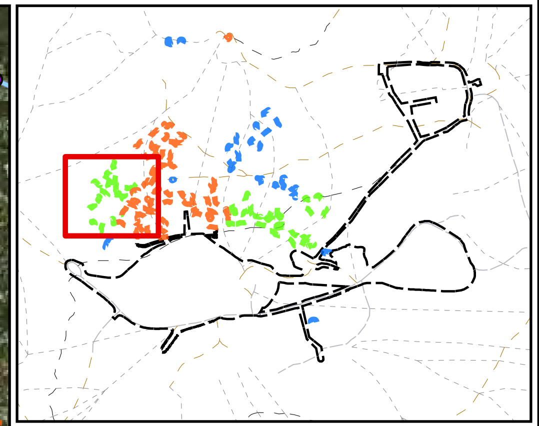

**Legend**

- Transects
- Quadrats
- Photo points
- Control site (2021)
- Baseline year 1
- Baseline year 2

## Figure 4: Bog 4.1/5/7 (control site)

0 4.5 9 13.5 18 22.5

Metres

Scale: 1:600 @ A3

*Coordinate System: GDA 1994 MGA Zone 55*

N

biosis

Matter: 34410,
Date: 15 June 2021 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
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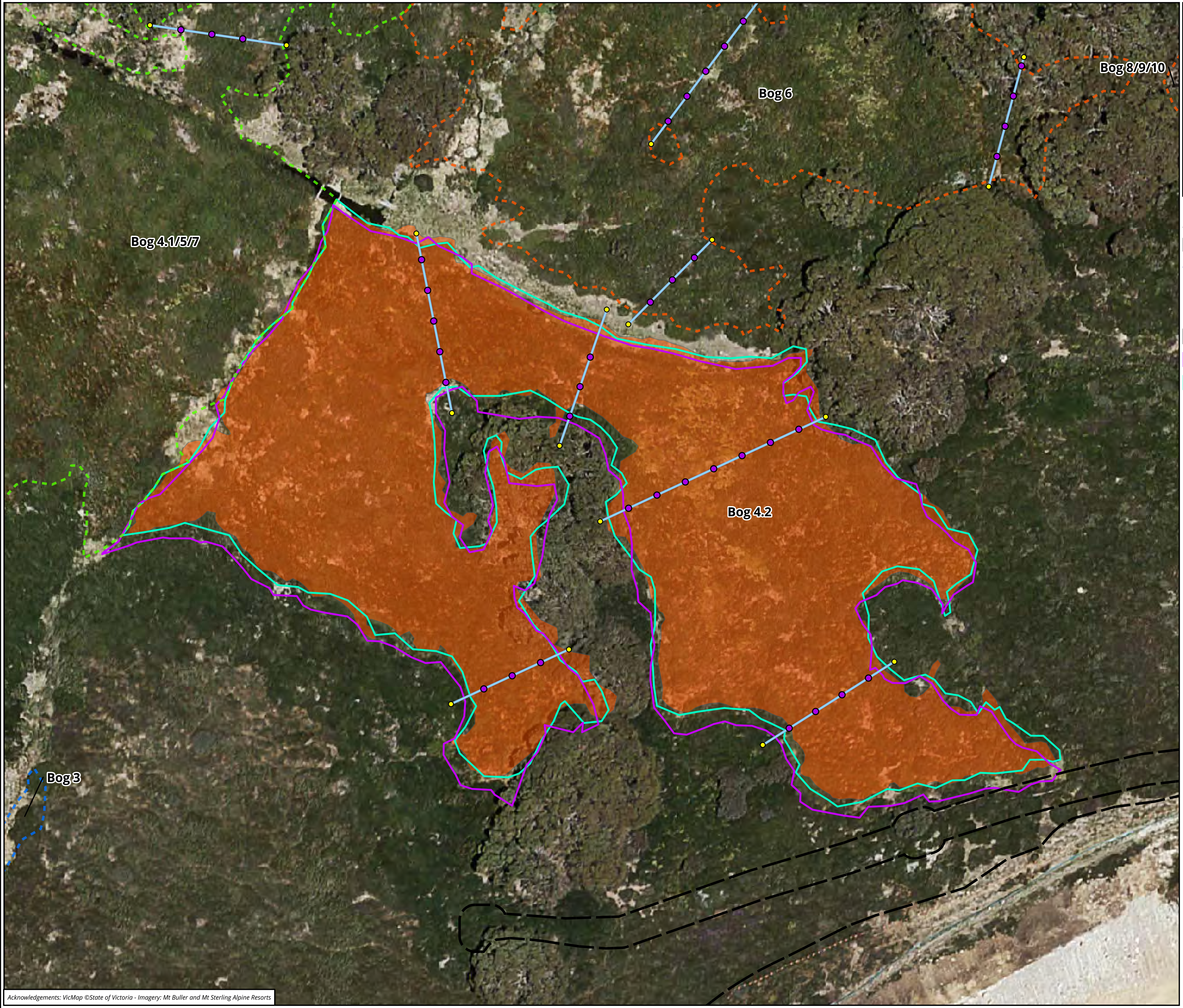


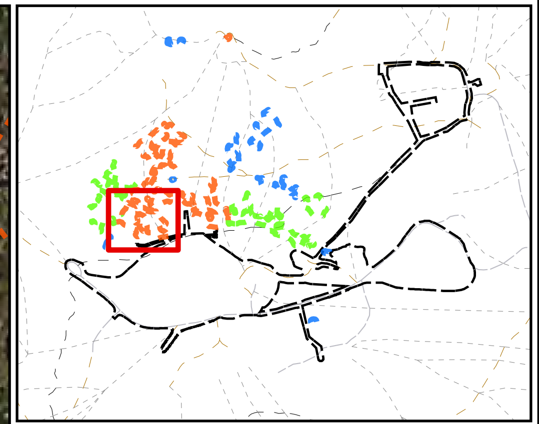



**Figure 4: Bog 4.2 (impact site)**



biosis

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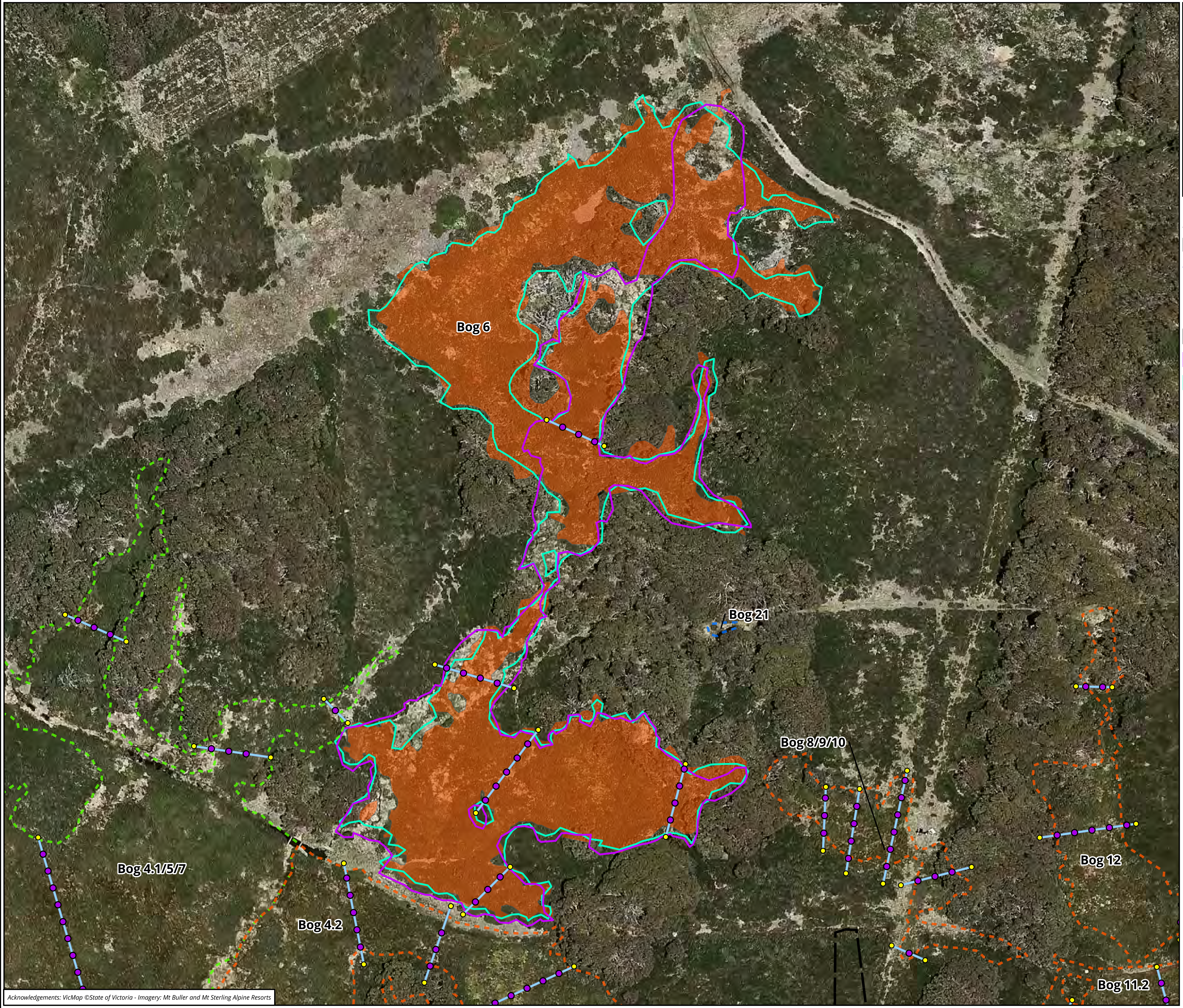


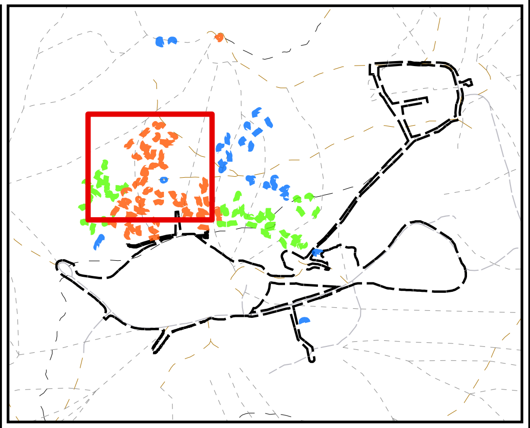

**Legend**

- Project Construction Footprint
- Transects
- Quadrats
- Photo points
- Impact site (2021)
- Baseline year 1
- Baseline year 2

**Figure 4: Bog 6 (impact site)**

0 6 12 18 24 30

Metres

Scale: 1:800 @ A3

*Coordinate System: GDA 1994 MGA Zone 55*

N

biosis.

Matter: 34410,
Date: 15 June 2021 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
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Project: P:\34400s\34410\Mapping\
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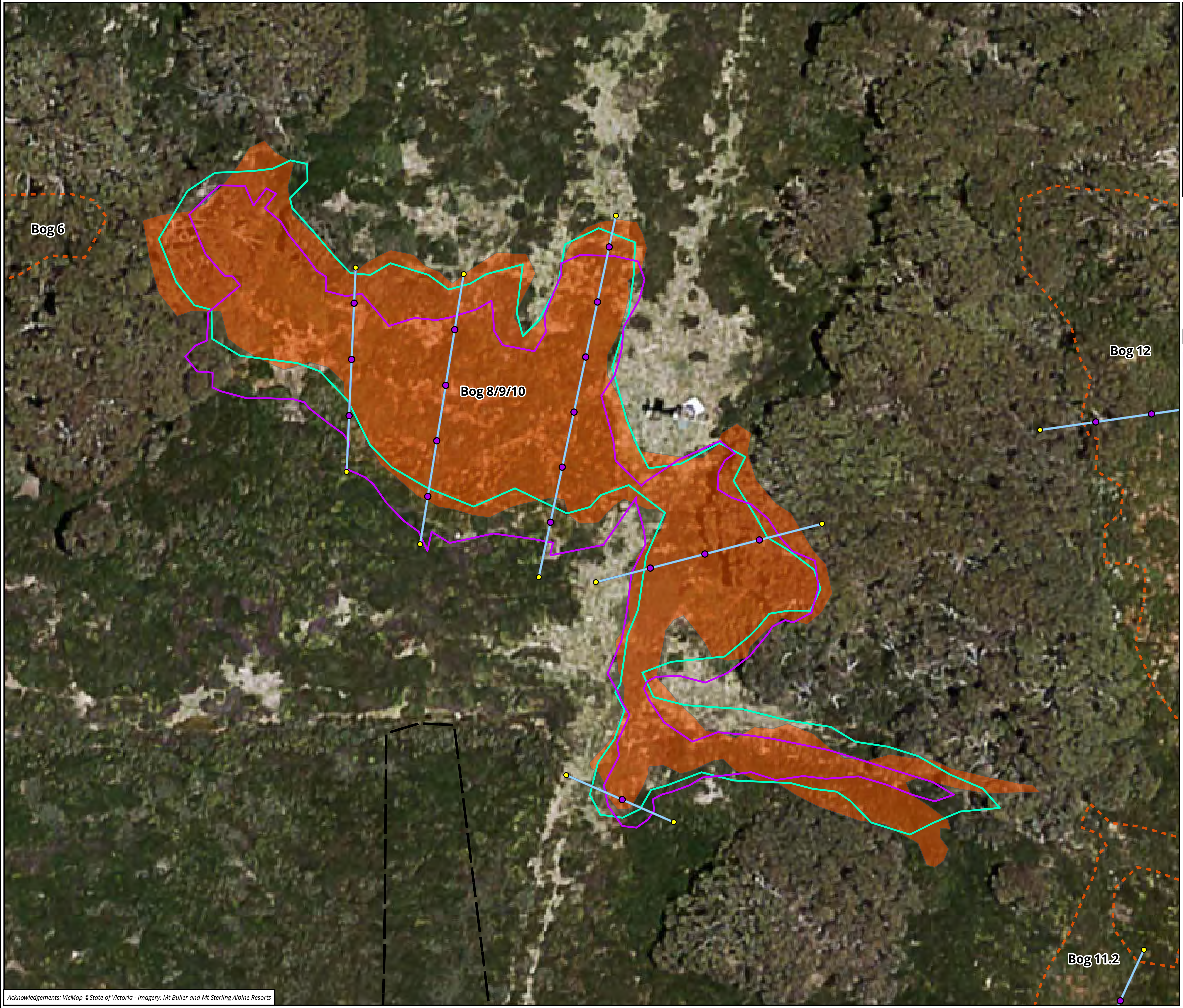


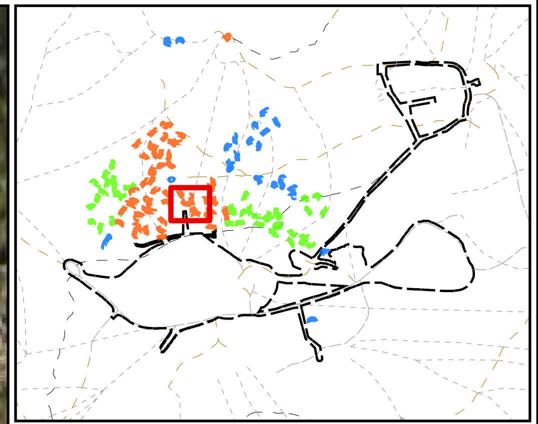

**Legend**

- Project Construction Footprint
- Transects
- Quadrats
- Photo points
- Impact site (2021)
- Baseline year 1
- Baseline year 2

**Figure 4: Bog 8/9/10 (impact site)**

0 2 4 6 8 10

Metres

Scale: 1:250 @ A3

*Coordinate System: GDA 1994 MGA Zone 55*

N

Matter: 34410,
Date: 15 June 2021 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
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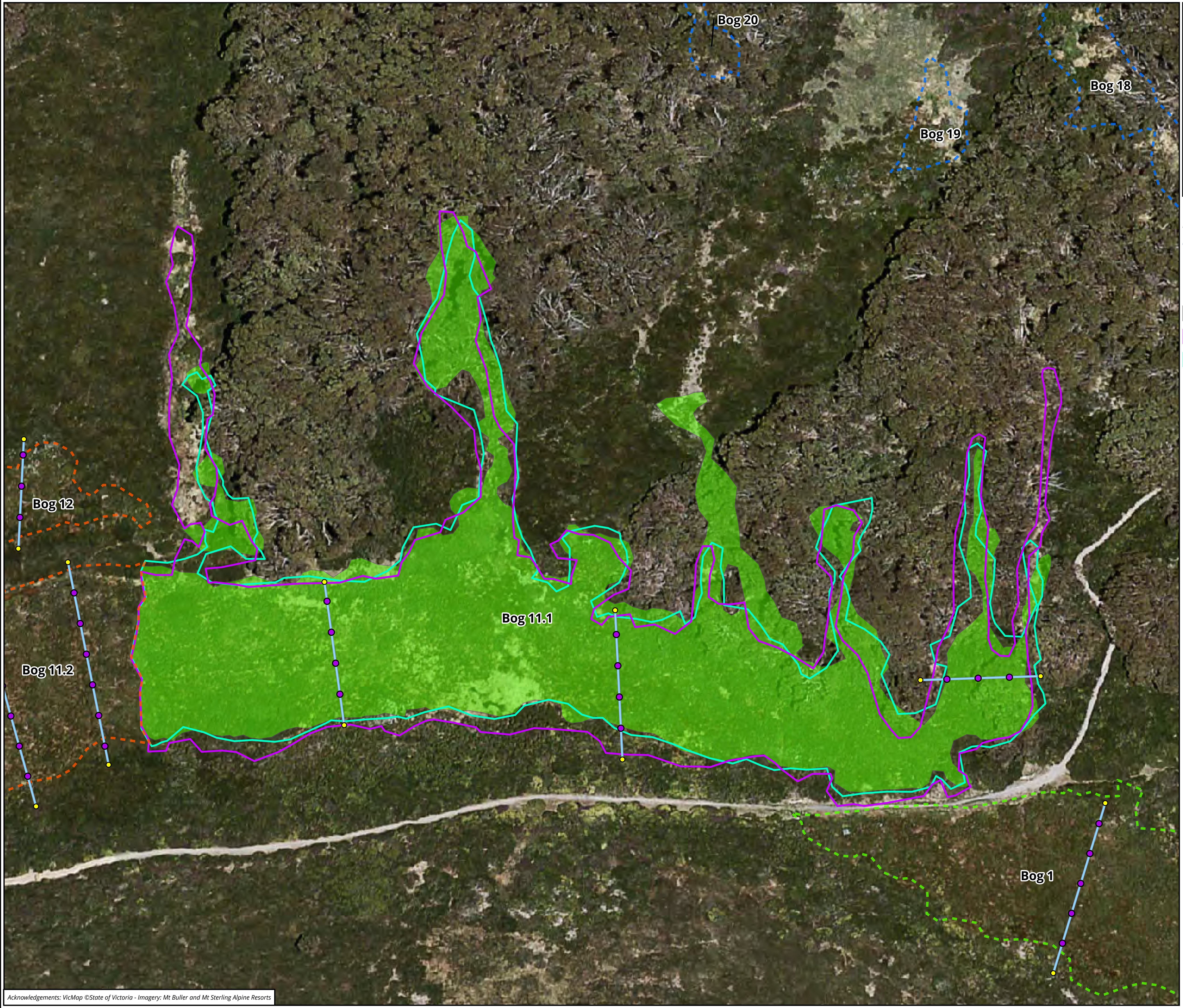


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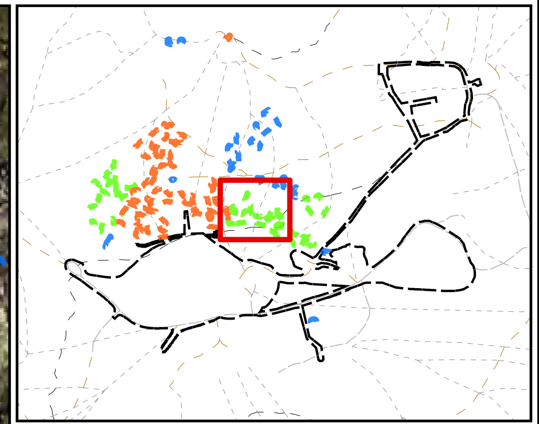

**Legend**

- Transects
- Quadrats
- Photo points
- Control site (2021)
- Baseline year 1
- Baseline year 2

**Figure 4: Bog 11.1 (control site)**

0 3.5 7 10.5 14 17.5

Metres

Scale: 1:450 @ A3

*Coordinate System: GDA 1994 MGA Zone 55*

N

biosis.

Matter: 34410,
Date: 15 June 2021 ,
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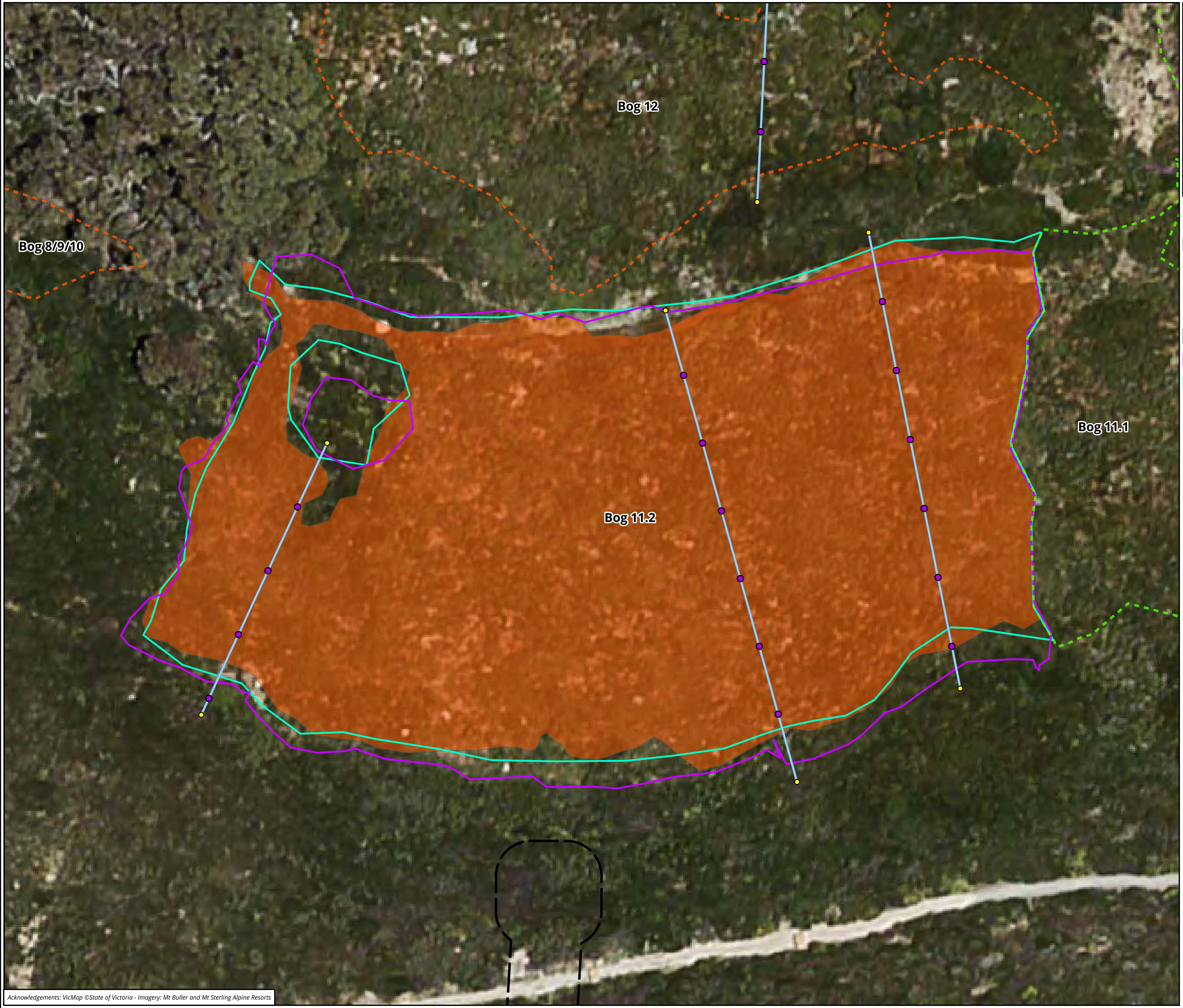


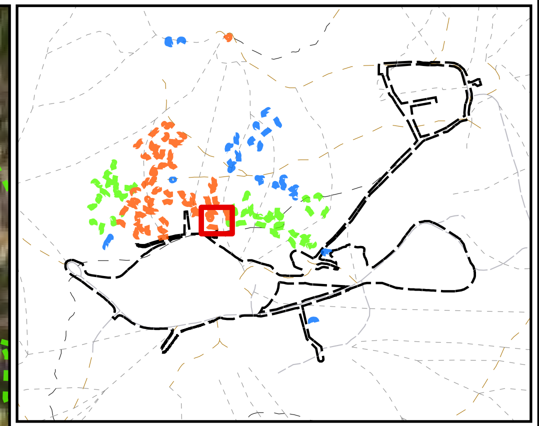

**Legend**

- Project Construction Footprint
- Transects
- Quadrats
- Photo points
- Impact site (2021)
- Baseline year 1
- Baseline year 2

**Figure 4: Bog 11.2 (impact site)**

0 1.5 3 4.5 6 7.5
Metres
Scale: 1:200 @ A3
*Coordinate System: GDA 1994 MGA Zone 55*

N

biosis.

Matter: 34410,
Date: 15 June 2021 ,
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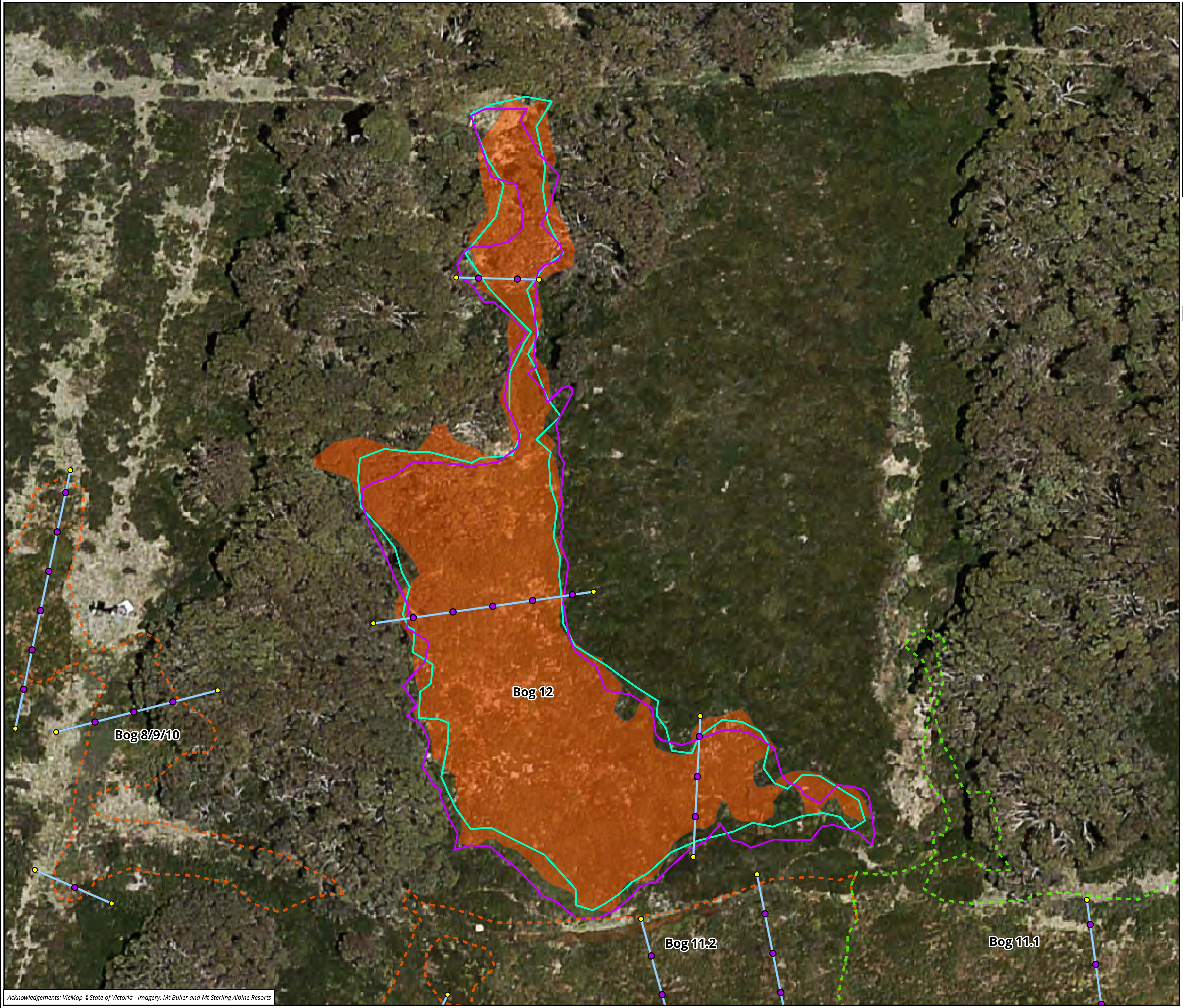
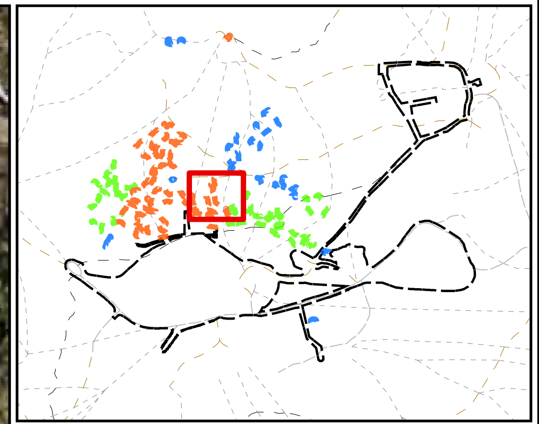


**Legend**

- Transects
- Quadrats
- Photo points
- Impact site (2021)
- Baseline year 1
- Baseline year 2

**Figure 4: Bog 12 (impact site)**

0 2.5 5 7.5 10 12.5

Metres

Scale: 1:350 @ A3

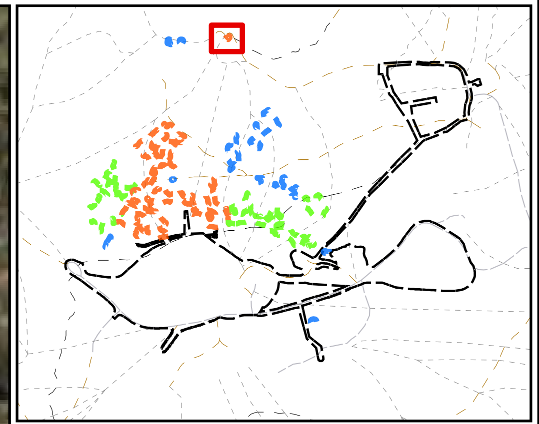
*Coordinate System: GDA 1994 MGA Zone 55*

N

biosis

Matter: 34410,
Date: 15 June 2021 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
Layout: 34410_F4_Bogs_Impact area
Project: P:\34400s\34410\Mapping\
34410_Report Figures.aprx


*Acknowledgements: VicMap ©State of Victoria - Imagery: Mt Buller and Mt Sterling Alpine Resorts*



**Legend**

- Transects
- Quadrats
- Photo points
- Impact site (2021)
- Baseline year 1
- Baseline year 2

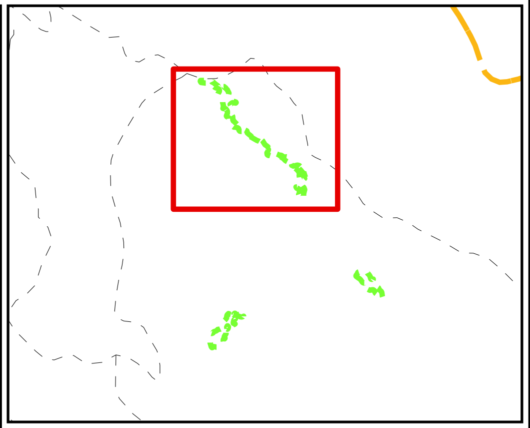
**Figure 4: Bog 13 (impact site)**

0 1.5 3 4.5 6 7.5
Metres
Scale: 1:200 @ A3
*Coordinate System: GDA 1994 MGA Zone 55*

N

biosis

Matter: 34410,
Date: 15 June 2021 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
Layout: 34410_F4_Bogs_Impact area
Project: P:\34400s\34410\Mapping\
34410_Report Figures.aprx

**Legend**

- Transects
- Quadrats
- Photo points
- Control site (2021)
- Baseline year 1
- Baseline year 2

**Figure 4: Bog S1 (control site)**

0 10 20 30 40 50

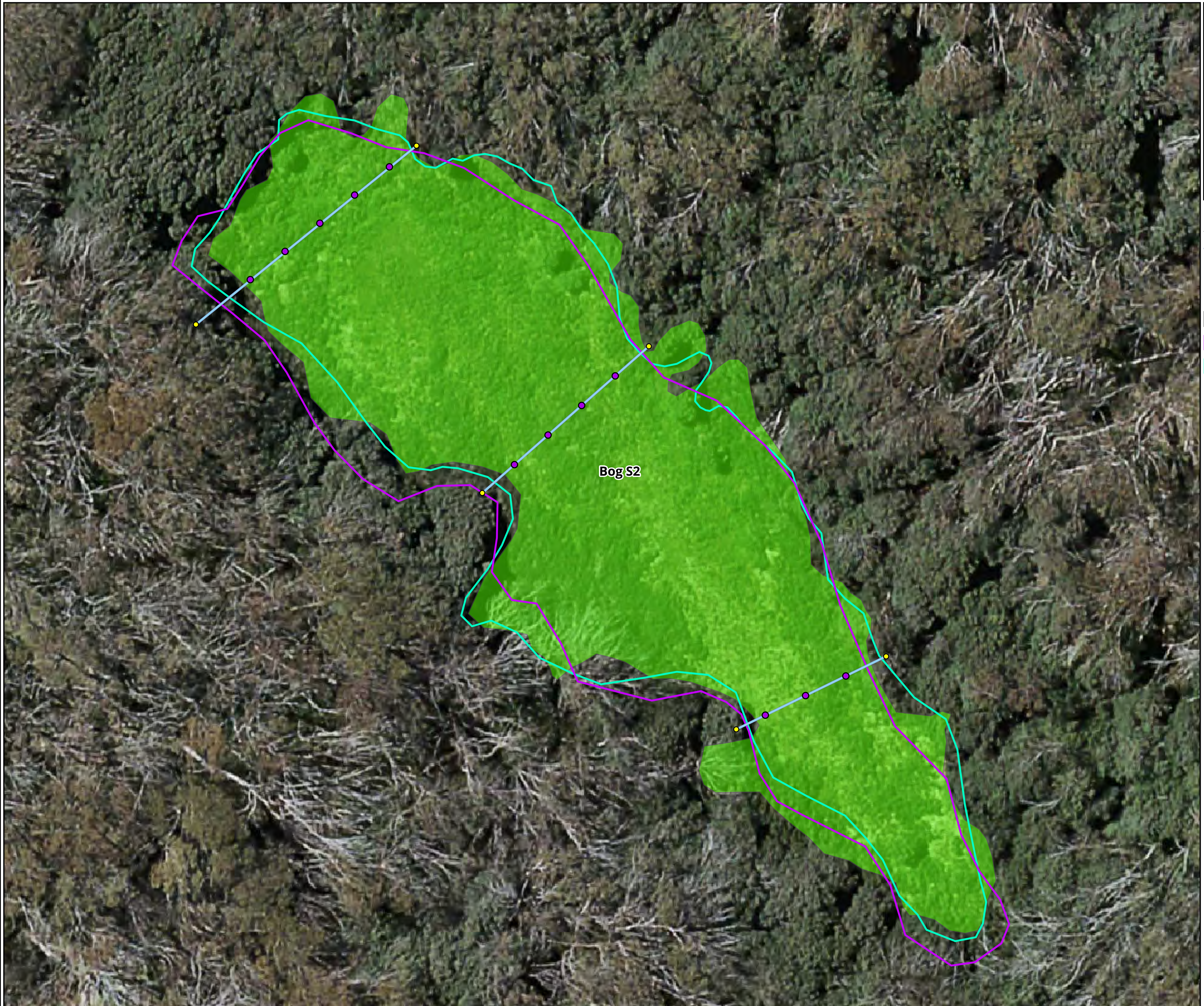
Metres

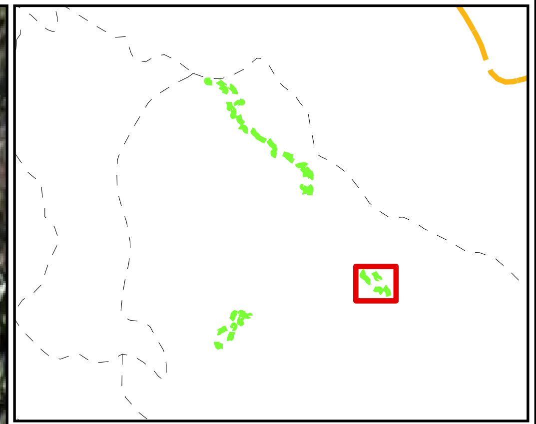
Scale: 1:1,300 @ A3

*Coordinate System: GDA 1994 MGA Zone 55*

N

Matter: 34410,
Date: 15 June 2021 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
Layout: 34410_F4_Bogs_Stirling
Project: P:\34400s\34410\Mapping\
34410_Report Figures.aprx



**Legend**

- Transects
- Quadrats
- Photo points
- Control site (2021)
- Baseline year 1
- Baseline year 2

**Figure 4: Bog S2 (control site)**

0 2.5 5 7.5 10 12.5

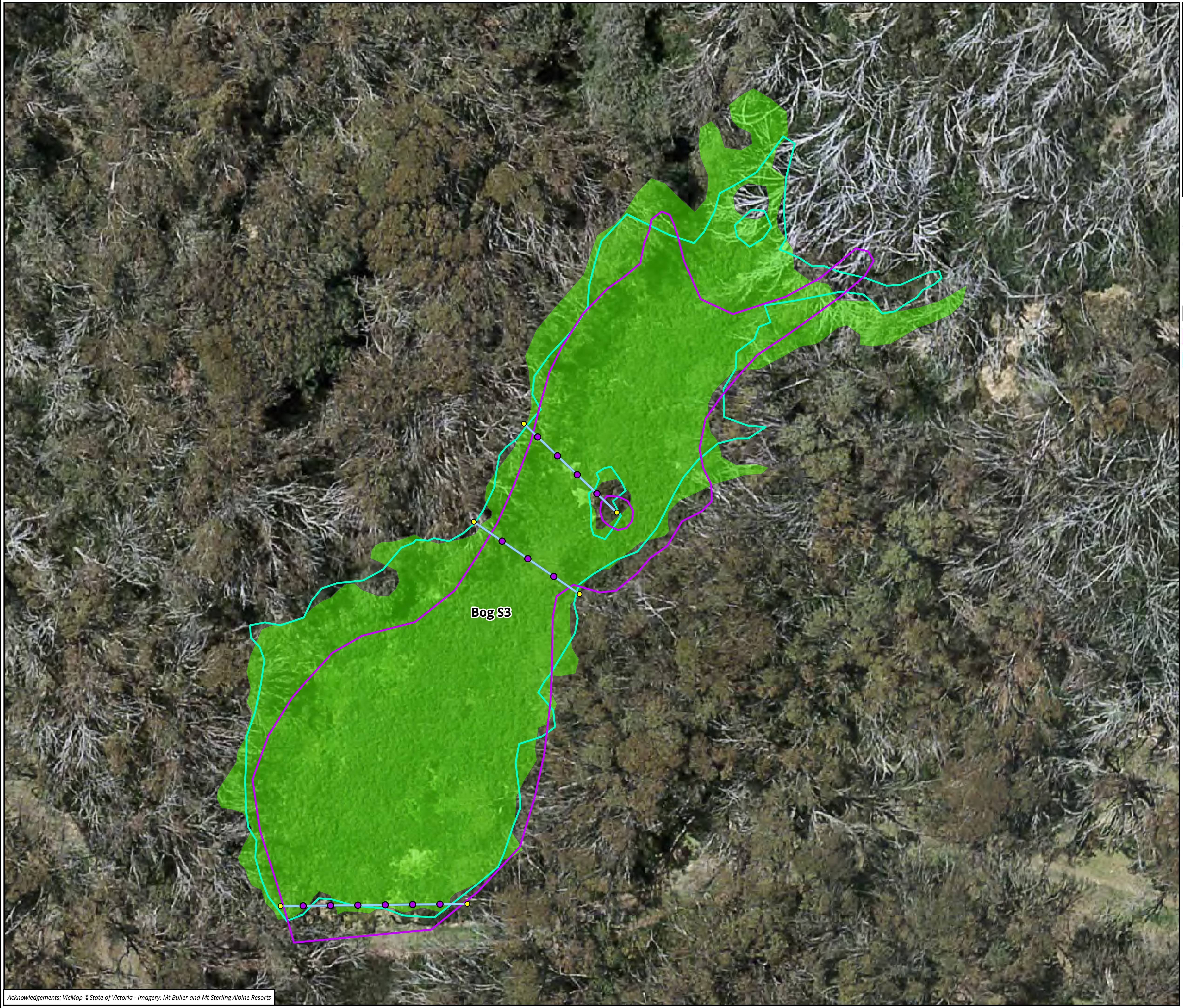
Metres

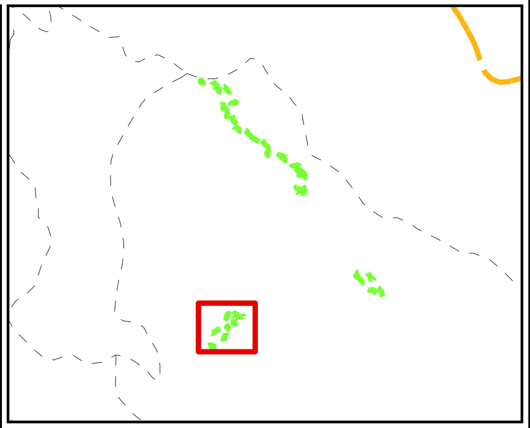
Scale: 1:320 @ A3

*Coordinate System: GDA 1994 MGA Zone 55*

Matter: 34410,
Date: 15 June 2021 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
Layout: 34410_F4_Bogs_Stirling
Project: P:\34400s\34410\Mapping\
34410_Report Figures.aprx

*Acknowledgements: VicMap ©State of Victoria - Imagery: Mt Buller and Mt Sterling Alpine Resorts*



**Legend**

- Transects
- Quadrats
- Photo points
- Control site (2021)
- Baseline year 1
- Baseline year 2

**Figure 4: Bog S3 (control site)**

0 3.5 7 10.5 14 17.5

Metres

Scale: 1:450 @ A3

*Coordinate System: GDA 1994 MGA Zone 55*

N

biosis.

Matter: 34410,
Date: 15 June 2021 ,
Prepared for: MG, Prepared by: SKM, Last edited by: smitchell
Layout: 34410_F4_Bogs_Stirling
Project: P:\34400s\34410\Mapping\
34410_Report Figures.aprx

## Photos

**Photo 1 Water meters installed at water storage drainage discharge points.**

**Photo 2 New and localised sedimentation identified in Bog 11.2 in IY2.**

**Photo 3 South-eastern boundary of Bog 4.2, where Alpine Bog vegetation has been removed.**

**Photo 4** One of the rocks that entered Bog 11.2 from the PCF in IY1 (18 February 2020).

**Photo 5** The same rock in Bog 11.2 in IY2, with death of surrounding vegetation (24 February 2021).

**Photo 6** **Sediment within Bog 6, with Yorkshire Fog and other weeds present in the background.**

**Photo 7** **Aqueduct between Bog 11.2 (right) and Bog 12 (left), facing east (BY1; 27 January 2018, before construction).**

**Photo 8** **Aqueduct between Bog 11.2 (right) and Bog 12 (left), facing east (IY1; 6 February 2020, during construction).**

**Photo 9** **Aqueduct between Bog 11.2 (right) and Bog 12 (left), facing east (IY2; 25 February 2021, after construction).**

**Photo 10 Continued sediment discharge from Bog 11.2 into the aqueduct (IY2; 25 February 2021).**

**Photo 11 Deer resting site at Bog 4.2 in IY1 (12 March 2020).**

**Photo 12 Deer resting site at Bog 4.2 in IY2 with recent sedimentation (arrow; 25 February 2021).**

**Photo 13 Deer wallow at the north-eastern edge of Bog S3 (IY1; 14 March 2020).**

**Photo 14 Deer wallow at the north-eastern edge of Bog S3 (IY2; 3 February 2021).**

**Photo 15 Example of dieback of non-bog-dependent native vegetation (right) outside of Bog 11.2 (left) in IY2 (27 January 2021)**

**Photo 16 Sword Rush infestation in Bog 4.1/5/7 in IY2.**

**Photo 17 Results of Blackberry control in IY1 in the middle of Bog S1 (IY2; 26 February 2021).**

# Appendices

# Appendix 1 HEMAMP monitoring calendar

Table A1.1 summarises the frequency and timing of the ecological, climatological and hydrological monitoring and highlights where datasets may be incomplete. The following codes are used in Table A1.1:

| Code | Meaning |
|---|---|
| Yes | Complete dataset for given month |
| Part | Partially complete dataset for given month |
| No | Missing dataset for given month |
| (C) | Data relevant to control sites |
| (I) | Data relevant to impact sites |
| (C/I) | Data relevant to control and impact sites |

**Table A1.1 Timing, frequency and completeness of HEMAMP datasets**

| | | | Baseline Year 1 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May |
| | | | | | | 2017 | | | | | | 2018 | | |
| Ecology | Transect monitoring | Control sites | | | | | | | | | Yes | | | |
| | | Impact sites | | | | | | | | Yes | Yes | | | |
| | Mapping | Control sites | | | | | | | | Yes | Yes | | | |
| | | Impact sites | | | | | | | | Yes | Yes | | | |
| Climate | Daily rainfall | Mt Buller (C/I) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | | Mt Stirling (C) | No | No | No | No | No | No | No | No | No | No | No | No |
| | Daily snow depth | Mt Buller (C/I) | Yes | Yes | Yes | Yes | Yes | | | | | | | |
| Hydrology | Surface water quality | Weir 1 Pickup 1 (C) | | | | | | No | | | Yes | | | |
| | | Weir 1 Pickup 2 (I) | | | | | | No | | | Yes | | | |
| | | Weir 2 (C/I) | | | | | | No | | | Yes | | | |
| | Groundwater quality | BH06 (C) | | | | | | No | | | Yes | | | |
| | | BH09 (I) | | | | | | No | | | Yes | | | |
| | | BH16 (C) | | | | | | No | | | Yes | | | |
| | | BH17 (I) | | | | | | No | | | Yes | | | |
| | | BH18 (C) | | | | | | No | | | Yes | | | |
| | Surface water flow | Weir 1 Pickup 1 (C) | No | No | No | No | No | No | No | No | No | No | No | No |
| | | Weir 1 Pickup 2 (I) | No | No | No | No | No | No | No | No | No | No | No | No |
| | | Weir 2 (C/I) | No | No | No | No | No | No | No | No | No | No | No | No |
| | Groundwater depth | BH06 (C) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Part | No | No | No |
| | | BH09 (I) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Part | No | No | No |
| | | BH16 (C) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Part | No | No | No |
| | | BH17 (I) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Part | No | No | No |
| | | BH18 (C) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Part | No | No | No |

| | | | Baseline Year 2 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Jun | Jul | Aug | Sep 2018 | Oct | Nov | Dec | Jan | Feb | Mar 2019 | Apr | May |
| Ecology | Transect monitoring | Control sites | | | | | | | | Yes | Yes | | | |
| | | Impact sites | | | | | | | | Yes | Yes | | | |
| | Mapping | Control sites | | | | | | | | | Yes | | | |
| | | Impact sites | | | | | | | | | Yes | | | |
| Climate | Daily rainfall | Mt Buller (C/I) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | | Mt Stirling (C) | No | No | No | No | No | Part | Yes | Yes | Yes | Yes | Yes | Part |
| | Daily snow depth | Mt Buller (C/I) | Yes | Yes | Yes | Yes | Yes | | | | | | | Yes |
| Hydrology | Surface water quality | Weir 1 Pickup 1 (C) | | | | | | Yes | | | Yes | | | |
| | | Weir 1 Pickup 2 (I) | | | | | | Yes | | | Yes | | | |
| | | Weir 2 (C/I) | | | | | | Yes | | | Yes | | | |
| | Groundwater quality | BH06 (C) | | | | | | Yes | | | Yes | | | |
| | | BH09 (I) | | | | | | Yes | | | Yes | | | |
| | | BH16 (C) | | | | | | Yes | | | Yes | | | |
| | | BH17 (I) | | | | | | Yes | | | Yes | | | |
| | | BH18 (C) | | | | | | Yes | | | Yes | | | |
| | Surface water flow | Weir 1 Pickup 1 (C) | No | No | No | No | No | No | No | Part | Part | Part | Part | Part |
| | | Weir 1 Pickup 2 (I) | No | No | No | No | No | No | No | Part | Part | Part | Part | Part |
| | | Weir 2 (C/I) | No | No | No | No | No | No | No | Part | Part | Part | Part | Part |
| | Groundwater depth | BH06 (C) | Part | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Part | No | No | No |
| | | BH09 (I) | Part | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Part | No | No | No |
| | | BH16 (C) | Part | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Part | No | No | No |
| | | BH17 (I) | Part | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Part | No | No | No |
| | | BH18 (C) | Part | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Part | No | No | No |

| | | | Impact Year 1 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Jun | Jul | Aug | Sep 2018 | Oct | Nov | Dec | Jan | Feb | Mar 2019 | Apr | May |
| Ecology | Transect monitoring | Control sites | | | | | | | | Yes | Yes | | | |
| | | Impact sites | | | | | | | | | Yes | | | |
| | Mapping | Control sites | | | | | | | | Yes | Yes | Yes | | |
| | | Impact sites | | | | | | | | Yes | Yes | Yes | | |
| Climate | Daily rainfall | Mt Buller (C/I) | Yes | Yes | Yes | Yes | Part | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | | Mt Stirling (C) | Part | Part | Part | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Daily snow depth | Mt Buller (C/I) | Yes | Yes | Yes | Yes | Yes | | | | | | | |
| Hydrology | Surface water quality | Weir 1 Pickup 1 (C) | | | | | | Yes | | | Yes | | | |
| | | Weir 1 Pickup 2 (I) | | | | | | Yes | | | Yes | | | |
| | | Weir 2 (C/I) | | | | | | Yes | | | Yes | | | |
| | Groundwater quality | BH06 (C) | | | | | | Yes | | | Yes | | | |
| | | BH09 (I) | | | | | | Yes | | | Yes | | | |
| | | BH16 (C) | | | | | | Yes | | | Yes | | | |
| | | BH17 (I) | | | | | | Yes | | | Yes | | | |
| | | BH18 (C) | | | | | | Yes | | | Yes | | | |
| | Surface water flow | Weir 1 Pickup 1 (C) | Part | Part | Part | No | No | No | No | No | No | No | No | No |
| | | Weir 1 Pickup 2 (I) | Part | Part | Part | No | No | No | No | No | No | No | No | No |
| | | Weir 2 (C/I) | Part | Part | Part | No | No | No | No | No | No | No | No | No |
| | Groundwater depth | BH06 (C) | No | No | No | No | No | No | No | No | No | No | No | No |
| | | BH09 (I) | No | No | No | No | No | No | No | No | No | No | No | No |
| | | BH16 (C) | No | No | No | No | No | No | No | No | No | No | No | No |
| | | BH17 (I) | No | No | No | No | No | No | No | No | No | No | No | No |
| | | BH18 (C) | No | No | No | No | No | No | No | No | No | No | No | No |

| | | | Impact Year 2 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Jun | Jul | Aug | Sep 2018 | Oct | Nov | Dec | Jan | Feb | Mar 2019 | Apr | May |
| Ecology | Transect monitoring | Control sites | | | | | | | | Yes | Yes | | | |
| | | Impact sites | | | | | | | | Yes | Yes | | | |
| | Mapping | Control sites | | | | | | | | | Yes | | | |
| | | Impact sites | | | | | | | | | Yes | | | |
| Climate | Daily rainfall | Mt Buller (C/I) | Yes | Yes | Part | Yes | Yes | Yes | Part | Part | Yes | Yes | Yes | Yes |
| | | Mt Stirling (C) | Part | Part | Part | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Part |
| | Daily snow depth | Mt Buller (C/I) | Yes | Yes | Yes | Yes | Yes | | | | | | | |
| Hydrology | Surface water quality | Weir 1 Pickup 1 (C) | | | | | | Yes | | | Yes | | | |
| | | Weir 1 Pickup 2 (I) | | | | | | Yes | | | Yes | | | |
| | | Weir 2 (C/I) | | | | | | Yes | | | Yes | | | |
| | Groundwater quality | BH06 (C) | | | | | | Yes | | | Yes | | | |
| | | BH09 (I) | | | | | | No | | | No | | | |
| | | BH16 (C) | | | | | | Yes | | | Yes | | | |
| | | BH17 (I) | | | | | | Yes | | | Yes | | | |
| | | BH18 (C) | | | | | | Yes | | | Part | | | |
| | Surface water flow | Weir 1 Pickup 1 (C) | No | No | No | No | No | No | No | No | No | No | No | No |
| | | Weir 1 Pickup 2 (I) | No | No | No | No | No | No | No | No | No | No | No | No |
| | | Weir 2 (C/I) | No | No | No | No | No | No | No | No | No | No | No | No |
| | Groundwater depth | BH06 (C) | No | No | No | No | No | No | No | No | No | No | No | No |
| | | BH09 (I) | No | No | No | No | No | No | No | No | No | No | No | No |
| | | BH16 (C) | No | No | No | No | No | No | No | No | No | No | No | No |
| | | BH17 (I) | No | No | No | No | No | No | No | No | No | No | No | No |
| | | BH18 (C) | No | No | No | No | No | No | No | No | No | No | No | No |

# Appendix 2 Flora species lists

The following status codes are used in this Appendix:

| Code | Meaning | Notes |
|---|---|---|
| **National significance** | | |
| CR | Critically endangered | Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) |
| EN | Endangered | |
| VU | Vulnerable | |
| **State significance** | | |
| cr | Critically endangered | Victorian *Flora and Fauna Guarantee Act 1988* (FFG Act) |
| e | Endangered | |
| v | Vulnerable | |
| P | Protected species (public land only) | |
| **Noxious weed status** | | |
| SP | State prohibited species | Victorian *Catchment and Land Protection Act 1994* (CaLP Act) statuses within the Goulburn Broken/North East catchments |
| RP | Regionally prohibited species | |
| RC | Regionally controlled species | |
| R | Restricted species | |
| **Other** | | |
| # | Native species outside its natural range | Assessed using VBA (DELWP 2021) and VicFlora (RBGV 2021) |
| ^ | Bog-dependent species | Refer to Diagnostic Key to Alpine Bogs (Appendix 3) |

**Table A2.1 Flora species list for all Alpine Bogs**

| Status | Scientific Name | Common Name |
|---|---|---|
| **Indigenous species** | | |
| | *Acaena novae-zelandiae* | Bidgee-widgee |
| | *Achrophyllum dentatum* | Toothed Mitre-moss |
| e P | *Aciphylla glacialis* | Snow Aciphyll |
| e P | *Acrothamnus montanus* | Snow Beard-heath |
| | *Agrostis parviflora s.s.* | Hair Bent |
| | *Anthosachne scabra s.s.* | Common Wheat-grass |
| e P | *Argyrotegium poliochlorum* | Grey-green Cudweed |
| P | *Asperula conferta* | Common Woodruff |
| P | *Asperula gunnii* | Mountain Woodruff |
| ^ | *Astelia alpina* var. *novae-hollandiae* | Silver Astelia |
| P ^ | *Baeckea gunniana* | Alpine Baeckea |
| e P ^ | *Baeckea latifolia* | Subalpine Baeckea |
| P ^ | *Baeckea utilis s.s.* | Mountain Baeckea |
| | *Bartramia robusta* | Common Apple-moss |
| P | *Blechnum penna-marina* subsp. *alpina* | Alpine Water-fern |
| P | *Brachyscome scapigera* | Tufted Daisy |
| P | *Brachyscome spathulata* | Spoon Daisy |
| | *Brachythecium paradoxum* | Feather Moss |
| | *Brachythecium rutabulum* | Rough-stalked Feather-moss |
| | *Brachythecium salebrosum* | Smooth-stalk Feather-moss |
| | *Brachythecium* spp. | Feather Moss |
| ^ | *Callistemon pityoides* | Alpine Bottlebrush |
| | *Campylopus introflexus* | Heath Star Moss |
| | *Carex appressa* | Tall Sedge |
| | *Carex austroflaccida* | Mountain Hook-sedge |
| | *Carex breviculmis* | Common Grass-sedge |
| e ^ | *Carex jackiana* | Carpet Sedge |
| | *Carex* spp. | Sedge |
| | *Catagonium nitens* subsp. *nitens* | Feather-tail Moss |
| e P | *Celmisia latifolia* | Victorian Snow-daisy |
| P | *Celmisia* spp. | Snow Daisy |
| v P | *Celmisia tomentella* | Silver Snow-daisy |
| P | *Chiloglottis cornuta* | Green Bird-orchid |
| P | *Chiloglottis* spp. | Bird Orchid |
| | *Chiloscyphus semiteres* var. *semiteres* | Common Crestwort |
| | *Chiloscyphus trialatus* (syn. *Chiloscyphus pallidus*) | Greasy Crestwort |
| | *Clematis aristata* | Mountain Clematis |
| P | *Coronidium monticola* | Mountain Everlasting |
| P | *Cotula alpina* | Alpine Cotula |
| e P | *Craspedia adenophora* | Sticky Billy-buttons |
| P | *Craspedia aurantia s.l.* | Orange/Green Billy-buttons |
| e P | *Craspedia lamicola* | Bog Billy-buttons |

| Status | Scientific Name | Common Name |
|---|---|---|
| P | *Craspedia* spp. | Billy Buttons |
| e P | *Craspedia sylvestris* | Mountain Forest Billy-buttons |
| ^ | *Empodisma minus* | Spreading Rope-rush |
| P ^ | *Epacris paludosa* | Swamp Heath |
| | *Epilobium billardiereanum* subsp. *billardiereanum* | Smooth Willow-herb |
| | *Epilobium billardiereanum* subsp. *hydrophilum* | Robust Willow-herb |
| v | *Epilobium sarmentaceum* | Mountain Willow-herb |
| | *Epilobium* spp. | Willow Herb |
| | *Eucalyptus pauciflora* | Snow Gum |
| P | *Euchiton involucratus s.s.* | Star Cudweed |
| P | *Euchiton sphaericus* | Annual Cudweed |
| P | *Euchiton* spp. | Cudweed |
| | *Exocarpos nanus* | Alpine Ballart |
| | *Gemmabryum sauteri* | Sauter's Thread-moss |
| | *Gentianella cunninghamii* subsp. *major* | Tall Snow-gentian |
| v | *Gentianella muelleriana* subsp. *willisiana* | Mt Buller Snow-gentian |
| | *Geranium potentilloides* var. 1 | Soft Crane's-bill |
| | *Geranium* sp. 7 | Alpine Swamp Crane's-bill |
| | *Gonocarpus micranthus* | Creeping Raspwort |
| | *Gonocarpus montanus* | Mat Raspwort |
| | *Gonocarpus tetragynus* | Common Raspwort |
| | *Goodenia hederacea* | Ivy Goodenia |
| P | *Grevillea australis* | Alpine Grevillea |
| | *Grimmia pulvinata* var. *africana* | Blunt-beak Grimmia |
| ^ | *Hierochloe redolens* | Sweet Holy-grass |
| | *Hovea montana* | Alpine Rusty-pods |
| e P | *Huperzia australiana* | Fir Clubmoss |
| | *Hydrocotyle hirta* | Hairy Pennywort |
| | *Hydrocotyle* spp. | Pennywort |
| | *Hygrolembidium acrocladum* | Fingerwort |
| | *Hymenodontopsis mnioides* (syn. *Pyrrhobryum mnioides*) | Woolly-stem Thyme-moss |
| | *Hypericum japonicum* | Matted St John's Wort |
| | *Isolepis aucklandica* | New Zealand Club-sedge |
| | *Isolepis habra* | Wispy Club-sedge |
| e | *Isolepis montivaga* | Fog Club-sedge |
| | *Isolepis* spp. | Club Sedge |
| | *Isolepis subtilissima* | Mountain Club-sedge |
| P | *Lagenophora montana* | Mountain Bottle-daisy |
| P | *Lagenophora stipitata s.s.* | Blue Bottle-daisy |
| | *Leionema phylicifolium* | Alpine Leionema |
| | *Leptospermum grandifolium* | Mountain Tea-tree |
| | *Libertia pulchella* | Pretty Grass-flag |
| | *Luzula modesta* | Southern Woodrush |
| | *Luzula* spp. | Woodrush |

| Status | Scientific Name | Common Name |
|---|---|---|
| P | *Lycopodium fastigiatum* | Mountain Clubmoss |
| cr P | *Lycopodium scariosum* | Spreading Clubmoss |
| | *Marchantia berteroana* | Common Marchantia |
| | *Melicytus* sp. aff. *dentatus* (snowfields variant) | Alpine Shrub-violet |
| | *Mentha laxiflora* | Forest Mint |
| P | *Microseris lanceolata* | Alpine Yam-daisy |
| P ^ | *Olearia algida* | Mountain Daisy-bush |
| e P | *Olearia phlogopappa* subsp. *flavescens* | Dusty Daisy-bush |
| | *Oreobolus distichus* | Fan Tuft-rush |
| | *Oreomyrrhis eriopoda* | Australian Caraway |
| | *Orites lancifolius* | Alpine Orites |
| | *Orthodontium lineare* | Cape Thread-moss |
| P | *Ozothamnus cupressoides* | Kerosene Bush |
| e | *Phebalium squamulosum* subsp. *alpinum* | Alpine Phebalium |
| P | *Picris angustifolia* subsp. *merxmuelleri* | Highland Picris |
| | *Pimelea alpina* | Alpine Rice-flower |
| | *Pimelea ligustrina* | Tall Rice-flower |
| | *Pimelea* spp. | Rice Flower |
| | *Plantago euryphylla* | Broad Plantain |
| | *Poa costiniana* | Bog Snow-grass |
| | *Poa ensiformis* | Sword Tussock-grass |
| | *Poa fawcettiae* | Horny Snow-grass |
| | *Poa hiemata* | Soft Snow-grass |
| | *Poa hothamensis* | Ledge Grass |
| | *Poaceae* spp. | Grass |
| | *Podocarpus lawrencei* | Mountain Plum-pine |
| P | *Podolepis robusta* | Alpine Podolepis |
| P | *Podolepis* spp. | Podolepis |
| | *Podolobium alpestre* | Alpine Podolobium |
| P | *Polystichum proliferum* | Mother Shield-fern |
| | *Polytrichum commune* | Common Haircap |
| | *Polytrichum* spp. | Haircap |
| P | *Prasophyllum alpestre* | Mauve Leek-orchid |
| P | *Prasophyllum* spp. | Leek Orchid |
| | *Ptychostomum pseudotriquetrum* | Bog Bryum |
| | *Ranunculus graniticola* | Granite Buttercup |
| e | *Ranunculus gunnianus* | Gunn's Alpine Buttercup |
| | *Ranunculus lappaceus* | Australian Buttercup |
| | *Ranunculus pimpinellifolius* | Bog Buttercup |
| | *Ranunculus scapiger* | Hairy Buttercup |
| | *Ranunculus* spp. | Buttercup |
| | *Rhaphidorrhynchium amoenum* | Common Signal-moss |
| P ^ | *Richea continentis* | Candle Heath |
| | *Rosulabryum capillare* | Capillary Thread-moss |
| | *Rubus parvifolius* | Small-leaf Bramble |

| Status | Scientific Name | Common Name |
|---|---|---|
| | *Rumex brownii* | Slender Dock |
| | *Rytidosperma nudiflorum* | Alpine Wallaby-grass |
| | *Rytidosperma penicillatum* | Weeping Wallaby-grass |
| | *Rytidosperma* spp. | Wallaby Grass |
| | *Sanionia uncinata* | Sickle-leaved Hook-moss |
| | *Schoenus calyptratus* | Alpine Bog-sedge |
| e | *Scleranthus brockiei* | Brock Knawel |
| P | *Senecio gunnii* | Mountain Fireweed |
| e P | *Senecio pinnatifolius* var. *alpinus* | Snowfield Groundsel |
| P ^ | *Sphagnum cristatum* | Peat Moss |
| | *Stellaria pungens* | Prickly Starwort |
| P | *Stylidium armeria* subsp. *armeria* | Common Triggerplant |
| e P | *Stylidium montanum* | Alpine Triggerplant |
| P | *Stylidium* spp. | Trigger Plant |
| | *Tasmannia xerophila* subsp. *xerophila* | Alpine Pepper |
| P | *Thelymitra* spp. | Sun Orchid |
| e P | *Trochocarpa clarkei* | Lilac Berry |
| | *Veronica serpyllifolia* | Thyme Speedwell |
| | *Viola betonicifolia* | Showy Violet |
| | *Wahlenbergia ceracea* | Waxy Bluebell |
| | *Wahlenbergia gloriosa* | Royal Bluebell |
| P | *Xerochrysum subundulatum* | Orange Everlasting |
| | *Zoopsis leitgebiana* | Glass Centipede |
| **Introduced species** | | |
| | *Acetosella vulgaris* | Sheep Sorrel |
| | *Achillea millefolium* | Milfoil |
| | *Agrostis capillaris* | Brown-top Bent |
| | *Anthoxanthum odoratum* | Sweet Vernal-grass |
| | *Cerastium glomeratum s.s.* | Sticky Mouse-ear Chickweed |
| | *Cerastium* spp. | Mouse-ear Chickweed |
| | *Cerastium vulgare* | Common Mouse-ear Chickweed |
| R/RC | *Cirsium vulgare* | Spear Thistle |
| | *Dactylis glomerata* | Cocksfoot |
| | *Erythranthe guttata* | Monkey Musk |
| | *Erythranthe moschata* | Musk Monkey-flower |
| | *Festuca rubra s.s.* | Creeping Fescue |
| | *Glyceria declinata* | Manna Grass |
| | *Holcus lanatus* | Yorkshire Fog |
| | *Hypochaeris radicata* | Flatweed |
| | *Juncus articulatus* subsp. *articulatus* | Jointed Rush |
| | *Juncus effusus* subsp. *effusus* | Soft Rush |
| | *Juncus ensifolius* | Sword Rush |
| | *Malus pumila* | Apple |
| | *Phleum pratense* | Timothy Grass |

| Status | Scientific Name | Common Name |
|---|---|---|
| | *Ranunculus repens* | Creeping Buttercup |
| RC | *Rubus anglocandicans* | Common Blackberry |
| | *Rumex conglomeratus* | Clustered Dock |
| | *Sonchus asper s.s.* | Rough Sow-thistle |
| | *Taraxacum officinale* spp. agg. | Garden Dandelion |
| | *Trifolium repens* var. *repens* | White Clover |
| | *Viola arvensis* | Field Pansy |

### Table A2.2 Bog-dependent flora species list

| Status | Scientific Name | Common Name |
|---|---|---|
| ^ | *Astelia alpina* var. *novae-hollandiae* | Silver Astelia |
| P ^ | *Baeckea gunniana* | Alpine Baeckea |
| e P ^ | *Baeckea latifolia* | Subalpine Baeckea |
| P ^ | *Baeckea utilis s.s.* | Mountain Baeckea |
| ^ | *Callistemon pityoides* | Alpine Bottlebrush |
| e ^ | *Carex jackiana* | Carpet Sedge |
| ^ | *Empodisma minus* | Spreading Rope-rush |
| P ^ | *Epacris paludosa* | Swamp Heath |
| ^ | *Hierochloe redolens* | Sweet Holy-grass |
| P ^ | *Olearia algida* | Mountain Daisy-bush |
| P ^ | *Richea continentis* | Candle Heath |
| P ^ | *Sphagnum cristatum* | Peat Moss |

### Table A2.3 Differences between Mountain Baeckea and Subalpine Baeckea

| Feature | Mountain Baeckea *Baeckea utilis s.s.* | Subalpine Baeckea *Baeckea latifolia* | Reference |
|---|---|---|---|
| Plant height | Up to 4 m (1–3 m) | Up to 1.5 m (1–3 m) | Bean 1997 (VicFlora 2021) |
| Branchlets | Yellowish to grey; oil glands absent | Pink to grey; oil glands present | Bean 1997 |
| Leaf shape | Narrowly obovate to elliptical (Oblanceolate to elliptic) | Broadly elliptical (Elliptic or obovate) | Bean 1997 (VicFlora 2021) |
| Leaf keel | Keeled or not keeled (Keeled) | Not keeled (Not distinctly keeled) | Bean 1997 (VicFlora 2021) |
| Leaf cross-section | Triangular, concavo-convex (More or less flat above) | Flat (More or less flat) | Bean 1997 (VicFlora 2021) |
| Leaf length | 3.4–7.0 mm (4.0–10.0 mm) | 6.4–9.0 mm (6.0–9.0 mm) | Bean 1997 (VicFlora 2021) |
| Leaf width | 0.9–2.3 mm (1.0–3.0 mm) | 2.3–5.3 mm (2.0–6.0 mm) | Bean 1997 (VicFlora 2021) |
| Petiole length | 0.5–0.8 mm | 1.2–1.5 mm | Bean 1997 |
| Pedicel length | 1.6–2.5 mm | 3.0–3.3 mm | Bean 1997 and VicFlora 2021 |
| Stamens | 8–10 (8–10, usually 8) | 6–8 (6–8, usually 8) | Bean 1997 (VicFlora 2021) |

# Appendix 3 Diagnostic Key to Alpine Bogs

This diagnostic key has been reproduced from the key to the EPBC Act listed Alpine Sphagnum Bogs and Associated Fens ecological community on the Australian mainland, prepared by the Australian Government Department of the Environment (DoE 2013). The key appeared in early draft versions of the National Recovery Plan but does not appear in the final version, although the final version does make reference to the key (DoE 2015; A. Tolsma, ARI, pers. comm., February 2019).

# Key to the listed Alpine *Sphagnum* bogs and Associated Fens ecological community on the Australian mainland

The listed ecological community comprises two main components, *Sphagnum* bogs and their associated fens. Fens, or fen pools, are species-poor communities typically linked to bogs. They are dominated by sedges and frequently inundated. The bogs which surround or link to fens generally display greater species diversity, and it is this diversity which in part guides the following key.

1. Are you above 1000m in elevation and in the Australian Alps bioregion?
Yes – go to 2 | No – Unlikely to be the listed community

2. Is live, hummock-forming *Sphagnum* present and abundant, or if burnt[1], can abundant pre-fire *Sphagnum* be inferred from burnt remnants?
Yes – Is the listed community | No, *Sphagnum* is minor or absent – go to 3

3. Does the site have a peat substrate evident?
Yes, or unsure – go to 4 | No – Unlikely to be the listed community

4. Is *Sphagnum* present?
Yes – go to 5 | No – go to 6

5. Is most of the non-*Sphagnum* vegetation cover composed of two or more of the diagnostic species listed below?
Yes – Is the listed community. | No – Not the listed community, but may be transitional or a degraded version[2]

6. Is most of the vegetation cover composed of 3 or more of the diagnostic species?
Yes – Is the listed community, possibly degraded. | No – Not the listed community, but may be transitional or a degraded version[2]

<u>Diagnostic species other than *Sphagnum*:</u>

- *Empodisma minus*
- *Epacris* spp (usually *E. paludosa, E. glacialis, E. celata or E. breviflora*)
- *Richea* spp (*R. continentis or R. victoriana*)
- *Baeckea* spp (usually *B. gunniana, B. latifolia or B.utilis*)
- *Astelia alpina*
- *Carpha nivicola*
- *Baloskion australe*
- *Carex gaudichaudiana*
- *Callistemon pityoides*
- *Hakea microcarpa*
- *Carex jackiana*[3]
- *Hierochloe redolens*[3]
- *Olearia algida*[3]

[1] If a site has been recently and severely burnt, *Sphagnum* and other key diagnostic species may be temporarily absent (live hummock-forming *Sphagnum* would normally comprise at least 20-30% cover).In this case, assessment of the site for the listed community should be delayed for at least 24 months. However, the presence of burnt hummocks over peat indicates the community is present.

[2] Clarification: no need to refer.

[3] This key originally appeared in a draft version of the National Recovery Plan for the Alpine Sphagnum Bogs and Associated Fens. The key has been left unchanged except for the addition of these three species and this footnote. These species have been added by Biosis for the purposes of monitoring Alpine Bogs at Mount Buller and Mount Stirling, Victoria. At these locations, Carex jackiana, Hierochloe redolens and Olearia algida are restricted to Alpine Bogs and are therefore amongst the diagnostic species.

# Appendix 4 Photo points

# Bog 1

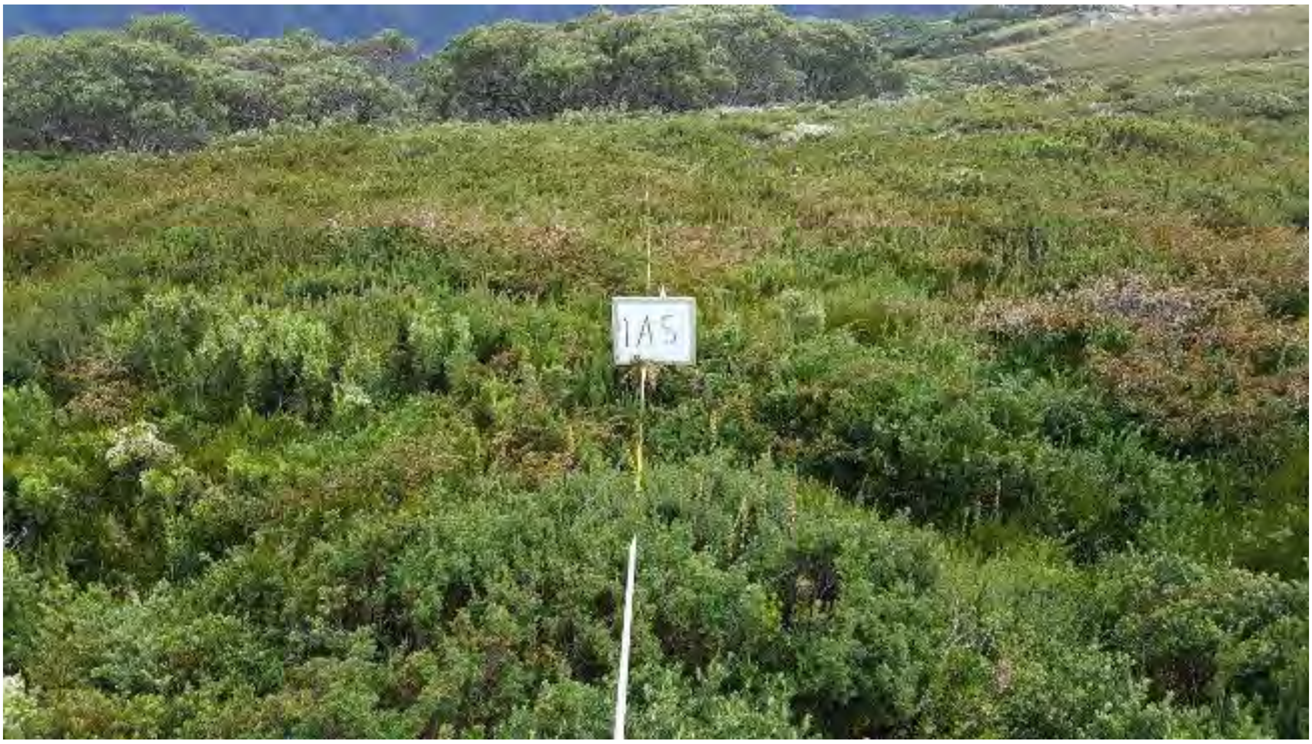



**Photo Point 1AS, Bog 1 (Control), Baseline Year 1, 9 February 2018**

**Photo Point 1AS, Bog 1 (Control), Baseline Year 2, 31 January 2019**

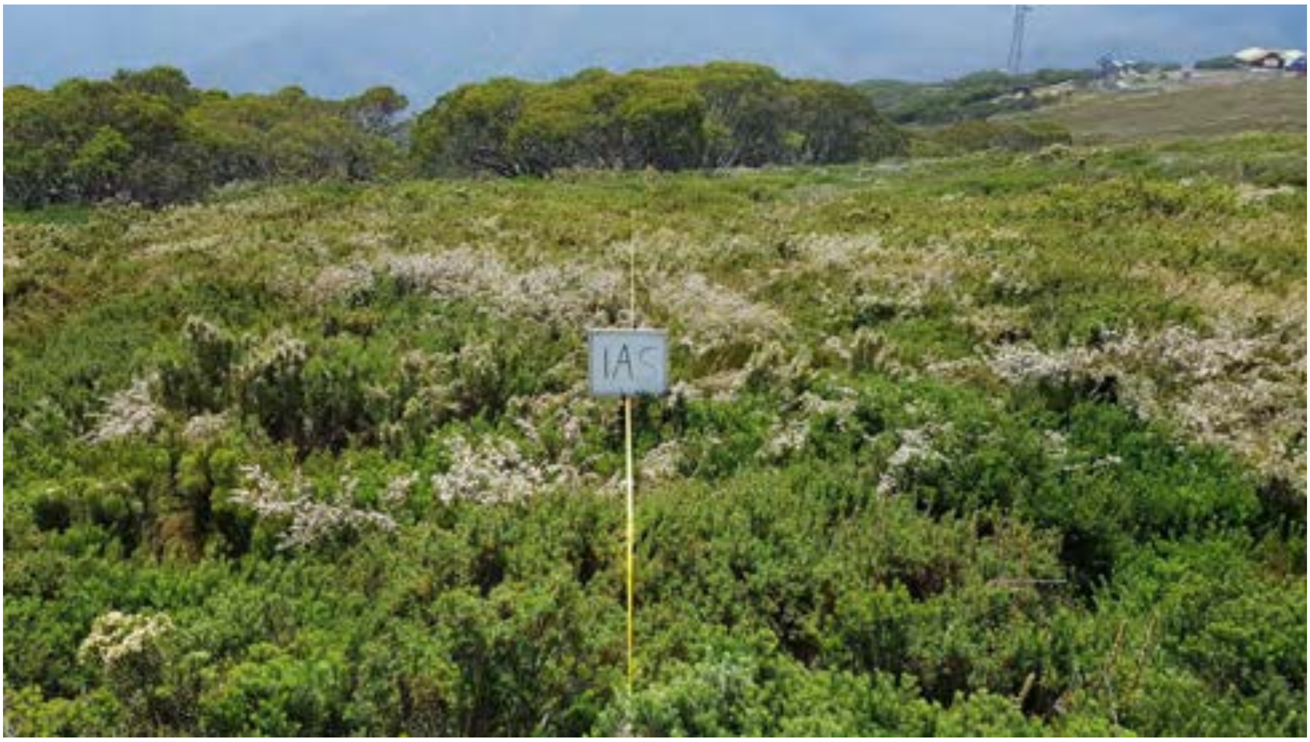



**Photo Point 1AS, Bog 1 (Control), Impact Year 1, 31 January 2020**


**Photo Point 1AS, Bog 1 (Control), Impact Year 2, 2 February 2021**


**Photo Point 1AE, Bog 1 (Control), Baseline Year 1, 9 February 2018**

**Photo Point 1AE, Bog 1 (Control), Baseline Year 2, 31 January 2019**


**Photo Point 1AE, Bog 1 (Control), Impact Year 1, 31 January 2020**


**Photo Point 1AE, Bog 1 (Control), Impact Year 2, 2 February 2021**


**Photo Point 1BS, Bog 1 (Control), Baseline Year 1, 9 February 2018**

**Photo Point 1BS, Bog 1 (Control), Baseline Year 2, 31 January 2019**

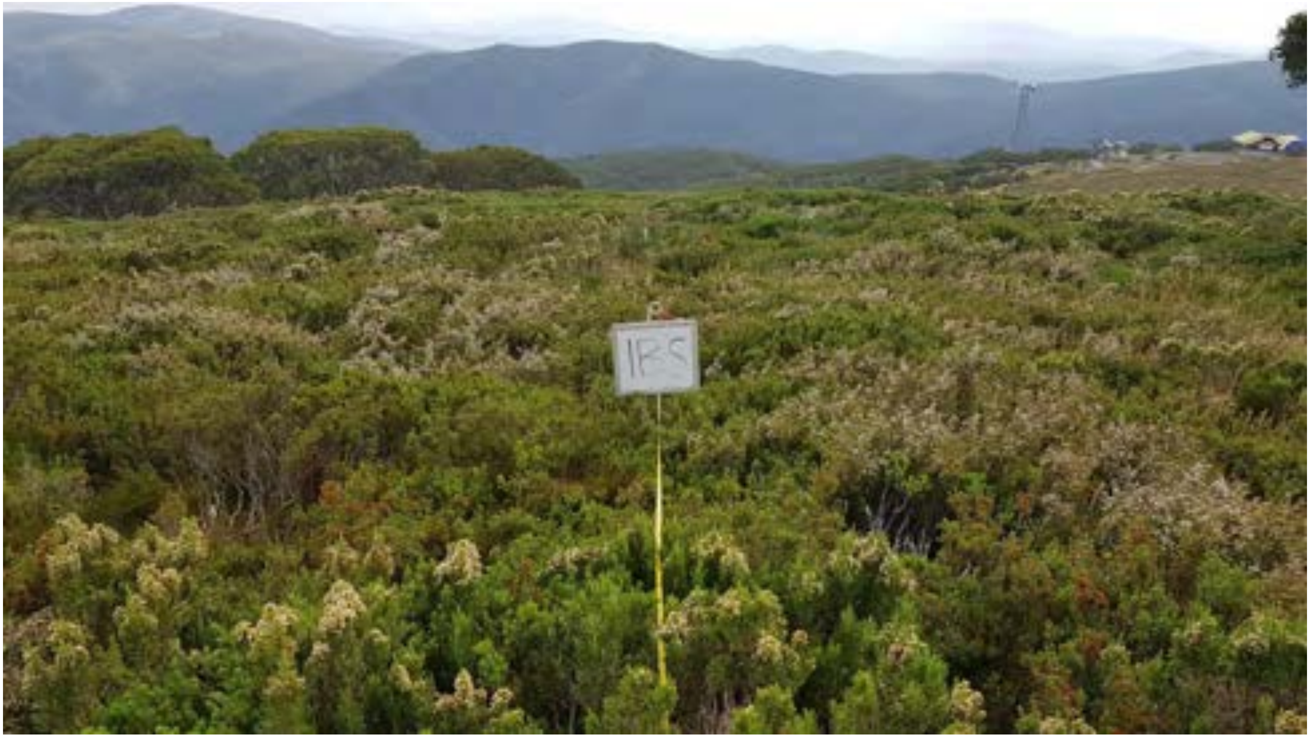



**Photo Point 1BS, Bog 1 (Control), Impact Year 1, 31 January 2020**


**Photo Point 1BS, Bog 1 (Control), Impact Year 2, 2 February 2021**


**Photo Point 1BE, Bog 1 (Control), Baseline Year 1, 9 February 2018**


**Photo Point 1BE, Bog 1 (Control), Baseline Year 2, 31 January 2019**


**Photo Point 1BE, Bog 1 (Control), Impact Year 1, 31 January 2020**


**Photo Point 1BE, Bog 1 (Control), Impact Year 2, 2 February 2021**


**Photo Point 1CS, Bog 1 (Control), Baseline Year 1, 9 February 2018**


**Photo Point 1CS, Bog 1 (Control), Baseline Year 2, 31 January 2019**


**Photo Point 1CS, Bog 1 (Control), Impact Year 1, 31 January 2020**


**Photo Point 1CS, Bog 1 (Control), Impact Year 2, 2 February 2021**


**Photo Point 1CE, Bog 1 (Control), Baseline Year 1, 9 February 2018**

**Photo Point 1CE, Bog 1 (Control), Baseline Year 2, 31 January 2019**


**Photo Point 1CE, Bog 1 (Control), Impact Year 1, 31 January 2020**


**Photo Point 1CE, Bog 1 (Control), Impact Year 2, 2 February 2021**

## Bog 2


**Photo Point 2AS, Bog 2 (Control), Baseline Year 1, 9 February 2018**

**Photo Point 2AS, Bog 2 (Control), Baseline Year 2, 31 January 2019**


**Photo Point 2AS, Bog 2 (Control), Impact Year 1, 3 February 2020**


**Photo Point 2AS, Bog 2 (Control), Impact Year 2, 26 January 2021**


**Photo Point 2AE, Bog 2 (Control), Baseline Year 1, 9 February 2018**


**Photo Point 2AE, Bog 2 (Control), Baseline Year 2, 31 January 2019**


**Photo Point 2AE, Bog 2 (Control), Impact Year 1, 3 February 2020**

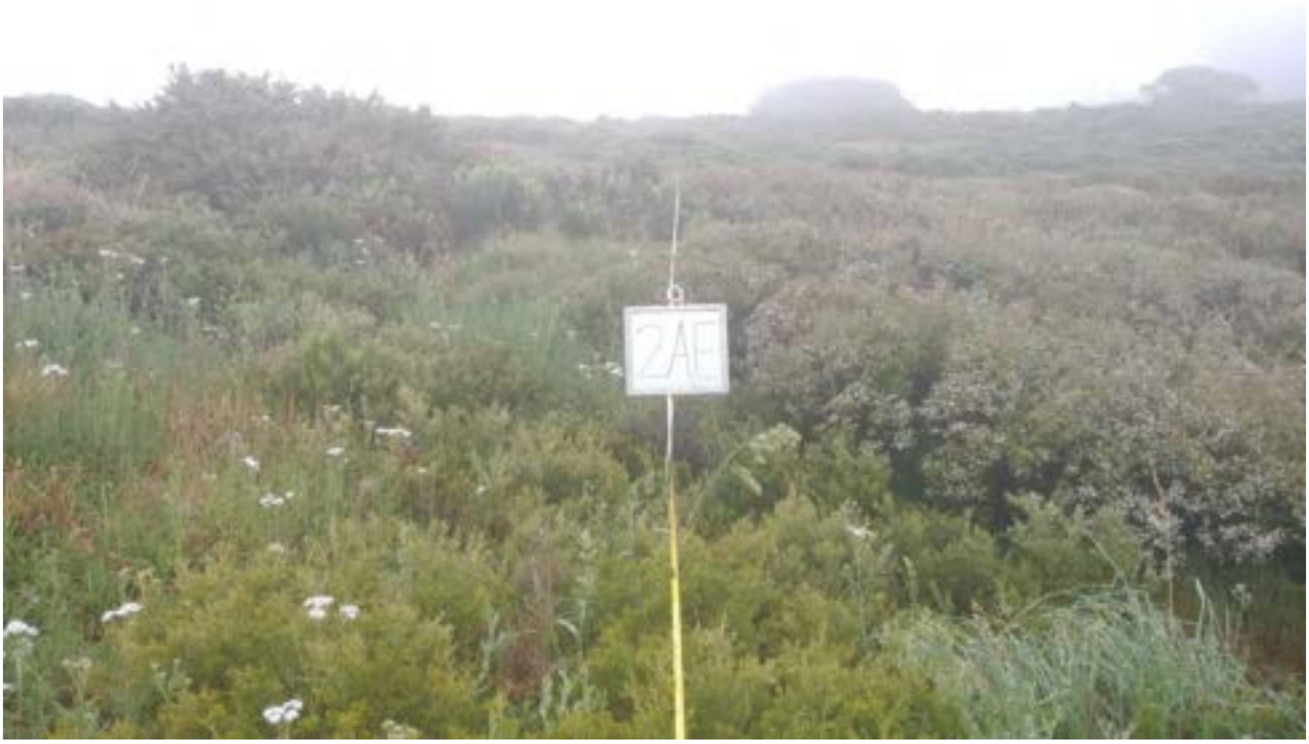



**Photo Point 2AE, Bog 2 (Control), Impact Year 2, 26 January 2021**


**Photo Point 2BS, Bog 2 (Control), Baseline Year 1, 9 February 2018**

**Photo Point 2BS, Bog 2 (Control), Baseline Year 2, 1 February 2019**


**Photo Point 2BS, Bog 2 (Control), Impact Year 1, 3 February 2020**


**Photo Point 2BS, Bog 2 (Control), Impact Year 2, 25 January 2021**


**Photo Point 2BE, Bog 2 (Control), Baseline Year 1, 9 February 2018**


**Photo Point 2BE, Bog 2 (Control), Baseline Year 2, 1 February 2019**


**Photo Point 2BE, Bog 2 (Control), Impact Year 1, 3 February 2020**


**Photo Point 2BE, Bog 2 (Control), Impact Year 2, 25 January 2021**


**Photo Point 2CS, Bog 2 (Control), Baseline Year 1, 9 February 2018**

**Photo Point 2CS, Bog 2 (Control), Baseline Year 2, 1 February 2019**


**Photo Point 2CS, Bog 2 (Control), Impact Year 1, 3 February 2020**

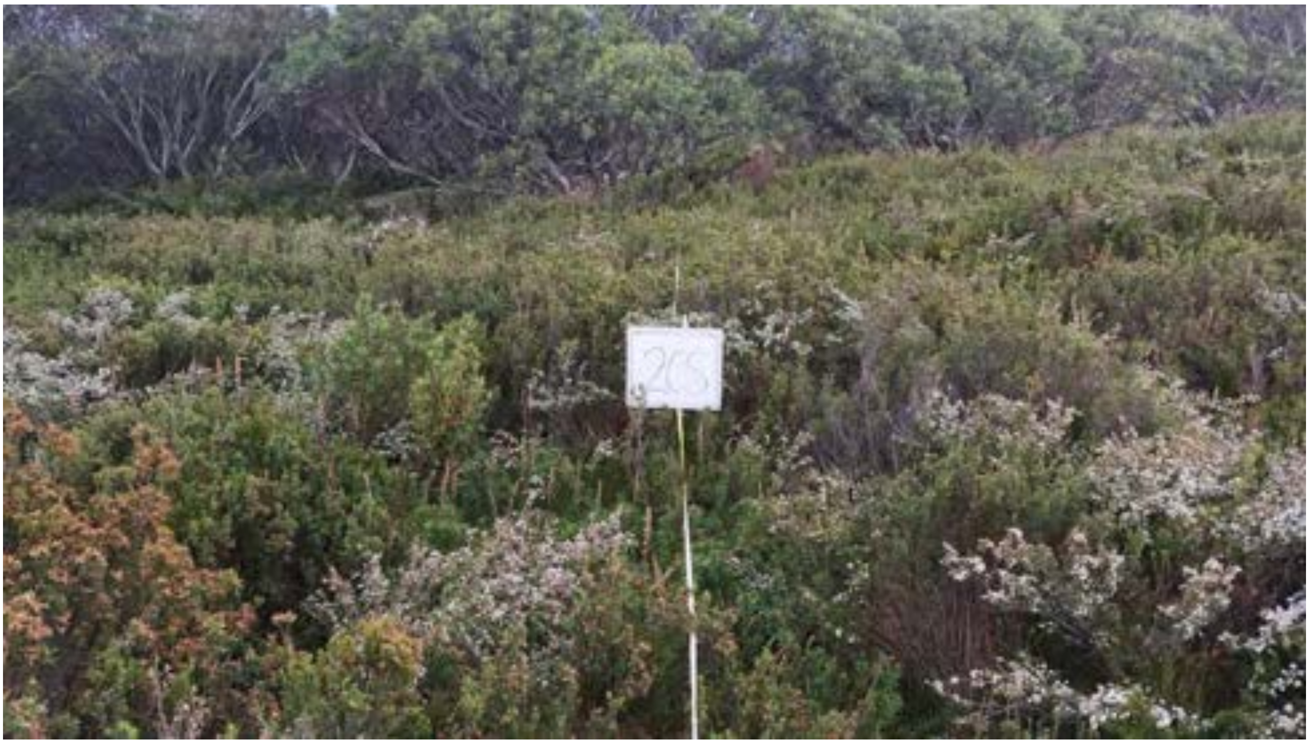



**Photo Point 2CS, Bog 2 (Control), Impact Year 2, 25 January 2021**

**Photo Point 2CE, Bog 2 (Control), Baseline Year 1, 9 February 2018**

**Photo Point 2CE, Bog 2 (Control), Baseline Year 2, 1 February 2019**


**Photo Point 2CE, Bog 2 (Control), Impact Year 1, 3 February 2020**

**Photo Point 2CE, Bog 2 (Control), Impact Year 2, 26 January 2021**

# Bog 4.1/5/7


**Photo Point 4.1AS, Bog 4.1/5/7 (Control), Baseline Year 1, 8 February 2018**

**Photo Point 4.1AS, Bog 4.1/5/7 (Control), Baseline Year 2, 14 February 2019**

**Photo Point 4.1AS, Bog 4.1/5/7 (Control), Impact Year 1, 4 February 2020**


**Photo Point 4.1AS, Bog 4.1/5/7 (Control), Impact Year 2, 2 February 2021**

**Photo Point 4.1AE, Bog 4.1/5/7 (Control), Baseline Year 1, 8 February 2018**

**Photo Point 4.1AE, Bog 4.1/5/7 (Control), Baseline Year 2, 14 February 2019**


**Photo Point 4.1AE, Bog 4.1/5/7 (Control), Impact Year 1, 4 February 2020**


**Photo Point 4.1AE, Bog 4.1/5/7 (Control), Impact Year 2, 2 February 2021**


**Photo Point 4.1BS, Bog 4.1/5/7 (Control), Baseline Year 1, 8 February 2018**

**Photo Point 4.1BS, Bog 4.1/5/7 (Control), Baseline Year 2, 14 February 2019**


**Photo Point 4.1BS, Bog 4.1/5/7 (Control), Impact Year 1, 4 February 2020**

**Photo Point 4.1BS, Bog 4.1/5/7 (Control), Impact Year 2, 1 February 2021**

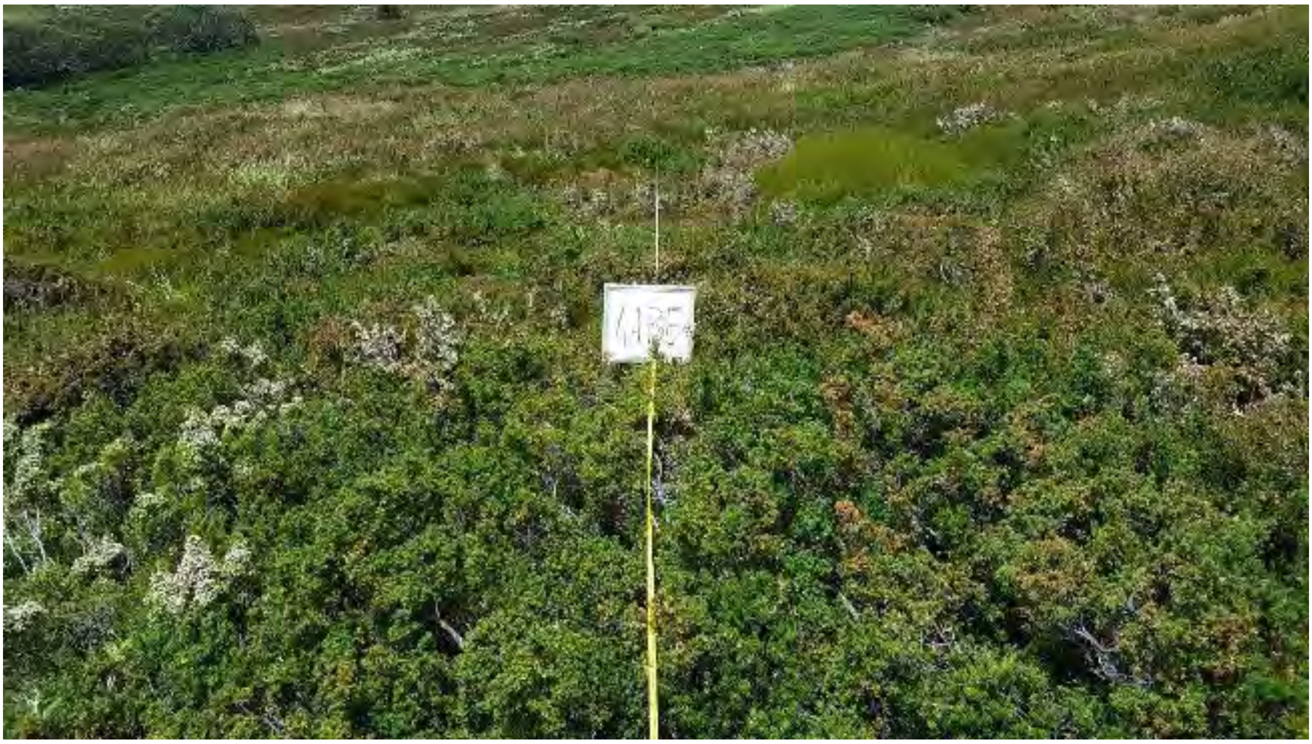



**Photo Point 4.1BE, Bog 4.1/5/7 (Control), Baseline Year 1, 8 February 2018**

**Photo Point 4.1BE, Bog 4.1/5/7 (Control), Baseline Year 2, 14 February 2019**

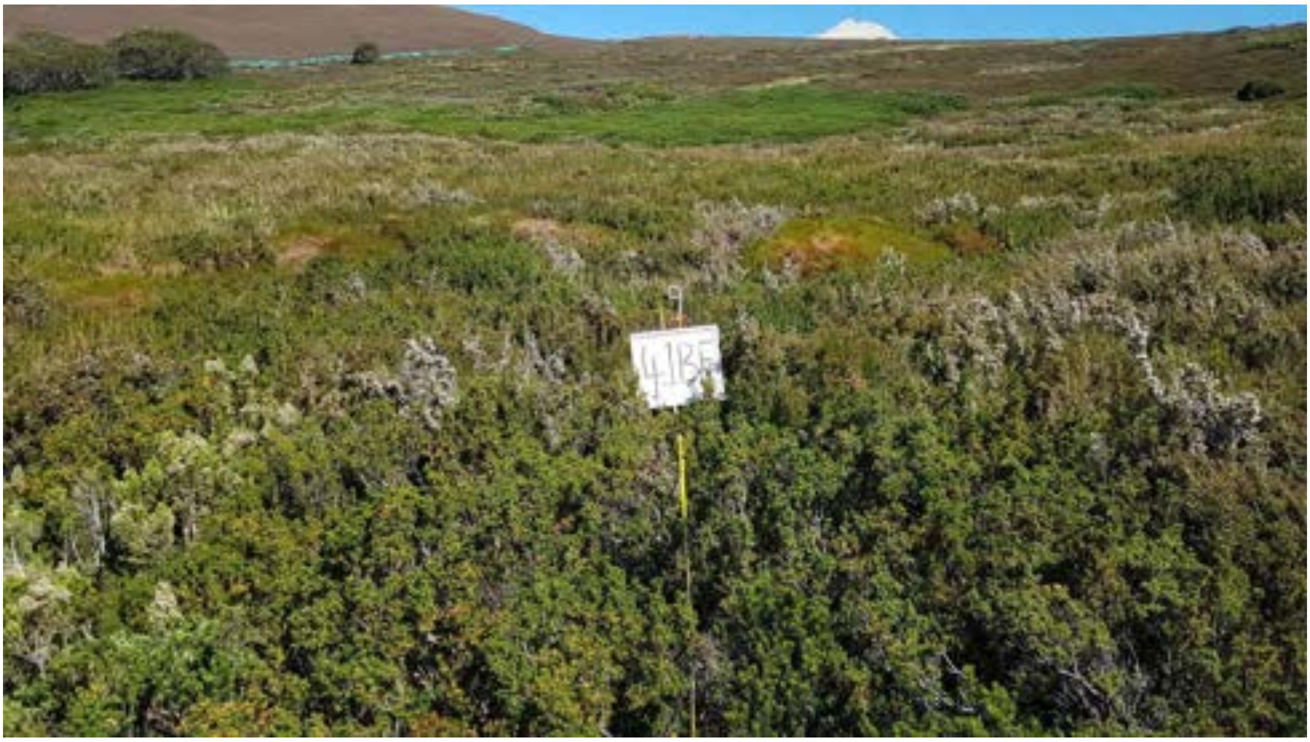



**Photo Point 4.1BE, Bog 4.1/5/7 (Control), Impact Year 1, 4 February 2020**

**Photo Point 4.1BE, Bog 4.1/5/7 (Control), Impact Year 2, 1 February 2021**

**Photo Point 4.1CS, Bog 4.1/5/7 (Control), Baseline Year 1, 8 February 2018**

**Photo Point 4.1CS, Bog 4.1/5/7 (Control), Baseline Year 2, 14 February 2019**


**Photo Point 4.1CS, Bog 4.1/5/7 (Control), Impact Year 1, 5 February 2020**

**Photo Point 4.1CS, Bog 4.1/5/7 (Control), Impact Year 2, 28 January 2021**


**Photo Point 4.1CE, Bog 4.1/5/7 (Control), Baseline Year 1, 8 February 2018**

**Photo Point 4.1CE, Bog 4.1/5/7 (Control), Baseline Year 2, 14 February 2019**


**Photo Point 4.1CE, Bog 4.1/5/7 (Control), Impact Year 1, 5 February 2020**

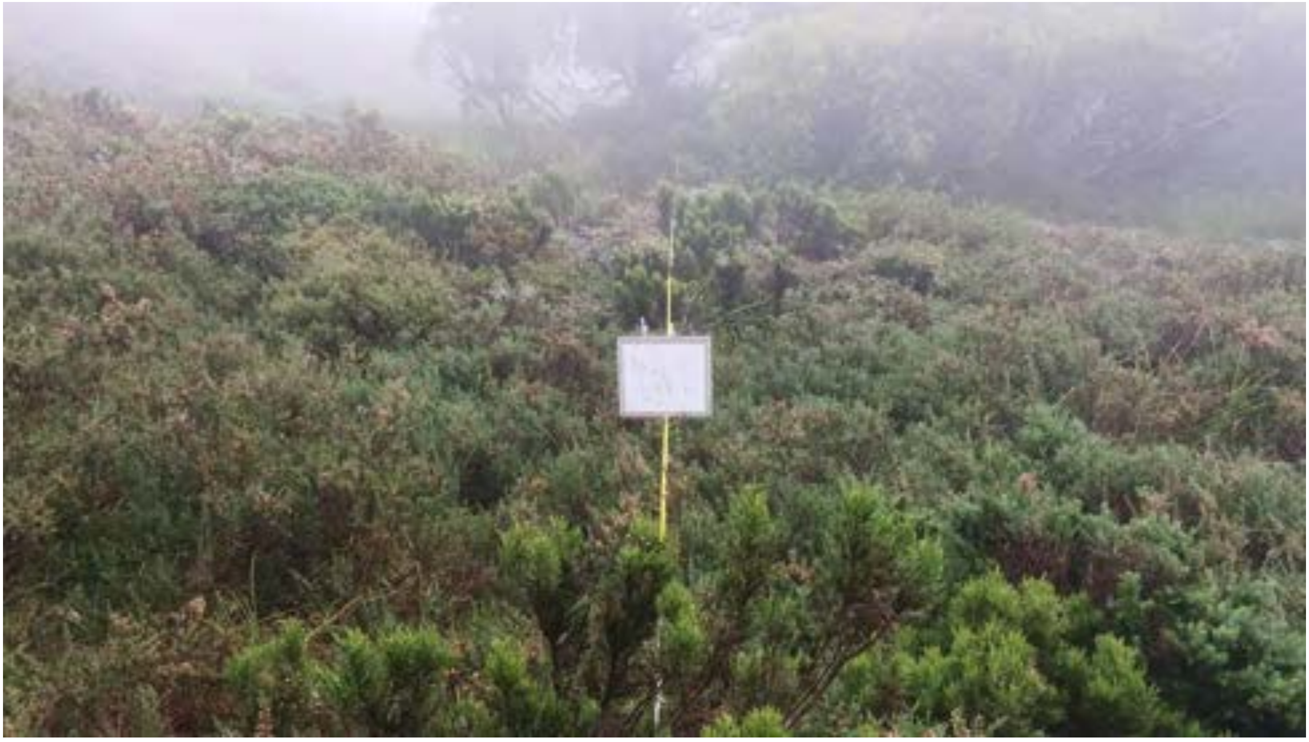


**Photo Point 4.1CE, Bog 4.1/5/7 (Control), Impact Year 2, 28 January 2021**


**Photo Point 5AS, Bog 4.1/5/7 (Control), Baseline Year 1, 8 February 2018**


**Photo Point 5AS, Bog 4.1/5/7 (Control), Baseline Year 2, 14 February 2019**

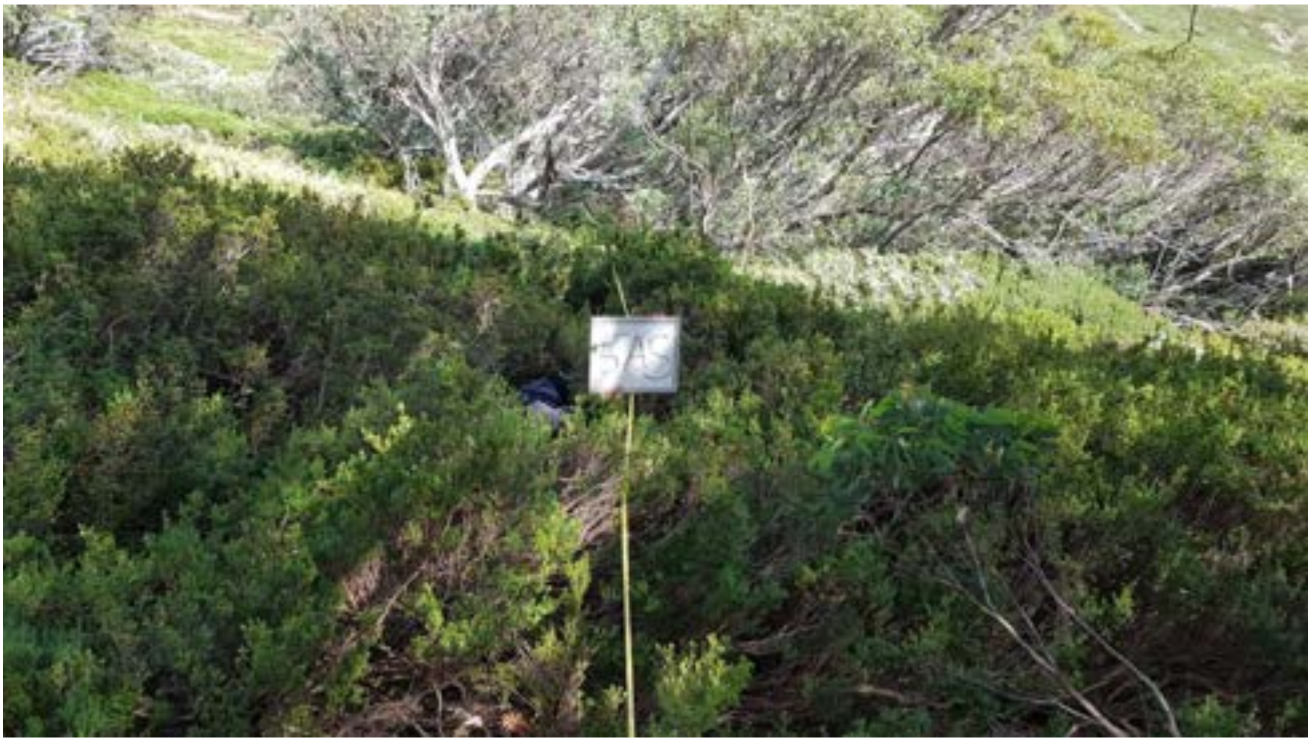



**Photo Point 5AS, Bog 4.1/5/7 (Control), Impact Year 1, 6 February 2020**

**Photo Point 5AS, Bog 4.1/5/7 (Control), Impact Year 2, 1 February 2021**


**Photo Point 5AE, Bog 4.1/5/7 (Control), Baseline Year 1, 8 February 2018**


**Photo Point 5AE, Bog 4.1/5/7 (Control), Baseline Year 2, 14 February 2019**


**Photo Point 5AE, Bog 4.1/5/7 (Control), Impact Year 1, 6 February 2020**


**Photo Point 5AE, Bog 4.1/5/7 (Control), Impact Year 2, 1 February 2021**


**Photo Point 7AS, Bog 4.1/5/7 (Control), Baseline Year 1, 1 February 2018**

**Photo Point 7AS, Bog 4.1/5/7 (Control), Baseline Year 2, 11 February 2019**


**Photo Point 7AS, Bog 4.1/5/7 (Control), Impact Year 1, 5 February 2020**

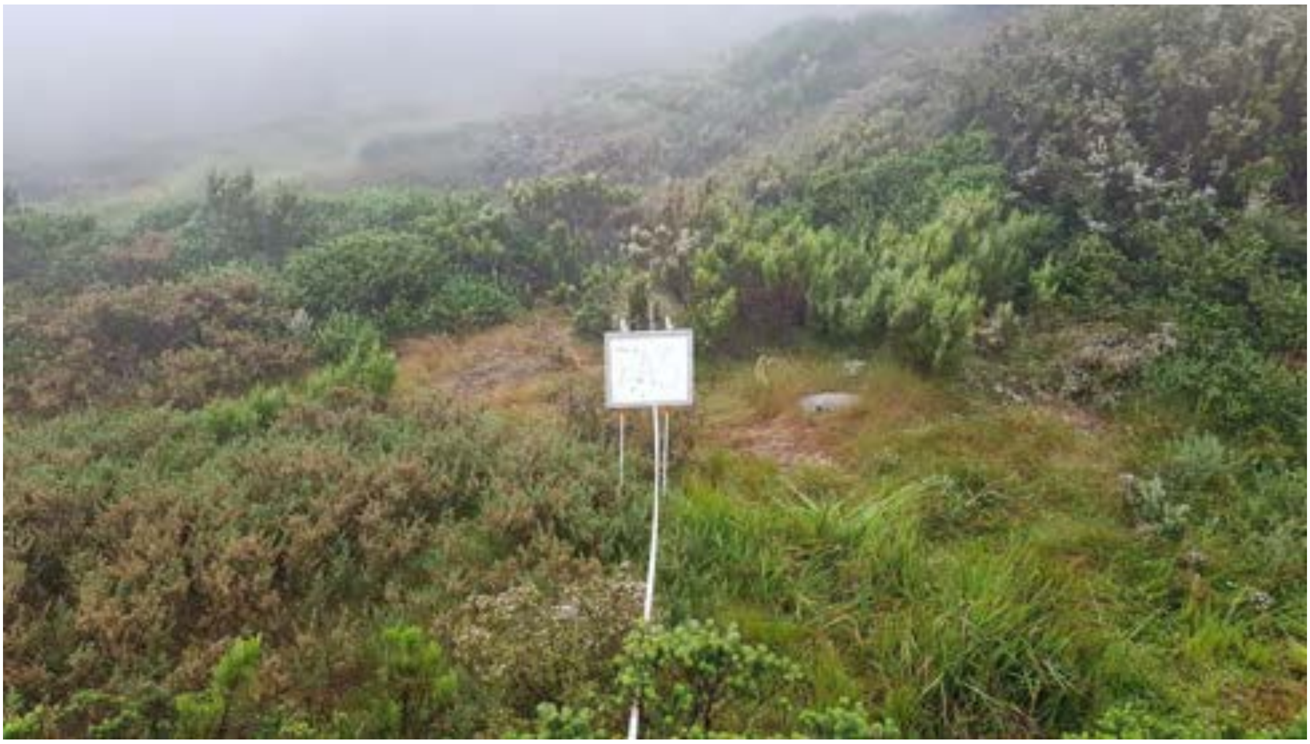


**Photo Point 7AS, Bog 4.1/5/7 (Control), Impact Year 2, 28 January 2021**


**Photo Point 7AE, Bog 4.1/5/7 (Control), Baseline Year 1, 1 February 2018**

**Photo Point 7AE, Bog 4.1/5/7 (Control), Baseline Year 2, 11 February 2019**


**Photo Point 7AE, Bog 4.1/5/7 (Control), Impact Year 1, 5 February 2020**

**Photo Point 7AE, Bog 4.1/5/7 (Control), Impact Year 2, 28 January 2021**

# Bog 4.2


**Photo Point 4.2AS, Bog 4.2 (Impact), Baseline Year 1, 30 January 2018**

**Photo Point 4.2AS, Bog 4.2 (Impact), Baseline Year 2, 1 February 2019**

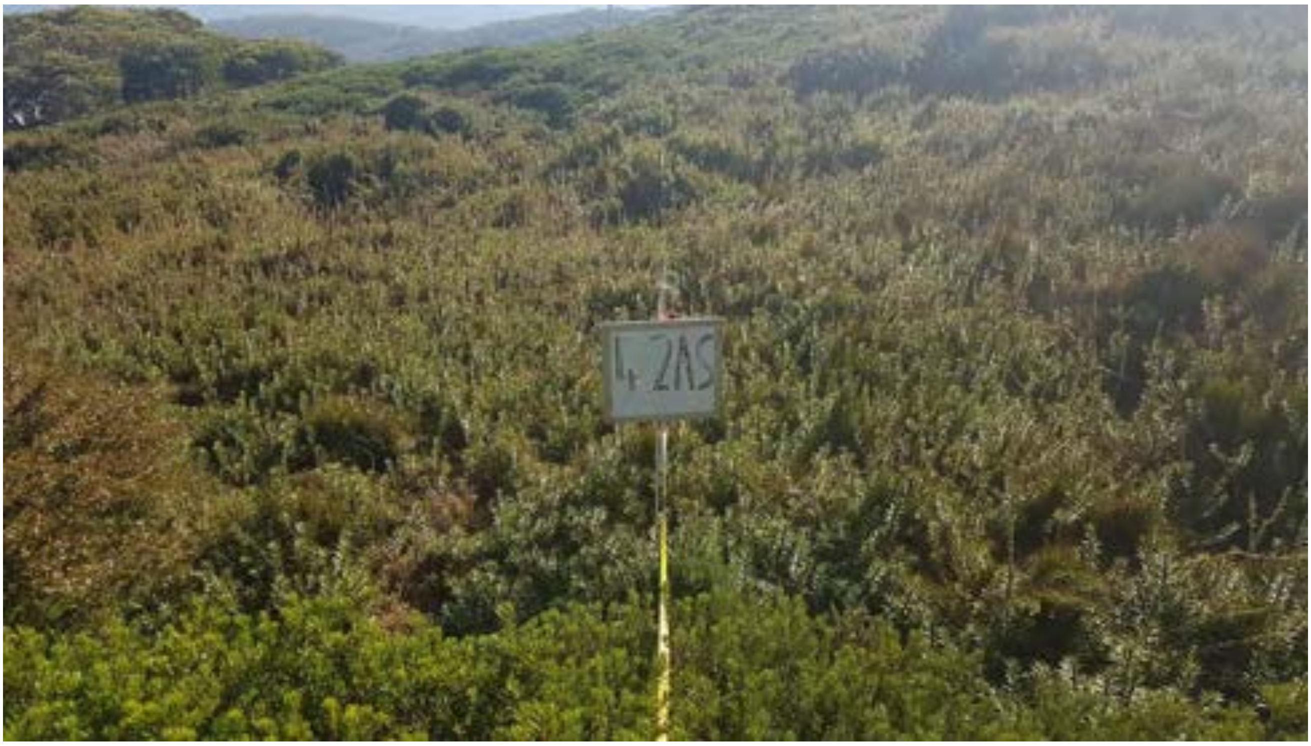



**Photo Point 4.2AS, Bog 4.2 (Impact), Impact Year 1, 5 February 2020**


**Photo Point 4.2AS, Bog 4.2 (Impact), Impact Year 2, 1 February 2021**

**Photo Point 4.2AE, Bog 4.2 (Impact), Baseline Year 1, 30 January 2018**

**Photo Point 4.2AE, Bog 4.2 (Impact), Baseline Year 2, 1 February 2019**

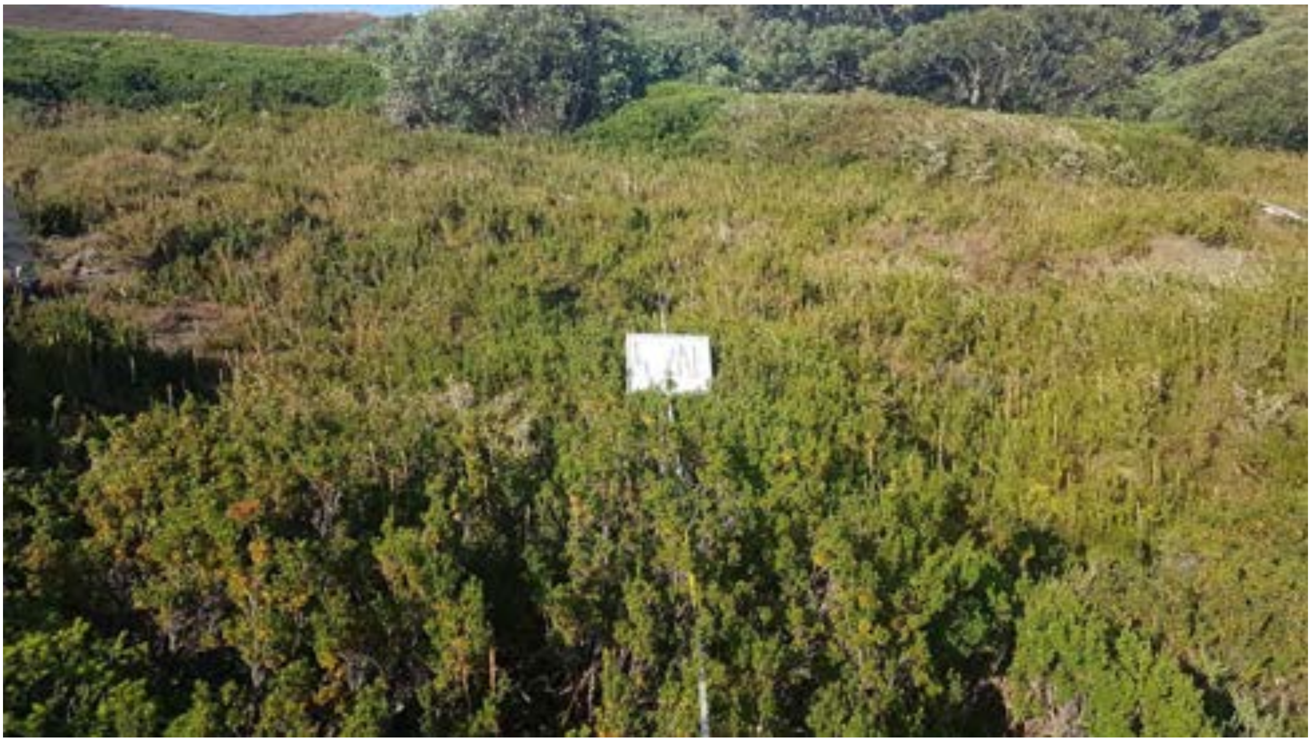


**Photo Point 4.2AE, Bog 4.2 (Impact), Impact Year 1, 5 February 2020**

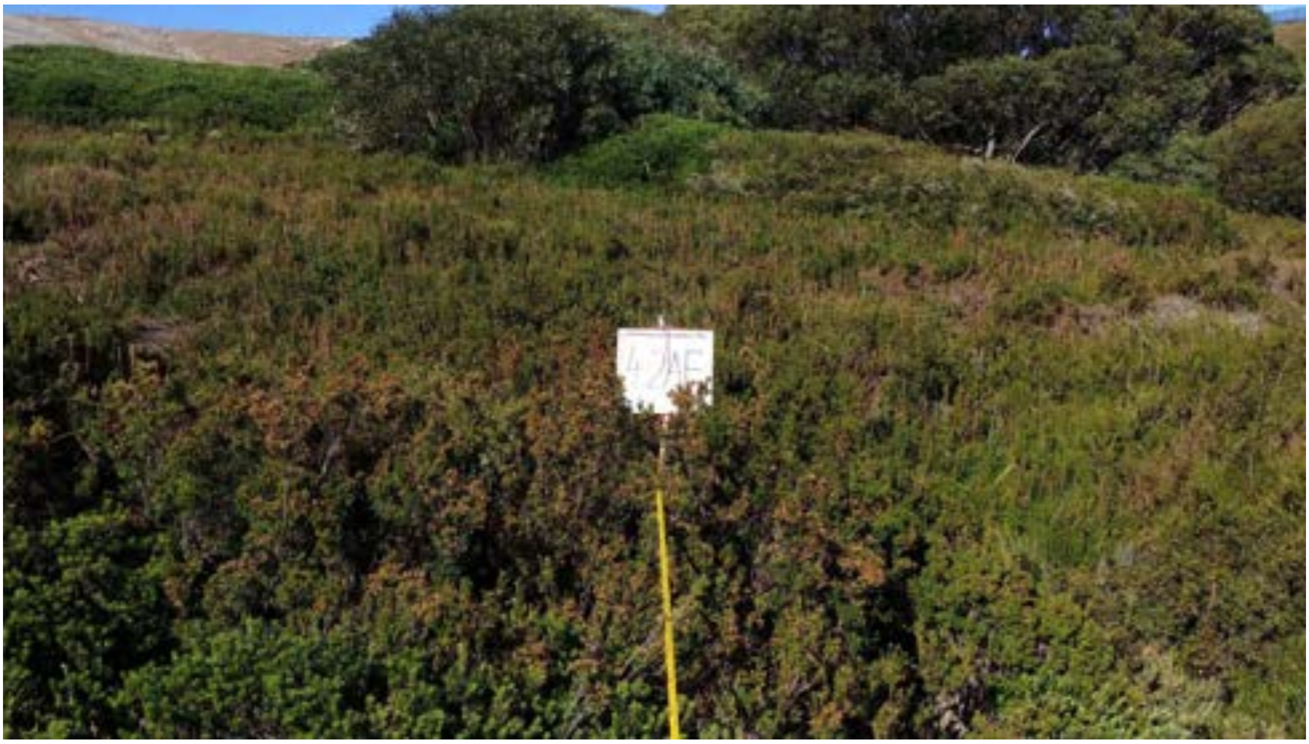


**Photo Point 4.2AE, Bog 4.2 (Impact), Impact Year 2, 1 February 2021**


**Photo Point 4.2BS, Bog 4.2 (Impact), Baseline Year 1, 30 January 2018**

**Photo Point 4.2BS, Bog 4.2 (Impact), Baseline Year 2, 1 February 2019**


**Photo Point 4.2BS, Bog 4.2 (Impact), Impact Year 1, 4 February 2020**

**Photo Point 4.2BS, Bog 4.2 (Impact), Impact Year 2, 1 February 2021**

**Photo Point 4.2BE, Bog 4.2 (Impact), Baseline Year 1, 30 January 2018**

**Photo Point 4.2BE, Bog 4.2 (Impact), Baseline Year 2, 1 February 2019**

**Photo Point 4.2BE, Bog 4.2 (Impact), Impact Year 1, 4 February 2020**

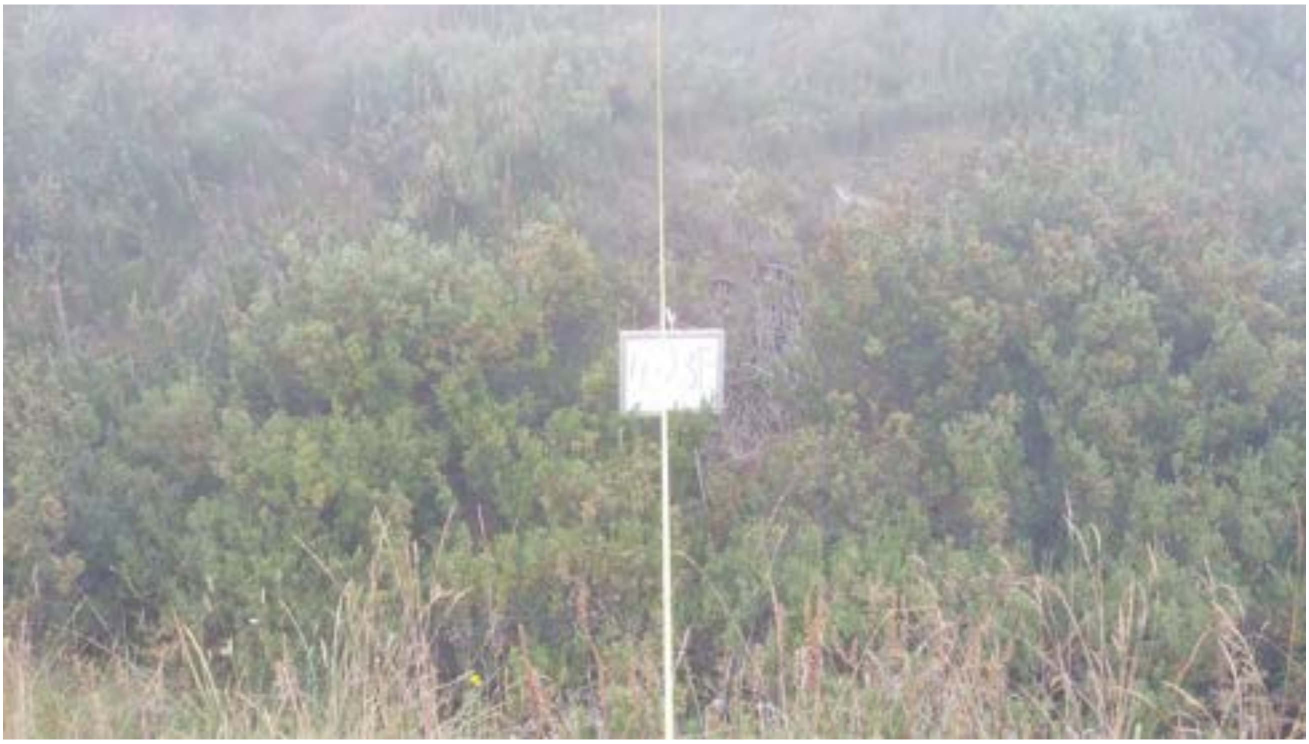


**Photo Point 4.2BE, Bog 4.2 (Impact), Impact Year 2, 1 February 2021**


**Photo Point 4.2CS, Bog 4.2 (Impact), Baseline Year 1, 31 January 2018**


**Photo Point 4.2CS, Bog 4.2 (Impact), Baseline Year 2, 1 February 2019**

**Photo Point 4.2CS, Bog 4.2 (Impact), Impact Year 1, 4 February 2020**

**Photo Point 4.2CS, Bog 4.2 (Impact), Impact Year 2, 2 February 2021**

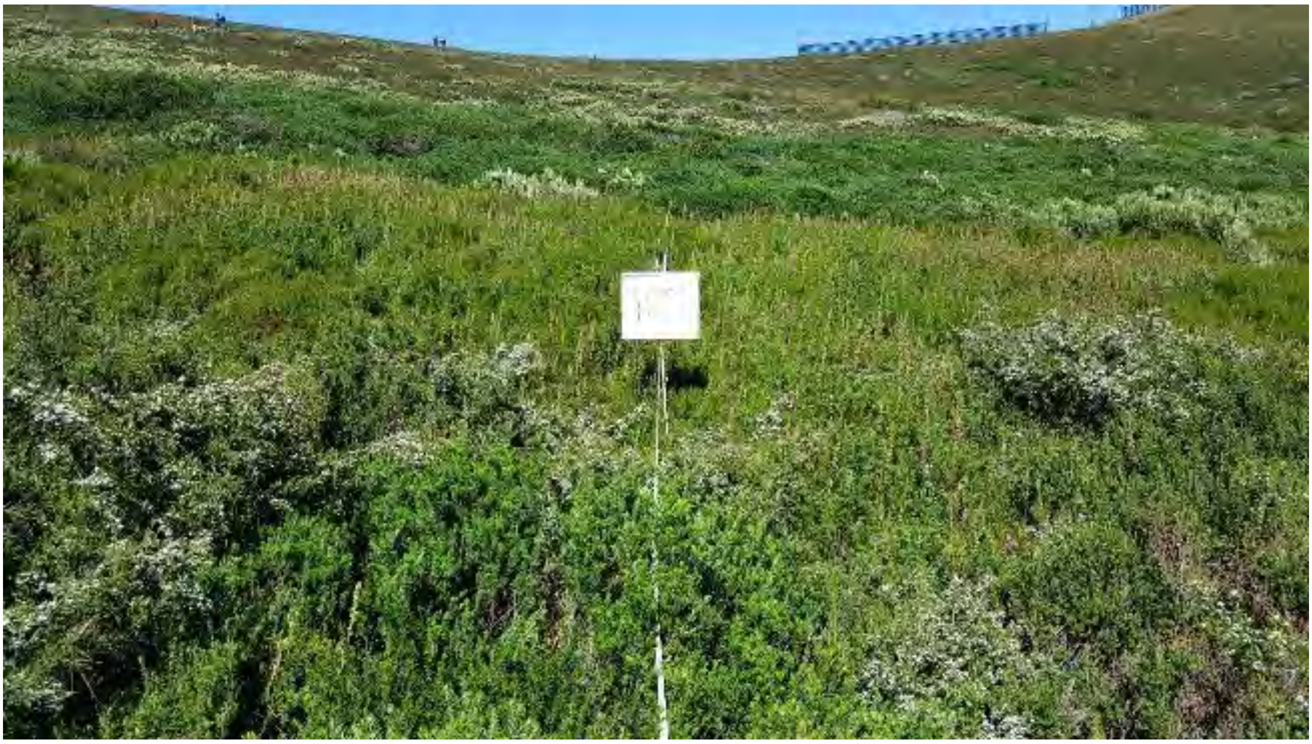


**Photo Point 4.2CE, Bog 4.2 (Impact), Baseline Year 1, 31 January 2018**

**Photo Point 4.2CE, Bog 4.2 (Impact), Baseline Year 2, 1 February 2019**

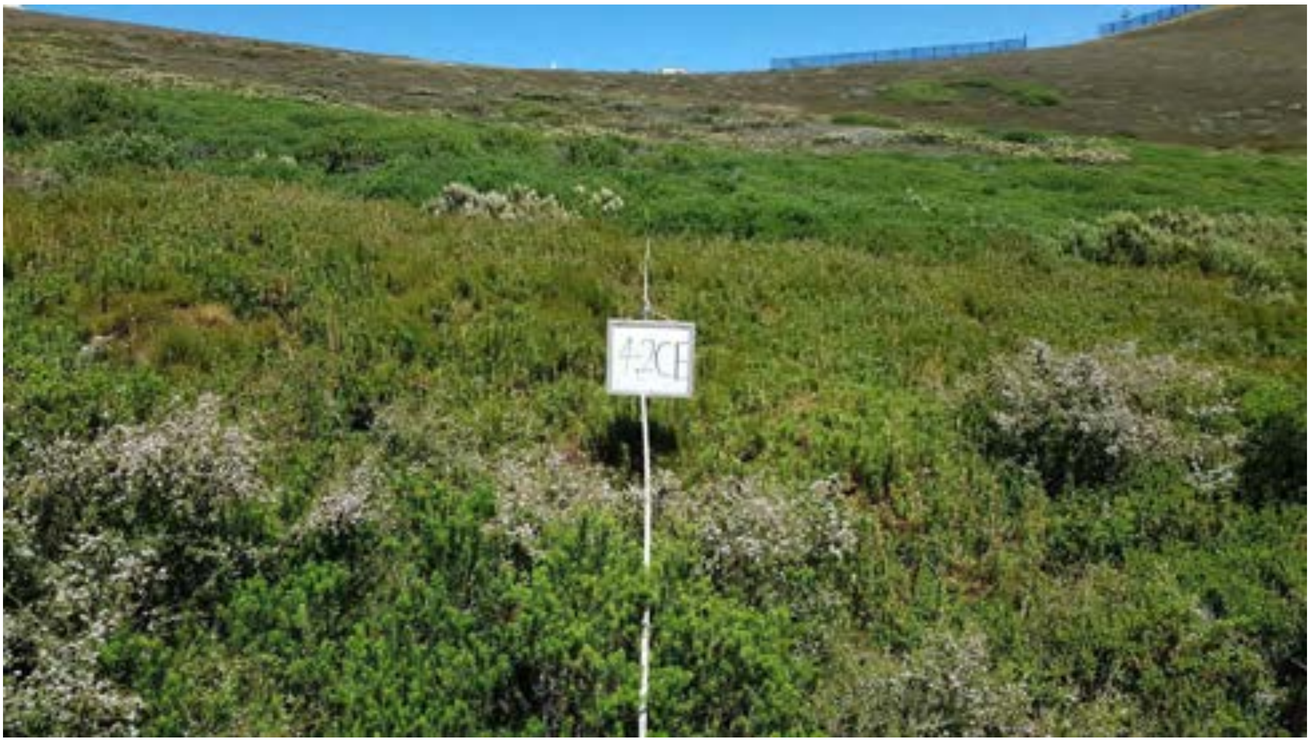



**Photo Point 4.2CE, Bog 4.2 (Impact), Impact Year 1, 4 February 2020**


**Photo Point 4.2CE, Bog 4.2 (Impact), Impact Year 2, 2 February 2021**


**Photo Point 4.2DS, Bog 4.2 (Impact), Baseline Year 1, 31 January 2018**


**Photo Point 4.2DS, Bog 4.2 (Impact), Baseline Year 2, 1 February 2019**


**Photo Point 4.2DS, Bog 4.2 (Impact), Impact Year 1, 4 February 2020**


**Photo Point 4.2DS, Bog 4.2 (Impact), Impact Year 2, 1 February 2021**


**Photo Point 4.2DE, Bog 4.2 (Impact), Baseline Year 1, 31 January 2018**

**Photo Point 4.2DE, Bog 4.2 (Impact), Baseline Year 2, 1 February 2019**

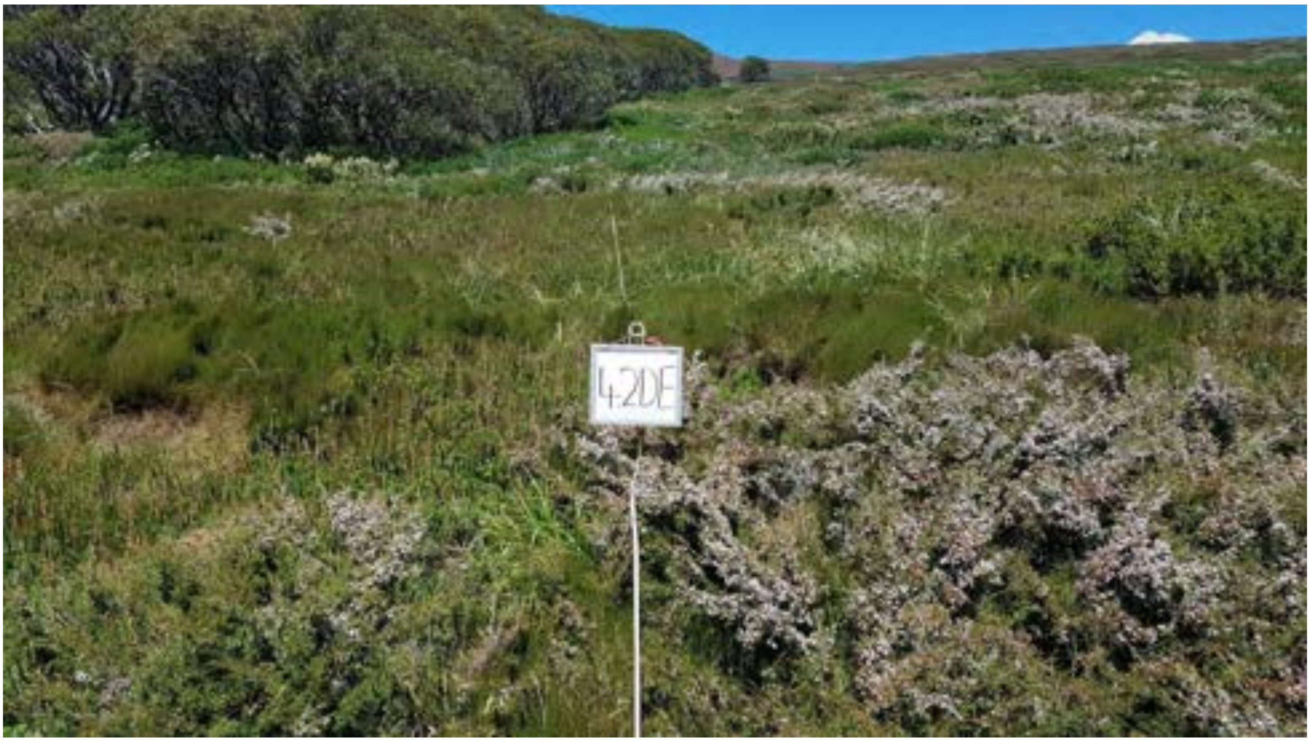



**Photo Point 4.2DE, Bog 4.2 (Impact), Impact Year 1, 4 February 2020**


**Photo Point 4.2DE, Bog 4.2 (Impact), Impact Year 2, 1 February 2021**

**Photo Point 4.2ES, Bog 4.2 (Impact), Baseline Year 1, 31 January 2018**

**Photo Point 4.2ES, Bog 4.2 (Impact), Baseline Year 2, 1 February 2019**

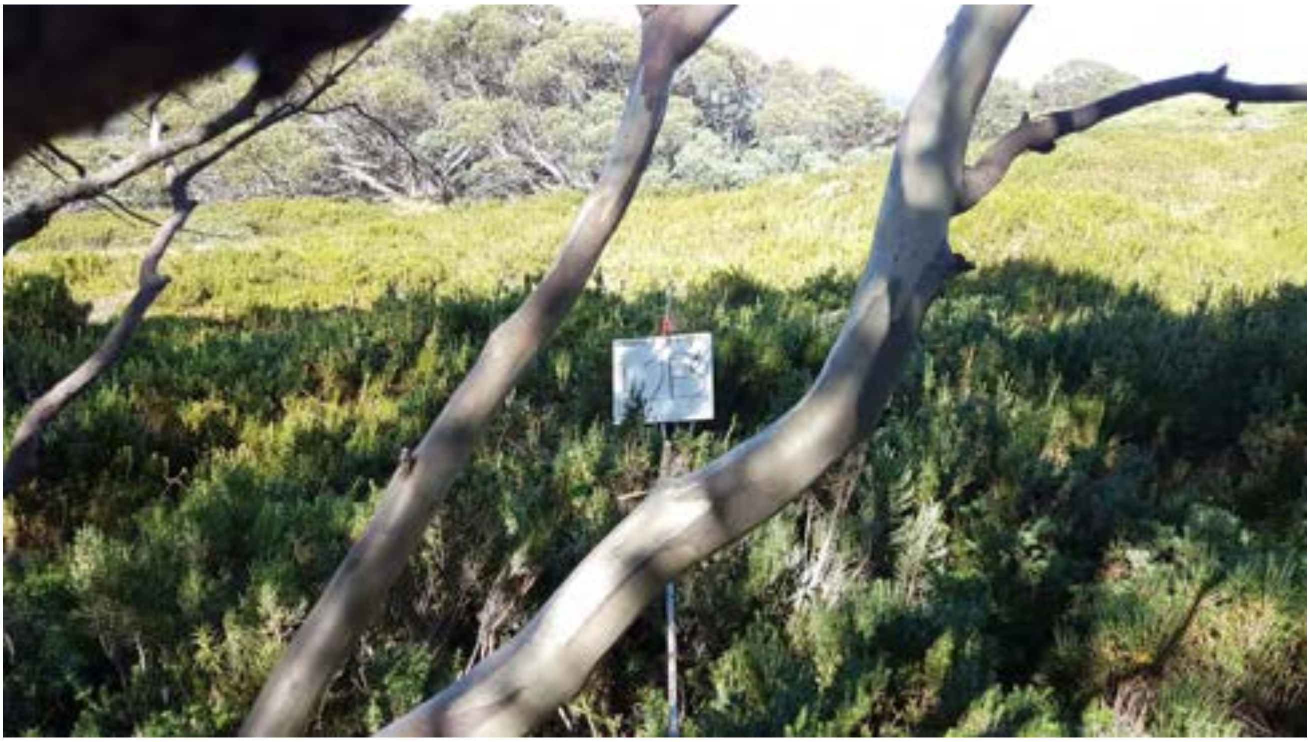


**Photo Point 4.2ES, Bog 4.2 (Impact), Impact Year 1, 4 February 2020**

**Photo Point 4.2ES, Bog 4.2 (Impact), Impact Year 2, 2 February 2021**

**Photo Point 4.2EE, Bog 4.2 (Impact), Baseline Year 1, 31 January 2018**

**Photo Point 4.2EE, Bog 4.2 (Impact), Baseline Year 2, 1 February 2019**


**Photo Point 4.2EE, Bog 4.2 (Impact), Impact Year 1, 4 February 2020**

**Photo Point 4.2EE, Bog 4.2 (Impact), Impact Year 1, 2 February 2021**

# Bog 6

**Photo Point 6AS, Bog 6 (Impact), Baseline Year 1, 31 January 2018**

**Photo Point 6AS, Bog 6 (Impact), Baseline Year 2, 1 February 2019**

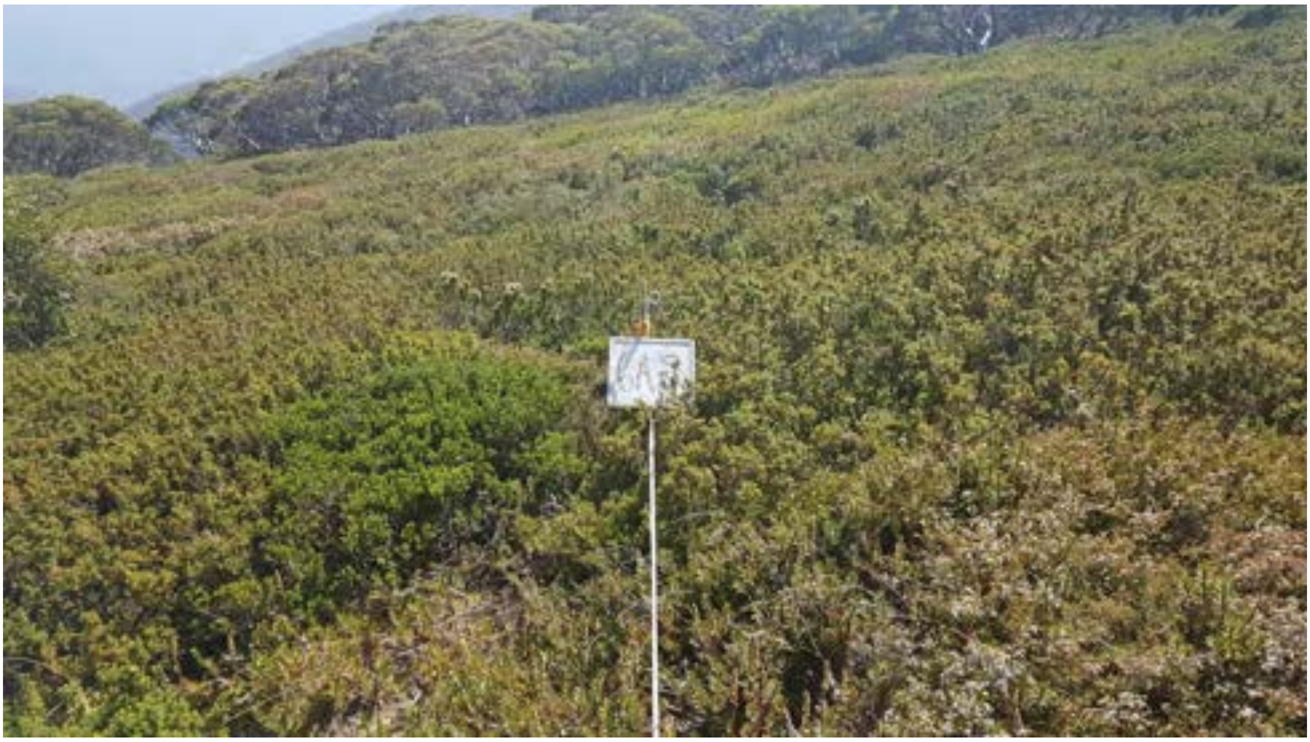



**Photo Point 6AS, Bog 6 (Impact), Impact Year 1, 5 February 2020**

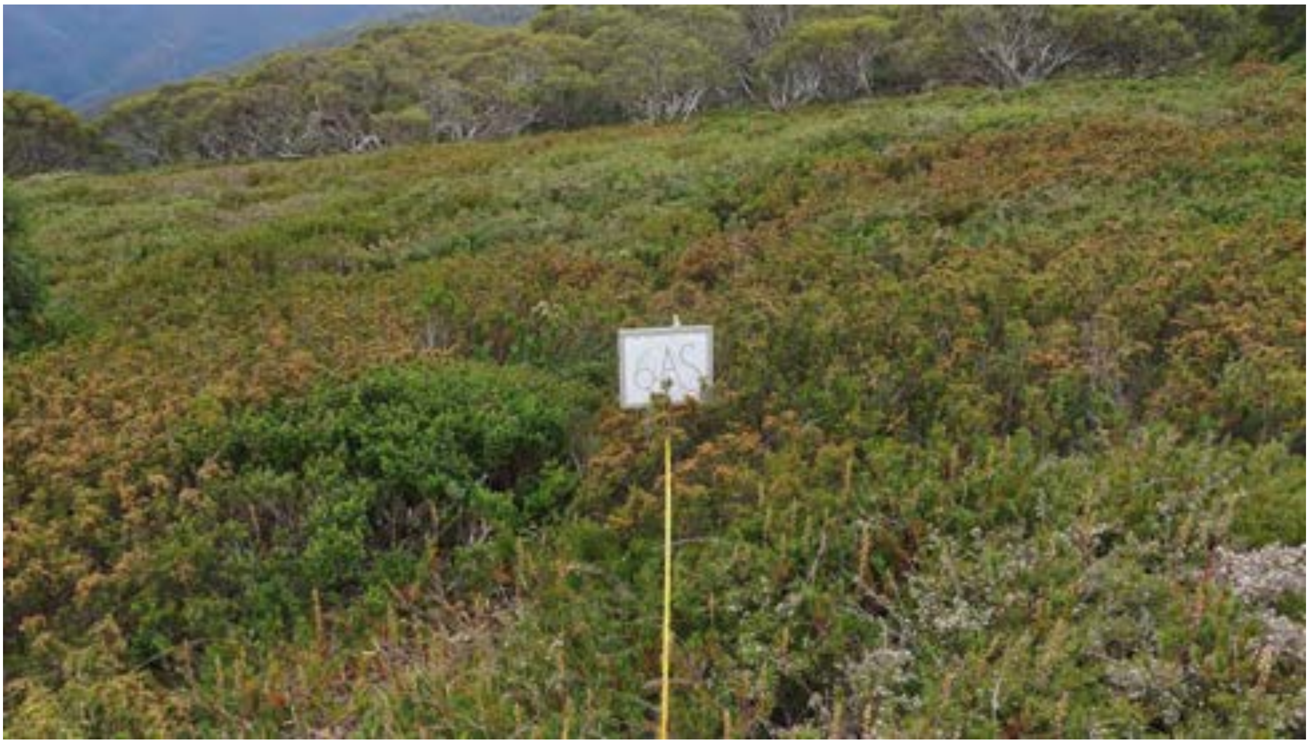



**Photo Point 6AS, Bog 6 (Impact), Impact Year 2, 28 January 2021**

**Photo Point 6AE, Bog 6 (Impact), Baseline Year 1, 31 January 2018**

**Photo Point 6AE, Bog 6 (Impact), Baseline Year 2, 1 February 2019**

**Photo Point 6AE, Bog 6 (Impact), Impact Year 1, 5 February 2020**

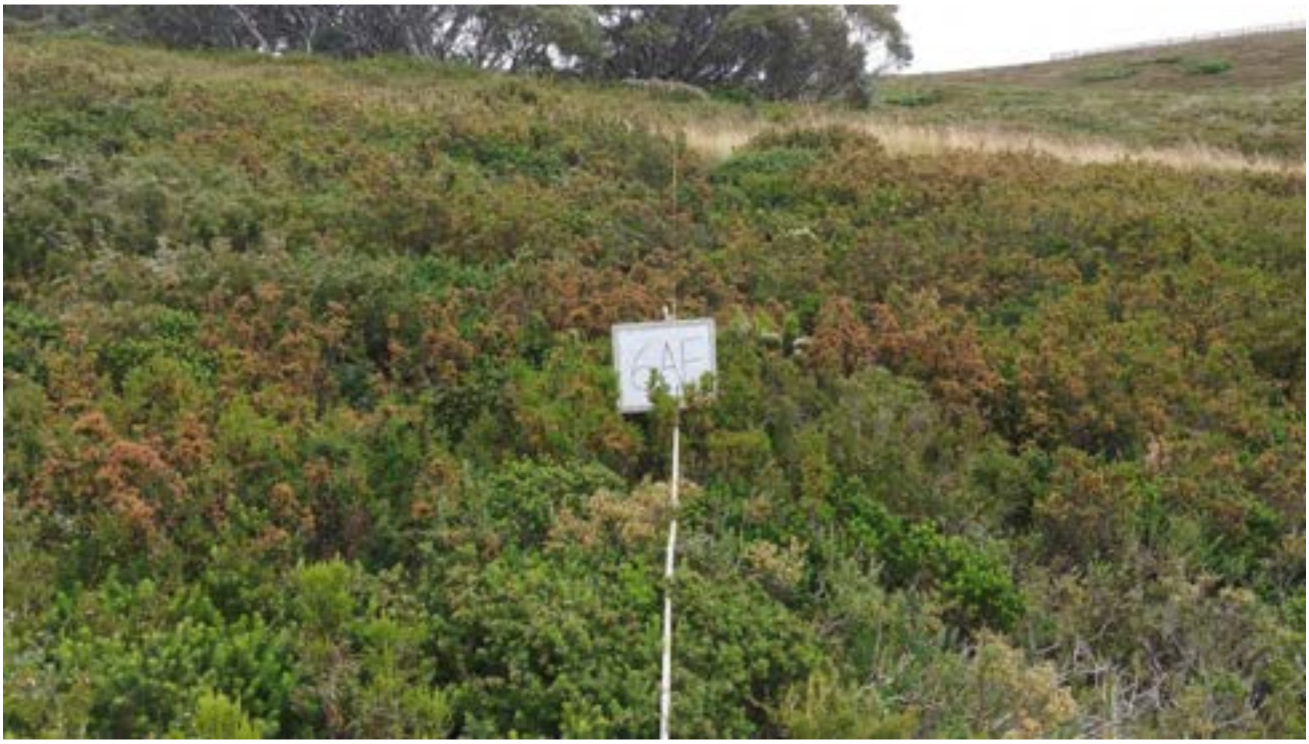


**Photo Point 6AE, Bog 6 (Impact), Impact Year 2, 28 January 2021**


**Photo Point 6BS, Bog 6 (Impact), Baseline Year 1, 31 January 2018**

**Photo Point 6BS, Bog 6 (Impact), Baseline Year 2, 14 February 2019**


**Photo Point 6BS, Bog 6 (Impact), Impact Year 1, 5 February 2020**


**Photo Point 6BS, Bog 6 (Impact), Impact Year 2, 27 January 2021**


**Photo Point 6BE, Bog 6 (Impact), Baseline Year 1, 31 January 2018**

**Photo Point 6BE, Bog 6 (Impact), Baseline Year 2, 14 February 2019**

**Photo Point 6BE, Bog 6 (Impact), Impact Year 1, 5 February 2020**

**Photo Point 6BE, Bog 6 (Impact), Impact Year 2, 27 January 2021**


**Photo Point 6CS, Bog 6 (Impact), Baseline Year 1, 1 February 2018**


**Photo Point 6CS, Bog 6 (Impact), Baseline Year 2, 11 February 2019**


**Photo Point 6CS, Bog 6 (Impact), Impact Year 1, 5 February 2020**


**Photo Point 6CS, Bog 6 (Impact), Impact Year 2, 28 January 2021**


**Photo Point 6CE, Bog 6 (Impact), Baseline Year 1, 1 February 2018**


**Photo Point 6CE, Bog 6 (Impact), Baseline Year 2, 11 February 2019**


**Photo Point 6CE, Bog 6 (Impact), Impact Year 1, 5 February 2020**


**Photo Point 6CE, Bog 6 (Impact), Impact Year 2, 28 January 2021**

**Photo Point 6DS, Bog 6 (Impact), Baseline Year 1, 1 February 2018**


**Photo Point 6DS, Bog 6 (Impact), Baseline Year 2, 11 February 2019**


**Photo Point 6DS, Bog 6 (Impact), Impact Year 1, 5 February 2020**

**Photo Point 6DS, Bog 6 (Impact), Impact Year 2, 28 January 2021**

**Photo Point 6DE, Bog 6 (Impact), Baseline Year 1, 1 February 2018**


**Photo Point 6DE, Bog 6 (Impact), Baseline Year 2, 11 February 2019**


**Photo Point 6DE, Bog 6 (Impact), Impact Year 1, 5 February 2020**

**Photo Point 6DE, Bog 6 (Impact), Impact Year 2, 28 January 2021**


**Photo Point 6ES, Bog 6 (Impact), Baseline Year 1, 1 February 2018**


**Photo Point 6ES, Bog 6 (Impact), Baseline Year 2, 11 February 2019**


**Photo Point 6ES, Bog 6 (Impact), Impact Year 1, 5 February 2020**

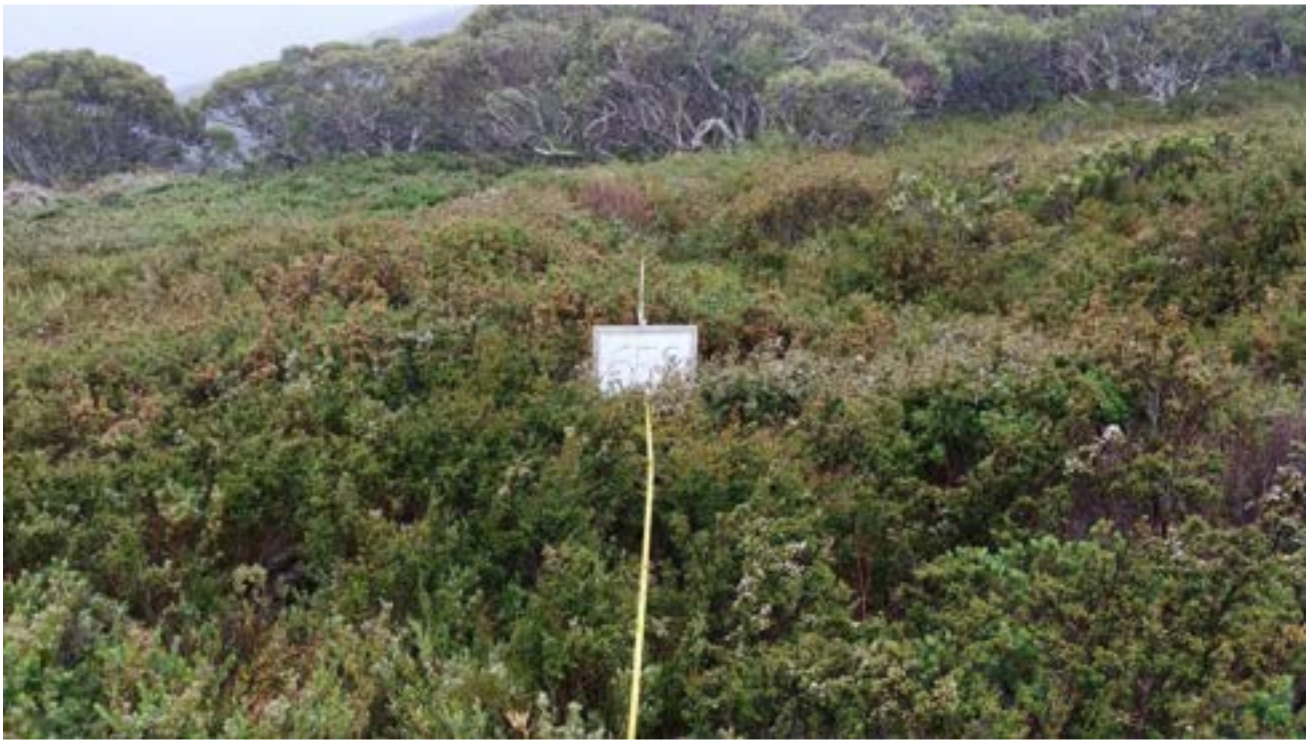


**Photo Point 6ES, Bog 6 (Impact), Impact Year 2, 28 January 2021**


**Photo Point 6EE, Bog 6 (Impact), Baseline Year 1, 1 February 2018**


**Photo Point 6EE, Bog 6 (Impact), Baseline Year 2, 11 February 2019**

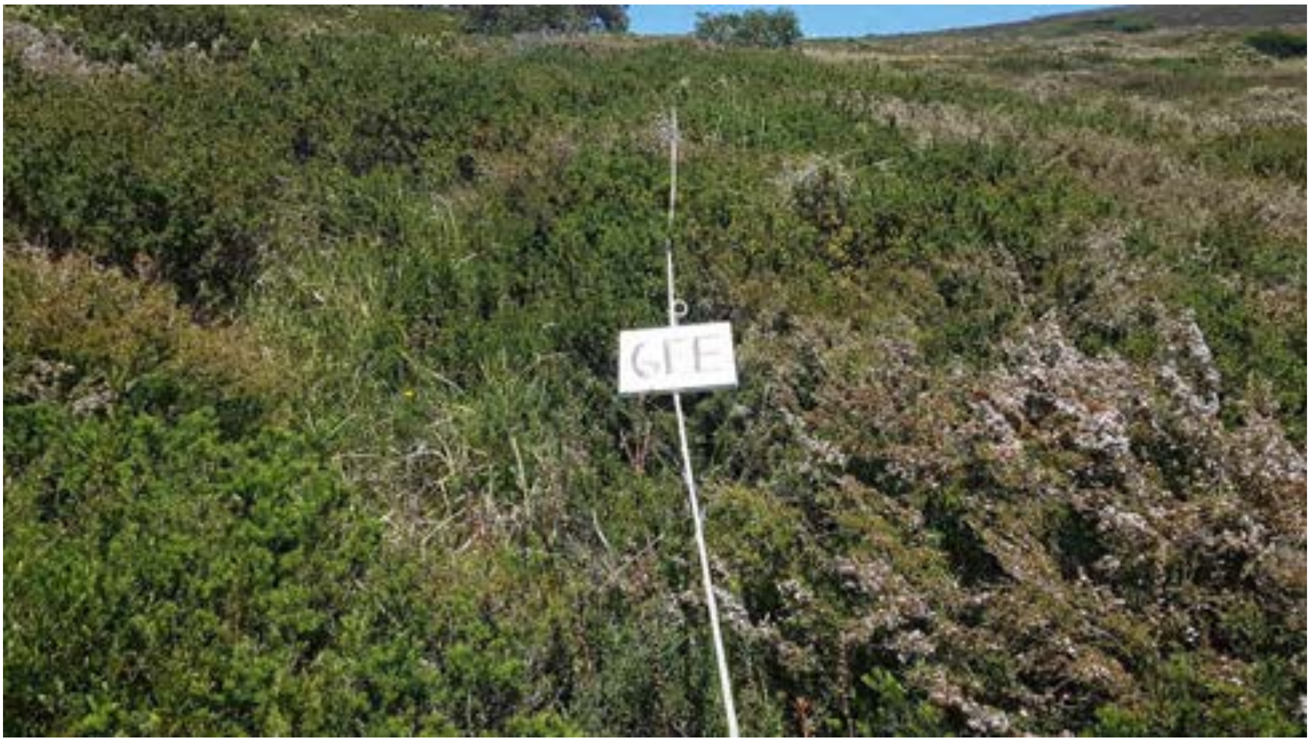



**Photo Point 6EE, Bog 6 (Impact), Impact Year 1, 5 February 2020**


**Photo Point 6EE, Bog 6 (Impact), Impact Year 2, 28 January 2021**

# Bog 8/9/10

**Photo Point 8AS, Bog 8/9/10 (Impact), Baseline Year 1, 26 January 2018**

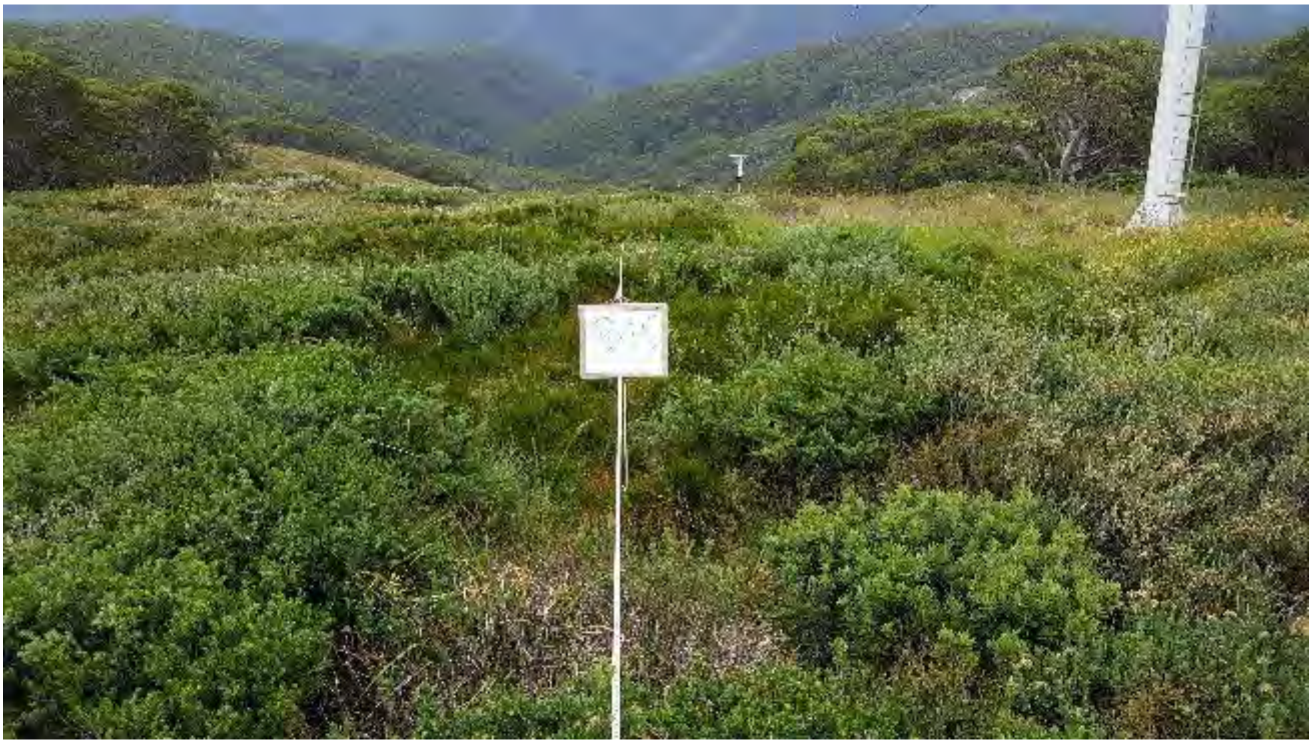


**Photo Point 8AS, Bog 8/9/10 (Impact), Baseline Year 2, 29 January 2019**


**Photo Point 8AS, Bog 8/9/10 (Impact), Impact Year 1, 18 February 2020**


**Photo Point 8AS, Bog 8/9/10 (Impact), Impact Year 2, 27 January 2021**

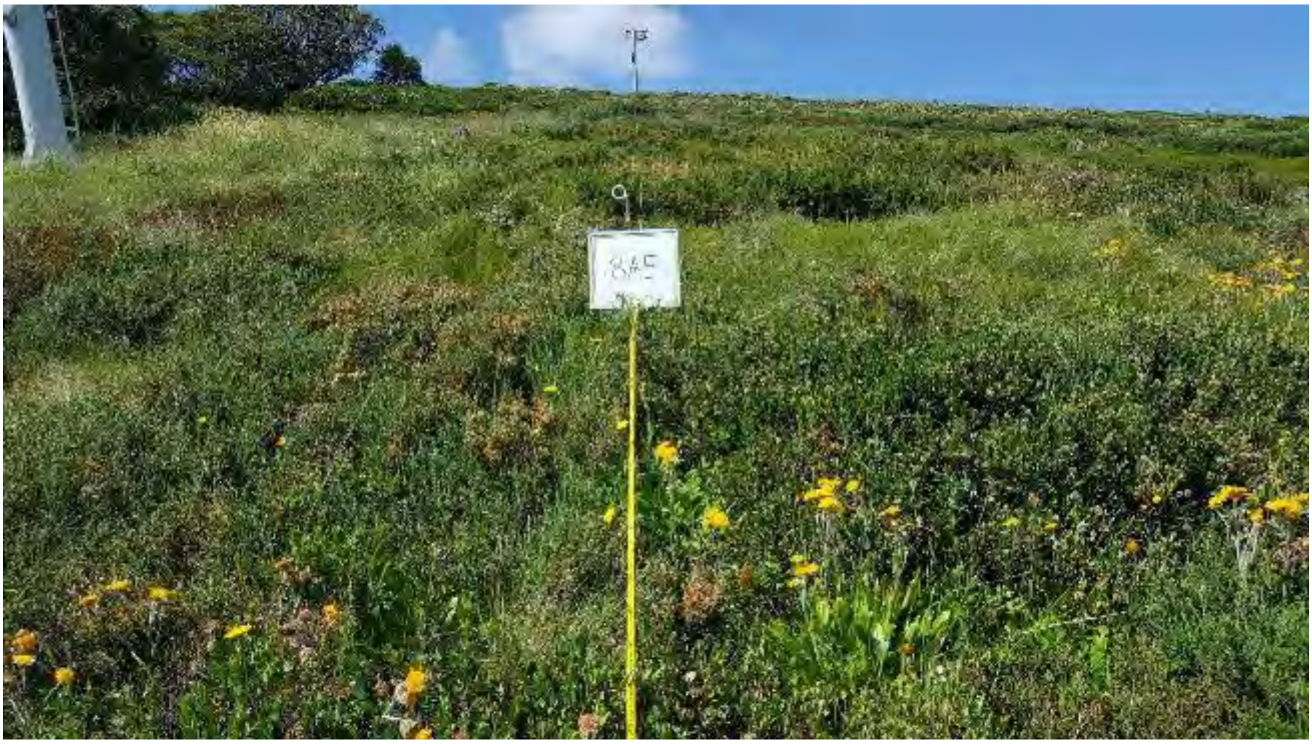


**Photo Point 8AE, Bog 8/9/10 (Impact), Baseline Year 1, 26 January 2018**

**Photo Point 8AE, Bog 8/9/10 (Impact), Baseline Year 2, 29 January 2019**


**Photo Point 8AE, Bog 8/9/10 (Impact), Impact Year 1, 18 February 2020**


**Photo Point 8AE, Bog 8/9/10 (Impact), Impact Year 2, 27 January 2021**

**Photo Point 8BS, Bog 8/9/10 (Impact), Baseline Year 1, 26 January 2018**

**Photo Point 8BS, Bog 8/9/10 (Impact), Baseline Year 2, 29 January 2019**


**Photo Point 8BS, Bog 8/9/10 (Impact), Impact Year 1, 18 February 2020**


**Photo Point 8BS, Bog 8/9/10 (Impact), Impact Year 2, 27 January 2021**

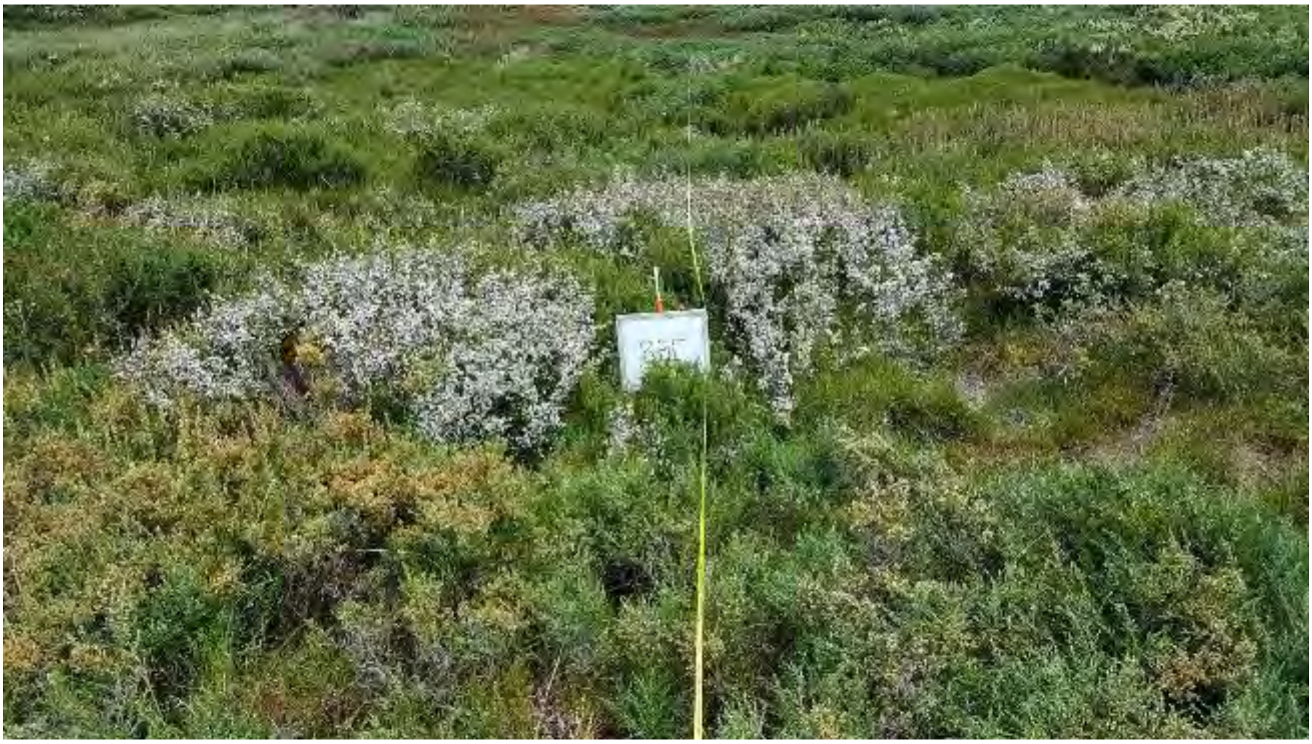


**Photo Point 8BE, Bog 8/9/10 (Impact), Baseline Year 1, 26 January 2018**

**Photo Point 8BE, Bog 8/9/10 (Impact), Baseline Year 2, 29 January 2019**

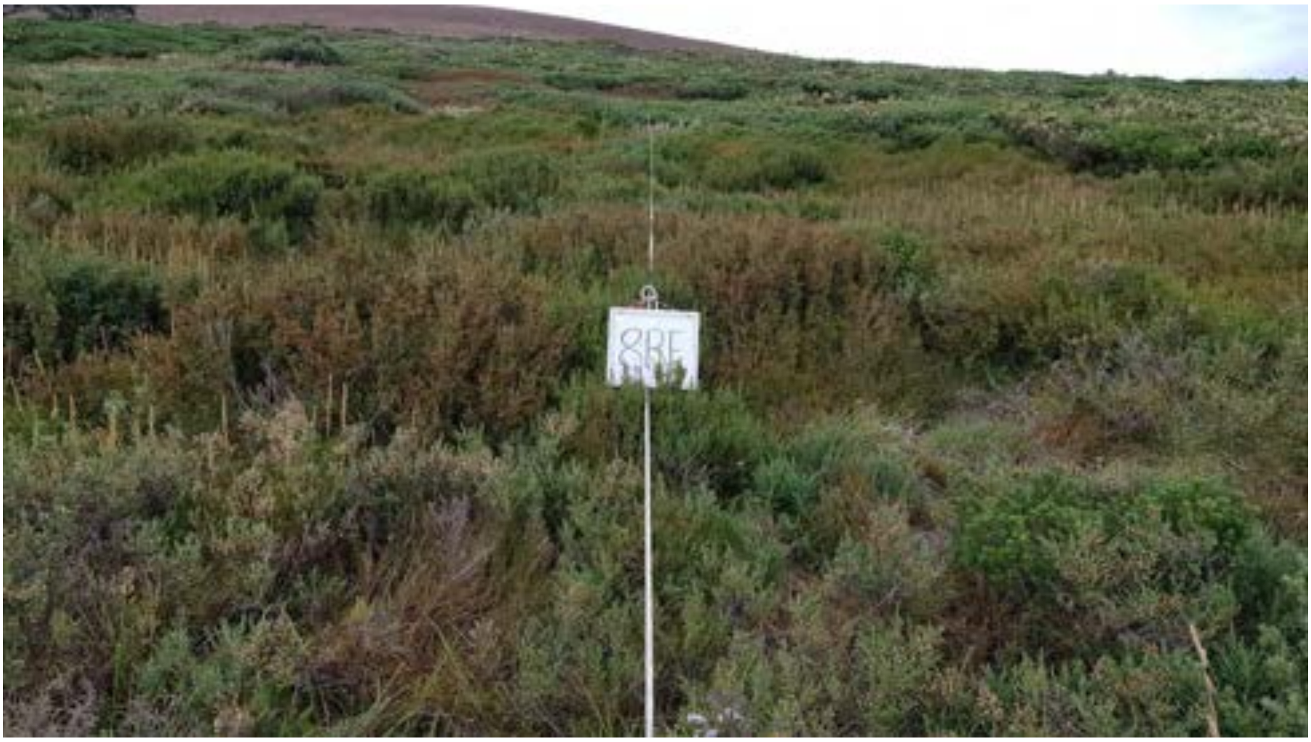


**Photo Point 8BE, Bog 8/9/10 (Impact), Impact Year 1, 18 February 2020**

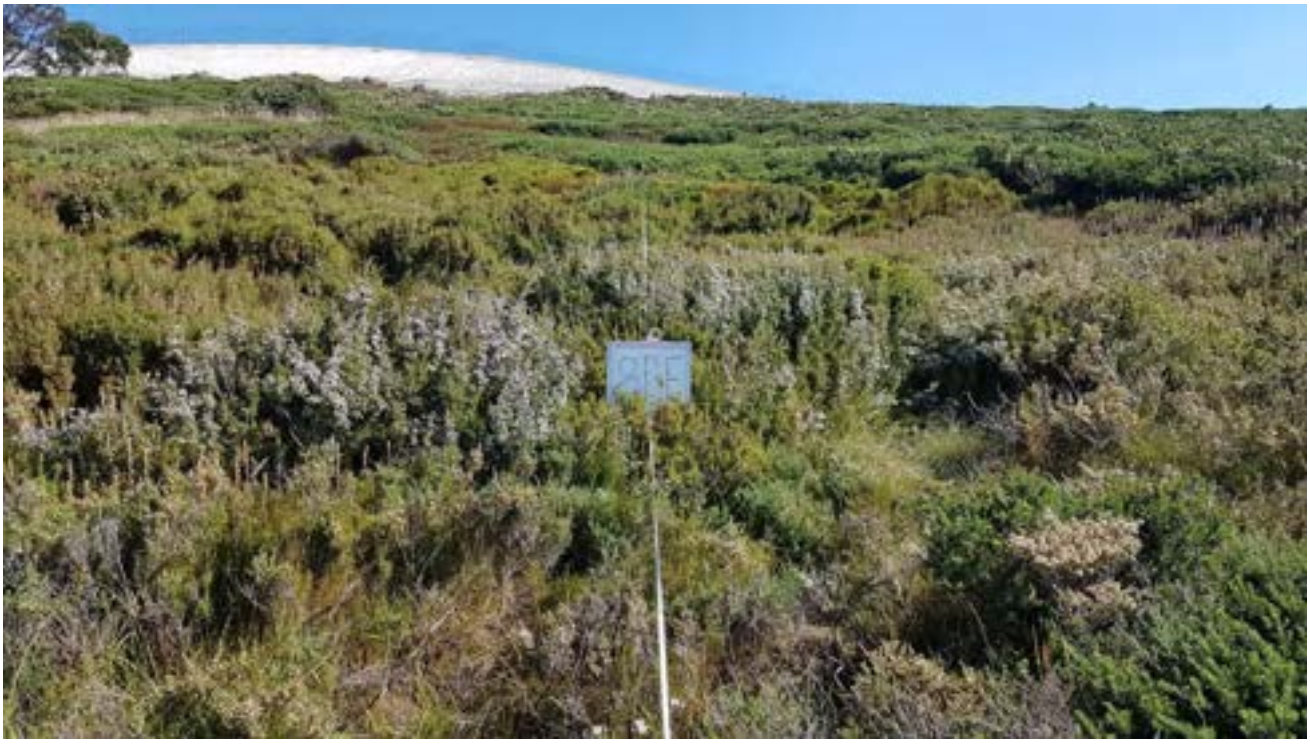


**Photo Point 8BE, Bog 8/9/10 (Impact), Impact Year 2, 27 January 2021**

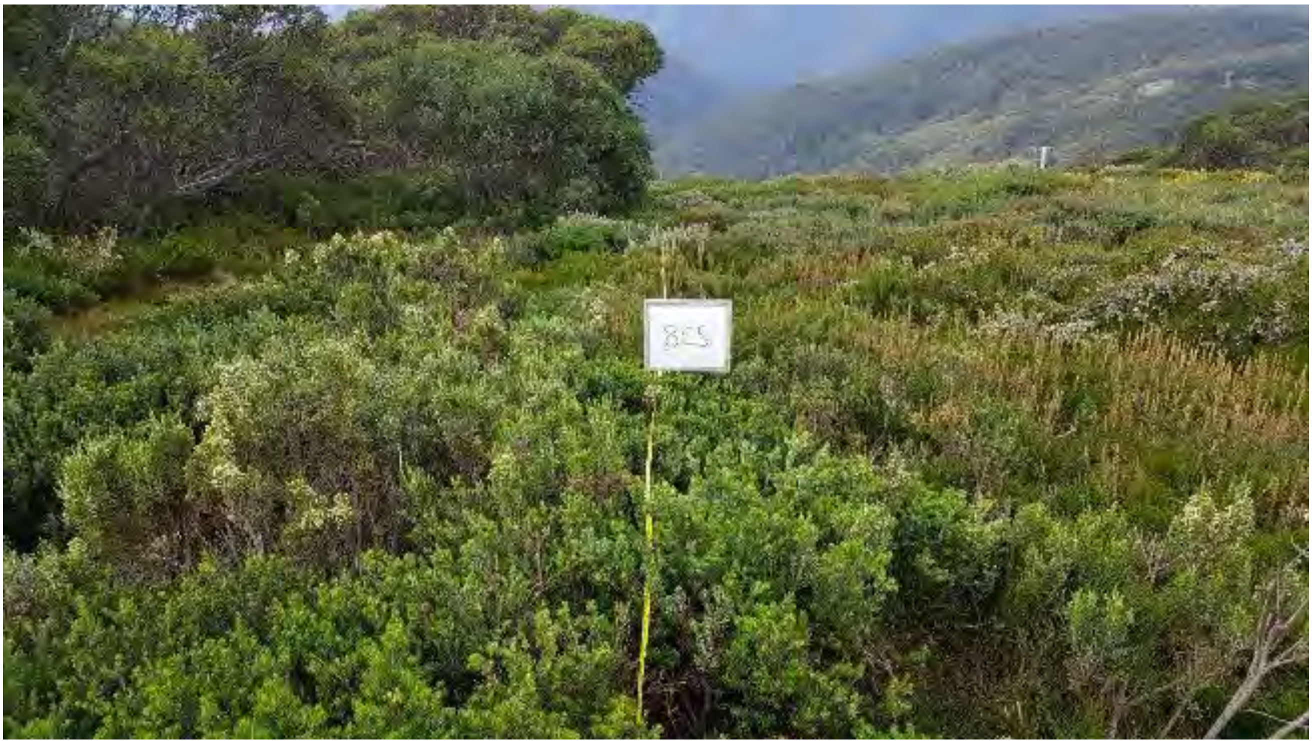



**Photo Point 8CS, Bog 8/9/10 (Impact), Baseline Year 1, 26 January 2018**

**Photo Point 8CS, Bog 8/9/10 (Impact), Baseline Year 2, 30 January 2019**


**Photo Point 8CS, Bog 8/9/10 (Impact), Impact Year 1, 20 February 2020**


**Photo Point 8CS, Bog 8/9/10 (Impact), Impact Year 2, 28 January 2021**

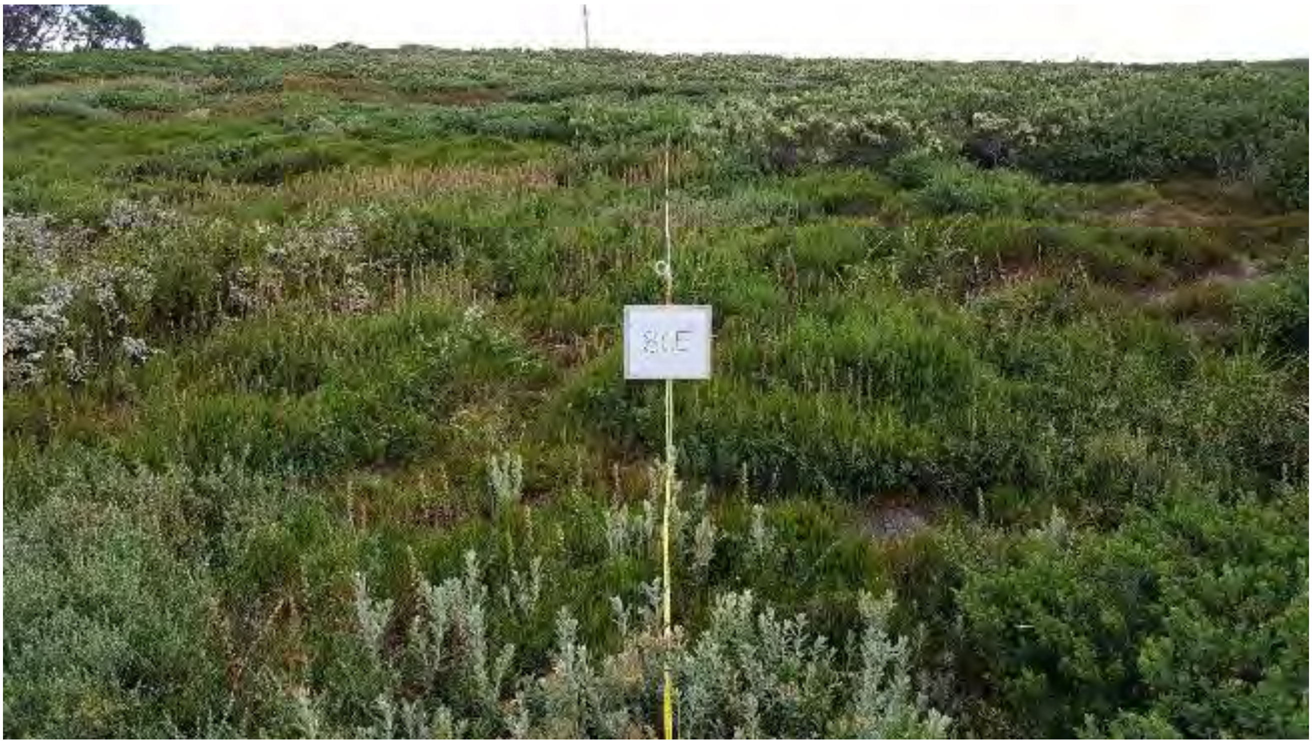



**Photo Point 8CE, Bog 8/9/10 (Impact), Baseline Year 1, 26 January 2018**

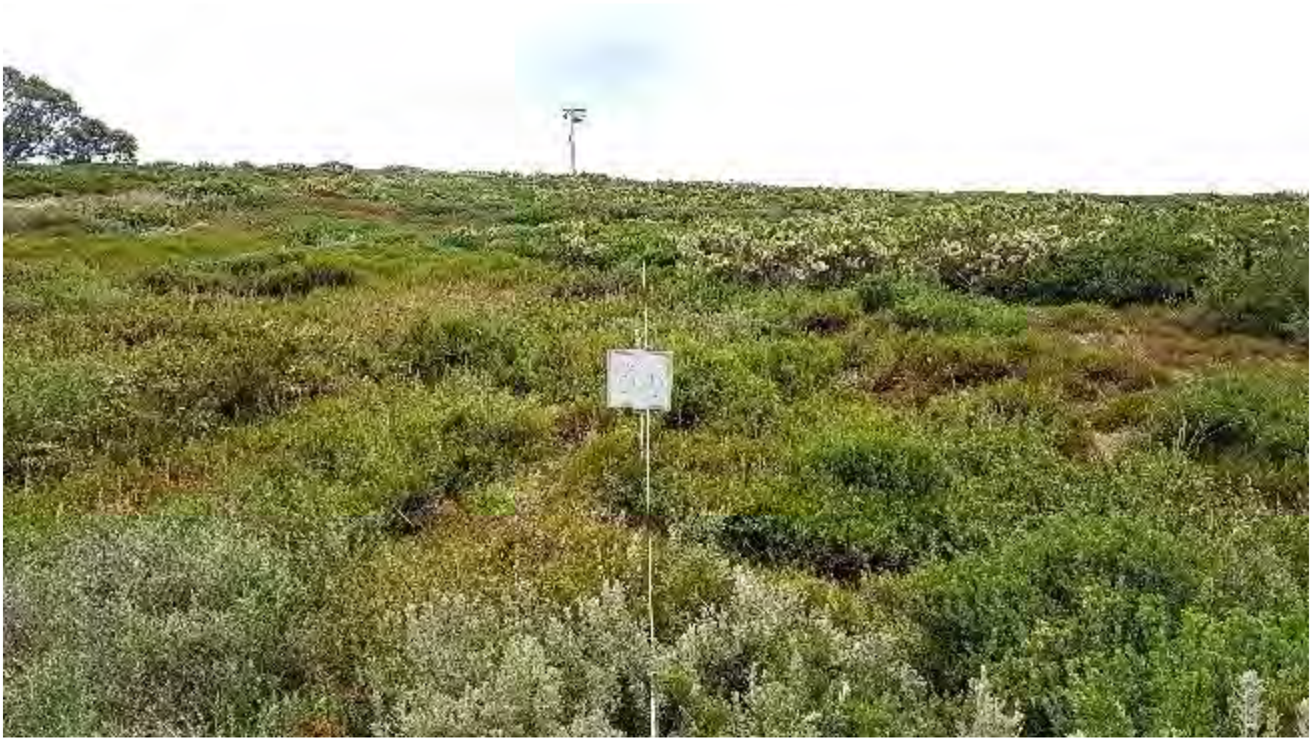


**Photo Point 8CE, Bog 8/9/10 (Impact), Baseline Year 2, 30 January 2019**

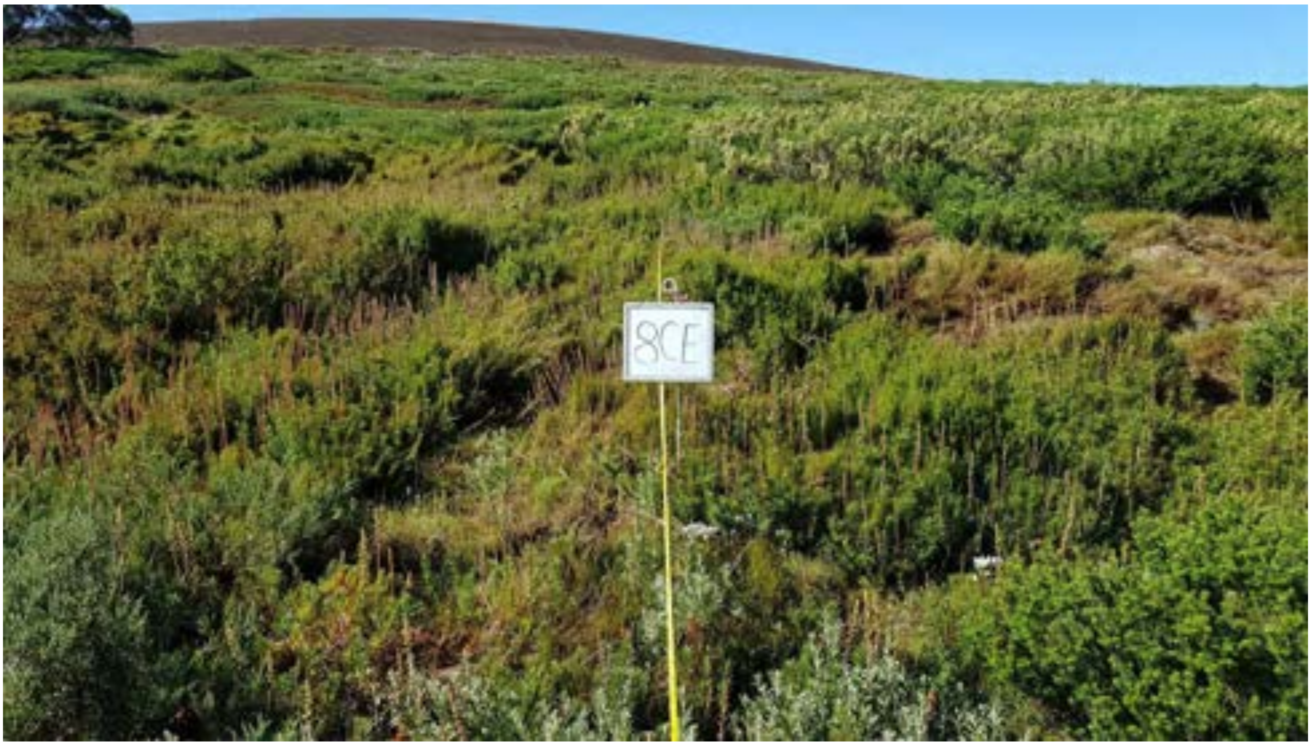



**Photo Point 8CE, Bog 8/9/10 (Impact), Impact Year 1, 20 February 2020**


**Photo Point 8CE, Bog 8/9/10 (Impact), Impact Year 2, 28 January 2021**


**Photo Point 9AS, Bog 8/9/10 (Impact), Baseline Year 1, 27 January 2018**

**Photo Point 9AS, Bog 8/9/10 (Impact), Baseline Year 2, 30 January 2019**


**Photo Point 9AS, Bog 8/9/10 (Impact), Impact Year 1, 7 February 2020**


**Photo Point 9AS, Bog 8/9/10 (Impact), Impact Year 2, 27 January 2021**

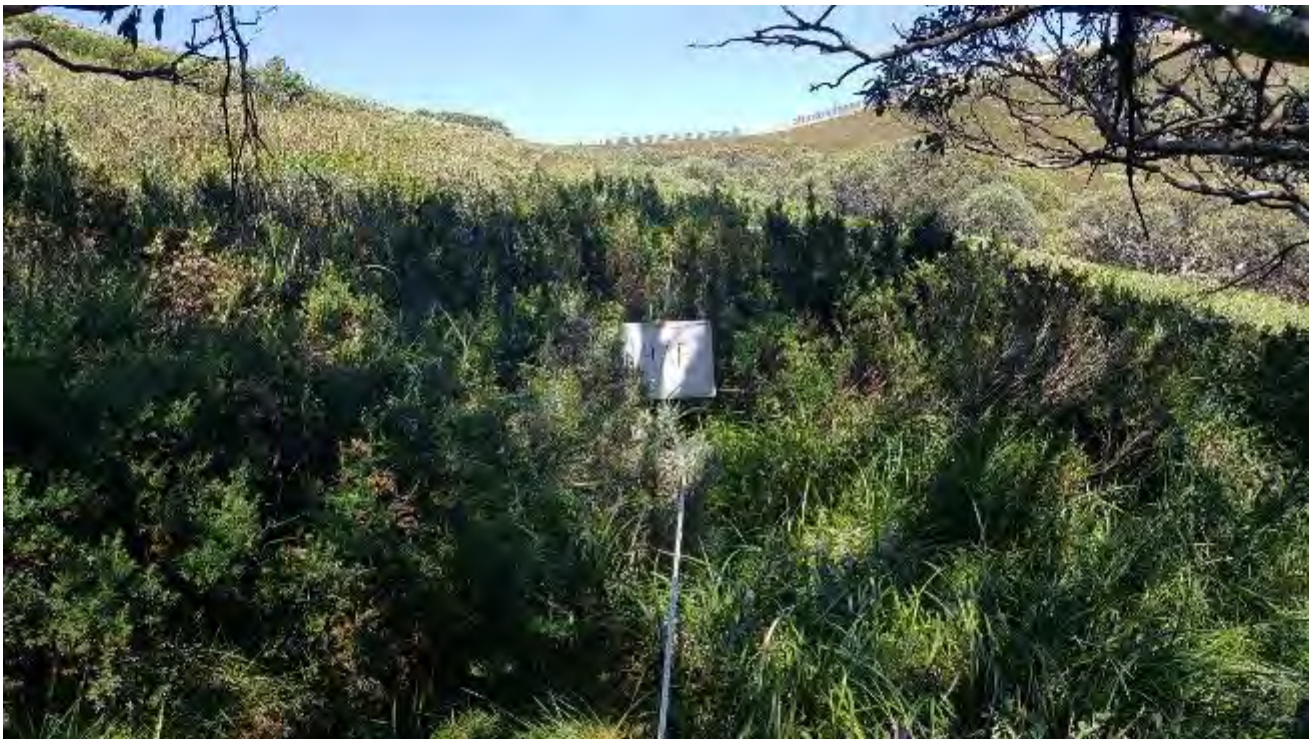


**Photo Point 9AE, Bog 8/9/10 (Impact), Baseline Year 1, 27 January 2018**

**Photo Point 9AE, Bog 8/9/10 (Impact), Baseline Year 2, 30 January 2019**


**Photo Point 9AE, Bog 8/9/10 (Impact), Impact Year 1, 7 February 2020**


**Photo Point 9AE, Bog 8/9/10 (Impact), Impact Year 2, 27 January 2021**


**Photo Point 10AS, Bog 8/9/10 (Impact), Baseline Year 1, 27 January 2018**

**Photo Point 10AS, Bog 8/9/10 (Impact), Baseline Year 2, 30 January 2019**


**Photo Point 10AS, Bog 8/9/10 (Impact), Impact Year 1, 7 February 2020**


**Photo Point 10AS, Bog 8/9/10 (Impact), Impact Year 2, 28 January 2021**

**Photo Point 10AE, Bog 8/9/10 (Impact), Baseline Year 1, 27 January 2018**

**Photo Point 10AE, Bog 8/9/10 (Impact), Baseline Year 2, 30 January 2019**


**Photo Point 10AE, Bog 8/9/10 (Impact), Impact Year 1, 7 February 2020**


**Photo Point 10AE, Bog 8/9/10 (Impact), Impact Year 2, 28 January 2021**

# Bog 11.1

**Photo Point 11.1AS, Bog 11.1 (Control), Baseline Year 1, 8 February 2018**

**Photo Point 11.1AS, Bog 11.1 (Control), Baseline Year 2, 31 January 2019**

**Photo Point 11.1AS, Bog 11.1 (Control), Impact Year 1, 3 February 2020**

**Photo Point 11.1AS, Bog 11.1 (Control), Impact Year 2, 25 January 2021**

**Photo Point 11.1AE, Bog 11.1 (Control), Baseline Year 1, 8 February 2018**

**Photo Point 11.1AE, Bog 11.1 (Control), Baseline Year 2, 31 January 2019**


**Photo Point 11.1AE, Bog 11.1 (Control), Impact Year 1, 3 February 2020**


**Photo Point 11.1AE, Bog 11.1 (Control), Impact Year 2, 25 January 2021**

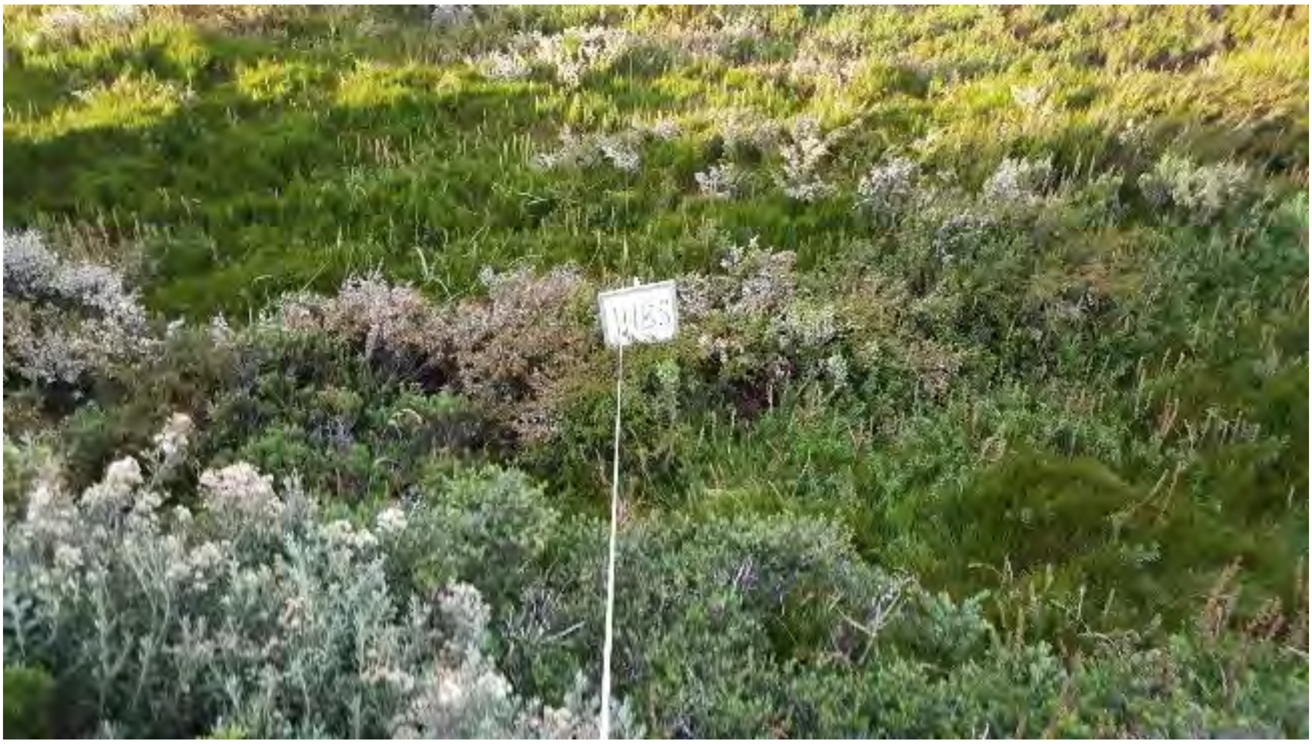


**Photo Point 11.1BS, Bog 11.1 (Control), Baseline Year 1, 8 February 2018**

**Photo Point 11.1BS, Bog 11.1 (Control), Baseline Year 2, 31 January 2019**

**Photo Point 11.1BS, Bog 11.1 (Control), Impact Year 1, 3 February 2020**

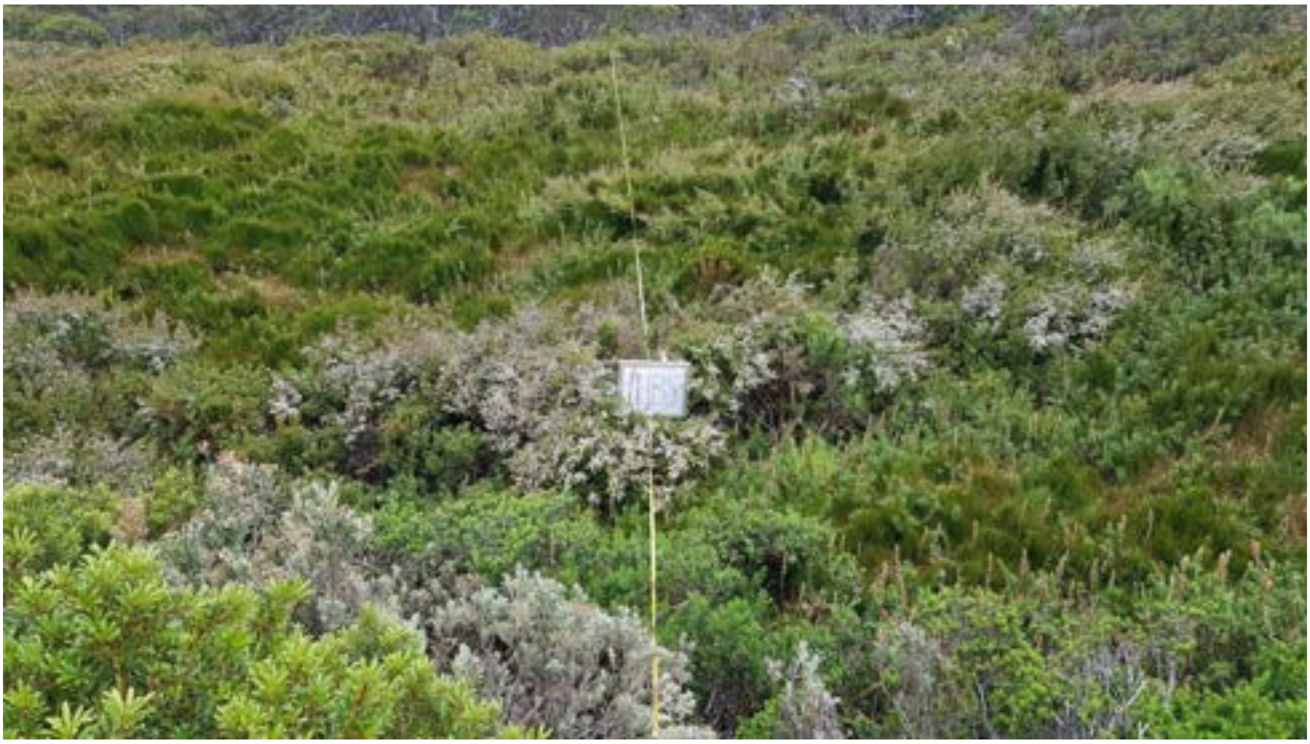


**Photo Point 11.1BS, Bog 11.1 (Control), Impact Year 2, 25 January 2021**


**Photo Point 11.1BE, Bog 11.1 (Control), Baseline Year 1, 8 February 2018**


**Photo Point 11.1BE, Bog 11.1 (Control), Baseline Year 2, 31 January 2019**

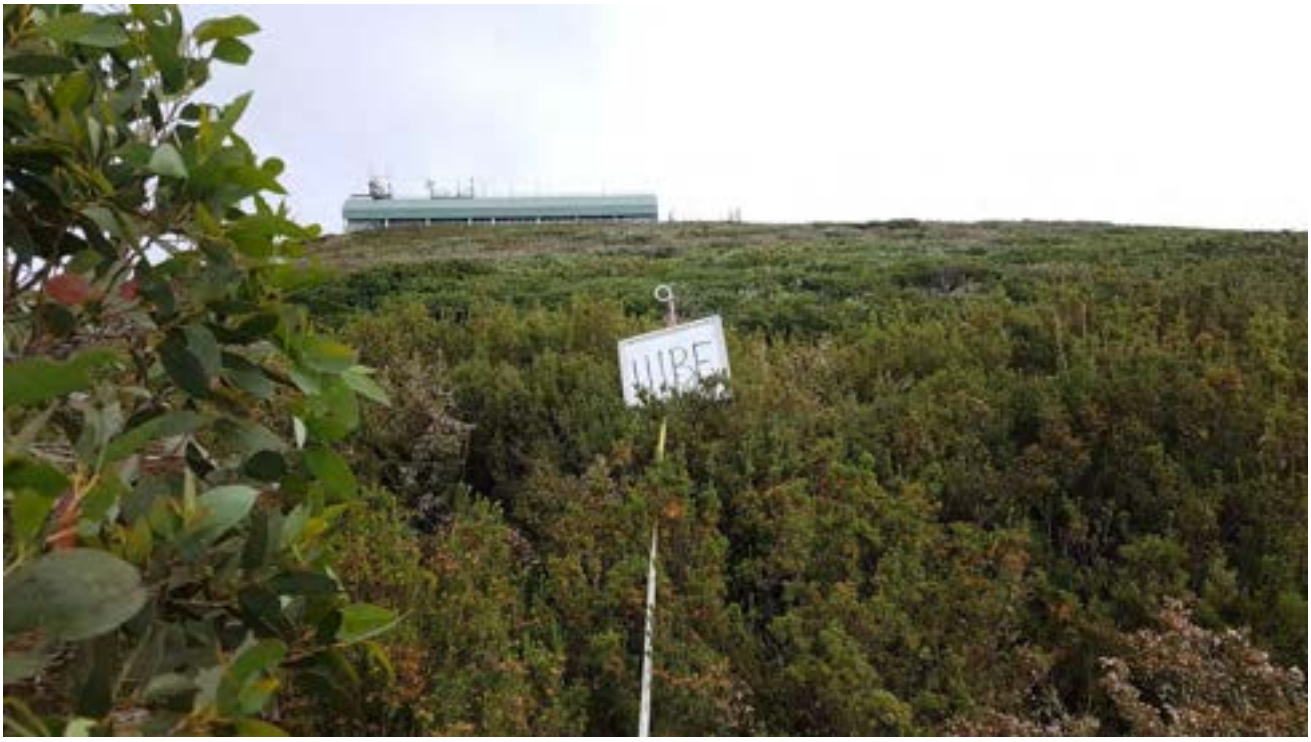



**Photo Point 11.1BE, Bog 11.1 (Control), Impact Year 1, 3 February 2020**


**Photo Point 11.1BE, Bog 11.1 (Control), Impact Year 2, 25 January 2021**

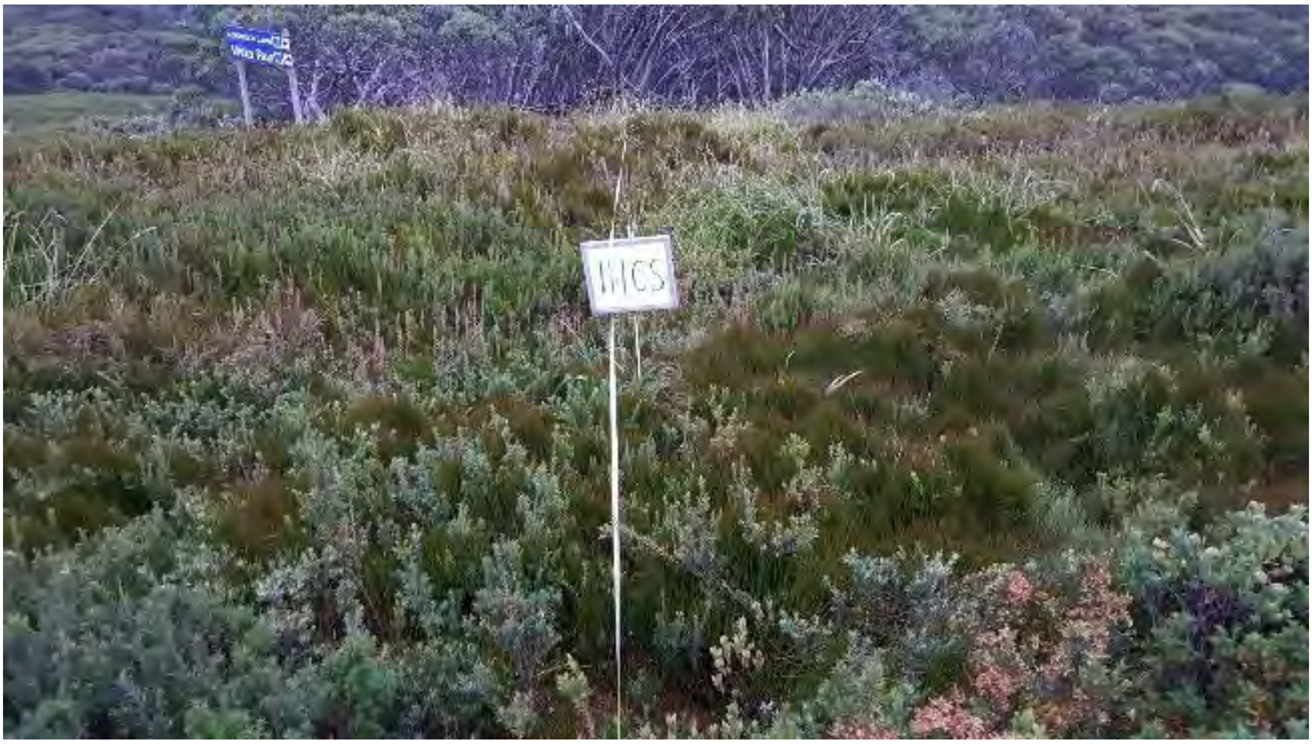


**Photo Point 11.1CS, Bog 11.1 (Control), Baseline Year 1, 8 February 2018**

**Photo Point 11.1CS, Bog 11.1 (Control), Baseline Year 2, 31 January 2019**

**Photo Point 11.1CS, Bog 11.1 (Control), Impact Year 1, 4 February 2020**

**Photo Point 11.1CS, Bog 11.1 (Control), Impact Year 2, 25 January 2021**

**Photo Point 11.1CE, Bog 11.1 (Control), Baseline Year 1, 8 February 2018**

**Photo Point 11.1CE, Bog 11.1 (Control), Baseline Year 2, 31 January 2019**

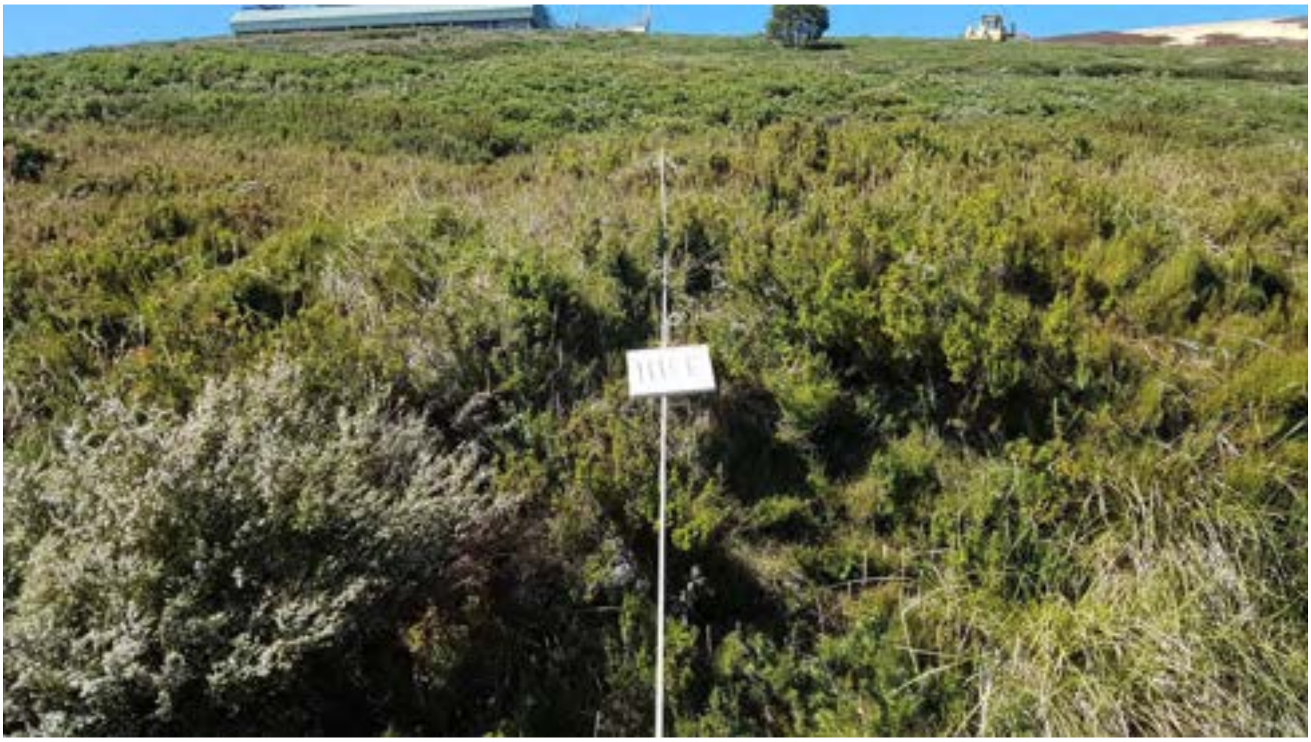


**Photo Point 11.1CE, Bog 11.1 (Control), Impact Year 1, 4 February 2020**


**Photo Point 11.1CE, Bog 11.1 (Control), Impact Year 2, 25 January 2021**

## Bog 11.2

**Photo Point 11.2AS, Bog 11.2 (Impact), Baseline Year 1, 28 January 2018**

**Photo Point 11.2AS, Bog 11.2 (Impact), Baseline Year 2, 31 January 2019**


**Photo Point 11.2AS, Bog 11.2 (Impact), Impact Year 1, 7 February 2020**


**Photo Point 11.2AS, Bog 11.2 (Impact), Impact Year 2, 26 January 2021**

**Photo Point 11.2AE, Bog 11.2 (Impact), Baseline Year 1, 28 January 2018**

**Photo Point 11.2AE, Bog 11.2 (Impact), Baseline Year 2, 31 January 2019**

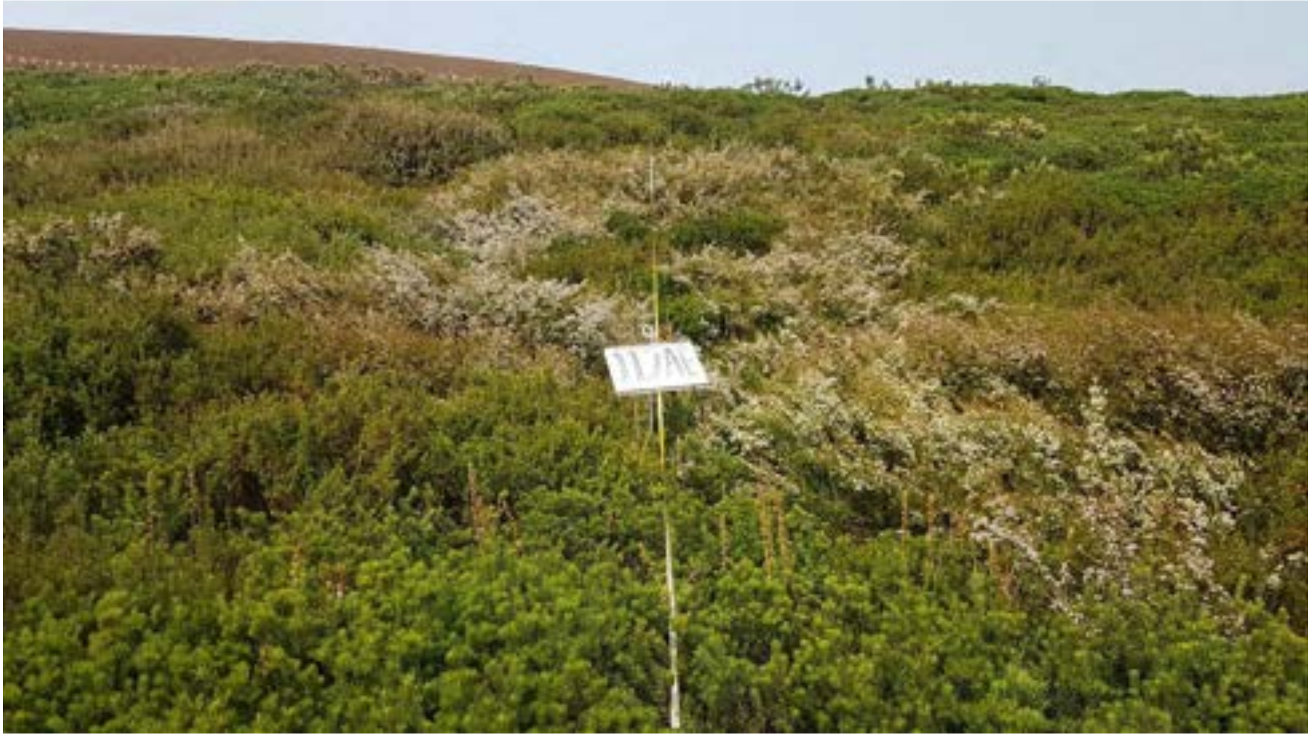


**Photo Point 11.2AE, Bog 11.2 (Impact), Impact Year 1, 7 February 2020**


**Photo Point 11.2AE, Bog 11.2 (Impact), Impact Year 2, 26 January 2021**

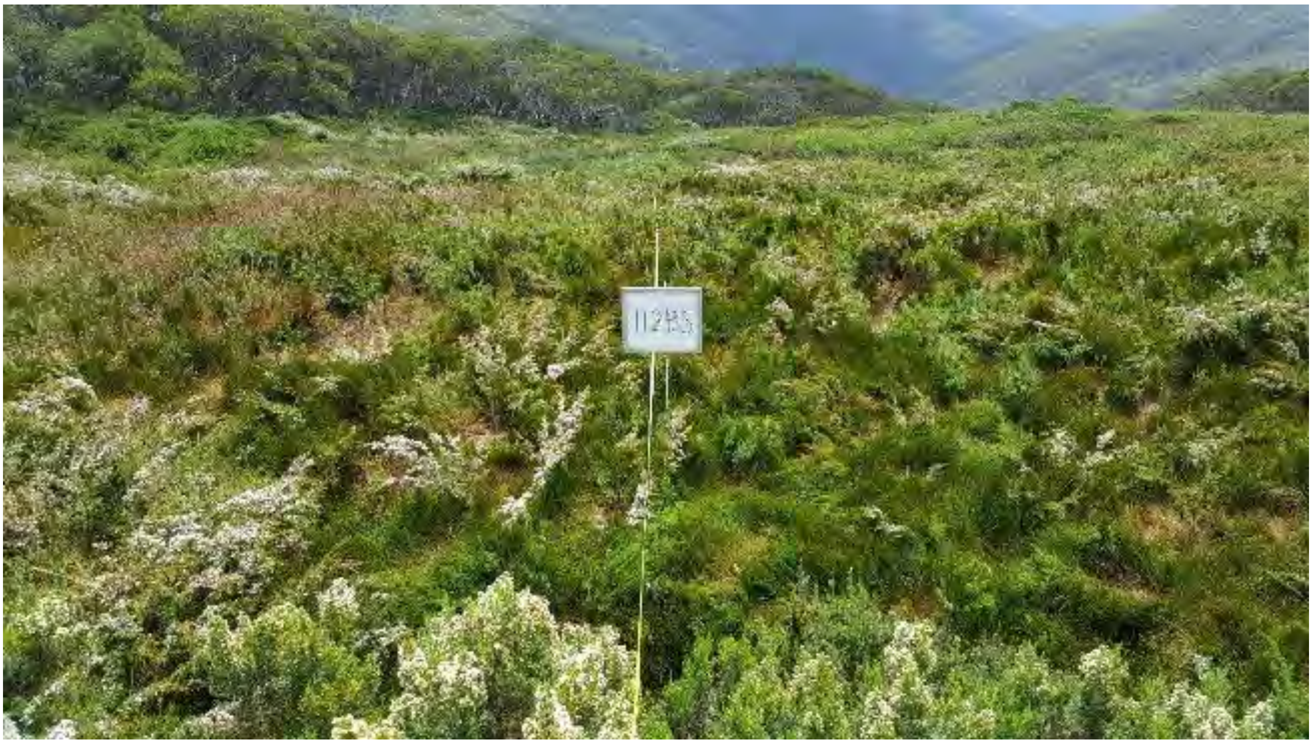


**Photo Point 11.2BS, Bog 11.2 (Impact), Baseline Year 1, 28 January 2018**

**Photo Point 11.2BS, Bog 11.2 (Impact), Baseline Year 2, 31 January 2019**

**Photo Point 11.2BS, Bog 11.2 (Impact), Impact Year 1, 20 February 2020**

**Photo Point 11.2BS, Bog 11.2 (Impact), Impact Year 2, 26 January 2021**

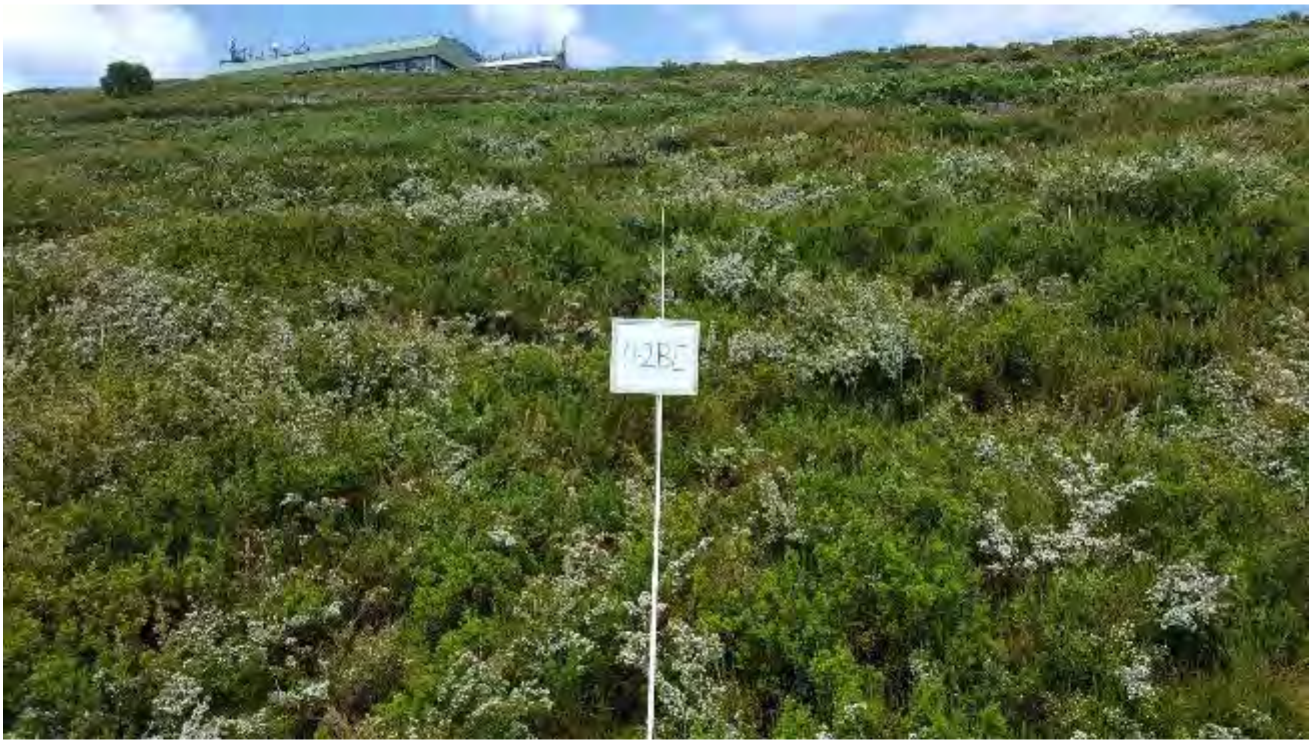


**Photo Point 11.2BE, Bog 11.2 (Impact), Baseline Year 1, 28 January 2018**

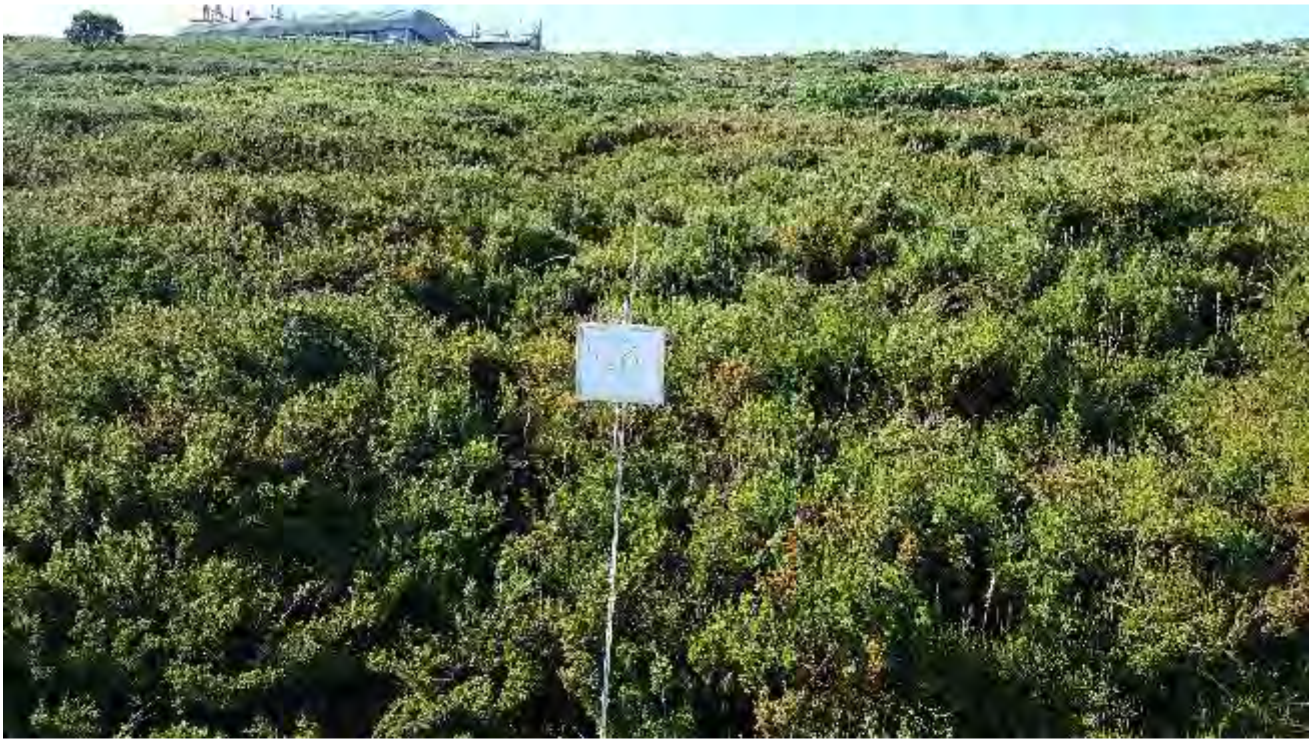


**Photo Point 11.2BE, Bog 11.2 (Impact), Baseline Year 2, 31 January 2019**

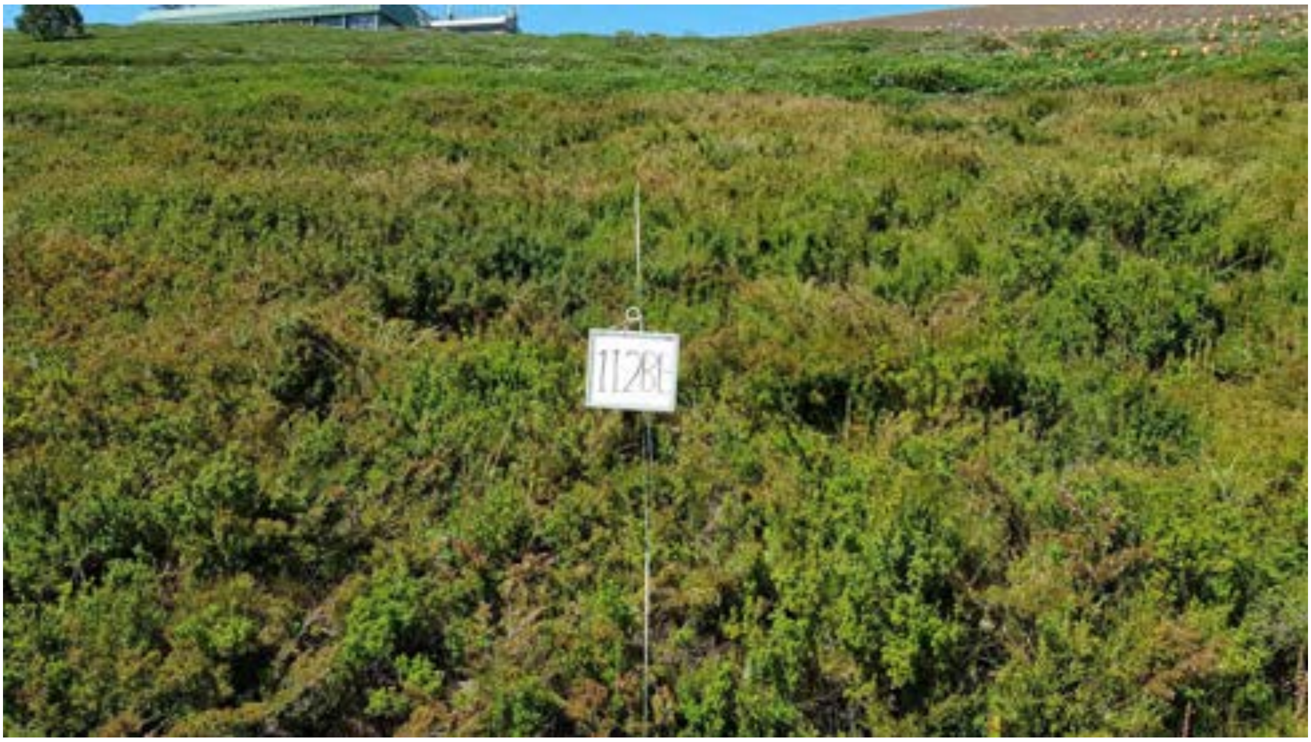



**Photo Point 11.2BE, Bog 11.2 (Impact), Impact Year 1, 20 February 2020**

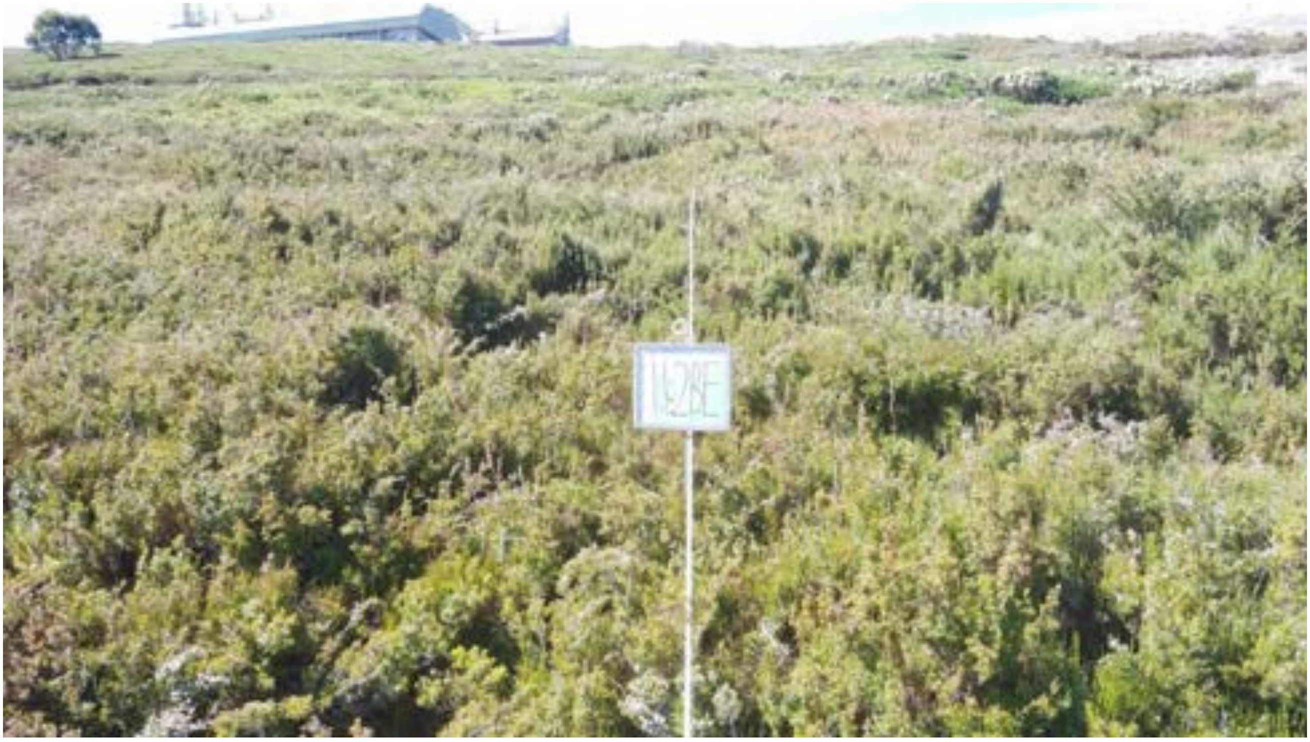


**Photo Point 11.2BE, Bog 11.2 (Impact), Impact Year 2, 26 January 2021**

**Photo Point 11.2CS, Bog 11.2 (Impact), Baseline Year 1, 28 January 2018**

**Photo Point 11.2CS, Bog 11.2 (Impact), Baseline Year 2, 31 January 2019**

**Photo Point 11.2CS, Bog 11.2 (Impact), Impact Year 1, 6 February 2020**

**Photo Point 11.2CS, Bog 11.2 (Impact), Impact Year 2, 27 January 2021**

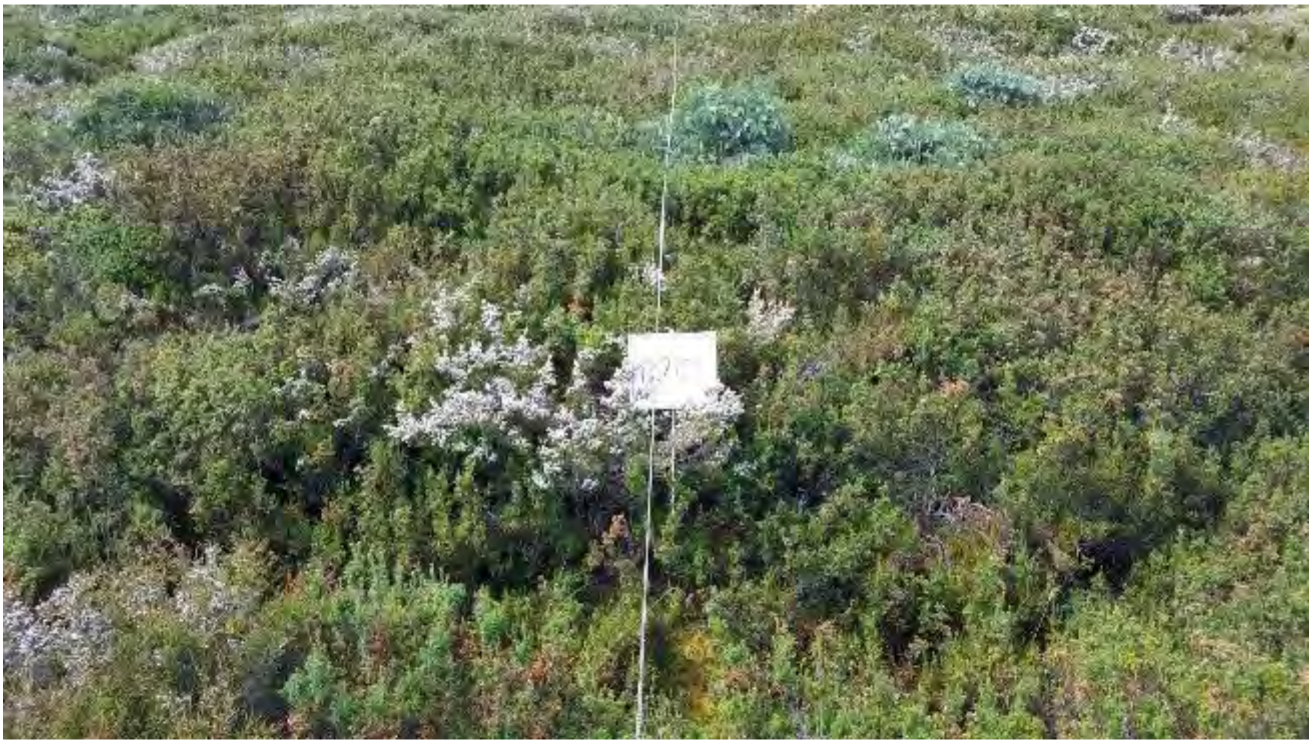


**Photo Point 11.2CE, Bog 11.2 (Impact), Baseline Year 1, 28 January 2018**


**Photo Point 11.2CE, Bog 11.2 (Impact), Baseline Year 2, 31 January 2019**

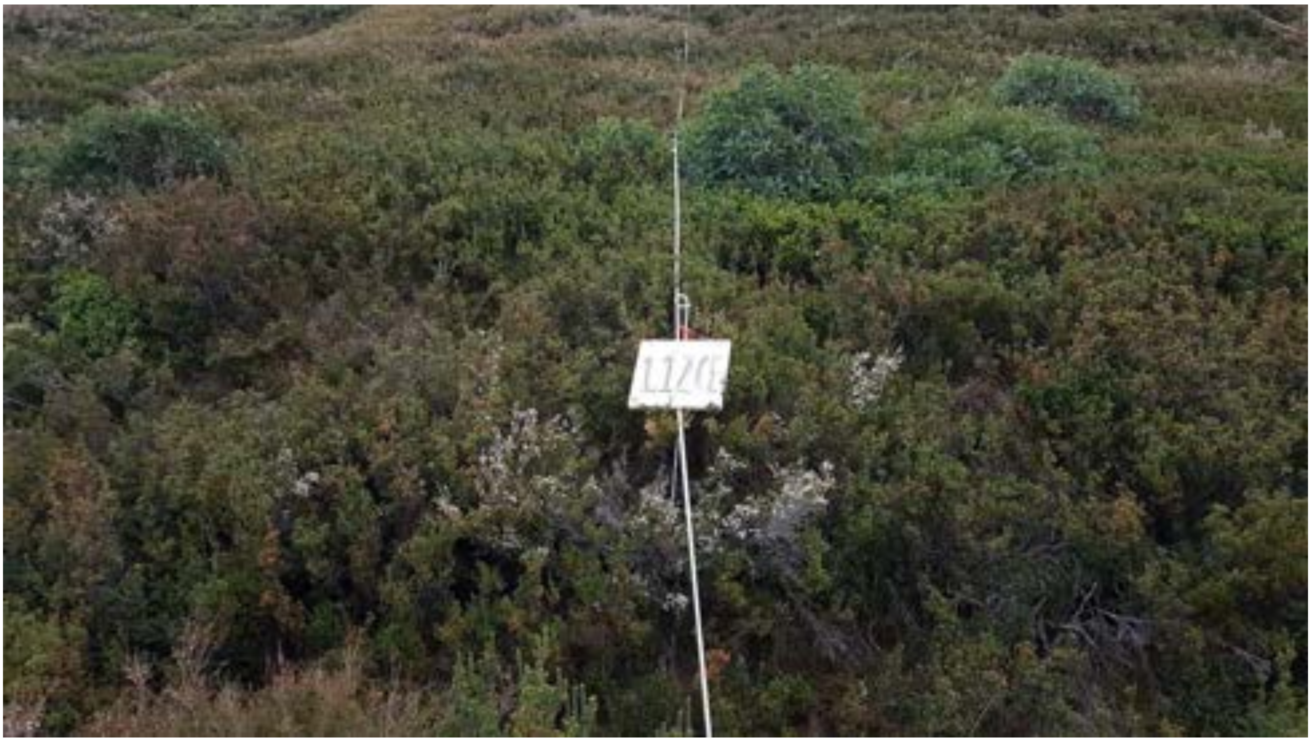


**Photo Point 11.2CE, Bog 11.2 (Impact), Impact Year 1, 6 February 2020**

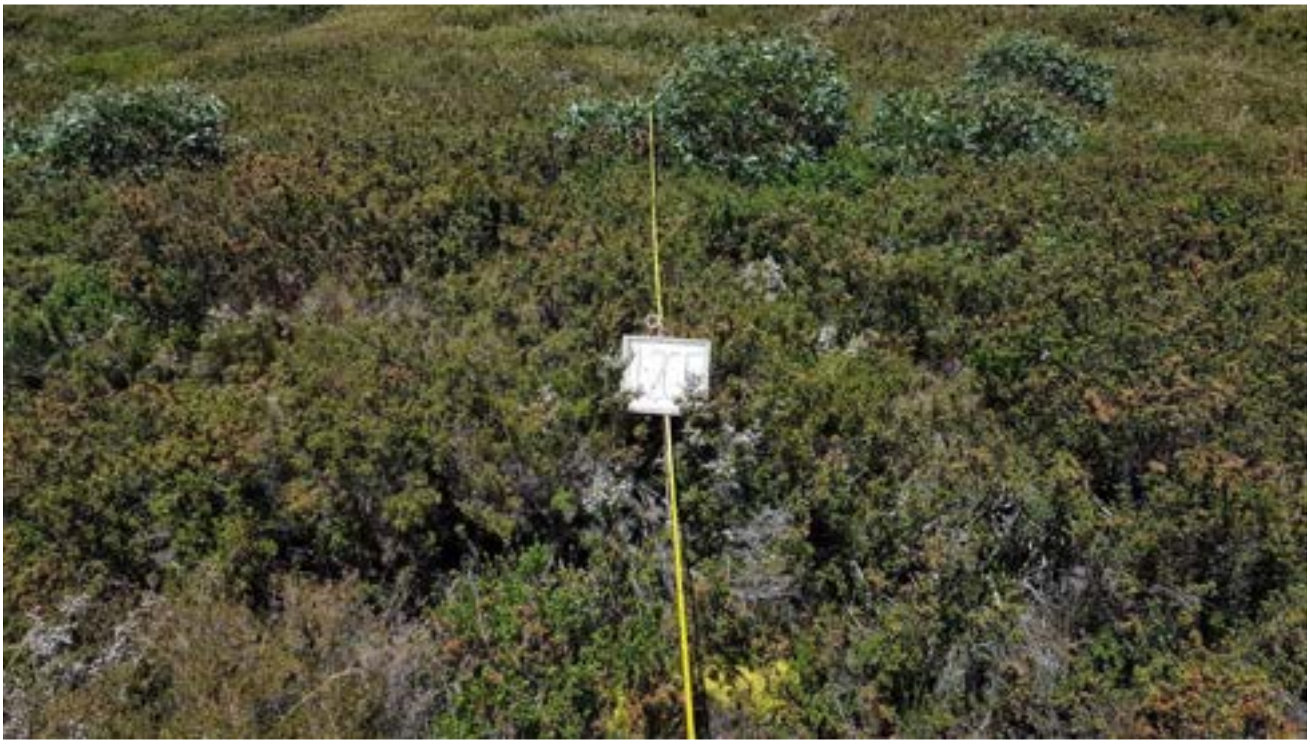


**Photo Point 11.2CE, Bog 11.2 (Impact), Impact Year 2, 27 January 2021**

# Bog 12

**Photo Point 12AS, Bog 12 (Impact), Baseline Year 1, 27 January 2018**

**Photo Point 12AS, Bog 12 (Impact), Baseline Year 2, 30 January 2019**

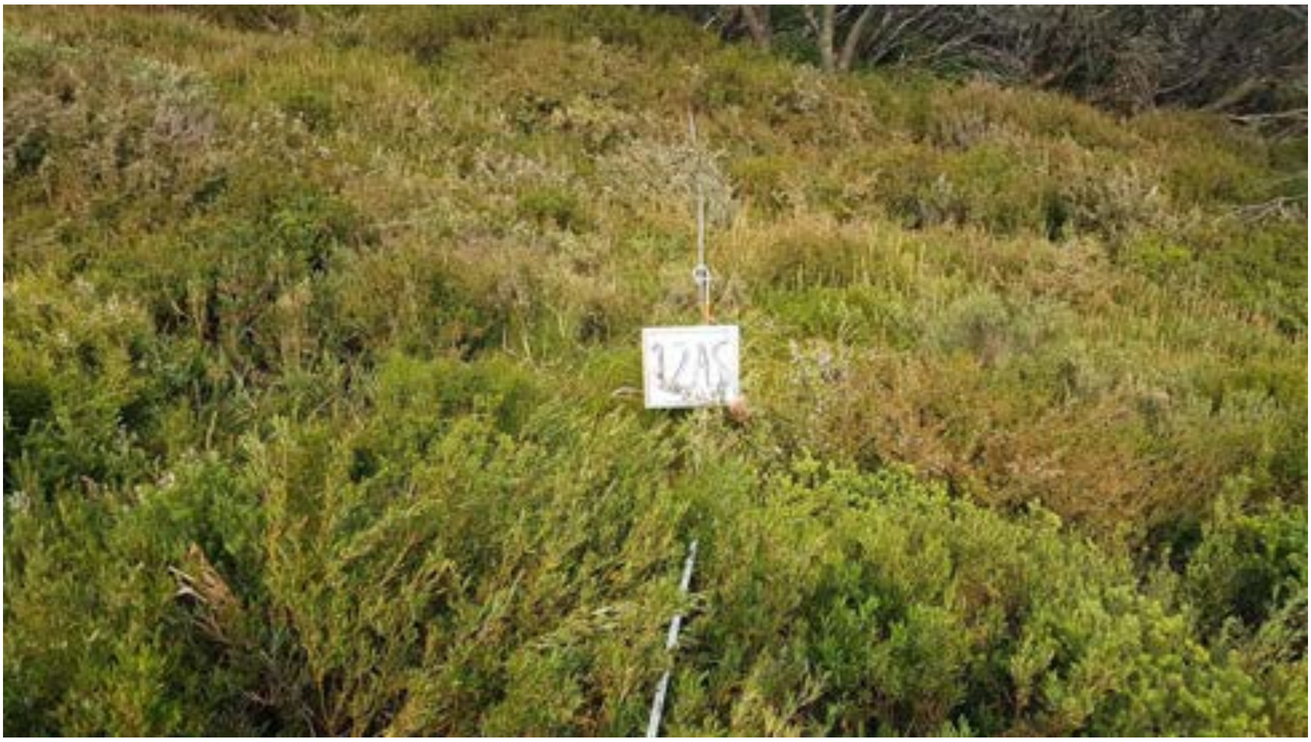



**Photo Point 12AS, Bog 12 (Impact), Impact Year 1, 7 February 2020**


**Photo Point 12AS, Bog 12 (Impact), Impact Year 2, 27 January 2021**

**Photo Point 12AE, Bog 12 (Impact), Baseline Year 1, 27 January 2018**

**Photo Point 12AE, Bog 12 (Impact), Baseline Year 2, 30 January 2019**


**Photo Point 12AE, Bog 12 (Impact), Impact Year 1, 7 February 2020**


**Photo Point 12AE, Bog 12 (Impact), Impact Year 2, 27 January 2021**

**Photo Point 12BS, Bog 12 (Impact), Baseline Year 1, 29 January 2018**

**Photo Point 12BS, Bog 12 (Impact), Baseline Year 2, 30 January 2019**


**Photo Point 12BS, Bog 12 (Impact), Impact Year 1, 6 February 2020**

**Photo Point 12BS, Bog 12 (Impact), Impact Year 2, 27 January 2021**

**Photo Point 12BE, Bog 12 (Impact), Baseline Year 1, 29 January 2018**

**Photo Point 12BE, Bog 12 (Impact), Baseline Year 2, 30 January 2019**

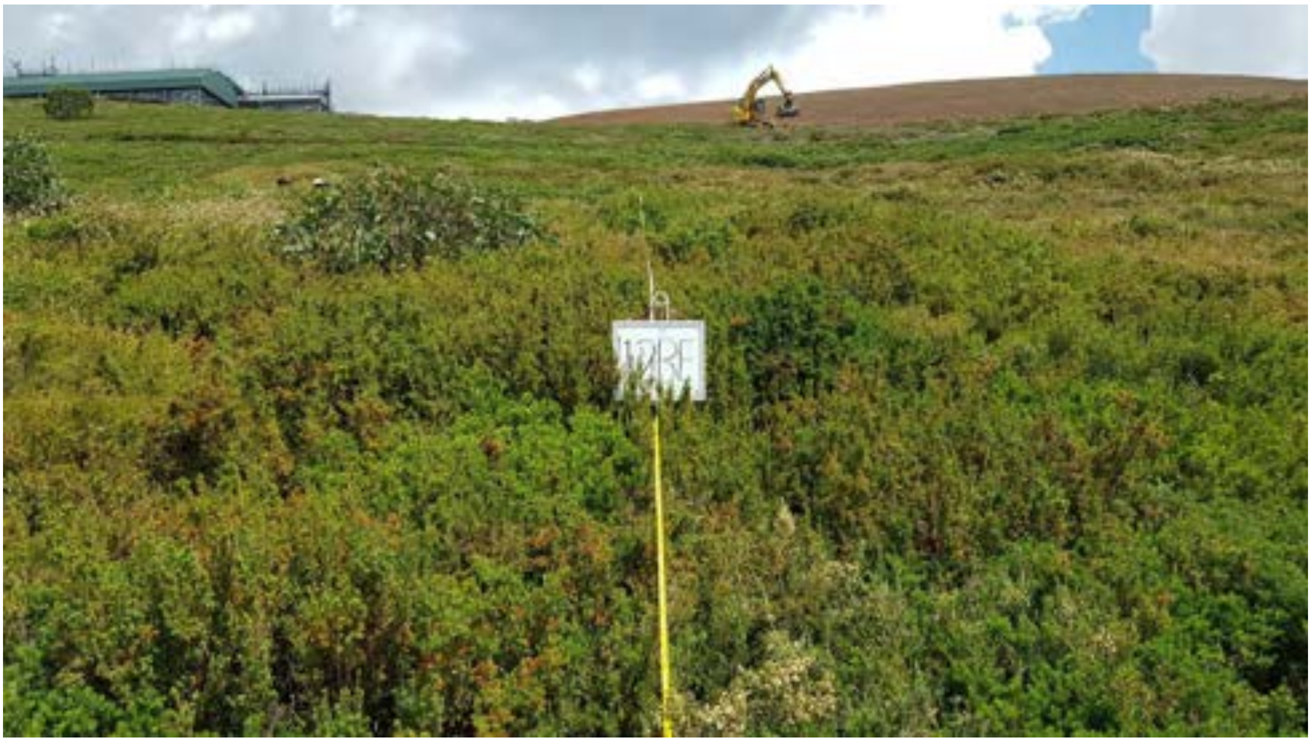



**Photo Point 12BE, Bog 12 (Impact), Impact Year 1, 6 February 2020**


**Photo Point 12BE, Bog 12 (Impact), Impact Year 2, 27 January 2021**

**Photo Point 12CS, Bog 12 (Impact), Baseline Year 1, 29 January 2018**

**Photo Point 12CS, Bog 12 (Impact), Baseline Year 2, 30 January 2019**


**Photo Point 12CS, Bog 12 (Impact), Impact Year 1, 7 February 2020**

**Photo Point 12CS, Bog 12 (Impact), Impact Year 2, 27 January 2021**

**Photo Point 12CE, Bog 12 (Impact), Baseline Year 1, 29 January 2018**

**Photo Point 12CE, Bog 12 (Impact), Baseline Year 2, 30 January 2019**


**Photo Point 12CE, Bog 12 (Impact), Impact Year 1, 7 February 2020**


**Photo Point 12CE, Bog 12 (Impact), Impact Year 2, 27 January 2021**

## Bog 13


**Photo Point 13AS, Bog 13 (Impact), Baseline Year 1, 2 February 2018**


**Photo Point 13AS, Bog 13 (Impact), Baseline Year 2, 14 February 2019**

**Photo Point 13AS, Bog 13 (Impact), Impact Year 1, 31 January 2020**

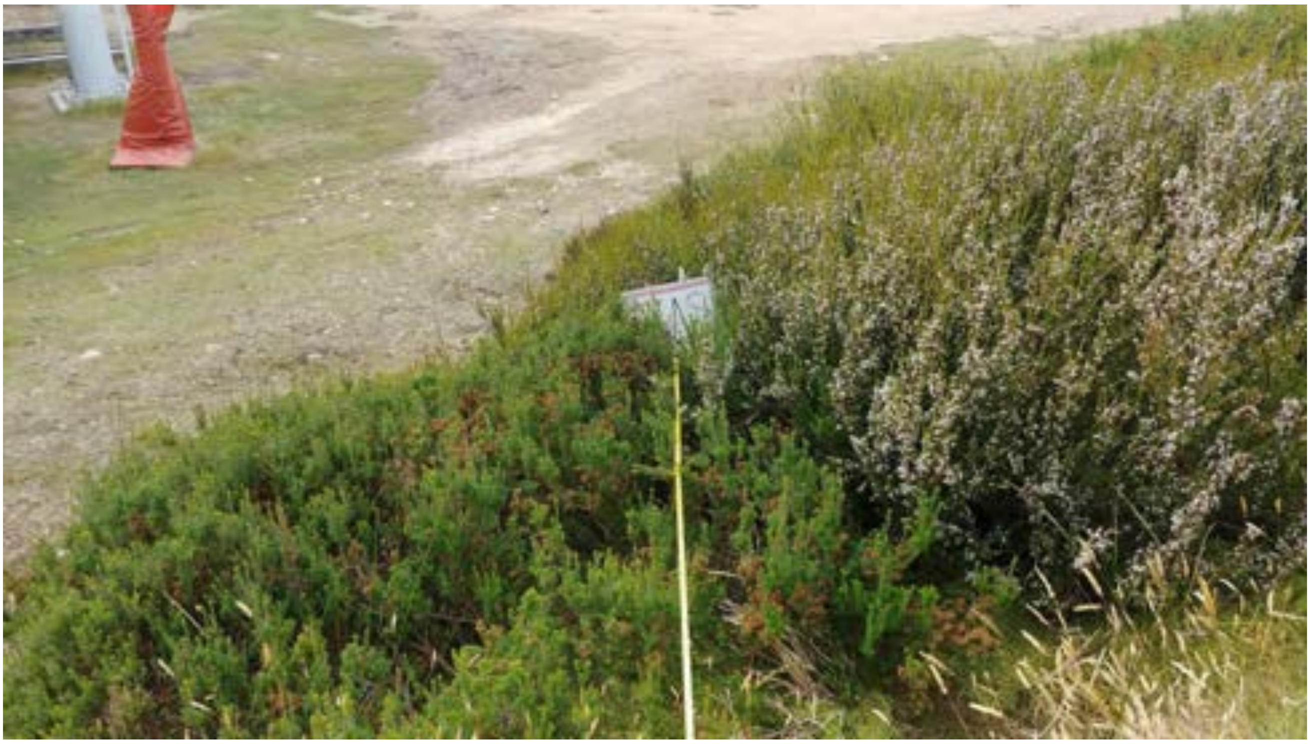


**Photo Point 13AS, Bog 13 (Impact), Impact Year 1, 4 February 2021**

**Photo Point 13AE, Bog 13 (Impact), Baseline Year 1, 2 February 2018**

**Photo Point 13AE, Bog 13 (Impact), Baseline Year 2, 14 February 2019**

**Photo Point 13AE, Bog 13 (Impact), Impact Year 1, 31 January 2020**

**Photo Point 13AE, Bog 13 (Impact), Impact Year 2, 4 February 2021**


**Photo Point 13BS, Bog 13 (Impact), Baseline Year 1, 2 February 2018**


**Photo Point 13BS, Bog 13 (Impact), Baseline Year 2, 14 February 2019**


**Photo Point 13BS, Bog 13 (Impact), Impact Year 1, 31 January 2020**

**Photo Point 13BS, Bog 13 (Impact), Impact Year 2, 4 February 2021**

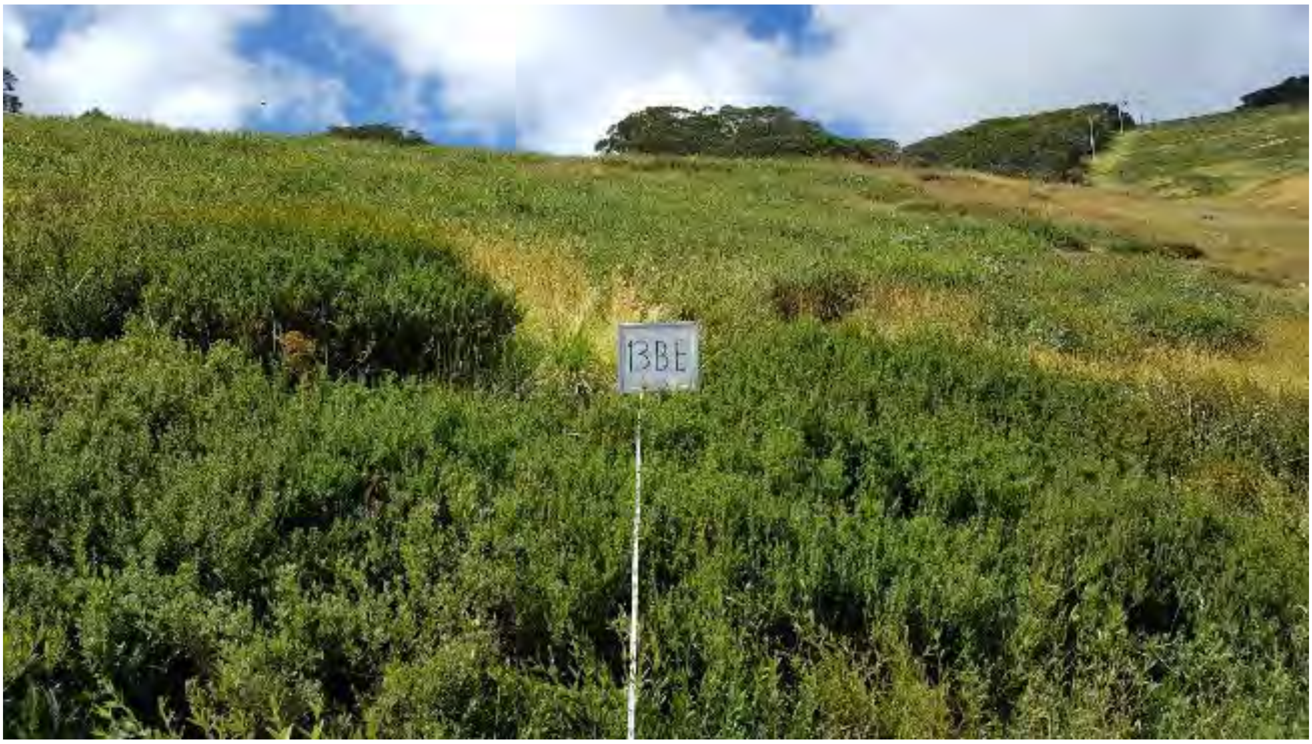



**Photo Point 13BE, Bog 13 (Impact), Baseline Year 1, 2 February 2018**


**Photo Point 13BE, Bog 13 (Impact), Baseline Year 2, 14 February 2019**


**Photo Point 13BE, Bog 13 (Impact), Impact Year 1, 31 January 2020**


**Photo Point 13BE, Bog 13 (Impact), Impact Year 2, 4 February 2021**


**Photo Point 13CS, Bog 13 (Impact), Baseline Year 1, 2 February 2018**

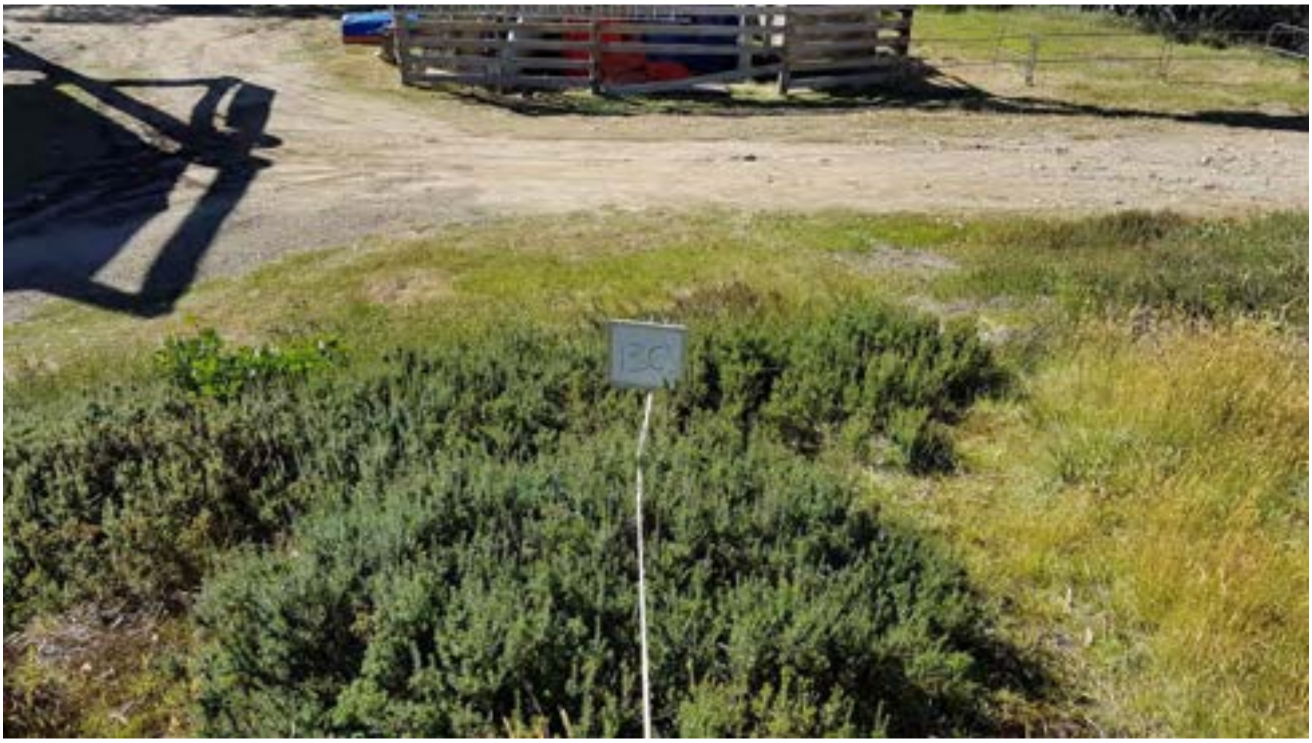


**Photo Point 13CS, Bog 13 (Impact), Baseline Year 2, 14 February 2019**


**Photo Point 13CS, Bog 13 (Impact), Impact Year 1, 31 January 2020**


**Photo Point 13CS, Bog 13 (Impact), Impact Year 2, 4 February 2021**


**Photo Point 13CE, Bog 13 (Impact), Baseline Year 1, 2 February 2018**


**Photo Point 13CE, Bog 13 (Impact), Baseline Year 2, 14 February 2019**


**Photo Point 13CE, Bog 13 (Impact), Impact Year 1, 31 January 2020**


**Photo Point 13CE, Bog 13 (Impact), Impact Year 2, 4 February 2021**

# Bog S1

**Photo Point S1AS, Bog S1 (Control), Baseline Year 1, 6 February 2018**

**Photo Point S1AS, Bog S1 (Control), Baseline Year 2, 13 February 2019**


**Photo Point S1AS, Bog S1 (Control), Impact Year 1, 28 January 2020**


**Photo Point S1AS, Bog S1 (Control), Impact Year 2, 4 February 2021**

**Photo Point S1AE, Bog S1 (Control), Baseline Year 1, 6 February 2018**

**Photo Point S1AE, Bog S1 (Control), Baseline Year 2, 13 February 2019**


**Photo Point S1AE, Bog S1 (Control), Impact Year 1, 28 January 2020**


**Photo Point S1AE, Bog S1 (Control), Impact Year 2, 4 February 2021**


**Photo Point S1BS, Bog S1 (Control), Baseline Year 1, 6 February 2018**


**Photo Point S1BS, Bog S1 (Control), Baseline Year 2, 13 February 2019**


**Photo Point S1BS, Bog S1 (Control), Impact Year 1, 28 January 2020**


**Photo Point S1BS, Bog S1 (Control), Impact Year 2, 4 February 2021**


**Photo Point S1BE, Bog S1 (Control), Baseline Year 1, 6 February 2018**


**Photo Point S1BE, Bog S1 (Control), Baseline Year 2, 13 February 2019**


**Photo Point S1BE, Bog S1 (Control), Impact Year 1, 28 January 2020**


**Photo Point S1BE, Bog S1 (Control), Impact Year 2, 4 February 2021**

**Photo Point S1CS, Bog S1 (Control), Baseline Year 1, 6 February 2018**

**Photo Point S1CS, Bog S1 (Control), Baseline Year 2, 13 February 2019**

Photo Point S1CS, Bog S1 (Control), Impact Year 1, 28 January 2020


Photo Point S1CS, Bog S1 (Control), Impact Year 2, 4 February 2021

**Photo Point S1CE, Bog S1 (Control), Baseline Year 1, 6 February 2018**


**Photo Point S1CE, Bog S1 (Control), Baseline Year 2, 13 February 2019**

**Photo Point S1CE, Bog S1 (Control), Impact Year 1, 28 January 2020**


**Photo Point S1CE, Bog S1 (Control), Impact Year 2, 4 February 2021**

## Bog S2


**Photo Point S2AS, Bog S2 (Control), Baseline Year 1, 6 February 2018**


**Photo Point S2AS, Bog S2 (Control), Baseline Year 2, 13 February 2019**

**Photo Point S2AS, Bog S2 (Control), Impact Year 1, 29 January 2020**

**Photo Point S2AS, Bog S2 (Control), Impact Year 2, 3 February 2021**


**Photo Point S2AE, Bog S2 (Control), Baseline Year 1, 6 February 2018**


**Photo Point S2AE, Bog S2 (Control), Baseline Year 2, 13 February 2019**


**Photo Point S2AE, Bog S2 (Control), Impact Year 1, 29 January 2020**

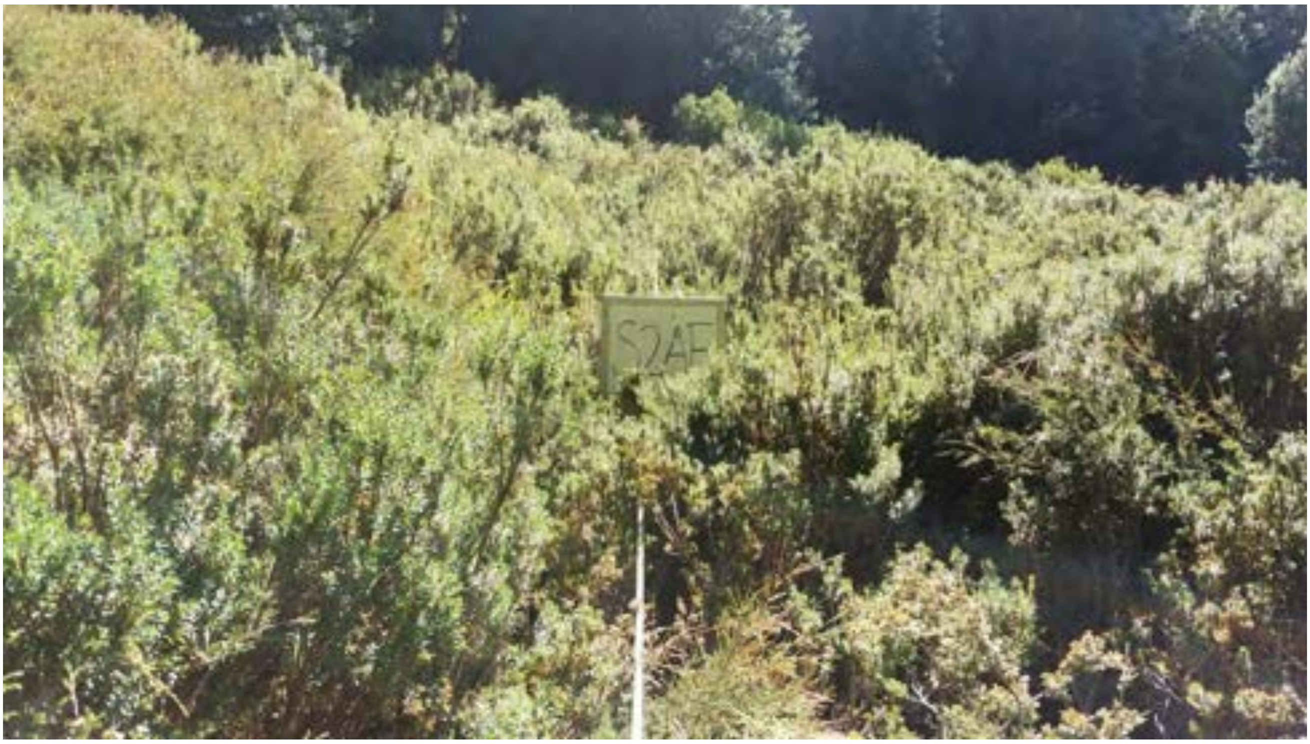



**Photo Point S2AE, Bog S2 (Control), Impact Year 2, 3 February 2021**

**Photo Point S2BS, Bog S2 (Control), Baseline Year 1, 7 February 2018**

**Photo Point S2BS, Bog S2 (Control), Baseline Year 2, 13 February 2019**


**Photo Point S2BS, Bog S2 (Control), Impact Year 1, 29 January 2020**

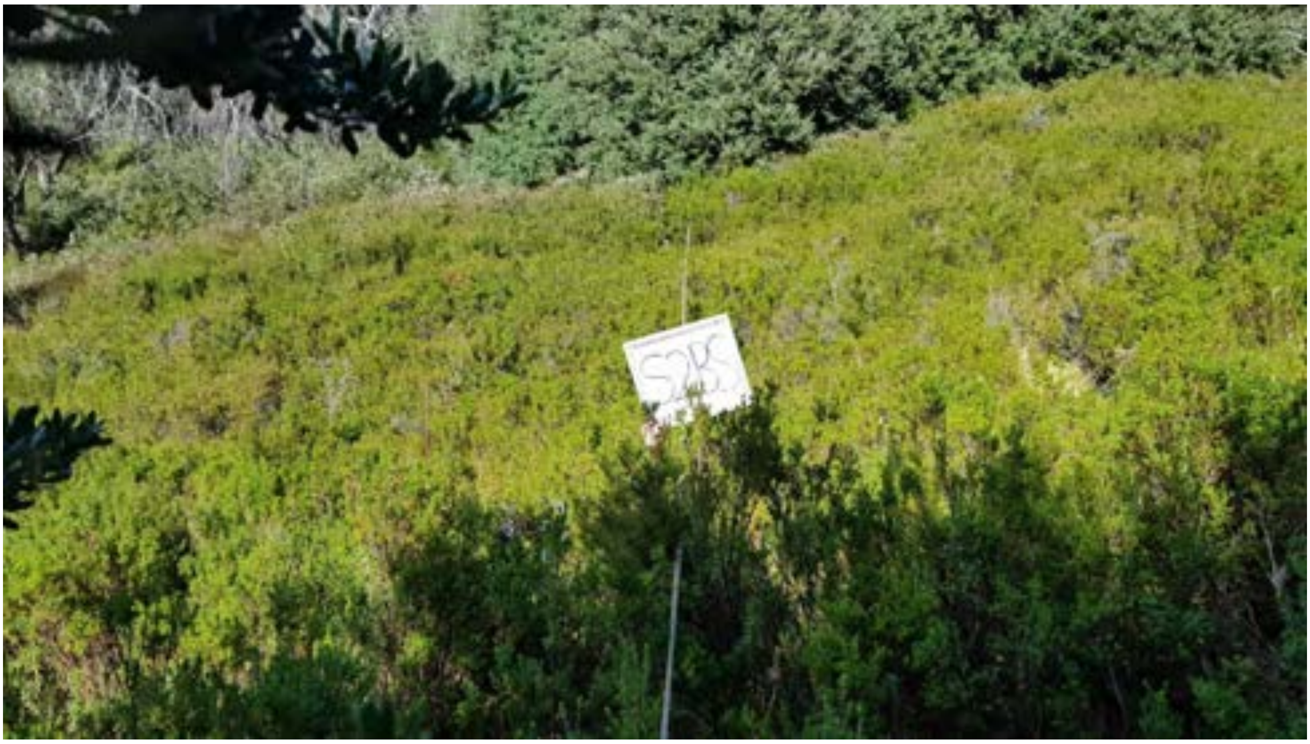



**Photo Point S2BS, Bog S2 (Control), Impact Year 2, 3 February 2021**

**Photo Point S2BE, Bog S2 (Control), Baseline Year 1, 7 February 2018**


**Photo Point S2BE, Bog S2 (Control), Baseline Year 2, 13 February 2019**


**Photo Point S2BE, Bog S2 (Control), Impact Year 1, 29 January 2020**


**Photo Point S2BE, Bog S2 (Control), Impact Year 2, 3 February 2021**


**Photo Point S2CS, Bog S2 (Control), Baseline Year 1, 7 February 2018**


**Photo Point S2CS, Bog S2 (Control), Baseline Year 2, 13 February 2019**

**Photo Point S2CS, Bog S2 (Control), Impact Year 1, 30 January 2020**

**Photo Point S2CS, Bog S2 (Control), Impact Year 2, 3 February 2021**

**Photo Point S2CE, Bog S2 (Control), Baseline Year 1, 7 February 2018**


**Photo Point S2CE, Bog S2 (Control), Baseline Year 2, 13 February 2019**


**Photo Point S2CE, Bog S2 (Control), Impact Year 1, 30 January 2020**


**Photo Point S2CE, Bog S2 (Control), Impact Year 2, 3 February 2021**

# Bog S3


**Photo Point S3AS, Bog S3 (Control), Baseline Year 1, 7 February 2018**


**Photo Point S3AS, Bog S3 (Control), Baseline Year 2, 12 February 2019**


**Photo Point S3AS, Bog S3 (Control), Impact Year 1, 29 January 2020**


**Photo Point S3AS, Bog S3 (Control), Impact Year 2, 3 February 2021**


**Photo Point S3AE, Bog S3 (Control), Baseline Year 1, 7 February 2018**

**Photo Point S3AE, Bog S3 (Control), Baseline Year 2, 12 February 2019**


**Photo Point S3AE, Bog S3 (Control), Impact Year 1, 29 January 2020**


**Photo Point S3AE, Bog S3 (Control), Impact Year 2, 3 February 2021**

**Photo Point S3BS, Bog S3 (Control), Baseline Year 1, 7 February 2018**

**Photo Point S3BS, Bog S3 (Control), Baseline Year 2, 12 February 2019**


**Photo Point S3BS, Bog S3 (Control), Impact Year 1, 29 January 2020**


**Photo Point S3BS, Bog S3 (Control), Impact Year 2, 3 February 2021**

**Photo Point S3BE, Bog S3 (Control), Baseline Year 1, 7 February 2018**


**Photo Point S3BE, Bog S3 (Control), Baseline Year 2, 12 February 2019**


**Photo Point S3BE, Bog S3 (Control), Impact Year 1, 29 January 2020**


**Photo Point S3BE, Bog S3 (Control), Impact Year 2, 3 February 2021**


**Photo Point S3CS, Bog S3 (Control), Baseline Year 1, 7 February 2018**


**Photo Point S3CS, Bog S3 (Control), Baseline Year 2, 12 February 2019**


**Photo Point S3CS, Bog S3 (Control), Impact Year 1, 29 January 2020**


**Photo Point S3CS, Bog S3 (Control), Impact Year 2, 3 February 2021**

**Photo Point S3CE, Bog S3 (Control), Baseline Year 1, 7 February 2018**

**Photo Point S3CE, Bog S3 (Control), Baseline Year 2, 12 February 2019**

**Photo Point S3CE, Bog S3 (Control), Impact Year 1, 29 January 2020**

**Photo Point S3CE, Bog S3 (Control), Impact Year 2, 3 February 2021**

# Appendix 5 Ecology data

**Table A5.1 Area of Alpine Bogs as determined by DGPS mapping**

| Site | Area (ha) | | | | |
|---|---|---|---|---|---|
| | Baseline Year 1 | Baseline Year 2 | Baseline Mean | Impact Year 1 | Impact Year 2 |
| **All impact sites** | **1.3797*** | **1.3536** | **1.3666** | **1.3217** | **1.3353** |
| **Bog 4.2** | 0.4014 | 0.3842 | 0.3928 | 0.3912 | 0.3823 |
| **Bog 6** | 0.4914* | 0.6723 | 0.6723* | 0.6380 | 0.6473 |
| **Bog 8/9/10** | 0.0667 | 0.0718 | 0.0692 | 0.0704 | 0.0762 |
| **Bog 11.2** | 0.1195 | 0.1120 | 0.1157 | 0.1094 | 0.1083 |
| **Bog 12** | 0.1145 | 0.1071 | 0.1108 | 0.1076 | 0.1157 |
| **Bog 13** | 0.0051 | 0.0063 | 0.0057 | 0.0051 | 0.0055 |
| **All control sites** | **2.1446** | **2.0178** | **2.0812** | **2.0902** | **2.1183** |
| **Bog 1** | 0.1781 | 0.1620 | 0.1700 | 0.1491 | 0.1595 |
| **Bog 2** | 0.1516 | 0.1481 | 0.1499 | 0.1459 | 0.1464 |
| **Bog 4.1/5/7** | 0.5562 | 0.5457 | 0.5509 | 0.5480 | 0.5597 |
| **Bog 11.1** | 0.2798 | 0.2590 | 0.2694 | 0.2571 | 0.2676 |
| **Bog S1** | 0.5712 | 0.4584 | 0.5148 | 0.5126 | 0.4992 |
| **Bog S2** | 0.1805 | 0.1778 | 0.1791 | 0.1785 | 0.1846 |
| **Bog S3** | 0.2271 | 0.2669 | 0.2470 | 0.2989 | 0.3013 |

*Note: As discussed in the IY1 monitoring report, mapping of Bog 6 in BY1 is unlikely to have captured the full extent of the Bog 6 entity as recognised in subsequent years and is therefore unreliable. The BY2 area for Bog 6 has therefore been used as the baseline mean and BY1 total for all impact sites.

**Table A5.2 Dimensions of Alpine Bogs as estimated by line transects**

| Site | Sum of dimensions (m) | | | | |
|---|---|---|---|---|---|
| | Baseline Year 1 | Baseline Year 2 | Baseline Mean | Impact Year 1 | Impact Year 2 |
| **All impact sites** | **356.2** | **353.2** | **354.7** | **355.6** | **354.2** |
| **Bog 4.2** | 92.2 | 92.6 | 92.4 | 92.2 | 92.6 |
| **Bog 6** | 79.6 | 75.8 | 77.7 | 77.4 | 78.2 |
| **Bog 8/9/10** | 66.4 | 67.8 | 67.1 | 65.2 | 65 |
| **Bog 11.2** | 67.2 | 66.4 | 66.8 | 66.8 | 67.2 |
| **Bog 12** | 40.6 | 41.0 | 40.8 | 41.4 | 40.6 |
| **Bog 13** | 10.2 | 9.6 | 9.9 | 12.6 | 10.6 |
| **All control sites** | **436.0** | **441.6** | **438.8** | **438.6** | **436.6** |
| **Bog 1** | 55.8 | 57.2 | 56.5 | 57.0 | 56.6 |
| **Bog 2** | 78.8 | 79.6 | 79.2 | 77.2 | 79 |
| **Bog 4.1/5/7** | 81.6 | 84.2 | 82.9 | 85.2 | 83.8 |
| **Bog 11.1** | 48.6 | 48.4 | 48.5 | 48.0 | 47.4 |
| **Bog S1** | 52.6 | 52.4 | 52.5 | 52.0 | 51.2 |
| **Bog S2** | 57.4 | 58.2 | 57.8 | 58.2 | 57 |
| **Bog S3** | 61.2 | 61.6 | 61.4 | 61.0 | 61.6 |

**Table A5.3 Cover of bare ground as estimated by line transects**

| Site | Cover of bare ground | | | | |
|---|---|---|---|---|---|
| | Baseline Year 1 | Baseline Year 2 | Baseline Mean | Impact Year 1 | Impact Year 2 |
| **All impact sites** | **1.9%** | **0.1%** | **1.0%** | **5.4%** | **4.6%*** |
| **Bog 4.2** | 3.4% | 0.0% | 1.7% | 5.8% | 5.2% |
| **Bog 6** | 3.8% | 0.0% | 1.9% | 8.2% | 5.3% |
| **Bog 8/9/10** | 0.7% | 0.0% | 0.3% | 6.0% | 3.7% |
| **Bog 11.2** | 0.0% | 0.0% | 0.0% | 3.7% | 8.0% |
| **Bog 12** | 0.8% | 0.8% | 0.8% | 3.1% | 0.4% |
| **Bog 13** | 0.0% | 0.0% | 0.0% | 0.0% | 1.7% |
| **All control sites** | **0.9%** | **0.2%** | **0.5%** | **4.8%** | **2.6%*** |
| **Bog 1** | 0.6% | 0.0% | 0.3% | 3.5% | 0.3% |
| **Bog 2** | 1.1% | 0.0% | 0.6% | 10.3% | 0.7% |
| **Bog 4.1/5/7** | 0.4% | 0.0% | 0.2% | 0.8% | 0.6% |
| **Bog 11.1** | 0.7% | 0.4% | 0.5% | 3.6% | 0.0% |
| **Bog S1** | 3.0% | 0.3% | 1.7% | 2.4% | 7.1% |
| **Bog S2** | 0.0% | 0.0% | 0.0% | 5.7% | 0.7% |
| **Bog S3** | 0.9% | 0.9% | 0.8% | 7.9% | 10.7% |

*Note: In IY2, the type of bare ground was also recorded. Results presented here are for all bare ground, regardless of type.

Table A5.4 Cover of bare ground categories in IY2 as estimated by line transects

| Site | Cover of bare ground | | | |
|---|---|---|---|---|
| | Bare ground – natural | Bare ground – deer | Bare ground – sedimentation | Bare ground – total |
| **All Impact Sites** | **1.3%** | **0.0%** | **3.4%** | **4.6%** |
| **Bog 4.2** | 2.2% | 0.0% | 3.0% | 5.2% |
| **Bog 6** | 1.1% | 0.0% | 4.2% | 5.3% |
| **Bog 8/9/10** | 1.1% | 0.0% | 2.5% | 3.7% |
| **Bog 11.2** | 0.8% | 0.0% | 7.2% | 8.0% |
| **Bog 12** | 0.4% | 0.0% | 0.0% | 0.4% |
| **Bog 13** | 1.7% | 0.0% | 0.0% | 1.7% |
| **All Control Sites** | **1.8%** | **0.9%** | **0.0%** | **2.6%** |
| **Bog 1** | 0.3% | 0.0% | 0.0% | 0.3% |
| **Bog 2** | 0.7% | 0.0% | 0.0% | 0.7% |
| **Bog 4.1/5/7** | 0.0% | 0.6% | 0.0% | 0.6% |
| **Bog 11.1** | 0.0% | 0.0% | 0.0% | 0.0% |
| **Bog S1** | 3.4% | 3.7% | 0.0% | 7.1% |
| **Bog S2** | 0.7% | 0.0% | 0.0% | 0.7% |
| **Bog S3** | 8.5% | 2.2% | 0.0% | 10.7% |

**Table A5.5 Bog-dependent flora species richness as determined by line and belt transects**

| Site | Number of bog-dependent flora species | | | | |
|---|---|---|---|---|---|
| | Baseline Year 1 | Baseline Year 2 | Baseline Mean | Impact Year 1 | Impact Year 2 |
| **All impact sites** | **10** | **11** | **10.5** | **11** | **10** |
| **Bog 4.2** | 8 | 9 | 8.5 | 8 | 8 |
| **Bog 6** | 8 | 8 | 8 | 9 | 8 |
| **Bog 8/9/10** | 9 | 5 | 7 | 8 | 7 |
| **Bog 11.2** | 6 | 6 | 6 | 6 | 5 |
| **Bog 12** | 7 | 7 | 7 | 6 | 6 |
| **Bog 13** | 3 | 5 | 4 | 6 | 4 |
| **All control sites** | **11** | **10** | **10.5** | **11** | **11** |
| **Bog 1** | 5 | 5 | 5 | 5 | 6 |
| **Bog 2** | 6 | 6 | 6 | 5 | 5 |
| **Bog 4.1/5/7** | 8 | 8 | 8 | 7 | 9 |
| **Bog 11.1** | 8 | 7 | 7.5 | 8 | 8 |
| **Bog S1** | 6 | 6 | 6 | 7 | 7 |
| **Bog S2** | 6 | 6 | 6 | 6 | 7 |
| **Bog S3** | 7 | 8 | 7.5 | 9 | 8 |

### Table A5.6 Cover of bog-dependent flora species as estimated by line transects

| Site | Cover of bog-dependent flora species | | | | |
|---|---|---|---|---|---|
| | Baseline Year 1 | Baseline Year 2 | Baseline Mean | Impact Year 1 | Impact Year 2 |
| **All impact sites** | **77.9%** | **78.5%** | **78.2%** | **79.7%** | **79.5%** |
| **Bog 4.2** | 87.5% | 87.3% | 87.4% | 87.3% | 87.7% |
| **Bog 6** | 72.2% | 72.4% | 72.3% | 72.6% | 74.1% |
| **Bog 8/9/10** | 75.6% | 75.6% | 75.6% | 77.5% | 74.9% |
| **Bog 11.2** | 88.1% | 90.5% | 89.3% | 91.0% | 91.0% |
| **Bog 12** | 72.8% | 72.4% | 72.6% | 73.5% | 75.1% |
| **Bog 13** | 43.6% | 48.7% | 46.2% | 59.0% | 53.0% |
| **All control sites** | **86.9%** | **88.8%** | **87.9%** | **88.3%** | **88.9%** |
| **Bog 1** | 88.0% | 90.5% | 89.3% | 90.2% | 90.2% |
| **Bog 2** | 89.0% | 91.1% | 90.0% | 91.3% | 90.4% |
| **Bog 4.1/5/7** | 81.2% | 83.9% | 82.5% | 83.7% | 83.7% |
| **Bog 11.1** | 87.4% | 87.7% | 87.5% | 88.1% | 88.4% |
| **Bog S1** | 84.8% | 86.9% | 85.9% | 86.9% | 89.2% |
| **Bog S2** | 97.0% | 99.3% | 98.1% | 98.0% | 98.7% |
| **Bog S3** | 84.2% | 85.2% | 84.7% | 82.3% | 85.2% |

Table A5.7 Cover of native non-bog-dependent flora species as estimated by line transects

| Site | Cover of native non-bog-dependent flora species | | | | |
|---|---|---|---|---|---|
| | Baseline Year 1 | Baseline Year 2 | Baseline Mean | Impact Year 1 | Impact Year 2 |
| **All impact sites** | **44.4%** | **46.1%** | **45.2%** | **46.5%** | **46.1%** |
| **Bog 4.2** | 24.7% | 26.9% | 25.8% | 27.1% | 29.5% |
| **Bog 6** | 62.5% | 65.7% | 64.1% | 61.5% | 65.7% |
| **Bog 8/9/10** | 49.4% | 51.7% | 50.6% | 53.3% | 50.6% |
| **Bog 11.2** | 24.9% | 23.6% | 24.3% | 25.7% | 24.7% |
| **Bog 12** | 61.5% | 61.5% | 61.5% | 63.4% | 56.4% |
| **Bog 13** | 66.7% | 72.6% | 69.7% | 79.5% | 72.6% |
| **All control sites** | **44.2%** | **46.1%** | **45.1%** | **43.5%** | **43.8%** |
| **Bog 1** | 42.9% | 44.2% | 43.5% | 45.4% | 44.8% |
| **Bog 2** | 41.6% | 41.4% | 41.5% | 41.2% | 40.5% |
| **Bog 4.1/5/7** | 39.2% | 42.3% | 40.8% | 39.8% | 39.0% |
| **Bog 11.1** | 41.2% | 44.4% | 42.8% | 40.4% | 43.0% |
| **Bog S1** | 54.5% | 57.9% | 56.2% | 46.8% | 47.1% |
| **Bog S2** | 32.3% | 32.3% | 32.3% | 33.0% | 34.7% |
| **Bog S3** | 61.2% | 63.7% | 62.5% | 60.6% | 61.5% |

**Table A5.8 Cover of weed species as estimated by line transects**

| Site | Cover of weed species | | | | |
|---|---|---|---|---|---|
| | Baseline Year 1 | Baseline Year 2 | Baseline Mean | Impact Year 1 | Impact Year 2 |
| **All impact sites** | **5.4%** | **6.3%** | **5.9%** | **7.3%** | **8.1%** |
| **Bog 4.2** | 4.5% | 4.7% | 4.6% | 4.3% | 4.5% |
| **Bog 6** | 4.4% | 6.9% | 5.7% | 7.8% | 9.7% |
| **Bog 8/9/10** | 6.0% | 9.0% | 7.5% | 11.0% | 11.5% |
| **Bog 11.2** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Bog 12** | 0.0% | 0.4% | 0.2% | 0.8% | 0.8% |
| **Bog 13** | 40.2% | 35.0% | 37.6% | 42.7% | 47.0% |
| **All control sites** | **3.3%** | **5.3%** | **4.3%** | **5.0%** | **4.9%** |
| **Bog 1** | 3.2% | 3.5% | 3.3% | 3.5% | 3.8% |
| **Bog 2** | 3.9% | 4.6% | 4.2% | 5.5% | 4.8% |
| **Bog 4.1/5/7** | 4.9% | 7.6% | 6.2% | 5.4% | 5.0% |
| **Bog 11.1** | 1.4% | 3.2% | 2.3% | 4.3% | 2.9% |
| **Bog S1** | 6.4% | 7.4% | 6.9% | 6.7% | 9.8% |
| **Bog S2** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Bog S3** | 2.2% | 9.5% | 5.8% | 8.5% | 7.6% |

### Table A5.9 Cover of Peat Moss *Sphagnum* spp. as estimated by line transects

| Site | Cover of Peat Moss *Sphagnum* spp. | | | | |
|---|---|---|---|---|---|
| | Baseline Year 1 | Baseline Year 2 | Baseline Mean | Impact Year 1 | Impact Year 2 |
| **All impact sites** | **5.4%** | **5.3%** | **5.4%** | **6.0%** | **6.0%** |
| **Bog 4.2** | 15.9% | 15.1% | 15.5% | 15.1% | 16.8% |
| **Bog 6** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Bog 8/9/10** | 0.0% | 0.0% | 0.0% | 2.1% | 0.0% |
| **Bog 11.2** | 3.2% | 2.7% | 2.9% | 2.1% | 2.9% |
| **Bog 12** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Bog 13** | 18.8% | 22.2% | 20.5% | 28.2% | 26.5% |
| **All control sites** | **15.5%** | **17.2%** | **16.4%** | **15.9%** | **16.4%** |
| **Bog 1** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Bog 2** | 3.4% | 3.0% | 3.2% | 2.1% | 3.4% |
| **Bog 4.1/5/7** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Bog 11.1** | 5.4% | 11.9% | 8.7% | 7.6% | 6.1% |
| **Bog S1** | 33.7% | 39.4% | 36.5% | 38.7% | 37.7% |
| **Bog S2** | 62.0% | 65.0% | 63.5% | 59.3% | 61.6% |
| **Bog S3** | 21.1% | 21.1% | 21.1% | 21.8% | 24.3% |

**Table A5.10 Proportion of Peat Moss *Sphagnum* spp. recorded as dead along line transects**

| Site | Proportion of Dead Peat Moss *Sphagnum* spp. | | | | |
|---|---|---|---|---|---|
| | Baseline Year 1 | Baseline Year 2 | Baseline Mean | Impact Year 1 | Impact Year 2 |
| **All impact sites** | **0.8%** | **0.9%** | **0.8%** | **8.4%** | **0.8%** |
| **Bog 4.2** | 1.2% | 1.2% | 1.2% | 2.5% | 1.1% |
| **Bog 6** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Bog 8/9/10** | 0.0% | 0.0% | 0.0% | 66.7% | 0.0% |
| **Bog 11.2** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Bog 12** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Bog 13** | 0.0% | 0.0% | 0.0% | 9.1% | 0.0% |
| **All control sites** | **2.6%** | **1.9%** | **2.2%** | **1.5%** | **2.5%** |
| **Bog 1** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Bog 2** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Bog 4.1/5/7** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Bog 11.1** | 0.0% | 15.2% | 10.4% | 0.0% | 0.0% |
| **Bog S1** | 7.0% | 0.0% | 3.2% | 1.7% | 5.4% |
| **Bog S2** | 1.6% | 1.6% | 1.6% | 2.3% | 0.5% |
| **Bog S3** | 0.0% | 0.0% | 0.0% | 0.0% | 3.9% |

# Appendix 6 Rainfall and snow depth data

**Table A6.1 Mount Buller monthly rainfall (millimetres)**

| Monitoring Year (MY) | Calendar Year | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | MY Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| - | **1985-1986** | 107 | 185 | 318 | 59 | 136 | 192 | 247 | 65 | 54 | 12 | 135 | 161 | **1672** |
| - | **1986-1987** | 53 | 342 | 0 | 95 | 261 | 142 | 204 | 80 | 114 | 122 | 84 | 196 | **1693** |
| - | **1987-1988** | 149 | 142 | 111 | 174 | 83 | 116 | 102 | 75 | 42 | 94 | 68 | 247 | **1402** |
| - | **1988-1989** | 298 | 240 | 143 | 184 | 171 | 207 | 161 | 59 | 49 | 180 | 156 | 279 | **2127** |
| - | **1989-1990** | 102 | 246 | 259 | 143 | 332 | 57 | 109 | 39 | 98 | 36 | 254 | 102 | **1777** |
| - | **1990-1991** | 192 | 432 | 334 | 112 | 75 | 53 | 48 | 185 | 6 | 53 | 46 | 27 | **1563** |
| - | **1991-1992** | 250 | 205 | 141 | 255 | 55 | 69 | 69 | 15 | 20 | 31 | 125 | 193 | **1427** |
| - | **1992-1993** | - | - | - | - | - | - | - | - | - | - | - | - | **-** |
| - | **1993-1994** | - | - | - | - | - | - | - | - | - | - | - | - | **-** |
| - | **1994-1995** | 9 | 60 | 111 | 96 | 73 | 198 | 9 | 44 | 35 | 17 | 53 | 58 | **763** |
| - | **1995-1996** | 264 | 3 | 17 | 51 | 67 | 12 | 13 | 12 | 31 | 0 | 0 | 0 | **469** |
| - | **1996-1997** | 34 | 178 | 151 | 163 | 70 | 0 | 36 | 41 | 84 | 21 | 35 | 194 | **1006** |
| - | **1997-1998** | 21 | 18 | 145 | 121 | 52 | 143 | 3 | 4 | 83 | 18 | 146 | 110 | **864** |
| - | **1998-1999** | 121 | 145 | 89 | 325 | 256 | 107 | 21 | 37 | 38 | 155 | 57 | 261 | **1612** |
| - | **1999-2000** | 159 | 93 | 151 | 113 | 92 | 95 | 67 | 55 | 118 | 62 | 62 | 98 | **1165** |
| - | **2000-2001** | - | - | - | - | - | - | - | - | - | - | - | - | **-** |
| - | **2001-2002** | 268 | 122 | 6 | 143 | 411 | 92 | 67 | 120 | 87 | 62 | 57 | 123 | **1558** |
| - | **2002-2003** | 254 | 193 | 55 | 195 | 104 | 64 | 68 | 56 | 70 | 44 | 174 | 110 | **1387** |
| - | **2003-2004** | 170 | 161 | 145 | 175 | 109 | 83 | 160 | 58 | 13 | 18 | 76 | 104 | **1272** |
| - | **2004-2005** | 205 | 194 | 236 | 171 | 71 | 157 | 129 | 76 | 107 | 45 | 61 | 40 | **1493** |
| - | **2005-2006** | 195 | 177 | 244 | 166 | 150 | 73 | 1 | 0 | 93 | 100 | 111 | 2 | **1311** |

| Monitoring Year (MY) | Calendar Year | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | MY Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| - | 2006-2007 | 15 | 20 | 164 | 171 | 19 | 63 | 23 | 85 | 50 | 308 | 45 | 247 | 1208 |
| - | 2007-2008 | 102 | 139 | 155 | 186 | 96 | 230 | 141 | 114 | 41 | 52 | 76 | 109 | 1442 |
| - | 2008-2009 | 132 | 160 | 171 | 77 | 38 | 227 | 140 | 19 | 7 | 92 | 140 | 113 | 1317 |
| - | 2009-2010 | 172 | 301 | 232 | 238 | 141 | 138 | 114 | 91 | 173 | 181 | 236 | 97 | 2114 |
| - | 2010-2011 | 140 | 134 | 258 | 235 | 193 | 197 | 274 | 183 | 292 | 98 | 130 | 98 | 2230 |
| - | 2011-2012 | 134 | 172 | 135 | 123 | 79 | 219 | 97 | 150 | 162 | 200 | 67 | 108 | 1647 |
| - | 2012-2013 | 172 | 184 | 183 | 131 | 71 | 83 | 108 | 1 | 109 | 145 | 53 | 129 | 1369 |
| - | 2013-2014 | 151 | 128 | 333 | 147 | 155 | 86 | 154 | 69 | 41 | 101 | 146 | 195 | 1705 |
| - | 2014-2015 | 258 | 282 | 37 | 96 | 52 | 80 | 75 | 149 | 115 | 41 | 131 | 229 | 1546 |
| - | 2015-2016 | 65 | 155 | 135 | 47 | 78 | 107 | 64 | 102 | 21 | 119 | 46 | 331 | 1270 |
| - | 2016-2017 | 318 | 270 | 269 | 222 | 158 | 123 | 126 | 139 | 58 | 40 | 156 | 115 | 1994 |
| BY1 | 2017-2018 | 32 | 241 | 336 | 213 | 110 | 68 | 281 | 88 | 18 | 60 | 153 | 122 | 1723 |
| BY2 | 2018-2019 | 186 | 134 | 248 | 62 | 41 | 162 | 126 | 51 | 52 | 95 | 36 | 211 | 1404 |
| IY1 | 2019-2020 | 262 | 204 | 111 | 136 | 70 | 148 | 45 | 114 | 96 | 109 | 358 | 137 | 1790 |
| IY2 | 2020-2021 | 179 | 75 | 129 | 118 | 271 | 45 | 69 | 122 | 77 | 134 | 52 | 142 | 1413 |

*Note: Missing monthly rainfall values were determined as an average (mean) of the previous 5 and following 5 (10 in total) rainfall statistics for that given month. Annual rainfalls have been highlighted if they include a predicted monthly rainfall value. Missing monthly rainfall values have been rare since the mid-2000s.

**Table A6.2 Mount Stirling monthly rainfall (millimetres)**

| Monitoring Year (MY) | Calendar Year | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | MY Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BY1 | 2017-2018 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| BY2 | 2018-2019 | - | - | - | - | - | 99 | 128 | 54 | 38 | 91 | 50 | 167 | 627 |
| IY1 | 2019-2020 | 126 | 167 | 147 | 103 | 88 | 122 | 52 | 110 | 75 | 222 | 368 | 105 | 1686 |
| IY2 | 2020-2021 | 56 | 55 | 101 | 111 | 326 | 47 | 67 | 166 | 126 | 141 | 47 | 139 | 1382 |

*Note: Months and years with incomplete data are highlighted in yellow.

**Table A6.3 Mount Buller monthly mean natural snow depth and maximum daily snow depth for the monitoring year (millimetres)**

| Monitoring Year (MY) | Calendar Year | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | MY Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **-** | **1993-1994** | 25 | 15 | 21 | 5 | 0 | - | - | - | - | - | - | - | **44** |
| **-** | **1994-1995** | 15 | 30 | 57 | 38 | 47 | - | - | - | - | - | - | - | **65** |
| **-** | **1995-1996** | 8 | 72 | 122 | 50 | 15 | - | - | - | - | - | - | - | **165** |
| **-** | **1996-1997** | 2 | 41 | 96 | 96 | 68 | - | - | - | - | - | - | - | **132** |
| **-** | **1997-1998** | 6 | 17 | 51 | 31 | 10 | - | - | - | - | - | - | - | **74** |
| **-** | **1998-1999** | 9 | 22 | 31 | 4 | - | - | - | - | - | - | - | - | **58** |
| **-** | **1999-2000** | 14 | 23 | 52 | 11 | - | - | - | - | - | - | - | - | **80** |
| **-** | **2000-2001** | 69 | 76 | 107 | 120 | - | - | - | - | - | - | - | - | **148** |
| **-** | **2001-2002** | 2 | 5 | 38 | 27 | - | - | - | - | - | - | - | - | **81** |
| **-** | **2002-2003** | 17 | 70 | 73 | 40 | 6 | - | - | - | - | - | - | - | **82** |
| **-** | **2003-2004** | 25 | 29 | 82 | 109 | 106 | - | - | - | - | - | - | - | **124** |
| **-** | **2004-2005** | 30 | 90 | 159 | 143 | 77 | - | - | - | - | - | - | - | **173** |
| **-** | **2005-2006** | 22 | 43 | 48 | 20 | 3 | - | - | - | - | - | - | - | **72** |
| **-** | **2006-2007** | 4 | 3 | 23 | 1 | 0 | - | - | - | - | - | - | - | **28** |
| **-** | **2007-2008** | 39 | 81 | 74 | 33 | 0 | - | - | - | - | - | - | - | **92** |
| **-** | **2008-2009** | 4 | 53 | 107 | 73 | 0 | - | - | - | - | - | - | - | **126** |
| **-** | **2009-2010** | 38 | 60 | 67 | 40 | 28 | - | - | - | - | - | - | - | **75** |
| **-** | **2010-2011** | 12 | 28 | 74 | 85 | 45 | - | - | - | - | - | - | - | **132** |
| **-** | **2011-2012** | 26 | 60 | 28 | 3 | 17 | - | - | - | - | - | - | - | **89** |
| **-** | **2012-2013** | 12 | 32 | 68 | 73 | 28 | - | - | - | - | - | - | - | **102** |
| **-** | **2013-2014** | 12 | 17 | 52 | 10 | - | - | - | - | - | - | - | - | **83** |
| **-** | **2014-2015** | 40 | 90 | 86 | 36 | - | - | - | - | - | - | - | - | **108** |
| **-** | **2015-2016** | 2 | 27 | 63 | 33 | - | - | - | - | - | - | - | - | **77** |
| **-** | **2016-2017** | 14 | 45 | 63 | 27 | - | - | - | - | - | - | - | 11 | **77** |
| **BY1** | **2017-2018** | 14 | 42 | 100 | 125 | 67 | - | - | - | - | - | - | - | **153** |

| Monitoring Year (MY) | Calendar Year | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | MY Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **BY2** | **2018-2019** | 32 | 57 | 123 | 111 | 55 | - | - | - | - | - | - | 22 | **156** |
| **IY1** | **2019-2020** | 14 | 27 | 69 | 55 | 1 | - | - | - | - | - | - | - | **101** |
| **IY2** | **2020-2021** | 3 | 11 | 24 | 13 | 3 | - | - | - | - | - | - | - | **62** |

# Appendix 7 Surface water and groundwater data

**Table A7.1 Mount Buller surface water quality field results**

| Parameter | BY1 | BY2 | | IY1 | | IY2 | |
|---|---|---|---|---|---|---|---|
| | Feb 2018 | Nov 2018 | Feb 2019 | Nov 2019 | Feb 2020 | Nov 2020 | Feb 2021 |
| **Weir 1 Pickup 1** | | | | | | | |
| Temperature (°C) | 9.1 | 8.2 | 9.1 | 8.3 | 7.7 | 7.9 | 10.2 |
| pH | 6.6 | 7.0 | 5.2 | 5.8 | 7.2 | 5.7 | 7.8 |
| Dissolved Oxygen (ppm or mg/L) | 9.8 | 8.2 | 12.6* | 13.3* | 9.2 | 10.5 | 12.1 |
| Oxidation-Reduction Potential (mV) | 210.0 | 204.5 | 121.8 | 156.3 | 130.5 | 131.2 | 96.7 |
| Electrical Conductivity (μS/cm) | 28.3 | 20.6 | 25.8 | 26.3 | 24.6 | 27.5 | 25.9 |
| **Weir 1 Pickup 2** | | | | | | | |
| Temperature (°C) | 8.7 | 7.5 | 7.6 | 6.7 | 7.7 | 7.5 | 8.8 |
| pH | 5.9 | 6.9 | 6.2 | 5.8 | 7.3 | 5.5 | 7.7 |
| Dissolved Oxygen (ppm or mg/L) | 9.8 | 7.8 | 13.0* | 12.4* | 9.2 | 10.0 | 12.3 |
| Oxidation-Reduction Potential (mV) | 230.0 | 216.6 | 108.1 | 173.7 | 129.4 | 135.4 | 66.8 |
| Electrical Conductivity (μS/cm) | 22.4 | 20.5 | 21.0 | 10.1 | 28.6 | 22.5 | 21.7 |
| **Weir 2** | | | | | | | |
| Temperature (°C) | 10.1 | 8.8 | 10.0 | 9.5 | 8.0 | 8.4 | 10.3 |
| pH | 7.0 | 6.9 | 6.4 | 6.0 | 7.2 | 5.8 | 7.6 |
| Dissolved Oxygen (ppm or mg/L) | 9.8 | 10.0 | 10.0* | 12.0* | 10.1 | 8.6 | 11.9 |
| Oxidation-Reduction Potential (mV) | 238.6 | 205.5 | 99.1 | 168.7 | 115.4 | 125.4 | 47.0 |
| Electrical Conductivity (μS/cm) | 20.0 | 23.0 | 26.4 | 29.6 | 30.6 | 28.9 | 28.7 |

*Note: These dissolved oxygen values were converted from percentage saturation to mg/L.

### Table A7.2 Mount Buller groundwater quality field results

| Parameter | BY1 | BY2 | | IY1 | | IY2 | |
|---|---|---|---|---|---|---|---|
| | Feb 2018 | Nov 2018 | Feb 2019 | Nov 2019 | Feb 2020 | Nov 2020 | Feb 2021 |
| **BH06** | | | | | | | |
| Temperature (°C) | 5.7 | 5.8 | 6.3 | 6.43 | 6.67 | 7.1 | 6.8 |
| pH | 4.32 | 5.65 | 4.97 | 5.04 | 4.9 | 4.24 | 5.48 |
| Dissolved Oxygen (ppm or mg/L) | 9.29 | 10.7 | 12.76* | 15.90* | 12.05* | 10.21 | 8.71 |
| Oxidation-Reduction Potential (mV) | 310 | 254 | 152 | 177.37 | 200.67 | 181.5 | 222.73 |
| Electrical Conductivity (µS/cm) | 53.3 | 24.4 | 44.4 | 34.97 | 61.63 | 36.53 | 53.23 |
| **BH09** | | | | | | | |
| Temperature (°C) | 5.7 | 5 | 8.4 | 5.23 | 7.47 | - | - |
| pH | 4.63 | 5.94 | 5.61 | 5.71 | 5.42 | - | - |
| Dissolved Oxygen (ppm or mg/L) | 9.89 | 10 | 13.90* | 27.20* | 10.78 | - | - |
| Oxidation-Reduction Potential (mV) | 267 | 231 | 106 | 213.33 | 184.2 | - | - |
| Electrical Conductivity (µS/cm) | 16.1 | 15 | 9.8 | 25.07 | 19.47 | - | - |
| **BH16** | | | | | | | |
| Temperature (°C) | 8.5 | 5.2 | 7.1 | 5.13 | 9 | 6.57 | 8.46 |
| pH | 6.09 | 5.83 | 5.19 | 6.73 | 5.38 | 3.95 | 5.37 |
| Dissolved Oxygen (ppm or mg/L) | 7.5 | 11.3 | 12.50* | 29.00* | 12.00* | 13.45 | 8.44 |
| Oxidation-Reduction Potential (mV) | 254 | 253 | 141 | 187.67 | 217.6 | 114.97 | 234.13 |
| Electrical Conductivity (µS/cm) | 23.1 | 21.6 | 20.1 | 29.97 | 21.5 | 26.67 | 22.56 |

| Parameter | BY1 | BY2 | | IY1 | | IY2 | |
|---|---|---|---|---|---|---|---|
| | Feb 2018 | Nov 2018 | Feb 2019 | Nov 2019 | Feb 2020 | Nov 2020 | Feb 2021 |
| **BH17** | | | | | | | |
| Temperature (°C) | 9.3 | 5.9 | 10 | 6.7 | 8.67 | 12.27 | 10.63 |
| pH | 4.91 | 6.57 | 5.89 | 5.9 | 5.9 | 6.3 | 5.48 |
| Dissolved Oxygen (ppm or mg/L) | 7.76 | 9.47 | 14.30* | 18.00* | 7.73 | 26.06 | 5.58 |
| Oxidation-Reduction Potential (mV) | 243 | 207 | 95 | 186 | 165.07 | 68.67 | 182.86 |
| Electrical Conductivity (μS/cm) | 44.4 | 43.3 | 43.1 | 32.7 | 51.3 | 34.23 | 45.46 |
| **BH18** | | | | | | | |
| Temperature (°C) | 14 | 6.3 | 12.1 | 5.97 | 10.83 | 12.2 | 10.2 |
| pH | 5.16 | 6.3 | 5.18 | 5.3 | 5.81 | 5.1 | 4.9 |
| Dissolved Oxygen (ppm or mg/L) | 5.99 | 8.60* | 13.10* | 13.60* | 5.76 | 28.6 | 4.97 |
| Oxidation-Reduction Potential (mV) | 145 | 227 | 115 | 207.67 | 184.9 | 93.7 | 209.7 |
| Electrical Conductivity (μS/cm) | 68.8 | 15.4 | 15.3 | 39.67 | 33.07 | 49.3 | 33 |

*Note: These dissolved oxygen values were converted from percentage saturation to mg/L.

**Table A7.3 Mount Buller surface water quality laboratory results and quality control results**

| Parameter | BY1 | | | BY2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Feb 2018 | | | Nov 2018 | | | Feb 2019 | | |
| | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD |
| **Weir 1 Pickup 1** | | | | | | | | | |
| Total Kjeldahl Nitrogen (mg N/L) | 0.2 | - | - | 0.3 | - | - | 0.2 | - | - |
| Phosphorus (mg P/L) | <0.05 | - | - | <0.05 | - | - | <0.05 | - | - |
| Suspended Solids (mg/L) | <2 | - | - | <2 | - | - | <2 | - | - |
| Total Dissolved Solids (mg/L) | 22 | - | - | 18 | - | - | 18 | - | - |
| Electrical Conductivity at 25°C (µS/cm) | 26 | - | - | 20 | - | - | 26 | - | - |
| Turbidity (NTU) | 0.8 | - | - | 1.5 | - | - | 0.6 | - | - |
| Chloride (mg/L) | 1 | - | - | 1 | - | - | 2 | - | - |
| Sulphate (mg/L) | <1 | - | - | <1 | - | - | <1 | - | - |
| Alkalinity Bicarbonate (mg/L) | 15 | - | - | 11 | - | - | 13 | - | - |
| Alkalinity Carbonate (mg/L) | <2 | - | - | <2 | - | - | <2 | - | - |
| Total Nitrogen (mg/L) | 0.3 | - | - | 0.4 | - | - | 0.3 | - | - |
| Nitrate + Nitrite (mg N/L) | 0.16 | - | - | 0.17 | - | - | 0.7 | - | - |
| Nitrate (mg N/L) | 0.16 | - | - | 0.17 | - | - | 0.17 | - | - |
| Calcium (mg/L) | 2 | - | - | 1.3 | - | - | 1.4 | - | - |
| Magnesium (mg/L) | 0.6 | - | - | 0.5 | - | - | 0.5 | - | - |
| Potassium (mg/L) | 0.2 | - | - | 0.2 | - | - | 0.2 | - | - |
| Sodium (mg/L) | 2.6 | - | - | 2.1 | - | - | 2.2 | - | - |

| Parameter | IY1 | | | | | | IY2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nov 2019 | | | Feb 2020 | | | Nov 2020 | | | Feb 2021 | | |
| | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD |
| **Weir 1 Pickup 1** | | | | | | | | | | | | |
| Total Kjeldahl Nitrogen (mg N/L) | 0.2 | - | - | <0.1 | <0.1 | 0 | <0.1 | - | - | <0.1 | <0.2 | 67 |
| Phosphorus (mg P/L) | <0.05 | - | - | <0.05 | <0.05 | 0 | <0.05 | - | - | 0.06 | <0.01 | 169 |
| Suspended Solids (mg/L) | 6 | - | - | <2 | 2 | 67 | <2 | - | - | <2 | 2.9 | 97 |
| Total Dissolved Solids (mg/L) | 10 | - | - | 14 | 14 | 0 | 12 | - | - | 14 | 500 | 189 |
| Electrical Conductivity at 25°C (µS/cm) | 17 | - | - | 21 | 21 | 0 | 24 | - | - | 24 | 21 | 13 |
| Turbidity (NTU) | 1.5 | - | - | 0.05 | 0.05 | 0 | 0.5 | - | - | 0.4 | 1.3 | 106 |
| Chloride (mg/L) | 1 | - | - | 1 | 1 | 0 | <1 | - | - | 1 | 40 | 190 |
| Sulphate (mg/L) | <1 | - | - | <1 | <1 | 0 | <1 | - | - | <1 | <5 | 133 |
| Alkalinity Bicarbonate (mg/L) | 10 | - | - | 11 | 12 | 9 | 13 | - | - | 13 | <20 | 26 |
| Alkalinity Carbonate (mg/L) | <2 | - | - | <2 | <2 | 0 | <2 | - | - | <2 | <10 | 133 |
| Total Nitrogen (mg/L) | 0.3 | - | - | 0.1 | 0.1 | 0 | 0.2 | - | - | 0.1 | <0.2 | 0 |
| Nitrate + Nitrite (mg N/L) | 0.12 | - | - | 0.11 | 0.11 | 0 | 0.16 | - | - | 0.14 | 0.15 | 7 |
| Nitrate (mg N/L) | 0.1 | - | - | 0.11 | 0.11 | 0 | 0.15 | - | - | 0.13 | 0.15 | 14 |
| Calcium (mg/L) | 0.9 | - | - | 1.5 | 1.4 | 7 | 1.6 | - | - | 1.8 | 1 | 57 |
| Magnesium (mg/L) | 0.4 | - | - | 0.5 | 0.5 | 0 | 0.5 | - | - | 0.6 | <0.5 | 184 |
| Potassium (mg/L) | 0.1 | - | - | 0.2 | 0.2 | 0 | 0.2 | - | - | 0.2 | <0.5 | 156 |
| Sodium (mg/L) | 1.4 | - | - | 1.9 | 1.8 | 5 | 2.1 | - | - | 2.4 | 2.5 | 4 |

| Parameter | BY1 | | | BY2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Feb 2018 | | | Nov 2018 | | | Feb 2019 | | |
| | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD |
| **Weir 1 Pickup 2** | | | | | | | | | |
| Total Kjeldahl Nitrogen (mg N/L) | <0.1 | - | - | 0.2 | - | - | 0.1 | - | - |
| Phosphorus (mg P/L) | <0.05 | - | - | <0.05 | - | - | <0.05 | - | - |
| Suspended Solids (mg/L) | <2 | - | - | 5 | - | - | <2 | - | - |
| Total Dissolved Solids (mg/L) | 18 | - | - | 12 | - | - | 15 | - | - |
| Electrical Conductivity at 25°C (µS/cm) | 20 | - | - | 20 | - | - | 21 | - | - |
| Turbidity (NTU) | 0.2 | - | - | 0.5 | - | - | 0.2 | - | - |
| Chloride (mg/L) | 1 | - | - | 1 | - | - | 2 | - | - |
| Sulphate (mg/L) | <1 | - | - | <1 | - | - | <1 | - | - |
| Alkalinity Bicarbonate (mg/L) | 11 | - | - | 11 | - | - | 10 | - | - |
| Alkalinity Carbonate (mg/L) | <2 | - | - | <2 | - | - | <2 | - | - |
| Total Nitrogen (mg/L) | 0.1 | - | - | 0.4 | - | - | 0.3 | - | - |
| Nitrate + Nitrite (mg N/L) | 0.12 | - | - | 0.16 | - | - | 0.12 | - | - |
| Nitrate (mg N/L) | 0.12 | - | - | 0.16 | - | - | 0.12 | - | - |
| Calcium (mg/L) | 1.5 | - | - | 1.3 | - | - | 1.2 | - | - |
| Magnesium (mg/L) | 0.5 | - | - | 0.5 | - | - | 0.4 | - | - |
| Potassium (mg/L) | 0.1 | - | - | 0.2 | - | - | 0.1 | - | - |
| Sodium (mg/L) | 2 | - | - | 1.8 | - | - | 1.7 | - | - |

| Parameter | IY1 | | | | | | IY2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nov 2019 | | | Feb 2020 | | | Nov 2020 | | | Feb 2021 | | |
| | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD |
| **Weir 1 Pickup 2** | | | | | | | | | | | | |
| Total Kjeldahl Nitrogen (mg N/L) | 0.4 | 0.6 | 40 | 0.1 | <0.1 | 67 | <0.1 | - | - | 0.2 | 0.2 | 0 |
| Phosphorus (mg P/L) | 0.05 | 0.07 | 33 | <0.05 | 0.05 | 67 | <0.05 | - | - | <0.05 | <0.05 | 0 |
| Suspended Solids (mg/L) | 20 | 19 | 5 | 15 | 14 | 7 | <2 | - | - | <2 | 1 | 0 |
| Total Dissolved Solids (mg/L) | 12 | 12 | 0 | 16 | 16 | 0 | 10 | - | - | 14 | 14 | 0 |
| Electrical Conductivity at 25°C (µS/cm) | 20 | 20 | 0 | 25 | 25 | 0 | 19 | - | - | 21 | 21 | 0 |
| Turbidity (NTU) | 7.5 | 7.4 | 1 | 3.6 | 3.5 | 3 | 0.1 | - | - | 0.1 | 0.1 | 0 |
| Chloride (mg/L) | 1 | 1 | 0 | 1 | 1 | 0 | <1 | - | - | 1 | 1 | 0 |
| Sulphate (mg/L) | <1 | <1 | 0 | <20 | <20 | 0 | <1 | - | - | <1 | <1 | 0 |
| Alkalinity Bicarbonate (mg/L) | 12 | 11 | 9 | 14 | 14 | 0 | 10 | - | - | 11 | 11 | 0 |
| Alkalinity Carbonate (mg/L) | <2 | <2 | 0 | <2 | <2 | 0 | <2 | - | - | <2 | <2 | 0 |
| Total Nitrogen (mg/L) | 0.7 | 0.8 | 13 | 0.3 | 0.2 | 40 | <0.1 | - | - | 0.3 | 0.3 | 0 |
| Nitrate + Nitrite (mg N/L) | 0.25 | 0.27 | 8 | 0.16 | 0.16 | 0 | 0.09 | - | - | 0.09 | 0.09 | 0 |
| Nitrate (mg N/L) | 0.23 | 0.24 | 4 | 0.16 | 0.16 | 0 | 0.08 | - | - | 0.09 | 0.09 | 0 |
| Calcium (mg/L) | 0.9 | 0.9 | 0 | 1.6 | 1.6 | 0 | 1.2 | - | - | 1.4 | 1.4 | 0 |
| Magnesium (mg/L) | 0.3 | 0.4 | 29 | 0.6 | 0.6 | 0 | 0.5 | - | - | 0.5 | 0.5 | 0 |
| Potassium (mg/L) | 0.1 | 0.2 | 67 | 0.3 | 0.3 | 0 | 0.1 | - | - | 0.2 | 0.2 | 0 |
| Sodium (mg/L) | 1.4 | 1.6 | 13 | 2.4 | 2.3 | 4 | 1.6 | - | - | 1.8 | 1.8 | 0 |

| Parameter | BY1 | | | BY2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Feb 2018 | | | Nov 2018 | | | Feb 2019 | | |
| | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD |
| **Weir 2** | | | | | | | | | |
| Total Kjeldahl Nitrogen (mg N/L) | 0.1 | <0.1 | 67 | 0.2 | 0.1 | 67 | 0.1 | 0.2 | 67 |
| Phosphorus (mg P/L) | <0.05 | <0.05 | 0 | 0.05 | <0.05 | 67 | <0.05 | <0.05 | 0 |
| Suspended Solids (mg/L) | <2 | <2 | 0 | 2 | 2 | 0 | <2 | 1 | 0 |
| Total Dissolved Solids (mg/L) | 20 | 20 | 0 | 12 | 15 | 22 | 10 | 18 | 57 |
| Electrical Conductivity at 25°C (µS/cm) | 27 | 27 | 0 | 22 | 22 | 0 | 26 | 26 | 0 |
| Turbidity (NTU) | 0.1 | 0.2 | 67 | 0.6 | 0.9 | 40 | 0.2 | 0.6 | 100 |
| Chloride (mg/L) | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 2 | 67 |
| Sulphate (mg/L) | <1 | <1 | 0 | <1 | <1 | 0 | <1 | <1 | 0 |
| Alkalinity Bicarbonate (mg/L) | 15 | 14 | 7 | 12 | 12 | 0 | 12 | 12 | 0 |
| Alkalinity Carbonate (mg/L) | <2 | <2 | 0 | <2 | <2 | 0 | <2 | <2 | 0 |
| Total Nitrogen (mg/L) | 0.2 | 0.1 | 67 | 0.3 | 0.3 | 0 | 0.2 | 0.3 | 40 |
| Nitrate + Nitrite (mg N/L) | 0.09 | 0.14 | 43 | 0.13 | 0.12 | 8 | 0.1 | 0.1 | 0 |
| Nitrate (mg N/L) | 0.09 | 0.14 | 43 | 0.13 | 0.12 | 8 | 0.1 | 0.1 | 0 |
| Calcium (mg/L) | 2 | 2.2 | 10 | 1.6 | 1.5 | 6 | 1.6 | 1.5 | 6 |
| Magnesium (mg/L) | 0.6 | 0.7 | 15 | 0.5 | 0.6 | 18 | 0.6 | 0.5 | 18 |
| Potassium (mg/L) | 0.2 | 0.2 | 0 | 0.2 | 0.2 | 0 | 0.2 | 0.2 | 0 |
| Sodium (mg/L) | 2.3 | 2.2 | 4 | 1.8 | 1.8 | 0 | 1.9 | 1.8 | 5 |

| Parameter | IY1 | | | | | | IY2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nov 2019 | | | Feb 2020 | | | Nov 2020 | | | Feb 2021 | | |
| | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD |
| **Weir 2** | | | | | | | | | | | | |
| Total Kjeldahl Nitrogen (mg N/L) | <0.1 | 0.5 | 164 | <0.1 | <0.1 | 0 | <0.1 | <0.1 | 0 | 0.2 | 0.2 | 0 |
| Phosphorus (mg P/L) | <0.05 | <0.01 | 133 | <0.05 | <0.05 | 0 | <0.05 | <0.05 | 0 | <0.05 | <0.05 | 0 |
| Suspended Solids (mg/L) | 3 | 1.6 | 61 | 13 | 14 | 7 | <2 | 1 | 0 | <2 | 1 | 0 |
| Total Dissolved Solids (mg/L) | 12 | 13 | 8 | 16 | 16 | 0 | 12 | 12 | 0 | 16 | 16 | 0 |
| Electrical Conductivity at 25°C (µS/cm) | 20 | 21 | 5 | 27 | 27 | 0 | 24 | 24 | 0 | 27 | 27 | 0 |
| Turbidity (NTU) | 0.5 | <1 | 0 | 4.6 | 4.6 | 0 | 0.1 | 0.1 | 0 | 0.1 | 0.1 | 0 |
| Chloride (mg/L) | 1 | 4.2 | 123 | 2 | 2 | 0 | <1 | 1 | 67 | 1 | 1 | 0 |
| Sulphate (mg/L) | <1 | <5 | 133 | <1 | <1 | 0 | <1 | <1 | 0 | <1 | <1 | 0 |
| Alkalinity Bicarbonate (mg/L) | 13 | <20 | 26 | 14 | 14 | 0 | 13 | 13 | 0 | 14 | 15 | 7 |
| Alkalinity Carbonate (mg/L) | <2 | <10 | 133 | <2 | <2 | 0 | <2 | <2 | 0 | <2 | <2 | 0 |
| Total Nitrogen (mg/L) | 0.1 | 0.58 | 141 | 0.1 | 0.2 | 67 | <0.1 | <0.1 | 0 | 0.2 | 0.3 | 40 |
| Nitrate + Nitrite (mg N/L) | 0.11 | 0.08 | 32 | 0.15 | 0.15 | 0 | 0.08 | 0.08 | 0 | 0.07 | 0.14 | 67 |
| Nitrate (mg N/L) | 0.11 | 0.08 | 32 | 0.15 | 0.15 | 0 | 0.07 | 0.07 | 0 | 0.07 | 0.13 | 60 |
| Calcium (mg/L) | 1.3 | 1.3 | 0 | 2 | 1.8 | 11 | 1.9 | 2 | 5 | 2.2 | 1.4 | 44 |
| Magnesium (mg/L) | 0.5 | 0.5 | 0 | 0.7 | 0.6 | 15 | 0.7 | 0.7 | 0 | 0.7 | 0.5 | 33 |
| Potassium (mg/L) | 0.2 | <0.5 | 156 | 0.3 | 0.3 | 0 | 0.2 | 0.2 | 0 | 0.2 | 0.1 | 67 |
| Sodium (mg/L) | 1.6 | 1.9 | 17 | 2.2 | 2.1 | 5 | 2 | 2.1 | 5 | 2.2 | 1.5 | 38 |

Table A7.4 Mount Buller groundwater quality laboratory results and quality control results

| Parameter | BY1 | | | BY2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Feb 2018 | | | Nov 2018 | | | Feb 2019 | | |
| | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD |
| **BH06** | | | | | | | | | |
| Total Kjeldahl Nitrogen (mg N/L) | 0.5 | - | - | 0.3 | 0.8 | 91 | 0.8 | 0.8 | 0 |
| Phosphorus (mg P/L) | <0.05 | - | - | <0.05 | 0.29 | 168 | <0.05 | <0.05 | 0 |
| Total Dissolved Solids (mg/L) | 42 | - | - | 22 | 10 | 75 | 30 | 20 | 40 |
| Electrical Conductivity at 25°C (µS/cm) | 51 | - | - | 24 | 23 | 4 | 42 | 43 | 2 |
| Chloride (mg/L) | 2 | - | - | 1 | 1 | 0 | 2 | 2 | 0 |
| Sulphate (mg/L) | <1 | - | - | <1 | <1 | 0 | <1 | <1 | 0 |
| Alkalinity Bicarbonate (mg/L) | 2 | - | - | 6 | 6 | 0 | 5 | 5 | 0 |
| Alkalinity Carbonate (mg/L) | <2 | - | - | <2 | <2 | 0 | <2 | <2 | 0 |
| Total Nitrogen (mg/L) | 5.3 | - | - | 1.7 | 2.3 | 30 | 4.4 | 4.4 | 0 |
| Nitrate + Nitrite (mg N/L) | 4.9 | - | - | 1.4 | 1.5 | 7 | 3.6 | 3.6 | 0 |
| Nitrate (mg N/L) | 4.9 | - | - | 1.4 | 1.5 | 7 | 3.6 | 3.6 | 0 |
| Calcium (mg/L) | 3 | - | - | 1.3 | 1.3 | 0 | 2.5 | 2.1 | 17 |
| Magnesium (mg/L) | 1.2 | - | - | 0.4 | 0.4 | 0 | 0.9 | 0.8 | 12 |
| Potassium (mg/L) | 0.4 | - | - | 0.4 | 0.4 | 0 | 0.4 | 0.4 | 0 |
| Sodium (mg/L) | 2.1 | - | - | 1.5 | 1.5 | 0 | 1.8 | 1.6 | 12 |

| Parameter | IY1 | | | | | | IY2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nov 2019 | | | Feb 2020 | | | Nov 2020 | | | Feb 2021 | | |
| | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD |
| **BH06** | | | | | | | | | | | | |
| Total Kjeldahl Nitrogen (mg N/L) | 0.5 | 0.7 | 33 | 1.1 | 0.9 | 20 | 0.4 | 0.5 | 22 | 0.3 | <0.2 | 100 |
| Phosphorus (mg P/L) | <0.05 | 0.19 | 153 | <0.05 | 0.01 | 86 | <0.05 | <0.05 | 0 | <0.05 | <0.01 | 133 |
| Total Dissolved Solids (mg/L) | 15 | 12 | 22 | 36 | 39 | 8 | 12 | 18 | 40 | 36 | | 200 |
| Electrical Conductivity at 25°C (µS/cm) | 25 | 23 | 8 | 55 | 56 | 2 | 28 | 26 | 7 | 55 | 53 | 4 |
| Chloride (mg/L) | 1 | 1 | 0 | 2 | 26 | 171 | 1 | 1 | 0 | 2 | 2.4 | 18 |
| Sulphate (mg/L) | <1 | <1 | 0 | <1 | <5 | 0 | <1 | <1 | 0 | <1 | <5 | 0 |
| Alkalinity Bicarbonate (mg/L) | 7 | 6 | 15 | 4 | <20 | 86 | 5 | 5 | 0 | 3 | <20 | 108 |
| Alkalinity Carbonate (mg/L) | <2 | <2 | 0 | <2 | <10 | 133 | <2 | <2 | 0 | <2 | <10 | 133 |
| Total Nitrogen (mg/L) | 2.3 | 2.4 | 4 | 6.3 | 5.9 | 7 | 2.3 | 2.4 | 4 | 5.4 | 5 | 8 |
| Nitrate + Nitrite (mg N/L) | 1.7 | 1.8 | 6 | 5.3 | 5 | 6 | 1.9 | 1.9 | 0 | 5.1 | 5.5 | 8 |
| Nitrate (mg N/L) | 1.7 | 1.7 | 0 | 5.3 | 5 | 6 | 1.9 | 1.9 | 0 | 5.1 | 5.5 | 8 |
| Calcium (mg/L) | 1.3 | 1.4 | 7 | 2.7 | <5 | 8 | 2.2 | 3.1 | 34 | 3.5 | 3.4 | 3 |
| Magnesium (mg/L) | 0.5 | 0.5 | 0 | 1 | <5 | 86 | 2.2 | 4.1 | 60 | 5.4 | 1.5 | 113 |
| Potassium (mg/L) | 0.3 | 0.3 | 0 | 0.5 | <5 | 133 | 1.8 | 2.8 | 43 | 3.8 | 0.7 | 138 |
| Sodium (mg/L) | 1.3 | 1.3 | 0 | 2.2 | 14 | 146 | 2.3 | 3.2 | 33 | 2.8 | 2.4 | 15 |

| Parameter | BY1 | | | BY2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Feb 2018 | | | Nov 2018 | | | Feb 2019 | | |
| | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD |
| **BH09** | | | | | | | | | |
| Total Kjeldahl Nitrogen (mg N/L) | 0.2 | - | - | 0.1 | - | - | 0.2 | - | - |
| Phosphorus (mg P/L) | 0.07 | - | - | <0.05 | - | - | <0.05 | - | - |
| Total Dissolved Solids (mg/L) | 12 | - | - | 12 | - | - | 8 | - | - |
| Electrical Conductivity at 25°C (μS/cm) | 16 | - | - | 15 | - | - | 17 | - | - |
| Chloride (mg/L) | 1 | - | - | 1 | - | - | 2 | - | - |
| Sulphate (mg/L) | <1 | - | - | <1 | - | - | <1 | - | - |
| Alkalinity Bicarbonate (mg/L) | 4 | - | - | 6 | - | - | 7 | - | - |
| Alkalinity Carbonate (mg/L) | <2 | - | - | <3.3 | - | - | <2 | - | - |
| Total Nitrogen (mg/L) | 0.7 | - | - | 0.6 | - | - | 0.7 | - | - |
| Nitrate + Nitrite (mg N/L) | 0.51 | - | - | 0.47 | - | - | 0.48 | - | - |
| Nitrate (mg N/L) | 0.5 | - | - | 0.47 | - | - | 0.48 | - | - |
| Calcium (mg/L) | 0.7 | - | - | 0.7 | - | - | 0.8 | - | - |
| Magnesium (mg/L) | 0.3 | - | - | 0.3 | - | - | 0.3 | - | - |
| Potassium (mg/L) | 0.1 | - | - | 0.1 | - | - | 0.2 | - | - |
| Sodium (mg/L) | 1.2 | - | - | 1.1 | - | - | 1.3 | - | - |

| Parameter | IY1 | | | | | | IY2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nov 2019 | | | Feb 2020 | | | Nov 2020 | | | Feb 2021 | | |
| | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD |
| **BH09** | | | | | | | | | | | | |
| Total Kjeldahl Nitrogen (mg N/L) | 0.2 | 0.4 | 67 | 0.2 | - | - | - | - | - | - | - | - |
| Phosphorus (mg P/L) | <0.05 | 0.09 | 113 | <0.05 | - | - | - | - | - | - | - | - |
| Total Dissolved Solids (mg/L) | 10 | 10 | 0 | 11 | - | - | - | - | - | - | - | - |
| Electrical Conductivity at 25°C (µS/cm) | 16 | 16 | 0 | 19 | - | - | - | - | - | - | - | - |
| Chloride (mg/L) | 1 | 1 | 0 | 2 | - | - | - | - | - | - | - | - |
| Sulphate (mg/L) | <1 | <1 | 0 | <1 | - | - | - | - | - | - | - | - |
| Alkalinity Bicarbonate (mg/L) | 7 | 7 | 0 | 7 | - | - | - | - | - | - | - | - |
| Alkalinity Carbonate (mg/L) | <2 | <2 | 0 | <2 | - | - | - | - | - | - | - | - |
| Total Nitrogen (mg/L) | 0.8 | 1 | 22 | 0.7 | - | - | - | - | - | - | - | - |
| Nitrate + Nitrite (mg N/L) | 0.55 | 0.6 | 9 | 0.54 | - | - | - | - | - | - | - | - |
| Nitrate (mg N/L) | 0.54 | 0.55 | 2 | 0.54 | - | - | - | - | - | - | - | - |
| Calcium (mg/L) | 0.6 | 0.6 | 0 | 1.1 | - | - | - | - | - | - | - | - |
| Magnesium (mg/L) | 0.2 | 0.3 | 40 | 0.3 | - | - | - | - | - | - | - | - |
| Potassium (mg/L) | 0.1 | 0.1 | 0 | 2.2 | - | - | - | - | - | - | - | - |
| Sodium (mg/L) | 1 | 1.1 | 10 | 5.4 | - | - | - | - | - | - | - | - |

| Parameter | BY1 | | | BY2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Feb 2018 | | | Nov 2018 | | | Feb 2019 | | |
| | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD |
| **BH16** | | | | | | | | | |
| Total Kjeldahl Nitrogen (mg N/L) | 0.3 | - | - | 0.3 | 0.1 | 100 | 0.3 | 0.2 | 40 |
| Phosphorus (mg P/L) | <0.05 | - | - | 0.05 | <0.05 | 67 | <0.05 | <0.05 | 0 |
| Total Dissolved Solids (mg/L) | 15 | - | - | 20 | 8 | 86 | 12 | 10 | 18 |
| Electrical Conductivity at 25°C (µS/cm) | 21 | - | - | 20 | 15 | 29 | 19 | 19 | 0 |
| Chloride (mg/L) | 1 | - | - | 1 | 1 | 0 | 2 | 1 | 67 |
| Sulphate (mg/L) | <1 | - | - | <1 | <1 | 0 | <1 | <1 | 0 |
| Alkalinity Bicarbonate (mg/L) | 5 | - | - | 7 | 7 | 0 | 6 | 6 | 0 |
| Alkalinity Carbonate (mg/L) | <2 | - | - | <2 | <2 | 0 | <2 | <2 | 0 |
| Total Nitrogen (mg/L) | 1.1 | - | - | 1.4 | 0.6 | 80 | 1.2 | 1 | 18 |
| Nitrate + Nitrite (mg N/L) | 0.84 | - | - | 1.1 | 0.48 | 78 | 0.87 | 0.88 | 1 |
| Nitrate (mg N/L) | 0.83 | - | - | 1.1 | 0.48 | 78 | 0.87 | 0.87 | 0 |
| Calcium (mg/L) | 0.8 | - | - | 1.1 | 0.8 | 32 | 0.9 | 0.8 | 12 |
| Magnesium (mg/L) | 0.3 | - | - | 0.3 | 0.3 | 0 | 0.2 | 0.2 | 0 |
| Potassium (mg/L) | 0.1 | - | - | 0.1 | 0.1 | 0 | 0.1 | 0.2 | 67 |
| Sodium (mg/L) | 1.6 | - | - | 1.9 | 1.1 | 53 | 1.6 | 1.5 | 6 |

| Parameter | IY1 | | | | | | IY2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nov 2019 | | | Feb 2020 | | | Nov 2020 | | | Feb 2021 | | |
| | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD |
| **BH16** | | | | | | | | | | | | |
| Total Kjeldahl Nitrogen (mg N/L) | 0.3 | - | - | 0.2 | - | - | 0.5 | - | - | 0.3 | 0.4 | 29 |
| Phosphorus (mg P/L) | <0.05 | - | - | 0.06 | - | - | <0.05 | - | - | 0.06 | 0.06 | 0 |
| Total Dissolved Solids (mg/L) | 12 | - | - | 11 | - | - | 15 | - | - | 11 | 14 | 24 |
| Electrical Conductivity at 25°C (µS/cm) | 20 | - | - | 19 | - | - | 23 | - | - | 20 | 20 | 0 |
| Chloride (mg/L) | 1 | - | - | 2 | - | - | 1 | - | - | 2 | 2 | 0 |
| Sulphate (mg/L) | <1 | - | - | <1 | - | - | <1 | - | - | <1 | <1 | 0 |
| Alkalinity Bicarbonate (mg/L) | 7 | - | - | 6 | - | - | 6 | - | - | 6 | 6 | 0 |
| Alkalinity Carbonate (mg/L) | <2 | - | - | <2 | - | - | <2 | - | - | <2 | <2 | 0 |
| Total Nitrogen (mg/L) | 1.3 | - | - | 1 | - | - | 1.5 | - | - | 1.2 | 1.2 | 0 |
| Nitrate + Nitrite (mg N/L) | 0.97 | - | - | 0.82 | - | - | 0.98 | - | - | 0.81 | 0.8 | 1 |
| Nitrate (mg N/L) | 0.96 | - | - | 0.82 | - | - | 0.97 | - | - | 0.8 | 0.8 | 0 |
| Calcium (mg/L) | 0.7 | - | - | 0.6 | - | - | 3.1 | - | - | 1.9 | 2 | 5 |
| Magnesium (mg/L) | 0.2 | - | - | 0.2 | - | - | 9.3 | - | - | 4.8 | 5.2 | 8 |
| Potassium (mg/L) | 0.1 | - | - | 0.4 | - | - | 2.6 | - | - | 1.5 | 1.7 | 13 |
| Sodium (mg/L) | 1.6 | - | - | 1.9 | - | - | 2.8 | - | - | 2.2 | 2.3 | 4 |

| Parameter | BY1 | | | BY2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Feb 2018 | | | Nov 2018 | | | Feb 2019 | | |
| | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD |
| **BH17** | | | | | | | | | |
| Total Kjeldahl Nitrogen (mg N/L) | 0.3 | - | - | 0.5 | - | - | 0.3 | - | - |
| Phosphorus (mg P/L) | 0.05 | - | - | 0.15 | - | - | <0.05 | - | - |
| Total Dissolved Solids (mg/L) | 30 | - | - | 35 | - | - | 30 | - | - |
| Electrical Conductivity at 25°C (µS/cm) | 43 | - | - | 41 | - | - | 42 | - | - |
| Chloride (mg/L) | 1 | - | - | 1 | - | - | 2 | - | - |
| Sulphate (mg/L) | <1 | - | - | <1 | - | - | <1 | - | - |
| Alkalinity Bicarbonate (mg/L) | 15 | - | - | 20 | - | - | 18 | - | - |
| Alkalinity Carbonate (mg/L) | <2 | - | - | <2 | - | - | <2 | - | - |
| Total Nitrogen (mg/L) | 1.5 | - | - | 1.7 | - | - | 1.2 | - | - |
| Nitrate + Nitrite (mg N/L) | 1.2 | - | - | 1.2 | - | - | 0.98 | - | - |
| Nitrate (mg N/L) | 1.2 | - | - | 1.2 | - | - | 0.98 | - | - |
| Calcium (mg/L) | 2.3 | - | - | 2.9 | - | - | 2.7 | - | - |
| Magnesium (mg/L) | 0.8 | - | - | 0.9 | - | - | 0.9 | - | - |
| Potassium (mg/L) | 0.3 | - | - | 0.4 | - | - | 0.4 | - | - |
| Sodium (mg/L) | 2.8 | - | - | 3.2 | - | - | 3.3 | - | - |

| Parameter | IY1 | | | | | | IY2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nov 2019 | | | Feb 2020 | | | Nov 2020 | | | Feb 2021 | | |
| | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD |
| **BH17** | | | | | | | | | | | | |
| Total Kjeldahl Nitrogen (mg N/L) | 0.7 | - | - | 0.1 | - | - | 0.8 | | - | 0.2 | - | - |
| Phosphorus (mg P/L) | 0.16 | - | - | 0.07 | - | - | <0.05 | 0.14 | 139 | 0.06 | - | - |
| Total Dissolved Solids (mg/L) | 28 | - | - | 29 | - | - | 30 | 20 | 40 | 34 | - | - |
| Electrical Conductivity at 25°C (µS/cm) | 42 | - | - | 46 | - | - | 48 | 39 | 21 | 42 | - | - |
| Chloride (mg/L) | 2 | - | - | 2 | - | - | 2 | 2 | 0 | 1 | - | - |
| Sulphate (mg/L) | <1 | - | - | <1 | - | - | <1 | 8 | 176 | <1 | - | - |
| Alkalinity Bicarbonate (mg/L) | 19 | - | - | 22 | - | - | 20 | 19 | 5 | 20 | - | - |
| Alkalinity Carbonate (mg/L) | <2 | - | - | <2 | - | - | <2 | <2 | 0 | <2 | - | - |
| Total Nitrogen (mg/L) | 2 | - | - | 1.1 | - | - | 2 | 0.7 | 96 | 1.1 | - | - |
| Nitrate + Nitrite (mg N/L) | 1.3 | - | - | 0.95 | - | - | 1.1 | <0.01 | 198 | 0.9 | - | - |
| Nitrate (mg N/L) | 1.3 | - | - | 0.94 | - | - | 1.1 | <0.01 | 198 | 0.9 | - | - |
| Calcium (mg/L) | 2.3 | - | - | 2.3 | - | - | 3.8 | 5.8 | 42 | 3 | - | - |
| Magnesium (mg/L) | 0.7 | - | - | 0.8 | - | - | 1.7 | 7.4 | 125 | 1.3 | - | - |
| Potassium (mg/L) | 0.3 | - | - | 0.5 | - | - | 1.3 | 4.3 | 107 | 0.8 | - | - |
| Sodium (mg/L) | 3.1 | - | - | 3.2 | - | - | 4.3 | 4.4 | 2 | 3.6 | - | - |

| Parameter | BY1 | | | BY2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Feb 2018 | | | Nov 2018 | | | Feb 2019 | | |
| | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD |
| **BH18** | | | | | | | | | |
| Total Kjeldahl Nitrogen (mg N/L) | 1.1 | 0.1 | 167 | 0.2 | - | - | 0.3 | - | - |
| Phosphorus (mg P/L) | 0.63 | 0.06 | 165 | 0.21 | - | - | 0.06 | - | - |
| Total Dissolved Solids (mg/L) | 18 | 42 | 80 | 22 | - | - | 20 | - | - |
| Electrical Conductivity at 25°C (µS/cm) | 25 | 60 | 82 | 28 | - | - | 27 | - | - |
| Chloride (mg/L) | 1 | <1 | 67 | 2 | - | - | 2 | - | - |
| Sulphate (mg/L) | 1 | <1 | 67 | <1 | - | - | <1 | - | - |
| Alkalinity Bicarbonate (mg/L) | 12 | 27 | 77 | 14 | - | - | 12 | - | - |
| Alkalinity Carbonate (mg/L) | <2 | <2 | 0 | <2 | - | - | <2 | - | - |
| Total Nitrogen (mg/L) | 1.1 | 0.3 | 114 | 0.2 | - | - | 0.3 | - | - |
| Nitrate + Nitrite (mg N/L) | 0.06 | 0.2 | 108 | <0.01 | - | - | 0.06 | - | - |
| Nitrate (mg N/L) | 0.06 | 0.2 | 108 | <0.01 | - | - | 0.05 | - | - |
| Calcium (mg/L) | 1.5 | 44 | 187 | 1.5 | - | - | 1.3 | - | - |
| Magnesium (mg/L) | 0.5 | 2 | 120 | 0.5 | - | - | 0.5 | - | - |
| Potassium (mg/L) | 0.1 | 0.9 | 160 | 0.3 | - | - | 0.1 | - | - |
| Sodium (mg/L) | 3.2 | 2.2 | 37 | 2.8 | - | - | 2.5 | - | - |

| Parameter | IY1 | | | | | | IY2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nov 2019 | | | Feb 2020 | | | Nov 2020 | | | Feb 2021 | | |
| | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD | Prim. | Dup. | RPD |
| **BH18** | | | | | | | | | | | | |
| Total Kjeldahl Nitrogen (mg N/L) | 0.5 | 1.3 | 89 | 0.3 | 0.7 | 80 | 0.8 | - | - | 0.3 | - | - |
| Phosphorus (mg P/L) | 0.15 | 0.02 | 153 | 0.07 | 0.04 | 55 | 0.15 | - | - | 0.07 | - | - |
| Total Dissolved Solids (mg/L) | 15 | 15 | 0 | 16 | 41 | 88 | 20 | - | - | | - | - |
| Electrical Conductivity at 25°C (µS/cm) | 25 | 26 | 4 | 28 | 31 | 10 | 39 | - | - | 32 | - | - |
| Chloride (mg/L) | 2 | 11 | 138 | 3 | 3.5 | 15 | 2 | - | - | 2 | - | - |
| Sulphate (mg/L) | <1 | <5 | 0 | <20* | <5 | 0 | <1 | - | - | <1 | - | - |
| Alkalinity Bicarbonate (mg/L) | 13 | <20 | 26 | 13 | <20 | 26 | 18 | - | - | 15 | - | - |
| Alkalinity Carbonate (mg/L) | <2 | <10 | 133 | <2 | <10 | 133 | <2 | - | - | <2 | - | - |
| Total Nitrogen (mg/L) | 0.5 | 1.3 | 89 | 0.3 | 0.7 | 80 | 0.8 | - | - | 0.3 | - | - |
| Nitrate + Nitrite (mg N/L) | <0.01 | <0.05 | 133 | 0.01 | <0.05 | 86 | 0.02 | - | - | 0.01 | - | - |
| Nitrate (mg N/L) | <0.01 | <0.02 | 67 | 0.01 | <0.02 | 0 | <0.01 | - | - | 0.01 | - | - |
| Calcium (mg/L) | 1.1 | 1.2 | 9 | 1.6 | <5 | 44 | 7 | - | - | 3.6 | - | - |
| Magnesium (mg/L) | 0.4 | <0.5 | 46 | 0.7 | <5 | 113 | 10 | - | - | 3.6 | - | - |
| Potassium (mg/L) | <0.1 | <0.5 | 133 | 0.6 | <5 | 123 | 4.8 | - | - | 2.2 | - | - |
| Sodium (mg/L) | 2.5 | 3.4 | 31 | 3.4 | 17 | 133 | 4.8 | - | - | 3.3 | - | - |

*Note: Limit of Reporting (LoR) increased due to interferences in the sample matrix.

# Appendix 8 Hydrology field data and laboratory reports

PURGING AND SAMPLING RECORD

PURGE METHOD..........BAILER

WQ METER TYPE

| | | | |
|---|---|---|---|
| HEMAMP: GROUND WATER SAMP<br>DATE: 25/11/20<br>SAMPLER: MATT BEATTIE<br>BORE ID: BOLLM 1 PV/1<br>RUS UP HILL | PURGE METHOD<br>WQ METER TYPE: YSI<br>WLEVEL METER TRPE.....DIP/INTERFACE<br>FIELD FILTERED: Y/N | SWL (Mtoc):<br>screen:from......................to......................m<br>NAPL check:......................<br>ref datum:....pvc<br>bore depth :...................... | logic check:<br>stick up: m<br>BORE DIAM: 50MM<br>WELL CAP SECURE: Y/N |

| TIME (.......) | VOLUME (L) | TEMP (C) | Ph (pH units) | elec.cond (....uS.....) | dis. Oxygen (..mg/L.......) | OX-red Pt (+- mV) | comments. Colour, Turbidity, sediment load, sheen odour, flow rate, purged dry? |
|---|---|---|---|---|---|---|---|
| 0736 | | 7.9 | 5.75 | 27.5 | 10.52 | -131.2 | clear / clean |
| 0735 | | 7.9 | 5.72 | 27.5 | 10.50 | -130.7 | |
| 0738 | | 7.9 | 5.73 | 27.5 | 10.51 | -131.7 | |
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| Field QA Checks | |
|---|---|
| Any violent reactions ? | Y/N |
| decontamination as per procedure? | Y/N |
| Was sampling eqipment prre-cleaned ? | Y/N Yes |

Comment: Duplicate samples collected, bottles used, access, conditionof headworks etc

HEMAMP DUPLICATE 1 (EUROFINS)

meters calibrated Y/N QA/QC taken Y/N samples cooled Y/N

| Purge Volumes | | | |
|---|---|---|---|
| Casding Int. Dia (mm) | 50 | 100 | 150 |
| vol (L/m of casing) | 2 | 7.9 | 17.7 |

PURGING AND SAMPLING RECORD

PURGE METHOD..........BAILER
WQ METER TYPE

| | | | |
|---|---|---|---|
| HEMAMP: GROUND WATER SAMP<br>DATE: 25/11/2020<br>SAMPLER: MATT BRATTEL<br>BORE ID: ROCKY 1 PW/2<br>CHS VP WELL | PURGE METHOD<br>WQ METER TYPE: YSI<br>WLEVEL METER TRPE.....DIP/INTERFACE<br>FIELD FILTERED: Y/N | SWL (Mtoc):<br>screen:from....................to.....................m<br>NAPL check:..................<br>ref datum:...pvc<br>bore depth :.................. | logic check:<br>stick up: m<br>BORE DIAM: 50MM<br>WELL CAP SECURE: Y/N |

| TIME (.......) | VOLUME (L) | TEMP (C) | Ph (pH units) | elec.cond (...............) | dis. Oxygen (..................) | OX-red Pt (+- mV) | comments. Colour, Turbidity, sediment load, sheen odour, flow rate, purged dry? |
|---|---|---|---|---|---|---|---|
| 0805 | | 7.5 | 5.50 | 22.5 | 10.09 | -138.5 | CLEAN / CLEAR |
| 0810 | | 7.5 | 5.54 | 22.5 | 9.82 | -138.1 | |
| 0815 | | 7.5 | 5.50 | 22.4 | 10.05 | -134.6 | |

| Field QA Checks | |
|---|---|
| Any violent reactions ? | Y/N |
| decontamination as per procedure? | Y/N |
| Was sampling eqipment prre-cleaned ? | Y/N |

Comment: Duplicate samples collected, bottles used, access, conditionof headworks etc

meters calibrated Y/N QA/QC taken Y/N samples cooled Y/N

| Purge Volumes | | | |
|---|---|---|---|
| Casding Int. Dia (mm) | 50 | 100 | 150 |
| vol (L/m of casing | 2 | 7.9 | 17.7 |

PURGING AND SAMPLING RECORD

PURGE METHOD..........BAILER
WQ METER TYPE

| | | | |
|---|---|---|---|
| HEMAMP: GROUND WATER SAMPI<br>DATE: 25/11/20<br>SAMPLER: Matt Baxter<br>BORE ID: Bally 2 P/N | PURGE METHOD<br>WQ METER TYPE: YSR<br>WLEVEL METER TRPE.....~~DIP/INTERFACE~~<br>FIELD FILTERED: Y/N | SWL (Mtoc):<br>screen:from..................to..................m<br>NAPL check:..................<br>ref datum:....pvc<br>bore depth :.................. | logic check:<br>stick up: m<br>BORE DIAM: 50MM<br>WELL CAP SECURE: Y/N |

| TIME (.......) | VOLUME (L) | TEMP (C) | Ph (pH units) | elec.cond (...............) | dis. Oxygen (...................) | OX-red Pt (+- mV) | comments. Colour, Turbidity, sediment load, sheen odour, flow rate, purged dry? |
|---|---|---|---|---|---|---|---|
| 0820 | | 8.4 | 5.85 | 29.0 | 8.2 | -127.9 | CLEAN VERY CLEAR |
| 0822 | | 8.4 | 5.87 | 29.1 | 7.98 | -129.9 | |
| 0825 | | 8.4 | 5.67 | 28.7 | 9.48 | -118.5 | |
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| Field QA Checks | |
|---|---|
| Any violent reactions ? | Y/N |
| decontamination as per procedure? | Y/N |
| Was sampling eqipment prre-cleaned ? | Y/N |

Comment: Duplicate samples collected, bottles used, access, conditionof headworks etc

Field Duplicate 1

meters calibrated Y/N QA/QC taken Y/N samples cooled Y/N

| Purge Volumes | | | |
|---|---|---|---|
| Casding Int. Dia (mm) | 50 | ~~100~~ | 150 |
| vol (L/m of casing | 2 | 7.9 | 17.7 |

PURGING AND SAMPLING RECORD

PURGE METHOD..........BAILER
WQ METER TYPE

| | | | |
|---|---|---|---|
| HEMAMP: GROUND WATER SAMPI<br>DATE: 25/11/20<br>SAMPLER: Matthew Love / Matt Beattie<br>BORE ID: BH06 | PURGE METHOD Bailer<br>WQ METER TYPE: YSI<br>WLEVEL METER TRPE.....DIP/INTERFACE 6.41m<br>FIELD FILTERED: Y/N | SWL (Mtoc): ~~dist down to water level~~ 6.41m 9.07<br>screen:from....................to.....................m<br>NAPL check:..........<br>ref datum:....pvc<br>bore depth :....9.07.......... | logic check: yes<br>stick up: m<br>BORE DIAM: 50MM<br>WELL CAP SECURE: Y/N |

| TIME (.......) | VOLUME (L) | TEMP (C) | Ph (pH units) | elec.cond (...............) | dis. Oxygen (..................) | OX-red Pt (+- mV) | comments. Colour, Turbidity, sediment load, sheen odour, flow rate, purged dry? |
|---|---|---|---|---|---|---|---|
| ~~10:30~~ | ~~4~~ | ~~16~~ | ~~6.47~~ | ~~1.5~~ | ~~9.51~~ | ~~208.2~~ | Slightly cloudy some sediment. |
| ~~10:37~~ | ~~4~~ | ~~14~~ | ~~6.17~~ | ~~1.7~~ | ~~9.30~~ | ~~194.7~~ | |
| ~~10:42~~ | ~~4~~ | ~~13.5~~ | ~~6.18~~ | ~~1.7~~ | ~~9.56~~ | ~~184.7~~ | |
| 11:00 | 4 | 7.1 | 4.63 | 36.5 | 10.16 | -186.3 | Slightly cloudy some sediment |
| 11:04 | 4 | 7.1 | 4.10 | 36.4 | 10.31 | -178.8 | |
| 11:08 | 4 | 7.2 | 3.99 | 36.6 | 10.16 | -179.7 | |
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| Field QA Checks | |
|---|---|
| Any violent reactions ? | Y/N |
| decontamination as per procedure? | Y/N |
| Was sampling eqipment prre-cleaned ? | Y/N |

Comment: Duplicate samples collected, bottles used, access, conditionof headworks etc
Field Duplicate 2 collected

meters calibrated Y/N QA/QC taken Y/N samples cooled Y/N

| Purge Volumes | | | |
|---|---|---|---|
| Casding Int. Dia (mm) | 50 | 100 | 150 |
| vol (L/m of casing | 2 | 7.9 | 17.7 |

PURGING AND SAMPLING RECORD

PURGE METHOD..........BAILER
WQ METER TYPE

| | | | |
|---|---|---|---|
| HEMAMP: GROUND WATER SAMP<br>DATE: 25/11/2020<br>SAMPLER: Mat Lowe/Matt B<br>BORE ID: BH16 | PURGE METHOD: BAILER<br>WQ METER TYPE: YSI<br>WLEVEL METER TRPE.....DIP/INTERFACE<br>FIELD FILTERED: Y/N | SWL (Mtoc): 0.15<br>screen:from.....................to.....................m<br>NAPL check:<br>ref datum:....pvc<br>bore depth :....2m | logic check:<br>stick up: m<br>BORE DIAM: 50MM<br>WELL CAP SECURE: Y/N |

| TIME (.......) | VOLUME (L) | TEMP (C) | Ph (pH units) | elec.cond (................) | dis. Oxygen (....................) | OX-red Pt (+- mV) | comments. Colour, Turbidity, sediment load, sheen odour, flow rate, purged dry? |
|---|---|---|---|---|---|---|---|
| 11:45 | 5 | 6.4 | 4.27 | 26.7 | ~~[illegible]~~ 16.5 | -107.5 | Cloudy red some sediment |
| 11:50 | 5 | 6.6 | 3.90 | 26.7 | 12.14 | -122.5 | |
| 11:55 | 5 | 6.7 | 3.67 | 26.6 | 11.71 | -114.4 | |
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Comment: Duplicate samples collected, bottles used, access, conditionof headworks etc

DUPLICATE 2 HYDROCARBONS TAKEN.

meters calibrated Y/N QA/QC taken Y/N samples cooled Y/N

| Field QA Checks | |
|---|---|
| Any violent reactions ? | Y/N |
| decontamination as per procedure? | Y/N |
| Was sampling eqipment prre-cleaned ? | Y/N |

| Purge Volumes | | | |
|---|---|---|---|
| Casding Int. Dia (mm) | 50 | 100 | 150 |
| vol (L/m of casing | 2 | 7.9 | 17.7 |

PURGING AND SAMPLING RECORD

PURGE METHOD..........BAILER
WQ METER TYPE

| | | | |
|---|---|---|---|
| HEMAMP: GROUND WATER SAMPI<br>DATE: 25/11/2020<br>SAMPLER: Mat Lane / Matt B<br>BORE ID: BH17 | PURGE METHOD Bailer<br>WQ METER TYPE:<br>WLEVEL METER TRPE.....DIP/INTERFACE<br>FIELD FILTERED: Y/N | SWL (Mtoc): 0<br>screen:from......................to......................m<br>NAPL check:..........................................<br>ref datum:....pvc<br>bore depth :...2.16 m.......................... | logic check:<br>stick up: m<br>BORE DIAM: 50MM<br>WELL CAP SECURE: Y/N |

| TIME (........) | VOLUME (L) | TEMP (C) | Ph (pH units) | elec.cond (.................) | dis. Oxygen (.....................) | OX-red Pt (+- mV) | comments. Colour, Turbidity, sediment load, sheen odour, flow rate, purged dry? |
|---|---|---|---|---|---|---|---|
| 1:06 | 3.5 | 17.6 | 7.61 | 28.1 | 32.41 | ~~[illegible]~~ -92 | SLIGHTLY CLOUDY |
| 1:10 | 3.5 | 17.3 | 5.68 | ~~[illegible]~~ 32 | 25.53 | -92 | |
| 1:15 | 3.5 | 11.9 | 7.61 | 42.5 | 20.25 | -92 | |
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| Field QA Checks | |
|---|---|
| Any violent reactions ? | Y/N |
| decontamination as per procedure? | Y/N |
| Was sampling eqipment prre-cleaned ? | Y/N |

| Purge Volumes | | | |
|---|---|---|---|
| Casding Int. Dia (mm) | 50 | 100 | 150 |
| vol (L/m of casing | 2 | 7.9 | 17.7 |

Comment: Duplicate samples collected, bottles used, access, conditionof headworks etc

FIELD DUPLICATE 3 Collected

meters calibrated Y/N QA/QC taken Y/N samples cooled Y/N

PURGING AND SAMPLING RECORD

PURGE METHOD..........BAILER
WQ METER TYPE

| | | | |
|---|---|---|---|
| HEMAMP: GROUND WATER SAMP<br>DATE: 25/11/20<br>SAMPLER: Marty Lowe/Matt Conn<br>BORE ID: BH18 | PURGE METHOD: Bailer<br>WQ METER TYPE:<br>WLEVEL METER TRPE.....DIP/INTERFACE<br>FIELD FILTERED: Y/N (N) | SWL (Mtoc): 1.06 m<br>screen:from....................to....................m<br>NAPL check:......................................<br>ref datum:....pvc<br>bore depth :..2.1m.................... | logic check:<br>stick up: m<br>BORE DIAM: 50MM<br>WELL CAP SECURE: Y/N |

| TIME (.......) | VOLUME (L) | TEMP (C) | Ph (pH units) | elec.cond (................) | dis. Oxygen (..................) | OX-red Pt (+- mV) | comments. Colour, Turbidity, sediment load, sheen odour, flow rate, purged dry? |
|---|---|---|---|---|---|---|---|
| 3:50pm | 2.5L | 12.9 | 5.68 | 49.3 | 32.43 | -105.5 | High sediment load, brown/clay colour, highly turbid |
| 3:55pm | 2.5L | 12.2 | 5.30 | 48.5 | 28.32 | -90.2 | |
| 4:00pm | 2.5L | 11.7 | 4.28 | 50.1 | 25.05 | -85.3 | |
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| Field QA Checks | |
|---|---|
| Any violent reactions ? | Y/N |
| decontamination as per procedure? | Y/N |
| Was sampling eqipment prre-cleaned ? | Y/N |

Comment: Duplicate samples collected, bottles used, access, conditionof headworks etc

meters calibrated Y/N QA/QC taken Y/N samples cooled Y/N

| Purge Volumes | | | |
|---|---|---|---|
| Casding Int. Dia (mm) | 50 | 100 | 150 |
| vol (L/m of casing | 2 | 7.9 | 17.7 |

PURGING AND SAMPLING RECORD

PURGE METHOD..........BAILER

WQ METER TYPE

Boggy 1 P/U 1

| | | | |
|---|---|---|---|
| HEMAMP: GROUND WATER SAMPL<br>DATE: 9/2/21<br>SAMPLER: Marlow C/Shea C<br>BORE ID: Boggy 1 P/U 1 | PURGE METHOD<br>WQ METER TYPE:<br>WLEVEL METER TRPE.....DIP/INTERFACE<br>FIELD FILTERED: Y/N | SWL (Mtoc):<br>screen:from....................to....................m<br>NAPL check:............................................<br>ref datum:....pvc<br>bore depth :............................................ | logic check:<br>stick up: m<br>BORE DIAM: 50MM<br>WELL CAP SECURE: Y/N |

11:58
11:55

| TIME (.......) | VOLUME (L) | TEMP (C) | Ph (pH units) | elec.cond (...............) | dis. Oxygen (mg/L (%)) | OX-red Pt (+- mV) | comments. Colour, Turbidity, sediment load, sheen odour, flow rate, purged dry? |
|---|---|---|---|---|---|---|---|
| 11.47 | - | 10.2 | 9.25 | 26.1 | 12.58 (129) | 62.5 | Clear |
| ~~11:55~~ | - | 10.2 | 7.13 | 25.9 | 12.09 (127.9) | 115 | |
| | - | 10.2 | 6.98 | 25.7 | 11.6 (122.9) | 111.7 | |
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| Field QA Checks | |
|---|---|
| Any violent reactions ? | Y/N |
| decontamination as per procedure? | Y/N |
| Was sampling eqipment prre-cleaned ? | Y/N |

| Purge Volumes | | | |
|---|---|---|---|
| Casding Int. Dia (mm) | 50 | 100 | 150 |
| vol (L/m of casing | 2 | 7.9 | 17.7 |

Comment: Duplicate samples collected, bottles used, access, conditionof headworks etc

ENFINS 1 Duplicate Collected

meters calibrated Y/N QA/QC taken Y/N samples cooled Y/N

PURGING AND SAMPLING RECORD

PURGE METHOD..........BAILER
WQ METER TYPE

Boggy 1 P/U 2

| | | | |
|---|---|---|---|
| HEMAMP: GROUND WATER SAMP<br>DATE: 9/2/21.<br>SAMPLER: Mathew C / Shen C<br>BORE ID: Boggy 1 P/U2 | PURGE METHOD<br>WQ METER TYPE:<br>WLEVEL METER TRPE.....DIP/INTERFACE<br>FIELD FILTERED: Y/N | SWL (Mtoc):<br>screen:from....................to....................m<br>NAPL check:..........<br>ref datum:....pvc<br>bore depth :.......... | logic check:<br>stick up: m<br>BORE DIAM: 50MM<br>WELL CAP SECURE: Y/N |

| TIME (.......) | VOLUME (L) | TEMP (C) | Ph (pH units) | elec.cond (...............) | dis. Oxygen (...mg/L (%)...) | OX-red Pt (+- mV) | comments. Colour, Turbidity, sediment load, sheen odour, flow rate, purged dry? |
|---|---|---|---|---|---|---|---|
| 11:58 | – | 8.8 | 8.22 | 25.5 | 13.11 (134) | 58.3. | Clear, |
| 12:01 | – | 8.8 | 7.58 | 17.5 | 11.61 (118.5) | 67.6 | |
| 12:03 | – | 8.7. | 7.38 | 22.2. | 12.19 (125.2) | 74.6. | |
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| Field QA Checks | |
|---|---|
| Any violent reactions ? | Y/N |
| decontamination as per procedure? | Y/N |
| Was sampling eqipment prre-cleaned ? | Y/N |

Comment: Duplicate samples collected, bottles used, access, conditionof headworks etc

FD1 collected

meters calibrated Y/N QA/QC taken Y/N samples cooled Y/N

| Purge Volumes | | | |
|---|---|---|---|
| Casding Int. Dia (mm) | 50 | 100 | 150 |
| vol (L/m of casing | 2 | 7.9 | 17.7 |

PURGING AND SAMPLING RECORD

Boggy 2 P/U

PURGE METHOD..........BAILER

WQ METER TYPE

| | | | |
|---|---|---|---|
| HEMAMP: GROUND WATER SAMP<br>DATE: 9/2/21<br>SAMPLER: Mathew L/Sian C<br>BORE ID: Boggy 2 P/U | PURGE METHOD<br>WQ METER TYPE:<br>WLEVEL METER TRPE.....DIP/INTERFACE<br>FIELD FILTERED: Y/N | SWL (Mtoc):<br>screen:from.....................to.....................m<br>NAPL check:.....................<br>ref datum:....pvc<br>bore depth :..................... | logic check:<br>stick up: m<br>BORE DIAM: 50MM<br>WELL CAP SECURE: Y/N |

| TIME (........) | VOLUME (L) | TEMP (C) | Ph (pH units) | elec.cond (...............) | dis. Oxygen (mg/L (%)) | OX-red Pt (+- mV) | comments. Colour, Turbidity, sediment load, sheen odour, flow rate, purged dry? |
|---|---|---|---|---|---|---|---|
| 12:12 | - | 10.3 | 7.5 | 28.6 | 11.67(120.3) | 56.6 | CLEAR! |
| 12:15 | - | 10.5 | 7.58 | 28.8 | 11.9(123.3) | 47.3 | |
| 12:17 | - | 10.4 | 7.66 | 28.7. | 12.0(125.3) | 57.2 | |
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| Field QA Checks | |
|---|---|
| Any violent reactions ? | Y/N |
| decontamination as per procedure? | Y/N |
| Was sampling eqipment prre-cleaned ? | Y/N |

Comment: Duplicate samples collected, bottles used, access, conditionof headworks etc

FD3. collected

meters calibrated Y/N QA/QC taken Y/N samples cooled Y/N

| Purge Volumes | | | |
|---|---|---|---|
| Casding Int. Dia (mm) | 50 | 100 | 150 |
| vol (L/m of casing | 2 | 7.9 | 17.7 |

NO BH09

PURGING AND SAMPLING RECORD

PURGE METHOD..........BAILER
WQ METER TYPE

| | | |
|---|---|---|
| HEMAMP: GROUND WATER SAMPI<br>DATE: 9/2/21<br>SAMPLER: Mark Lowe /Sken (?)<br>BORE ID: BH06 | PURGE METHOD Bailer<br>WQ METER TYPE:<br>WLEVEL METER TRPE.....DIP/INTERFACE<br>FIELD FILTERED: Y/N | SWL (Mtoc): 7.96<br>screen:from.....6.........to.....9.........m<br>NAPL check:.......................................<br>ref datum:....pvc<br>bore depth :.......9.10m............................ |
| logic check:<br>stick up: m<br>BORE DIAM: 50MM<br>WELL CAP SECURE: Y/N | | |

| TIME (.......) | VOLUME (L) | TEMP (C) | Ph (pH units) | elec.cond (...............) | dis. Oxygen (mg/L (%)) | OX-red Pt (+- mV) | comments. Colour, Turbidity, sediment load, sheen odour, flow rate, purged dry? |
|---|---|---|---|---|---|---|---|
| 2:27 | 4 | 6.5 | 7.3 | 68.2 | 10.25 (102.2) | 190.2. | |
| 2:30 | | 6.8 | 5.16 | 52.5 | 8.1 (83.3) | 225.1 | ~~Grey~~ Brown, Moderably turbid. |
| 2:32 | | 9.1 | 4.04 | 59.0 | 7.79 (78.4) | 252.9. | |
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| Field QA Checks | |
|---|---|
| Any violent reactions ? | Y/N |
| decontamination as per procedure? | Y/N |
| Was sampling eqipment prre-cleaned ? | Y/N |

Comment: Duplicate samples collected, bottles used, access, conditionof headworks etc

Eurofins. 2 collected

meters calibrated Y/N QA/QC taken Y/N samples cooled Y/N

| Purge Volumes | | | |
|---|---|---|---|
| Casding Int. Dia (mm) | 50 | 100 | 150 |
| vol (L/m of casing | 2 | 7.9 | 17.7 |

PURGING AND SAMPLING RECORD

PURGE METHOD..........BAILER
WQ METER TYPE

| | | |
|---|---|---|
| HEMAMP: GROUND WATER SAMPL<br>DATE: 9/2/21<br>SAMPLER: Mathew L/Shen C<br>BORE ID: BH16 | PURGE METHOD Bailer<br>WQ METER TYPE:<br>WLEVEL METER TRPE.....DIP/INTERFACE<br>FIELD FILTERED: Y/N | SWL (Mtoc): dist down to water level 0.29m<br>screen:from....1.1....to....2.1....m<br>NAPL check:..........<br>ref datum:....pvc<br>bore depth :....2m.......... |
| logic check:<br>stick up: m<br>BORE DIAM: 50MM<br>WELL CAP SECURE: Y/N | | |

| TIME (.......) | VOLUME (L) | TEMP (C) | Ph (pH units) | elec.cond (..............) | dis. Oxygen (mg/L (%)) | OX-red Pt (+- mV) | comments. Colour, Turbidity, sediment load, sheen odour, flow rate, purged dry? |
|---|---|---|---|---|---|---|---|
| 7:54 | 4.5L | 8.3 | 6.22 | 22.6 | 9.61 (100.8) | 219.5 | |
| 7:56 | 4.5 | 8.5 | 5.13 | 22.5 | 7.82 (81.7) | 242.2 | Moderately Turbid, ~~Br~~ Slight Brown. |
| 7:58 | | 8.6 | 4.76 | 22.6 | 7.82 (82.4) | 240.4 | |
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| Field QA Checks | |
|---|---|
| Any violent reactions ? | Y/N |
| decontamination as per procedure? | Y/N |
| Was sampling eqipment prre-cleaned ? | Y/N |

Comment: Duplicate samples collected, bottles used, access, conditionof headworks etc

FD2 collected.

meters calibrated Y/N QA/QC taken Y/N samples cooled Y/N

| Purge Volumes | | | |
|---|---|---|---|
| Casding Int. Dia (mm) | 50 | 100 | 150 |
| vol (L/m of casing | 2 | 7.9 | 17.7 |

PURGING AND SAMPLING RECORD

PURGE METHOD..........BAILER
WQ METER TYPE

| HEMAMP: GROUND WATER SAMPL | PURGE METHOD Bailer | SWL (Mtoc): dist down to water level (to casing at top) | logic check: |
|---|---|---|---|
| DATE: 4/2/19 | WQ METER TYPE: | screen:from.....................to.....................m | stick up: m |
| SAMPLER: Matt Lowe/Shen Chi | WLEVEL METER TRPE.....DIP/INTERFACE | NAPL check:................................................ | BORE DIAM: 50MM |
| BORE ID: BH17 | FIELD FILTERED: Y/N | ref datum:....pvc | WELL CAP SECURE: Y/N |
| | | bore depth :...7m.......................................... | |

| TIME (.......) | VOLUME (L) | TEMP (C) | Ph (pH units) | elec.cond (.................) | dis. Oxygen (...mg/L (%)) | OX-red Pt (+- mV) | comments. Colour, Turbidity, sediment load, sheen odour, flow rate, purged dry? |
|---|---|---|---|---|---|---|---|
| 3:25 | 4.5 | 10.5 | 5.55 | 45.4 | 5.93 (64.9) | 195.3. | clear, very low turbidity |
| 3:28 | 4.5 | 10.6 | 5.47. | 45.5 | 5.33 (58.6) | 181.7 | |
| 3:30 | 4.5 | 10.8 | 5.47 | 45.5 | 5.48/60.4 | 171.6. | |
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| Field QA Checks | |
|---|---|
| Any violent reactions ? | Y/N |
| decontamination as per procedure? | Y/N |
| Was sampling eqipment prre-cleaned ? | Y/N |

Comment: Duplicate samples collected, bottles used, access, conditionof headworks etc

| Purge Volumes | | | |
|---|---|---|---|
| Casding Int. Dia (mm) | 50 | 100 | 150 |
| vol (L/m of casing | 2 | 7.9 | 17.7 |

meters calibrated Y/N QA/QC taken Y/N samples cooled Y/N

PURGING AND SAMPLING RECORD

PURGE METHOD..........BAILER
WQ METER TYPE

0.87

| | | | |
|---|---|---|---|
| HEMAMP: GROUND WATER SAMPI<br>DATE: 9/2/21<br>SAMPLER: Matt Lowe/Shen Chi<br>BORE ID: BH 18 | PURGE METHOD Bailer<br>WQ METER TYPE:<br>WLEVEL METER TRPE.....DIP/INTERFACE<br>FIELD FILTERED: Y/N | SWL (Mtoc): dist down to water level<br>screen:from.....................to.....................m<br>NAPL check:..........................................<br>ref datum:....pvc<br>bore depth :......2.2........................ | logic check:<br>stick up: m<br>BORE DIAM: 50MM<br>WELL CAP SECURE: Y/N |

| | TIME (.......) | VOLUME (L) | TEMP (C) | Ph (pH units) | elec.cond (...............) | dis. Oxygen (mg/L (%)) | OX-red Pt (+- mV) | comments. Colour, Turbidity, sediment load, sheen | odour, flow rate, purged dry? |
|---|---|---|---|---|---|---|---|---|---|
| 3:51 | | 2.5 | 10.0 | 5.02 | 33.3 | 6.99 (75.7) | 217.4 | Brown, Highly Turbid. | |
| 3:53 | | | 10.2 | 4.79. | 33.3 | 3.95 (42.9) | 211.5 | | |
| | | | 10.3. | 4.74 | 32.4 | 3.96 (43.2) | 200.3. | | |
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| Field QA Checks | |
|---|---|
| Any violent reactions ? | Y/N |
| decontamination as per procedure? | Y/N |
| Was sampling eqipment prre-cleaned ? | Y/N |

Comment: Duplicate samples collected, bottles used, access, conditionof headworks etc

meters calibrated Y/N QA/QC taken Y/N samples cooled Y/N

| Purge Volumes | | | |
|---|---|---|---|
| Casding Int. Dia (mm) | 50 | 100 | 150 |
| vol (L/m of casing | 2 | 7.9 | 17.7 |

# CERTIFICATE OF ANALYSIS

| | |
|---|---|
| **Batch No:** | **20-55111** |
| *Final Report* | **870279** |
| *Client:* | **Mt Buller & Mt Stirling Resort** |
| *Contact:* | **Matt Beattie** |
| *Address:* | C/O Post Office<br>MT BULLER VIC 3723<br>AUSTRALIA |
| *PO No:* | **Not Available** |
| *Sampler Name:* | **Matt Beattie** |
| *ALS Program Ref:* | **WSBULLER** |
| *Program Description:* | **Mt Buller Water Supply** |
| *Client Ref:* | **HEMAMP- Boggy 1 & Boggy 2** |


| | |
|---|---|
| *Laboratory* | Scoresby Laboratory |
| *Address* | Caribbean Business Park,<br>22 Dalmore Drive,<br>Scoresby,<br>VIC 3179 |
| *Phone* | 03 8756 8000 |
| *Fax* | 03 9763 1862 |
| Contact: | Christine Desiniotis<br>Client Manager<br>Christine.Desiniotis@alsglobal.com |


| | |
|---|---|
| Date Sampled: | **25-Nov-2020** |
| Date Samples Received: | **26-Nov-2020** |
| *Date Issued:* | **10-Jan-2021** |

The hash (#) below indicates methods not covered by NATA accreditation in the performance of this service .

| *Analysis* | | *Method* | *Laboratory* | *Analysis* | | *Method* | *Laboratory* |
|---|---|---|---|---|---|---|---|
| DO | # | CLIENT | Scoresby | EC | # | CLIENT | Scoresby |
| pH | # | CLIENT | Scoresby | Temp. | # | CLIENT | Scoresby |
| Alkalinity | | WD037 | Scoresby | Chloride | | WD045G | Scoresby |
| EC | | WA010 | Scoresby | TCN | | EK062 | Scoresby |
| NO3-N | | EK058GV | Scoresby | NOX as N (DA) | | EK058GV & 059GV | Scoresby |
| OES Scan | | WG005A (Si not NATA); EA065-69 | Scoresby | SS at 104+/- 2°C | | WA025 | Scoresby |
| TDS at 180°C +/- 5°C | | WA015 | Scoresby | SO4 DA | | WD041G | Scoresby |
| TKN/TP (HL) | | WK061A | Scoresby | Turbidity | | WA045 | Scoresby |

**ORP Boggy 1 p/u1 -131.1**
**ORP Boggy 1 p/u2 -136.2**
**ORP Boggy 2 p/u -125.6**

*Signatories*

| *Name* | *Title* | *Name* | *Title* |
|---|---|---|---|
| **Christine Desiniotis** | **Client Manager** | **Chatura Perera** | **Team Leader Nutrients** |
| **Chatura Perera** | **Team Leader Nutrients** | **Mario Solorzano** | **Analyst** |
| **Ricky Singh** | **Analyst** | **Suresh Sundaramoorthy** | **Chemist** |

Samples not collected by ALS and are tested as received.

Soil microbiological testing was commenced within 4 days from the day collected unless otherwise stated.
Water microbiological testing was commenced on the day received and within 24 hours of sampling unless otherwise stated.
MM524: Plate count results <10 per mL and >300 per mL are deemed as approximate.
MM526: Plate count results <2,500 per mL and >250,000 per mL are deemed as approximate.
Calculated results are based on raw data.
Legionella species refers to Legionella species other than Legionella pneumophila
Measurement Uncertainties values for your compliance results are available at this link

*Batch No:* **20-55111**
*Report Number:* **870279**
*Client:* **Mt Buller & Mt Stirling Resort**
*ALS Program Ref:* **WSBULLER**
*Program Description:* **Mt Buller Water Supply**

| Sample No | Site Code | Site Description | Sample Type | Sampled Date/Time |
|---|---|---|---|---|
| 6787599 | | Boggy 1 p/u1 | WATER | 25/11/20 07:35 |
| 6787600 | | Boggy 1 p/u2 | WATER | 25/11/20 08:00 |
| 6787601 | | Boggy 2 p/u | WATER | 25/11/20 08:30 |

| *Analysis - Analyte* | *Sample No. / Site Code / Units* | 6787599 | 6787600 | 6787601 |
|---|---|---|---|---|
| Temp. - Water Temperature (CS) | °C | 7.9 | 7.5 | 8.4 |
| pH - pH (CS) | Units | 5.74 | 5.52 | 5.79 |
| EC - Electrical Conductivity (CS) | uS/cm | 27.5 | 22.5 | 29.0 |
| DO - Dissolved Oxygen (CS) | mg/L | 10.51 | 9.91 | 8.52 |
| TKN/TP (HL) - Total Kjeldahl Nitrogen as N | mg N / L | <0.1 | <0.1 | <0.1 |
| TKN/TP (HL) - Phosphorus, total as P | mg P / L | <0.05 | <0.05 | <0.05 |
| SS at 104+/- 2°C - Suspended Solids | mg/L | <2 | <2 | <2 |
| TDS at 180°C +/- 5°C - Total Dissolved Solids | mg/L | 12 | 10 | 12 |
| EC - Electrical Conductivity @ 25C | uS/cm | 24 | 19 | 24 |
| Turbidity - Turbidity, NTU | NTU | 0.5 | 0.1 | 0.1 |
| Chloride - Chloride, as Cl | mg/L | <1 | <1 | <1 |
| SO4 DA - Sulphate, as SO4 | mg/L | <1 | <1 | <1 |
| Alkalinity - Bicarbonate, as Bicarbonate | mg/L | 13 | 10 | 13 |
| Alkalinity - Carbonate, as Carbonate | mg/L | <2 | <2 | <2 |
| TCN - Total Nitrogen as N (Calc) | mg/L | 0.2 | <0.1 | <0.1 |
| NOX as N (DA) - Nitrate + Nitrite, as N | mg N / L | 0.16 | 0.09 | 0.08 |
| NO3-N - Nitrate, as N | mg N / L | 0.15 | 0.08 | 0.07 |
| OES Scan - Calcium | mg/L | 1.6 | 1.2 | 1.9 |
| OES Scan - Magnesium | mg/L | 0.5 | 0.5 | 0.7 |
| OES Scan - Potassium | mg/L | 0.2 | 0.1 | 0.2 |
| OES Scan - Sodium | mg/L | 2.1 | 1.6 | 2.0 |

*A blank space indicates no test performed.*

Batch No: 20-55111

Report Number: 870279

Client: Mt Buller & Mt Stirling Resort

ALS Program Ref: WSBULLER

Program Description: Mt Buller Water Supply

# Quality Control

| Chemistry | SS at 104+/- 2°C | TDS at 180°C +/- 5°C | EC | Turbidity |
|---|---|---|---|---|
| | SS | TDS 180 | EC @ 25C | Turbidity |
| **6788757 BLANK Value (uS/cm)** | | | **<2** | |
| **6790077 BLANK Value (NTU)** | | | | **<0.1** |
| 6790097 DUPLICATE Sample Value (uS/cm) | | | 1800 | |
| 6790097 DUPLICATE Duplicate Value (uS/cm) | | | 1800 | |
| **6790097 DUPLICATE % RPD (%)** | | | **0.2** | |
| 6790130 DUPLICATE Sample Value (NTU) | | | | 0.3 |
| 6790130 DUPLICATE Duplicate Value (NTU) | | | | 0.3 |
| **6790130 DUPLICATE % RPD (%)** | | | | **1.1** |
| 6790654 DUPLICATE Sample Value (mg/L) | 360 | | | |
| 6790654 DUPLICATE Duplicate Value (mg/L) | 360 | | | |
| **6790654 DUPLICATE % RPD (%)** | **1.1** | | | |
| 6792389 SPIKE Sample Value (mg/L) | | 55 | | |
| 6792389 SPIKE Expected Value (mg/L) | | 2600 | | |
| **6792389 SPIKE % Recovery (%)** | | **99.0** | | |
| 6792432 DUPLICATE Sample Value (mg/L) | | 580 | | |
| 6792432 DUPLICATE Duplicate Value (mg/L) | | 600 | | |
| **6792432 DUPLICATE % RPD (%)** | | **2.1** | | |

| Chemistry | Chloride | SO4 DA | Alkalinity | Alkalinity |
|---|---|---|---|---|
| | Cl | SO4 | Bicarbonate | Carbonate |
| 6789139 DUPLICATE Sample Value (mg/L) | 1800 | 430 | | |
| 6789139 DUPLICATE Duplicate Value (mg/L) | 1800 | 440 | | |
| **6789139 DUPLICATE % RPD (%)** | **0.0** | **0.6** | | |
| 6789574 DUPLICATE Sample Value (mg/L) | | | 73 | <2 |
| 6789574 DUPLICATE Duplicate Value (mg/L) | | | 75 | <2 |
| **6789574 DUPLICATE % RPD (%)** | | | **2.8** | **0** |

| Metals | OES Scan | OES Scan | OES Scan | OES Scan |
|---|---|---|---|---|
| | Ca | Mg | K | Na |
| **6792347 BLANK Value (mg/L)** | **<0.1** | **<0.1** | **<0.1** | **<0.1** |
| 6792352 DUPLICATE Sample Value (mg/L) | 5.7 | 3.0 | 1.1 | 14 |
| 6792352 DUPLICATE Duplicate Value (mg/L) | 5.8 | 3.1 | 1.1 | 14 |
| **6792352 DUPLICATE % RPD (%)** | **2.9** | **2.9** | **0.7** | **1.1** |
| 6792353 SPIKE Sample Value (mg/L) | 5.7 | 3.0 | 1.1 | |
| 6792353 SPIKE Expected Value (mg/L) | 7.7 | 5.0 | 3.1 | |
| **6792353 SPIKE % Recovery (%)** | **86.2** | **84.1** | **88.4** | |
| **6792358 BLANK Value (mg/L)** | **<0.1** | **<0.1** | **<0.1** | **<0.1** |
| 6792360 DUPLICATE Sample Value (mg/L) | 20 | 9 | 33 | 170 |
| 6792360 DUPLICATE Duplicate Value (mg/L) | 19 | 9 | 32 | 160 |
| **6792360 DUPLICATE % RPD (%)** | **2.7** | **2.1** | **3.2** | **2.7** |
| 6792365 SPIKE Sample Value (mg/L) | 27 | 6 | 31 | |
| 6792365 SPIKE Expected Value (mg/L) | 47 | 26 | 51 | |
| **6792365 SPIKE % Recovery (%)** | **98.6** | **99.9** | **99.6** | |

| Nutrients | TKN/TP (HL) | TKN/TP (HL) | NOX as N (DA) | NO3-N |
|---|---|---|---|---|
| | TKN | TP | NOX as N | NO3 |
| 6789139 DUPLICATE Sample Value (mg N / L) | | | 15 | 15 |
| 6789139 DUPLICATE Duplicate Value (mg N / L) | | | 16 | 16 |
| **6789139 DUPLICATE % RPD (%)** | | | **1.0** | **1.0** |
| 6792183 SPIKE Sample Value (mg N / L) | 73 | 8.0 | | |
| 6792183 SPIKE Expected Value (mg N / L) | 93 | 28 | | |
| **6792183 SPIKE % Recovery (%)** | **106** | **100** | | |
| 6792186 DUPLICATE Sample Value (mg N / L) | 73 | 8.0 | | |
| 6792186 DUPLICATE Duplicate Value (mg N / L) | 74 | 8.0 | | |
| **6792186 DUPLICATE % RPD (%)** | **1.1** | **0.4** | | |
| **6792189 BLANK Value (mg N / L)** | **<0.1** | **<0.05** | | |

## CERTIFICATE OF ANALYSIS

| | | | |
|---|---|---|---|
| **Batch No:** | **20-55110** | *Page* | **Page 1 of 3** |
| *Final Report* | **870256** | *Laboratory* | Scoresby Laboratory |
| | | *Address* | Caribbean Business Park,<br>22 Dalmore Drive,<br>Scoresby,<br>VIC 3179 |
| *Client:* | **Mt Buller & Mt Stirling Resort** | *Phone* | 03 8756 8000 |
| *Contact:* | **Matt Beattie** | *Fax* | 03 9763 1862 |
| *Address:* | C/O Post Office<br>MT BULLER VIC 3723<br>AUSTRALIA | Contact: | Christine Desiniotis<br>Client Manager<br>Christine.Desiniotis@alsglobal.com |
| *PO No:* | **Not Available** | Date Sampled: | **25-Nov-2020** |
| *Sampler Name:* | **Matt Beattie** | Date Samples Received: | **26-Nov-2020** |
| *ALS Program Ref:* | **WSBULLER** | *Date Issued:* | **10-Jan-2021** |
| *Program Description:* | **Mt Buller Water Supply** | | |
| *Client Ref:* | **HEMAMP Water Storage Proj** | | |

The hash (#) below indicates methods not covered by NATA accreditation in the performance of this service .

| *Analysis* | | *Method* | *Laboratory* | *Analysis* | | *Method* | *Laboratory* |
|---|---|---|---|---|---|---|---|
| DO | # | CLIENT | Scoresby | EC | # | CLIENT | Scoresby |
| pH | # | CLIENT | Scoresby | Temp. | # | CLIENT | Scoresby |
| Alkalinity | | WD037 | Scoresby | Chloride | | WD045G | Scoresby |
| EC | | WA010 | Scoresby | TCN | | EK062 | Scoresby |
| NO3-N | | EK058GV | Scoresby | NOX as N (DA) | | EK058GV & 059GV | Scoresby |
| OES Scan | | WG005A (Si not NATA); EA065-69 | Scoresby | TDS at 180°C +/- 5°C | | WA015 | Scoresby |
| SO4 DA | | WD041G | Scoresby | TKN/TP (HL) | | WK061A | Scoresby |

**ORP BH6 -180.5**

**No sample for BH9. Bore could not be found.**

*Signatories*

| *Name* | *Title* | *Name* | *Title* |
|---|---|---|---|
| **Christine Desiniotis** | **Client Manager** | **Chatura Perera** | **Team Leader Nutrients** |
| **Chatura Perera** | **Team Leader Nutrients** | **Mario Solorzano** | **Analyst** |
| **Ricky Singh** | **Analyst** | | |

Samples not collected by ALS and are tested as received.

Soil microbiological testing was commenced within 4 days from the day collected unless otherwise stated.
Water microbiological testing was commenced on the day received and within 24 hours of sampling unless otherwise stated.
MM524: Plate count results <10 per mL and >300 per mL are deemed as approximate.
MM526: Plate count results <2,500 per mL and >250,000 per mL are deemed as approximate.
Calculated results are based on raw data.
Legionella species refers to Legionella species other than Legionella pneumophila
Measurement Uncertainties values for your compliance results are available at this link

Batch No: 20-55110
Report Number: 870256
Client: Mt Buller & Mt Stirling Resort
ALS Program Ref: WSBULLER
Program Description: Mt Buller Water Supply

| Sample No | Site Code | Site Description | Sample Type | Sampled Date/Time |
|---|---|---|---|---|
| 6787594 | | BH6 | WATER | 25/11/20 11:15 |

| Analysis - Analyte | Sample No. / Site Code / Units | 6787594 |
|---|---|---|
| Temp. - Water Temperature (CS) | °C | 7.1 |
| pH - pH (CS) | Units | 4.1 |
| EC - Electrical Conductivity (CS) | uS/cm | 36.5 |
| DO - Dissolved Oxygen (CS) | mg/L | 10.25 |
| TKN/TP (HL) - Total Kjeldahl Nitrogen as N | mg N / L | 0.4 |
| TKN/TP (HL) - Phosphorus, total as P | mg P / L | <0.05 |
| TDS at 180°C +/- 5°C - Total Dissolved Solids | mg/L | 12 |
| EC - Electrical Conductivity @ 25C | uS/cm | 28 |
| Chloride - Chloride, as Cl | mg/L | 1 |
| SO4 DA - Sulphate, as SO4 | mg/L | <1 |
| Alkalinity - Bicarbonate, as Bicarbonate | mg/L | 5 |
| Alkalinity - Carbonate, as Carbonate | mg/L | <2 |
| TCN - Total Nitrogen as N (Calc) | mg/L | 2.3 |
| NOX as N (DA) - Nitrate + Nitrite, as N | mg N / L | 1.9 |
| NO3-N - Nitrate, as N | mg N / L | 1.9 |
| OES Scan - Calcium | mg/L | 2.2 |
| OES Scan - Magnesium | mg/L | 2.2 |
| OES Scan - Potassium | mg/L | 1.8 |
| OES Scan - Sodium | mg/L | 2.3 |

*A blank space indicates no test performed.*

# Quality Control

| Chemistry | TDS at 180°C +/- 5°C | EC | Chloride | SO4 DA |
|---|---|---|---|---|
| | TDS 180 | EC @ 25C | Cl | SO4 |
| 6789139 DUPLICATE Sample Value (mg/L) | | | 1800 | 430 |
| 6789139 DUPLICATE Duplicate Value (mg/L) | | | 1800 | 440 |
| **6789139 DUPLICATE % RPD (%)** | | | **0.0** | **0.6** |
| **6790250 BLANK Value (uS/cm)** | | **<2** | | |
| 6790272 DUPLICATE Sample Value (uS/cm) | | 18000 | | |
| 6790272 DUPLICATE Duplicate Value (uS/cm) | | 18000 | | |
| **6790272 DUPLICATE % RPD (%)** | | **0.7** | | |
| 6792389 SPIKE Sample Value (mg/L) | 55 | | | |
| 6792389 SPIKE Expected Value (mg/L) | 2600 | | | |
| **6792389 SPIKE % Recovery (%)** | **99.0** | | | |
| 6792432 DUPLICATE Sample Value (mg/L) | 580 | | | |
| 6792432 DUPLICATE Duplicate Value (mg/L) | 600 | | | |
| **6792432 DUPLICATE % RPD (%)** | **2.1** | | | |

| Chemistry | Alkalinity | Alkalinity |
|---|---|---|
| | Bicarbonate | Carbonate |
| 6789574 DUPLICATE Sample Value (mg/L) | 73 | <2 |
| 6789574 DUPLICATE Duplicate Value (mg/L) | 75 | <2 |
| **6789574 DUPLICATE % RPD (%)** | **2.8** | **0** |

| Metals | OES Scan | OES Scan | OES Scan | OES Scan |
|---|---|---|---|---|
| | Ca | Mg | K | Na |
| **6792347 BLANK Value (mg/L)** | **<0.1** | **<0.1** | **<0.1** | **<0.1** |
| 6792352 DUPLICATE Sample Value (mg/L) | 5.7 | 3.0 | 1.1 | 14 |
| 6792352 DUPLICATE Duplicate Value (mg/L) | 5.8 | 3.1 | 1.1 | 14 |
| **6792352 DUPLICATE % RPD (%)** | **2.9** | **2.9** | **0.7** | **1.1** |
| 6792353 SPIKE Sample Value (mg/L) | 5.7 | 3.0 | 1.1 | |
| 6792353 SPIKE Expected Value (mg/L) | 7.7 | 5.0 | 3.1 | |
| **6792353 SPIKE % Recovery (%)** | **86.2** | **84.1** | **88.4** | |

| Nutrients | TKN/TP (HL) | TKN/TP (HL) | NOX as N (DA) | NO3-N |
|---|---|---|---|---|
| | TKN | TP | NOX as N | NO3 |
| 6789139 DUPLICATE Sample Value (mg N / L) | | | 15 | 15 |
| 6789139 DUPLICATE Duplicate Value (mg N / L) | | | 16 | 16 |
| **6789139 DUPLICATE % RPD (%)** | | | **1.0** | **1.0** |
| 6792183 SPIKE Sample Value (mg N / L) | 73 | 8.0 | | |
| 6792183 SPIKE Expected Value (mg N / L) | 93 | 28 | | |
| **6792183 SPIKE % Recovery (%)** | **106** | **100** | | |
| 6792186 DUPLICATE Sample Value (mg N / L) | 73 | 8.0 | | |
| 6792186 DUPLICATE Duplicate Value (mg N / L) | 74 | 8.0 | | |
| **6792186 DUPLICATE % RPD (%)** | **1.1** | **0.4** | | |
| **6792189 BLANK Value (mg N / L)** | **<0.1** | **<0.05** | | |

ALS Water

# CERTIFICATE OF ANALYSIS

| | | | |
|---|---|---|---|
| **Batch No:** | **20-55113** | *Page* | **Page 1 of 3** |
| *Final Report* | **870535** | | |
| | | *Laboratory* | Scoresby Laboratory |
| *Client:* | **Mt Buller & Mt Stirling Resort** | *Address* | Caribbean Business Park,<br>22 Dalmore Drive,<br>Scoresby,<br>VIC 3179 |
| *Contact:* | **Matt Beattie** | | |
| *Address:* | C/O Post Office<br>MT BULLER VIC 3723<br>AUSTRALIA | *Phone* | 03 8756 8000 |
| | | *Fax* | 03 9763 1862 |
| | | Contact: | Christine Desiniotis<br>Client Manager<br>Christine.Desiniotis@alsglobal.com |
| | | Date Sampled: | **25-Nov-2020** |
| *PO No:* | **Not Available** | | |
| | | Date Samples Received: | **26-Nov-2020** |
| *Sampler Name:* | **Matt Beattie** | *Date Issued:* | **10-Jan-2021** |
| *ALS Program Ref:* | **WSBULLER** | | |
| *Program Description:* | **Mt Buller Water Supply** | | |
| *Client Ref:* | **HEMAMP - BH16, BH17, BH18** | | |

The hash (#) below indicates methods not covered by NATA accreditation in the performance of this service .

| *Analysis* | | *Method* | *Laboratory* | *Analysis* | | *Method* | *Laboratory* |
|---|---|---|---|---|---|---|---|
| DO | # | CLIENT | Scoresby | EC | # | CLIENT | Scoresby |
| pH | # | CLIENT | Scoresby | Temp. | # | CLIENT | Scoresby |
| Alkalinity | | WD037 | Scoresby | Chloride | | WD045G | Scoresby |
| EC | | WA010 | Scoresby | TCN | | EK062 | Scoresby |
| NO3-N | | EK058GV | Scoresby | NOX as N (DA) | | EK058GV & 059GV | Scoresby |
| OES Scan | | WG005A (Si not NATA); EA065-69 | Scoresby | TDS at 180°C +/- 5°C | | WA015 | Scoresby |
| SO4 DA | | WD041G | Scoresby | TKN/TP (HL) | | WK061A | Scoresby |

**ORP BH16 -114.7**
**ORP BH17 -72.8**
**ORP BH18 -92.5**

*Signatories*

| *Name* | *Title* | *Name* | *Title* |
|---|---|---|---|
| **Christine Desiniotis** | **Client Manager** | **Chatura Perera** | **Team Leader Nutrients** |
| **Chatura Perera** | **Team Leader Nutrients** | **Mario Solorzano** | **Analyst** |
| **Ricky Singh** | **Analyst** | | |

Samples not collected by ALS and are tested as received.

Soil microbiological testing was commenced within 4 days from the day collected unless otherwise stated.
Water microbiological testing was commenced on the day received and within 24 hours of sampling unless otherwise stated.
MM524: Plate count results <10 per mL and >300 per mL are deemed as approximate.
MM526: Plate count results <2,500 per mL and >250,000 per mL are deemed as approximate.
Calculated results are based on raw data.
Legionella species refers to Legionella species other than Legionella pneumophila
Measurement Uncertainties values for your compliance results are available at this link

*Batch No:* **20-55113**
*Report Number:* **870535**
*Client:* **Mt Buller & Mt Stirling Resort**
*ALS Program Ref:* **WSBULLER**
*Program Description:* **Mt Buller Water Supply**

| Sample No | Site Code | Site Description | Sample Type | Sampled Date/Time |
|---|---|---|---|---|
| 6787665 | | BH16 | WATER | 25/11/20 11:45 |
| 6787666 | | BH17 | WATER | 25/11/20 13:15 |
| 6787667 | | BH18 | WATER | 25/11/20 15:55 |

| *Analysis - Analyte* | *Sample No. / Site Code / Units* | 6787665 | 6787666 | 6787667 |
|---|---|---|---|---|
| Temp. - Water Temperature (CS) | °C | 6.4 | 12.2 | 12.1 |
| pH - pH (CS) | Units | 3.9 | 7.64 | 5.10 |
| EC - Electrical Conductivity (CS) | uS/cm | 26.6 | 33.3 | 49.3 |
| DO - Dissolved Oxygen (CS) | mg/L | 13.54 | 25.78 | 28.32 |
| TKN/TP (HL) - Total Kjeldahl Nitrogen as N | mg N / L | 0.5 | 0.8 | 0.8 |
| TKN/TP (HL) - Phosphorus, total as P | mg P / L | <0.05 | <0.05 | 0.15 |
| TDS at 180°C +/- 5°C - Total Dissolved Solids | mg/L | 15 | 30 | 20 |
| EC - Electrical Conductivity @ 25C | uS/cm | 23 | 48 | 39 |
| Chloride - Chloride, as Cl | mg/L | 1 | 2 | 2 |
| SO4 DA - Sulphate, as SO4 | mg/L | <1 | <1 | <1 |
| Alkalinity - Bicarbonate, as Bicarbonate | mg/L | 6 | 20 | 18 |
| Alkalinity - Carbonate, as Carbonate | mg/L | <2 | <2 | <2 |
| TCN - Total Nitrogen as N (Calc) | mg/L | 1.5 | 2.0 | 0.8 |
| NOX as N (DA) - Nitrate + Nitrite, as N | mg N / L | 0.98 | 1.1 | 0.02 |
| NO3-N - Nitrate, as N | mg N / L | 0.97 | 1.1 | <0.01 |
| OES Scan - Calcium | mg/L | 3.1 | 3.8 | 7.0 |
| OES Scan - Magnesium | mg/L | 9.3 | 1.7 | 10 |
| OES Scan - Potassium | mg/L | 2.6 | 1.3 | 4.8 |
| OES Scan - Sodium | mg/L | 2.8 | 4.3 | 4.8 |

*A blank space indicates no test performed.*

Batch No: 20-55113
Report Number: 870535
Client: Mt Buller & Mt Stirling Resort
ALS Program Ref: WSBULLER
Program Description: Mt Buller Water Supply

# Quality Control

| Chemistry | TDS at 180°C +/- 5°C | EC | Chloride | SO4 DA |
|---|---|---|---|---|
| | TDS 180 | EC @ 25C | Cl | SO4 |
| 6789139 DUPLICATE Sample Value (mg/L) | | | 1800 | 430 |
| 6789139 DUPLICATE Duplicate Value (mg/L) | | | 1800 | 440 |
| **6789139 DUPLICATE % RPD (%)** | | | **0.0** | **0.6** |
| **6790250 BLANK Value (uS/cm)** | | **<2** | | |
| 6790272 DUPLICATE Sample Value (uS/cm) | | 18000 | | |
| 6790272 DUPLICATE Duplicate Value (uS/cm) | | 18000 | | |
| **6790272 DUPLICATE % RPD (%)** | | **0.7** | | |
| 6792389 SPIKE Sample Value (mg/L) | 55 | | | |
| 6792389 SPIKE Expected Value (mg/L) | 2600 | | | |
| **6792389 SPIKE % Recovery (%)** | **99.0** | | | |
| 6792432 DUPLICATE Sample Value (mg/L) | 580 | | | |
| 6792432 DUPLICATE Duplicate Value (mg/L) | 600 | | | |
| **6792432 DUPLICATE % RPD (%)** | **2.1** | | | |

| Chemistry | Alkalinity | Alkalinity |
|---|---|---|
| | Bicarbonate | Carbonate |
| 6789574 DUPLICATE Sample Value (mg/L) | 73 | <2 |
| 6789574 DUPLICATE Duplicate Value (mg/L) | 75 | <2 |
| **6789574 DUPLICATE % RPD (%)** | **2.8** | **0** |

| Metals | OES Scan | OES Scan | OES Scan | OES Scan |
|---|---|---|---|---|
| | Ca | Mg | K | Na |
| **6792358 BLANK Value (mg/L)** | **<0.1** | **<0.1** | **<0.1** | **<0.1** |
| 6792360 DUPLICATE Sample Value (mg/L) | 20 | 9 | 33 | 170 |
| 6792360 DUPLICATE Duplicate Value (mg/L) | 19 | 9 | 32 | 160 |
| **6792360 DUPLICATE % RPD (%)** | **2.7** | **2.1** | **3.2** | **2.7** |
| 6792365 SPIKE Sample Value (mg/L) | 27 | 6 | 31 | |
| 6792365 SPIKE Expected Value (mg/L) | 47 | 26 | 51 | |
| **6792365 SPIKE % Recovery (%)** | **98.6** | **99.9** | **99.6** | |

| Nutrients | TKN/TP (HL) | TKN/TP (HL) | NOX as N (DA) | NO3-N |
|---|---|---|---|---|
| | TKN | TP | NOX as N | NO3 |
| 6789139 DUPLICATE Sample Value (mg N / L) | | | 15 | 15 |
| 6789139 DUPLICATE Duplicate Value (mg N / L) | | | 16 | 16 |
| **6789139 DUPLICATE % RPD (%)** | | | **1.0** | **1.0** |
| 6792183 SPIKE Sample Value (mg N / L) | 73 | 8.0 | | |
| 6792183 SPIKE Expected Value (mg N / L) | 93 | 28 | | |
| **6792183 SPIKE % Recovery (%)** | **106** | **100** | | |
| 6792186 DUPLICATE Sample Value (mg N / L) | 73 | 8.0 | | |
| 6792186 DUPLICATE Duplicate Value (mg N / L) | 74 | 8.0 | | |
| **6792186 DUPLICATE % RPD (%)** | **1.1** | **0.4** | | |
| **6792189 BLANK Value (mg N / L)** | **<0.1** | **<0.05** | | |

# CERTIFICATE OF ANALYSIS

| | | | |
|---|---|---|---|
| **Batch No:** | **20-55115** | *Page* | **Page 1 of 3** |
| *Final Report* | **870538** | *Laboratory* | Scoresby Laboratory |
| *Client:* | **Mt Buller & Mt Stirling Resort** | *Address* | Caribbean Business Park,<br>22 Dalmore Drive,<br>Scoresby,<br>VIC 3179 |
| *Contact:* | **Matt Beattie** | *Phone* | 03 8756 8000 |
| *Address:* | C/O Post Office<br>MT BULLER VIC 3723<br>AUSTRALIA | *Fax* | 03 9763 1862 |
| | | Contact: | Christine Desiniotis<br>Client Manager<br>Christine.Desiniotis@alsglobal.com |
| *PO No:* | **Not Available** | Date Sampled: | **25-Nov-2020** |
| *Sampler Name:* | **Matt Beattie** | Date Samples Received: | **26-Nov-2020** |
| *ALS Program Ref:* | **WSBULLER** | *Date Issued:* | **10-Jan-2021** |
| *Program Description:* | **Mt Buller Water Supply** | | |
| *Client Ref:* | **HEMAMP - FD1, FD2, FD3** | | |

The hash (#) below indicates methods not covered by NATA accreditation in the performance of this service .

| *Analysis* | | *Method* | *Laboratory* | *Analysis* | | *Method* | *Laboratory* |
|---|---|---|---|---|---|---|---|
| DO | # | CLIENT | Scoresby | EC | # | CLIENT | Scoresby |
| pH | # | CLIENT | Scoresby | Temp. | # | CLIENT | Scoresby |
| Alkalinity | | WD037 | Scoresby | Chloride | | WD045G | Scoresby |
| EC | | WA010 | Scoresby | TCN | | EK062 | Scoresby |
| NO3-N | | EK058GV | Scoresby | NOX as N (DA) | | EK058GV & 059GV | Scoresby |
| OES Scan | | WG005A (Si not NATA); EA065-69 | Scoresby | SS at 104+/- 2°C | | WA025 | Scoresby |
| TDS at 180°C +/- 5°C | | WA015 | Scoresby | SO4 DA | | WD041G | Scoresby |
| TKN/TP (HL) | | WK061A | Scoresby | Turbidity | | WA045 | Scoresby |

**ORP FD1 -121.5**
**ORP FD2 -180.5**
**ORP FD3 -92.5**

*Signatories*

| *Name* | *Title* | *Name* | *Title* |
|---|---|---|---|
| **Christine Desiniotis** | **Client Manager** | **Chatura Perera** | **Team Leader Nutrients** |
| **Chatura Perera** | **Team Leader Nutrients** | **Mario Solorzano** | **Analyst** |
| **Ricky Singh** | **Analyst** | **Suresh Sundaramoorthy** | **Chemist** |

Samples not collected by ALS and are tested as received.

Soil microbiological testing was commenced within 4 days from the day collected unless otherwise stated.
Water microbiological testing was commenced on the day received and within 24 hours of sampling unless otherwise stated.
MM524: Plate count results <10 per mL and >300 per mL are deemed as approximate.
MM526: Plate count results <2,500 per mL and >250,000 per mL are deemed as approximate.
Calculated results are based on raw data.
Legionella species refers to Legionella species other than Legionella pneumophila
Measurement Uncertainties values for your compliance results are available at this link

Batch No: 20-55115
Report Number: 870538
Client: Mt Buller & Mt Stirling Resort
ALS Program Ref: WSBULLER
Program Description: Mt Buller Water Supply

| Sample No | Site Code | Site Description | Sample Type | Sampled Date/Time |
|---|---|---|---|---|
| 6787714 | | FD1 | WATER | 25/11/20 08:30 |
| 6787715 | | FD2 | WATER | 25/11/20 11:15 |
| 6787716 | | FD3 | WATER | 25/11/20 15:55 |

| Analysis - Analyte | Sample No. / Site Code / Units | 6787714 | 6787715 | 6787716 |
|---|---|---|---|---|
| Temp. - Water Temperature (CS) | °C | 8.4 | 7.1 | 12.1 |
| pH - pH (CS) | Units | 5.75 | 4.15 | 5.10 |
| EC - Electrical Conductivity (CS) | uS/cm | 28.9 | 36.5 | 49.3 |
| DO - Dissolved Oxygen (CS) | mg/L | 8.5 | 10.21 | 28.32 |
| TKN/TP (HL) - Total Kjeldahl Nitrogen as N | mg N / L | <0.1 | 0.5 | 0.7 |
| TKN/TP (HL) - Phosphorus, total as P | mg P / L | <0.05 | <0.05 | 0.14 |
| SS at 104+/- 2°C - Suspended Solids | mg/L | <2 | | |
| TDS at 180°C +/- 5°C - Total Dissolved Solids | mg/L | 12 | 18 | 20 |
| EC - Electrical Conductivity @ 25C | uS/cm | 24 | 26 | 39 |
| Turbidity - Turbidity, NTU | NTU | 0.1 | | |
| Chloride - Chloride, as Cl | mg/L | 1 | 1 | 2 |
| SO4 DA - Sulphate, as SO4 | mg/L | <1 | <1 | 8 |
| Alkalinity - Bicarbonate, as Bicarbonate | mg/L | 13 | 5 | 19 |
| Alkalinity - Carbonate, as Carbonate | mg/L | <2 | <2 | <2 |
| TCN - Total Nitrogen as N (Calc) | mg/L | <0.1 | 2.4 | 0.7 |
| NOX as N (DA) - Nitrate + Nitrite, as N | mg N / L | 0.08 | 1.9 | <0.01 |
| NO3-N - Nitrate, as N | mg N / L | 0.07 | 1.9 | <0.01 |
| OES Scan - Calcium | mg/L | 2.0 | 3.1 | 5.8 |
| OES Scan - Magnesium | mg/L | 0.7 | 4.1 | 7.4 |
| OES Scan - Potassium | mg/L | 0.2 | 2.8 | 4.3 |
| OES Scan - Sodium | mg/L | 2.1 | 3.2 | 4.4 |

*A blank space indicates no test performed.*

Batch No: 20-55115
Report Number: 870538
Client: Mt Buller & Mt Stirling Resort
ALS Program Ref: WSBULLER
Program Description: Mt Buller Water Supply

# Quality Control

## Chemistry

| | SS at 104+/- 2°C | TDS at 180°C +/- 5°C | EC | Turbidity |
|---|---|---|---|---|
| | SS | TDS 180 | EC @ 25C | Turbidity |
| **6788757 BLANK Value (uS/cm)** | | | **<2** | |
| **6790077 BLANK Value (NTU)** | | | | **<0.1** |
| 6790097 DUPLICATE Sample Value (uS/cm) | | | 1800 | |
| 6790097 DUPLICATE Duplicate Value (uS/cm) | | | 1800 | |
| **6790097 DUPLICATE % RPD (%)** | | | **0.2** | |
| 6790130 DUPLICATE Sample Value (NTU) | | | | 0.3 |
| 6790130 DUPLICATE Duplicate Value (NTU) | | | | 0.3 |
| **6790130 DUPLICATE % RPD (%)** | | | | **1.1** |
| **6790250 BLANK Value (uS/cm)** | | | **<2** | |
| 6790272 DUPLICATE Sample Value (uS/cm) | | | 18000 | |
| 6790272 DUPLICATE Duplicate Value (uS/cm) | | | 18000 | |
| **6790272 DUPLICATE % RPD (%)** | | | **0.7** | |
| 6790654 DUPLICATE Sample Value (mg/L) | 360 | | | |
| 6790654 DUPLICATE Duplicate Value (mg/L) | 360 | | | |
| **6790654 DUPLICATE % RPD (%)** | **1.1** | | | |
| 6792389 SPIKE Sample Value (mg/L) | | 55 | | |
| 6792389 SPIKE Expected Value (mg/L) | | 2600 | | |
| **6792389 SPIKE % Recovery (%)** | | **99.0** | | |
| 6792432 DUPLICATE Sample Value (mg/L) | | 580 | | |
| 6792432 DUPLICATE Duplicate Value (mg/L) | | 600 | | |
| **6792432 DUPLICATE % RPD (%)** | | **2.1** | | |

## Chemistry

| | Chloride | SO4 DA | Alkalinity | Alkalinity |
|---|---|---|---|---|
| | Cl | SO4 | Bicarbonate | Carbonate |
| 6789139 DUPLICATE Sample Value (mg/L) | 1800 | 430 | | |
| 6789139 DUPLICATE Duplicate Value (mg/L) | 1800 | 440 | | |
| **6789139 DUPLICATE % RPD (%)** | **0.0** | **0.6** | | |
| 6789574 DUPLICATE Sample Value (mg/L) | | | 73 | <2 |
| 6789574 DUPLICATE Duplicate Value (mg/L) | | | 75 | <2 |
| **6789574 DUPLICATE % RPD (%)** | | | **2.8** | **0** |

## Metals

| | OES Scan | OES Scan | OES Scan | OES Scan |
|---|---|---|---|---|
| | Ca | Mg | K | Na |
| **6792358 BLANK Value (mg/L)** | **<0.1** | **<0.1** | **<0.1** | **<0.1** |
| 6792360 DUPLICATE Sample Value (mg/L) | 20 | 9 | 33 | 170 |
| 6792360 DUPLICATE Duplicate Value (mg/L) | 19 | 9 | 32 | 160 |
| **6792360 DUPLICATE % RPD (%)** | **2.7** | **2.1** | **3.2** | **2.7** |
| 6792365 SPIKE Sample Value (mg/L) | 27 | 6 | 31 | |
| 6792365 SPIKE Expected Value (mg/L) | 47 | 26 | 51 | |
| **6792365 SPIKE % Recovery (%)** | **98.6** | **99.9** | **99.6** | |

## Nutrients

| | TKN/TP (HL) | TKN/TP (HL) | NOX as N (DA) | NO3-N |
|---|---|---|---|---|
| | TKN | TP | NOX as N | NO3 |
| 6789139 DUPLICATE Sample Value (mg N / L) | | | 15 | 15 |
| 6789139 DUPLICATE Duplicate Value (mg N / L) | | | 16 | 16 |
| **6789139 DUPLICATE % RPD (%)** | | | **1.0** | **1.0** |
| 6792183 SPIKE Sample Value (mg N / L) | 73 | 8.0 | | |
| 6792183 SPIKE Expected Value (mg N / L) | 93 | 28 | | |
| **6792183 SPIKE % Recovery (%)** | **106** | **100** | | |
| 6792186 DUPLICATE Sample Value (mg N / L) | 73 | 8.0 | | |
| 6792186 DUPLICATE Duplicate Value (mg N / L) | 74 | 8.0 | | |
| **6792186 DUPLICATE % RPD (%)** | **1.1** | **0.4** | | |
| **6792189 BLANK Value (mg N / L)** | **<0.1** | **<0.05** | | |

eurofins | Environment Testing

**ALS Water Resources Group (Scoresby)**
**22 Dalmore Drive**
**Scoresby**
**VIC 3179**

**NATA Accredited**
**Accreditation Number 1261**
**Site Number 1254**

Accredited for compliance with ISO/IEC 17025 – Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

**Attention:** **Christine Desiniotis**

**Report** **760012-W**
Project name WSBULLER
Project ID 20-55182
Received Date Nov 27, 2020

| **Client Sample ID** | | | **DUPLICATE 1 - SURFACE WATER** | **DUPLICATE 2 - GROUND WATER** |
|---|---|---|---|---|
| **Sample Matrix** | | | **Water** | **Water** |
| **Eurofins Sample No.** | | | **M20-No50920** | **M20-No50921** |
| **Date Sampled** | | | **Nov 25, 2020** | **Nov 25, 2020** |
| Test/Reference | LOR | Unit | | |
| | | | | |
| Chloride | 1 | mg/L | 30 | 64 |
| Conductivity (at 25°C) | 10 | uS/cm | 19 | 18 |
| Nitrate & Nitrite (as N) | 0.05 | mg/L | 0.17 | 1.0 |
| Nitrate (as N) | 0.02 | mg/L | 0.17 | 1.0 |
| Phosphate total (as P) | 0.01 | mg/L | < 0.01 | < 0.01 |
| Sulphate (as SO4) | 5 | mg/L | 5.2 | 35 |
| Total Dissolved Solids Dried at 180°C ± 2°C | 10 | mg/L | 40 | 33 |
| Total Kjeldahl Nitrogen (as N) | 0.2 | mg/L | < 0.2 | 0.4 |
| Total Nitrogen (as N) | 0.2 | mg/L | < 0.2 | 1.4 |
| Total Suspended Solids Dried at 103–105°C | 1 | mg/L | < 1 | - |
| Turbidity | 1 | NTU | 1.3 | - |
| **Alkalinity (speciated)** | | | | |
| Bicarbonate Alkalinity (as CaCO3) | 20 | mg/L | < 20 | < 20 |
| Carbonate Alkalinity (as CaCO3) | 10 | mg/L | < 10 | < 10 |
| **Alkali Metals** | | | | |
| Calcium | 0.5 | mg/L | 0.9 | 0.7 |
| Magnesium | 0.5 | mg/L | < 0.5 | < 0.5 |
| Potassium | 0.5 | mg/L | < 0.5 | < 0.5 |
| Sodium | 0.5 | mg/L | 2.1 | 2.0 |

### Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

| Description | Testing Site | Extracted | Holding Time |
|---|---|---|---|
| Chloride | Melbourne | Dec 01, 2020 | 28 Days |
| - Method: LTM-INO-4090 Chloride by Discrete Analyser | | | |
| Conductivity (at 25°C) | Melbourne | Dec 01, 2020 | 28 Days |
| - Method: LTM-INO-4030 Conductivity | | | |
| Nitrate & Nitrite (as N) | Melbourne | Dec 01, 2020 | 28 Days |
| - Method: LTM-INO-4120 Analysis of NOx NO2 NH3 by FIA | | | |
| Nitrate (as N) | Melbourne | Dec 01, 2020 | 28 Days |
| - Method: LTM-INO-4120 Analysis of NOx NO2 NH3 by FIA | | | |
| Phosphate total (as P) | Melbourne | Dec 01, 2020 | 28 Days |
| - Method: LTM-INO-4040 Phosphate by CFA | | | |
| Sulphate (as SO4) | Melbourne | Dec 01, 2020 | 28 Days |
| - Method: LTM-INO-4110 Sulfate by Discrete Analyser | | | |
| Total Kjeldahl Nitrogen (as N) | Melbourne | Dec 07, 2020 | 7 Days |
| - Method: APHA 4500-Norg B,D Total Kjeldahl Nitrogen by FIA | | | |
| Total Suspended Solids Dried at 103–105°C | Melbourne | Dec 01, 2020 | 7 Days |
| - Method: LTM-INO-4070 Analysis of Suspended Solids in Water by Gravimetry | | | |
| Turbidity | Melbourne | Dec 01, 2020 | 2 Days |
| - Method: Turbidity by classical using APHA 2130B (LTM-INO-4140) | | | |
| Alkalinity (speciated) | Melbourne | Dec 01, 2020 | 14 Days |
| - Method: LTM-INO-4250 Alkalinity by Electrometric Titration | | | |
| Alkali Metals | Melbourne | Dec 01, 2020 | 180 Days |
| - Method: LTM-MET-3010 Alkali Metals Sulfur Silicon Phosphorus by ICP-AES | | | |
| Total Dissolved Solids Dried at 180°C ± 2°C | Melbourne | Dec 01, 2020 | 7 Days |
| - Method: LTM-INO-4170 Total Dissolved Solids in Water | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Company Name:** | ALS Water Resources Group (Scoresby) | **Order No.:** | | **Received:** | Nov 27, 2020 1:00 PM |
| **Address:** | 22 Dalmore Drive | **Report #:** | 760012 | **Due:** | Dec 4, 2020 |
| | Scoresby | **Phone:** | 03 8756 8100 | **Priority:** | 5 Day |
| | VIC 3179 | **Fax:** | 03 9763 8721 | **Contact Name:** | Christine Desiniotis |
| **Project Name:** | WSBULLER | | | | |
| **Project ID:** | 20-55182 | | | | |

**Eurofins Analytical Services Manager : Michael Morrison**

| **Sample Detail** | | | | | | Bicarbonate Alkalinity (as CaCO3) | Calcium | Carbonate Alkalinity (as CaCO3) | Chloride | Conductivity (at 25°C) | Magnesium | Nitrate & Nitrite (as N) | Nitrate (as N) | Phosphate total (as P) | Potassium | Sodium | Sulphate (as SO4) | Total Kjeldahl Nitrogen (as N) | Total Nitrogen (as N) | Total Suspended Solids Dried at 103–105°C | Turbidity | Total Dissolved Solids Dried at 180°C ± 2°C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Melbourne Laboratory - NATA Site # 1254 & 14271** | | | | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| **Sydney Laboratory - NATA Site # 18217** | | | | | | | | | | | | | | | | | | | | | | |
| **Brisbane Laboratory - NATA Site # 20794** | | | | | | | | | | | | | | | | | | | | | | |
| **Perth Laboratory - NATA Site # 23736** | | | | | | | | | | | | | | | | | | | | | | |
| **Mayfield Laboratory** | | | | | | | | | | | | | | | | | | | | | | |
| **External Laboratory** | | | | | | | | | | | | | | | | | | | | | | |
| **No** | **Sample ID** | **Sample Date** | **Sampling Time** | **Matrix** | **LAB ID** | | | | | | | | | | | | | | | | | |
| 1 | DUPLICATE 1 - SURFACE WATER | Nov 25, 2020 | 7:30AM | Water | M20-No50920 | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 2 | DUPLICATE 2 - GROUND WATER | Nov 25, 2020 | 11:50AM | Water | M20-No50921 | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | | X |
| **Test Counts** | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 |

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## Internal Quality Control Review and Glossary

### General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

### Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

### Units

| | | |
|---|---|---|
| **mg/kg:** milligrams per kilogram | **mg/L:** milligrams per litre | **ug/L:** micrograms per litre |
| **ppm:** Parts per million | **ppb:** Parts per billion | **%:** Percentage |
| **org/100mL:** Organisms per 100 millilitres | **NTU:** Nephelometric Turbidity Units | **MPN/100mL:** Most Probable Number of organisms per 100 millilitres |

### Terms

| | |
|---|---|
| **Dry** | Where a moisture has been determined on a solid sample the result is expressed on a dry basis. |
| **LOR** | Limit of Reporting. |
| **SPIKE** | Addition of the analyte to the sample and reported as percentage recovery. |
| **RPD** | Relative Percent Difference between two Duplicate pieces of analysis. |
| **LCS** | Laboratory Control Sample - reported as percent recovery. |
| **CRM** | Certified Reference Material - reported as percent recovery. |
| **Method Blank** | In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water. |
| **Surr - Surrogate** | The addition of a like compound to the analyte target and reported as percentage recovery. |
| **Duplicate** | A second piece of analysis from the same sample and reported in the same units as the result to show comparison. |
| **USEPA** | United States Environmental Protection Agency |
| **APHA** | American Public Health Association |
| **TCLP** | Toxicity Characteristic Leaching Procedure |
| **COC** | Chain of Custody |
| **SRA** | Sample Receipt Advice |
| **QSM** | US Department of Defense Quality Systems Manual Version 5.3 |
| **CP** | Client Parent - QC was performed on samples pertaining to this report |
| **NCP** | Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within. |
| **TEQ** | Toxic Equivalency Quotient |

### QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

### QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

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**Quality Control Results**

| Test | Units | Result 1 | | | Acceptance Limits | Pass Limits | Qualifying Code |
|---|---|---|---|---|---|---|---|
| **Method Blank** | | | | | | | |
| Chloride | mg/L | < 1 | | | 1 | Pass | |
| Conductivity (at 25°C) | uS/cm | < 10 | | | 10 | Pass | |
| Nitrate & Nitrite (as N) | mg/L | < 0.05 | | | 0.05 | Pass | |
| Nitrate (as N) | mg/L | < 0.02 | | | 0.02 | Pass | |
| Phosphate total (as P) | mg/L | < 0.01 | | | 0.01 | Pass | |
| Sulphate (as SO4) | mg/L | < 5 | | | 5 | Pass | |
| Total Dissolved Solids Dried at 180°C ± 2°C | mg/L | < 10 | | | 10 | Pass | |
| Total Kjeldahl Nitrogen (as N) | mg/L | < 0.2 | | | 0.2 | Pass | |
| Total Suspended Solids Dried at 103–105°C | mg/L | < 1 | | | 1 | Pass | |
| Turbidity | NTU | < 1 | | | 1 | Pass | |
| **Method Blank** | | | | | | | |
| **Alkalinity (speciated)** | | | | | | | |
| Bicarbonate Alkalinity (as CaCO3) | mg/L | < 20 | | | 20 | Pass | |
| Carbonate Alkalinity (as CaCO3) | mg/L | < 10 | | | 10 | Pass | |
| **Method Blank** | | | | | | | |
| **Alkali Metals** | | | | | | | |
| Calcium | mg/L | < 0.5 | | | 0.5 | Pass | |
| Magnesium | mg/L | < 0.5 | | | 0.5 | Pass | |
| Potassium | mg/L | < 0.5 | | | 0.5 | Pass | |
| Sodium | mg/L | < 0.5 | | | 0.5 | Pass | |
| **LCS - % Recovery** | | | | | | | |
| Chloride | % | 116 | | | 70-130 | Pass | |
| Conductivity (at 25°C) | % | 89 | | | 70-130 | Pass | |
| Nitrate & Nitrite (as N) | % | 101 | | | 70-130 | Pass | |
| Nitrate (as N) | % | 101 | | | 70-130 | Pass | |
| Phosphate total (as P) | % | 92 | | | 70-130 | Pass | |
| Sulphate (as SO4) | % | 112 | | | 70-130 | Pass | |
| Total Dissolved Solids Dried at 180°C ± 2°C | % | 100 | | | 70-130 | Pass | |
| Total Kjeldahl Nitrogen (as N) | % | 78 | | | 70-130 | Pass | |
| Total Suspended Solids Dried at 103–105°C | % | 97 | | | 70-130 | Pass | |
| **LCS - % Recovery** | | | | | | | |
| **Alkalinity (speciated)** | | | | | | | |
| Carbonate Alkalinity (as CaCO3) | % | 100 | | | 70-130 | Pass | |
| **LCS - % Recovery** | | | | | | | |
| **Alkali Metals** | | | | | | | |
| Calcium | % | 105 | | | 80-120 | Pass | |
| Magnesium | % | 99 | | | 80-120 | Pass | |
| Potassium | % | 95 | | | 80-120 | Pass | |
| Sodium | % | 87 | | | 80-120 | Pass | |

| Test | Lab Sample ID | QA Source | Units | Result 1 | | | Acceptance Limits | Pass Limits | Qualifying Code |
|---|---|---|---|---|---|---|---|---|---|
| **Spike - % Recovery** | | | | | | | | | |
| | | | | Result 1 | | | | | |
| Nitrate & Nitrite (as N) | M20-De02708 | NCP | % | 101 | | | 70-130 | Pass | |
| Nitrate (as N) | M20-De02708 | NCP | % | 101 | | | 70-130 | Pass | |
| Phosphate total (as P) | M20-No48013 | NCP | % | 95 | | | 70-130 | Pass | |
| Sulphate (as SO4) | M20-No51065 | NCP | % | 81 | | | 70-130 | Pass | |
| Total Kjeldahl Nitrogen (as N) | S20-No49791 | NCP | % | 77 | | | 70-130 | Pass | |
| Total Suspended Solids Dried at 103–105°C | B20-No47270 | NCP | % | 106 | | | 70-130 | Pass | |
| **Spike - % Recovery** | | | | | | | | | |
| **Alkali Metals** | | | | Result 1 | | | | | |

| Test | Lab Sample ID | QA Source | Units | Result 1 | | | Acceptance Limits | Pass Limits | Qualifying Code |
|---|---|---|---|---|---|---|---|---|---|
| Calcium | M20-No50919 | NCP | % | 118 | | | 75-125 | Pass | |
| Magnesium | M20-No50919 | NCP | % | 119 | | | 75-125 | Pass | |
| Potassium | M20-No50919 | NCP | % | 115 | | | 75-125 | Pass | |
| Sodium | M20-No50919 | NCP | % | 115 | | | 75-125 | Pass | |
| **Test** | **Lab Sample ID** | **QA Source** | **Units** | **Result 1** | | | **Acceptance Limits** | **Pass Limits** | **Qualifying Code** |
| **Duplicate** | | | | | | | | | |
| | | | | Result 1 | Result 2 | RPD | | | |
| Chloride | M20-No51065 | NCP | mg/L | 120 | 110 | 14 | 30% | Pass | |
| Conductivity (at 25°C) | M20-No52075 | NCP | uS/cm | ** | 1500 | 4.0 | 30% | Pass | |
| Nitrate & Nitrite (as N) | M20-De02708 | NCP | mg/L | < 0.05 | < 0.05 | <1 | 30% | Pass | |
| Nitrate (as N) | M20-De02708 | NCP | mg/L | < 0.02 | < 0.02 | <1 | 30% | Pass | |
| Phosphate total (as P) | M20-No50920 | CP | mg/L | < 0.01 | < 0.01 | <1 | 30% | Pass | |
| Sulphate (as SO4) | M20-No51065 | NCP | mg/L | 22 | 21 | 19 | 30% | Pass | |
| Total Dissolved Solids Dried at 180°C ± 2°C | P20-No49835 | NCP | mg/L | 3600 | 4400 | 22 | 30% | Pass | |
| Total Suspended Solids Dried at 103–105°C | M20-No47420 | NCP | mg/L | 4.2 | 5.0 | 17 | 30% | Pass | |
| Turbidity | M20-No52275 | NCP | NTU | 380 | 380 | <1 | 30% | Pass | |
| **Duplicate** | | | | | | | | | |
| **Alkalinity (speciated)** | | | | Result 1 | Result 2 | RPD | | | |
| Bicarbonate Alkalinity (as CaCO3) | M20-No52075 | NCP | mg/L | 460 | 440 | 5.0 | 30% | Pass | |
| Carbonate Alkalinity (as CaCO3) | M20-No52075 | NCP | mg/L | < 10 | < 10 | <1 | 30% | Pass | |
| **Duplicate** | | | | | | | | | |
| **Alkali Metals** | | | | Result 1 | Result 2 | RPD | | | |
| Calcium | M20-No50919 | NCP | mg/L | 27 | 26 | 5.0 | 30% | Pass | |
| Magnesium | M20-No50919 | NCP | mg/L | 55 | 54 | 2.0 | 30% | Pass | |
| Potassium | M20-No50919 | NCP | mg/L | < 5 | < 5 | <1 | 30% | Pass | |
| Sodium | M20-No50919 | NCP | mg/L | 680 | 670 | 1.0 | 30% | Pass | |
| **Duplicate** | | | | | | | | | |
| | | | | Result 1 | Result 2 | RPD | | | |
| Total Kjeldahl Nitrogen (as N) | M20-No50921 | CP | mg/L | 0.4 | < 0.2 | 200 | 30% | Fail | Q15 |

**Comments**

### Sample Integrity

| | |
|---|---|
| Custody Seals Intact (if used) | N/A |
| Attempt to Chill was evident | Yes |
| Sample correctly preserved | Yes |
| Appropriate sample containers have been used | Yes |
| Sample containers for volatile analysis received with minimal headspace | Yes |
| Samples received within HoldingTime | Yes |
| Some samples have been subcontracted | No |

### Qualifier Codes/Comments

| Code | Description |
|---|---|
| Q15 | The RPD reported passes Eurofins Environment Testing's QC - Acceptance Criteria as defined in the Internal Quality Control Review and Glossary page of this report. |

### Authorised By

| | |
|---|---|
| Callum McEwan | Analytical Services Manager |
| Emily Rosenberg | Senior Analyst-Metal (VIC) |
| Scott Beddoes | Senior Analyst-Inorganic (VIC) |

**Glenn Jackson**
**General Manager**

Final report - this Report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

# CERTIFICATE OF ANALYSIS

| | | | |
|---|---|---|---|
| **Batch No:** | **21-08206** | *Page* | **Page 1 of 4** |
| *Final Report* | **893808** | *Laboratory* | Scoresby Laboratory |
| *Client:* | **Mt Buller & Mt Stirling Resort** | *Address* | Caribbean Business Park, 22 Dalmore Drive, Scoresby, VIC 3179 |
| *Contact:* | **Muhammad Abdullah** | *Phone* | 03 8756 8000 |
| *Address:* | C/O Post Office<br>MT BULLER VIC 3723<br>AUSTRALIA | *Fax* | 03 9763 1862 |
| | | Contact: | Christine Desiniotis<br>Client Manager<br>Christine.Desiniotis@alsglobal.com |
| *PO No:* | **Not Available** | Date Sampled: | **09-Feb-2021** |
| *Sampler Name:* | **Mathew L / Shen Chi** | Date Samples Received: | **10-Feb-2021** |
| *ALS Program Ref:* | **WSBULLER** | *Date Issued:* | **10-May-2021** |
| *Program Description:* | **Mt Buller Water Supply** | | |
| *Client Ref:* | **HEMAMP- Boggy 1 & Boggy 2** | | |

The hash (#) below indicates methods not covered by NATA accreditation in the performance of this service .

| *Analysis* | | *Method* | *Laboratory* | *Analysis* | | *Method* | *Laboratory* |
|---|---|---|---|---|---|---|---|
| DO | # | CLIENT | Scoresby | EC | # | CLIENT | Scoresby |
| pH | # | CLIENT | Scoresby | Redox | # | CLIENT | Scoresby |
| Temp. | # | CLIENT | Scoresby | Alkalinity | | WD037 | Scoresby |
| Chloride | | WD045G | Scoresby | EC | | WA010 | Scoresby |
| TCN | | WK062 | Scoresby | NO3-N | | EK058GV | Scoresby |
| NOX as N (DA) | | EK058GV & 059GV | Scoresby | OES Scan | | WG005A (Si not NATA) | Scoresby |
| SS at 104+/- 2°C | | WA025 | Scoresby | TDS at 180°C +/- 5°C | | WA015 | Scoresby |
| SO4 DA | | WD041G | Scoresby | TKN/TP (HL) | | WK061A | Scoresby |
| Turbidity | | WA045 | Scoresby | | | | |

*Signatories*

| *Name* | *Title* | *Name* | *Title* |
|---|---|---|---|
| **Christine Desiniotis** | **Client Manager** | **Chatura Perera** | **Team Leader Nutrients** |
| **Hoa Nguyen** | **Analyst** | **Joseph De Alwis** | **Analyst** |
| **John Levvey** | **Principal Trace Metals Chemist** | | |

Samples not collected by ALS and are tested as received. Samples are tested within holding time unless otherwise stated.
Soil microbiological testing was commenced within 4 days from the day collected unless otherwise stated.
Water microbiological testing was commenced on the day received and within 24 hours of sampling unless otherwise stated.
MM524: Plate count results <10 per mL and >300 per mL are deemed as approximate.
MM526: Plate count results <2,500 per mL and >250,000 per mL are deemed as approximate.
Calculated results are based on raw data.
Legionella species refers to Legionella species other than Legionella pneumophila
Measurement Uncertainties values for your compliance results are available at this link

Batch No: 21-08206
Report Number: 893808
Client: Mt Buller & Mt Stirling Resort
ALS Program Ref: WSBULLER
Program Description: Mt Buller Water Supply

| Sample No | Site Code | Site Description | Sample Type | Sampled Date/Time |
|---|---|---|---|---|
| 6877707 | | Boggy 1 p/u1 | WATER | 09/02/21 11:50 |
| 6877708 | | Boggy 1 p/u2 | WATER | 09/02/21 12:00 |
| 6877709 | | Boggy 2 p/u | WATER | 09/02/21 12:15 |

| *Analysis - Analyte* | *Sample No. / Site Code / Units* | 6877707 | 6877708 | 6877709 |
|---|---|---|---|---|
| Temp. - Water Temperature (CS) | °C | 10.2 | 8.8 | 10.3 |
| pH - pH (CS) | Units | 7.78 | 7.72 | 7.58 |
| EC - Electrical Conductivity (CS) | uS/cm | 25.9 | 22.2 | 28.7 |
| DO - Dissolved Oxygen (CS) | mg/L | 12.05 | 12.19 | 11.91 |
| Redox - Redox Potential against Ag/AgCl reference | mV | 97.5 | 66.7 | 47.1 |
| TKN/TP (HL) - Total Kjeldahl Nitrogen as N | mg N / L | <0.1 | 0.2 | 0.2 |
| TKN/TP (HL) - Phosphorus, total as P | mg P / L | 0.06 | <0.05 | 0.05 |
| SS at 104+/- 2°C - Suspended Solids | mg/L | <2 | <2 | <2 |
| TDS at 180°C +/- 5°C - Total Dissolved Solids | mg/L | 14 | 14 | 16 |
| EC - Electrical Conductivity @ 25C | uS/cm | 24 | 21 | 27 |
| Turbidity - Turbidity, NTU | NTU | 0.4 | 0.1 | 0.1 |
| Chloride - Chloride, as Cl | mg/L | 1 | 1 | 1 |
| SO4 DA - Sulphate, as SO4 | mg/L | <1 | <1 | <1 |
| Alkalinity - Bicarbonate, as Bicarbonate | mg/L | 13 | 11 | 14 |
| Alkalinity - Carbonate, as Carbonate | mg/L | <2 | <2 | <2 |
| TCN - Total Nitrogen as N (Calc) | mg/L | 0.1 | 0.3 | 0.2 |
| NOX as N (DA) - Nitrate + Nitrite, as N | mg N / L | 0.14 | 0.09 | 0.07 |
| NO3-N - Nitrate, as N | mg N / L | 0.13 | 0.09 | 0.07 |
| OES Scan - Calcium | mg/L | 1.8 | 1.4 | 2.2 |
| OES Scan - Magnesium | mg/L | 0.6 | 0.5 | 0.7 |
| OES Scan - Potassium | mg/L | 0.2 | 0.2 | 0.2 |
| OES Scan - Sodium | mg/L | 2.4 | 1.8 | 2.2 |

*A blank space indicates no test performed.*

Batch No: 21-08206
Report Number: 893808
Client: Mt Buller & Mt Stirling Resort
ALS Program Ref: WSBULLER
Program Description: Mt Buller Water Supply

# Quality Control

## Chemistry

| | SS at 104+/- 2°C | TDS at 180°C +/- 5°C | EC | Turbidity |
|---|---|---|---|---|
| | SS | TDS 180 | EC @ 25C | Turbidity |
| **6880241 BLANK Value (uS/cm)** | | | **<2** | |
| 6880846 DUPLICATE Sample Value (mg/L) | 210 | | | |
| 6880846 DUPLICATE Duplicate Value (mg/L) | 200 | | | |
| **6880846 DUPLICATE % RPD (%)** | **5.8** | | | |
| **6882449 BLANK Value (NTU)** | | | | **<0.1** |
| 6882465 DUPLICATE Sample Value (NTU) | | | | 0.6 |
| 6882465 DUPLICATE Duplicate Value (NTU) | | | | 0.6 |
| **6882465 DUPLICATE % RPD (%)** | | | | **0.6** |
| 6882491 DUPLICATE Sample Value (uS/cm) | | | 160 | |
| 6882491 DUPLICATE Duplicate Value (uS/cm) | | | 160 | |
| **6882491 DUPLICATE % RPD (%)** | | | **0.7** | |
| **6884784 BLANK Value (mg/L)** | **<2** | | | |
| 6888456 SPIKE Sample Value (mg/L) | | 79 | | |
| 6888456 SPIKE Expected Value (mg/L) | | 2100 | | |
| **6888456 SPIKE % Recovery (%)** | | **125** | | |
| 6888464 DUPLICATE Sample Value (mg/L) | | 480 | | |
| 6888464 DUPLICATE Duplicate Value (mg/L) | | 480 | | |
| **6888464 DUPLICATE % RPD (%)** | | **0.0** | | |
| **6888525 BLANK Value (mg/L)** | | **<5** | | |

## Chemistry

| | Chloride | SO4 DA | Alkalinity | Alkalinity |
|---|---|---|---|---|
| | Cl | SO4 | Bicarbonate | Carbonate |
| **6879734 BLANK Value (mg/L)** | **<1** | **<1** | | |
| 6879740 SPIKE Sample Value (mg/L) | 14 | <5 | | |
| 6879740 SPIKE Expected Value (mg/L) | 210 | 200 | | |
| **6879740 SPIKE % Recovery (%)** | **107** | **121** | | |
| 6879749 DUPLICATE Sample Value (mg/L) | 340 | 460 | | |
| 6879749 DUPLICATE Duplicate Value (mg/L) | 340 | 460 | | |
| **6879749 DUPLICATE % RPD (%)** | **0.5** | **0.5** | | |
| 6883422 DUPLICATE Sample Value (mg/L) | | | 24 | <2 |
| 6883422 DUPLICATE Duplicate Value (mg/L) | | | 24 | <2 |
| **6883422 DUPLICATE % RPD (%)** | | | **0.5** | **0** |

## Metals

| | OES Scan | OES Scan | OES Scan | OES Scan |
|---|---|---|---|---|
| | Ca | Mg | K | Na |
| **6885217 BLANK Value (mg/L)** | **<0.1** | **<0.1** | **<0.1** | **<0.1** |
| 6885224 DUPLICATE Sample Value (mg/L) | 3.2 | 2.6 | 1.0 | 17 |
| 6885224 DUPLICATE Duplicate Value (mg/L) | 3.1 | 2.5 | 0.9 | 16 |
| **6885224 DUPLICATE % RPD (%)** | **4.4** | **4.1** | **2.6** | **4.5** |
| 6885226 SPIKE Sample Value (mg/L) | 3.2 | 2.6 | 1.0 | 17 |
| 6885226 SPIKE Expected Value (mg/L) | 5.2 | 4.6 | 3.0 | 19 |
| **6885226 SPIKE % Recovery (%)** | **92.2** | **91.6** | **95.4** | **87.6** |

## Nutrients

| | TKN/TP (HL) | TKN/TP (HL) | NOX as N (DA) | NO3-N |
|---|---|---|---|---|
| | TKN | TP | NOX as N | NO3 |
| **6879734 BLANK Value (mg N / L)** | | | **<0.01** | |
| 6879740 SPIKE Sample Value (mg N / L) | | | <0.01 | |
| 6879740 SPIKE Expected Value (mg N / L) | | | 10 | |
| **6879740 SPIKE % Recovery (%)** | | | **94.0** | |
| 6879749 DUPLICATE Sample Value (mg N / L) | | | 0.15 | 0.14 |
| 6879749 DUPLICATE Duplicate Value (mg N / L) | | | 0.15 | 0.14 |
| **6879749 DUPLICATE % RPD (%)** | | | **2.0** | **1.4** |
| 6880043 SPIKE Sample Value (mg N / L) | | | | 0.14 |
| 6880043 SPIKE Expected Value (mg N / L) | | | | 8.0 |
| **6880043 SPIKE % Recovery (%)** | | | | **97.1** |
| 6881135 SPIKE Sample Value (mg N / L) | 57 | 7.0 | | |
| 6881135 SPIKE Expected Value (mg N / L) | 77 | 27 | | |
| **6881135 SPIKE % Recovery (%)** | **85.5** | **96.0** | | |

*Batch No:* **21-08206**
*Report Number:* **893808**
*Client:* **Mt Buller & Mt Stirling Resort**
*ALS Program Ref:* **WSBULLER**
*Program Description:* **Mt Buller Water Supply**

| | TKN/TP (HL) | TKN/TP (HL) | NOX as N (DA) | NO3-N |
|---|---|---|---|---|
| | TKN | TP | NOX as N | NO3 |
| 6881138 DUPLICATE Sample Value (mg N / L) | 57 | 7.0 | | |
| 6881138 DUPLICATE Duplicate Value (mg N / L) | 54 | 6.9 | | |
| **6881138 DUPLICATE % RPD (%)** | **5.0** | **2.3** | | |
| **6881142 BLANK Value (mg N / L)** | **<0.1** | **<0.05** | | |

# CERTIFICATE OF ANALYSIS

| | | | |
|---|---|---|---|
| **Batch No:** | **21-08201** | *Page* | **Page 1 of 3** |
| *Final Report* | **893814** | *Laboratory* | Scoresby Laboratory |
| | | *Address* | Caribbean Business Park,<br>22 Dalmore Drive,<br>Scoresby,<br>VIC 3179 |
| *Client:* | **Mt Buller & Mt Stirling Resort** | *Phone* | 03 8756 8000 |
| *Contact:* | **Muhammad Abdullah** | *Fax* | 03 9763 1862 |
| *Address:* | C/O Post Office<br>MT BULLER VIC 3723<br>AUSTRALIA | Contact: | Christine Desiniotis<br>Client Manager<br>Christine.Desiniotis@alsglobal.com |
| *PO No:* | **Not Available** | Date Sampled: | **09-Feb-2021** |
| *Sampler Name:* | **Mathew L / Shen Chi** | Date Samples Received: | **10-Feb-2021** |
| *ALS Program Ref:* | **WSBULLER** | *Date Issued:* | **10-May-2021** |
| *Program Description:* | **Mt Buller Water Supply** | | |
| *Client Ref:* | **HEMAMP - BH6** | | |

The hash (#) below indicates methods not covered by NATA accreditation in the performance of this service .

| *Analysis* | | *Method* | *Laboratory* | *Analysis* | | *Method* | *Laboratory* |
|---|---|---|---|---|---|---|---|
| DO | # | CLIENT | Scoresby | EC | # | CLIENT | Scoresby |
| pH | # | CLIENT | Scoresby | Redox | # | CLIENT | Scoresby |
| Temp. | # | CLIENT | Scoresby | Alkalinity | | WD037 | Scoresby |
| Chloride | | WD045G | Scoresby | EC | | WA010 | Scoresby |
| TCN | | WK062 | Scoresby | NO3-N | | EK058GV | Scoresby |
| NOX as N (DA) | | EK058GV & 059GV | Scoresby | OES Scan | | WG005A (Si not NATA) | Scoresby |
| TDS at 180°C +/- 5°C | | WA015 | Scoresby | SO4 DA | | WD041G | Scoresby |
| TKN/TP (HL) | | WK061A | Scoresby | | | | |

**Unable to locate BH9.**

*Signatories*

| *Name* | *Title* | *Name* | *Title* |
|---|---|---|---|
| **Christine Desiniotis** | **Client Manager** | **Hoa Nguyen** | **Analyst** |
| **Joseph De Alwis** | **Analyst** | **John Levvey** | **Principal Trace Metals Chemist** |

Samples not collected by ALS and are tested as received. Samples are tested within holding time unless otherwise stated.

Soil microbiological testing was commenced within 4 days from the day collected unless otherwise stated.

Water microbiological testing was commenced on the day received and within 24 hours of sampling unless otherwise stated.

MM524: Plate count results <10 per mL and >300 per mL are deemed as approximate.

MM526: Plate count results <2,500 per mL and >250,000 per mL are deemed as approximate.

Calculated results are based on raw data.

Legionella species refers to Legionella species other than Legionella pneumophila

Measurement Uncertainties values for your compliance results are available at this link

Batch No: 21-08201
Report Number: 893814
Client: Mt Buller & Mt Stirling Resort
ALS Program Ref: WSBULLER
Program Description: Mt Buller Water Supply

| Sample No | Site Code | Site Description | Sample Type | Sampled Date/Time |
|---|---|---|---|---|
| 6877651 | | BH6 | WATER | 09/02/21 14:30 |

| Analysis - Analyte | Sample No. / Site Code / Units | 6877651 |
|---|---|---|
| Temp. - Water Temperature (CS) | °C | 6.8 |
| pH - pH (CS) | Units | 6.0 |
| EC - Electrical Conductivity (CS) | uS/cm | 53.2 |
| DO - Dissolved Oxygen (CS) | mg/L | 8.72 |
| Redox - Redox Potential against Ag/AgCl reference | mV | 225.1 |
| TKN/TP (HL) - Total Kjeldahl Nitrogen as N | mg N / L | 0.3 |
| TKN/TP (HL) - Phosphorus, total as P | mg P / L | <0.05 |
| TDS at 180°C +/- 5°C - Total Dissolved Solids | mg/L | 36 |
| EC - Electrical Conductivity @ 25C | uS/cm | 55 |
| Chloride - Chloride, as Cl | mg/L | 2 |
| SO4 DA - Sulphate, as SO4 | mg/L | <1 |
| Alkalinity - Bicarbonate, as Bicarbonate | mg/L | 3 |
| Alkalinity - Carbonate, as Carbonate | mg/L | <2 |
| TCN - Total Nitrogen as N (Calc) | mg/L | 5.4 |
| NOX as N (DA) - Nitrate + Nitrite, as N | mg N / L | 5.1 |
| NO3-N - Nitrate, as N | mg N / L | 5.1 |
| OES Scan - Calcium | mg/L | 3.5 |
| OES Scan - Magnesium | mg/L | 5.4 |
| OES Scan - Potassium | mg/L | 3.8 |
| OES Scan - Sodium | mg/L | 2.8 |

*A blank space indicates no test performed.*

# Quality Control

## Chemistry

| | TDS at 180°C +/- 5°C | EC | Chloride | SO4 DA |
|---|---|---|---|---|
| | TDS 180 | EC @ 25C | Cl | SO4 |
| **6879734 BLANK Value (mg/L)** | | | **<1** | **<1** |
| 6879740 SPIKE Sample Value (mg/L) | | | 14 | <5 |
| 6879740 SPIKE Expected Value (mg/L) | | | 210 | 200 |
| **6879740 SPIKE % Recovery (%)** | | | **107** | **121** |
| 6879749 DUPLICATE Sample Value (mg/L) | | | 340 | 460 |
| 6879749 DUPLICATE Duplicate Value (mg/L) | | | 340 | 460 |
| **6879749 DUPLICATE % RPD (%)** | | | **0.5** | **0.5** |
| **6879765 BLANK Value (uS/cm)** | | **<2** | | |
| 6879767 DUPLICATE Sample Value (uS/cm) | | 2900 | | |
| 6879767 DUPLICATE Duplicate Value (uS/cm) | | 2900 | | |
| **6879767 DUPLICATE % RPD (%)** | | **0.7** | | |
| 6888456 SPIKE Sample Value (mg/L) | 79 | | | |
| 6888456 SPIKE Expected Value (mg/L) | 2100 | | | |
| **6888456 SPIKE % Recovery (%)** | **125** | | | |
| 6888464 DUPLICATE Sample Value (mg/L) | 480 | | | |
| 6888464 DUPLICATE Duplicate Value (mg/L) | 480 | | | |
| **6888464 DUPLICATE % RPD (%)** | **0.0** | | | |
| **6888525 BLANK Value (mg/L)** | **<5** | | | |

## Chemistry

| | Alkalinity | Alkalinity |
|---|---|---|
| | Bicarbonate | Carbonate |
| 6883422 DUPLICATE Sample Value (mg/L) | 24 | <2 |
| 6883422 DUPLICATE Duplicate Value (mg/L) | 24 | <2 |
| **6883422 DUPLICATE % RPD (%)** | **0.5** | **0** |

## Metals

| | OES Scan | OES Scan | OES Scan | OES Scan |
|---|---|---|---|---|
| | Ca | Mg | K | Na |
| **6888715 BLANK Value (mg/L)** | **<0.1** | **<0.1** | **<0.1** | **<0.1** |
| 6888718 DUPLICATE Sample Value (mg/L) | 4.0 | 0.3 | 1.1 | 1.7 |
| 6888718 DUPLICATE Duplicate Value (mg/L) | 4.0 | 0.3 | 1.1 | 1.8 |
| **6888718 DUPLICATE % RPD (%)** | **2.1** | **1.4** | **1.6** | **0.8** |
| 6888719 SPIKE Sample Value (mg/L) | 4.0 | 0.3 | 1.1 | 1.7 |
| 6888719 SPIKE Expected Value (mg/L) | 6.0 | 2.3 | 3.1 | 3.8 |
| **6888719 SPIKE % Recovery (%)** | **109** | **103** | **109** | **104** |

## Nutrients

| | TKN/TP (HL) | TKN/TP (HL) | NOX as N (DA) | NO3-N |
|---|---|---|---|---|
| | TKN | TP | NOX as N | NO3 |
| **6879734 BLANK Value (mg N / L)** | | | **<0.01** | |
| 6879740 SPIKE Sample Value (mg N / L) | | | <0.01 | |
| 6879740 SPIKE Expected Value (mg N / L) | | | 10 | |
| **6879740 SPIKE % Recovery (%)** | | | **94.0** | |
| 6879749 DUPLICATE Sample Value (mg N / L) | | | 0.15 | 0.14 |
| 6879749 DUPLICATE Duplicate Value (mg N / L) | | | 0.15 | 0.14 |
| **6879749 DUPLICATE % RPD (%)** | | | **2.0** | **1.4** |
| 6880043 SPIKE Sample Value (mg N / L) | | | | 0.14 |
| 6880043 SPIKE Expected Value (mg N / L) | | | | 8.0 |
| **6880043 SPIKE % Recovery (%)** | | | | **97.1** |
| 6881135 SPIKE Sample Value (mg N / L) | 57 | 7.0 | | |
| 6881135 SPIKE Expected Value (mg N / L) | 77 | 27 | | |
| **6881135 SPIKE % Recovery (%)** | **85.5** | **96.0** | | |
| 6881138 DUPLICATE Sample Value (mg N / L) | 57 | 7.0 | | |
| 6881138 DUPLICATE Duplicate Value (mg N / L) | 54 | 6.9 | | |
| **6881138 DUPLICATE % RPD (%)** | **5.0** | **2.3** | | |
| **6881142 BLANK Value (mg N / L)** | **<0.1** | **<0.05** | | |

ALS Water

# CERTIFICATE OF ANALYSIS

| | | | |
|---|---|---|---|
| **Batch No:** | **21-08203** | *Page* | **Page 1 of 3** |
| *Final Report* | **893780** | *Laboratory* | Scoresby Laboratory |
| *Client:* | **Mt Buller & Mt Stirling Resort** | *Address* | Caribbean Business Park,<br>22 Dalmore Drive,<br>Scoresby,<br>VIC 3179 |
| *Contact:* | **Muhammad Abdullah** | *Phone* | 03 8756 8000 |
| *Address:* | C/O Post Office<br>MT BULLER VIC 3723<br>AUSTRALIA | *Fax* | 03 9763 1862 |
| | | Contact: | Christine Desiniotis<br>Client Manager<br>Christine.Desiniotis@alsglobal.com |
| *PO No:* | **Not Available** | Date Sampled: | **09-Feb-2021** |
| *Sampler Name:* | **Mathew / Shen Chi** | Date Samples Received: | **10-Feb-2021** |
| *ALS Program Ref:* | **WSBULLER** | *Date Issued:* | **10-May-2021** |
| *Program Description:* | **Mt Buller Water Supply** | | |
| *Client Ref:* | **HEMAMP - BH16/ BH17/ BH18** | | |

The hash (#) below indicates methods not covered by NATA accreditation in the performance of this service .

| *Analysis* | | *Method* | *Laboratory* | *Analysis* | | *Method* | *Laboratory* |
|---|---|---|---|---|---|---|---|
| DO | # | CLIENT | Scoresby | EC | # | CLIENT | Scoresby |
| pH | # | CLIENT | Scoresby | Redox | # | CLIENT | Scoresby |
| Temp. | # | CLIENT | Scoresby | Alkalinity | | WD037 | Scoresby |
| Chloride | | WD045G | Scoresby | EC | | WA010 | Scoresby |
| TCN | | WK062 | Scoresby | NO3-N | | EK058GV | Scoresby |
| NOX as N (DA) | | EK058GV & 059GV | Scoresby | OES Scan | | WG005A (Si not NATA) | Scoresby |
| TDS at 180°C +/- 5°C | | WA015 | Scoresby | SO4 DA | | WD041G | Scoresby |
| TKN/TP (HL) | | WK061A | Scoresby | | | | |

*Signatories*

| *Name* | *Title* | *Name* | *Title* |
|---|---|---|---|
| **Christine Desiniotis** | **Client Manager** | **Hoa Nguyen** | **Analyst** |
| **Joseph De Alwis** | **Analyst** | **John Levvey** | **Principal Trace Metals Chemist** |

Samples not collected by ALS and are tested as received. Samples are tested within holding time unless otherwise stated.

Soil microbiological testing was commenced within 4 days from the day collected unless otherwise stated.

Water microbiological testing was commenced on the day received and within 24 hours of sampling unless otherwise stated.

MM524: Plate count results <10 per mL and >300 per mL are deemed as approximate.

MM526: Plate count results <2,500 per mL and >250,000 per mL are deemed as approximate.

Calculated results are based on raw data.

Legionella species refers to Legionella species other than Legionella pneumophila

Measurement Uncertainties values for your compliance results are available at this link

| Sample No | Site Code | Site Description | Sample Type | Sampled Date/Time |
|---|---|---|---|---|
| 6877669 | | BH16 | WATER | 09/02/21 14:55 |
| 6877670 | | BH17 | WATER | 09/02/21 15:25 |
| 6877671 | | BH18 | WATER | 09/02/21 15:55 |

| *Analysis - Analyte* | *Sample No. Site Code Units* | 6877669 | 6877670 | 6877671 |
|---|---|---|---|---|
| Temp. - Water Temperature (CS) | °C | 8.5 | 10.6 | 10.2 |
| pH - pH (CS) | Units | 5.4 | 5.48 | 4.85 |
| EC - Electrical Conductivity (CS) | uS/cm | 22.6 | 45.5 | 33.3 |
| DO - Dissolved Oxygen (CS) | mg/L | 8.4 | 5.56 | 5.12 |
| Redox - Redox Potential against Ag/AgCl reference | mV | 232.2 | 181.7 | 211.5 |
| TKN/TP (HL) - Total Kjeldahl Nitrogen as N | mg N / L | 0.3 | 0.2 | 0.3 |
| TKN/TP (HL) - Phosphorus, total as P | mg P / L | 0.06 | 0.06 | 0.07 |
| TDS at 180°C +/- 5°C - Total Dissolved Solids | mg/L | 11 | 34 | 21 |
| EC - Electrical Conductivity @ 25C | uS/cm | 20 | 42 | 32 |
| Chloride - Chloride, as Cl | mg/L | 2 | 1 | 2 |
| SO4 DA - Sulphate, as SO4 | mg/L | <1 | <1 | <1 |
| Alkalinity - Bicarbonate, as Bicarbonate | mg/L | 6 | 20 | 15 |
| Alkalinity - Carbonate, as Carbonate | mg/L | <2 | <2 | <2 |
| TCN - Total Nitrogen as N (Calc) | mg/L | 1.2 | 1.1 | 0.3 |
| NOX as N (DA) - Nitrate + Nitrite, as N | mg N / L | 0.81 | 0.90 | 0.01 |
| NO3-N - Nitrate, as N | mg N / L | 0.80 | 0.90 | 0.01 |
| OES Scan - Calcium | mg/L | 1.9 | 3.0 | 3.6 |
| OES Scan - Magnesium | mg/L | 4.8 | 1.3 | 3.6 |
| OES Scan - Potassium | mg/L | 1.5 | 0.8 | 2.2 |
| OES Scan - Sodium | mg/L | 2.2 | 3.6 | 3.3 |

*A blank space indicates no test performed.*

Batch No: 21-08203
Report Number: 893780
Client: Mt Buller & Mt Stirling Resort
ALS Program Ref: WSBULLER
Program Description: Mt Buller Water Supply

# Quality Control

## Chemistry

| | TDS at 180°C +/- 5°C | EC | Chloride | SO4 DA |
|---|---|---|---|---|
| | TDS 180 | EC @ 25C | Cl | SO4 |
| **6879734 BLANK Value (mg/L)** | | | **<1** | **<1** |
| 6879740 SPIKE Sample Value (mg/L) | | | 14 | <5 |
| 6879740 SPIKE Expected Value (mg/L) | | | 210 | 200 |
| **6879740 SPIKE % Recovery (%)** | | | **107** | **121** |
| 6879749 DUPLICATE Sample Value (mg/L) | | | 340 | 460 |
| 6879749 DUPLICATE Duplicate Value (mg/L) | | | 340 | 460 |
| **6879749 DUPLICATE % RPD (%)** | | | **0.5** | **0.5** |
| **6879765 BLANK Value (uS/cm)** | | **<2** | | |
| 6879767 DUPLICATE Sample Value (uS/cm) | | 2900 | | |
| 6879767 DUPLICATE Duplicate Value (uS/cm) | | 2900 | | |
| **6879767 DUPLICATE % RPD (%)** | | **0.7** | | |
| 6888456 SPIKE Sample Value (mg/L) | 79 | | | |
| 6888456 SPIKE Expected Value (mg/L) | 2100 | | | |
| **6888456 SPIKE % Recovery (%)** | **125** | | | |
| 6888464 DUPLICATE Sample Value (mg/L) | 480 | | | |
| 6888464 DUPLICATE Duplicate Value (mg/L) | 480 | | | |
| **6888464 DUPLICATE % RPD (%)** | **0.0** | | | |
| **6888525 BLANK Value (mg/L)** | **<5** | | | |

## Chemistry

| | Alkalinity | Alkalinity |
|---|---|---|
| | Bicarbonate | Carbonate |
| 6883422 DUPLICATE Sample Value (mg/L) | 24 | <2 |
| 6883422 DUPLICATE Duplicate Value (mg/L) | 24 | <2 |
| **6883422 DUPLICATE % RPD (%)** | **0.5** | **0** |

## Metals

| | OES Scan | OES Scan | OES Scan | OES Scan |
|---|---|---|---|---|
| | Ca | Mg | K | Na |
| **6888715 BLANK Value (mg/L)** | **<0.1** | **<0.1** | **<0.1** | **<0.1** |
| 6888718 DUPLICATE Sample Value (mg/L) | 4.0 | 0.3 | 1.1 | 1.7 |
| 6888718 DUPLICATE Duplicate Value (mg/L) | 4.0 | 0.3 | 1.1 | 1.8 |
| **6888718 DUPLICATE % RPD (%)** | **2.1** | **1.4** | **1.6** | **0.8** |
| 6888719 SPIKE Sample Value (mg/L) | 4.0 | 0.3 | 1.1 | 1.7 |
| 6888719 SPIKE Expected Value (mg/L) | 6.0 | 2.3 | 3.1 | 3.8 |
| **6888719 SPIKE % Recovery (%)** | **109** | **103** | **109** | **104** |

## Nutrients

| | TKN/TP (HL) | TKN/TP (HL) | NOX as N (DA) | NO3-N |
|---|---|---|---|---|
| | TKN | TP | NOX as N | NO3 |
| **6879734 BLANK Value (mg N / L)** | | | **<0.01** | |
| 6879740 SPIKE Sample Value (mg N / L) | | | <0.01 | |
| 6879740 SPIKE Expected Value (mg N / L) | | | 10 | |
| **6879740 SPIKE % Recovery (%)** | | | **94.0** | |
| 6879749 DUPLICATE Sample Value (mg N / L) | | | 0.15 | 0.14 |
| 6879749 DUPLICATE Duplicate Value (mg N / L) | | | 0.15 | 0.14 |
| **6879749 DUPLICATE % RPD (%)** | | | **2.0** | **1.4** |
| 6880043 SPIKE Sample Value (mg N / L) | | | | 0.14 |
| 6880043 SPIKE Expected Value (mg N / L) | | | | 8.0 |
| **6880043 SPIKE % Recovery (%)** | | | | **97.1** |
| 6881135 SPIKE Sample Value (mg N / L) | 57 | 7.0 | | |
| 6881135 SPIKE Expected Value (mg N / L) | 77 | 27 | | |
| **6881135 SPIKE % Recovery (%)** | **85.5** | **96.0** | | |
| 6881138 DUPLICATE Sample Value (mg N / L) | 57 | 7.0 | | |
| 6881138 DUPLICATE Duplicate Value (mg N / L) | 54 | 6.9 | | |
| **6881138 DUPLICATE % RPD (%)** | **5.0** | **2.3** | | |
| **6881142 BLANK Value (mg N / L)** | **<0.1** | **<0.05** | | |

CERTIFICATE OF ANALYSIS

| | | | |
|---|---|---|---|
| **Batch No:** | **21-08204** | *Page* | **Page 1 of 4** |
| *Final Report* | **893790** | *Laboratory* | Scoresby Laboratory |
| *Client:* | **Mt Buller & Mt Stirling Resort** | *Address* | Caribbean Business Park, 22 Dalmore Drive, Scoresby, VIC 3179 |
| *Contact:* | **Muhammad Abdullah** | *Phone* | 03 8756 8000 |
| *Address:* | C/O Post Office<br>MT BULLER VIC 3723<br>AUSTRALIA | *Fax* | 03 9763 1862 |
| | | Contact: | Christine Desiniotis<br>Client Manager<br>Christine.Desiniotis@alsglobal.com |
| *PO No:* | **Not Available** | Date Sampled: | **09-Feb-2021** |
| *Sampler Name:* | **Mathew L / Shen Chi** | Date Samples Received: | **10-Feb-2021** |
| *ALS Program Ref:* | **WSBULLER** | *Date Issued:* | **10-May-2021** |
| *Program Description:* | **Mt Buller Water Supply** | | |
| *Client Ref:* | **HEMAMP - FD1/ FD2 / FD3** | | |

The hash (#) below indicates methods not covered by NATA accreditation in the performance of this service .

| *Analysis* | | *Method* | *Laboratory* | *Analysis* | | *Method* | *Laboratory* |
|---|---|---|---|---|---|---|---|
| DO | # | CLIENT | Scoresby | EC | # | CLIENT | Scoresby |
| pH | # | CLIENT | Scoresby | Redox | # | CLIENT | Scoresby |
| Temp. | # | CLIENT | Scoresby | Alkalinity | | WD037 | Scoresby |
| Chloride | | WD045G | Scoresby | EC | | WA010 | Scoresby |
| TCN | | WK062 | Scoresby | NO3-N | | EK058GV | Scoresby |
| NOX as N (DA) | | EK058GV & 059GV | Scoresby | OES Scan | | WG005A (Si not NATA) | Scoresby |
| SS at 104+/- 2°C | | WA025 | Scoresby | TDS at 180°C +/- 5°C | | WA015 | Scoresby |
| SO4 DA | | WD041G | Scoresby | TKN/TP (HL) | | WK061A | Scoresby |
| Turbidity | | WA045 | Scoresby | | | | |

*Signatories*

| *Name* | *Title* | *Name* | *Title* |
|---|---|---|---|
| **Christine Desiniotis** | **Client Manager** | **Chatura Perera** | **Team Leader Nutrients** |
| **Hoa Nguyen** | **Analyst** | **Joseph De Alwis** | **Analyst** |
| **John Levvey** | **Principal Trace Metals Chemist** | | |

Samples not collected by ALS and are tested as received. Samples are tested within holding time unless otherwise stated.

Soil microbiological testing was commenced within 4 days from the day collected unless otherwise stated.

Water microbiological testing was commenced on the day received and within 24 hours of sampling unless otherwise stated.

MM524: Plate count results <10 per mL and >300 per mL are deemed as approximate.

MM526: Plate count results <2,500 per mL and >250,000 per mL are deemed as approximate.

Calculated results are based on raw data.

Legionella species refers to Legionella species other than Legionella pneumophila

Measurement Uncertainties values for your compliance results are available at this link

Batch No: **21-08204**
Report Number: **893790**
Client: **Mt Buller & Mt Stirling Resort**
ALS Program Ref: **WSBULLER**
Program Description: **Mt Buller Water Supply**

| Sample No | Site Code | Site Description | Sample Type | Sampled Date/Time |
|---|---|---|---|---|
| 6877683 | | FD1 | WATER | 09/02/21 12:00 |
| 6877684 | | FD2 | WATER | 09/02/21 14:55 |
| 6877685 | | FD3 | WATER | 09/02/21 12:15 |

| Analysis - Analyte | Sample No. Site Code Units | 6877683 | 6877684 | 6877685 |
|---|---|---|---|---|
| Temp. - Water Temperature (CS) | °C | 8.8 | 8.5 | 10.3 |
| pH - pH (CS) | Units | 7.72 | 5.4 | 7.88 |
| EC - Electrical Conductivity (CS) | uS/cm | 22.2 | 22.6 | 28.7 |
| DO - Dissolved Oxygen (CS) | mg/L | 12.19 | 8.4 | 11.91 |
| Redox - Redox Potential against Ag/AgCl reference | mV | 66.7 | 232.2 | 47.1 |
| TKN/TP (HL) - Total Kjeldahl Nitrogen as N | mg N / L | 0.2 | 0.4 | 0.2 |
| TKN/TP (HL) - Phosphorus, total as P | mg P / L | <0.05 | 0.06 | <0.05 |
| SS at 104+/- 2°C - Suspended Solids | mg/L | <2 | | <2 |
| TDS at 180°C +/- 5°C - Total Dissolved Solids | mg/L | 14 | 14 | 16 |
| EC - Electrical Conductivity @ 25C | uS/cm | 21 | 20 | 27 |
| Turbidity - Turbidity, NTU | NTU | 0.1 | | 0.1 |
| Chloride - Chloride, as Cl | mg/L | 1 | 2 | 1 |
| SO4 DA - Sulphate, as SO4 | mg/L | <1 | <1 | <1 |
| Alkalinity - Bicarbonate, as Bicarbonate | mg/L | 11 | 6 | 15 |
| Alkalinity - Carbonate, as Carbonate | mg/L | <2 | <2 | <2 |
| TCN - Total Nitrogen as N (Calc) | mg/L | 0.3 | 1.2 | 0.3 |
| NOX as N (DA) - Nitrate + Nitrite, as N | mg N / L | 0.09 | 0.80 | 0.14 |
| NO3-N - Nitrate, as N | mg N / L | 0.09 | 0.80 | 0.13 |
| OES Scan - Calcium | mg/L | 1.4 | 2.0 | 1.4 |
| OES Scan - Magnesium | mg/L | 0.5 | 5.2 | 0.5 |
| OES Scan - Potassium | mg/L | 0.2 | 1.7 | 0.1 |
| OES Scan - Sodium | mg/L | 1.8 | 2.3 | 1.5 |

*A blank space indicates no test performed.*

# Quality Control

| Chemistry | SS at 104+/- 2°C | TDS at 180°C +/- 5°C | EC | Turbidity |
|---|---|---|---|---|
| | SS | TDS 180 | EC @ 25C | Turbidity |
| **6879765 BLANK Value (uS/cm)** | | | **<2** | |
| 6879767 DUPLICATE Sample Value (uS/cm) | | | 2900 | |
| 6879767 DUPLICATE Duplicate Value (uS/cm) | | | 2900 | |
| **6879767 DUPLICATE % RPD (%)** | | | **0.7** | |
| **6880241 BLANK Value (uS/cm)** | | | **<2** | |
| 6880846 DUPLICATE Sample Value (mg/L) | 210 | | | |
| 6880846 DUPLICATE Duplicate Value (mg/L) | 200 | | | |
| **6880846 DUPLICATE % RPD (%)** | **5.8** | | | |
| **6882449 BLANK Value (NTU)** | | | | **<0.1** |
| 6882465 DUPLICATE Sample Value (NTU) | | | | 0.6 |
| 6882465 DUPLICATE Duplicate Value (NTU) | | | | 0.6 |
| **6882465 DUPLICATE % RPD (%)** | | | | **0.6** |
| 6882491 DUPLICATE Sample Value (uS/cm) | | | 160 | |
| 6882491 DUPLICATE Duplicate Value (uS/cm) | | | 160 | |
| **6882491 DUPLICATE % RPD (%)** | | | **0.7** | |
| **6884784 BLANK Value (mg/L)** | **<2** | | | |
| 6888456 SPIKE Sample Value (mg/L) | | 79 | | |
| 6888456 SPIKE Expected Value (mg/L) | | 2100 | | |
| **6888456 SPIKE % Recovery (%)** | | **125** | | |
| 6888464 DUPLICATE Sample Value (mg/L) | | 480 | | |
| 6888464 DUPLICATE Duplicate Value (mg/L) | | 480 | | |
| **6888464 DUPLICATE % RPD (%)** | | **0.0** | | |
| **6888525 BLANK Value (mg/L)** | | **<5** | | |

| Chemistry | Chloride | SO4 DA | Alkalinity | Alkalinity |
|---|---|---|---|---|
| | Cl | SO4 | Bicarbonate | Carbonate |
| **6879734 BLANK Value (mg/L)** | **<1** | **<1** | | |
| 6879740 SPIKE Sample Value (mg/L) | 14 | <5 | | |
| 6879740 SPIKE Expected Value (mg/L) | 210 | 200 | | |
| **6879740 SPIKE % Recovery (%)** | **107** | **121** | | |
| 6879749 DUPLICATE Sample Value (mg/L) | 340 | 460 | | |
| 6879749 DUPLICATE Duplicate Value (mg/L) | 340 | 460 | | |
| **6879749 DUPLICATE % RPD (%)** | **0.5** | **0.5** | | |
| 6883422 DUPLICATE Sample Value (mg/L) | | | 24 | <2 |
| 6883422 DUPLICATE Duplicate Value (mg/L) | | | 24 | <2 |
| **6883422 DUPLICATE % RPD (%)** | | | **0.5** | **0** |

| Metals | OES Scan | OES Scan | OES Scan | OES Scan |
|---|---|---|---|---|
| | Ca | Mg | K | Na |
| **6886014 BLANK Value (mg/L)** | **<0.1** | **<0.1** | **<0.1** | **<0.1** |
| 6886021 DUPLICATE Sample Value (mg/L) | 4.5 | 0.1 | 0.5 | 26 |
| 6886021 DUPLICATE Duplicate Value (mg/L) | 4.5 | 0.1 | 0.5 | 26 |
| **6886021 DUPLICATE % RPD (%)** | **0.7** | **0.0** | **0.0** | **0.4** |
| 6886022 SPIKE Sample Value (mg/L) | 4.5 | 0.1 | 0.5 | 26 |
| 6886022 SPIKE Expected Value (mg/L) | 6.5 | 2.1 | 2.5 | 28 |
| **6886022 SPIKE % Recovery (%)** | **96.1** | **99.9** | **99.5** | **88.0** |
| **6888715 BLANK Value (mg/L)** | **<0.1** | **<0.1** | **<0.1** | **<0.1** |
| 6888718 DUPLICATE Sample Value (mg/L) | 4.0 | 0.3 | 1.1 | 1.7 |
| 6888718 DUPLICATE Duplicate Value (mg/L) | 4.0 | 0.3 | 1.1 | 1.8 |
| **6888718 DUPLICATE % RPD (%)** | **2.1** | **1.4** | **1.6** | **0.8** |
| 6888719 SPIKE Sample Value (mg/L) | 4.0 | 0.3 | 1.1 | 1.7 |
| 6888719 SPIKE Expected Value (mg/L) | 6.0 | 2.3 | 3.1 | 3.8 |
| **6888719 SPIKE % Recovery (%)** | **109** | **103** | **109** | **104** |

| Nutrients | TKN/TP (HL) | TKN/TP (HL) | NOX as N (DA) | NO3-N |
|---|---|---|---|---|
| | TKN | TP | NOX as N | NO3 |
| **6879734 BLANK Value (mg N / L)** | | | **<0.01** | |
| 6879740 SPIKE Sample Value (mg N / L) | | | <0.01 | |

| | |
|---|---|
| *Page:* | **Page 4 of 4** |
| *Batch No:* | **21-08204** |
| *Report Number:* | **893790** |
| *Client:* | **Mt Buller & Mt Stirling Resort** |
| *ALS Program Ref:* | **WSBULLER** |
| *Program Description:* | **Mt Buller Water Supply** |

| | TKN/TP (HL) | TKN/TP (HL) | NOX as N (DA) | NO3-N |
|---|---|---|---|---|
| | TKN | TP | NOX as N | NO3 |
| 6879740 SPIKE Expected Value (mg N / L) | | | 10 | |
| **6879740 SPIKE % Recovery (%)** | | | **94.0** | |
| 6879749 DUPLICATE Sample Value (mg N / L) | | | 0.15 | 0.14 |
| 6879749 DUPLICATE Duplicate Value (mg N / L) | | | 0.15 | 0.14 |
| **6879749 DUPLICATE % RPD (%)** | | | **2.0** | **1.4** |
| 6880043 SPIKE Sample Value (mg N / L) | | | | 0.14 |
| 6880043 SPIKE Expected Value (mg N / L) | | | | 8.0 |
| **6880043 SPIKE % Recovery (%)** | | | | **97.1** |
| 6881135 SPIKE Sample Value (mg N / L) | 57 | 7.0 | | |
| 6881135 SPIKE Expected Value (mg N / L) | 77 | 27 | | |
| **6881135 SPIKE % Recovery (%)** | **85.5** | **96.0** | | |
| 6881138 DUPLICATE Sample Value (mg N / L) | 57 | 7.0 | | |
| 6881138 DUPLICATE Duplicate Value (mg N / L) | 54 | 6.9 | | |
| **6881138 DUPLICATE % RPD (%)** | **5.0** | **2.3** | | |
| **6881142 BLANK Value (mg N / L)** | **<0.1** | **<0.05** | | |

**ALS Water Resources Group (Scoresby)**
**22 Dalmore Drive**
**Scoresby**
**VIC 3179**

NATA Accredited
Accreditation Number 1261
Site Number 1254

Accredited for compliance with ISO/IEC 17025 – Testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

**Attention:** **Christine Desiniotis**

| | |
|---|---|
| **Report** | **772982-W** |
| Project name | WS BULLER |
| Project ID | 21-08208 |
| Received Date | Feb 10, 2021 |

| **Client Sample ID** | | | **DUPLICATE 1 (SURFACE WATER)** | **DUPLICATE 2 (GROUND WATER)** |
|---|---|---|---|---|
| **Sample Matrix** | | | **Water** | **Water** |
| **Eurofins Sample No.** | | | **M21-Fe19575** | **M21-Fe19576** |
| **Date Sampled** | | | **Feb 09, 2021** | **Feb 09, 2021** |
| Test/Reference | LOR | Unit | | |
| | | | | |
| Chloride | 1 | mg/L | 40 | 2.4 |
| Conductivity (at 25°C) | 10 | uS/cm | 21 | 53 |
| Nitrate & Nitrite (as N) | 0.05 | mg/L | 0.15 | 5.5 |
| Nitrate (as N) | 0.02 | mg/L | 0.15 | 5.5 |
| Phosphate total (as P) | 0.01 | mg/L | < 0.01 | < 0.01 |
| Sulphate (as SO4) | 5 | mg/L | < 5 | < 5 |
| Total Dissolved Solids Dried at 180°C ± 2°C | 10 | mg/L | 500 | 11000 |
| Total Kjeldahl Nitrogen (as N) | 0.2 | mg/L | < 0.2 | < 0.2 |
| Total Nitrogen (as N) | 0.2 | mg/L | < 0.2 | 5.0 |
| Total Suspended Solids Dried at 103–105°C | 1 | mg/L | 2.9 | - |
| Turbidity | 1 | NTU | 1.3 | - |
| **Alkalinity (speciated)** | | | | |
| Bicarbonate Alkalinity (as CaCO3) | 20 | mg/L | < 20 | < 20 |
| Carbonate Alkalinity (as CaCO3) | 10 | mg/L | < 10 | < 10 |
| **Alkali Metals** | | | | |
| Calcium | 0.5 | mg/L | 1.0 | 3.4 |
| Magnesium | 0.5 | mg/L | < 0.5 | 1.5 |
| Potassium | 0.5 | mg/L | < 0.5 | 0.7 |
| Sodium | 0.5 | mg/L | 2.5 | 2.4 |

## Sample History

Where samples are submitted/analysed over several days, the last date of extraction and analysis is reported.
A recent review of our LIMS has resulted in the correction or clarification of some method identifications. Due to this, some of the method reference information on reports has changed. However, no substantive change has been made to our laboratory methods, and as such there is no change in the validity of current or previous results.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

| Description | Testing Site | Extracted | Holding Time |
|---|---|---|---|
| Chloride | Melbourne | Feb 10, 2021 | 28 Days |
| - Method: LTM-INO-4090 Chloride by Discrete Analyser | | | |
| Conductivity (at 25°C) | Melbourne | Feb 10, 2021 | 28 Days |
| - Method: LTM-INO-4030 Conductivity | | | |
| Nitrate & Nitrite (as N) | Melbourne | Feb 10, 2021 | 28 Days |
| - Method: LTM-INO-4120 Analysis of NOx NO2 NH3 by FIA | | | |
| Nitrate (as N) | Melbourne | Feb 10, 2021 | 28 Days |
| - Method: LTM-INO-4120 Analysis of NOx NO2 NH3 by FIA | | | |
| Phosphate total (as P) | Melbourne | Feb 10, 2021 | 28 Days |
| - Method: LTM-INO-4040 Phosphate by CFA | | | |
| Sulphate (as SO4) | Melbourne | Feb 10, 2021 | 28 Days |
| - Method: LTM-INO-4110 Sulfate by Discrete Analyser | | | |
| Total Kjeldahl Nitrogen (as N) | Melbourne | Feb 10, 2021 | 7 Days |
| - Method: APHA 4500-Norg B,D Total Kjeldahl Nitrogen by FIA | | | |
| Total Suspended Solids Dried at 103–105°C | Melbourne | Feb 10, 2021 | 7 Days |
| - Method: LTM-INO-4070 Analysis of Suspended Solids in Water by Gravimetry | | | |
| Turbidity | Melbourne | Feb 10, 2021 | 2 Days |
| - Method: Turbidity by classical using APHA 2130B (LTM-INO-4140) | | | |
| Alkalinity (speciated) | Melbourne | Feb 10, 2021 | 14 Days |
| - Method: LTM-INO-4250 Alkalinity by Electrometric Titration | | | |
| Alkali Metals | Melbourne | Feb 10, 2021 | 180 Days |
| - Method: LTM-MET-3010 Alkali Metals Sulfur Silicon Phosphorus by ICP-AES | | | |
| Total Dissolved Solids Dried at 180°C ± 2°C | Melbourne | Feb 10, 2021 | 7 Days |
| - Method: LTM-INO-4170 Total Dissolved Solids in Water | | | |

**Company Name:** ALS Water Resources Group (Scoresby)
**Address:** 22 Dalmore Drive
Scoresby
VIC 3179

**Project Name:** WS BULLER
**Project ID:** 21-08208

**Order No.:**
**Report #:** 772982
**Phone:** 03 8756 8100
**Fax:** 03 9763 8721

**Received:** Feb 10, 2021 3:05 PM
**Due:** Feb 15, 2021
**Priority:** 3 Day
**Contact Name:** Christine Desiniotis

**Eurofins Analytical Services Manager : Michael Morrison**

| Sample Detail | | | | | | Bicarbonate Alkalinity (as CaCO3) | Calcium | Carbonate Alkalinity (as CaCO3) | Chloride | Conductivity (at 25°C) | Magnesium | Nitrate & Nitrite (as N) | Nitrate (as N) | Phosphate total (as P) | Potassium | Sodium | Sulphate (as SO4) | Total Kjeldahl Nitrogen (as N) | Total Nitrogen (as N) | Total Suspended Solids Dried at 103–105°C | Turbidity | Total Dissolved Solids Dried at 180°C ± 2°C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Melbourne Laboratory - NATA Site # 1254 & 14271** | | | | | | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| **Sydney Laboratory - NATA Site # 18217** | | | | | | | | | | | | | | | | | | | | | | |
| **Brisbane Laboratory - NATA Site # 20794** | | | | | | | | | | | | | | | | | | | | | | |
| **Perth Laboratory - NATA Site # 23736** | | | | | | | | | | | | | | | | | | | | | | |
| **Mayfield Laboratory** | | | | | | | | | | | | | | | | | | | | | | |
| **External Laboratory** | | | | | | | | | | | | | | | | | | | | | | |
| **No** | **Sample ID** | **Sample Date** | **Sampling Time** | **Matrix** | **LAB ID** | | | | | | | | | | | | | | | | | |
| 1 | DUPLICATE 1 (SURFACE WATER) | Feb 09, 2021 | | Water | M21-Fe19575 | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 2 | DUPLICATE 2 (GROUND WATER) | Feb 09, 2021 | | Water | M21-Fe19576 | X | X | X | X | X | X | X | X | X | X | X | X | X | X | | | X |
| **Test Counts** | | | | | | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 |

## Internal Quality Control Review and Glossary

### General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follows guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013 and are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry basis, unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion, unless otherwise stated.
4. Actual LORs are matrix dependant. Quoted LORs may be raised where sample extracts are diluted due to interferences.
5. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
6. SVOC analysis on waters are performed on homogenised, unfiltered samples, unless noted otherwise.
7. Samples were analysed on an 'as received' basis.
8. Information identified on this report with blue colour, indicates data provided by customer, that may have an impact on the results.
9. This report replaces any interim results previously issued.

### Holding Times

Please refer to 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours prior to sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and regardless of any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling, therefore compliance to these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether the holding time is 7 days however for all other VOCs such as BTEX or C6-10 TRH then the holding time is 14 days.

****NOTE:** pH duplicates are reported as a range NOT as RPD

### Units

| | | |
|---|---|---|
| **mg/kg:** milligrams per kilogram | **mg/L:** milligrams per litre | **ug/L:** micrograms per litre |
| **ppm:** Parts per million | **ppb:** Parts per billion | **%:** Percentage |
| **org/100mL:** Organisms per 100 millilitres | **NTU:** Nephelometric Turbidity Units | **MPN/100mL:** Most Probable Number of organisms per 100 millilitres |

### Terms

| | |
|---|---|
| **Dry** | Where a moisture has been determined on a solid sample the result is expressed on a dry basis. |
| **LOR** | Limit of Reporting. |
| **SPIKE** | Addition of the analyte to the sample and reported as percentage recovery. |
| **RPD** | Relative Percent Difference between two Duplicate pieces of analysis. |
| **LCS** | Laboratory Control Sample - reported as percent recovery. |
| **CRM** | Certified Reference Material - reported as percent recovery. |
| **Method Blank** | In the case of solid samples these are performed on laboratory certified clean sands and in the case of water samples these are performed on de-ionised water. |
| **Surr - Surrogate** | The addition of a like compound to the analyte target and reported as percentage recovery. |
| **Duplicate** | A second piece of analysis from the same sample and reported in the same units as the result to show comparison. |
| **USEPA** | United States Environmental Protection Agency |
| **APHA** | American Public Health Association |
| **TCLP** | Toxicity Characteristic Leaching Procedure |
| **COC** | Chain of Custody |
| **SRA** | Sample Receipt Advice |
| **QSM** | US Department of Defense Quality Systems Manual Version 5.3 |
| **CP** | Client Parent - QC was performed on samples pertaining to this report |
| **NCP** | Non-Client Parent - QC performed on samples not pertaining to this report, QC is representative of the sequence or batch that client samples were analysed within. |
| **TEQ** | Toxic Equivalency Quotient |

### QC - Acceptance Criteria

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is 30% however the following acceptance guidelines are equally applicable:

Results <10 times the LOR : No Limit

Results between 10-20 times the LOR : RPD must lie between 0-50%

Results >20 times the LOR : RPD must lie between 0-30%

Surrogate Recoveries: Recoveries must lie between 20-130% Phenols & 50-150% PFASs

PFAS field samples that contain surrogate recoveries in excess of the QC limit designated in QSM 5.3 where no positive PFAS results have been reported have been reviewed and no data was affected.

WA DWER (n=10): PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

### QC Data General Comments

1. Where a result is reported as a less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch, but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown is not data from your samples.
3. Organochlorine Pesticide analysis - where reporting LCS data, Toxaphene & Chlordane are not added to the LCS.
4. Organochlorine Pesticide analysis - where reporting Spike data, Toxaphene is not added to the Spike.
5. Total Recoverable Hydrocarbons - where reporting Spike & LCS data, a single spike of commercial Hydrocarbon products in the range of C12-C30 is added and it's Total Recovery is reported in the C10-C14 cell of the Report.
6. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling.Therefore laboratory analysis is unlikely to be completed within holding time. Analysis will begin as soon as possible after sample receipt.
7. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of Recovery the term "INT" appears against that analyte.
8. Polychlorinated Biphenyls are spiked only using Aroclor 1260 in Matrix Spikes and LCS.
9. For Matrix Spikes and LCS results a dash " -" in the report means that the specific analyte was not added to the QC sample.
10. Duplicate RPDs are calculated from raw analytical data thus it is possible to have two sets of data.

eurofins Environment Testing

**Quality Control Results**

| Test | | | Units | Result 1 | | | Acceptance Limits | Pass Limits | Qualifying Code |
|---|---|---|---|---|---|---|---|---|---|
| **Method Blank** | | | | | | | | | |
| Chloride | | | mg/L | < 1 | | | 1 | Pass | |
| Conductivity (at 25°C) | | | uS/cm | < 10 | | | 10 | Pass | |
| Nitrate & Nitrite (as N) | | | mg/L | < 0.05 | | | 0.05 | Pass | |
| Nitrate (as N) | | | mg/L | < 0.02 | | | 0.02 | Pass | |
| Phosphate total (as P) | | | mg/L | < 0.01 | | | 0.01 | Pass | |
| Sulphate (as SO4) | | | mg/L | < 5 | | | 5 | Pass | |
| Total Kjeldahl Nitrogen (as N) | | | mg/L | < 0.2 | | | 0.2 | Pass | |
| Total Nitrogen (as N) | | | mg/L | < 0.2 | | | 0.2 | Pass | |
| Total Suspended Solids Dried at 103–105°C | | | mg/L | < 1 | | | 1 | Pass | |
| Turbidity | | | NTU | < 1 | | | 1 | Pass | |
| **Method Blank** | | | | | | | | | |
| **Alkalinity (speciated)** | | | | | | | | | |
| Bicarbonate Alkalinity (as CaCO3) | | | mg/L | < 20 | | | 20 | Pass | |
| Carbonate Alkalinity (as CaCO3) | | | mg/L | < 10 | | | 10 | Pass | |
| **Method Blank** | | | | | | | | | |
| **Alkali Metals** | | | | | | | | | |
| Calcium | | | mg/L | < 0.5 | | | 0.5 | Pass | |
| Magnesium | | | mg/L | < 0.5 | | | 0.5 | Pass | |
| Potassium | | | mg/L | < 0.5 | | | 0.5 | Pass | |
| Sodium | | | mg/L | < 0.5 | | | 0.5 | Pass | |
| **LCS - % Recovery** | | | | | | | | | |
| Chloride | | | % | 117 | | | 70-130 | Pass | |
| Conductivity (at 25°C) | | | % | 87 | | | 70-130 | Pass | |
| Nitrate & Nitrite (as N) | | | % | 102 | | | 70-130 | Pass | |
| Nitrate (as N) | | | % | 102 | | | 70-130 | Pass | |
| Phosphate total (as P) | | | % | 105 | | | 70-130 | Pass | |
| Sulphate (as SO4) | | | % | 94 | | | 70-130 | Pass | |
| Total Nitrogen (as N) | | | % | 92 | | | 70-130 | Pass | |
| Total Suspended Solids Dried at 103–105°C | | | % | 104 | | | 70-130 | Pass | |
| **LCS - % Recovery** | | | | | | | | | |
| **Alkalinity (speciated)** | | | | | | | | | |
| Carbonate Alkalinity (as CaCO3) | | | % | 92 | | | 70-130 | Pass | |
| **LCS - % Recovery** | | | | | | | | | |
| **Alkali Metals** | | | | | | | | | |
| Calcium | | | % | 105 | | | 80-120 | Pass | |
| Magnesium | | | % | 107 | | | 80-120 | Pass | |
| Potassium | | | % | 103 | | | 80-120 | Pass | |
| Sodium | | | % | 113 | | | 80-120 | Pass | |
| **Test** | **Lab Sample ID** | **QA Source** | **Units** | **Result 1** | | | **Acceptance Limits** | **Pass Limits** | **Qualifying Code** |
| **Spike - % Recovery** | | | | | | | | | |
| | | | | Result 1 | | | | | |
| Nitrate & Nitrite (as N) | S21-Fe11497 | NCP | % | 102 | | | 70-130 | Pass | |
| Nitrate (as N) | S21-Fe11497 | NCP | % | 102 | | | 70-130 | Pass | |
| Phosphate total (as P) | P21-Fe11948 | NCP | % | 103 | | | 70-130 | Pass | |
| Total Kjeldahl Nitrogen (as N) | B21-Fe15836 | NCP | % | 85 | | | 70-130 | Pass | |
| Total Nitrogen (as N) | P21-Fe11948 | NCP | % | 75 | | | 70-130 | Pass | |
| Total Suspended Solids Dried at 103–105°C | B21-Fe12529 | NCP | % | 92 | | | 70-130 | Pass | |
| **Spike - % Recovery** | | | | | | | | | |
| **Alkalinity (speciated)** | | | | Result 1 | | | | | |
| Bicarbonate Alkalinity (as CaCO3) | S21-Fe13810 | NCP | % | 104 | | | 70-130 | Pass | |

| Test | Lab Sample ID | QA Source | Units | Result 1 | | | Acceptance Limits | Pass Limits | Qualifying Code |
|---|---|---|---|---|---|---|---|---|---|
| Carbonate Alkalinity (as CaCO3) | B21-Fe12984 | NCP | % | 100 | | | 70-130 | Pass | |
| **Spike - % Recovery** | | | | | | | | | |
| **Alkali Metals** | | | | Result 1 | | | | | |
| Calcium | B21-Fe15103 | NCP | % | 93 | | | 75-125 | Pass | |
| Magnesium | B21-Fe15103 | NCP | % | 98 | | | 75-125 | Pass | |
| Potassium | B21-Fe15103 | NCP | % | 96 | | | 75-125 | Pass | |
| Sodium | B21-Fe15103 | NCP | % | 100 | | | 75-125 | Pass | |
| **Test** | **Lab Sample ID** | **QA Source** | **Units** | **Result 1** | | | **Acceptance Limits** | **Pass Limits** | **Qualifying Code** |
| **Duplicate** | | | | | | | | | |
| | | | | Result 1 | Result 2 | RPD | | | |
| Chloride | M21-Fe08540 | NCP | mg/L | 72 | 43 | 4.0 | 30% | Pass | |
| Conductivity (at 25°C) | M21-Fe19575 | CP | uS/cm | 21 | 24 | 13 | 30% | Pass | |
| Nitrate & Nitrite (as N) | S21-Fe07311 | NCP | mg/L | 0.07 | 0.07 | 3.0 | 30% | Pass | |
| Nitrate (as N) | S21-Fe07311 | NCP | mg/L | 0.07 | 0.07 | 2.0 | 30% | Pass | |
| Phosphate total (as P) | M21-Fe19575 | CP | mg/L | < 0.01 | < 0.01 | <1 | 30% | Pass | |
| Sulphate (as SO4) | M21-Fe08540 | NCP | mg/L | 78 | 83 | 3.0 | 30% | Pass | |
| Total Kjeldahl Nitrogen (as N) | B21-Fe15835 | NCP | mg/L | 320 | 170 | 15 | 30% | Pass | |
| Total Nitrogen (as N) | M21-Fe19575 | CP | mg/L | < 0.2 | 0.2 | 8.0 | 30% | Pass | |
| Total Suspended Solids Dried at 103–105°C | S21-Fe16916 | NCP | mg/L | 2.8 | 2.2 | 24 | 30% | Pass | |
| **Duplicate** | | | | | | | | | |
| **Alkalinity (speciated)** | | | | Result 1 | Result 2 | RPD | | | |
| Bicarbonate Alkalinity (as CaCO3) | M21-Fe19575 | CP | mg/L | < 20 | < 20 | <1 | 30% | Pass | |
| Carbonate Alkalinity (as CaCO3) | M21-Fe19575 | CP | mg/L | < 10 | < 10 | <1 | 30% | Pass | |
| **Duplicate** | | | | | | | | | |
| **Alkali Metals** | | | | Result 1 | Result 2 | RPD | | | |
| Calcium | B21-Fe15103 | NCP | mg/L | 210 | 200 | 2.0 | 30% | Pass | |
| Magnesium | B21-Fe15103 | NCP | mg/L | 110 | 100 | 10 | 30% | Pass | |
| Potassium | B21-Fe15103 | NCP | mg/L | < 5 | < 5 | <1 | 30% | Pass | |
| Sodium | B21-Fe15103 | NCP | mg/L | 390 | 400 | 4.0 | 30% | Pass | |

## Comments

### Sample Integrity

| | |
|---|---|
| Custody Seals Intact (if used) | N/A |
| Attempt to Chill was evident | Yes |
| Sample correctly preserved | Yes |
| Appropriate sample containers have been used | Yes |
| Sample containers for volatile analysis received with minimal headspace | Yes |
| Samples received within HoldingTime | Yes |
| Some samples have been subcontracted | No |

### Authorised by:

| | |
|---|---|
| Michael Morrison | Analytical Services Manager |
| Emily Rosenberg | Senior Analyst-Metal (VIC) |
| Scott Beddoes | Senior Analyst-Inorganic (VIC) |

**Glenn Jackson**
**General Manager**

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

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