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Mt Buller Water Security Off-Stream Storage Project:

Hydrological and Ecological Monitoring and Adaptive Management Program (HEMAMP) Condition 8 Assessment

Prepared for Alpine Resort Victoria - Mount Buller Mount Stirling Resorts

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Mt Buller Water Security Off-Stream Storage Project: Hydrological and Ecological Monitoring and Adaptive Management Program (HEMAMP) Condition 8 Assessment

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Summary

Mount Buller is an alpine resort, three hours drive from Melbourne, located in the Victorian Alps and managed by Alpine Resorts Victoria. Approximately 3 ha of Alpine Bog vegetation occur in patches at Mount Buller. Alpine Bogs are protected by state and federal environmental legislation, under the *Flora and Fauna Guarantee Act 1988* (FFG Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

During 2019–2020, a large off-stream water storage facility was constructed, between the summit and the village. Indirect impacts to some Alpine Bogs were considered possible, because of hydrological changes upslope. To address this risk prior to construction commencing, an EPBC Act referral was approved (EPBC 2014/7303) with a list of conditions, including:

- The development and implementation of a Hydrological and Ecological Monitoring and Adaptive Management Program (HEMAMP; Condition 6); and
- A review of the effectiveness of monitoring, mitigations or management measures (Condition 8) to achieve no more than a 10% reduction in Alpine Bog extent (Condition 2b).

This report addresses the requirement of Condition 8 with a focus on Condition 2(b) and includes a desktop review of all HEMAMP related documents, a site visit and a site meeting to gather additional information.

The monitoring, mitigation and management measures detailed in the HEMAMP have been effective in achieving the outcome of no more than 10% reduction in indirectly affected Alpine Bog extent.

Several individual measures however have either not been fully implemented or have resulted in a reduction in indirect Alpine Bog extent. Overall, the Alpine Bogs have reduced in extent by 6.8%, classified as an amber level reduction. Careful management and monitoring should be undertaken over the remainder of the monitoring period to ensure that the observed decline is reversed.

1. Introduction

Mount Buller is an alpine resort, three hours drive from Melbourne, located in the Victorian Alps and managed by Alpine Resorts Victoria (Mt Buller and Mt Stirling Resort Management, 2022a). In winter Mount Buller offers visitors up to 300 ha of skiable terrain accessible via 20 lifts (Mt Buller and Mt Stirling Resort Management, 2022b) and in summer visitors undertake a range of activities including bushwalking, four-wheel driving and mountain bike riding (Mt Buller and Mt Stirling Resort Management, 2022a).

Native vegetation on Mount Buller comprises several treeless sub-alpine Ecological Vegetation Classes (EVCs) and Sub-alpine Woodland EVC (DELWP, 2022), with approximately 3 ha of alpine bog vegetation known to be scattered within the resort (Biosis, 2019c). Alpine bogs include several plant communities and are protected by state and federal environmental legislation; with the 'Alpine Bog Community' listed as threatened under the *Flora and Fauna Guarantee Act 1988* (FFG Act) and the 'Alpine Sphagnum Bogs and Associated Fens' (ASBAF) ecological community listed as endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

During 2019–2020, a large off-stream water storage facility was constructed at Mount Buller (Figure 1), between the summit and the village (Biosis, 2019c). As most of the Alpine Bog communities on Mount Buller are positioned downslope of the Project Construction Footprint, direct impacts to these communities were assessed as unlikely. However, indirect impacts because of hydrological changes upslope were considered possible, especially given Alpine Bogs are "*dependent on the maintenance of local hydrological conditions, particularly groundwater*" (Department of the Environment, 2015).

To address this risk, prior to construction commencing, an EPBC Act referral was approved (EPBC 2014/7303) with a list of conditions, including:

Condition 6, which requires:

"The approval holder must implement the Hydrological and Ecological Monitoring and Adaptive Management Program (HEMAMP) for the life of the approval…"

The main objective of the HEMAMP (Biosis, 2019a) is to maintain the extent and condition of the downslope Alpine Bogs, including baseline data collection, annual monitoring and if required, revised monitoring, mitigations or management measures.

Condition 8 of the EPBC Act approval stipulates:

"Within three (3) months following the third anniversary of commencement of the action, the approval holder must assess the effectiveness of the monitoring, mitigation, and management measures in the HEMAMP in achieving the outcome in condition 2(b)…."

Condition 2(b) requires:

"…. No more than a 10 per cent (0.090 hectare) reduction in the total combined area of indirectly affected areas of Alpine bogs".

This report addresses the requirement of Condition 8 with a focus on Condition 2(b) and includes a desktop review of all HEMAMP related documents, two site visits and site meetings to gather additional information.

Figure 1. New water storage dam (Boggy Creek Reservoir) above alpine bog monitoring areas, Mt Buller

2. Methods

2.1 Audit area

Six Alpine Bogs identified as at risk of indirect impacts from the water storage project were the focus of this HEMAMP Condition 8 assessment report (Figure 2 in: Biosis, 2022a)

2.2 Desktop Review

Prior to undertaking the site visits and site meetings, the following documents were reviewed with a focus on monitoring, mitigation and management information relevant to changes in extent of the indirectly affected Alpine Bogs:

- HEMAMP (Biosis, 2019a);
- HEMAMP Protocol (Biosis, 2022a);
- HEMAMP Baseline Years 1 and 2 Monitoring (Biosis, 2019c);
- HEMAMP Impact Year 1 Monitoring (Biosis, 2020b);
- HEMAMP Impact Year 2 Monitoring (Biosis, 2021);
- HEMAMP Impact Year 3 Monitoring (Biosis, 2022b); and
- Ecological Rehabilitation Plan (Biosis, 2020a).
- Ecological Rehabilitation Plan – Addendum (Biosis 2022c).
- Mt Buller HEMAMP Groundwater and Surface Water Monitoring Review (GHD, 2022).

2.3 Site visits and site meetings

Two site visits were undertaken on 17 January and 17 February 2023 and, site meetings with the Environmental Services - Mt Stirling Operations Manager (Louise Perrin) was undertaken on 18 January and 17 February 2023.

3. Results

3.1 Desktop Review

The desktop review focused on assessing the effectiveness of the monitoring, mitigation, and management measures stipulated in the HEMAMP in achieving the outcome of no more than 10% reduction of indirectly affected Alpine Bog extent. A review of the effectiveness of each (monitoring, mitigation and management) is summarised below.

3.1.1 Effectiveness of monitoring on Alpine Bog extent

Ecological monitoring — Ecological monitoring has been undertaken in accordance with the HEMAMP for the three years since construction (Table A1.1; Biosis, 2022b). Alpine Bog: extent, composition (bog-dependent flora species richness), encroachment (non bog-dependent flora species and weeds) and structure (peat moss cover) have all been monitored, analysed and reported, over the three years since construction (Biosis, 2020b, 2021, 2022b).

This ecological monitoring identified changes in indirectly affected Alpine Bog extent when compared to changes in the extent of control sites: a reduction of 6.8% from baseline data by Year 3 (Biosis, 2022b). According to the HEMAMP, this reduction in extent is an 'amber' trigger level (Biosis, 2022a), triggering management actions including:

"……*sediment control, weed control, pest animal (deer and rabbit) control and revegetation. In accordance with the HEMAMP Protocol (Biosis 2022b), if the criteria that are within the 'amber' trigger level do not return to the 'green' trigger level within 3 years (i.e. by IY6), management actions and effort will need to be increased* (Biosis, 2022b)*."*

This 'amber' trigger level reduction in extent was analysed in detail in the Year 3 ecological monitoring report (Biosis, 2022b). It was noted that:

- The control sites at Mount Stirling had a 9.7% increase in extent from baseline;
- The control sites at Mount Buller had a 1.3% increase in extent from baseline;
- The combined control sites had a 5.1% increase in extent from baseline; and
- The indirectly affected Alpine Bogs had a 1.8% loss of extent from baseline.

When indirectly affected Alpine Bogs were compared to Mount Buller control sites only, the reduction in extent dropped to 3.1%. According to the HEMAMP, this reduction in extent is a 'green' trigger level. Excluding Mount Stirling control site extent data from the analysis of extent calculation was a recommendation in the Year 3 ecological monitoring report (Biosis, 2022b).

Climate monitoring — Climate monitoring at Mount Buller and Mount Stirling has been undertaken in accordance with the HEMAMP (Biosis, 2021) and other climate observations have also been noted e.g. rime ice events which occurred in Year 3. Though no links between climate data and changes in indirectly affected Alpine Bog extent were discussed in the ecological monitoring reports (Biosis, 2020b, 2021, 2022b), in relation to rime ice, the Year 3 ecological monitoring report (Biosis, 2022b) noted that:

"*The effect of rime ice events in IY3 has been relatively localised and spread evenly across monitoring sites. It is therefore unlikely that rime ice events have contributed to the decline in **area** of impacts sites relative to control sites*."

Hydrological monitoring — Some hydrological monitoring data has been collected in accordance with the HEMAMP over the three years since construction (Table A1.1; Biosis, 2021a; Biosis, 2022b; GHD, 2022). Unfortunately, due to several factors, most surface water flow and groundwater depth data is missing (Biosis, 2021; Biosis 2022b; GHD, 2022). The Year 2 ecological monitoring report (Biosis, 2021) noted that:

"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."

This includes inferences related to how hydrological changes may be contributing to a reduction in the indirectly affected Alpine Bog extent, because it is unknown if these hydrological factors have changed.

3.1.2 Effectiveness of mitigation measures on Alpine Bog extent

Mitigation measures, designed to avoid and minimise impacts to the indirectly affected Alpine Bogs resulting from the water storage project were incorporated into the design and construction phase of the project and detailed in the HEMAMP (Section 8.1; Biosis, 2019a). Four key mitigation measures were planned: drainage, watering system, micrositing and safety bund. The drainage and watering system mitigations measure are permanent and remain in place following the completion of the dam construction, whereas the micrositing and safety bund were temporary mitigations measures, removed following the completion of the construction project.

Drainage — To mitigate the risk that construction of the water storage facility may impact surface and ground water quality and quantity in the Alpine Bogs:

- Around the water storage facility and access tracks, water runoff was to be directed "*along the natural flow path towards the downslope Alpine Bogs.*"
- Overflow water was to also be directed towards the Alpine Bogs; with sediment protection incorporated.
- An internal drainage system was to be incorporated into the water storage and earth embankment to control groundwater pressure. Groundwater seepage was to be collected and re-distributed to an aqueduct running through the downslope Alpine Bogs.

The Year 1 ecological monitoring report (Biosis, 2020b) made the following observations related to overflow water sediment protection and the aqueduct:

"*Sediment, primarily from the dam embankment, appears to have washed downhill and into the impact sites. Some sediment has been collected by the aqueduct, which is situated east-west through the middle of the Alpine Bogs….. some areas that are buried in 10–20 centimetres of sediment have been colonised by weeds, resulting in loss of Alpine Bog **extent**….. There is a risk that these weeds will*

*become permanently established on new bare ground caused by sedimentation, resulting in a permanent loss of bog **extent**."*

The Year 1 ecological monitoring report (Biosis, 2020b) also noted that sedimentation was observed at one control site (Bog 11.1).

In relation to weeds impacting indirectly affected Alpine Bog extent, weed cover in these sites has increased from a baseline of 5.4/6.3% to 8.8% by Year 3 (Biosis, 2022b). This increase in weed cover in the indirectly affected Alpine Bogs is a 'red' trigger level, requiring management actions. Management actions related to weed control are discussed below (Section 3.1.3).

Some information related to overflow water was provided in the Year 3 monitoring report (Biosis, 2022b). Artificial watering of the Alpine Bogs had been occurring, with this artificial watering attributed to an error associated with an overflow pipe on a water tank positioned above the Alpine Bogs. It was unknown when this artificial watering from the overflow pipe commenced but it was reported to have stopped in November 2021. In relation to indirectly affected Alpine Bog extent, it was noted that:

"*The 1.3% increase in the **area** of Mount Buller control sites has been driven by an increase in area at Mount Buller's eastern control sites (Bogs 1, 2 and 11.1), which may have benefitted from artificial watering*."

Watering system — To mitigate the risk that construction of the water storage facility will impact on surface and groundwater quality and quantity:

- Construction of an underground watering system to allow environmental watering of priority Alpine Bogs by recharging underwater springs.
- Including an underground infiltration trench lined with aggregates and geocloth to prevent sediments and weeds from entering the Alpine Bogs.
- And controls to allow the discharge of water to eastern or western Alpine Bogs, as required, with the aim of mimicking the nature groundwater seepage and surface water flow patterns.

Impacts to indirectly affected Alpine Bog extent associated with the environmental watering system, noted in the Year 2 ecological monitoring report (Biosis, 2021) include:

"…. *approximately 8 square metres of Bog 4.2 was directly removed during construction of the environmental watering system in April and May….. these direct impacts will have contributed to loss of bog extent in IY2*."

Also, in relation to the environmental watering system and indirectly affected Alpine Bog extent, the Year 3 ecological monitoring report (Biosis, 2022b) notes:

"…. *dieback of native vegetation immediately downslope of the environmental watering system*"

And, although the cause of this dieback was unknown, the Year 3 ecological monitoring report suggests it could be the result of supplementary watering of the aqueduct from the environmental watering system. The Year 3 monitoring report therefore recommends: "*The potential role of the environmental watering system in localised hydrological changes must be investigated further*."

And speculates that:

"*In general, the localised hydrological changes appear to have had a positive effect on Alpine Bog vegetation, mostly at impact sites. As non bog-dependent species die back, they have been or are likely to be replaced by bog-dependent species and result in increases in bog **extent**. However, the mortality of non bog-dependent species may also provide opportunities for weeds to colonise, which has already occurred at Locations D6 and D16. While this may not result in a direct loss of Alpine Bog **extent**, it is likely to place further weed pressures on nearby Alpine Bogs and should therefore continue to be monitored and treated, if necessary*."

Micrositing — To mitigate risk of direct impacts to the indirectly affected Alpine Bogs during the construction phase, a qualified ecologist was to mark out the Alpine Bogs. The Year 2 ecological monitoring report states that, during the construction of the environmental watering system, eight square meters of Alpine Bog 4.2 was removed and that:

"*This was despite the south-eastern boundary of Bog 4.2 being flagged off by an ecologist and environmental manager before construction*" (Biosis, 2021).

Safety bund — During construction, a safety bund was to be installed at the northern edge of the dam, to minimise loose material moving downslope and to allow monitoring to continue during construction.

In relation to the movement of loose material (e.g. sediments and boulders) and indirectly affected Alpine Bog extent, the Year 2 ecological monitoring report (Biosis, 2021) noted:

"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…. 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…. 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**."

There is no reference to the safety bund in the ecological monitoring reports (Biosis, 2020b, 2021, 2022b).

3.1.3 Effectiveness of management actions on Alpine Bog extent

Originally the HEMAMP had three management actions (Biosis, 2019a): further investigation, environmental watering and weed management. The updated HEMAP Protocol (Biosis, 2022a) includes an additional three management actions: pest animal control, revegetation and water quality remediation. A summary of the effectiveness of these management actions on indirectly affected Alpine Bog extent, according to the monitoring reports (Biosis, 2019c, 2020b, 2021) is summarised below.

Further investigation — As stated in the update HEMAMP (Biosis, 2019b):

"The first step in any adaptive management will be further investigation to determine why a threshold may have been breached and to respond accordingly."

Recommendations of further investigation have been highlighted in each of the ecological monitoring reports. Most of these further investigation recommendations are relevant to other management actions (i.e. environmental watering, weed management, pest animal control, revegetation and water quality remediation).

For example, the Year 2 ecological monitoring report (Biosis, 2021) recommended that:

"*The presence or absence of Silver Astelia Astelia alpina var. novae-hollandiae from impact sites (particularly Bogs 4.2 and 6) should be <u>further investigated</u> 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*."

This further investigation recommendation was undertaken and based on these results the Year 3 ecological monitoring report recommended the following:

"*The RMB must organise for the propagation of Silver Astelia from material of Mount Buller provenance. The resultant tubestock should be planted in Bogs 4.2 and/or 6 during the revegetation works that are planned for autumn 2024 (tubestock of this species will not be available earlier). Precise planting locations should be determined with reference to the location of any remaining Silver Astelia individuals in the vicinity*."

Environmental watering

Management actions related to environmental watering are reliant on monitoring of surface water flows and ground water depth via a 'feedback loop'. Specifically, the updated HEMAMP (Biosis, 2019b) states that:

"*The amount of environmental water that is delivered will be proportionate to the divergence that has occurred in the hydrological model. The precise amount of water and the timeframe over which it is delivered will require close monitoring of amounts discharged from the environmental watering system and how these amounts affect surface water flows and groundwater levels. This will require increased frequency of data collation from the surface water and groundwater data loggers and inputting of this data into the hydrological model to verify whether the divergence is being reversed i.e. a feedback loop*."

The updated HEMAMP includes details about the hydrological model for which this 'feedback loop' is reliant (Biosis, 2019b). However, the hydrological model requires regular inputs of surface water flow and groundwater depth data to assess the effectiveness of the environmental watering program; and only partial hydrological data has been collected during the first three years since construction (Biosis, 2021, 2022b). Theis has delayed the development of the hydrological model and implementation of a feedback loop (if required). (Biosis, 2020b, 2021, 2022b).

Weed management

The weed management action, as described in the updated HEMAMP, may be required to ensure that weeds do not establish in the indirectly affected Alpine Bogs, changing the hydrology and creating conditions that favour weed invasion (Biosis, 2019b). A review of the Year 3 ecological monitoring

report notes several weed management actions that were implemented that year, applicable to indirectly affected Alpine Bog extent:

- 1500 hours of weed control, mostly undertaken as manual removal and with some herbicide use; and
- The establishment of ongoing trials using methods such as manual removal, heat treatment and smothering.

From Mount Buller and Mount Stirling combined, 2.5 tonnes of weed material was removed during this year.

Pest animal control

Pest animal controls are described in the updated HEMAMP as required to ensure that other management actions are successful (Biosis, 2019b). Pest animals, such as deer and rabbits can have direct impacts on the extent of Alpine Bogs, including browsing, digging and trampling. A review of the Year 3 ecological monitoring report (Biosis, 2022b) notes the following pest animal controls were implemented that year, applicable to indirectly affected Alpine Bog extent:

- Culling of 74 Sambar Deer Cervus unicolor; and
- Applying blood and bone around revegetation sites and after significant rain events, to deter browsing by European Rabbit *Oryctolagus cuniculus*.

Revegetation

The revegetation management action, as described in the updated HEMAMP, may be required to: reduce weed invasion, re-establish Alpine Bog areas impacted by sedimentation or to re-introduce bog-depended flora species, if lost (Biosis, 2019b). The HEMAMP refers to the Ecological Rehabilitation Plan (Biosis, 2020a) for details related to revegetation. The Ecological Rehabilitation Plan is centred on the principle of 'No Bare Ground' and requires 137,800 tubestock to be planted at a maximum rate of 15,000 per year, starting in autumn 2021.

Water quality remediation

The water quality remediation management action, as described in the updated HEMAMP, may be required if monitoring indicates that water quality parameters vary from baseline water quality results (Biosis, 2019b). The water quality remediation example provided in the updated HEMAMP focused on sedimentation and included identifying the source and implementing management actions with a focus on isolation and removing the source. Water quality remediation management actions implemented during Year 3 to address a loss of indirectly affected Alpine Bog extent attributed to sedimentation included (Biosis, 2022b):

- *"Installation and maintenance of more than 500 metres of sediment socks.*
- *Installation and maintenance of more than 20 metres of sediment fence, followed by disassembly before the declared snow season (end of IY3)."*

3.2 Site visits and site meetings

Site visits focused on observing monitoring, mitigation and management actions relevant to indirectly affected Alpine Bog extent. Site meetings followed each site visit and provided an opportunity to clarify information gathered during the desktop review and site visits. A summary of site visit observations and site meeting information, applicable to indirectly affected Alpine Bog extent is provided below.

3.2.1 Effectiveness of monitoring on Alpine Bog extent

Ecological monitoring — Some small patches of dieback were observed within the indirectly affected Alpine Bogs (e.g. Figure 2 foreground), however ARV suggested this patch of dieback may have been present pre-construction, based on feedback provided by Biosis. A larger area (up to 25 m^2) of dieback of adjoining non-bog vegetation was also observed (e.g. Figure 2 background), however, it is likely this dieback was also present in the area pre-construction. Non-bog vegetation dieback is discussed in detail in the Year 3 ecological monitoring report (Biosis, 2022b).

Climate monitoring — Climate monitoring data was provided during the site meeting.

Hydrological monitoring — Several groundwater boreholes were observed during the site visit (e.g. Figure 3). During the site meeting, the collection of groundwater depth and surface water flow data for input into the hydrological model as part of the 'feedback loop' was discussed. Since 2021, hydrological data has been collected and it is the intention of the ARV to continue this data collection ongoing and at required intervals. ARV anticipates that this hydrological data will be analysed in the year 4 monitoring reports.

Figure 2. Example of small areas of dieback observed with the indirectly affected Alpine Bog (11.2) in the foreground, with dieback of adjoining non-bog vegetation in the background (facing west). Both patches were reported as being observed pre-construction.

Figure 3. Example of a groundwater monitoring borehole being sampled (provided by ARV during the site meeting).

3.2.2 Effectiveness of mitigation measures on Alpine Bog extent

Drainage — Drainage lines were observed beside the dam and into the indirectly affected Alpine Bogs (e.g. Figure 4). These drainage lines included some sediment controls and boulders as energy dissipation measures. The aqueduct, with water present, was observed north of indirectly affected Alpine Bog 11.2 (Figure 5). The source of this water was discussed during the site meetings. Water in the aqueduct is sourced from a combination of naturally occurring ground and surface water, and potentially any excess flow through from below the dam and through the bogs. Sedimentation observed in the aqueduct was also discussed. Sedimentation has always occurred in the aqueduct, including pre-construction of the dam. Additional sedimentation was observed in the aqueduct during the dam construction and was associated with construction non-compliances. This collected, sediment was then flushed out and concentrated into Bog 6, contributing to impacts observed within this bog. Most of the sediment remaining in it now is old, remnant material.

Environmental watering — The general location of the western extent of the environmental watering system was observed, including an area of indirectly affected Alpine Bog 4.2 which was removed (8 square metres) during the construction of the environmental watering system (Figure 6). The environmental watering discharge point infrastructure located between the dam and the Alpine Bogs was also observed.

Micrositing — During the site meetings, some additional information about micrositing was provided. RMB and an ecologist from Biosis undertook micrositing pre-construction, on the 8 and 9 October 2019. Example photos were provided by ARV (e.g. Figure 7).

Safety bund — During the site meetings, additional information related to the safety bund was created provided. The safety bund was installed after some initial rocks had rolled from the site, over the sediment fence into the Alpine Bogs. ARV, Biosis and the regulators agreed these rocks should be left in situ, as removing them would create more damage. Photos of the safety bund installed after this initial rock fall were provided by ARV (e.g. Figure 8).

Figure 4. Example of a drainage line beside (west of) the dam.

Figure 5. A section of the aqueduct north of indirectly affected Alpine Bog 11.2 with some evidence of sedimentation.

Figure 6. Upper edge of indirectly affected Alpine Bog 4.2 where 8 m^2 of this bog was removed during the construction of the environmental watering system, with evidence of rehabilitation / revegetation observed.

Figure 7. Example of micrositing (provided by ARV).

Figure 8. Safety bunding installed during the dam construction (provided by ARV during the site visits).

3.2.3 Effectiveness of management actions on Alpine Bog extent

Further investigation — During the site meetings, an update related to the Silver Astelia further investigation (see section 3.1.3) was provided by ARV. Alpine Nursery, who are providing tubestock to revegetate the dam and surrounding project area, have not previously stocked Silver Astelia seed. However, as this species requires re-introducing to the indirectly affected Alpine Bogs, in 2023 Alpine Nursery plans to collect Silver Astelia seed, with the aim of germinating these plants over winter ready for planting as tubestock in autumn 2024. While this is underway, a permitted trial has commenced, dividing Silver Astelia plants from surrounding Alpine Bogs to begin the re-establishment of Silver Astelia in the indirectly affected Alpine Bogs.

Environmental watering — During the site meeting, the collection of groundwater depth and surface water flow data for input into the hydrological model as part of the 'feedback loop' was discussed. Groundwater depth and some surface water flow data has been collected since 2021, and it is the intention of the ARV to continue and improve this data collection from this point forward. By 2024 this data will be input into the hydrological model, with the results used to guide the environmental watering of the indirectly affected Alpine Bogs.

Weed management — Several environmental weeds including introduced *Juncus* species were observed scattered along the upper edge of the indirectly affected Alpine Bogs and along the aqueduct (e.g. Figure 8). During the site meetings some additional information about weed management was

discussed. ARV confirmed that 2.5 tonnes of weed material was removed from Mount Buller and Mount Stirling during the prior year; predominantly *Juncus* spp. Rushes, *Erythranthe guttata* Monkey flower, *Erythranthe moschata* Musk Monkey-flower, and *Glyceria declinata* Manna Grass.

Pest animal control — During the site meetings pest animal control was discussed with the following addition information provided. Blood and bone was applied in small amounts to protect key areas twice last summer. Rabbits were also baited using 1080 on carrot in summer 2020/2021 and summer 2021/2022. Currently, rabbit numbers are very low and there is little/no evidence of browsing. By the end of 2022, 126 deer were removed. Deer control occurs ongoing (when conditions are right) by contractors approved by the Game Management Authority under permit from October to May annually.

Revegetation — Some revegetation was observed along the southern edge of indirectly affected Alpine Bog 4.2 (e.g. Figure 10). Some 'bare ground' was observed within the indirectly affected Alpine Bogs, including surrounds planted tubestock (Figure 10) and in areas where sedimentation has occurred (e.g. Figure 9). During the site meeting, additional information was provided related to the revegetation of the dam and surrounds, post-construction. There are two rehabilitation plans: the Ecological Rehabilitation Plan, and the Addendum. The Addendum is focused on addressing impacts associated with non-compliances in the indirectly affected Alpine Bogs. The ARV has implemented the Ecological Rehabilitation Plan since construction of the dam was completed. This includes planting 15,000 tubestock per year onsite. Another 15,000 plants are arriving onsite on 8 March 2023, with an additional 2500 for the indirectly affected Alpine Bogs. Creative Lines are contracted by ARV to provide independent annual monitoring reports on progress of Ecological Rehabilitation Plan implementation. The 2022 Ecological Rehabilitation Plan Monitoring Report was provided as an example.

Water quality remediation — Several observations related to sedimentation and water quality remediation were made during the site visit. Evidence of past sedimentation was observed along the southern edge of indirectly affected Alpine Bog 11.2 (Figure 11) and within the aqueduct (Figure 4). Sediment controls observed included a fence installed along the southern edge of some indirectly affected Alpine Bogs (e.g. Figure 12), along the edge of the track which runs along the northern edge of the dam (Figure 6) and within the drainage lines installed beside the dam (Figure 3). During the site meetings, some additional monitoring information was provided. Sediment controls are monitored weekly (data on a spreadsheet) and reported monthly to Alpine Planning – formerly Department of Energy, Environment and Climate Action (DEECA), now Department of Transport and Planning (DTP).

Figure 9. Rock encroachment and point of sedimentation and weed establishment observed on the upper edge of indirectly affected Alpine Bog 11.2.

Figure 10. Revegetation along the upper extent of indirectly affected Alpine Bog 4.2.

Figure 11. Evidence of past sedimentation on the southern edge of indirectly affected Alpine Bog 11.2.

Figure 12. Example of sediment controls installed above the indirectly affected Alpine Bogs.

4. Discussion

Combining the desktop review, the site visits and meetings results; a summary of the effectiveness of each of the monitoring, mitigation measures and management actions on the extent of the indirectly affected Alpine Bogs is provided below. This summary uses a similar 'green', 'amber' and 'red' trigger level system used in the ecological monitoring reports, where 'green' is effective, 'amber' is partially effective and 'red' is ineffective.

4.1 Effectiveness of monitoring on Alpine Bog extent

Ecological monitoring has been undertaken for the last three years and has been effective at identifying ecological changes. Climate monitoring and hydrological quality data has also been undertaken, though the management of this data has only been partially effective. However, surface water flow and groundwater depth has not been monitored in accordance with the HEMAMP and has therefore been ineffective.

Ecological monitoring:	Effective
Climate monitoring:	Partially effective
Hydrological monitoring:	Ineffective

4.2 Effectiveness of mitigation measures on Alpine Bog extent

The effectiveness of these mitigation measures focuses on the construction phase of the project only. The long-term effectiveness of the drainage and watering system are addressed in section 4.3 (below). The safety bund and drainage system were partially effective: both were installed during construction however sediments and boulders were still able to enter the indirectly affected Alpine Bogs, resulting in a loss of extent. The environmental watering system was effectively micro-sited prior to construction, however during construction the micrositing was not adhered to and was ineffective, resulting in the removal of 8 square meters of Bog 4.2.

Drainage:	Partially effective
Watering system:	Effective
Micrositing:	Partially effective
Safety bund:	Partially effective

4.3 Effectiveness of management actions on Alpine Bog extent

The further investigation management action has been implemented and, where implemented, has been effective. The effectiveness of the environmental watering management action could not be assessed, as surface water flow and groundwater depth data have not been collected and therefore, the hydrological model not updated, or the 'feedback loop' (including turning on the environmental watering system) implemented. Weed management, pest animal control revegetation and water quality remediation have all been implemented effectively.

Further investigation:	Effective
Environmental watering:	Not assessed
Weed management:	Effective

Pest animal control:	Effective
Revegetation:	Effective
Water quality remediation:	Effective

4.4 Combined effectiveness of monitoring, mitigations measures and management actions on Alpine Bog extent

Overall, the combined monitoring, mitigations measures and management actions have been effective at achieving Condition 2(b):

"…. no more than a 10 per cent (0.090 hectare) reduction in the total combined area of indirectly affected areas of Alpine bogs".

In the three years since construction, indirectly affected Alpine Bog extent has reduced between 3.1% (when Mt Stirling control sites are excluded from the calculation) and 6.8% (when Mt Stirling control sites are included in the calculation). Though this is currently within the 10% threshold, if the decline continues from 3.1% then over ten years, the 10% threshold may be breached or if this decline continues from 6.8% then the 10% threshold may be breached in the next two years.

COMBINED MONITORING, MITIGATION MEASURES AND MANAGEMENT ACTIONS:	Effective

5. Recommendations

R1 – As indicated and as intended by resort management, ground and surface water monitoring should continue to ensure that the modelling can be completed and environmental watering requirements can be determined. Timing 2023, 2024, 2025.

R2 – Establish environmental watering regime and commence watering if required. Inspect and maintain associated infrastructure. Timing – annual.

R3 – Maintain or replace sediment control measures where sediments, rocks and weed propagules are entering bog areas from upslope. Timing – ongoing.

6. References

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