Mt Buller and Mt Stirling Alpine Resort Management Board

Mt Buller Sustainable Water Security Project: Off-stream Storage

Hydrological and Hydrogeological Report

July 2014

Executive Summary

GHD Pty Ltd (GHD) was engaged by the Mt Buller and Mt Stirling Alpine Resort Management Board (RMB) to undertake a variety of technical investigations as part of developing the concept design for the Mt Buller Sustainable Water Security – Off Stream Storage Project.

This report documents the results of the hydrological and hydrogeological investigations undertaken, and, based on the results presents a series of conclusions in terms of potential impacts of the proposed development. A number of relevant impact mitigation and management measures are also identified.

Hydrology

The proposed storage is located in the upper northern reaches of the Delatite River catchment, (within the Boggy Creek sub catchment) and is approximately 150 m from the neighbouring Howqua River catchment divide. Both rivers are part of the Goulburn River catchment.

The surface water and groundwater spring flow draining from the northern slopes of the Boggy Creek catchment is collected in an aqueduct (north and downslope from the proposed storage) which directs the water in a north-westerly direction towards a decommissioned weir. The aqueduct overflows from a weir structure and at specific locations along its length. These overflows define the flowpath for tributaries of Boggy Creek immediately downstream of the aqueduct.

Hydrogeology/Aquifers

Subsurface intrusive investigations were undertaken to characterise the complex geology and hydrogeology of the storage site. The geology comprises granites, overlain by several episodes of sediment deposition, volcanics, and associated weathering.

Groundwater flow is complex with flow comprising both porous media (sediments, reworked and weathered granite) and fracture flow systems (basalt and granite). Groundwater flow is topographically controlled, radiating from the summit, however at a local scale, fracturing and secondary porosity features are expected to influence groundwater movement.

Alpine bogs (including sphagnum), groundwater dependent ecosystems (GDE’s), have been mapped north of the proposed storage site. The Alpine bogs are a threatened community under Commonwealth and State legislation. Waterlogging, including shallow groundwater is considered important for their existence.

The depth to groundwater at the storage footprint was around 12.5 m below surface (summer 2014 monitoring). The depth to groundwater reduces with increasing distance northwards, and ultimately the surface expression of groundwater can be observed north of the proposed storage near the aqueduct. A series of springs and groundwater seepage areas have been mapped. During the late summer (2014) period water levels at a number of bores in the vicinity of the Alpine bogs were observed at 1 m below the surface. Water levels in late autumn were observed at the surface indicating a significant seasonal variation and rapid recharge response times in groundwater depth.

Groundwater quality is high (Segment A), with low groundwater salinities.

Identification of Risk and Impact Assessment

A risk assessment was undertaken to identify the potential impacts of the proposed storage construction on the surface water and groundwater environments. The following conclusions are made regarding the site hydrology, hydrogeology, and impact assessment:

- A recharge analysis incorporating mapping of individual alpine bog areas was undertaken to assess changes to surface water and groundwater recharge. The analysis indicated:
  - An approximate 2.5% reduction in the total catchment area to the Boggy Creek Diversion (at Boggy 1 pump station). This is considered to have negligible impact to the Mt Buller Resort water supply.
  - Variable levels of potential impact to individual bogs (as a result of rainfall interception by the storage) based on the catchment area of the bog and its location in relation to the storage dam. Of the 12 mapped Alpine bogs, 6 bogs had interpreted ‘groundwater’ catchments that were potentially influenced by the proposed storage construction. A worst case reduction in direct catchment recharge (50%) was interpreted at bog F. The analysis was considered conservative as it did not account for lateral groundwater flow from other parts of the Mt Buller summit.
- ‘Carbonaceous Mudstone’ identified during field investigations potentially represents an Acid Sulphate Soil (ASS). Further investigations are required to inform this risk, however the likelihood is considered low.
- Contamination of surface or groundwater could occur through construction activities (for example through a fuel spill).

Mitigation Measures

To protect the Alpine bogs, a number of mitigation measures have been proposed to proactively supply environmental water to the bogs:

- Designing drainage and landscaping works of the storage (and its embankments) to redirect surface run-off to the bog catchment areas most likely to be affected by reduced recharge.
- Diversion and management of the seepage water captured by the drainage blanket underlying the storage, to supply the bogs potentially impacted by reduced recharge.
- Artificial watering of potentially impacted bogs using a designed (subsurface) irrigation system.

There is some uncertainty associated with the assessment and quantification of impacts to the Alpine bogs by reductions in recharge. The efficacy of the artificial watering, the design and operational requirements of such a system, contingency measures, and geotechnical considerations (stability) with watering regimes require further investigation.

To mitigate against surface and groundwater contamination during construction, an appropriate project specific Construction Environment Management Plan (CEMP) should be implemented.

Groundwater Management Plan

It is recommended that a project and site specific Groundwater Management Plan (GMP) be developed. This plan would form part of a project Monitoring and Management Plan and would be integrated with ecological and surface water monitoring activities. Monitoring activities would be undertaken to characterise existing conditions. Monitoring information would be also used to inform the detailed design and construction phases of the project, and to assist with post construction adaptive management and impact mitigation aspects associated with the Alpine bogs. An indicative scope and outline of the GMP has been included in this document.

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1. Introduction

1.1 Background

The Mt Buller and Mt Stirling Alpine Resort Management Board (RMB) is responsible for the management of the Mt Buller and Mt Stirling Resorts. These Resorts cover an area of 5,000 hectares in North East Victoria. The RMB has a series of performance obligations and objectives associated with its management of Mt Buller and Mt Stirling. One of these objectives is the provision of a safe and reliable water supply.

The Mt Buller Alpine Resort (the Resort) has significant constraints on its water supply. The water requirements of the Resort are determined by the need to service the resident and visitor populations, and to maintain the amenity and functionality of the Resort during winter for skiing and snow-play.

The RMB has established the Mt Buller Sustainable Water Security Project which encompasses a series of projects designed to assist it in meeting its obligation to provide a safe and reliable water supply to the Resort, both now and in the future. One component of the Mt Buller Sustainable Water Security Project is the development of an Off-Stream Storage facility and an associated upgrade of the Resort water supply and treatment infrastructure. Based on a number of previous investigations, assessments and reviews, the RMB have determined that a 100 ML on-mountain storage is required to assist it in meeting future water supply demands.

GHD Pty Ltd (GHD) was engaged by the RMB to undertake geotechnical, hydrological and hydrogeological as part of the concept design for the Off Stream Storage Project.

This report documents the results of the hydrogeological investigations and includes the following specific, technical information:

- Geological setting;
- Monitoring bore construction;
- Site potentiometry;
- Site groundwater quality;
- Hydrological setting;
- Discussion of the potential impacts of dam construction on the groundwater and surface hydrology environment.

Based on the results of the hydrogeological and hydrology investigations, conclusions are made regarding the potential impacts of the proposed development, and relevant mitigation measures are identified.

This report should be read in conjunction with the limitations of the investigations, which have been documented in Section 1.2.

1.2 Limitations

This report: has been prepared by GHD for Mt Buller and Mt Stirling Alpine Resort Management Board and may only be used and relied on by Mt Buller and Mt Stirling Alpine Resort Management Board for the purpose agreed between GHD and the Mt Buller and Mt Stirling Alpine Resort Management Board as set out in section 2.1 of this report.

GHD otherwise disclaims responsibility to any person other than Mt Buller and Mt Stirling Alpine Resort Management Board arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

This Report should not be altered, amended or abbreviated, issued in part or issued incomplete in any manner whatsoever without prior checking and approval by GHD which GHD may provide or withhold in its absolute discretion. GHD expressly disclaims responsibility for any liability which may arise from circumstances of issue of this Report in part or incomplete or its modification in any way whatsoever.

GHD has prepared this report on the basis of information provided by Mt Buller and Mt Stirling Alpine Resort Management Board and by others. GHD has not independently verified or checked this information beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

Site conditions (including the presence of any hazardous substances and/or site contamination) may change after the date of this Report. GHD expressly disclaims responsibility:

- Arising from, or in connection with, any change to the site conditions; and
- To update this Report if the site conditions change.

2. Scope of Works

2.1 Scope

The hydrogeological and hydrological investigations consisted of:

- Completion of the development of the 14 monitoring bores installed for the project;
- An initial water level gauging event for the 14 monitoring bores;
- Water sampling and analysis from all groundwater bores, where possible, as well as at 2 surface water locations;
- Slug testing at all monitoring bores, where possible;
- Discussion of the potential impacts of the proposed water storage development on the groundwater environment and identification of impact mitigation measures; and
- Discussion of the potential hydrological impacts of the proposed water storage development, and identification of mitigation measures.

The hydrogeological and hydrological field work to investigate groundwater and surface water conditions at the site was undertaken from February 10th to 12th, 2014.

2.2 Methodology

The method applied for the hydrogeological and hydrological assessment was to describe the existing conditions based on a desktop review of available literature relating to the local geological, hydrological (catchment) and hydrogeological conditions, coupled with site specific groundwater investigations. The tasks undertaken were:

- Review of published and unpublished hydrogeological reports pertaining to the area in the immediate proximity of the site;
- Provide a description of the geology and relationships between aquifers at the local and regional scale, including the degree of confinement of the systems, the protection offered to the aquifers by the soil profile, unsaturated zone or aquitards, or the potential for downward seepage through to the aquifers via fissures, permeable soils;
- Describe the groundwater flow systems through the distribution of groundwater potentials, watertable depth and morphology, directions and rate of groundwater flow and seasonal fluctuations;
- Describe interpreted/inferred recharge, discharge and interactions between surface water and groundwater;
- Describe the groundwater and localised surface water chemistry / quality in relation to the interpreted geology and flow systems;
- Identify the groundwater segment and list the protected beneficial uses of the groundwater in relation to the SEPP (*Groundwaters of Victoria*);
- Identify the location of users/receptors of the groundwater systems such as bore owners, streams and wetlands; and
- Provide a concise summary of the conceptual hydrogeological model for the site.

These tasks informed a risk and impact assessment, which is presented in sections 7 and 8 of this report.

2.3 Assumptions

Hydrogeological investigations have relied on a number of data sources:

- Published geological and hydrogeological mapping;
- Government produced literature including zones, overlays, meteorological and topographical data;
- State Groundwater Management System (Victorian Data Warehouse); and
- Geotechnical Field investigation program.

These data sources have been referenced, where relevant, throughout the report and a complete list of references is provided in Section 11 of this report.

3. Site Hydrology

The proposed off-stream storage site is located in the upper northern reaches of the Delatite River catchment, within the Boggy Creek catchment and adjacent to the catchment divide (150 m) with the neighbouring Howqua River catchment. Both the Delatite and Howqua catchments are part of the Goulburn River catchment.

The Boggy Creek catchment is characterised by very steep topography, high average annual rainfall in the order of 1450 mm/year (BOM, 2003) and average annual evapotranspiration in the order of 1150 mm/year (BOM, 2003).

The storage is located approximately 800 m upstream of the Boggy Creek Diversion at Boggy 1 pump station. The Boggy Creek Diversion diverts water from Boggy Creek and an unnamed tributary for Mt Buller's water supply, and has a combined catchment area of approximately 0.58 km^2. A second water supply offtake (Boggy 2) occurs further downstream and is supplied by a larger catchment.

The storage is proposed to be located within 100 m of a number of environmentally significant Alpine bogs. Localised catchment mapping is discussed in Section 7.

4. Site Hydrogeology

4.1 Geology

4.1.1 Regional Geological Setting

A review of the Warburton 1:250,000 geology map issued by the Geological Survey of Victoria was undertaken to assess the likely geology at the selected site during the concept design phase.

The regional geology has been shown in Figure 1, which shows the footprint of the proposed water storage. The regional geological plan identifies three geologies:

- Tertiary age basalts (designated orange on plan);
- Devonian age granites (designated red on plan); and,
- Devonian age hornfels (Cobbannah Group), formed by the contact metamorphism of country rock during the granite emplacement.

4.1.2 Site Investigations

Geotechnical investigations were undertaken from November 2013 to March 2014 which involved test pit excavations and the drilling of boreholes. The site investigations were undertaken to characterise conditions within the footprint of the proposed water storage, to determine characteristics of potential borrow materials, and to establish groundwater conditions.

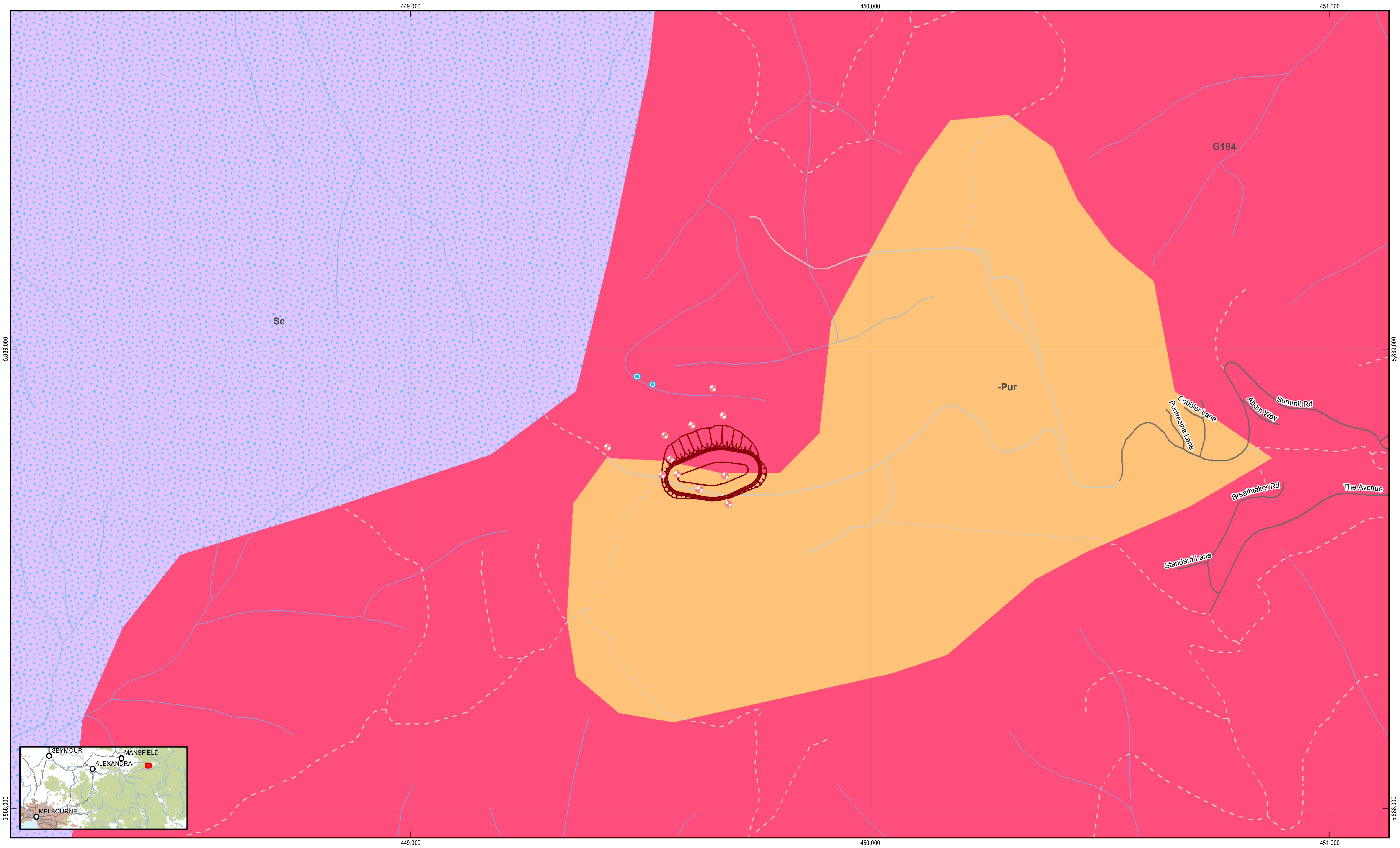
Details of the geotechnical investigations have been reported in the Geotechnical Factual Report (GHD, June 2014, reference 31/30733/230606). Fourteen of the geotechnical boreholes were completed as groundwater monitoring bores. The location of the monitoring bores is presented in Figure 2.

Lithological logs including bore construction details have been documented in the Project Geotechnical Factual Report (GHD, July 2014). Further geological mapping has been reported in the Project Geotechnical Risk Assessment Report (GHD, July 2014b, reference 31/30733/233153).

Figure 2 also shows the footprint of the dam and the groundwater monitoring bore locations. An interpreted 1 m contour has been superimposed upon the plan, which indicates that the proposed storage is located close to a ridge line. The land to the north and west falls in topography away from the ridge line.

4.1.3 Summary of Storage Site Geology

The subsurface intrusive investigations confirmed the regional mapping, with granite rock being confirmed as the basement rock in a number of investigation locations. The granite was intruded during the Devonian period with a subsequent period of uplift, exhumation and weathering. Eventually the granite formed a prehistoric land surface for an uncertain period of time. During this period the rock surface became deeply weathered and soil like. These granitic soils are also known as “grus”. With increasing depth beneath the project area the granite becomes less weathered and more competent.



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0 50 100 200 300

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Monitoring Bore Locations	Control Footprint	Sealed road (arterial and local)	**Geological unit 250k**
● Surface Water Monitoring Locations	Stream	Unsealed road	**Geographic Feature ID**
		Track and bike path	🟧 -Pur (Older Volcanics)
			🟥 G184 (Devonian Granite)
			▨ Sc (Cobbannah Group Hornfels)

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Site Geology

Figure 1

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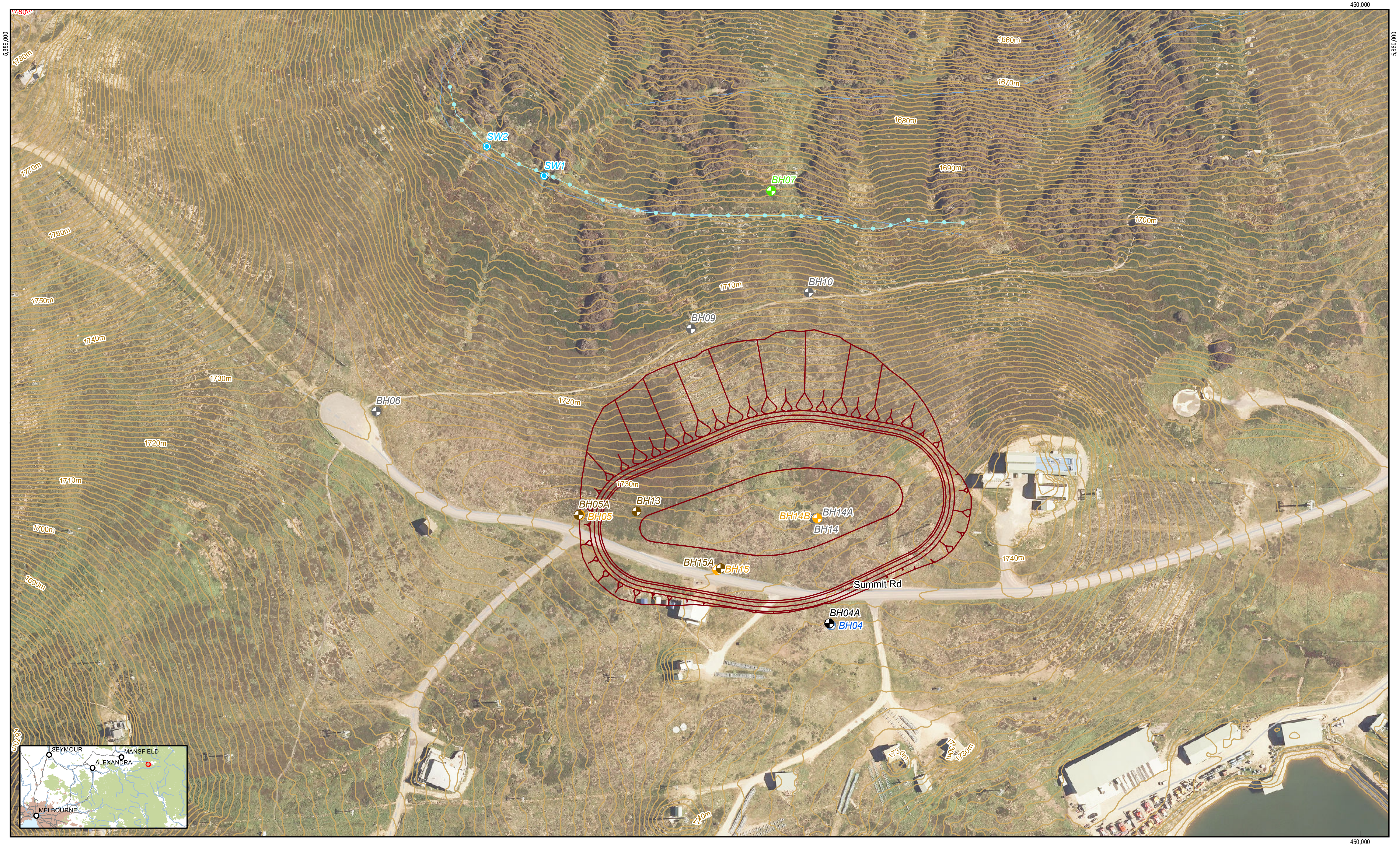
Data Source: DEPI: Vicmap - 2013; GHD - 2013. Created by: mjahanshahi



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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Monitoring Bore Locations

Interpreted Geology

- Basalt
- Bogg
- Colluvium
- Granite
- Granitic Alluvium
- Lake Alluvium
- Surface Water Monitoring Locations
- Aqueduct
- Control Footprint
- Contour 1m
- Stream
- Unsealed road
- Track and bike path

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Bore Location Map

Figure 2

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Data Source: DEPI: Vicmap - 2013; GHD - 2013. Contours, DEPI, 2013 Created by: mjahanshahi

Since the early Tertiary period, the granite has been capped in places with a relatively complex lithological profile comprising several phases of deposition of sediments and volcanics. These filled a palaeovalley formed in the Devonian granite which still exists beneath the project area.

The commencement of valley infilling began in the early Tertiary and was possibly related to the relatively rapid uplift of the area. A significant deposit of colluvium comprising mostly cobble and boulder size high strength sandstone was deposited into the base of the valley. The colluvial material has been interpreted to depths of between 0.7 m (test pit TP03) and 21.2 m (borehole BH15). These colluvial sediments comprise variable mixtures of matrix to clast supported cobbles and boulders. The cobbles and boulders are typically of high to very high strength meta-sandstone. The matrix was generally of sandy clays, gravels, sands and sandy silts. The sediments are interpreted to be ancient (Tertiary age) landslide deposits.

Subsequent volcanic activity released basalt of the Older Volcanics onto the valley floor. A period of deposition then commenced in a swampy environment potentially formed when lava flows and/or colluvial deposits dammed drainage lines allowing water to collect in the base of the valley. These swamp deposits formed organic rich carbonaceous clays and silts which have subsequently lithified to weak mudstones with minor impersistant coal seams. These sediments were encountered at depths from 6.0 m to 15.5 m below surface level at the time of investigations. A second, later lava flow deposited an upper capping of basalt lava over the valley fill sediments. This basalt layer has protected the valley fill materials from erosion during the uplift of the area. This basalt layer is highly variably weathered (from extremely weathered to fresh) due to the exposure of this rock at surface for much of the last 30-40 million years. Outcrops of basalt in a fresh state have, however, been located in the south east portion of the proposed storage area.

A layer of residual soil exists across the site tending to be clay rich, being either derived from the basalt, or granitic geology. A layer of sandy clay topsoil is present beneath much of the storage area to a depth of approximately 200 mm to 400 mm.

4.1.4 Summary Geology: Stockpile Areas and Ancillary Infrastructure

Whilst the intrusive geotechnical and geological investigation work was focused on the storage area, basic geological mapping was completed at the proposed stockpile areas, at the treatment plant site and at the two tank sites. The results of this mapping are presented in Figure 1 and also further defined in the Geotechnical Risk Assessment Report (GHD July 2014b).

4.2 Identified Aquifers

4.2.1 SAFE aquifer layers

Due to the limited drilling information in the area, to gain an appreciation of the thickness of each major aquifer and aquitard underlying the study area, the Secure Allocation Future Entitlement (SAFE) framework mapping program was interrogated.

The results are presented in Table 1. The SAFE mapping is broad scale, which results in the collective classification of the geology into a single aquifer system.

Table 1 SAFE Aquifer Report

Aquifer / Aquitard	Description	Depth (m)	
		From	To
BSE Mesozoic and Palaeozoic Bedrock (basement)	Sedimentary (fractured rock): Sandstone, siltstone, mudstone, shale. Igneous (fractured rock): includes volcanics, granites, granodiorites	0	>200

Source: DEPI 2014c

4.2.2 Site Aquifer Interpretation

All of the above described lithologies, where saturated, represent aquifers to varying degrees. Both the granite and competent Older Volcanic basalt represent fractured rock aquifers where groundwater is stored and transmitted by fractures, joints and other discontinuities within the rockmass.

Due to the nature of their emplacement, granites tend to be massive rock masses, with low fracture densities, compared to the extrusive Older Volcanics basalt where fracture density is generally higher.

Groundwater flow systems within the granite are likely to be complex. Flow within the slightly weathered to fresh granite would likely be dominated by the secondary porosity mechanisms. With increased weathering, or reworking of extremely weathered granite (granitic soils and grus), groundwater flow may be analogous to porous media flow.

The carbonaceous mudstone unit tends to be fine grained and therefore it is likely to act like an aquitard, forming either a perching bed or confining layer for the underlying saturated granite (granite rock and soils).

The colluvium comprises variable mixtures of both fine and coarse grained sediments. It is interpreted to behave as a porous media continuum where saturated.

Surface expression of groundwater, i.e. spring flow, occurs across a wide area within the upper reaches of the Boggy Creek catchment. At the proposed storage site, expression is around 250 m downslope from the Mt Buller Summit Road at approximately 1,710 m AHD. The surface expression is 100 m from the proposed excavation (cut) of the storage and can often be mapped or defined by the Alpine bog communities. The surface water draining from the northern slopes of the Boggy Creek catchment is collected in an aqueduct which directs the water in a north-westerly direction across the mountain towards a decommissioned weir.

4.3 Groundwater Monitoring Network

4.3.1 Construction Summary

A summary of the monitoring bore locations and construction is provided in Table 2. All bores were constructed from 50 mm PVC casing with machine slotted, 50 mm screens. The monitoring bores were constructed under bore construction licence WLE058684 issued by Goulburn-Murray Water. The bore construction was consistent with the BCL conditions, and the NUDLC (2012) guidelines.

Table 2 Bore Construction Summary

Bore ID	Zone 55 Co-ordinates		Total Depth (m bgl)	Screen (m bgl)		
	Easting	Northing		Top	Bottom	Screened Lithology
BH04	449,692.8	5,888,663	15.68	8.68	14.68	Carbonaceous Mudstone
BH04A	449,692.6	5,888,663	2.56	1.56	2.56	Basalt
BH05	449,547.4	5,888,727	19.8	14	19.8	Granitic Soils
BH05A	449,546.6	5,888,727	2.5	1.5	2.5	Colluvium
BH06	449,429.0	5,888,787	9	6	9	Granite
BH07	449,658.3	5,888,915	1	0	1	Bog/Granitic Soil
BH09	449,611.8	5,888,835	6	3	6	Granite
BH10	449,679.9	5,888,856	9	6	9	Granite
BH13	449,580.0	5,888,729	9	6	9	Colluvium
BH14	449,683.5	5,888,724	19.5	16.5	19.5	Granite
BH14A	449,683.9	5,888,725	15	12	15	Granite
BH14B	449,684.4	5,888,725	9.5	6.5	9.5	Granitic Soils
BH15	449,626.7	5,888,695	23	20	23	Granitic Soils
BH15A	449,629.6	5,888,696	6	3	6	Colluvium

Note: m bgl – metres below ground level

4.3.2 Bore Development

All of the bores at Mt Buller had been developed prior to hydrogeological investigation, except for bores BH15 and BH15A which had only been drilled the week before. Both bores were developed using manual bailing methods on February 11th 2014. Records of bore development are provided in Appendix A. Bore BH15A was developed successfully, and left to recover.

Bore BH15 was bailed dry before 3 bores volumes were removed. The last groundwater removed had high sediment loads, high turbidity of a light brown colour, indicating that the bore had not been sufficiently developed. Upon further investigation, the total depth of bore BH15 noted to be 18.3 m below the top of casing (m btoc). This indicated that the screen was fully silted up.

It is suspected that sediment has entered the bore through the screen at this location. The bore was observed over time to recover water, meaning that there is still hydraulic connection with groundwater, however it is likely that results from this bore are unreliable without further investigation into the condition of the bore or removal of the sediment in the base.

4.4 Neighbouring Groundwater Use

A search of the State Groundwater Management System (GMS) was undertaken to identify and characterise groundwater use in the region. There were no other registered groundwater bores within a 3 km radius of the proposed water storage.

4.5 Site Potentiometry

4.5.1 Groundwater Gauging

Water levels, total depth and stick up were measured at each bore location shown in Figure 2, the results of which are summarised in Table 3. Shallow bores BH04A, BH05A and BH07 (located in the Alpine bog at the northern edge of the site) were dry at the time of initial monitoring (mid February 2014).

4.5.2 Seasonal Groundwater Response

Due to the relatively recent installation of groundwater bores, there is insufficient monitoring data to determine the seasonal variability in groundwater levels.

Given the alpine climate (refer Table 17) it is considered a reasonable expectation for groundwater levels to exhibit a marked seasonal behaviour, with groundwater levels at their deepest towards the close of summer. Spring flow is also expected to decline during the same period.

4.5.3 Groundwater Flow

In general terms, groundwater flow occurs from the higher topographies to the lower topographies. With the proposed storage being located close to a ridge line based on topographic interpretation, groundwater flow would radiate from the ridge, i.e. components of groundwater flow to the north, and the south away from the ridge line.

Based on the bores screening the granite, the depth to groundwater in the granite becomes shallower relative to the ground level along flow lines. At the ridge line (footprint of the proposed water storage), the depth to groundwater is around 12.5 m below surface (bore BH14), and with increasing distances northwards (down slope), the depth to water shallows to 2.5 m (BH09).

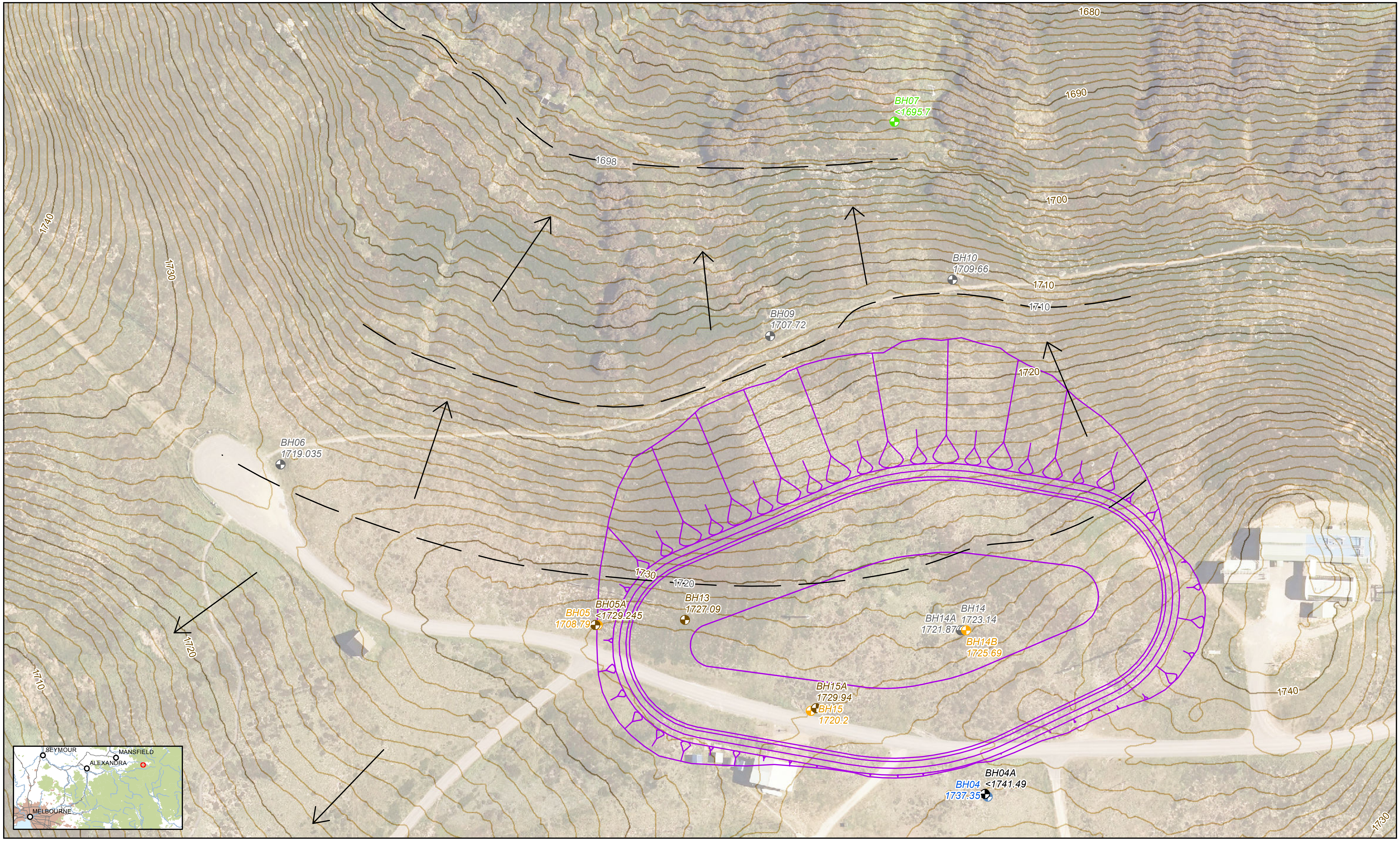
Interpreted groundwater contours are shown in Figure 3 for the groundwater monitoring event completed in February 2014. Note the interpretation focuses on groundwater flow towards the north (and sensitive receptors which are discussed later in the section 4.10). As noted above, there would be a component of flow towards the south which is not shown in Figure 3.

Table 3 Groundwater Water Levels

Bore	Geology Sequence	Measured Bore Depth (m btoc)	Stick up (m bgl)	Feb 2014		May 2014	
				SWL (m btoc)	RWL (m AHD)	SWL (m btoc)	RWL (m AHD)
BH04	Carbonaceous Mudstone	15.58	-0.10	6.97	1,737.35	5.48	1,730.52
BH04A	Basalt	2.38	-0.07	DRY	<1,741.49	1.71	1,734.29
BH05	Granitic Soil	19.67	-0.10	17.99	1,708.79	13.80	1,720.06
BH05A	Colluvium	2.33	-0.12	DRY	<1,729.245	0.30	1,733.52
BH06	Granite	9.02	-0.10	7.67	1,719.04	-	-
BH07	Granite	1.77	-0.09	DRY	<1,695.7	0.0 (at surface)	1,690.06
BH09	Granite	5.82	-0.10	2.72	1,707.72	0.57	1,710.22
BH10	Granite	8.825	-0.09	4.15	1,709.66	2.61	1,705.47
BH13	Colluvium	8.87	-0.09	5.32	1,727.09	2.18	1,733.65
BH14	Granite	19.35	-0.11	12.52	1,723.14	13.17	1,721.03
BH14A	Granite	14.98	-0.09	12.61	1,721.87	13.60	1,720.53
BH14B	Granitic Soil	9.44	-0.09	9.03	1,725.69	8.38	1,725.67
BH15	Granitic Soil	18.29	-0.11	13.06	1,720.20	13.45	1,722.63
BH15A	Weathered basalt/Colluvium	5.5	-0.12	4.03	1,729.94	1.75	1,734.34

Notes:

1. m bgl – metres below ground level
2. m AHD – metres relative to Australian Height Datum
3. SWL – Standing Water Level
4. RWL – Reduced Water Level



Paper Size A3

0 5 10 20 30 40

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Interpreted Geology

- ● Basalt
- ● Bog
- ● Colluvium
- ● Granite
- ● Granitic Alluvium
- ● Lake Alluvium
- — Granite Groundwater Contours
- — Control Footprint

Ground Elevation (mAHD)

- — 10m contour
- — 1m contour

→ Groundwater flow direction

*1699m contour based on spring flow observations

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Granite Groundwater Contours
February 2014

Figure 3

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G:\31\3073314\GIS\Maps\Deliverables\31-30733_001_Groundwater Contours.mxd

Data Source: DEPI: Vicmap - 2013; GHD - 2013. Created by: jlearmonth

Further north and down the mountain, spring flow (daylighting expression of groundwater) is noted near bore BH07. During the site inspection completed in February 2014, the ground was waterlogged, and spring flow activity was identified near the aqueduct. Water level monitoring in May 2014 identified water at surface with bore BH7. This interpretation i.e. groundwater level at surface, has been incorporated into Figure 3.

Little information is available about the groundwater flow direction in other geological sequences. It appears that both the colluvium and granitic soils follow the land contours across the top portion of the site.

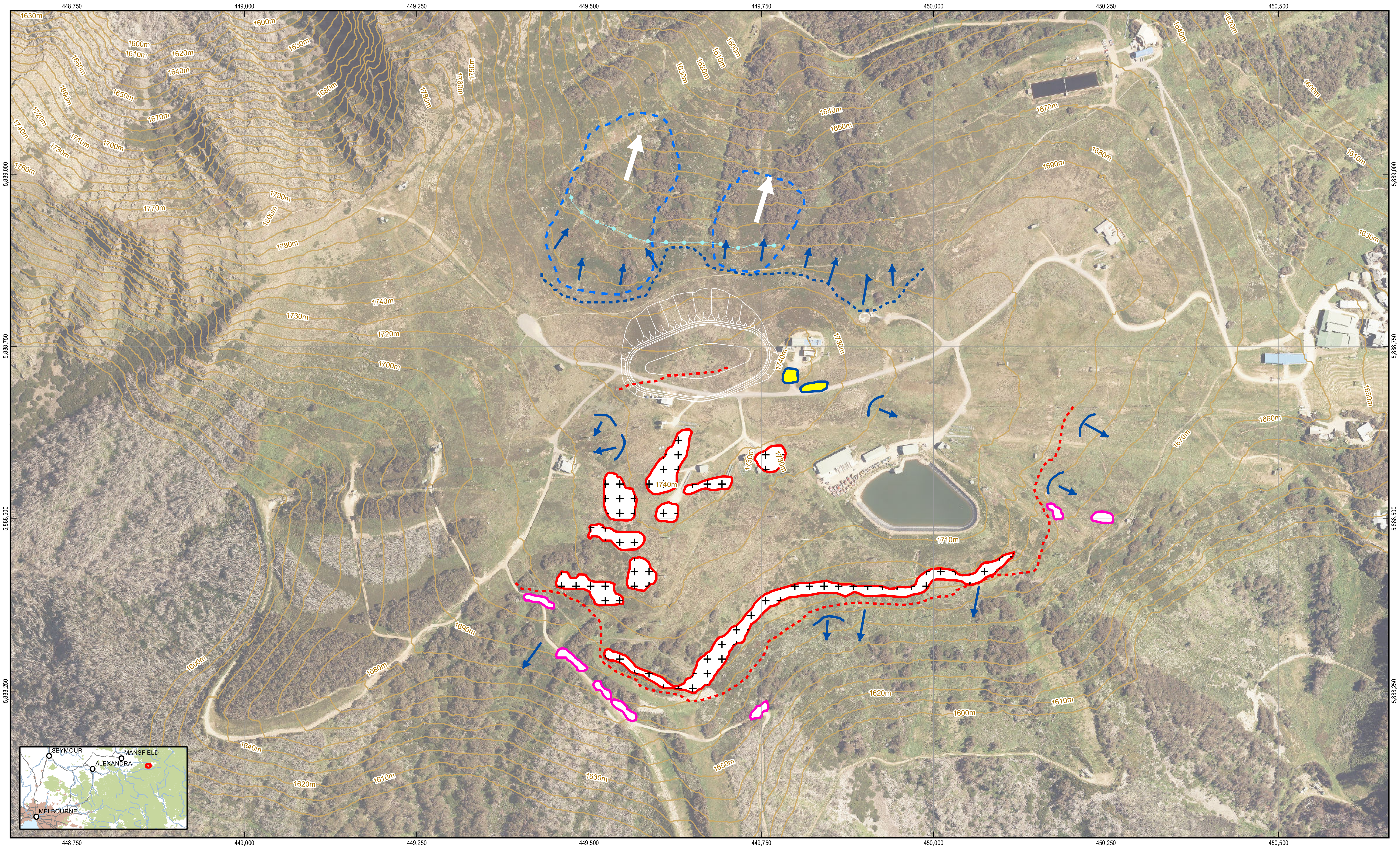
During the site investigation activities, mapping of spring activity was undertaken and an interpretation of identified spring eyes has been presented in Figure 4.

A number of springs were identified in areas adjoining the proposed storage footprint, some with obvious visual evidence of flows, other areas represented by saturated, water logged ground. The springs are emitted on either side of the ridgeline, and in particular, below the 1,710 m AHD interpreted topographic contour.

There are 4 nested monitoring bore sites on Mt Buller at the proposed storage site, which have been summarised in Table 4.

Table 4 Vertical Hydraulic Gradients

Nested Bores	Aquifer	Feb 2014		May 2014	
		Head Difference (m)	Vertical Gradient	Head Difference (m)	Vertical Gradient
BH04/04A	Carbonaceous mudstone / Basalt (shallow)	Shallow bore dry	Downwards	3.7	Downwards
BH05/05A	Granitic Soil / Colluvium (shallow)	Shallow bore dry	Downwards	13.5	Downwards
BH14/14A/14B	Granite / Granite / Granite Soil (shallow)	2 m to 3 m	Downwards	5	Downwards
BH15/15A	Granitic Soil / Colluvium (shallow)	9.7 m	Downwards	11.7	Downwards



Paper Size A3

0 25 50 100 150 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Aqueduct
- Inferred geological boundary
- Remnant landslide feature
- Spring/groundwater discharge
- Devonian granite outcrop
- Remnant landslide feature
- Tertiary alluvial outcrop
- Tertiary basalt outcrop
- Control_Footprint_v5
- Contour 10m

Mt Buller & Mt Stirling Resort Management
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Springflow Mapping

Figure 4

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Data source: Underground Services, Buller Ski Lifts and South East Water, 2013. Created by:mjahanshahi

February 2014

As the shallow bores BH04A and BH05A are dry, i.e. insufficient depth to intersect groundwater, a hydraulic gradient cannot be determined. Bore BH15A shows less than 10 m of downward pressure head between the granitic soil and the colluvium. This indicates a downwards vertical hydraulic gradient between the colluvium and the underlying granitic soil.

Bores BH14, BH14A and BH14B show an approximate 4 m downward pressure gradient between the granitic soil and the granite, while also indicating a slight upward gradient of 1.5 m between the deeper, moderately weathered granite at bore BH14, and the extremely weathered granite at bore BH14A. The difference in pressure gradient is most probably a result of the bores screening different fracture systems within the granite.

May 2014

A second episode of groundwater gauging was undertaken in May 2014. During this monitoring event shallow monitoring bores that were previously dry had made water. It was noted that during March through to May, rainfall was marginally above average.

Hydraulic gradients were vertical at all nest monitoring sites.

4.5.4 Other Sources

A search of the GMS was undertaken to identify the presence of any active State Observation Network (SON) bore. The SON bores can provide valuable information for a region as they provide a water level monitoring record, and at some sites, water quality monitoring data. Most SON bores are monitored at a quarterly frequency, however monthly monitoring frequencies are adopted in some regions of the State.

No SON bores were identified within a 5 km radius of the study area.

4.6 Aquifer (Slug) Testing

4.6.1 Rationale

Slug testing of groundwater monitoring bores was undertaken to determine field estimates of the saturated hydraulic conductivity of the different geological units across the site. The testing procedure complied with AS2368 (1990).

4.6.2 Methodology

The testing involved the displacement of water (i.e. creation of a slug) and the measurement of water level recovery. The ‘slug’ was created using a weighted bailer, which was either raised or lowered within the borehole depending on whether a falling or rising head test was undertaken. An Insitu® Leveltroll 700™ pressure transducer (30 PSI/21 m range) and datalogger was lowered to near the base of the monitoring bore being tested, below the base of the anticipated slug level. The Leveltroll 700™ was programmed to collect rapid measurements of water level changes within the first few seconds of water displacement.

The slug remained in place until water levels were considered to have equilibrated, as determined from inspection of the measured water levels. Multiple tests were undertaken on the bore to obtain a representative value of the hydraulic conductivity.

4.6.3 Slug Test Results

The slug test data were analysed using a commercial aquifer test software package (Aqtesolve, 2007). A summary of the slug test analysis results are presented in Table 5. Slug test analysis was completed using the Bouwer-Rice and Hvorslev methods. It is noted that water levels in bores BH05, BH06, BH14A and BH15A were within the screened interval of the bore and only the results of the rising head tests have been presented for these bores.

Results indicate hydraulic conductivities for granites ranged from 0.03 m/day to 1.1 m/day, colluvium from 0.04 m/day to 6.5 m/day, granitic soils from 0.07 m/day to 0.16 m/day, and carbonaceous mudstone 0.02 m/day. Most values were comparable to typical hydraulic conductivities of the screened soils at the bore location.

Bores BH05, BH06, BH10 and BH14 are screened within the fractured granite aquifer, the range of results from 0.03 m/day to 1.1 m/day is indicative of the variable and uncertain nature of groundwater flow, which relies on connections within the rock fractures and secondary porosity. This is also evident in the bore logs at these locations, with high core loss occurring at bore BH10 (1.1 m/day), while almost no loss being observed at bore BH14 (0.03 m/day).

Bore BH04 intercepts the Carbonaceous mudstone and has the lowest hydraulic conductivity (0.02 m/day) of all bores tested at the Mt Buller site. This value is typical of clayey sands, silts and sandy silts (Fetter, 1988), which are present within the screened zone of bore BH04.

Bore BH15A shows an abnormally high hydraulic conductivity for weathered basalt and clay, returning an average result of 6.5 m/day. This result is typical of the hydraulic conductivity of sand (Fetter, 2001), and suggests that the test carried out at this location is questionable or that the underlying colluvium is affecting the result.

Bore BH09 shows higher hydraulic conductivity than is common for clayey sand, typically 0.0009 m/day to 0.09 m/day (Fetter, 2001). This suggests that the portion of sand within the screened zone is more dominant that the clay content.

Results from bore BH15 remain questionable given that the screened interval of the bore is blocked, and that the hole is only open to 18 m below the surface. However, this test does indicate that there is some form of connection to the aquifer system screened in the bore.

Table 5 Slug Test Results

Bore	Analytical Method	Geological Unit	Lithology	Hydraulic Conductivity (m/day)					
				FH1	FH2	RH1	RH2	Average Solution	Average Bore
BH04	Bouwer-Rice	Carbonaceous Mudstone	Fine sand with carbonaceous bands, silt, silty sand and some gravels	0.01	0.01	0.01	0.05	0.02	0.02
	Hvorslev			0.01	0.01	0.02	0.05	0.02	
BH05	Bouwer-Rice	Granitic Soils	Weathered granite, sandy clay, clayey sand	0.0.0	-	0.1	0.1	0.10	0.16
	Hvorslev			0.03	-	0.2	0.2	0.21	
BH06	Bouwer-Rice	Granite	Weathered granite, fractured	0.54	0.5	0.81	0.60	0.7	0.89
	Hvorslev			-	-	1.15	1.0	1.1	
BH09	Bouwer-Rice	Granite	Sandy clay/clayey sand	0.6	0.5	0.64	0.7	0.6	0.77
	Hvorslev			0.9	0.8	1.03	1.1	0.9	
BH10	Bouwer-Rice	Granite	Weathered granite, fractured	0.84	0.9	1.04	0.9	0.92	1.07
	Hvorslev			1	1.2	1.48	1.2	1.2	
BH13	Bouwer-Rice	Colluvium	Sand/cobbles with clay bands	0.03	0.02	0.03	0.03	0.03	0.04
	Hvorslev			0.06	0.02	0.05	0.04	0.04	
BH14	Bouwer-Rice	Granite	Weathered granite, fractured	0.03	0.02	0.02	0.02	0.03	0.03
	Hvorslev			0.04	0.03	0.02	0.03	0.03	
BH14A	Bouwer-Rice	Granite	Extremely weathered granite	0.00	0.00	0.1	0.15	0.14	0.16
	Hvorslev			-	-	0.16	0.2	0.2	
BH15	Bouwer-Rice	Granitic Soils	Clayey sand (possible reworked alluvial deposits)	0.01	0.02	0.02	0.13	0.05	0.07
	Hvorslev			0.01	0.02	0.08	0.3	0.1	
BH15A	Bouwer-Rice	Basalt/Colluvium	Weathered seams of basalt to sandy clay (colluvium)	2.1	2.3	6.5	3.3	4.9	6.5
	Hvorslev			-	-	10.2	5.9	8.05	

Note: FH – Falling Head, RH – Rising Head

4.7 Groundwater Sampling

4.7.1 Methodology

Monitoring bores were purged of standing water (minimum three casing volumes, where possible) prior to sampling using a dedicated, disposable bailer to eliminate cross contamination. Field water quality parameters were collected at the time of sampling using a calibrated water quality meter.

The groundwater samples were submitted to ALS Environmental Laboratories (ALS) for analysis under chain of custody documentation and appropriate storage and preservation procedures. ALS is registered with NATA[1] for the nominated analyses. The laboratory testing included the following suite of analytes:

- Total Dissolved Solids (TDS) and Electrical Conductivity (EC);
- pH;
- Dissolved metals;
- Nitrate as N;
- Major cations; and
- Major anions.

4.7.2 Observed Water Quality Parameters

Water samples were collected from 11 bores, and two surface water locations (suffixed SW) along the aqueduct, as shown in Figure 2. Bores BH06, BH10, BH14 and BH15A could be sampled following the removal of 3 bore volumes, while all other bores were bailed dry and were sampled once water levels had recovered sufficiently to obtain a groundwater sample. It was noted that recovery of water levels in bores BH14B and BH15 was slow, and required greater than 24 hrs to achieve. Field purging records have been attached in Appendix B and field equipment calibration records attached in Appendix C.

Water quality was monitored during bore sampling for temperature, pH, electrical conductivity (EC), dissolved oxygen (DO), and oxidation reduction potential (ORP). The final purge records prior to sampling have been summarised in Table 6. A discussion of the field water quality is provided in Section 4.8.

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[1] NATA – National Association of Testing Authorities

Table 6 Field Water Quality Monitoring

Bore	Temperature (^oC)	pH (pH units)	Dissolved Oxygen (ppm)	Oxidation – Reduction Potential (mV)	Electrical Conductivity (µS/cm)
BH04	7.2	7.16	6.93	124	120
BH05	8.2	6.49	6.04	-4	100.9
BH06	7.6	4.92	7.31	219	32.3
BH09	9.4	5.52	6.03	189	23.0
BH10	9.1	4.79	6.91	177	12.6
BH13	7.7	4.24	6.88	220	16.2
BH14	7.3	6.22	7.30	194	50.1
BH14A	8.1	5.46	5.62	164	86.6
BH14B	10.1	5.65	8.32	204	55.0
BH15	*12.9*	*7.17*	*3.48*	*-78*	*101.1*
BH15A	7.6	5.29	7.55	131	18.4
SW1	12.8	7.47	10.57	177	24.7
SW2	10.5	4.79	0.51	101	8.5

Note:

1. As bore BH15 was blocked over its screen interval, the field monitoring results are considered unrepresentative.

4.7.3 Laboratory Analytical Results

The laboratory analytical results for the groundwater monitoring bores have been summarised in Table 7. To provide a general indication of the groundwater quality, the ANZECC (2000) guidelines for the protection (95%) of fresh water ecosystems have been included in Table 7, although it is noted that most analytes do not have a guideline concentration. The certified laboratory reports have been attached in Appendix D. A discussion on the groundwater quality has been provided in Section 4.8.

Table 7 Summary of Water Quality Results

Analyte	Units	EQL	ANZECC (2000) 95% Ecosystem	BH04	BH05	BH06	BH09	BH10	BH13	BH14	BH14A	BH14B	BH15	BH15A	SW1	SW2
				13/02/14	13/02/14	12/02/14	12/02/14	12/02/14	13/02/14	11/02/14	12/02/14	13/02/14	13/02/14	12/02/14	13/02/14	13/02/14
Electrical conductivity *(lab)	µS/cm	1		102	44	45	34	20	17	69	96	70	88	26	28	51
Total Dissolved Solids	mg/L	10		70	27	33	30	17	10	50	66	51	55	20	15	29
pH (Lab)	pH unit	0.01		8.03	7.94	7.05	7.15	7.16	6.12	6.71	6.87	6.9	6.86	6.8	6.42	6.16
Nitrate (as N)	mg/L	0.01	0.158	0.04	0.23	3.12	0.27	0.8	0.18	0.15	0.02	0.08	0.1	0.37	0.03	0.14
Nitrite (as N)	mg/L	0.01		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	0.01	<0.01	<0.01
Nitrogen (Total Oxidised)	mg/L	0.01		0.04	0.23	3.12	0.27	0.8	0.18	0.15	0.02	0.08	0.15	0.38	0.03	0.14
Alkalinity (total) as CaCO3	mg/L	1		51	16	4	11	3	3	30	41	24	40	8	12	24
Alkalinity (Bicarbonate as CaCO3)	mg/L	1		51	16	4	11	3	3	30	41	24	40	8	12	24
Alkalinity (Carbonate as CaCO3)	mg/L	1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Alkalinity (Hydroxide) as CaCO3	mg/L	1		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate	mg/L			62.22	19.52	4.88	13.42	3.66	3.66	36.6	50.02	29.28	48.8	9.76	14.64	29.28
Carbonate	mg/L			<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
Calcium (Filtered)	mg/L	1		4	1	1	1	<1	<1	4	7	5	3	1	2	4
Chloride	mg/L	1		2	1	2	2	1	1	2	3	2	2	1	<1	<1
Magnesium (Filtered)	mg/L	1		1	<1	<1	<1	<1	<1	3	4	3	2	1	<1	2
Potassium (Filtered)	mg/L	1		<1	2	<1	<1	<1	<1	1	2	2	7	<1	<1	<1
Sodium (Filtered)	mg/L	1		19	5	4	5	2	<1	5	2	2	6	1	2	3
Sulphate (Filtered)	mg/L	1		13	3	<1	1	<1	<1	15	5	7	<1	4	<1	<1
Anions Total	meq/L	0.01		1.35	0.41	0.14	0.3	0.09	0.09	0.97	1.01	0.68	0.86	0.27	0.24	0.48
Cations Total	meq/L	0.01		1.11	0.32	0.22	0.27	0.09	<0.01	0.69	0.82	0.63	0.75	0.18	0.19	0.49
Ionic Balance	%	0.01		-	-	-	-	0.71	-	-	-	3.58	-	-	-	1.54
Iron (Filtered)	mg/L	0.05		<0.05	<0.05	<0.05	0.43	<0.05	0.05	<0.05	<0.05	0.74	1.64	<0.05	0.28	0.34

4.7.4 QA/QC

GHD implemented a quality assurance/quality control (QA/QC) program as part of its field procedures, based on relevant Australian Standards (Standards Australia 2005) and industry common practice. The QA/QC program undertaken as part of the assessment by GHD included the following:

- Implementation of GHD field procedures including sampling equipment decontamination between sampling points;
- Preservation of samples with ice during transport from the field to the laboratory;
- Transportation of samples with accompanying COC documentation;
- Collection of blind and split duplicate samples and calculated review of Relative Percent Difference (RPDs);
- Comparison of field and analytical data;
- Compliance with sample holding times; and
- Review of internal analysis of QC and laboratory duplicates.

The QC sampling program conducted during this investigation involved collection of samples for data reliability purposes assessing possible errors due to possible sources of cross contamination, inconsistencies in sampling, and analytical techniques used.

A quantitative measure of the accuracy of the results obtained was undertaken by calculating the relative percentage difference (RPD) values for each duplicate pair. The RPD values were calculated using the following equation.

$$RPD(\%) = \frac{(C_o - C_s)}{\left(\frac{C_o + C_s}{2}\right)} \times 100$$

where C_o = concentration obtained from the original sample

C_s = concentration obtained from the split or duplicate sample

The RPD was used to normalise each pair of results, allowing data interpretation and reliability. An RPD range of 30% to 50% is generally considered acceptable based on AS4482.1 (2005). For duplicate results near the detection limit, RPD values as high as 80% may still be acceptable.

Two duplicates and one rinsate were collected during field investigations, further more standard laboratory QA/QC tests (internal QA/QC) were carried out by ALS Laboratories. Results from these tests are available in Appendix E.

There were no anomalies in any of the rinsate blank data. Most RPDs were within the guideline ranges, except for sulphate (67%). Other analytes in the duplicate were within the RPD guidelines and therefore the results of the analysis are deemed acceptable.

4.8 Groundwater Quality Discussion

4.8.1 Legislative Context

Under the *Environment Protection Act* (1970), and on the recommendation of the EPA Victoria, the Victorian Government enacted the State Environment Protection Policy (SEPP)

(*Groundwaters of Victoria*). This policy aims to maintain and, where possible, improve groundwater quality to protect beneficial uses. Groundwater with higher concentrations of salinity (measured as mg/L TDS) is deemed to have fewer beneficial uses.

SEPP (*Groundwaters of Victoria*) forms the primary guide to determining existing impacts and the risk of impacts to groundwater quality. The policy is based on a number of principles which include:

- Groundwater is an undervalued resource and all Victorians have a shared responsibility for its protection;
- Protection of groundwater (and aquifers) is fundamental to the protection of connected surface waters;
- Groundwater (and aquifers) should be protected to the greatest extent practicable from serious or irreversible damage arising from human activity; and
- Intergovernmental agreement on the Environment (IGAE) principles is applicable (e.g. polluter pays, intergenerational equity and the precautionary principle).

The policy provides that groundwater is categorised into segments, with each segment having particular identified uses. The segments and their beneficial uses are summarised in Table 8.

Table 8 Protected beneficial uses and groundwater segments

	Segment (mg/L TDS)				
	A1	A2	B	C	D
	0–500	501–1,000	1,001–3,501	3,501–13,000	>13,000
Maintenance of ecosystems	✓	✓	✓	✓	✓
Potable water:					
Desirable	✓				
Acceptable		✓			
Potable mineral water supply	✓	✓	✓		
Agriculture, parks and gardens	✓	✓	✓		
Stock watering	✓	✓	✓	✓	
Industrial water use	✓	✓	✓	✓	✓
Primary contact recreation (e.g. swimming / bathing)	✓	✓	✓	✓	
Buildings and structures	✓	✓	✓	✓	✓

Note: TDS – Total Dissolved Solids (mg/L). Source EPA 1997

EPA Victoria may determine these beneficial uses do not apply to groundwater where:

- There is insufficient yield;

- The background level of a water quality indicator other than TDS precludes a beneficial use;
- The soil characteristics preclude a beneficial use; and
- A Groundwater Quality Restricted Use Zone (GQRUZ) has been declared.

SEPP (*Groundwaters of Victoria*) requires that occupational health and safety, odour and amenity also be considered, due to the fact that vapours sourced from impacted groundwater may present a potential risk to workers, and that odours or discolouration may result in degradation of overall beneficial use.

4.8.2 Beneficial Uses

Based on a review of the groundwater sampling results, the groundwater quality is fresh and falls within Segment A. A discussion on the existing and relevant groundwater beneficial uses has been summarised in Table 9.

Table 9 Existing and Potential Groundwater Beneficial Uses

Use	Existing	Potential
Maintenance of ecosystems	Springs and groundwater seeps have been identified down-gradient of the site. The maintenance of groundwater quality to protect ecosystems at the point of discharge to the receiving environment is required.	
Potable water	No groundwater bores have been identified within a 5 km radius of the site.	Whilst the groundwater quality is such that it is suitable for development for potable purposes, its use is likely to be limited by bore yields. Groundwater discharges to waterways, e.g. Boggy Creek, which are the existing source of water supply to the resort.
Potable mineral water supply		The site is not located within a recognised mineral water province nor does it have qualities, e.g. spritzig or effervescence which is desirable in a mineral water. Accordingly this beneficial is not relevant.
Agriculture, parks and gardens		The groundwater quality is suitable for irrigation purposes. It is expected that bore yields (and existing land use) may limit the development of groundwater for such purposes.
Stock watering		The groundwater quality is suitable for stock watering purposes, however such use is not permitted within the Alpine Resort.
Industrial water use		Based on the zoning of the land and its setting, the use of groundwater for industrial purposes is of limited likelihood.
Primary contact recreation (e.g. swimming / bathing)		Given the existing land use, development of groundwater for such purposes is considered highly unlikely.
Buildings and Structures	Groundwater levels (refer Table 3) are generally greater than 2 m below the surface in the flatter areas of the site where buildings are likely to be located. In steeper country, however, shallow groundwater levels, including spring flow is possible.	

4.8.3 Site Groundwater Quality

Laboratory results of the surface water and groundwater quality have been summarised in Table 7.

Salinity

The groundwater quality is high, with groundwater salinity being very fresh and generally below 80 mg/L TDS. EC / TDS ratios ranged from 0.5 to 0.9 with an average of 0.7.

The salinity of the groundwater suggests localised groundwater flow paths and/or short residence times within the aquifer. The salinity identified in some groundwater monitoring bores was similar to that at characterised at two surface sites (SW1 and SW2) in the aqueduct.

pH

Both laboratory and field pH were determined. The field pH ranged from near neutral (7.1) to acidic (4.3). The laboratory measured pH was between 6 and 8 units.

The low groundwater salinity identified in monitoring bores suggests a strong connection with infiltrating rainfall. It is not unexpected that the groundwater is slightly acid, owing to the generation of carbonic acid (CO_2 dissolution in rainfall).

ORP

Apart from bores BH05 and BH15 which had negative ORP potentials, all other bores were strongly oxidising with potentials generally above 100 mV.

Nitrate

Most bores have detectable concentrations of nitrate. The laboratory analysis indicates that the concentration of nitrate in bores BH05, BH06, BH09, BH10, BH13 and BH15A exceed the ANZECC (2000) guideline for concentration of Nitrate (as N) of 0.158 mg/L.

4.8.4 Piper Plots

The analytical program has included a suite of major cations and anions. Using this data, a Piper trilinear diagram was constructed to characterise the groundwater at the project site.

The Piper diagram is a graphical representation of the major ion chemistry and can be used to determine the hydrochemical facies of a particular groundwater. The plot is constructed from the cations calcium, magnesium, sodium and potassium, and the anions chloride, sulphate, bicarbonate and carbonate. These are the most common ions within water and are conservative species. Groundwater of differing facies will plot in different areas within the trilinear diagram enabling differentiation. A groundwater is then described by the dominant cation and anion chemistry.

In the context of this assessment, the Piper diagram has been used to identify major chemistry differences between different sampling sites. The diagrams have been shown in Figure 5 with the plots based on bore identity, and geology (aquifer) developed by each monitoring bore.

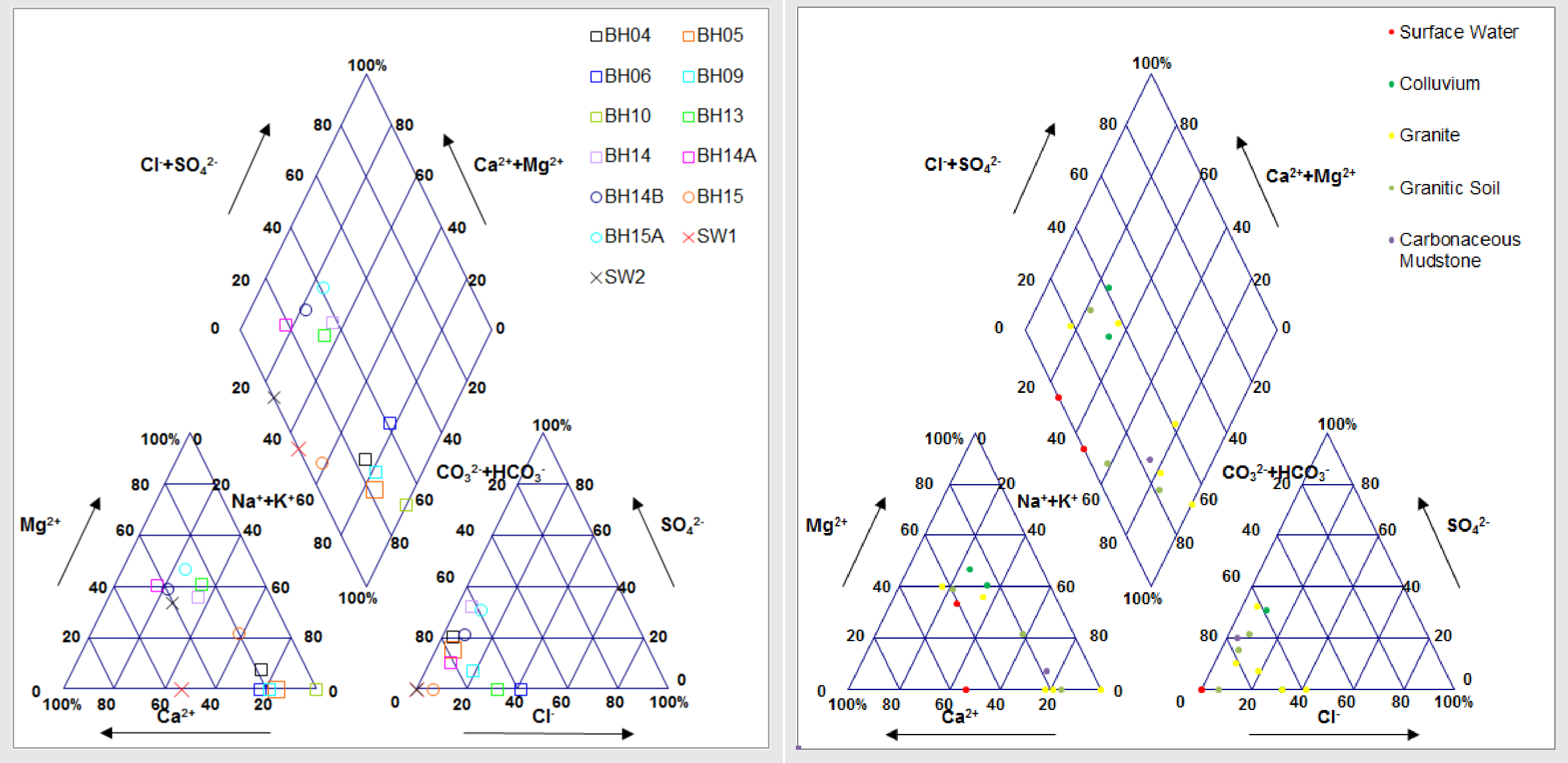
The dominant ionic species for the groundwater is bicarbonate (anion), however there is not a dominant cation species. Some bores are a sodium-type water, however it is not consistent across all monitoring sites, and differs within interpreted aquifers. These plots show that there is no obvious correlation to chemical composition and interpreted geology.

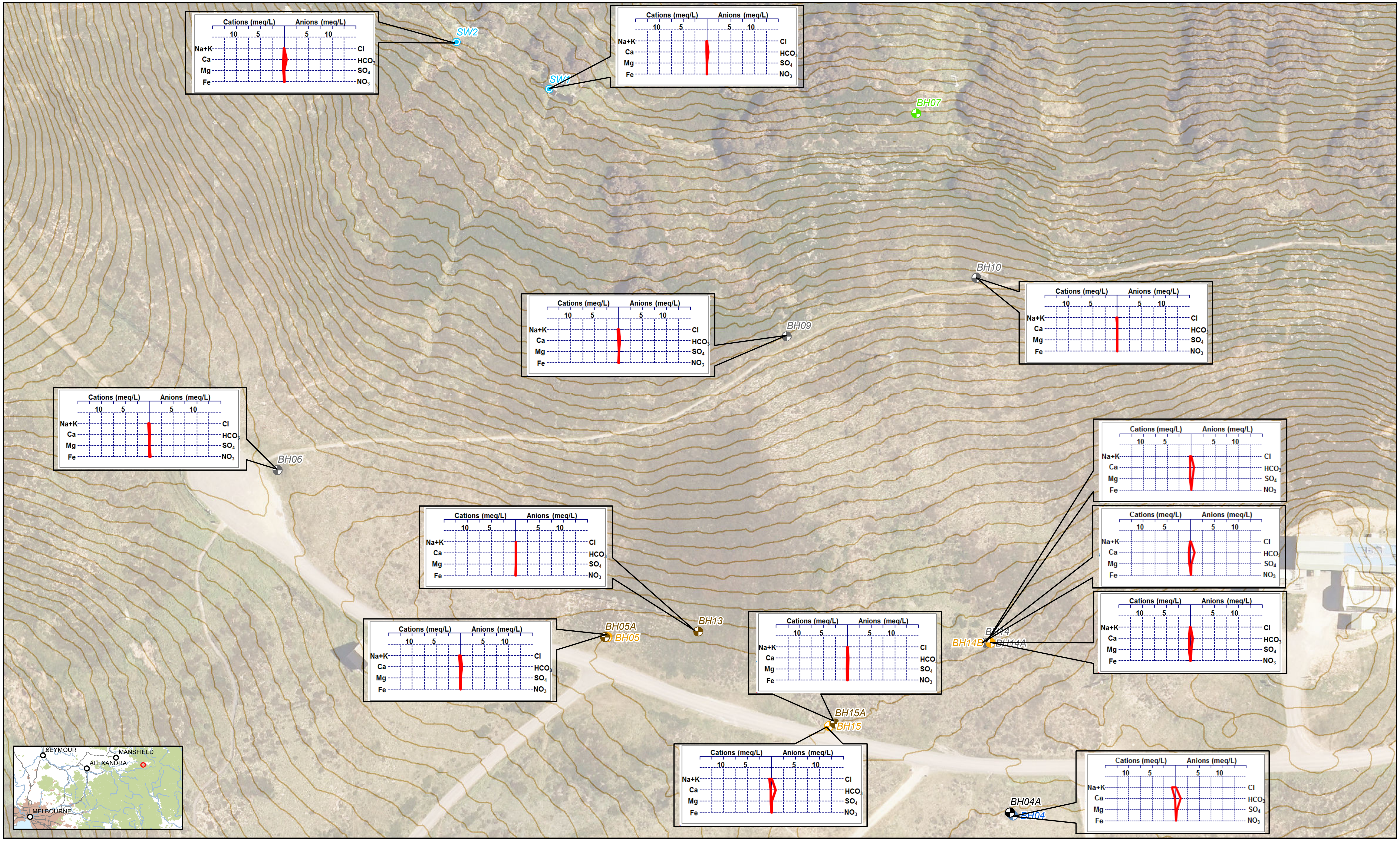
Surface water sample SW2, taken from the aqueduct close to the surface expression of groundwater (i.e. spring), shows a similar anion signature to the calcium carbonate bores. Surface water sample SW1 was collected from the concrete weir.

4.8.5 Stiff Diagrams

Figure 6 shows the location of ground and surface water samples, along with the corresponding stiff diagrams. As the water was so fresh, and contained minimal cations and anions the stiff diagrams indicate largely the same chemical signature from all sites. Surface water sample SW2, and monitoring bores BH4, BH14, BH14A, and BH15 all show higher amounts of carbonate, which are not as pronounced in other bores.

Figure 5 Piper Plot





Paper Size A3

0 5 10 20 30 40

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

● Surface Water Monitoring Locations

Interpreted Geology

● Basalt

● Bogg

● Colluvium

● Granite

● Granitic Alluvium

● Lake Alluvium

— Contour 1m

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Mt Buller Sustainable Water Security Project

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Date	22 Jul 2014

GHD

Stiff Diagrams

Figure 6

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Data Source: DEPI: Vicmap - 2013; GHD - 2013. Created by: jlearmonth

4.9 Acid Sulphate Soils

4.9.1 Definition

The occurrence of ASS can be present in the form of:

- PASS – Soil that contains unoxidised iron (metal) sulphides. When exposed to oxygen through excavation, drainage or disturbance, these soils produce sulphuric acid.
- Actual Acid Sulphate Soil – Potential ASS that has been exposed to oxygen and water, and has generated acidity.

These soils are rich in organics and were formed in low oxygen or anaerobic depositional environments. They are rich in sulphides and when oxygen is introduced, the sulphides oxidise to sulphate, with resultant soils having low pH and potentially high concentrations of the heavy metals. When water levels rise, pH and heavy metals are subsequently mobilised into the environment and can potentially impact deep-rooted vegetation, aquatic flora and fauna, and can be aggressive to reactive materials (e.g. concrete, steel) of foundations, underground structures (e.g. piles, pipes, basements) or buried services in contact with groundwater.

4.9.2 Potential Acid Soils in the study area

In Victoria, ASS materials are commonly associated with Holocene age geology (i.e. Recent Quaternary) or lithified sedimentary rocks that may contain disseminated pyrite (when unweathered).

A review of published mapping was undertaken which included the CSIRO Australian Soil Resource Information System (CSIRO 2014). Whilst it is noted that the mapping is regionally based, it indicates there to be an extremely low risk of encountering ASS materials. Specific testing is required to conclusively confirm whether this material is a potentially acid sulphate soil.

4.10 Groundwater Dependent Ecosystems

4.10.1 Definition

A groundwater dependent ecosystem (GDE) is an ecosystem which has its species composition and natural ecological processes determined by groundwater. That is, they are natural ecosystems that require access to groundwater to meet all, or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services. If the availability of groundwater to a GDE is reduced, or if the quality is allowed to deteriorate, these ecosystems would be impacted.

It is widely acknowledged that a poor understanding exists in recognising GDEs, or understanding the hydrogeological processes affecting GDEs, or their environmental water requirements. GDEs can be broadly grouped into three categories:

- Ecosystems that depend on the surface expression of groundwater:
  - Swamps and wetlands can be sites of groundwater discharge and may represent GDEs. The sites may be permanent or ephemeral systems that receive seasonal

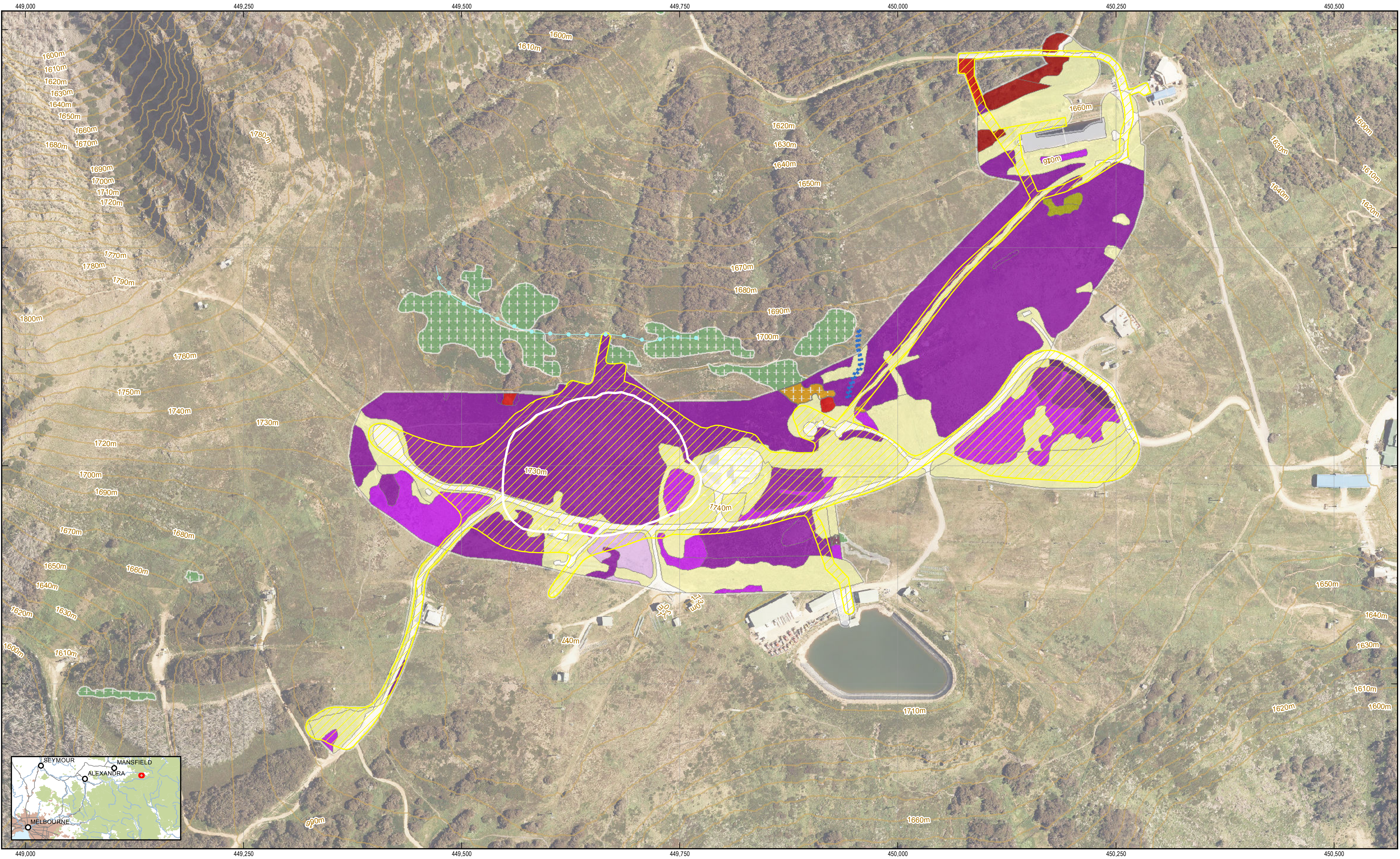
  or continuous groundwater contribution to water ponding or shallow water tables. Tidal flats and inshore waters may also be sites of groundwater discharge. Wetlands can include ecosystems on potential acid sulphate soils and in these cases maintenance of high water levels may be required to prevent waters from becoming acidic.
  - Permanent or ephemeral stream systems may receive seasonal or continuous groundwater contribution to flow as baseflow. Interaction would depend upon the nature of stream bed and underlying aquifer material and the relative water level heads in the aquifer and the stream.
- Ecosystems that depend on the subsurface presence of groundwater. Terrestrial vegetation such as trees and woodlands may be supported either seasonally or permanently by groundwater. These may comprise shallow or deep rooted communities that use groundwater to meet some or all of their water requirements. Animals may depend upon such vegetation and therefore indirectly depend upon groundwater. Groundwater quality generally needs to be high to sustain the vegetation growth.
- Ecosystems that reside within a groundwater resource. These are referred to as hypogean ecosystems. Micro-organisms in groundwater systems can exert a direct influence on water quality, for example, stygofauna typically found in karstic, fractured rock or alluvial aquifers.

4.10.2 GDEs in the study area

The National Groundwater Dependent Ecosystem Atlas (BOM, 2012) was interrogated to identify potential GDEs within the study area, the results of which are shown in Figure 7. The Department of Primary Industries' (DPI) Mapping of Terrestrial Groundwater Dependent Ecosystems (2011) was also consulted as an alternative information source.

The search within the National Groundwater Dependent Ecosystem Atlas (BOM, 2012) indicated that South Buller Creek and Little Buller Creek were identified as a high potential for groundwater interaction, while Buller Creek, Boggy Creek, Whiskey Creek, Gin Creek and Cow Camp Creek were identified as moderate potential. The DPI (2011) data indicated several areas around the proposed water storage site as being potentially groundwater dependent.

Mapping of Ecological Vegetation Classes (EVCs) is presented in Figure 8. Native vegetation surrounding the proposed storage footprint falls predominantly within the Alpine Grassy Heathland EVC. Sphagnum bogs have been mapped near the proposed storage, and these are considered to be a nationally threatened community under the Commonwealth *Environment Protection and Biodiversity Conservation Act* (1999).



Paper Size A3

0 20 40 80 120 160

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

LEGEND

- Aqueduct
- ▭ Control Footprint
- Contour 10m
- Drainage Line
- 🟪 (HZ1) EVC 1004 - Alpine Grassy Heathland
- 🟪 (HZ2) EVC 1004 - Alpine Grassy Heathland
- ▭ (HZ3) EVC 1004 - Alpine Grassy Heathland
- 🟥 (HZ4) EVC 43 - Sub-alpine Woodland
- 🟧 (HZ6) EVC 210 - Sub-alpine Wet Heathland
- 🟥 (HZ7) EVC 43 - Sub-alpine Woodland
- 🟩 (HZ8) EVC 42 - Sub-alpine Shrubland
- ▨ (HZ9) EVC 1011 – Alpine Peaty Heathland
- 🟪 (HZ10) EVC 1004 – Alpine Grassy Heathland
- 🟨 MiTV - Minor Treeless Vegetation
- ▭ NNV - Non-Native Vegetation
- ▭ Project Construction Footprint
- 🟩 Alpine Bogs (mapped by ARI)
- ▭ Project Investigation Area

HZ6, HZ9 and the 'Alpine Bog Community mapped by ARI' all equate to the EPBC Act-listed community Alpine Sphagnum Bogs and Associated Fens

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Ecological Vegetation Classes and Habitat Zones

Figure 8

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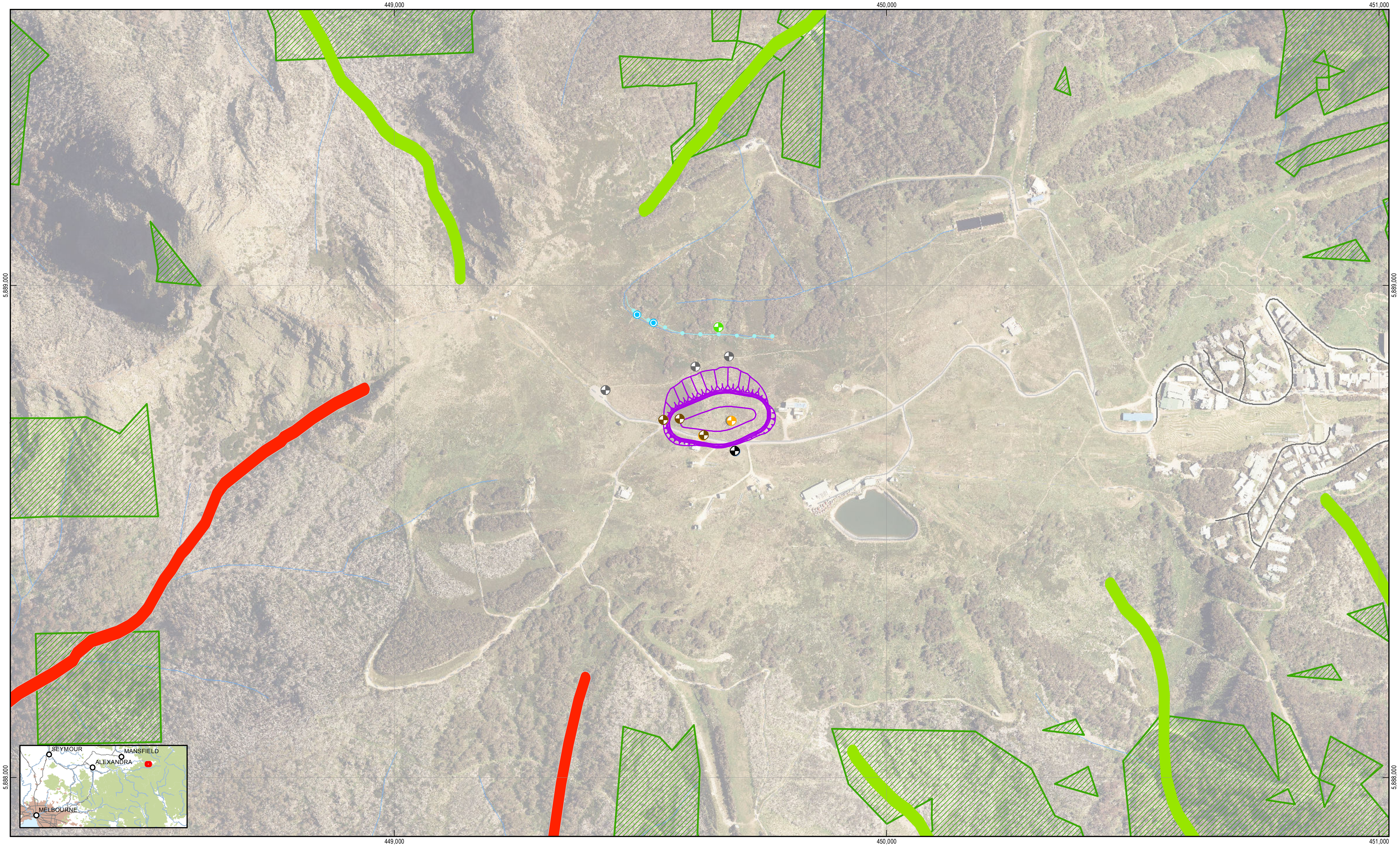
Data source: Underground Services, Buller Ski Lifts and South East Water, 2013. Created by:mjahanshahi



Paper Size A3

0 35 70 140 210 280

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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LEGEND

◎ Surface Water Monitoring Locations

Monitoring Bore Locations

Interpreted Geology

- ◐ Basalt
- ◐ Bog
- ◐ Colluvium
- ◐ Granite
- ◐ Granitic Alluvium
- ◐ Lake Alluvium

Aqueduct

Control Footprint

Identified GDEs (BOM, 2012)

- 🟥 High potential for GW interaction
- 🟩 Moderate potential for GW interaction
- ▨ Identified Groundwater Dependant Ecosystems (DPI, 2011)

Stream

Sealed road (arterial and local)

Unsealed road

Track and bike path

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Identified Groundwater Dependent Ecosystems

Figure 7

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\\ghdnet\ghd\AU\Melbourne\Projects\31\3073314\GIS\Maps\Deliverables\31-30733_001_GDE.mxd

Data Source: DEPI: Vicmap - 2013; GHD - 2013; DPI - 2011; BOM - 2012. Created by: jlearmonth

4.11 Groundwater Management

The Victorian Department of Environment and Primary Industries (DEPI) have recognised areas of intensive groundwater use throughout Victoria. The principle management unit for groundwater resources in Victoria is the Groundwater Management Unit or GMU. A GMU may be a Groundwater Management Area (GMA), a Water Supply Protection Area (WSPA) or an Unincorporated Area. These are declared under the *Water Act* (1989) to ultimately provide sustained management of the groundwater resources.

Under the *Water Act* (1989), the Minister may declare the total volume of groundwater (and/or surface water) which may be taken in an area. This is termed the Permissible Consumptive Volume (PCV).

A WSPA is essentially a GMA with a management plan. Within WSPAs, caps or moratoriums on the issue of additional extraction licenses are often present. An unincorporated area is a region falling outside of a GMA or WSPA. The total volume of water allocated under the PCV is a trigger for declaration of a GMA.

Based on a review of the SAFE mapping layers, the site is not located within a designated GMA, and is thus classified as being ‘unincorporated’. This is consistent with the lack of groundwater development in the region (and the landuse setting).

5. Conceptual Hydrogeological Model

5.1 Overview

The information gathered during the field work and from the bores drilled as part of the geotechnical investigation was synthesised to generate a conceptual hydrogeological model of the project area including the proposed storage area and nearby sensitive ecosystems.

Each aspect of this model is described below, and depicted diagrammatically in Figure 9.

The limitations of the model are discussed in Section 5.3. Scaled geological models to support the proposed storage design were under development at the time of reporting.

5.2 Description

Orientation

A conceptualised hydrogeological cross section has been prepared for the proposed water storage site and is shown in Figure 9. This section is approximately north – south in orientation, extending from the Mt Buller Summit Road to the northern extents of the aqueduct. In positioning the section through the eastern portion of the site, it includes the basalt, Carbonaceous sediments and granite and was developed using information interpreted from bores BH4, BH14, BH10 and BH7 only. In some cases these bores have been ‘projected’ onto the section line.

Aquifers

The section shows the juxtaposition of the sediments and volcanics, overlying the granite bedrock, down to the outcropping of the granite, and the water table further down the slope. The indicative position of the proposed water storage and its associated embankment footprint is also shown on the conceptualised section.

The regional water table aquifer is that which has formed within the Devonian granites. As noted earlier, the granitic terrain forms a relatively complex aquifer system, with flow processes occurring in the deeper zones dominated by fracturing and secondary porosity, and flow in the weathered zones analogous to a porous media continuum. A significant permeability contrast would exist, with the weathered zone and granite sands having a significantly greater permeability and storage relative to the deeper fresher granite. This is confirmed in the slug testing when contrasting the hydraulic conductivity of BH14 of 0.03 m/day with that of BH10 (1.1 m/day).

It is considered likely that all the identified hydrogeological units are in variable hydraulic connection with each other, as supported by the similar groundwater chemistries. Some localised perching may occur through:

- Retarding of vertical migration by the Carbonaceous Mudstone;
- Permeability contrasts within the granite, between granitic soils and weathered granite; and
- Local low permeability horizons, i.e. clay layers, within the colluvium.

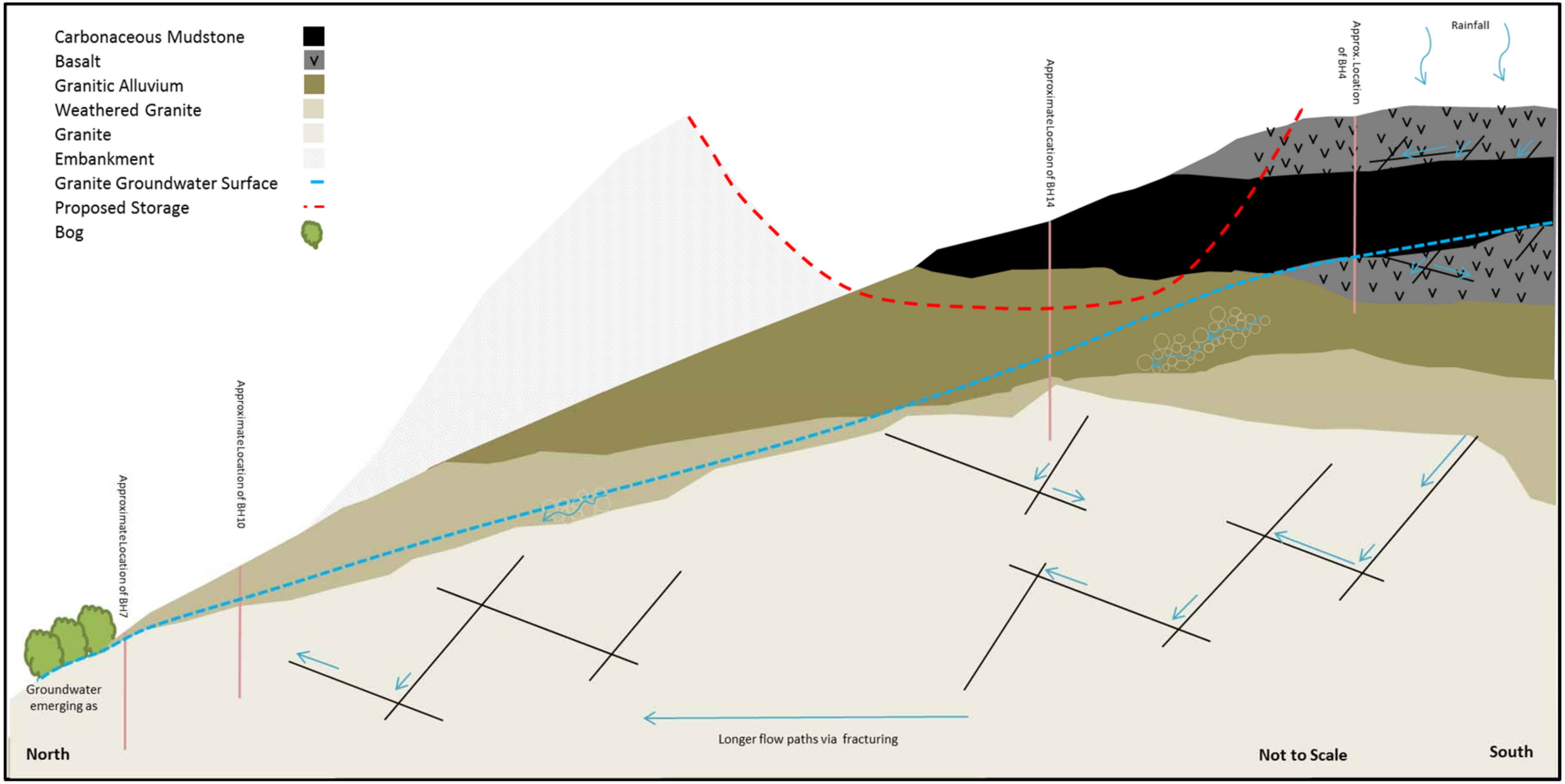


Figure 9 Conceptualised Cross Section

The aquifers are recharged via infiltrating rainfall, and with contributions in the spring from snow melt. The low salinity of the groundwater and bicarbonate influence are evidence to support the short residence times of groundwater in the aquifer, and short, or highly localised groundwater flow paths between recharge, and groundwater discharge. Slug test results indicate that the carbonaceous mudstone (with a hydraulic conductivity of 0.02 m/day) is likely to locally retard vertical flows, which would result in longer groundwater residence time across this zone, infiltrating into the granitic sediments below.

Where the change in topography is dramatic, or where the storage capacity of the aquifers is exceeded or saturated, fractures in the granite daylight, spring flow and groundwater seepage occurs. This is depicted in Figure 9 by the location of the bog and the groundwater table reaching the surface. The mapping of localised springs is shown in Figure 4. Spring flows eventually reach the aqueduct, located further downslope. The aqueduct ultimately confluences with the headwaters of the Boggy Creek.

In the project area, the depth to groundwater reduces with increasing distance northwards and as the topography falls, and ultimately the surface expression of groundwater can be observed near the aqueduct. At the proposed dam site (refer Figure 9) groundwater depth would vary depending upon whether it is associated with the excavation (cut) area or the embankment (fill). During the late summer period (2014) water levels within the Alpine bogs (at bore BH7) were observed at 1 m below the surface, with levels in late Autumn (2014) observed at the surface, indicating a significant seasonal variation in groundwater depth within these localised Alpine Bog communities.

5.3 Limitations

The bore data used to construct this conceptual model are located close to the footprint of the proposed water storage. There is limited to no hydrogeological or geological data available in a broader regional context. It is difficult to fully infer the nature of all of the identified hydrogeological units without further bore and water level data.

6. Assessment of Risks

6.1 Proposed Development

The concept design footprint of the proposed storage has been added to the figures incorporated into this report. The proposed storage would be excavated into the softer ground materials at the site, with these materials being used to form embankments. It is understood that the storage would have a membrane liner system and under-drainage to minimise pore water pressure build-up.

Owing to the position of the storage and the complexity of the hydrogeological units, the excavations required to construct the storage would result in:

- Partial removal of mostly thin, extremely weathered basalt in the southern parts;
- Partial removal of Carbonaceous mudstone sediments, towards the centre the storage footprint;
- Colluvium and ancient landslide deposits in the west; and
- Weathered granite in the east and north.

The footprint and cross section of the proposed storage has also been shown on the conceptualised hydrogeological section (refer Figure 9).

The construction and operation of the storage has the potential to locally effect the groundwater environment, and therefore indirectly impact ecosystems that may rely upon groundwater for their health.

In addition to the construction of the proposed storage, there would be associated ancillary structures to support the water supply. This would include:

- Dual 200 m diameter water pipelines (generally <3 m deep trenching);
- Baldy 1 ML storage tank (approximate 15 m diameter x 6 m deep);
- Realignment of water supply services (<2 m deep trenching);
- Sun Valley Reservoir Transfer pipeline (<3 m deep trenching);
- Transfer pump station at new storage;
- Stage 1B Booster tank and pump station (4 ML/day); and
- New raw water treatment plant.

Whilst this reporting has focussed upon the proposed storage, this other infrastructure may also interact with the groundwater environment. Accordingly this infrastructure has been included in the hydrogeological risk assessment. It is noted that further site specific hydrogeological investigations may be required to support the detailed design of this infrastructure and better inform the risk assessment.

6.2 Process

To determine the potential impacts of the proposed storage construction and operation on the groundwater environment and current and future land use, it is necessary to understand the risks. The following methodology was used to determine the groundwater impact pathways and define risk ratings for the project:

1. Determine the ‘impact pathway’ – how the project impacts on a given groundwater value or issue
2. Describe the ‘consequences’ of the impact pathway to define levels of consequence (Table 10)
3. Determine the ‘likelihood’ of the consequence occurring to the level assigned in step 2. Likelihood descriptors are provided in Table 11.
4. Determine the maximum credible ‘consequence level’ associated with the impact as defined in Table 10.
5. Form the consequence and likelihood levels assigned to the impact pathway. Use the risk matrix to determine the risk rating (Table 12).
6. Define the level of data/information availability associated with the risk assessment rating (Table 13).

6.2.1 Consequence criteria

Consequence criteria (Table 10) range on a scale of magnitude from ‘insignificant’ to ‘catastrophic’. Magnitude was considered a function of the size of the impact (the spatial area affected and expected recovery time of the environmental system).

Consequence criteria descriptions indicating a minimal size impact over a local area, and with a recovery time potential within the range of normal variability were considered to be at the negligible end of the scale. Conversely, catastrophic consequence criteria describe scenarios involving a very high magnitude event, affecting a catchment area, or requiring several years to reach functional recovery.

Surface Water

With the surface water assessment, impacts are generally simplified into those that affect surface water quality and/or surface water flow. Construction of the dam alters the surface water catchment area for downstream receiving environments.

Groundwater

With the groundwater assessment, impacts are generally simplified into those that affect groundwater quality and/or groundwater level. Falls or rises in groundwater level affect hydraulic gradients and groundwater movement. The effect on movement or groundwater flow translates to a change in groundwater availability, be it available for environmental reserves (e.g. groundwater dependent ecosystems) or resource users.

Table 10 Consequence Criteria

Criteria	Insignificant	Minor	Moderate	Major	Catastrophic
Direct impacts to the surface water environment	Negligible change to surface water flow regime and quality.	Temporary or highly localised changes to surface water flow regime, and quality but no significant implication for surface water users or the environment.	Changes to surface water flow regime and quality and with minor implications (localised) (reduction in available volume or quality but existing users still viable or negligible impact to receiving environments).	Surface water flow regime or quality significantly compromised (existing uses of surface water no longer viable, and/or impact on waterway flows/receiving environment).	Widespread impacts on the surface water flow regime, and surface water quality degradation or contamination.
Direct impacts to the groundwater environment	Negligible change to groundwater regime, quality and availability.	Temporary or highly localised changes to groundwater regime, quality and availability but no significant implication for groundwater users or the environment.	Changes to groundwater regime, quality and availability with minor implications (localised) (reduction in available volume or quality but existing users still viable or negligible impact to receiving environments).	Groundwater regime, quality or availability significantly compromised (existing uses of groundwater no longer viable, and/or impact on waterway flows/receiving environment.	Widespread groundwater resource depletion, groundwater quality degradation or contamination.

The probability or likelihood of a consequence occurring (refer Table 11) has also been assigned a qualitative descriptor. Risks are ranked from ‘Negligible’ through to ‘Extreme’, and are derived from the risk matrix (refer Table 12). The risk ranking therefore indicates the need for management intervention. This could include:

- Further assessment, investigation;
- Management actions, implementation of mitigation measures (if available).

The severity of the risk ranking also provides an indication of the timing or prioritisation of the intervention. For example, an ‘Extreme’ risk ranking may require immediate attention, further assessment and/or mitigation measures to be implemented within short time frames to reduce the risk to an acceptable ranking. Conversely, a ‘Negligible’ risk ranking may require a watching brief only.

Table 11 Likelihood Categories

Descriptor	Explanation
Almost Certain	The event is expected to occur in most circumstances >50% chance of occurring
Likely	The event will probably occur in most circumstances 25–50% chance of occurring
Possible	The event could occur 5–25% chance of occurring
Unlikely	The event could occur but not expected 1–5% chance of occurring
Rare	The event may occur only in exceptional circumstances Less than 1% chance of occurring

Table 12 Risk Rating Matrix

	Consequence				
Likelihood	Insignificant	Minor	Moderate	Major	Catastrophic
Almost Certain	Low	Medium	High	Extreme	Extreme
Likely	Low	Medium	High	High	Extreme
Possible	Negligible	Low	Medium	High	High
Unlikely	Negligible	Low	Medium	Medium	High
Rare	Negligible	Negligible	Low	Medium	Medium

The level of data / information availability relating to the assessment of risk was considered in the following categories shown in Table 13. The rating of data / information availability was used to determine where any additional focus was required in mitigating the risk. For example, if a risk has a ‘catastrophic’ consequence and a low level of data or information available then more effort should be focussed on understanding and mitigating this risk, than an ‘insignificant’ consequence with a high level of data and information available.

Table 13 Data/Information Availability Ratings

Criteria	Low Availability	Medium Availability	High Availability
Data / Information	Data and information is not specific to the region, conditions and industry and has very limited historical records or statistical support.	Data and information has some aspects specific to project region and conditions but not all. Historical records / statistical data is limited in some areas.	Data and information is specific to the region and conditions, and industry has sufficient historical records / statistics to support risk rating.

6.3 Risk Rankings

The results of the hydrological and hydrogeological risk assessments completed by GHD have been summarised in Table 14. Measures to mitigate risks have been included in the assessment. In some cases further investigations may be required to select a preferred mitigation measure, after consideration of its practicality, cost and time implications.

Table 14 Risk Register (Surface Water and Groundwater)

Risk	Pathway / Issue	Likelihood	Consequence	Risk Ranking	Data / Information availability	Mitigation Options
SW1	Construction of the storage (and ancillary infrastructure) results in contamination of surface water.	Unlikely	Moderate	Medium	Low	Development and implementation of a Construction Environmental Management Plan.
SW2	Reduction in Surface Water flow Construction and operation of the storage (and ancillary infrastructure) results in the significant reduction in surface water flow to Alpine bogs.	Unlikely	Moderate	Medium	Medium	Ecological monitoring Diversion of surface water flows around the dam towards the Alpine bogs, aligned with natural flow paths. Lack of flow monitoring data currently exists within the aqueduct and Boggy Creek – installation of flow monitoring is recommended. Installation of flow gauging would aid further analysis of impacts (but in itself does not represent a mitigation measure).
SW3	Reduction in Surface Water flow Construction and operation of the storage (and ancillary infrastructure) results in the significant reduction in surface water flow to surface water supply.	Unlikely	Moderate	Medium	Low	
GW1	Construction of the storage (and ancillary infrastructure) results in contamination of groundwater.	Unlikely	Moderate	Medium	Low	Development and implementation of a Construction Environmental Management Plan.
GW2	Dislocation of Groundwater flow Construction and operation of the storage (and ancillary infrastructure) results in the dislocation of groundwater flow resulting in significant reduction in flows to potential GDEs	Possible	Moderate	Medium	Medium	Integrated program of groundwater and ecological monitoring Diversion of dam under drainage to prioritised bog areas. Sub surface irrigation during stress periods

Risk	Pathway / Issue	Likelihood	Consequence	Risk Ranking	Data / Information availability	Mitigation Options
GW3	Dislocation of Groundwater flow Construction and operation of the storage (and ancillary infrastructure) results in the significant reduction in recharge to the groundwater system.	Possible	Minor	Low	Medium	For linear features such as buried (trenched) pipelines: - Selection and micro-alignment of the pipeline route to avoid or minimise severing of spring areas; - Installation of permeable pipe bedding or foundation materials (where possible) to minimise retarding of groundwater flow; - Installation of trench breakers to prevent the lateral migration of seepage along the pipeline trench.
GW4	Dislocation of Groundwater flow Construction and operation of the storage results in the significant reduction in discharge to the aqueduct.	Possible	Minor	Low	Medium	
GW5	Excavations to construct water storages expose and activate potential ASS	Unlikely	Moderate	Medium	Low	Investigations to characterise the presence of ASS materials at the proposed water storage sites. Implementation of an ASS management plan if required.
GW6	Construction dewatering resulting in resource depletion e.g. construction of the Baldy Storage	Possible	Moderate	Medium	Low	Timing of construction Selection of construction method Management of water recovered from dewatering activities (i.e. reuse for irrigation).

7. Discussion of Surface Water Risks

7.1 Impact to Surface Water Quality

7.1.1 Definition

The surface water quality must be protected to preserve the identified beneficial uses. Potential surface water quality changes may arise from:

- Spillage, improper handling, storage and application of hazardous materials;
- Disposal of fluids or waste to the surface water; and
- Generation of increased sediments loads through construction earthworks.

These potential impacts could arise during the construction of the proposed storage.

7.1.2 Assessment

The surface water runoff downstream of the storage site is currently diverted at the Boggy Creek Diversion, and is used to supply water to Mt Buller for drinking and snowmaking purposes.

It is possible that construction activities may result in localised surface water quality impacts as a result of spillage or improper handling and application of hazardous materials (e.g. the refuelling and maintenance of plant and equipment), or through disturbance and mobilisation or erodible materials.

The likelihood of degradation to surface water quality is considered to be low. It is a reasonable expectation that the construction would occur with the implementation of a construction environmental management plan (CEMP) which would have controls to minimise the impacts, for example:

- EPA (Vic) Publication 480: Environmental Guidelines for Major Construction Sites:
- EPA (Vic) Publication 275: Construction Techniques for Sediment Pollution Control:
- EPA (Vic) Publication 347: Bunding Guidelines:

Furthermore, a hazardous material (pollutants) needs sufficient time and pathways (e.g. excavations) to access the surface environment. It is a reasonable expectation that should a release of hazardous material occur to the environment, incident response procedures are likely to occur promptly and reduce the severity of the consequence, e.g. spill kits.

It is recommended that the surface water quality is monitored during the construction of the storage, to allow identification of any issues and reduce the risk of surface water contamination.

7.2 Dislocation of Surface Water Flow

7.2.1 Conceptualisation

To quantify the potential impacts, a preliminary recharge analysis was undertaken to assess the changes in the catchment as a result of the storage construction. The analysis assumes that:

- The component of rainfall that falls within the (internal) (Dam Base area) of the dam becomes lost from the catchment as it is intercepted and captured by the dam
- The component of rainfall that falls within the (external) (Dam Embankment area) of the storage runs off and remains within the existing catchment.

For example (for either an Alpine bog or waterway):

$$Impact\ to\ Alpine\ Bog = Recharge\ to\ Bog - Loss\ of\ Recharge\ from\ storage\ construction$$

Where, for surface water run-off:

$$Recharge\ to\ Bog = Catchment\ Area\ of\ Bog - Catchment\ Area\ of\ Storage$$

The catchment area of the storage is the footprint of the dam less the area of the externally draining embankments.

A conceptualised recharge model is shown Figure 10, which is a schematic of the summit of Mt Buller. In sectional view it shows the geology. In plan view, it shows an Alpine bog, and at lower topography, a waterway.

The surface catchment of the Alpine bog includes areas topographically up-gradient of the bog. The Alpine bog may be fed by run-off, or from groundwater seepage, or both. Note that the groundwater catchment for the bog may be larger than its surface expression. The catchment of the lower waterway is that area topographically up-gradient of it, where rainfall run-off can drain into the waterway. The waterway may also receive base flow from groundwater seepage. The total recharge to the waterway is therefore that falling on the up-gradient catchment area less, the amount that either spills from drainage lines at higher elevations, or is not intercepted (and removed from the system) by bogs.

Note that other facets of the conceptualisation are relevant to the groundwater environment and are discussed in Section 8.

7.2.2 Assessment

The footprint of the dam results in a loss of surface water runoff to downstream catchments, as all rainfall interception within the internal storage area is captured within the storage. Rainfall interception onto the external parts of dam embankments, however, is assumed to be diverted towards receiving downstream catchments in the direction of the natural surface water flow paths via a drainage system.

An assessment of the reduction in catchment area as a result of the dam footprint was conducted to identify (and quantify) potential risks to downstream environments as a result of the construction of the storage. The potential reduction in surface water catchment area if the runoff collected within the embankments does not discharge to downstream catchments is also reported.

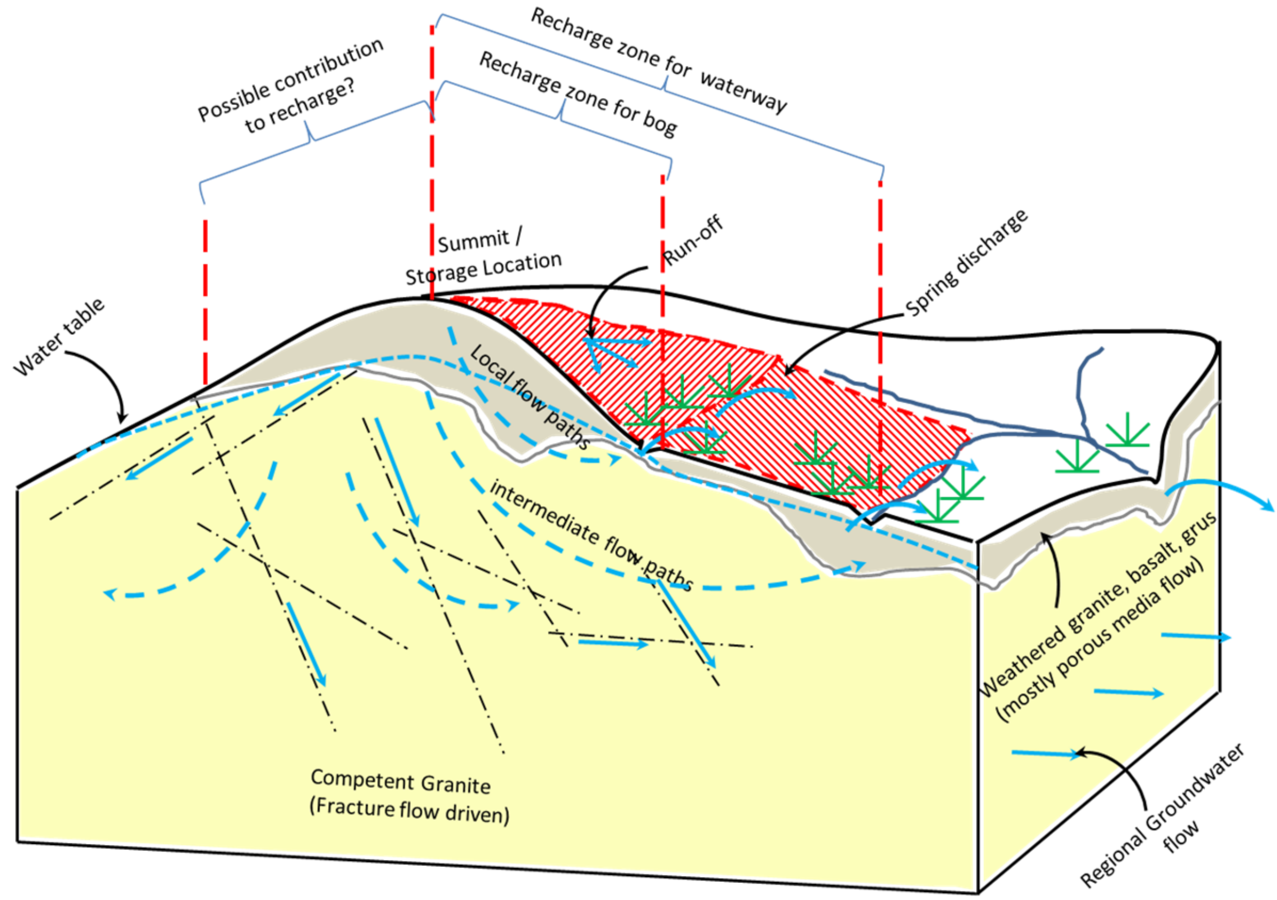
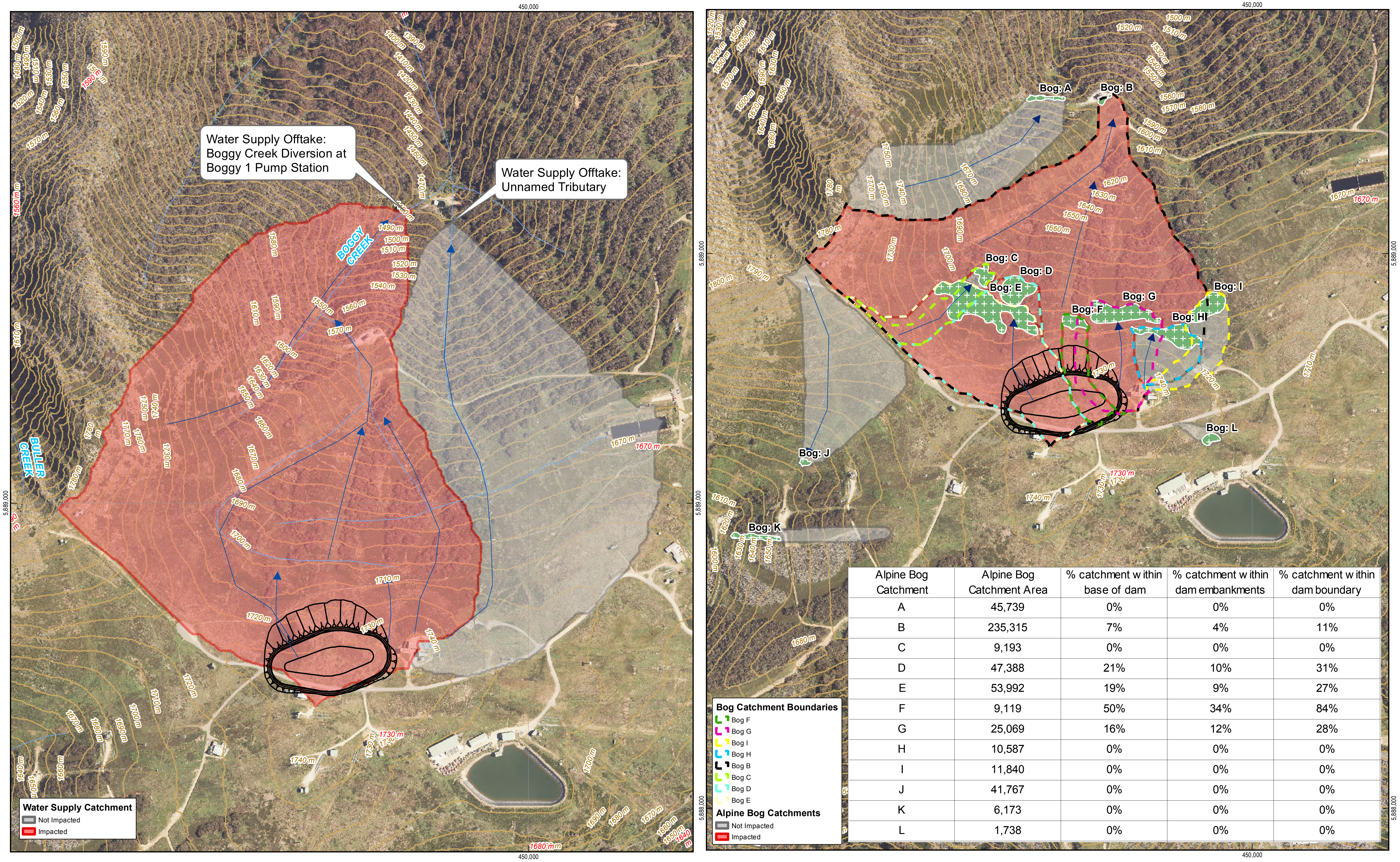


Figure 10 Conceptualised Recharge

Figure 11 schematically shows the surface water catchments for part of the Boggy Creek water supply and the Alpine bogs which are potentially impacted as a result of interception via the dam footprint. The surface water catchments were delineated using GIS techniques, using the 1 m LiDAR surface elevation contours.

The intersection of the surface water catchments and the dam (and embankment) footprints were then used to estimate the percentage reduction in the catchment areas. Alpine bog locations were based on mapping completed by the Department of Environment and Primary Industries (DEPI) Arthur Rylah Institute for Environmental Research (ARI)).

For analysis and discussion purposes, the bogs in Figure 11 have been assigned an alphabetised identity. Also note that when determining the catchments, each waterway and Alpine bog have been treated individually, i.e. bog E falls within the catchment of bog D, however in assessing the change in catchment area, it is nominally assumed that all runoff supplies bog D. From a surface water perspective, this may not be correct, however it adds some conservatism to the analysis.



Alpine Bog Catchment	Alpine Bog Catchment Area	% catchment w ithin base of dam	% catchment w ithin dam embankments	% catchment w ithin dam boundary
A	45,739	0%	0%	0%
B	235,315	7%	4%	11%
C	9,193	0%	0%	0%
D	47,388	21%	10%	31%
E	53,992	19%	9%	27%
F	9,119	50%	34%	84%
G	25,069	16%	12%	28%
H	10,587	0%	0%	0%
I	11,840	0%	0%	0%
J	41,767	0%	0%	0%
K	6,173	0%	0%	0%
L	1,738	0%	0%	0%

Paper Size A3

0 25 50 100 150 200

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

- FlowLines
- Alpine Bogs (mapped by ARI)
- Dam Footprint
- Contours (10m)

Mt Buller & Mt Stirling Resort Management
Mt Buller Sustainable Water Security Project

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Surface Water and Alpine Bog Catchments

Figure 11

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Data Source: DEPI: Vicmap - 2013; GHD - 2013. Created by: mjahanshahi

Impact to Catchment Waterways (reduction in recharge from rainfall run-off)

A summary of the results of the change in catchment areas to waterways has been provided in Table 15. The results indicate that the construction of the storage could result in an approximate 4.4% reduction in the Boggy Creek catchment area to the Boggy 1 water supply diversion, i.e. that part of the catchment above the water supply take point which is collected within (intercepted by) the dam. However, the dam construction does not impact the catchment of the adjacent unnamed tributary which also feeds into the Resort water supply.

Rain falling on the outer embankment (Dam Embankment Area) of the storage would be expected to contribute to catchment flows. Only the rain falling directly within the Dam Base area (internal) area would be unavailable for runoff or recharge.

Water supplies for the resort are sourced from both the Boggy 1 and Boggy 2 pump stations. The slight reduction in loss of catchment run-off is not expected to compromise the water supply to the Resort, particularly given the majority of the catchment reduction is associated with direct interception by the storage itself.

Table 15 Water Supply Catchments

Water Supply Catchment	Water Supply Catchment Area (m^2)	Dam Base Area (m^2) (% of catchment area)	Dam Embankment Area (m^2) (% of catchment area)	Total Area of Dam (m^2) (% of catchment area)
Boggy Creek (Boggy 1 Offtake)	377,040	16,721 (4.4%)	9,296 (2.5%)	26,017 (6.9%)
Unnamed Tributary	207,897	-	-	-
Total Water Supply Catchment	584,937	16,721 (2.8%)	9,296 (1.6%)	26,017 (4.4%)

Note:

1. Area of Catchment within Dam Base Area – that part of the catchment that underlies the ‘storage’ area of the dam, i.e. where rainfall would be captured by the dam and ‘lost’ from being available for recharge due to direct interception.
2. Area of Catchment within Dam Embankment Area – that part of the catchment that underlies the embankment area of the dam, i.e. where rainfall would run-off and is assumed to result in recharge to the catchment
3. Total Area of Dam = ΣArea within Dam Base Area + Dam Embankment Area

Impact to Alpine Bogs (reduction in recharge from rainfall run-off)

A summary of the results of the change in catchment areas to the 12 mapped bogs (bog: A to bog: K) has been provided in Table 16. Assessment of the Alpine bog catchments (Table 16) indicates the following:

- The catchments of bogs A, C, H – L (inclusive), and therefore recharge to these areas, is not impacted by the presence of the proposed storage.
- The estimated reductions in potential run-off to mapped Alpine bogs varies between 7% and 50% with most less than 21%.
- An estimated 50% of the catchment of bog F falls within the Dam Base Area. Accordingly it is estimated that there could be up to a 50% reduction in surface water recharge to the Alpine bog due to direct interception by the storage. This assumes that all rainfall run-off on embankments is retained in the catchment of bog F and not redirected to a neighbouring catchment.

To address this potential shortfall in recharge to the Alpine bogs, a potential mitigation measure is to direct runoff from the boundaries of the storage into the natural flow paths of the downstream Alpine bog catchments (shown in Figure 11). This diversion could be made to preferentially direct water to the bogs identified as being most impacted (for example bog F) based on the above catchment area analysis.

Figure 11 also displays the primary natural flow paths based on the surface topography. This highlights that any runoff during construction of the storage has the potential to transport contaminants and silt to downstream receiving environments. Appropriate mitigation measures and landscaping, which protect the catchment from sedimentation (and erosion) impacts, would be required.

7.2.3 Comment on the Role of the Aqueduct

An aqueduct is located to the north of the proposed water storage (refer Figure 3). It is understood that it was originally engineered to harvest water draining from the headwaters of Boggy Creek for the Resort drinking water supply.

The aqueduct is no longer used for the direct supply of water to the Resort, however the channel and weir structure provides an artificial standing water body (refer photographic record attached as Appendix A), as well as intercepting spring flow and seepage waters emanating from the mount. Based on site inspection undertaken by GHD aquatic ecologists (GHD 2014c) it overflows at specific locations along the length, which in turn define the flowpath for tributaries of Boggy Creek immediately downstream of the aqueduct. Some decommissioned infrastructure associated with this previous water supply remains and the headworks provide a small standing body of water in the centre of the aqueduct.

Flow within the aqueduct is not gauged. The potential direct impact as a result of changes in run-off (and groundwater recharge) has not been quantified.

Table 16 Alpine Bog Surface Water Catchments

Alpine bog catchment	Alpine Bog catchment area (m^2)	Area of catchment within Dam Base Area (m^2)	% catchment within Dam Base Area	Area of catchment within Dam Embankment Area (m^2)	% catchment within Dam Embankment Area	Total Area of Dam within catchment (m^2)	% of catchment occupied by Total Area of Dam
A	45,739	**-**	**0%**	-	0%	-	0%
B	235,315	**16,721**	**7%**	9,296	4%	26,018	11%
C	9,193	**-**	**0%**	-	0%	-	0%
D	47,388	**10,002**	**21%**	4,770	10%	14,772	31%
E	53,992	**10,002**	**19%**	4,770	9%	14,772	27%
F	9,119	**4,575**	**50%**	3,127	34%	7,702	84%
G	25,069	**3,983**	**16%**	3,033	12%	7,016	28%
H	10,587	**-**	**0%**	-	0%	-	0%
I	11,840	**-**	**0%**	-	0%	-	0%
J	41,767	**-**	**0%**	-	0%	-	0%
K	6,173	**-**	**0%**	-	0%	-	0%
L	1,738	**-**	**0%**	-	0%	-	0%

Note:

1. Area of Catchment within Dam Base – that part of the catchment that underlies the ‘storage’ area of the dam, i.e. where rainfall would be captured by the dam and ‘lost’ from being available for recharge due to direct interception.
2. Area of Catchment within Dam Embankment – that part of the catchment that underlies the embankment area of the dam, i.e. where rainfall would run-off and is assumed to result in recharge to the catchment
3. Total Area of Dam = ΣArea within Dam Base Area + Dam Embankment Area

8. Discussion of Groundwater Risks

8.1 Impact to Groundwater Quality

8.1.1 Definition

As required by the *Environment Protection Act* (1970) and the SEPP (*Groundwaters of Victoria*), groundwater has defined beneficial uses dependent on its salinity. The groundwater quality must be protected to preserve the identified beneficial uses. Potential groundwater quality changes may arise from:

- Spillage, improper handling, storage and application of hazardous materials;
- Disposal of fluids or waste to groundwater;and
- Spillage, road run-off during operation of the project.

These potential impacts could arise during the construction of the proposed storage.

8.1.2 Assessment

The background groundwater quality of the watertable aquifer is very high, with groundwater falling within Segment A. Therefore it is has a range of beneficial uses.

It is possible that construction activities may result in localised groundwater quality impacts as a result of spillage or improper handling and application of hazardous materials (e.g. the refuelling and maintenance of plant and equipment).

The likelihood of such environmental incidents is low. It is a reasonable expectation that the construction would occur with the implementation of a construction environmental management plan (CEMP). Furthermore, a hazardous material (pollutants) needs sufficient time and pathways (e.g. excavations) to access the groundwater environment. It is a reasonable expectation that should a release of hazardous material occur to the environment, incident response procedures are likely to occur promptly and reduce the severity of the consequence.

It is noted that a number of groundwater monitoring bores have nitrate concentrations above the ANZECC (2000) guidelines for the protection of aquatic ecosystems. It is not known whether this represents naturally elevated background concentrations, or is a result of site activities such as the use of treated waste water for snow making purposes. Further investigations are required to assess this.

8.2 Dislocation of Groundwater Flow

8.2.1 Definition

The construction of the storage can potentially disrupt localised groundwater flow via three processes:

- The footprint of the dam is of sufficient size that it reduces rainfall recharge to the local groundwater environment;
- It may, via the proposed sub-surface drainage, intercept groundwater flow that may have emerged elsewhere as spring flow; and

- It may sever aquifers and divert local groundwater flow, potentially shifting spring eyes.

These process may result in reduced groundwater recharge (and lower or deeper groundwater levels), or a reduction in flow to down-gradient receiving environments such as potential GDEs or the aqueduct. The bogs were not identified as GDEs (BOM 2014), however it is noted that the mapping is broad scale. Detailed mapping by GHD and DEPI has identified Alpine bogs near the proposed storage. These are considered to be a threatened community under State and Commonwealth legislation. Waterlogging, including shallow groundwater is important for their existence.

8.2.2 Climate Data

Groundwater levels are influenced by rainfall recharge and therefore exhibit a seasonality trend. The site was inspected during the summer period and therefore it is a reasonable expectation that groundwater levels (and spring flow) were nearing their seasonal lows. This is supported by water levels being recorded in monitoring bore BH7, near the aqueduct, at the time of bore installation, with the levels dropping below the base of the bores approximately two weeks later. Further groundwater monitoring (refer to Section 10) is required to characterise seasonal groundwater trends.

Climate data was obtained from the Bureau of Meteorology from the monitoring station located at Mt Buller (Station No. 83024). The mean data is summarised in Table 17 which is based on a 133 year period of rainfall record.

Table 17 Summary of Climate Data

Month	Entire Record (1889 – 2014)				1996-2014
	Maximum Temperature (^{o}C)	Minimum Temperature (^{o}C)	Rainfall (mm)	Evaporation (mm)	Rainfall (mm)
Jan	30.5	3.4	72.8	145.0	71.1
Feb	29.5	3.8	61.7	121.4	85.4
Mar	26.4	1.8	83.6	90.96	91.6
Apr	20.5	-0.35	97.6	44.9	81.9
May	15.4	-2.3	135.2	22.0	117.6
Jun	11.3	-3.7	146.0	12.4	142.5
Jul	9.6	-4.4	138.4	13.9	148.1
Aug	11.7	-4.4	178.7	24.1	173.8
Sep	16.1	-3.3	131.8	43.6	160.3
Oct	21.2	-1.9	139.0	76.4	130.4
Nov	25.2	0.2	105.4	97.1	119.2
Dec	28.4	1.85	91.9	125.2	98.7
Annual	31.8	-5.3	1373.6	813.7	1363.3

Note: 1 Record length: Rainfall: 1899 – present., Site elevation: 1,707 m

The monthly rainfall cumulative distribution is presented in Figure 12. The cumulative rainfall frequency indicates that 50% of the monthly rainfall at Mt Buller is around 100 mm or less.

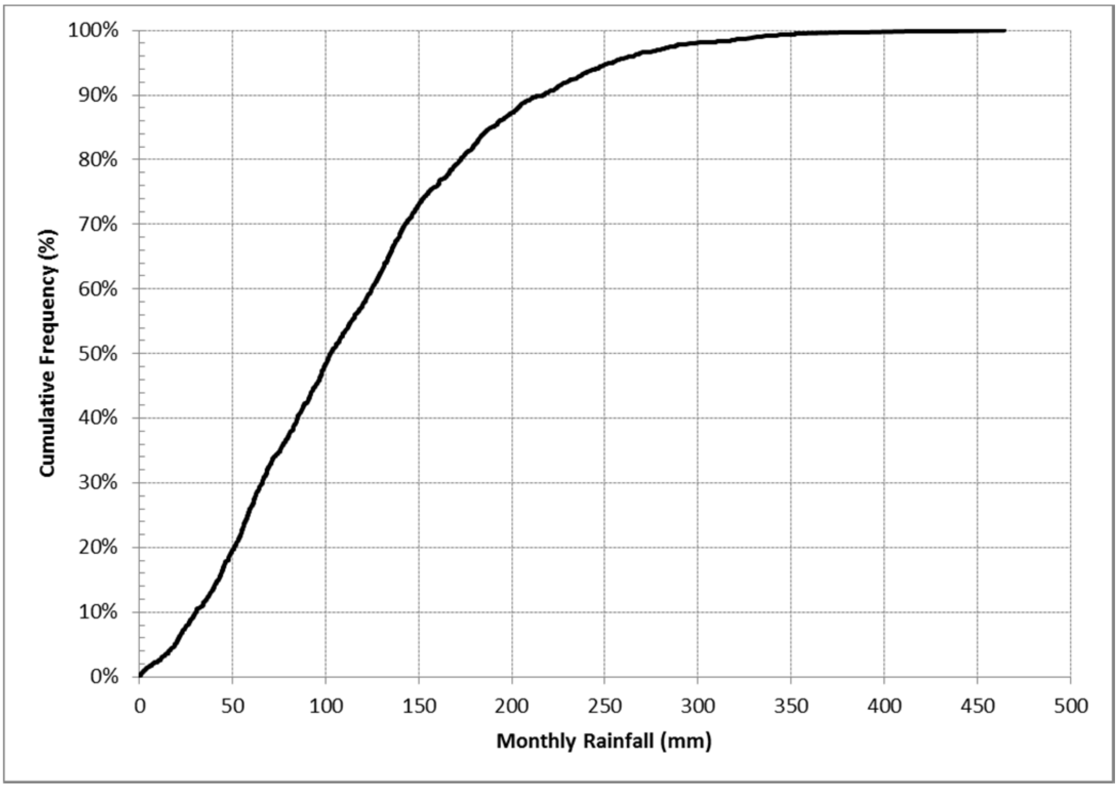

Figure 12 Monthly Rainfall Cumulative Distribution

Source: Bureau of Meteorology Mt Buller (Station No. 83024)

The long term annual rainfall for the site is 1,373 mm, and the average over the last 18 years (encompassing the Millennium Drought which occurred during the 1996 – 2010 period) has been similar at 1,363 mm. Annual rainfall totals during the Millennium drought have been summarised in Table 18. With the exception of 1996 – 1997 and 2006, rainfall totals have been around the long term average.

Table 18 Summary of Millennium Drought (1996-2010) Rainfall

Year	Total Annual Rainfall (mm)#
1996	988.6
1997	945.8
1998	1513.5
1999	1343.5
2000	1122.3
2001	1547.6
2002	1386.5
2003	1512.8
2004	1490.7

Year	Total Annual Rainfall (mm)#
2005	1377.2
2006	421.7
2007	1785.1
2008	1338.6
2009	1624.9
2010	2258.8

Source: Bureau of Meteorology Mt Buller (Station No. 83024)

8.2.3 Conceptualisation

To determine the sustainable yield of an aquifer system requires intensive and extensive hydrogeological investigations, including characterisation of the aquifer system in terms of:

- Permeability;
- Aquifer thickness and saturated thickness;
- Aquifer extent;
- Groundwater level and temporal behaviour;
- Determination of recharge areas, mechanisms and rates; and
- The degree of interaction of all surface water features with the groundwater system.

To quantify the potential impact on groundwater flow and downstream receiving environments such as the Alpine bogs, a preliminary catchment recharge assessment was undertaken adopting a similar approach to that documented in Section 7.2, i.e. it assumes that a percentage of the annual rainfall that falls on the outcropping aquifer material infiltrates and reaches the water table.

For example (for an Alpine bog):

$$Impact\ to\ Alpine\ Bog = Recharge\ to\ Bog - Loss\ of\ Recharge\ from\ storage\ construction$$

Where, for groundwater:

$$Recharge\ to\ Bog = Catchment\ Area\ of\ Bog - Catchment\ Area\ of\ Storage$$

In the case of the proposed storage, it is assumed that:

- Rainfall is captured within the Dam Base Area (internal area of the storage) (and lost from the groundwater or surface water system)
- Rainfall on the Dam Embankment Area (external embankments) is assumed to run-off, but (instantaneously) form recharge to the groundwater (without evaporative or transpiration losses)
- Groundwater intercepted by the drainage blanket is ignored, i.e. captured and diverted from the groundwater system as surface water run-off.

In both the surface water (Section 7.2) and groundwater analysis, evaporative and transpiration losses are ignored as the analysis compares changes to the catchment area from the storage footprint. Similarly, water movement in the unsaturated zone is bundled as groundwater flow, i.e. not differentiating transient soil water storage.

The groundwater system has been included in the recharge conceptualising (refer Figure 10). The conceptualisation shows competent granites covered by a variable thickness veneer of unconsolidated sediments (e.g. grus) and basalt. Groundwater is recharged by infiltrating rainfall, with the summit of Mt Buller essentially forming a groundwater divide, with groundwater flow radiating from the higher topographies to the lower elevations. Groundwater discharge on the conceptualisation is shown as springs and seeps to Alpine bogs and waterways. Groundwater will comprise both local and longer flow paths. Localised groundwater flow paths will predominate, particularly where porous media flow processes dominate (and where weathering and soil cover thicknesses are variable). Intermediate length flow paths may also exist, with flow dominated in the fracture systems.

The groundwater recharge analysis assumes that rainfall recharge (and thus flows to springs) is sourced by vertical movement, directly from infiltrating rainfall in the aquifer ‘surface expression’ catchment. These assumptions may not always be valid. For example, flow in the fractured rock aquifer system may be recharged from elsewhere and not necessarily from its immediately overlying surface expression.

8.2.4 Assessment

Based on the above conceptualisation, the catchments for each of the mapped Alpine bogs are the same as those determined from the rainfall run-off analysis, i.e. refer Table 16.

- The catchments of bogs A, C, H – L (inclusive), and therefore groundwater recharge to these areas, is not impacted by the presence of the proposed storage.
- The estimated reductions in potential groundwater recharge to mapped Alpine bogs varies between 7% and 50% with most less than 21%.
- An estimated 50% of the catchment of bog F falls within the Dam Base Area. Accordingly it is estimated that there could be up to a 50% reduction in recharge to groundwater. This assumes that all rainfall run-off on embankments is converted into groundwater recharge (or at least ultimately recharge to the down-gradient receptors). It further assumes that embankment run-off is retained in the catchment of bog F and not redirected to a neighbouring catchment.

8.2.5 Discussion of potential impact to Alpine bogs

It is understood that Alpine bogs (including sphagnum bogs) thrive in permanent wet areas or slopes where soils are waterlogged. Shallow groundwater and an impeded drainage system (such as that potentially caused by a change in geology, or landslip) are factors which maintain water tables at or near the surface are considered key conditions for sphagnum development. A reduction in springflow, as a result of the proposed storage construction and operation is therefore potentially detrimental.

The recharge analysis suggests that for one specific bog (bog F), there is potentially a 50% reduction in the recharge to the local groundwater. Other bogs may have less than 21% loss in recharge, or not be affected at all. However, this should be treated with caution and as a worst case scenario as:

- The analysis assumes that only vertical infiltration results in groundwater recharge (and supply to the down-gradient bogs). It does not account for lateral flow which would occur within the granites (and basalt) aquifers, which could be sourced from outside of the defined areal recharge catchment.

Groundwater flow would be controlled by the both the fracturing within the granite and the contacts between the geological units. Groundwater potentially feeding the spring flow may not be sourced from immediately up-gradient of the springs. The intake area may have lateral flow components. Tracer testing would be required to inform localised groundwater flow contributions.

Furthermore, the analysis does not account for flow that would be intercepted by the drainage blanket constructed beneath the proposed storage. In addition to this potential reduction in recharge, under-drainage has the potential to intercept groundwater flow (both vertical recharge components and lateral flow components).

It is therefore concluded that although the construction of the proposed storage has potential to reduce groundwater accessions immediately down-gradient of the structure, it is difficult to quantify the reduction in groundwater supply to spring flow (and the bogs). Preliminary recharge estimates suggest that of the 5 Alpine bogs potentially affected, bog F is estimated to be the most affected with up to a 50% reduction in recharge as a worst case. However as described previously, this does not account for lateral groundwater flow, through-flow to the area from other parts of the summit or aquifer, or management of embankment run-off.

8.2.6 Mitigation Measures

Artificial Recharge / Watering

There is little information or precedent for the artificial recharge of Alpine bog communities, or its success, however artificial watering of GDEs has been undertaken elsewhere nationally.

In Western Australia, there are examples where artificial recharge has been applied (in management plans) to support GDEs, e.g. Yanchep Cave Fauna, and sensitive flora and fauna habitats potentially impacted by mineral sands mining to the south of Perth. Similarly to Victoria, the protection of the GDE involves either modelling or predictive drawdown estimates (to determine the potential for impact and establishment of protection triggers), and/or integrated water level and ecosystem monitoring.

Proposed Mitigation Measures

A mitigation measure proposed is to provide the Alpine bog with an alternate, artificial recharge source. Water would be either sourced from the storage, which based on normal operating circumstances would be full at the end of the winter diversion period (September), or the redistribution of groundwater seepage captured by the underdrainage blanket.

Recharge to the Alpine bog areas could then be achieved by applying subsurface irrigation, either using injection bores, or a soakage trench system.

Such an artificial recharge system may incorporate:

- Storage overflow and perimeter embankment drains which divert flow towards the bogs. Incorporation of appropriate erosion protection, and consideration of geotechnical stability are assumed;
- An under-drainage outlet pipe which incorporates a network of branches which distribute the captured water to the down gradient bog. Preference would be given to

the bogs, identified through a monitoring program, as most likely to experience the greatest reduction in flow; and

- An allowance for subsurface irrigation of the impacted bog areas during dry periods, e.g. late summer, is made from the total storage volume, based on groundwater levels or bog condition monitoring. Irrigation could utilise the infrastructure described above or could be achieved via separate infrastructure.

The artificial recharge system to be installed would be finalised during the detailed design of the proposed storage and ancillary infrastructure. To inform the design and understanding of the environmental water requirements of the Alpine bogs, a period of groundwater monitoring integrated with ecological and surface water monitoring is required prior to construction. Monitoring would be required to encompass the seasonal variability in groundwater behaviour.

The elements of a groundwater monitoring program have been documented in Appendix G,

Design and Operational Considerations

In order for artificial watering to be successful there needs to be:

- An understanding of the environmental constraints of the unsaturated profile, e.g. storage capacity, root depth, access to the bog / root elements, water quality requirements and natural factors potentially influencing the condition of the bog ;
- An understanding of how best, where and when to introduce and transmit artificial watering;
- Chemistry constraints on the source water for artificial recharge, e.g. suspended solids, hydrochemistry compatibilities;
- Sustainability aspects of the recharge system and effectiveness over the long term; and
- Geotechnical stability (slope and embankment) considerations.

As previously indicated, this implies a need for baseline monitoring prior to construction, and on-going monitoring to assess the benefits afforded by the artificial recharge.

Therefore, any mitigation measure should seek to mimic the pre-construction prevailing water regime, saturation extents and ecosystem condition. An artificial watering regime should be based on defined trigger levels designed to maintain the baseline conditions.

In addition to direct, artificial recharge applications, landscaping around the access tracks and embankment of the proposed storage is recommended to direct run-off towards the bogs.

It would also be important to design a system that minimises intervention i.e. on-going maintenance and monitoring costs. These aspects are beyond the scope of this document, but would be addressed during detailed design e.g. gravity drainage / pressure systems, access to the water supply, maintenance and contingency actions, safety to the public, sizing and layouts.

8.2.7 Ancillary Infrastructure

In terms of ancillary infrastructure, such as pipelines, potential exists for these to cross (and sever) springs. The pipeline trench may also present a preferred pathway for the migration of seepage and dislocation of groundwater. To mitigate against this risk, there are a number of actions which can be employed:

- Avoid or minimise severing by selection of the pipeline route alignment;
- Minimise excavation depths;
- Micro-alignment changes during the construction; and
- Installation of trench breakers/blockers to prevent development of preferential pathways.

Hydrogeological investigations for the concept design did not specifically cover the ancillary infrastructure. Further geotechnical works would be required to support the detailed design process. Hydrogeological works could be incorporated into any further works to characterise these sites (and routes) and inform the risk assessment. It is assumed appropriate drainage design would be applied to manage groundwater and associated flow constraints.

8.3 Activation of ASS (by groundwater)

8.3.1 Definition

The occurrence of ASS can be present in the form of:

- Potential Acid Sulphate Soils (PASS) – Soil that contains unoxidised iron sulfides. When exposed to oxygen through drainage or disturbance, these soils produce sulfuric acid
- Actual Acid Sulfate Soil (AASS) – Potential ASS that has been exposed to oxygen and water, and has generated acidity.

These soils are rich in organics and were formed in low oxygen or anaerobic depositional environments. They are rich in sulphides and when oxygen is introduced, the sulphides oxidise to sulphate, with resultant soils having low pH and potentially high concentrations of the heavy metals. When water levels rise, pH and heavy metals are subsequently mobilised into the environment and can potentially impact deep-rooted vegetation, aquatic flora and fauna, and can be aggressive to reactive materials (e.g. concrete, steel) of foundations, underground structures (e.g. piles, pipes, basements) or buried services in contact with groundwater.

8.3.2 Assessment

For the proposed project, the Carbonaceous Mudstone derived soils are considered to have characteristics which may make them PASS. Excavation of these materials above the watertable and their management (e.g. acid run-off from stockpiles and treatment areas, filling) may activate PASS conditions.

The Carbonaceous Mudstone has been observed (exposed at surface) within the Sun Valley Reservoir (SVR). Although no known ASS related issues have been reported at SVR, or any testing undertaken, to further inform this risk, it is recommended that investigations are undertaken during the detailed design phase to confirm whether the Carbonaceous Mudstone, particularly in areas where significant ground disturbance is proposed are PASS. An ASS management plan can be implemented to document procedures for the management. A summary of the components of an ASS management plan is provided in Table 19.

Table 19 Acid Sulphate Soils Management

Description	Elements
Site Overview	Stratigraphy and lithology Hydrology and hydrogeology Sensitive receptors
ASS Occurrence	Vertical and spatial distribution of ASS onsite and potentially offsite Results and interpretations of ASS assessment
Description of Proposed Works	Description of any dewatering, drainage, soil excavation works Storage / stockpiling, bunding methods Reuse and disposal options
ASS Management Strategy	Strategies for preventing oxidation of metal sulphides, and avoiding disturbance Planned treatment strategies for ASS materials, leachate and stormwater Water table management strategies (on and offsite), during and post disturbance Containment strategies for contaminated stormwater, leachate (both short and long term)
Timing of Activities	How planned management activities would integrate with other components of the project.
Performance Criteria	Set criteria for all stages of the project, including during and post construction to monitor the effectiveness of ASS management activities. Consider soil, groundwater and surface water management.
Monitoring Program	Design (locations, frequencies, parameters, procedures) Water monitoring strategies
Contingency Procedures	Contingencies for when ASS management strategies fail. Establishment of trigger levels. Restorative actions, remedial actions, monitoring program amendments
Consultation and approvals	Records of all approvals and consultation with regulatory agencies and stakeholders.

Note: Adapted from DSE (2010)

8.4 Construction Dewatering

8.4.1 Definition

The majority of impacts to groundwater arise from altering localised groundwater levels.

The extraction of groundwater, from the dewatering of an excavation within saturated conditions, results in the creation of a hydraulic gradient towards the excavation. This results in groundwater inflow, and a decline in groundwater levels remote from the seepage face (or dewatering point).

The decline in water level is referred to as the ‘drawdown cone’ or ‘cone of depression’ around the pumping bore, or drawdown zone around an excavation. Excessive groundwater inflows can be an impediment to subsurface construction, and pose issues in terms of depletion of a resource, management of the volume recovered and the effects of drawdown, e.g. depletion of spring flow.

The extent of drawdown depends primarily on the nature of the aquifer, the pumping rate and pumping duration. If the aquifer system consists of fractured rock, or is of odd shape, the shape and extent of drawdown may vary in certain preferential directions. If the drawdown extends a certain distance from the extraction centre such that it intersects other bores or (in the case of unconfined aquifers) it intersects with environmental features such as creeks, rivers and dependent ecosystems, it is said to have interfered with these features.

Dewatering may be required during construction to maintain safe working conditions in the storage earthworks and associated pipeline trenching, but also the construction of the larger proposed storage tanks (ancillary infrastructure).

8.4.2 Assessment

The deepest parts of the proposed storage are estimated to be approximately 11 m below the surface and therefore potential exists for the intersection of the water table, and groundwater seepage into earthworks.

In terms of the fractured rock materials (Older Volcanics basalt and granite), groundwater seepage would occur if excavations intersected secondary porosity features within the rock mass. The likelihood of intersecting water bearing fractures cannot be fully determined without pumping test investigations (pre-construction), or during the construction activities when excavation faces are exposed during earthworks.

Construction dewatering, may be required depending upon the prevailing climate and groundwater levels at the time of construction. A drainage blanket is to be constructed beneath the proposed storage and therefore excavations may encounter seepage. Pipeline trenches or deeper foundation slabs may also encounter seepage.

It is considered a reasonable assumption that short term, i.e. days to weeks, sump pumping or similar methods may be employed to stabilise excavations where seepage is intersected. Dewatering would cease following construction of the drainage blanket, or in the case of ancillary infrastructure, laying of pipelines or foundation slabs, and therefore it is not expected to pose a significant risk. Re-use of the recovered groundwater seepage for the irrigation of surrounding vegetation is a potential mitigation feature. Timing of the works and selection of the construction methods can also influence the amount of dewatering required.

As with the proposed storage, some structures may require permanent drainage to maintain safe structural conditions should high groundwater levels be present. A possible mitigation option is to redirect recovered groundwater seepage (from drains etc) into the sensitive vegetation areas (bogs). The method by which this is undertaken should be designed so as to avoid compromising the slope stability of the project area.

9. Conclusion

Hydrogeological investigations were undertaken to characterise the groundwater environment as part of geotechnical investigations into the construction of a proposed off-stream storage and ancillary infrastructure. The investigations included the construction of 14 groundwater bores, aquifer testing, groundwater gauging and water quality sampling.

The hydrogeology of the dam site is relatively complex, comprising a number of localised groundwater flow processes occurring with fractured basalt, and weathered granite aquifers, grus, and granitic sediments. Superimposed upon the flow processes occurring within these aquifers, are ancient landslide structures which may further influence local groundwater movement.

The following conclusions are made regarding the site hydrogeology, and risk assessment:

- The groundwater quality is high with salinities falling within Segment A. The low salinities confirm localised groundwater flow paths;
- No significant geochemical differences were identified between the various aquifer units screened. This supports interaction between the various geologies;
- Aquifer (slug) testing identified variable hydraulic conductivities, ranging from <0.1 to 6.5 m/day;
- Groundwater flow is topographically controlled, radiating from the summit, however at a local scale, fracturing and secondary porosity features are expected to influence groundwater movement;
- Spring flow has been mapped at a number of locations in and adjoining the proposed storage site location, particularly on the northern side of the site;
- There is no nearby abstractive groundwater use;
- Groundwater is connected to surface water within the local area;
- A significant seasonal variation in groundwater levels has been observed based upon a limited period of monitoring, with conditions in late summer leading to a reduction in water level at approximately 1 m below surface within the Alpine bog area, and anecdotal visual observations indicating spring flows reducing in some locations;
- Although regional scale GDE mapping (by others) did not identify GDEs, Alpine bogs (including sphagnum) have been mapped north of the proposed storage site. Alpine bogs are a threatened community under Commonwealth and State legislation. Waterlogging, including shallow groundwater is important for their existence.

A risk assessment was undertaken to identify the potential risks of the proposed storage construction on the surface water and groundwater environments.

A high level hydrological assessment was undertaken to provide an indication of the reduction of surface water catchments as a result of construction of the storage. The results indicate that:

- The footprint of the proposed storage results in approximately 2.5% reduction in the total catchment area for the Boggy Creek Diversion at Boggy 1 pump station. Water supplies for the resort are sourced from both the Boggy 1 and Boggy 2 pump stations. The slight reduction in loss of catchment run-off is not expected to compromise the water supply to the Resort, particularly since the majority of the loss is associated with direct interception by the storage.

- Construction of the storage could result in the loss of up to 30% of the surface water catchment area (through direct interception) of specific downslope Alpine bogs. It is surmised that the Alpine bogs rely on a combination of water sources such as surface water (rainfall, run-off and snow melt) and groundwater flows. This reliance may be time varying, intermittent or opportunistic. Mitigation measures to protect the bogs from loss of recharge as a result of storage construction could include landscaping works to redirect surface water flows and redistribute them to the bog catchment areas most likely to be affected.

In terms of potential impacts to the groundwater environment:

- Dislocation of groundwater by construction (and operation) of the proposed storage is considered to represent a potential hydrogeological risk. Alpine bogs (and associated ecosystems) rely on waterlogged conditions, of which spring flow (the surface expression of groundwater) is considered to be an important contributor at the site.

  Based on summer 2014 monitoring information, the proposed elevation of the drainage blanket underlying the proposed storage does not intersect groundwater, however a seasonal understanding of water level behaviour is not available. Conservatively, higher water levels could be reasonably expected during the winter and spring periods. Under such water level regimes, the drainage blanket may intercept water that currently flows towards the bogs. The groundwater flow systems within the granite which lead to spring flows are complex and difficult to quantify. It is therefore difficult to determine the extent of any dislocation.

  As a worst case scenario, of the 12 mapped Alpine bogs, 6 bogs had interpreted catchments that were potentially influenced by the proposed storage construction. These worst case estimated reductions range between 0% (no effect) and 50%, with the worst case estimated reduction in direct catchment recharge (50%) occurring at bog F. This worst case reduction in recharge does not account for lateral groundwater flow, and through-flow to the area from other parts of the summit. In addition, the analysis does not account for flow that could be intercepted by the drainage blanket (when groundwater levels are high), constructed beneath the proposed storage and discharged in a managed manner.

- The storage would not impact all of the bogs mapped and potential impacts are expected to be limited to areas in close proximity to the storage. The redistribution of groundwater seepage captured by under storage drainage, sub surface irrigation (using stored water), and diversion of overflow and perimeter drainage around embankments (using landscaping) are all methods that could be applied to artificially recharge the bogs. The bogs currently identified as likely to experience the most significant changes in flow, or those that are identified through monitoring as being at greatest risk, should be targeted for these mitigation measures.

- The implementation of mitigation measures involving artificial recharge or redirection of surface waters must be cognisant of potential geotechnical stability issues (for example by creating over saturated or unstable ground conditions). Geotechnical considerations necessitate careful control on water application and detailed design of the application system and its management. Therefore, any mitigation measure should seek to mimic the current observed water levels and saturation extents. An artificial watering regime should be based on defined trigger levels designed to maintain the condition of the bogs and their associated communities.

- The complexity of the underlying geology on the site and the movement of water though and across the site means that there is significant uncertainty associated with the assessment of the impact to the Alpine bogs as a result of the direct rainfall interception (reduction in recharge). It is surmised that the Alpine bogs and their associated ecosystem rely upon groundwater (springflow) during the drier, summer periods. It is noted that there were episodes during the recent Millennium drought where bogs were exposed to significant (short term) reductions in rainfall recharge, e.g. 2006. Monitoring (e.g. Summer 2014) indicates that periods may occur where water levels can be 1 m, below surface within the bog area. No local information linking changes in the extent or condition of the Alpine bogs with varying rainfall has been identified.

  A reduction in direct recharge may reduce groundwater spring flow, but it may not necessarily result in decreased water levels at the bog, i.e. access to water is maintained. Furthermore, there is currently a lack of information on how the estimated groundwater recharge reductions may translate into changes in Alpine bog condition.
- Contamination of surface or groundwater could occur through construction activities (for example through a fuel spill), however the risk of degradation can be mitigated by the implementation of an appropriate project specific construction environment management plan (CEMP).
- A soil type identified during the geotechnical program and referred to as ‘Carbonaceous Mudstone’ potentially represents an Acid Sulphate Soil. Further investigations are required to inform this risk, however the likelihood is considered low.

Given the difficulties in quantifying the potential change in groundwater spring flow, or that intercepted and captured by under storage drainage infrastructure , further monitoring is required to inform the risk assessment, specifically the seasonal water level variation, aqueduct flow and baseline health of the bog communities. Tracer testing investigations may better inform groundwater flow paths.

10. Recommendations

The following recommendations are made:

- Drainage should be designed around the periphery of the storage to direct runoff along the natural flow paths towards downstream Alpine bogs. Priority should be given to the bogs considered most likely to experience reductions in surface or groundwater flows.
- Incorporate groundwater inputs into a Monitoring and Management Plan to minimise degradation of the groundwater and surface water environment. Design and construction activities are required to be cognisant of the site topography and sensitivity.
- Establish an ecological monitoring program (in consultation with a suitably qualified ecologist) a minimum 12 months prior to the commencement of construction.
- Implement a Groundwater Management Plan (refer Appendix G).which incorporates monitoring of the Alpine bog community and evaluation of localised groundwater flow contributions. This may include:
  - additional monitoring bore installation adjacent to and within Alpine bogs potentially affected by changes in upslope recharge;
  - additional monitoring bore installation in unaffected areas as an experimental control; and
  - tracer testing and spring mapping.
- Implement flow monitoring on the aqueduct a minimum 12 months prior to the commencement of construction.
- Assess the potential for ASS materials within the interpreted Carbonaceous Mudstone sediments. Implement an ASS Management Program should the presence of ASS materials be confirmed.
- Review of the risk assessment during detailed design of the proposed storage and as part of finalising ancillary infrastructure (micro-alignment) locations.

11. References

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Appendix A – Bore Development Records

GHD

CALCULATIONS

Client .... Job no. .... Sheet .... of ....
Project .... Calcs by .... Date ....
Subject Bore 15 : Bore Development Checked by .... Date 11/2/14

Water Level = 12.64 mbtoc

Total Depth = 18.29 mbtoc

Stick up = -0.11

Bore volumes to bail

18.29 - 12.64 = 5.65m

5.65m x 2 = 11.3 L

∴ 3 volumes = 33.9 L ~34L

L	DO	EC µS	pH	ORD	Temp.	
10	2.76	85.3	7.53	-44	7.6	h. turb, l brown h. sed!
12	0.72	63.9	6.70	-277	8.0	h. sed, v. thick l. brown no more water

Jenn L 2013 2

GHD CALCULATIONS

Client

Job no.

Sheet of

Project

Calcs by

Date

Subject Bore 15A : Bore Development

Checked by

Date 11/2/14

Total Depth
5.50 mbtoc

Water Level = 4.02 mbtoc

Stick-up = -0.12

Bore volumes

5.50 - 4.02 = 1.48m

1.48m x 2 = 2.96 L
2.96 x 2 = 6.
∴ 3 bore volumes = ~~8.88L~~ ~ ~~9L~~ 18 L.

L	DO	EC µS	pH	Ox	temp	time	
5	5.33	34.7	5.82	137mV	7.9°C	11.45	cloudy brown mod. turb. mod. sed
11	6.85	26.0	5.52	149	7.8	11:51	
18	8.45	21.5	5.53	224	7.8	11.58	〃

Appendix B – Field Purging Records

GHD | MANAGEMENT ENGINEERING ENVIRONMENT

Purging and Sampling Record

Bore ID: BH04

Job Information

Client: Mt Buller & Mt Stirling ARMB
Project: Control Centre Hydrogeological
Proj. No.: 31/30733/14
Sampler: JC
Date: 12/2/2014

Sampling Information

Purge Method: Bail
Sample Method:
WQ Meter Type:
Flow Cell: [✓ Y] / N **Pump Depth:** ....m
WLevel Meter Type: Dip/~~Interface~~
Field Filtered? Y / N (filter vessel, disposable filter/syringe)

Bore Information

SWL(mTOC): 6.99 m
Screen: From:..........to.......... m
NAPL Check:
Ref.datum: TOPVC
Bore Depth: 15.58 m
Logic Check:
Stick Up: 50 mm
Bore Diam.: 0.10 mm
Well Cap Secure? Y

Time (..........)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (uS)	Dis.Oxygen (..........)	Ox-Red Pt. (± mV)	SWL (m TOC)	(..........)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate, purged dry?
Stable when 3 consecutive readings:		-	+/- 0.05 pH	+/- 3%	+/- 10%	+/- 10 mV	stable		
8.10	1	8.6	7.24	142.5	2.38	178	clear	/	WC = 8.5
8.15	10	6.8	7.54	104	2.76	133	g-b	n. turb.	= 17
8.24	20	7.1	8.11	114.8	3.49	115	—	" —	= 34
8.34	30	[illegible]	7.47	112.9	3.65	127	—	" —	= 102 L
8:44	40	7.0	7.74	118.7	6.29	102	—	" — see photo	
8.55	45	7.2	7.16	120	6.93	124			practically dry recovering clearer,
		—	dry	—					very sediment
9:16	13/2/14	—	sampled.				7.33		

Field QA Checks:

Air bubbles in vials? Y / N Any violent reactions? Y / N
Decontamination as per GHD procedure? Y / N
Was sampling equipment pre-cleaned? Y / N
COC updated? Y / N Parameters stabilised Y / N

Parameters	BTEX	TPH	PAH	CHC	PCB	OCP	OPP	Tot. Metal	Biol.			
Preservatives												

Comment: Duplicate samples collected, bottles used, access, condition of headworks etc

Meters Calibrated Y / N QA/QC Taken Y / N Samples cooled Y / N

Purge Volumes

Casing Int. Dia (mm)	50	100	150
Vol (L/m of casing)	2.0	7.9	17.7

*Double for gravel pack

Purging and Sampling Record

Bore ID: BH04A

Job Information

Client: Mt Buller & Mt Stirling ARMB
Project: Control Centre Hydrogeological
Proj. No.: 31/30733/14
Sampler: J.L
Date: 12/2/2014

Sampling Information

Purge Method: BAIL
Sample Method: ……
WQ Meter Type: ……
Flow Cell: Y / N **Pump Depth:** ……m
WLevel Meter Type: Dip/Interface
Field Filtered? Y / N (filter vessel, disposable filter/syringe)

Bore Information

SWL(mTOC): Dry @ 2.38 m **Logic Check:** ……
Screen: From: ……**to**…… m **Stick Up:** -0.07 m
NAPL Check: …… **Bore Diam.:** 50 mm
Ref.datum: TOPVC **Well Cap Secure?** Y
Bore Depth: 2.38 m

Time (………..)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (………..)	Dis.Oxygen (………..)	Ox-Red Pt. (± mV)	SWL (m TOC)	(………..)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate, purged dry?
Stable when 3 consecutive readings:		*-*	*+/- 0.05 pH*	*+/- 3%*	*+/- 10%*	*+/- 10 mV*	*stable*		
					DRY				

Field QA Checks:

Air bubbles in vials? Y / N Any violent reactions? Y / N
Decontamination as per GHD procedure? Y / N
Was sampling equipment pre-cleaned? Y / N
COC updated? Y / N Parameters stabilised Y / N

Parameters	BTEX	TPH	PAH	CHC	PCB	OCP	OPP	Tot. Metal	Biol.				
Preservatives													

Comment: Duplicate samples collected, bottles used, access, condition of headworks etc

Meters Calibrated Y / N QA/QC Taken Y / N Samples cooled Y / N

Purge Volumes

Casing Int. Dia (mm)	50	100	150
Vol (L/m of casing)	2.0	7.9	17.7

*Double for gravel pack

GHD | MANAGEMENT ENGINEERING ENVIRONMENT

Purging and Sampling Record

Bore ID: BH05

Job Information

Client: Mt Buller & Mt Stirling ARMB
Project: Control Centre Hydrogeological
Proj. No.: 31/30733/14
Sampler: JL
Date: 12/2/2014

Sampling Information

Purge Method: Bail
Sample Method: Bail
WQ Meter Type:
Flow Cell: [✓ Y] / N **Pump Depth:** ……m
WLevel Meter Type: Dip/~~Interface~~
Field Filtered? Y / N (filter vessel, disposable filter/syringe)

Bore Information

SWL(mTOC): 14.77 m **Logic Check:**
Screen: From:……**to**…… m **Stick Up:** -0.10 m
NAPL Check: **Bore Diam.:** 50 mm
Ref.datum: TOPVC **Well Cap Secure?** Y
Bore Depth: 19.67 m

Time (……)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (mS)	Dis.Oxygen (ppm)	Ox-Red Pt. (± mV)	SWL (m TOC)	(……)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate, purged dry?
Stable when 3 consecutive readings:		-	+/- 0.05 pH	+/- 3%	+/- 10%	+/- 10 mV	stable		
9:24	1	9.8	7.38	24.9	7.76	175			clear, WC= 5m
9:34	10	9.3	6.17	34.1	6.34	136			turbid, l. brown = 10L
9:47	15	8.2	6.49	100.9	6.04	-4			— " — = 20L
			— dry.						as dry as practicable 3x 20 = 60L bail
8:30	13/2		sampled		—		15.19		
									Attempted to get grab sample
									from 05A but couldn't
									bail any water.

Field QA Checks:

Air bubbles in vials? Y / N Any violent reactions? Y / N
Decontamination as per GHD procedure? Y / N
Was sampling equipment pre-cleaned? Y / N
COC updated? Y / N Parameters stabilised Y / N

Parameters	BTEX	TPH	PAH	CHC	PCB	OCP	OPP	Tot. Metal	Biol.				
Preservatives													

Comment: Duplicate samples collected, bottles used, access, condition of headworks etc RB taken from WQ meter before bailing. Dupl taken here.

Meters Calibrated Y / N QA/QC Taken Y / N Samples cooled Y / N

Purge Volumes

Casing Int. Dia (mm)	50	100	150
Vol (L/m of casing)	2.0	7.9	17.7

*Double for gravel pack

BH05A stickup = -0.115

Purging and Sampling Record

Bore ID: BH06

Job Information	*Sampling Information*	*Bore Information*
Client: Mt Buller & Mt Stirling ARMB	**Purge Method:** BAIL	**SWL(mTOC):** 7.69 m **Logic Check:**
Project: Control Centre Hydrogeological	**Sample Method:**	**Screen: From:** ….. **to** ….. m **Stick Up:** -0.095 m
Proj. No.: 31/30733/14	**WQ Meter Type:**	**NAPL Check:** ….. **Bore Diam.:** 50 mm
Sampler: JL	**Flow Cell:** [✓ Y] / N **Pump Depth:** ….. m	**Ref.datum:** TOPVC **Well Cap Secure?** Y
Date: 12/2/2014	**WLevel Meter Type:** Dip/~~Interface~~	**Bore Depth:** 9.02 m
	Field Filtered? Y / N (filter vessel, disposable filter/syringe)	

Time (……….)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (μS)	Dis.Oxygen (ppm)	Ox-Red Pt. (± mV)	SWL (m TOC)	(……….)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate, purged dry?
Stable when 3 consecutive readings:		-	*+/- 0.05 pH*	*+/- 3%*	*+/- 10%*	*+/- 10 mV*	*stable*		
1022	1	9.7	7.14	37.5	5.61	109			clear : Wc = 2.3 m.
10:33	10	7.4	5.32	32.9	7.17	197			h. turbid, l. brown = 4.6 L
10:44	20	7.9	4.94	33.2	7.17	213			— " — = 9.2 L
10:51	27	7.6	4.97	32.3	7.31	219			— " — = [illegible].6 L
									~7[illegible]
			— Sample taken						

Field QA Checks:

Air bubbles in vials? Y / N Any violent reactions? Y / N

Decontamination as per GHD procedure? Y / N

Was sampling equipment pre-cleaned? Y / N

COC updated? Y / N Parameters stabilised Y / N

Parameters	BTEX	TPH	PAH	CHC	PCB	OCP	OPP	Tot. Metal	Biol.				
Preservatives													

Comment: Duplicate samples collected, bottles used, access, condition of headworks etc

Meters Calibrated Y / N QA/QC Taken Y / N Samples cooled Y / N

Purge Volumes

Casing Int. Dia (mm)	50	100	150
Vol (L/m of casing)	2.0	7.9	17.7

*Double for gravel pack

GHD MANAGEMENT ENGINEERING ENVIRONMENT

Purging and Sampling Record

Bore ID: BH07

Job Information	*Sampling Information*	*Bore Information*	
Client: Mt Buller & Mt Stirling ARMB	**Purge Method:** BAIL	**SWL(mTOC):** DRY to ~2cm m	**Logic Check:**
Project: Control Centre Hydrogeological	**Sample Method:**	**Screen: From:** …… **to** …… m	**Stick Up:** -0.09 m
Proj. No.: 31/30733/14	**WQ Meter Type:**	**NAPL Check:**	**Bore Diam.:** 50 mm
Sampler: BS/JL	**Flow Cell: Y / N** **Pump Depth:** ……m	**Ref.datum:** TOPVC	**Well Cap Secure?** Y
Date: 13/2/2014	**WLevel Meter Type:** Dip/Interface	**Bore Depth:** 1.77 m	
	Field Filtered? Y / N (filter vessel, disposable filter/syringe)		

Time (……….)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (uS)	Dis.Oxygen (ppm)	Ox-Red Pt. (± mV)	SWL (m TOC)	(……….)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate, purged dry?
Stable when 3 consecutive readings:		-	*+/- 0.05 pH*	*+/- 3%*	*+/- 10%*	*+/- 10 mV*	*stable*		
11:22	-	12.8	7.42	24.7	10.57	177			B-G algae, clear, water (SW1)
									not flowing
	BORE			DRY					end of probe grey
									sediment. (7)
11:34	-	10.5	4.79	8.5	0.51	101			Brown/Black sediment, cannot reach
									trickling water, but sample taken
									close by (SW2)

Field QA Checks:

Air bubbles in vials? Y / N Any violent reactions? Y / N
Decontamination as per GHD procedure? Y / N
Was sampling equipment pre-cleaned? Y / N
COC updated? Y / N Parameters stabilised Y / N

Parameters	**BTEX**	**TPH**	**PAH**	**CHC**	**PCB**	**OCP**	**OPP**	**Tot. Metal**	**Biol.**				
Preservatives													

Comment: Duplicate samples collected, bottles used, access, condition of headworks etc

Meters Calibrated Y / N **QA/QC Taken Y / N** **Samples cooled Y / N**

Purge Volumes			
Casing Int. Dia (mm)	50	100	150
Vol (L/m of casing)	2.0	7.9	17.7

*Double for gravel pack

GHD | MANAGEMENT ENGINEERING ENVIRONMENT

Purging and Sampling Record

Bore ID: BH9

Job Information

Client: Mt Buller & Mt Stirling ARMB
Project: Control Centre Hydrogeological
Proj. No.: 31/30733/14
Sampler: JL.
Date: 12/2/2014

Sampling Information

Purge Method: BAIL
Sample Method:
WQ Meter Type:
Flow Cell: Y / N   Pump Depth: ……m
WLevel Meter Type: Dip/Interface

Bore Information

SWL(mTOC): 2.46 m   Logic Check:
Screen: From: …… to: …… m   Stick Up: -0.10 m
NAPL Check: Bore Diam.: 50 mm
Ref.datum: TOC S   Well Cap Secure? Y
Bore Depth: 5.82 m

Field Filtered? Y / N (filter vessel, disposable filter/syringe)

Time (……….)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (……….)	Dis.Oxygen (……….)	Ox-Red Pt. (± mV)	SWL (m TOC)	(……….)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate, purged dry?
Stable when 3 consecutive readings:		-	*+/- 0.05 pH*	*+/- 3%*	*+/- 10%*	*+/- 10 mV*	*stable*		
2:17	10	14.6	7.27	44.5	2.44	154			clear 5.4 m
2:24	20	10.1	5.68	36.2	3.22	187			" 10.8 L
2:30	26	9.4	5.57	23.0	6.03	185			s.cloudy, as dry as practicable 20.6 L
									64.8
									=65L

— sampled when it recovered in 2:43. —

Field QA Checks:

Air bubbles in vials? Y / N   Any violent reactions? Y / N
Decontamination as per GHD procedure? Y / N
Was sampling equipment pre-cleaned? Y / N
COC updated? Y / N   Parameters stabilised Y / N

Parameters	BTEX	TPH	PAH	CHC	PCB	OCP	OPP	Tot. Metal	Biol.				
Preservatives													

Comment: Duplicate samples collected, bottles used, access, condition of headworks etc

Meters Calibrated Y / N   QA/QC Taken Y / N   Samples cooled Y / N

Purge Volumes

Casing Int. Dia (mm)	50	100	150
Vol (L/m of casing)	2.0	7.9	17.7

*Double for gravel pack

GHD MANAGEMENT ENGINEERING ENVIRONMENT

Purging and Sampling Record

Bore ID: BH09

Job Information

Client: Mt Buller & Mt Stirling ARMB
Project: Control Centre Hydrogeological
Proj. No.: 31/30733/14
Sampler: B.S
Date: 12 / 2 /2014

Sampling Information

Purge Method:
Sample Method:
WQ Meter Type:
Flow Cell: Y / N **Pump Depth:** ……m
WLevel Meter Type: Dip/Interface
Field Filtered? Y / N (filter vessel, disposable filter/syringe)

Bore Information

SWL(mTOC): 2.72 m
Screen: From:……**to**…… m
NAPL Check:
Ref.datum: TOPVC
Bore Depth: 5.82 m
Logic Check:
Stick Up: -0.10 m
Bore Diam.: 50 mm
Well Cap Secure? Y

Time (……)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (……)	Dis.Oxygen (……)	Ox-Red Pt. (± mV)	SWL (m TOC)	(……)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate, purged dry?
Stable when 3 consecutive readings:		-	+/- 0.05 pH	+/- 3%	+/- 10%	+/- 10 mV	stable		
		loggers started @ ~~3:55~~ 3:54							
			slug inserted @ 3:55						
			slug removed @ 4:00						
			slug inserted @ 4:05						
			slug removed @ 4:10						
	stopped logging / test finished @ 4:15								

Field QA Checks:

Air bubbles in vials? Y / N Any violent reactions? Y / N
Decontamination as per GHD procedure? Y / N
Was sampling equipment pre-cleaned? Y / N
COC updated? Y / N Parameters stabilised Y / N

Parameters	BTEX	TPH	PAH	CHC	PCB	OCP	OPP	Tot. Metal	Biol.				
Preservatives													

Comment: Duplicate samples collected, bottles used, access, condition of headworks etc

Meters Calibrated Y / N QA/QC Taken Y / N Samples cooled Y / N

Purge Volumes

Casing Int. Dia (mm)	50	100	150
Vol (L/m of casing)	2.0	7.9	17.7

*Double for gravel pack

GHD | MANAGEMENT ENGINEERING ENVIRONMENT

Purging and Sampling Record

Bore ID: 3H10

Job Information

Client: Mt Buller & Mt Stirling ARMB
Project: Control Centre Hydrogeological
Proj. No.: 31/30733/14
Sampler: SL
Date: 12/2/2014

Sampling Information

Purge Method: BAIL
Sample Method: ....
WQ Meter Type: ....
Flow Cell [✓ Y] / N **Pump Depth:** ....m
WLevel Meter Type: Dip/~~Interface~~
Field Filtered? Y / N (filter vessel, disposable filter/syringe)

Bore Information

SWL(mTOC): 4.15 m **Logic Check:** ....
Screen: From: ....**to**.......... m **Stick Up:** -.009 m
NAPL Check: ....**Bore Diam.:** 50 mm
Ref.datum: TOPVC **Well Cap Secure?** Y
Bore Depth: 8.825 m

Time (..........)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (mS)	Dis.Oxygen (ppm)	Ox-Red Pt. (± mV)	SWL (m TOC)	(..........)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate, purged dry?
Stable when 3 consecutive readings:		-	*+/- 0.05 pH*	*+/- 3%*	*+/- 10%*	*+/- 10 mV*	*stable*		
3:51	10	9	4.91	12.8	7.28	210			cloudy WC= 4.7m
356	20	8.6	4.60	12.7	8.97	205			-"- =9.4 L
4:04	30	8.7	4.63	13.1	6.98	181			-"- gravel=18.8 L
4:11	40	8.6	4.65	12.9	7.43	182			-"- =56.4
4:18	50	9.1	4.77	12.7	6.53	181			-"- =60 l
4:26	60	9.1	4.79	12.6	6.96	177			-"-
				sampled					

Field QA Checks:

Air bubbles in vials? Y / N Any violent reactions? Y / N
Decontamination as per GHD procedure? Y / N
Was sampling equipment pre-cleaned? Y / N
COC updated? Y / N Parameters stabilised Y / N

Parameters	BTEX	TPH	PAH	CHC	PCB	OCP	OPP	Tot. Metal	Biol.				
Preservatives													

Comment: Duplicate samples collected, bottles used, access, condition of headworks etc

Meters Calibrated Y / N QA/QC Taken Y / N Samples cooled Y / N

Purge Volumes

Casing Int. Dia (mm)	50	100	150
Vol (L/m of casing)	2.0	7.9	17.7

*Double for gravel pack

GHD MANAGEMENT ENGINEERING ENVIRONMENT

Purging and Sampling Record

Bore ID: BH10

Job Information

Client: Mt Buller & Mt Stirling ARMB
Project: Control Centre Hydrogeological
Proj. No.: 31/30733/14
Sampler: B.S
Date: 12/2/2014

Sampling Information

Purge Method:
Sample Method:
WQ Meter Type:
Flow Cell: Y / N **Pump Depth:** ....m
WLevel Meter Type: Dip/Interface
Field Filtered? Y / N (filter vessel, disposable filter/syringe)

Bore Information

SWL(mTOC): 4.15 m **Logic Check:**
Screen: From:.....**to**..... m **Stick Up:** -0.09 m
NAPL Check: **Bore Diam.:** 50 mm
Ref.datum: TOPVC **Well Cap Secure?** Y
Bore Depth: 8.825 m

Time (..........)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (..........)	Dis.Oxygen (..........)	Ox-Red Pt. (± mV)	SWL (m TOC)	(..........)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate, purged dry?
Stable when 3 consecutive readings:		-	*+/- 0.05 pH*	*+/- 3%*	*+/- 10%*	*+/- 10 mV*	*stable*		
			logging started @ 3:15						
			Slug inserted @ [illegible] 3:17						
			slug removed @ 3:22						
			slug inserted @ 3:27						
			slug removed @ 3:32						
			finished testing @ 3:38						

Field QA Checks:

Air bubbles in vials? Y / N Any violent reactions? Y / N
Decontamination as per GHD procedure? Y / N
Was sampling equipment pre-cleaned? Y / N
COC updated? Y / N Parameters stabilised Y / N

Parameters	BTEX	TPH	PAH	CHC	PCB	OCP	OPP	Tot. Metal	Biol.				
Preservatives													

Comment: Duplicate samples collected, bottles used, access, condition of headworks etc

Meters Calibrated Y / N QA/QC Taken Y / N Samples cooled Y / N

Purge Volumes

Casing Int. Dia (mm)	50	100	150
Vol (L/m of casing)	2.0	7.9	17.7

*Double for gravel pack

GHD MANAGEMENT ENGINEERING ENVIRONMENT

Purging and Sampling Record

Bore ID: BH13

Job Information

Client: Mt Buller & Mt Stirling ARMB
Project: Control Centre Hydrogeological
Proj. No.: 31/30733/14
Sampler: B.S
Date: 12 / 2 / /2014

Sampling Information

Purge Method:
Sample Method:
WQ Meter Type:
Flow Cell: Y / N **Pump Depth:** ....m
WLevel Meter Type: Dip/Interface
Field Filtered? Y / N (filter vessel, disposable filter/syringe)

Bore Information

SWL(mTOC): 5.32 m **Logic Check:**
Screen: From:..........**to**.......... m **Stick Up:** -0.09 m
NAPL Check:
Bore Diam.: 50 mm
Ref.datum: TOPVC **Well Cap Secure?** Y
Bore Depth: 8.87 m

Time (..........)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (..........)	Dis.Oxygen (..........)	Ox-Red Pt. (± mV)	SWL (m TOC)	(..........)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate, purged dry?
Stable when 3 consecutive readings:		-	*+/- 0.05 pH*	*+/- 3%*	*+/- 10%*	*+/- 10 mV*	*stable*		
logger inserted @		Logger		started	@ 1	:38			
			Slug	inserted	@ 1:	39			
			Slug	removed	@ 1:	54			
			slug	inserted	@ 2:0	9			
			slug	removed	@ 2:2	4			
			slug	test finished	hed @	~~3~~ 2:39			

Field QA Checks:

Air bubbles in vials? Y / N Any violent reactions? Y / N
Decontamination as per GHD procedure? Y / N
Was sampling equipment pre-cleaned? Y / N
COC updated? Y / N Parameters stabilised Y / N

Parameters	BTEX	TPH	PAH	CHC	PCB	OCP	OPP	Tot. Metal	Biol.				
Preservatives													

Comment: Duplicate samples collected, bottles used, access, condition of headworks etc

Meters Calibrated Y / N QA/QC Taken Y / N Samples cooled Y / N

Purge Volumes

Casing Int. Dia (mm)	50	100	150
Vol (L/m of casing)	2.0	7.9	17.7

*Double for gravel pack

GHD | MANAGEMENT ENGINEERING ENVIRONMENT

Purging and Sampling Record

Bore ID: BH13

Job Information	*Sampling Information*	*Bore Information*	
Client: Mt Buller & Mt Stirling ARMB	**Purge Method:** BAIL	**SWL(mTOC):** 5.40 m	**Logic Check:**
Project: Control Centre Hydrogeological	**Sample Method:**	**Screen: From:** … **to** … m	**Stick Up:** -0.09 m
Proj. No.: 31/30733/14	**WQ Meter Type:**	**NAPL Check:**	**Bore Diam.:** 50 mm
Sampler: JC	**Flow Cell:** Y / N **Pump Depth:** …m	**Ref.datum:** TOPVC	**Well Cap Secure?** Y
Date: 13 / 7 / 2014	**WLevel Meter Type:** Dip/Interface	**Bore Depth:** 8.81 m	
	Field Filtered? Y / N (filter vessel, disposable filter/syringe)		

Time (……….)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (mS)	Dis.Oxygen (……….)	Ox-Red Pt. (± mV)	SWL (m TOC)	(……….)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate, purged dry?
Stable when 3 consecutive readings:		-	*+/- 0.05 pH*	*+/- 3%*	*+/- 10%*	*+/- 10 mV*	*stable*		
7:45	10	8.2	6.05	78.3	6.51	218			h.turb, black 3.5m
7:55	12	7.7	4.24	16.2	6.88	220			— " — 7L
									14L
			dry						@ 10L lost end of baile 46L
									down hole, ~~at~~ cleaned another
									bailer to use after this)
			5.515 was	WL when came back to					
			sample	@ 12:05pm					
			5.59 when	re-dipped after bailer removed					

Field QA Checks:

Air bubbles in vials? Y / N Any violent reactions? Y / N
Decontamination as per GHD procedure? Y / N
Was sampling equipment pre-cleaned? Y / N
COC updated? Y / N Parameters stabilised Y / N

Parameters	BTEX	TPH	PAH	CHC	PCB	OCP	OPP	Tot. Metal	Biol.				
Preservatives													

Comment: Duplicate samples collected, bottles used, access, condition of headworks etc DUP 2 taken here.

Meters Calibrated Y / N QA/QC Taken Y / N Samples cooled Y / N

Purge Volumes

Casing Int. Dia (mm)	50	100	150
Vol (L/m of casing)	2.0	7.9	17.7

*Double for gravel pack

GHD MANAGEMENT ENGINEERING ENVIRONMENT

Purging and Sampling Record

Bore ID: BH14

Job Information

Client: Mt Buller & Mt Stirling ARMB
Project: Control Centre Hydrogeological
Proj. No.: 31/30733/14
Sampler: B.S
Date: 13 / 2 /2014

Sampling Information

Purge Method: BAIL
Sample Method:
WQ Meter Type:
Flow Cell: Y / N   **Pump Depth:** ……….m
WLevel Meter Type: Dip/Interface
Field Filtered? Y / N (filter vessel, disposable filter/syringe)

Bore Information

SWL(mTOC): 12.52 m   **Logic Check:**
Screen: From: ………. **to** ………. m   **Stick Up:** -0.11 m
NAPL Check: **Bore Diam.:** 50 mm
Ref.datum: TOPVC   **Well Cap Secure?** Y
Bore Depth: 19.35 m

Time (……….)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (……….)	Dis.Oxygen (……….)	Ox-Red Pt. (± mV)	SWL (m TOC)	(……….)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate, purged dry?
Stable when 3 consecutive readings:		-	+/- 0.05 pH	+/- 3%	+/- 10%	+/- 10 mV	stable		
		Started		logging @		7:27			
slug test →									
		slug inserted @			7:29				
		slug removed			@ 7:39				
		slug inserted @			7:51				
		slug removed @			8:01				
		logger stopped			@ 8:14				

Field QA Checks:

Air bubbles in vials? Y / N   Any violent reactions? Y / N
Decontamination as per GHD procedure? Y / N
Was sampling equipment pre-cleaned? Y / N
COC updated? Y / N   Parameters stabilised Y / N

Parameters	BTEX	TPH	PAH	CHC	PCB	OCP	OPP	Tot. Metal	Biol.				
Preservatives													

Comment: Duplicate samples collected, bottles used, access, condition of headworks etc

Meters Calibrated Y / N   QA/QC Taken Y / N   Samples cooled Y / N

Purge Volumes

Casing Int. Dia (mm)	50	100	150
Vol (L/m of casing)	2.0	7.9	17.7

*Double for gravel pack

GHD MANAGEMENT ENGINEERING ENVIRONMENT

Purging and Sampling Record

Bore ID: BH14

Job Information	Sampling Information	Bore Information
Client: Mt Buller & Mt Stirling ARMB	**Purge Method:** Bailor	**SWL(mTOC):** 12.47 m
Project: Control Centre Hydrogeological	**Sample Method:** Bailor	**Screen: From:** ………… **to** ………… m
Proj. No.: 31/30733/14	**WQ Meter Type:** V1925	**NAPL Check:** …………
Sampler: B	**Flow Cell:** Y / [✓ N] **Pump Depth:** ……….m	**Ref.datum:** TOPVC
Date: 11 / 2 / 2014	**WLevel Meter Type:** [✓ Dip]/Interface	**Bore Depth:** 19.335 m
	Field Filtered? Y / N (filter vessel, disposable filter/syringe)	

Logic Check: …………

Stick Up: -0.11 m

Bore Diam.: 50 mm

Well Cap Secure? Y

Time (………..)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (µS)	Dis.Oxygen (ppm)	Ox-Red Pt. (± mV)	SWL (m TOC)	(………..)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate, purged dry?
Stable when 3 consecutive readings:		-	+/- 0.05 pH	+/- 3%	+/- 10%	+/- 10 mV	stable		
	19.335 − 12.47 = 6.865 ~7 3×4 = 12L + 4×2 = 8L 20L×3 = 60L								
14:36	10	7.7	6.17	48.8	7.57	187	–	–	Milky white, mod turb., low sed. load
14:47	20	7.3	6.09	46.7	6.58	194	–	–	" " "
14:57	30	7.1	6.08	45.0	7.06	189	–	–	" " "
15:13	40	7.1	6.01	47.9	7.49	202	–	–	" " "
15:26	50	7.67	6.44	48.1	7.09	199	–	–	" " "
15:39	60	7.3	6.22	50.1	7.30	194	–	–	" " "
	— SAMPLE TAKEN —								

Field QA Checks:

Air bubbles in vials? Y / N Any violent reactions? Y / N

Decontamination as per GHD procedure? Y / N

Was sampling equipment pre-cleaned? Y / N

COC updated? Y / N Parameters stabilised Y / N

Parameters	BTEX	TPH	PAH	CHC	PCB	OCP	OPP	Tot. Metal	Biol.				
Preservatives													

Comment: Duplicate samples collected, bottles used, access, condition of headworks etc

Meters Calibrated Y / N QA/QC Taken Y / N Samples cooled Y / N

Purge Volumes

Casing Int. Dia (mm)	50	100	150
Vol (L/m of casing)	2.0	7.9	17.7

*Double for gravel pack

GHD MANAGEMENT ENGINEERING ENVIRONMENT

Purging and Sampling Record

Bore ID: BH14N

Job Information	*Sampling Information*	*Bore Information*	
Client: Mt Buller & Mt Stirling ARMB	**Purge Method:**	**SWL(mTOC):** 12.61 m	**Logic Check:**
Project: Control Centre Hydrogeological	**Sample Method:**	**Screen: From:** … **to:** … m	**Stick Up:** -0.09 m
Proj. No.: 31/30733/14	**WQ Meter Type:**	**NAPL Check:**	**Bore Diam.:** 50 mm
Sampler: B.S	**Flow Cell:** Y / N **Pump Depth:** …m	**Ref.datum:** TOPVC	**Well Cap Secure?** Y
Date: 13 / 2 / 2014	**WLevel Meter Type:** Dip/Interface	**Bore Depth:** 14.98 m	
	Field Filtered? Y / N (filter vessel, disposable filter/syringe)		

Time (……….)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (……….)	Dis.Oxygen (……….)	Ox-Red Pt. (± mV)	SWL (m TOC)	(……….)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate, purged dry?
Stable when 3 consecutive readings:		-	*+/- 0.05 pH*	*+/- 3%*	*+/- 10%*	*+/- 10 mV*	*stable*		
			started		logging	@ 8:21			
slug test									
			slug	inserted	@	8:22			
			slug	removed		@ 8:37			
			slug	inserted	@	8:52			
			slug	removed	@	9:07			
			finished		logging	@	9:22		

Field QA Checks:

Air bubbles in vials? Y / N Any violent reactions? Y / N
Decontamination as per GHD procedure? Y / N
Was sampling equipment pre-cleaned? Y / N
COC updated? Y / N Parameters stabilised Y / N

Parameters	**BTEX**	**TPH**	**PAH**	**CHC**	**PCB**	**OCP**	**OPP**	**Tot. Metal**	**Biol.**				
Preservatives													

Comment: Duplicate samples collected, bottles used, access, condition of headworks etc

Meters Calibrated Y / N QA/QC Taken Y / N Samples cooled Y / N

Purge Volumes

Casing Int. Dia (mm)	50	100	150
Vol (L/m of casing)	2.0	7.9	17.7

*Double for gravel pack

GHD MANAGEMENT ENGINEERING ENVIRONMENT

Purging and Sampling Record

Bore ID: BH14A

Job Information

Client: Mt Buller & Mt Stirling ARMB
Project: Control Centre Hydrogeological
Proj. No.: 31/30733/14
Sampler: B.S
Date: 11 / 2 / 2014

Sampling Information

Purge Method: Bailer
Sample Method: Bailer
WQ Meter Type: V1925
Flow Cell: Y / [✓ N]
Pump Depth: ....m
WLevel Meter Type: [✓ Dip]/Interface
Field Filtered? Y / N (filter vessel, disposable filter/syringe)

Bore Information

SWL(mTOC): 12.00 m
Logic Check: ....
Screen: From:..........**to**.......... m
Stick Up: -0.09 m
NAPL Check: ....
Bore Diam.: 50 mm
Ref.datum: P.V.C
Well Cap Secure? y
Bore Depth: 14.955 m

Time (..........)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (.µS.....)	Dis.Oxygen (.ppm.....)	Ox-Red Pt. (± mV)	SWL (m TOC)	(..........)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate, purged dry?
Stable when 3 consecutive readings:		-	+/- 0.05 pH	+/- 3%	+/- 10%	+/- 10 mV	stable		
		Assumed to be in			screen	14.955 - 12 =			2.955 x 4 = 11.82 x 3 = 35.5L
14:01	5	7.1	5.82	85.6	8.13	188	–	–	Slightly milky, mod sed load, mod turb
14:06	10	6.8	5.57	85.3	4.02	172	–	–	" " "
14:12	11	8.1	5.46	86.6	5.62	164	–	–	" " bailed dry
	12/2/14 → come back to sample wL @ 13.10								
		↳ sampled							

Field QA Checks:

Air bubbles in vials? Y / [✓ N] Any violent reactions? Y / [✓ N]
Decontamination as per GHD procedure? [✓ Y] / N
Was sampling equipment pre-cleaned? [✓ Y] / N
COC updated? Y / [✓ N] Parameters stabilised Y / [✓ N]

Parameters	BTEX	TPH	PAH	CHC	PCB	OCP	OPP	Tot. Metal	Biol.				
Preservatives													

Comment: Duplicate samples collected, bottles used, access, condition of headworks etc

Meters Calibrated [✓ Y] / N QA/QC Taken Y / [✓ N] Samples cooled Y / N

Purge Volumes

Casing Int. Dia (mm)	50	100	150
Vol (L/m of casing)	2.0	7.9	17.7

*Double for gravel pack

GHD | MANAGEMENT ENGINEERING ENVIRONMENT

Purging and Sampling Record

Bore ID: BH14B

Job Information	*Sampling Information*	*Bore Information*
Client: Mt Buller & Mt Stirling ARMB	**Purge Method:**	**SWL(mTOC):** 9.03 m
Project: Control Centre Hydrogeological	**Sample Method:**	**Screen:** From: to: m
Proj. No.: 31/30733/14	**WQ Meter Type:**	**NAPL Check:**
Sampler: B.S	**Flow Cell:** Y / N **Pump Depth:** m	**Ref.datum:** TOPVC
Date: 13 / 2 / 2014	**WLevel Meter Type:** Dip/Interface	**Bore Depth:** 9.44 m
	Field Filtered? Y / N (filter vessel, disposable filter/syringe)	

Logic Check:
Stick Up: -0.09 m
Bore Diam.: 50 mm
Well Cap Secure? Y

Time (..........)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (..........)	Dis.Oxygen (..........)	Ox-Red Pt. (± mV)	SWL (m TOC)	(..........)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate, purged dry?
Stable when 3 consecutive readings:		-	+/- 0.05 pH	+/- 3%	+/- 10%	+/- 10 mV	stable		
	* Could		not	slug test	due	to insufficient		amount	of water.

Field QA Checks:
Air bubbles in vials? Y / N   Any violent reactions? Y / N
Decontamination as per GHD procedure? Y / N
Was sampling equipment pre-cleaned? Y / N
COC updated? Y / N   Parameters stabilised Y / N

Parameters	BTEX	TPH	PAH	CHC	PCB	OCP	OPP	Tot. Metal	Biol.				
Preservatives													

Comment: Duplicate samples collected, bottles used, access, condition of headworks etc

Meters Calibrated Y / N   QA/QC Taken Y / N   Samples cooled Y / N

Purge Volumes			
Casing Int. Dia (mm)	50	100	150
Vol (L/m of casing)	2.0	7.9	17.7

*Double for gravel pack

GHD MANAGEMENT ENGINEERING ENVIRONMENT

Purging and Sampling Record

Bore ID: BH14B

Job Information

Client: Mt Buller & Mt Stirling ARMB
Project: Control Centre Hydrogeological
Proj. No.: 31/30733/14
Sampler: B.S
Date: 11 / 2 / 2014

Sampling Information

Purge Method: Bailor
Sample Method: Bailor
WQ Meter Type: V1925
Flow Cell: Y / [✓ N] **Pump Depth:** ....m
WLevel Meter Type: [✓ Dip]/Interface
Field Filtered? Y / N (filter vessel, disposable filter/syringe)

Bore Information

SWL(mTOC): 8.58 m **Logic Check:** ....
Screen: From:............**to**.......... m **Stick Up:** -0.09 m
NAPL Check:.............................. **Bore Diam.:** 50 mm
Ref.datum: TOC **Well Cap Secure?** Y
Bore Depth: 9.445 m

Time (..........)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (µS/cm)	Dis.Oxygen (..........)	Ox-Red Pt. (± mV)	SWL (m TOC)	(..........)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate, purged dry?
Stable when 3 consecutive readings:		-	*+/- 0.05 pH*	*+/- 3%*	*+/- 10%*	*+/- 10 mV*	*stable*		0.865 × 4 = 3.46 × 3 = 10.38L
	Assumed		to be in		screen	9.5445 −		9.445 =	0.125 × 4 = 0.5 × 3 = 1.5L
13:25	1	9.8	5.77	57.1	10.51	273	–		Milky brown, mod sed. load, mod turbidity
13:27	2	8.6	5.83	49.3	8.62	273	–		" " "
13:30	3	8.0	5.63	50.4	8.58	273	–	–	" " " ~~, seems to be dry~~
13:45	4	9.8	5.60	53.9	9.05	208	–	–	" " "
13:47	4.5	10.1	5.65	55	8.32	204	–	–	" Bailed dry
12/2/14 (am) →		came	back to		sample	→ SWL @		9.12 →	not enough water to sample

Field QA Checks:

Air bubbles in vials? Y / N Any violent reactions? Y / N
Decontamination as per GHD procedure? Y / N
Was sampling equipment pre-cleaned? Y / N
COC updated? Y / N Parameters stabilised Y / N

Parameters	BTEX	TPH	PAH	CHC	PCB	OCP	OPP	Tot. Metal	Biol.				
Preservatives													

Comment: Duplicate samples collected, bottles used, access, condition of headworks etc

Meters Calibrated Y / N **QA/QC Taken Y / N** **Samples cooled Y / N**

Purge Volumes

Casing Int. Dia (mm)	50	100	150
Vol (L/m of casing)	2.0	7.9	17.7

*Double for gravel pack

GHD | MANAGEMENT ENGINEERING ENVIRONMENT

Purging and Sampling Record

Bore ID: BH15

Job Information

Client: Mt Buller & Mt Stirling ARMB
Project: Control Centre Hydrogeological
Proj. No.: 31/30733/14
Sampler: BS
Date: 12/2/2014

Sampling Information

Purge Method: ……
Sample Method: ……
WQ Meter Type: ……
Flow Cell: Y / N **Pump Depth:** ……m
WLevel Meter Type: Dip/Interface
Field Filtered? Y / N (filter vessel, disposable filter/syringe)

Bore Information

SWL(mTOC): 13.06 m **Logic Check:** ……
Screen: From: ……**to**…… m **Stick Up:** -0.11 m
NAPL Check: …… **Bore Diam.:** 50 mm
Ref.datum: TOPVC **Well Cap Secure?** Y
Bore Depth: 18.29 m

Time (……)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (……)	Dis.Oxygen (……)	Ox-Red Pt. (± mV)	SWL (m TOC)	(……)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate, purged dry?
Stable when 3 consecutive readings:		-	+/- 0.05 pH	+/- 3%	+/- 10%	+/- 10 mV	stable		
		Slug	test	started	@ 11	:22			
		Slug	inserted	@	11:24				
		Slug	removed	@	11:39				
		slug	inserted	@	11:54				
		Slug	removed	@	12:09				
		slug	test	stopped	@ 12:	25			

Field QA Checks:

Air bubbles in vials? Y / N Any violent reactions? Y / N
Decontamination as per GHD procedure? Y / N
Was sampling equipment pre-cleaned? Y / N
COC updated? Y / N Parameters stabilised Y / N

Parameters	BTEX	TPH	PAH	CHC	PCB	OCP	OPP	Tot. Metal	Biol.				
Preservatives													

Comment: Duplicate samples collected, bottles used, access, condition of headworks etc

Meters Calibrated Y / N **QA/QC Taken Y / N** **Samples cooled Y / N**

Purge Volumes

Casing Int. Dia (mm)	50	100	150
Vol (L/m of casing)	2.0	7.9	17.7

*Double for gravel pack

GHD MANAGEMENT ENGINEERING ENVIRONMENT

Purging and Sampling Record

Bore ID: BH15

Job Information

Client: Mt Buller & Mt Stirling ARMB
Project: Control Centre Hydrogeological
Proj. No.: 31/30733/14
Sampler: JL
Date: 12 / 7 / 2014

Sampling Information

Purge Method: BAIL
Sample Method:
WQ Meter Type:
Flow Cell: Y / N **Pump Depth:** ....m
WLevel Meter Type: Dip/Interface
Field Filtered? Y / N (filter vessel, disposable filter/syringe)

Bore Information

SWL(mTOC): 13.15 m **Logic Check:**
Screen: From:..........to.......... m **Stick Up:** -0.11 m
NAPL Check:
Bore Diam.: 50 mm
Ref.datum: TOPUC
Well Cap Secure? Y
Bore Depth: 18.79 m

Time (..........)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (..........)	Dis.Oxygen (..........)	Ox-Red Pt. (± mV)	SWL (m TOC)	(..........)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate, purged dry?
Stable when 3 consecutive readings:		-	+/- 0.05 pH	+/- 3%	+/- 10%	+/- 10 mV	stable		
10	13:34	12.9	7.17	101.1	3.48	-78			m. turbid, brown . WC = 5m
			—	dry		—			= 10L
									screen = 20L
13/7	8:51	—	sampled				12.11		purge = 60

Field QA Checks:

Air bubbles in vials? Y / N Any violent reactions? Y / N
Decontamination as per GHD procedure? Y / N
Was sampling equipment pre-cleaned? Y / N
COC updated? Y / N Parameters stabilised Y / N

Parameters	BTEX	TPH	PAH	CHC	PCB	OCP	OPP	Tot. Metal	Biol.				
Preservatives													

Comment: Duplicate samples collected, bottles used, access, condition of headworks etc

Meters Calibrated Y / N QA/QC Taken Y / N Samples cooled Y / N

Purge Volumes

Casing Int. Dia (mm)	50	100	150
Vol (L/m of casing)	2.0	7.9	17.7

*Double for gravel pack

MANAGEMENT
ENGINEERING
ENVIRONMENT

Purging and Sampling Record

Bore ID: BH15A

Job Information	*Sampling Information*	*Bore Information*	
Client: Mt Buller & Mt Stirling ARMB	**Purge Method:** BAIL	**SWL(mTOC):** 4.03 m	**Logic Check:**
Project: Control Centre Hydrogeological	**Sample Method:**	**Screen: From:** ... **to** ... m	**Stick Up:** -0.12 m
Proj. No.: 31/30733/14	**WQ Meter Type:**	**NAPL Check:**	**Bore Diam.:** 50 mm
Sampler: JL	**Flow Cell:** Y / N **Pump Depth:** ... m	**Ref.datum:** TO PVC	**Well Cap Secure?** Y
Date: 21 / 2 / 2014	**WLevel Meter Type:** Dip/Interface	**Bore Depth:** 5.50 m	
	Field Filtered? Y / N (filter vessel, disposable filter/syringe)		

Time (..........)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (..........)	Dis.Oxygen (..........)	Ox-Red Pt. (± mV)	SWL (m TOC)	(..........)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate, purged dry?
Stable when 3 consecutive readings:		-	+/- 0.05 pH	+/- 3%	+/- 10%	+/- 10 mV	stable		
1145	10	10.3	7.87	22.7	8.18	131			m brown h turb. WC = 1.5m
1152	2L	7.6	5.29	16.4	7.55				— " — = 3L
									= 6L
									= 18L
									= 20L
				Sampled					

Field QA Checks:

Air bubbles in vials? Y / N Any violent reactions? Y / N
Decontamination as per GHD procedure? Y / N
Was sampling equipment pre-cleaned? Y / N
COC updated? Y / N Parameters stabilised Y / N

Parameters	BTEX	TPH	PAH	CHC	PCB	OCP	OPP	Tot. Metal	Biol.				
Preservatives													

Comment: Duplicate samples collected, bottles used, access, condition of headworks etc

Meters Calibrated Y / N QA/QC Taken Y / N Samples cooled Y / N

Purge Volumes

Casing Int. Dia (mm)	50	100	150
Vol (L/m of casing)	2.0	7.9	17.7

*Double for gravel pack

GHD MANAGEMENT ENGINEERING ENVIRONMENT

Purging and Sampling Record

Bore ID: BH15A

Job Information	*Sampling Information*	*Bore Information*
Client: Mt Buller & Mt Stirling ARMB	**Purge Method:**	**SWL(mTOC):** 4.03 m **Logic Check:**
Project: Control Centre Hydrogeological	**Sample Method:**	**Screen: From:** ... **to** ... m **Stick Up:** -0.12 m
Proj. No.: 31/30733/14	**WQ Meter Type:**	**NAPL Check:** **Bore Diam.:** 50 mm
Sampler: B.S	**Flow Cell:** Y / N **Pump Depth:** ... m	**Ref.datum:** P.V.C **Well Cap Secure?** Y
Date: 12 / 2 / 2014	**WLevel Meter Type:** Dip/Interface	**Bore Depth:** 5.50 m
	Field Filtered? Y / N (filter vessel, disposable filter/syringe)	

Time (..........)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (..........)	Dis.Oxygen (..........)	Ox-Red Pt. (± mV)	SWL (m TOC)	(..........)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate, purged dry?
Stable when 3 consecutive readings:		-	*+/- 0.05 pH*	*+/- 3%*	*+/- 10%*	*+/- 10 mV*	*stable*		
	Slug test			WL (initial)		= 4.03			
	loggers		started @ 10:09						
			Slug inserted @ 10:10						
			Slug removed @ 10:25						
			slug inserted @ 10:40						
			slug removed @ 10:55						
		Test ended @ 11:10							

Field QA Checks:

Air bubbles in vials? Y / N Any violent reactions? Y / N

Decontamination as per GHD procedure? Y / N

Was sampling equipment pre-cleaned? Y / N

COC updated? Y / N Parameters stabilised Y / N

Parameters	BTEX	TPH	PAH	CHC	PCB	OCP	OPP	Tot. Metal	Biol.				
Preservatives													

Comment: Duplicate samples collected, bottles used, access, condition of headworks etc

Meters Calibrated Y / N QA/QC Taken Y / N Samples cooled Y / N

Purge Volumes

Casing Int. Dia (mm)	50	100	150
Vol (L/m of casing)	2.0	7.9	17.7

*Double for gravel pack

GHD MANAGEMENT ENGINEERING ENVIRONMENT

Purging and Sampling Record

Slug tests various.

Bore ID: BH04

Job Information	Sampling Information	Bore Information	
Client: Mt Buller & Mt Stirling ARMB	Purge Method:	SWL(mTOC): 6.97 m	Logic Check:
Project: Control Centre Hydrogeological	Sample Method:	Screen: From: to: m	Stick Up: -0.10 m
Proj. No.: 31/30733/14	WQ Meter Type:	NAPL Check:	Bore Diam.: 50 mm
Sampler: J.L	Flow Cell: Y / N Pump Depth: m	Ref.datum: P.V.C	Well Cap Secure? Y
Date: / / /2014	WLevel Meter Type: Dip/Interface	Bore Depth: 15.53 m	
	Field Filtered? Y / N (filter vessel, disposable filter/syringe)		

Time (..........)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (..........)	Dis.Oxygen (..........)	Ox-Red Pt. (± mV)	SWL (m TOC)	(..........)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate, purged dry?
Stable when 3 consecutive readings:		*-*	*+/- 0.05 pH*	*+/- 3%*	*+/- 10%*	*+/- 10 mV*	*stable*		
									BH06 depth 902 btoc
									SWL 7.67

Field QA Checks:

Air bubbles in vials? Y / N Any violent reactions? Y / N
Decontamination as per GHD procedure? Y / N
Was sampling equipment pre-cleaned? Y / N
COC updated? Y / N Parameters stabilised Y / N

Parameters	BTEX	TPH	PAH	CHC	PCB	OCP	OPP	Tot. Metal	Biol.				
Preservatives													

Comment: Duplicate samples collected, bottles used, access, condition of headworks etc

Meters Calibrated Y / N QA/QC Taken Y / N Samples cooled Y / N

Purge Volumes

Casing Int. Dia (mm)	50	100	150
Vol (L/m of casing)	2.0	7.9	17.7

*Double for gravel pack

MANAGEMENT
ENGINEERING
ENVIRONMENT

Purging and Sampling Record

Time (...........)	Volume (L)	Temp (°C)	pH (pH units)	Elec.Cond (...........)	Dis.Oxygen (...........)	Ox-Red Pt. (± mV)	SWL (m)	(...........)	Comment: Colour, turbidity, sediment load, sheen, odour, flow rate purged dry?
Stable when (3 consecutive readings):		*-*	*+/- 0.05 pH*	*+/- 3%*	*+/- 10%*	*+/- 10 mV*	*stable*		
									BH04 - Slug Test
									Slug down 12:45 2 lengths slug
									Slug up 1:02 not full recovery,
									logger disturbed
									on way up.
									slug down 1:17 - change to 1
									length of slug
									Slug up 1:32.
									BH05 depth 19.67
									SWL 17.99
									rope not long enough #1
									slug down @ 2:28 - 1 length.
									up @ 2:45
									down @ 3:00
									up @
									BH05A depth 20.33
									WL <0.10
									(below sensor).
									stick up = -0.115

Appendix C – Equipment Calibration Records

Equipment Calibration Form
TPS 90-FLMV

enqip

Prepared by: Mario Lopez		**Authorised by:** Mario Lopez	
Created: 30/03/2012	**ID** CHK-012	**Version:** 5.0	**Page:** 1 of 1

Enqip #: 21414
Company: GHD
Consultant: Jennifer Learmonth
PO#: 31\30733\14

Equipment calibrated/checked by Technician:

UNIT IDENTIFICATION

Model Number	90-FLMV
Serial Number	V1925
Unit Type	TPS Water Quality Meter 90-FLMV

INSPECTION RECORD	
Batteries checked	☑
Date/time correct	☑
Electrodes cleaned and checked (Decon/Cleaned)	☑
Temperature check	☑

CALIBRATION

Sensor	Cal. Solution	Value	Reading
pH	pH: Buffer Solution 4.01	4.01	4.01
	pH: Buffer Solution 6.88	6.88	6.88
Redox	Standard ORP solution	240mV	225 mV
O_2	Dissolved Oxygen: 0ppm Standard	0ppm	0 ppm
Conductivity	Standard Conductivity Solution	2760µs/cm	2760 µs/cm
TDS	Standard Saliniy	36ppK	36 ppK

QC Signature

Date 7.2.14

Appendix D – Certified Laboratory Reports

CERTIFICATE OF ANALYSIS

Work Order	: **EM1401293**	Page	: 1 of 6
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MR GRANT JONES	Contact	: Shirley LeCornu
Address	: LEVEL 8, 180 LONSDALE ST MELBOURNE VIC, AUSTRALIA 3001	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: grant.jones@ghd.com	E-mail	: shirley.lecornu@alsenviro.com
Telephone	: +61 03 8687 8000	Telephone	: +61-3-8549 9630
Facsimile	: +61 03 8687 8111	Facsimile	: +61-3-8549 9601
Project	: 313073314 MT BULLER	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 14-FEB-2014
Sampler	: JL	Issue Date	: 21-FEB-2014
Site	: ----		
		No. of samples received	: 16
Quote number	: MEBQ/177/13	No. of samples analysed	: 16

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **Ionic balances were calculated using: major anions - chloride, alkalinity and sulfate; and major cations - calcium, magnesium, potassium and sodium.**
- **Samples were filtered through a 0.45um filter prior to the dissolved metals analysis.**

NATA Accredited Laboratory 825

Accredited for compliance with
ISO/IEC 17025.

WORLD RECOGNISED
ACCREDITATION

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics
Eric Chau	Metals Team Leader	Melbourne Inorganics

Analytical Results

Sub-Matrix: **GROUNDWATER** (Matrix: **WATER**)

			Client sample ID	**RB**	**BH04**	**BH05**	**BH06**	**BH09**
			Client sampling date / time	12-FEB-2014 15:00	13-FEB-2014 15:00	13-FEB-2014 15:00	12-FEB-2014 15:00	12-FEB-2014 15:00
Compound	*CAS Number*	*LOR*	*Unit*	**EM1401293-001**	**EM1401293-002**	**EM1401293-003**	**EM1401293-004**	**EM1401293-005**
EA005: pH								
pH Value	----	0.01	pH Unit	----	**8.03**	**7.94**	**7.05**	**7.15**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	----	**102**	**44**	**45**	**34**
EA015: Total Dissolved Solids								
Total Dissolved Solids @180°C	----	10	mg/L	----	**70**	**27**	**33**	**30**
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	----	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	----	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	----	**51**	**16**	**4**	**11**
Total Alkalinity as CaCO3	----	1	mg/L	----	**51**	**16**	**4**	**11**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	----	**13**	**3**	<1	**1**
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	----	**2**	**1**	**2**	**2**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	----	**4**	**1**	**1**	**1**
Magnesium	7439-95-4	1	mg/L	----	**1**	<1	<1	<1
Sodium	7440-23-5	1	mg/L	----	**19**	**5**	**4**	**5**
Potassium	7440-09-7	1	mg/L	----	<1	**2**	<1	<1
EG020F: Dissolved Metals by ICP-MS								
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	**0.43**
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	----	0.01	mg/L	----	<0.01	<0.01	<0.01	<0.01
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	----	**0.04**	**0.23**	**3.12**	**0.27**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	----	**0.04**	**0.23**	**3.12**	**0.27**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	----	**1.35**	**0.41**	**0.14**	**0.30**
Total Cations	----	0.01	meq/L	----	**1.11**	**0.32**	**0.22**	**0.27**

Analytical Results

Sub-Matrix: **GROUNDWATER** (Matrix: **WATER**)

			Client sample ID	**BH10**	**BH13**	**BH14**	**BH14A**	**BH14B**
			Client sampling date / time	12-FEB-2014 15:00	13-FEB-2014 15:00	11-FEB-2014 15:00	12-FEB-2014 15:00	13-FEB-2014 15:00
Compound	*CAS Number*	*LOR*	*Unit*	**EM1401293-006**	**EM1401293-007**	**EM1401293-008**	**EM1401293-009**	**EM1401293-010**
EA005: pH								
pH Value	----	0.01	pH Unit	**7.16**	**6.12**	**6.71**	**6.87**	**6.90**
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**20**	**17**	**69**	**96**	**70**
EA015: Total Dissolved Solids								
Total Dissolved Solids @180°C	----	10	mg/L	**17**	**10**	**50**	**66**	**51**
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**3**	**3**	**30**	**41**	**24**
Total Alkalinity as CaCO3	----	1	mg/L	**3**	**3**	**30**	**41**	**24**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	<1	**15**	**5**	**7**
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	**1**	**1**	**2**	**3**	**2**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	<1	<1	**4**	**7**	**5**
Magnesium	7439-95-4	1	mg/L	<1	<1	**3**	**4**	**3**
Sodium	7440-23-5	1	mg/L	**2**	<1	**5**	**2**	**2**
Potassium	7440-09-7	1	mg/L	<1	<1	**1**	**2**	**2**
EG020F: Dissolved Metals by ICP-MS								
Iron	7439-89-6	0.05	mg/L	<0.05	**0.05**	<0.05	<0.05	**0.74**
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	----	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.80**	**0.18**	**0.15**	**0.02**	**0.08**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.80**	**0.18**	**0.15**	**0.02**	**0.08**
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**0.09**	**0.09**	**0.97**	**1.01**	**0.68**
Total Cations	----	0.01	meq/L	**0.09**	<0.01	**0.69**	**0.82**	**0.63**
Ionic Balance	----	0.01	%	**0.71**	----	----	----	**3.58**

Analytical Results

Sub-Matrix: **GROUNDWATER** (Matrix: **WATER**)			*Client sample ID*	**BH15**	**BH15A**	**DUP1**	**DUP2**	----
			Client sampling date / time	13-FEB-2014 15:00	12-FEB-2014 15:00	13-FEB-2014 15:00	13-FEB-2014 15:00	----
Compound	*CAS Number*	*LOR*	*Unit*	**EM1401293-011**	**EM1401293-012**	**EM1401293-013**	**EM1401293-014**	**----**
EA005: pH								
pH Value	----	0.01	pH Unit	**6.86**	**6.80**	**6.77**	**5.93**	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**88**	**26**	**44**	**17**	----
EA015: Total Dissolved Solids								
Total Dissolved Solids @180°C	----	10	mg/L	**55**	**20**	**24**	**11**	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**40**	**8**	**15**	**3**	----
Total Alkalinity as CaCO3	----	1	mg/L	**40**	**8**	**15**	**3**	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	**4**	**6**	<1	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	**2**	**1**	**1**	**1**	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**3**	**1**	**1**	<1	----
Magnesium	7439-95-4	1	mg/L	**2**	**1**	<1	<1	----
Sodium	7440-23-5	1	mg/L	**6**	**1**	**4**	<1	----
Potassium	7440-09-7	1	mg/L	**7**	<1	**2**	<1	----
EG020F: Dissolved Metals by ICP-MS								
Iron	7439-89-6	0.05	mg/L	**1.64**	<0.05	<0.05	**0.06**	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	----	0.01	mg/L	**0.05**	**0.01**	<0.01	<0.01	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.10**	**0.37**	**0.21**	**0.17**	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.15**	**0.38**	**0.21**	**0.17**	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**0.86**	**0.27**	**0.45**	**0.06**	----
Total Cations	----	0.01	meq/L	**0.75**	**0.18**	**0.28**	<0.01	----

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Client sample ID*	**SW1**	**SW2**	----	----	----
			Client sampling date / time	13-FEB-2014 15:00	13-FEB-2014 15:00	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EM1401293-015**	**EM1401293-016**	**----**	**----**	**----**
EA005: pH								
pH Value	----	0.01	pH Unit	**6.42**	**6.16**	----	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**28**	**51**	----	----	----
EA015: Total Dissolved Solids								
Total Dissolved Solids @180°C	----	10	mg/L	**15**	**29**	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**12**	**24**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**12**	**24**	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	<1	----	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	<1	<1	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**2**	**4**	----	----	----
Magnesium	7439-95-4	1	mg/L	<1	**2**	----	----	----
Sodium	7440-23-5	1	mg/L	**2**	**3**	----	----	----
Potassium	7440-09-7	1	mg/L	<1	<1	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Iron	7439-89-6	0.05	mg/L	**0.28**	**0.34**	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	----	0.01	mg/L	<0.01	<0.01	----	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.03**	**0.14**	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.03**	**0.14**	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**0.24**	**0.48**	----	----	----
Total Cations	----	0.01	meq/L	**0.19**	**0.49**	----	----	----
Ionic Balance	----	0.01	%	----	**1.54**	----	----	----

QUALITY CONTROL REPORT

Work Order	: **EM1401293**	Page	: 1 of 8
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MR GRANT JONES	Contact	: Shirley LeCornu
Address	: LEVEL 8, 180 LONSDALE ST MELBOURNE VIC, AUSTRALIA 3001	Address	: 4 Westall Rd Springvale VIC Australia 3171
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Project	: 313073314 MT BULLER	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Site	: ----		
C-O-C number	: ----	Date Samples Received	: 14-FEB-2014
Sampler	: JL	Issue Date	: 21-FEB-2014
Order number	: ----		
		No. of samples received	: 16
Quote number	: MEBQ/177/13	No. of samples analysed	: 16

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key :
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Dilani Fernando	Senior Inorganic Chemist	Melbourne Inorganics
Eric Chau	Metals Team Leader	Melbourne Inorganics

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR:- No Limit; Result between 10 and 20 times LOR:- 0% - 50%; Result > 20 times LOR:- 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA005: pH (QC Lot: 3299456)									
EM1401174-001	Anonymous	EA005: pH Value	----	0.01	pH Unit	6.42	6.43	0.2	0% - 20%
EM1401283-002	Anonymous	EA005: pH Value	----	0.01	pH Unit	6.92	6.93	0.1	0% - 20%
EA005: pH (QC Lot: 3299457)									
EM1401293-009	BH14A	EA005: pH Value	----	0.01	pH Unit	6.87	6.85	0.3	0% - 20%
EA010: Conductivity (QC Lot: 3299917)									
EM1401235-003	Anonymous	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	55700	55300	0.7	0% - 20%
EM1401272-001	Anonymous	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	158	159	0.8	0% - 20%
EA010: Conductivity (QC Lot: 3299918)									
EM1401293-006	BH10	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	20	20	0.0	0% - 50%
EM1401293-016	SW2	EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	51	51	0.0	0% - 20%
EA015: Total Dissolved Solids (QC Lot: 3300541)									
EM1401264-001	Anonymous	EA015H: Total Dissolved Solids @180°C	----	10	mg/L	6860	6840	0.3	0% - 20%
EM1401286-001	Anonymous	EA015H: Total Dissolved Solids @180°C	----	10	mg/L	3000	3060	1.6	0% - 20%
EA015: Total Dissolved Solids (QC Lot: 3302042)									
EM1401250-006	Anonymous	EA015H: Total Dissolved Solids @180°C	----	10	mg/L	2600	2500	4.0	0% - 20%
EM1401266-001	Anonymous	EA015H: Total Dissolved Solids @180°C	----	10	mg/L	10900	10700	1.3	0% - 20%
EA015: Total Dissolved Solids (QC Lot: 3302043)									
EM1401293-013	DUP1	EA015H: Total Dissolved Solids @180°C	----	10	mg/L	24	25	4.1	No Limit
EM1401303-004	Anonymous	EA015H: Total Dissolved Solids @180°C	----	10	mg/L	742	742	0.0	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 3299834)									
EM1401268-006	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	803	804	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	803	804	0.0	0% - 20%
EM1401284-005	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	6	6	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	6	6	0.0	No Limit
ED037P: Alkalinity by PC Titrator (QC Lot: 3299836)									
EM1401293-004	BH06	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	4	4	0.0	No Limit
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	4	4	0.0	No Limit
EM1401293-013	DUP1	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
ED037P: Alkalinity by PC Titrator (QC Lot: 3299836) - continued									
EM1401293-013	DUP1	ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	15	15	0.0	0% - 50%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	15	15	0.0	0% - 50%
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 3299635)									
EM1401268-006	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	718	722	0.6	0% - 20%
EM1401293-003	BH05	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	3	3	0.0	No Limit
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 3299638)									
EM1401293-013	DUP1	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	6	6	0.0	No Limit
ED045G: Chloride Discrete analyser (QC Lot: 3299634)									
EM1401268-006	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	5620	5670	1.0	0% - 20%
EM1401293-003	BH05	ED045G: Chloride	16887-00-6	1	mg/L	1	1	0.0	No Limit
ED045G: Chloride Discrete analyser (QC Lot: 3299639)									
EM1401293-013	DUP1	ED045G: Chloride	16887-00-6	1	mg/L	1	2	0.0	No Limit
ED093F: Dissolved Major Cations (QC Lot: 3299632)									
EM1401268-006	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	113	114	1.3	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	483	492	1.8	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	2980	3050	2.4	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	63	62	0.0	0% - 20%
EM1401293-002	BH04	ED093F: Calcium	7440-70-2	1	mg/L	4	4	0.0	No Limit
		ED093F: Magnesium	7439-95-4	1	mg/L	1	1	0.0	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	19	18	0.0	0% - 50%
		ED093F: Potassium	7440-09-7	1	mg/L	<1	<1	0.0	No Limit
ED093F: Dissolved Major Cations (QC Lot: 3299637)									
EM1401293-013	DUP1	ED093F: Calcium	7440-70-2	1	mg/L	1	1	0.0	No Limit
		ED093F: Magnesium	7439-95-4	1	mg/L	<1	<1	0.0	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	4	4	0.0	No Limit
		ED093F: Potassium	7440-09-7	1	mg/L	2	2	0.0	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 3301810)									
EM1401268-001	Anonymous	EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.0	No Limit
EM1401293-001	RB	EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.0	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 3301811)									
EM1401293-012	BH15A	EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.0	No Limit
EM1401302-063	Anonymous	EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.0	No Limit
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 3299633)									
EM1401268-006	Anonymous	EK057G: Nitrite as N	----	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EM1401293-002	BH04	EK057G: Nitrite as N	----	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 3299636)									
EM1401293-013	DUP1	EK057G: Nitrite as N	----	0.01	mg/L	<0.01	<0.01	0.0	No Limit

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 3299353)									
EM1401287-001	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EM1401293-009	BH14A	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	0.02	0.02	0.0	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA010: Conductivity (QCLot: 3299917)								
EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	1413 µS/cm	99.8	98	102
EA010: Conductivity (QCLot: 3299918)								
EA010: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	1413 µS/cm	99.8	98	102
EA015: Total Dissolved Solids (QCLot: 3300541)								
EA015H: Total Dissolved Solids @180°C	----	10	mg/L	<10	2000 mg/L	98.7	97	105
EA015: Total Dissolved Solids (QCLot: 3302042)								
EA015H: Total Dissolved Solids @180°C	----	10	mg/L	<10	2000 mg/L	101	97	105
EA015: Total Dissolved Solids (QCLot: 3302043)								
EA015H: Total Dissolved Solids @180°C	----	10	mg/L	<10	2000 mg/L	103	97	105
ED037P: Alkalinity by PC Titrator (QCLot: 3299834)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	98.2	91	105
ED037P: Alkalinity by PC Titrator (QCLot: 3299836)								
ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	----	200 mg/L	97.5	91	105
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 3299635)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	99.2	87	117
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 3299638)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	101	87	117
ED045G: Chloride Discrete analyser (QCLot: 3299634)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	98.2	89	117
ED045G: Chloride Discrete analyser (QCLot: 3299639)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	97.2	89	117
ED093F: Dissolved Major Cations (QCLot: 3299632)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	5 mg/L	100	91	113
ED093F: Magnesium	7439-95-4	1	mg/L	<1	5 mg/L	103	90	112
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	95.3	84	114
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	97.2	84	114
ED093F: Dissolved Major Cations (QCLot: 3299637)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	5 mg/L	99.6	91	113
ED093F: Magnesium	7439-95-4	1	mg/L	<1	5 mg/L	104	90	112
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	96.3	84	114
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	92.5	84	114
EG020F: Dissolved Metals by ICP-MS (QCLot: 3301810)								

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EG020F: Dissolved Metals by ICP-MS (QCLot: 3301810) - continued								
EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	98.2	94	106
EG020F: Dissolved Metals by ICP-MS (QCLot: 3301811)								
EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	97.8	94	106
EK057G: Nitrite as N by Discrete Analyser (QCLot: 3299633)								
EK057G: Nitrite as N	----	0.01	mg/L	<0.01	0.5 mg/L	101	91	107
EK057G: Nitrite as N by Discrete Analyser (QCLot: 3299636)								
EK057G: Nitrite as N	----	0.01	mg/L	<0.01	0.5 mg/L	101	91	107
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 3299353)								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.5 mg/L	106	80	120

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 3299635)							
EM1401268-007	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	10 mg/L	# Not Determined	70	130
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 3299638)							
EM1401293-014	DUP2	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	10 mg/L	108	70	130
ED045G: Chloride Discrete analyser (QCLot: 3299634)							
EM1401268-007	Anonymous	ED045G: Chloride	16887-00-6	400 mg/L	# Not Determined	70	130
ED045G: Chloride Discrete analyser (QCLot: 3299639)							
EM1401293-014	DUP2	ED045G: Chloride	16887-00-6	400 mg/L	112	70	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 3299633)							
EM1401268-007	Anonymous	EK057G: Nitrite as N	----	0.5 mg/L	101	75	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 3299636)							
EM1401293-014	DUP2	EK057G: Nitrite as N	----	0.5 mg/L	98.0	75	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 3299353)							
EM1401293-002	BH04	EK059G: Nitrite + Nitrate as N	----	0.5 mg/L	95.3	70	130

Matrix Spike (MS) and Matrix Spike Duplicate (MSD) Report

The quality control term Matrix Spike (MS) and Matrix Spike Duplicate (MSD) refers to intralaboratory split samples spiked with a representative set of target analytes. The purpose of these QC parameters are to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) and Matrix Spike Duplicate (MSD) Report						
				Spike	*Spike Recovery (%)*		*Recovery Limits (%)*		*RPDs (%)*	
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*MSD*	*Low*	*High*	*Value*	*Control Limit*
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 3299353)										
EM1401293-002	BH04	EK059G: Nitrite + Nitrate as N	----	0.5 mg/L	95.3	----	70	130	----	----
EK057G: Nitrite as N by Discrete Analyser (QCLot: 3299633)										
EM1401268-007	Anonymous	EK057G: Nitrite as N	----	0.5 mg/L	101	----	75	130	----	----
ED045G: Chloride Discrete analyser (QCLot: 3299634)										
EM1401268-007	Anonymous	ED045G: Chloride	16887-00-6	400 mg/L	# Not Determined	----	70	130	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 3299635)										
EM1401268-007	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	10 mg/L	# Not Determined	----	70	130	----	----
EK057G: Nitrite as N by Discrete Analyser (QCLot: 3299636)										
EM1401293-014	DUP2	EK057G: Nitrite as N	----	0.5 mg/L	98.0	----	75	130	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 3299638)										
EM1401293-014	DUP2	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	10 mg/L	108	----	70	130	----	----
ED045G: Chloride Discrete analyser (QCLot: 3299639)										
EM1401293-014	DUP2	ED045G: Chloride	16887-00-6	400 mg/L	112	----	70	130	----	----

INTERPRETIVE QUALITY CONTROL REPORT

Work Order : **EM1401293**

Client : GHD PTY LTD
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Project : 313073314 MT BULLER
Site : ----
C-O-C number : ----
Sampler : JL
Order number : ----

Quote number : MEBQ/177/13

Page : 1 of 10

Laboratory : Environmental Division Melbourne
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QC Level : NEPM 2013 Schedule B(3) and ALS QCS3 requirement

Date Samples Received : 14-FEB-2014
Issue Date : 21-FEB-2014

No. of samples received : 16
No. of samples analysed : 16

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Interpretive Quality Control Report contains the following information:

- Analysis Holding Time Compliance
- Quality Control Parameter Frequency Compliance
- Brief Method Summaries
- Summary of Outliers

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with recommended holding times (USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: ✘ = Holding time breach ; ✓ = Within holding time.

Method	*Sample Date*	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)		***Date extracted***	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EA005: pH							
Clear Plastic Bottle - Natural (EA005) BH14	**11-FEB-2014**	**----**	----	----	**19-FEB-2014**	11-FEB-2014	✘
Clear Plastic Bottle - Natural (EA005) BH06, BH09, BH10, BH14A, BH15A	**12-FEB-2014**	**----**	----	----	**19-FEB-2014**	12-FEB-2014	✘
Clear Plastic Bottle - Natural (EA005) BH04, BH05, BH13, BH14B, BH15, DUP1, DUP2, SW1, SW2	**13-FEB-2014**	**----**	----	----	**19-FEB-2014**	13-FEB-2014	✘
EA010: Conductivity							
Clear Plastic Bottle - Natural (EA010) BH14	**11-FEB-2014**	**----**	----	----	**19-FEB-2014**	11-MAR-2014	✓
Clear Plastic Bottle - Natural (EA010) BH06, BH09, BH10, BH14A, BH15A	**12-FEB-2014**	**----**	----	----	**19-FEB-2014**	12-MAR-2014	✓
Clear Plastic Bottle - Natural (EA010) BH04, BH05, BH13, BH14B, BH15, DUP1, DUP2, SW1, SW2	**13-FEB-2014**	**----**	----	----	**19-FEB-2014**	13-MAR-2014	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method ***Container** / Client Sample ID(s)*	***Sample Date***	*Extraction / Preparation* ***Date extracted***	 *Due for extraction*	 *Evaluation*	*Analysis* ***Date analysed***	 *Due for analysis*	 *Evaluation*
EA015: Total Dissolved Solids							
Clear Plastic Bottle - Natural (EA015H) BH14	**11-FEB-2014**	---	18-FEB-2014	----	**18-FEB-2014**	18-FEB-2014	✓
Clear Plastic Bottle - Natural (EA015H) BH06, BH09, BH10, BH14A, BH15A	**12-FEB-2014**	---	19-FEB-2014	----	**18-FEB-2014**	19-FEB-2014	✓
Clear Plastic Bottle - Natural (EA015H) BH04, BH05, BH13, BH14B, BH15, DUP1, DUP2, SW1, SW2	**13-FEB-2014**	---	20-FEB-2014	----	**19-FEB-2014**	20-FEB-2014	✓
ED037P: Alkalinity by PC Titrator							
Clear Plastic Bottle - Natural (ED037-P) BH14	**11-FEB-2014**	---	25-FEB-2014	----	**18-FEB-2014**	25-FEB-2014	✓
Clear Plastic Bottle - Natural (ED037-P) BH06, BH09, BH10, BH14A, BH15A	**12-FEB-2014**	---	26-FEB-2014	----	**18-FEB-2014**	26-FEB-2014	✓
Clear Plastic Bottle - Natural (ED037-P) BH04, BH05, BH13, BH14B, BH15, DUP1, DUP2, SW1, SW2	**13-FEB-2014**	---	27-FEB-2014	----	**18-FEB-2014**	27-FEB-2014	✓
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA							
Clear Plastic Bottle - Natural (ED041G) BH14	**11-FEB-2014**	---	11-MAR-2014	----	**18-FEB-2014**	11-MAR-2014	✓
Clear Plastic Bottle - Natural (ED041G) BH06, BH09, BH10, BH14A, BH15A	**12-FEB-2014**	---	12-MAR-2014	----	**18-FEB-2014**	12-MAR-2014	✓
Clear Plastic Bottle - Natural (ED041G) BH04, BH05, BH13, BH14B, BH15, DUP1, DUP2, SW1, SW2	**13-FEB-2014**	---	13-MAR-2014	----	**18-FEB-2014**	13-MAR-2014	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method	***Sample Date***	*Extraction / Preparation*			*Analysis*		
***Container** / Client Sample ID(s)*		***Date extracted***	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
ED045G: Chloride Discrete analyser							
Clear Plastic Bottle - Natural (ED045G) BH14	**11-FEB-2014**	---	11-MAR-2014	----	**18-FEB-2014**	11-MAR-2014	✓
Clear Plastic Bottle - Natural (ED045G) BH06, BH09, BH10, BH14A, BH15A	**12-FEB-2014**	---	12-MAR-2014	----	**18-FEB-2014**	12-MAR-2014	✓
Clear Plastic Bottle - Natural (ED045G) BH04, BH05, BH13, BH14B, BH15, DUP1, DUP2, SW1, SW2	**13-FEB-2014**	---	13-MAR-2014	----	**18-FEB-2014**	13-MAR-2014	✓
ED093F: Dissolved Major Cations							
Clear Plastic Bottle - Natural (ED093F) BH14	**11-FEB-2014**	---	18-FEB-2014	----	**18-FEB-2014**	18-FEB-2014	✓
Clear Plastic Bottle - Natural (ED093F) BH06, BH09, BH10, BH14A, BH15A	**12-FEB-2014**	---	19-FEB-2014	----	**18-FEB-2014**	19-FEB-2014	✓
Clear Plastic Bottle - Natural (ED093F) BH04, BH05, BH13, BH14B, BH15, DUP1, DUP2, SW1, SW2	**13-FEB-2014**	---	20-FEB-2014	----	**18-FEB-2014**	20-FEB-2014	✓
EG020F: Dissolved Metals by ICP-MS							
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) BH14	**11-FEB-2014**	---	10-AUG-2014	----	**19-FEB-2014**	10-AUG-2014	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) RB, BH06, BH09, BH10, BH14A, BH15A	**12-FEB-2014**	---	11-AUG-2014	----	**19-FEB-2014**	11-AUG-2014	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) BH04, BH05, BH13, BH15, DUP1, DUP2	**13-FEB-2014**	---	12-AUG-2014	----	**19-FEB-2014**	12-AUG-2014	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020A-F) BH14B, SW1, SW2	**13-FEB-2014**	---	12-AUG-2014	----	**19-FEB-2014**	12-AUG-2014	✓

Matrix: **WATER**

Evaluation: ✗ = Holding time breach ; ✓ = Within holding time.

Method **Container** / Client Sample ID(s)		**Sample Date**	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	**Date analysed**	Due for analysis	Evaluation
EK057G: Nitrite as N by Discrete Analyser								
Clear Plastic Bottle - Natural (EK057G) BH14		**11-FEB-2014**	---	13-FEB-2014	----	**14-FEB-2014**	13-FEB-2014	✗
Clear Plastic Bottle - Natural (EK057G) BH06, BH10, BH15A	BH09, BH14A,	**12-FEB-2014**	---	14-FEB-2014	----	**14-FEB-2014**	14-FEB-2014	✓
Clear Plastic Bottle - Natural (EK057G) BH04, BH13, BH15, DUP2, SW2	BH05, BH14B, DUP1, SW1,	**13-FEB-2014**	---	15-FEB-2014	----	**14-FEB-2014**	15-FEB-2014	✓
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK059G) BH14		**11-FEB-2014**	---	11-MAR-2014	----	**18-FEB-2014**	11-MAR-2014	✓
Clear Plastic Bottle - Sulfuric Acid (EK059G) BH06, BH10, BH15A	BH09, BH14A,	**12-FEB-2014**	---	12-MAR-2014	----	**18-FEB-2014**	12-MAR-2014	✓
Clear Plastic Bottle - Sulfuric Acid (EK059G) BH04, BH13, BH15, DUP2, SW2	BH05, BH14B, DUP1, SW1,	**13-FEB-2014**	---	13-MAR-2014	----	**18-FEB-2014**	13-MAR-2014	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(where) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type *Analytical Methods*	*Method*	*Count* *QC*	*Regular*	*Rate (%)* ***Actual***	***Expected***	*Evaluation*	*Quality Control Specification*
Laboratory Duplicates (DUP)							
Alkalinity by PC Titrator	ED037-P	4	32	**12.5**	**10.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	3	21	**14.3**	**10.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Conductivity	EA010	4	30	**13.3**	**10.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	4	39	**10.3**	**10.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	3	23	**13.0**	**10.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	18	**11.1**	**10.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	3	24	**12.5**	**10.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
pH	EA005	3	28	**10.7**	**10.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	3	23	**13.0**	**10.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	6	60	**10.0**	**10.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Laboratory Control Samples (LCS)							
Alkalinity by PC Titrator	ED037-P	2	32	**6.3**	**5.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Chloride by Discrete Analyser	ED045G	4	21	**19.0**	**10.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Conductivity	EA010	2	30	**6.7**	**5.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	39	**5.1**	**5.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	2	23	**8.7**	**5.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	18	**5.6**	**5.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	2	24	**8.3**	**5.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	23	**8.7**	**5.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	3	60	**5.0**	**5.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Method Blanks (MB)							
Chloride by Discrete Analyser	ED045G	2	21	**9.5**	**5.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Conductivity	EA010	2	30	**6.7**	**5.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	39	**5.1**	**5.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Major Cations - Dissolved	ED093F	2	23	**8.7**	**5.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	18	**5.6**	**5.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	2	24	**8.3**	**5.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	23	**8.7**	**5.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Total Dissolved Solids (High Level)	EA015H	3	60	**5.0**	**5.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Matrix Spikes (MS)							
Chloride by Discrete Analyser	ED045G	2	21	**9.5**	**5.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	39	**5.1**	**5.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	18	**5.6**	**5.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Nitrite as N by Discrete Analyser	EK057G	2	24	**8.3**	**5.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	23	**8.7**	**5.0**	✓	NEPM 2013 Schedule B(3) and ALS QCS3 requirement

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
pH	EA005	WATER	APHA 21st ed. 4500 H+ B. pH of water samples is determined by ISE either manually or by automated pH meter. This method is compliant with NEPM (2013) Schedule B(3)
Conductivity	EA010	WATER	APHA 21st ed., 2510 B Conductivity is determined by ISE, either manually or automated measurement. This method is compliant with NEPM (2013) Schedule B(3)
Total Dissolved Solids (High Level)	EA015H	WATER	In-House, APHA 21st ed., 2540C A gravimetric procedure that determines the amount of `filterable` residue in an aqueous sample. A well-mixed sample is filtered through a glass fibre filter (1.2um). The filtrate is evaporated to dryness and dried to constant weight at 180+/-5C. This method is compliant with NEPM (2013) Schedule B(3)
Alkalinity by PC Titrator	ED037-P	WATER	APHA 21st ed., 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (2013) Schedule B(3)
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	APHA 21st ed., 4500-SO4 Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (2013) Schedule B(3)
Chloride by Discrete Analyser	ED045G	WATER	APHA 21st ed., 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocyanate forms highly-coloured ferric thiocyanate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Major Cations - Dissolved	ED093F	WATER	Major Cations is determined based on APHA 21st ed., 3120; USEPA SW 846 - 6010 The ICPAES technique ionises the 0.45um filtered sample atoms emitting a characteristic spectrum. This spectrum is then compared against matrix matched standards for quantification. This method is compliant with NEPM (2013) Schedule B(3) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (2013) Schedule B(3) Hardness parameters are calculated based on APHA 21st ed., 2340 B. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	(APHA 21st ed., 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020): Samples are 0.45 um filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Nitrite as N by Discrete Analyser	EK057G	WATER	APHA 21st ed., 4500-NO2- B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrate as N by Discrete Analyser	EK058G	WATER	APHA 21st ed., 4500-NO3- F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	WATER	APHA 21st ed., 4500-NO3- F. Combined oxidised Nitrogen (NO2+NO3) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
Ionic Balance by PCT DA and Turbi SO4 DA	EN055 - PG	WATER	APHA 21st Ed. 1030F. The Ionic Balance is calculated based on the major Anions and Cations. The major anions include Alkalinity, Chloride and Sulfate which determined by PCT and DA. The Cations are determined by Turbi SO4 by DA. This method is compliant with NEPM (2013) Schedule B(3)

Summary of Outliers

Outliers : Quality Control Samples

The following report highlights outliers flagged in the Quality Control (QC) Report. Surrogate recovery limits are static and based on USEPA SW846 or ALS-QWI/EN/38 (in the absence of specific USEPA limits). This report displays QC Outliers (breaches) only.

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	**Analyte**	CAS Number	Data	Limits	**Comment**
Matrix Spike (MS) Recoveries							
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA	EM1401268-007	Anonymous	**Sulfate as SO4 - Turbidimetric**	14808-79-8	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
ED045G: Chloride Discrete analyser	EM1401268-007	Anonymous	**Chloride**	16887-00-6	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

- **For all matrices, no Method Blank value outliers occur.**
- **For all matrices, no Duplicate outliers occur.**
- **For all matrices, no Laboratory Control outliers occur.**

Regular Sample Surrogates

- **For all regular sample matrices, no surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

This report displays Holding Time breaches only. Only the respective Extraction / Preparation and/or Analysis component is/are displayed.

Matrix: **WATER**

Method	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)	*Date extracted*	*Due for extraction*	***Days overdue***	*Date analysed*	*Due for analysis*	***Days overdue***
EA005: pH						
Clear Plastic Bottle - Natural BH14	----	----	----	19-FEB-2014	11-FEB-2014	**8**
Clear Plastic Bottle - Natural BH06, BH09, BH10, BH14A, BH15A	----	----	----	19-FEB-2014	12-FEB-2014	**7**
Clear Plastic Bottle - Natural BH04, BH05, BH13, BH14B, BH15, DUP1, DUP2, SW1, SW2	----	----	----	19-FEB-2014	13-FEB-2014	**6**
EK057G: Nitrite as N by Discrete Analyser						

Matrix: **WATER**

Method	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)	*Date extracted*	*Due for extraction*	***Days overdue***	*Date analysed*	*Due for analysis*	***Days overdue***
EK057G: Nitrite as N by Discrete Analyser - Analysis Holding Time Compliance						
Clear Plastic Bottle - Natural						
BH14	----	----	----	14-FEB-2014	13-FEB-2014	**1**

Outliers : Frequency of Quality Control Samples

The following report highlights breaches in the Frequency of Quality Control Samples.

- **No Quality Control Sample Frequency Outliers exist.**

ALS Group

Environmental Division

SAMPLE RECEIPT NOTIFICATION (SRN)

Comprehensive Report

Work Order	: **EM1401293**		
Client	: **GHD PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MR GRANT JONES	Contact	: Shirley LeCornu
Address	: LEVEL 8, 180 LONSDALE ST MELBOURNE VIC, AUSTRALIA 3001	Address	: 4 Westall Rd Springvale VIC Australia 3171
E-mail	: grant.jones@ghd.com	E-mail	: shirley.lecornu@alsenviro.com
Telephone	: +61 03 8687 8000	Telephone	: +61-3-8549 9630
Facsimile	: +61 03 8687 8111	Facsimile	: +61-3-8549 9601
Project	: 313073314 MT BULLER	Page	: 1 of 3
Order number	: ----		
C-O-C number	: ----	Quote number	: EM2013GHDSER0715 (MEBQ/177/13)
Site	: ----		
Sampler	: JL	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement

Dates

Date Samples Received	: 14-FEB-2014	Issue Date	: 17-FEB-2014 14:06
Client Requested Due Date	: 21-FEB-2014	Scheduled Reporting Date	: **21-FEB-2014**

Delivery Details

Mode of Delivery	: Carrier	Temperature	: 1.5-1.8 - Ice present
No. of coolers/boxes	: 2	No. of samples received	: 16
Security Seal	: N/A	No. of samples analysed	: 16

General Comments

- This report contains the following information:
    - Sample Container(s)/Preservation Non-Compliances
    - Summary of Sample(s) and Requested Analysis
    - Proactive Holding Time Report
    - Requested Deliverables
- **Sample containers do not comply to pretreatment / preservation standards (AS, APHA, USEPA). Please refer to the Sample Container(s)/Preservation Non-Compliance Log at the end of this report for details.**
- **Samples to be filtered through a 0.45um filter prior to the dissolved metals analysis.**
- **Please refer to the Proactive Holding Time Report table below which summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory. The absence of this summary table indicates that all samples have been received within the recommended holding times for the analysis requested.**
- **Please direct any queries related to sample condition / numbering / breakages to Peter Ravlic.**
- **Analytical work for this work order will be conducted at ALS Springvale.**
- Sample Disposal - Aqueous (14 days), Solid (60 days) from date of completion of work order.

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

Method *Client sample ID*	Sample Container Received	Preferred Sample Container for Analysis
EG020A-F : Dissolved Metals by ICP-MS - Suite A		
BH14B	- Clear Plastic Bottle - Unfiltered; Lab-acidified	- Clear Plastic Bottle - Nitric Acid; Filtered
SW1	- Clear Plastic Bottle - Unfiltered; Lab-acidified	- Clear Plastic Bottle - Nitric Acid; Filtered
SW2	- Clear Plastic Bottle - Unfiltered; Lab-acidified	- Clear Plastic Bottle - Nitric Acid; Filtered

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process neccessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

If no sampling time is provided, the sampling time will default to 15:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory for processing purposes and will be shown bracketed without a time component.

Matrix: **WATER**

Laboratory sample ID	*Client sampling date / time*	*Client sample ID*	WATER - EA005: pH pH	WATER - EA010 Conductivity	WATER - EA015H Total Dissolved Solids - High Level	WATER - EG020F Dissolved Metals by ICPMS	WATER - EK058G Nitrate as N by Discrete Analyser	WATER - EN055 - PG Ionic Balance by ED037P, ED041G, ED045G &	WATER - NT-01 Major Cations (Ca, Mg, Na, K)	WATER - NT-02 Major Anions (Chloride, Sulphate, Alkalinity)
EM1401293-001	12-FEB-2014 15:00	RB	✓	✓	✓	✓	✓	✓	✓	✓
EM1401293-002	13-FEB-2014 15:00	BH04	✓	✓	✓	✓	✓	✓	✓	✓
EM1401293-003	13-FEB-2014 15:00	BH05	✓	✓	✓	✓	✓	✓	✓	✓
EM1401293-004	12-FEB-2014 15:00	BH06	✓	✓	✓	✓	✓	✓	✓	✓
EM1401293-005	12-FEB-2014 15:00	BH09	✓	✓	✓	✓	✓	✓	✓	✓
EM1401293-006	12-FEB-2014 15:00	BH10	✓	✓	✓	✓	✓	✓	✓	✓
EM1401293-007	13-FEB-2014 15:00	BH13	✓	✓	✓	✓	✓	✓	✓	✓
EM1401293-008	11-FEB-2014 15:00	BH14	✓	✓	✓	✓	✓	✓	✓	✓
EM1401293-009	12-FEB-2014 15:00	BH14A	✓	✓	✓	✓	✓	✓	✓	✓
EM1401293-010	13-FEB-2014 15:00	BH14B	✓	✓	✓	✓	✓	✓	✓	✓
EM1401293-011	13-FEB-2014 15:00	BH15	✓	✓	✓	✓	✓	✓	✓	✓
EM1401293-012	12-FEB-2014 15:00	BH15A	✓	✓	✓	✓	✓	✓	✓	✓
EM1401293-013	13-FEB-2014 15:00	DUP1	✓	✓	✓	✓	✓	✓	✓	✓
EM1401293-014	13-FEB-2014 15:00	DUP2	✓	✓	✓	✓	✓	✓	✓	✓
EM1401293-015	13-FEB-2014 15:00	SW1	✓	✓	✓	✓	✓	✓	✓	✓
EM1401293-016	13-FEB-2014 15:00	SW2	✓	✓	✓	✓	✓	✓	✓	✓

Proactive Holding Time Report

The following table summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory.

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method		Due for extraction	Due for analysis	Samples Received		Instructions Received	
Client Sample ID(s)	Container			Date	Evaluation	Date	Evaluation
EA005: pH							
BH04	Clear Plastic Bottle - Natural	----	13-FEB-2014	14-FEB-2014	×	----	----
BH05	Clear Plastic Bottle - Natural	----	13-FEB-2014	14-FEB-2014	×	----	----
BH06	Clear Plastic Bottle - Natural	----	12-FEB-2014	14-FEB-2014	×	----	----
BH09	Clear Plastic Bottle - Natural	----	12-FEB-2014	14-FEB-2014	×	----	----
BH10	Clear Plastic Bottle - Natural	----	12-FEB-2014	14-FEB-2014	×	----	----
BH13	Clear Plastic Bottle - Natural	----	13-FEB-2014	14-FEB-2014	×	----	----
BH14A	Clear Plastic Bottle - Natural	----	12-FEB-2014	14-FEB-2014	×	----	----
BH14B	Clear Plastic Bottle - Natural	----	13-FEB-2014	14-FEB-2014	×	----	----
BH14	Clear Plastic Bottle - Natural	----	11-FEB-2014	14-FEB-2014	×	----	----
BH15A	Clear Plastic Bottle - Natural	----	12-FEB-2014	14-FEB-2014	×	----	----
BH15	Clear Plastic Bottle - Natural	----	13-FEB-2014	14-FEB-2014	×	----	----
DUP1	Clear Plastic Bottle - Natural	----	13-FEB-2014	14-FEB-2014	×	----	----
DUP2	Clear Plastic Bottle - Natural	----	13-FEB-2014	14-FEB-2014	×	----	----
RB	Clear Plastic Bottle - Natural	----	12-FEB-2014	14-FEB-2014	×	----	----
SW1	Clear Plastic Bottle - Natural	----	13-FEB-2014	14-FEB-2014	×	----	----
SW2	Clear Plastic Bottle - Natural	----	13-FEB-2014	14-FEB-2014	×	----	----
EK057G: Nitrite as N by Discrete Analyser							
BH14	Clear Plastic Bottle - Natural	13-FEB-2014	----	14-FEB-2014	×	----	----

Requested Deliverables

ALL ACCOUNTS

- A4 - AU Tax Invoice (INV)	Email	ghdvicaccounts@ghd.com

ALL RESULTS ADDRESS

- *AU Certificate of Analysis - NATA	Email	vic_enviro_labreports@ghd.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep)	Email	vic_enviro_labreports@ghd.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA	Email	vic_enviro_labreports@ghd.com
- A4 - AU Sample Receipt Notification - Environmental HT	Email	vic_enviro_labreports@ghd.com
- Chain of Custody (CoC)	Email	vic_enviro_labreports@ghd.com
- EDI Format - ENMRG	Email	vic_enviro_labreports@ghd.com
- EDI Format - ESDAT GHD	Email	vic_enviro_labreports@ghd.com
- EDI Format - XTab	Email	vic_enviro_labreports@ghd.com

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- *AU Certificate of Analysis - NATA (COA)	Email	grant.jones@ghd.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	grant.jones@ghd.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	grant.jones@ghd.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	grant.jones@ghd.com
- A4 - AU Tax Invoice (INV)	Email	grant.jones@ghd.com
- Chain of Custody (CoC) (COC)	Email	grant.jones@ghd.com
- EDI Format - ENMRG (ENMRG)	Email	grant.jones@ghd.com
- EDI Format - ESDAT GHD (ESDAT_GHD)	Email	grant.jones@ghd.com
- EDI Format - XTab (XTAB)	Email	grant.jones@ghd.com

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- *AU QC Report - DEFAULT (Anon QC Rep) - NATA	Email	jennifer.learmonth@ghd.com
- A4 - AU Sample Receipt Notification - Environmental HT	Email	jennifer.learmonth@ghd.com
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CHAIN OF CUSTODY RECORD

GHD

Page 1 of 1

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Job Number	31307331 4
GHD Office	MELBOURNE
Project	MT BULLER
GHD Project Manager	G JONES
GHD Contact	J. LEARMONTH
Requested Completion Date	STANDARD
Quote No./GHD Reference	
Laboratory:	ALS
Address:	
Laboratory Contact:	SHIRLEY LECORNU

PLEASE NOTE:
Sign white copy on receipt and release of samples.
Samples are to be delivered to the Laboratory Address.
On receipt of samples, the **laboratory contact should sign white copy** and fax to GHD Contact.
On completion of analyses please **return white copy with results.**
Yellow copy is retained by laboratory.
Pink copy is returned to the sampler once the courier has signed for the samples.
E-mail results to the e-mail address of the relevant GHD office and cc GHD Project Manager and GHD Contact with the GHD Job Number in the e-mail subject line.

Results to be provided in ESDAT compatibile format

						Container			Analyses Required									
Sample I.D.	Date	Time ALS I.D	Composite Sample	Sample Matrix S: Soil SL: Sludge W: Water A: Air GW: Groundwater	Preservative	Type J: soil jar B: bag V: vial G: glass bottle P: plastic bottle	Number	Volume (mL)	pH	TDS	EC	Ca, K, Mg, Na	SO4, Cl	carbonate	bicarbonate	total iron	nitrate.	Remarks
RB	12/2	1		GW		P	1		✓	✓	✓	✓	✓	✓	✓	✓	✓	
BH04	13/2.	2		↓		↓	2		↓	↓	↓	↓	↓	↓	↓	↓	↓	
BH05	↓	3		↓		↓	↓		↓	↓	↓	↓	↓	↓	↓	↓	↓	*preservative washed
BH06	12/2	4		↓		↓	↓		↓	↓	↓	↓	↓	↓	↓	↓	↓	out of metals
BH09	13/2	5		↓		↓	↓		↓	↓	↓	↓	↓	↓	↓	↓	↓	bottle, not filtered
BH10	↓	6		↓		↓	↓		↓	↓	↓	↓	↓	↓	↓	↓	↓	Please filter
BH13	↓	7		↓		↓	↓		↓	↓	↓	↓	↓	↓	↓	↓	↓	upon arrival
BH14	11/2	8		↓		↓	↓		↓	↓	↓	↓	↓	↓	↓	↓	↓	at the lab ASAP
BH14A	12/2	9		↓		↓	↓		↓	↓	↓	↓	↓	↓	↓	↓	↓	
BH14B *	13/2	10		↓		↓	↓		↓	↓	↓	↓	↓	↓	↓	↓	↓	
BH15	↓	11		↓		↓	↓		↓	↓	↓	↓	↓	↓	↓	↓	↓	
BH15A	12/2	12		↓		↓	↓		↓	↓	↓	↓	↓	↓	↓	↓	↓	
DUP1	13/2	13		↓		↓	↓		↓	↓	↓	↓	↓	↓	↓	↓	↓	
DUP2	↓	14		↓		↓	↓		↓	↓	↓	↓	↓	↓	↓	↓	↓	
SW1 *	↓	15		W		↓	↓		↓	↓	↓	↓	↓	↓	↓	↓	↓	
SW2 *	↓	16		↓		↓	↓		↓	↓	↓	↓	↓	↓	↓	↓	↓	

Environmental Division
Melbourne
Work Order
EM1401293
Telephone : +61-3-8549 9600

Sampled by:	J LEARMONTH	Date/Time	13/2/14	Relinquished by: J LEARMONTH	Date/Time 14/2/14
Received by:	J. McKay	Date/Time	14/2/14	Relinquished by: J. McKay	Date/Time 14/2/14
Received by Courier:	VA 301	Date/Time		Relinquished by:	Date/Time
Received by Lab:	Maree (A417)	Date/Time	14/2 13:05		

Remarks:

Appendix E – QA/QC Results

Field Blanks (WATER)
Filter: SDG in('EM1401293')

SDG	EM1401293
Field_ID	RB
Sampled_Date-Time	12/02/2014 15:00
Sample_Type	Rinsate

Chem_Group	**ChemName**	**Units**	**EQL**	
Alkalinity	Alkalinity (total) as CaCO3	mg/l	1	
	Alkalinity (Bicarbonate as CaCO3)	mg/l	1	
	Alkalinity (Carbonate as CaCO3)	mg/l	1	
	Alkalinity (Hydroxide) as CaCO3	mg/l	1	
	Bicarbonate	mg/l		
	Carbonate	mg/l		
Inorganics	Electrical conductivity *(lab)	µS/cm	1	
	pH (Lab)	pH_Units	0.01	
	Total Dissolved Solids	mg/l	10	
Major Ions	Calcium (Filtered)	mg/l	1	
	Chloride	mg/l	1	
	Magnesium (Filtered)	mg/l	1	
	Potassium (Filtered)	mg/l	1	
	Sodium (Filtered)	mg/l	1	
	Sulphate (Filtered)	mg/l	1	
	Anions Total	meq/L	0.01	
	Cations Total	meq/L	0.01	
	Ionic Balance	%	0.01	
Metals	Iron (Filtered)	mg/l	0.05	<0.05
Nutrients	Nitrate (as N)	mg/l	0.01	
	Nitrite (as N)	mg/l	0.01	
	Nitrogen (Total Oxidised)	mg/l	0.01	

Field Duplicates (WATER)
Filter: SDG in('EM1401293')

			SDG	EM1401293	EM1401293		EM1401293	EM1401293	
			Field_ID	BH05	DUP1	**RPD**	BH13	DUP2	**RPD**
			Sampled_Date-Time	13/02/2014 15:00	13/02/2014 15:00		13/02/2014 15:00	13/02/2014 15:00	
Chem_Group	**ChemName**	**Units**	**EQL**						
Alkalinity	Alkalinity (total) as CaCO3	mg/l	1	16.0	15.0	6	3.0	3.0	0
	Alkalinity (Bicarbonate as CaCO3)	mg/l	1	16.0	15.0	6	3.0	3.0	0
	Alkalinity (Carbonate as CaCO3)	mg/l	1	<1.0	<1.0	0	<1.0	<1.0	0
	Alkalinity (Hydroxide) as CaCO3	mg/l	1	<1.0	<1.0	0	<1.0	<1.0	0
Inorganics	Electrical conductivity *(lab)	µS/cm	1	44.0	44.0	0	17.0	17.0	0
	pH (Lab)	pH_Units	0.01	7.94	6.77	16	6.12	5.93	3
	Total Dissolved Solids	mg/l	10	27.0	24.0	12	10.0	11.0	10
Major Ions	Calcium (Filtered)	mg/l	1	1.0	1.0	0	<1.0	<1.0	0
	Chloride	mg/l	1	1.0	1.0	0	1.0	1.0	0
	Magnesium (Filtered)	mg/l	1	<1.0	<1.0	0	<1.0	<1.0	0
	Potassium (Filtered)	mg/l	1	2.0	2.0	0	<1.0	<1.0	0
	Sodium (Filtered)	mg/l	1	5.0	4.0	22	<1.0	<1.0	0
	Sulphate (Filtered)	mg/l	1	**3.0**	**6.0**	**67**	<1.0	<1.0	0
	Anions Total	meq/L	0.01	0.41	0.45	9	0.09	0.06	40
	Cations Total	meq/L	0.01	0.32	0.28	13	<0.01	<0.01	0
Metals	Iron (Filtered)	mg/l	0.05	<0.05	<0.05	0	0.05	0.06	18
Nutrients	Nitrate (as N)	mg/l	0.01	0.23	0.21	9	0.18	0.17	6
	Nitrite (as N)	mg/l	0.01	<0.01	<0.01	0	<0.01	<0.01	0
	Nitrogen (Total Oxidised)	mg/l	0.01	0.23	0.21	9	0.18	0.17	6

*RPDs have only been considered where a concentration is greater than 1 times the EQL.

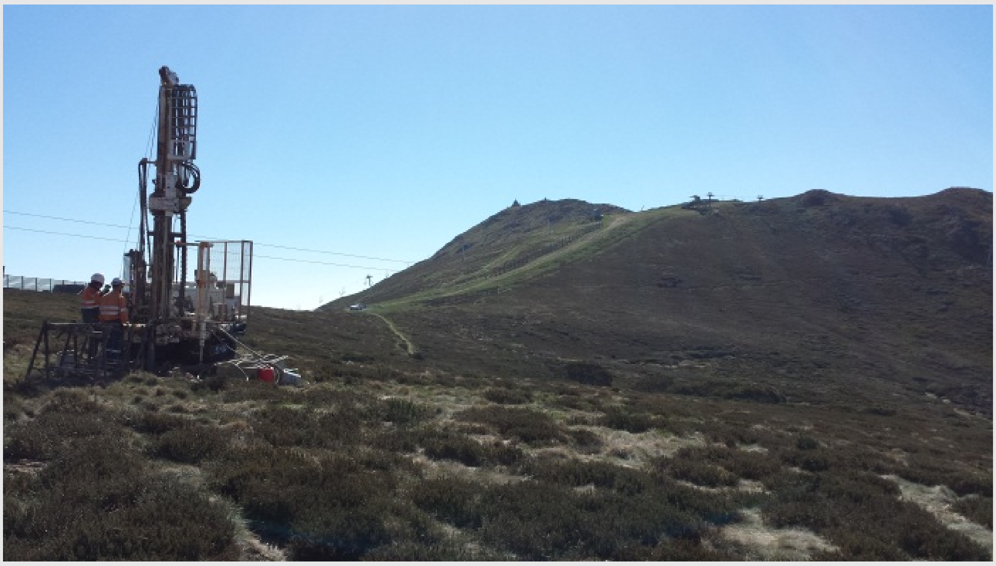
**High RPDs are in bold (Acceptable RPDs for each EQL multiplier range are: 50 (1-10 x EQL); 50 (10-30 x EQL); 50 (> 30 x EQL))

***Interlab Duplicates are matched on a per compound basis as methods vary between laboratories. Any methods in the row header relate to those used in the primary laboratory

Appendix F – Site Photographic Record

Taken looking south-west from BH1 location. This photo shows the opposite side of the slope to the proposed dam location

Taken while drilling BH14, looking north-west across to the summit of Mt Buller



Looking south-west up to Mt Buller Summit from aproximately half way down the slope towards the walking track

Photo taken from Boggy Creek T-Bar Station looking towards the Mt Buller Summit. View westwards towards summit on southern extent of Storage

Photo looking east across the top of the slope. View eastwards towards Control Centre across potential footprint of Storage.

Photo taken from the aqueduct looking up the slope (south-east) toward Control Centre. Proposed Storage area tin the centre near existing ski lift line.

Photo taken from the walking track (BH9/10) looking up the slope (south). Proposed Storage positioned near horizon.

Photo taken along the aqueduct near BH7

Photo taken of the aqueduct weir located west of BH7 along aqueduct

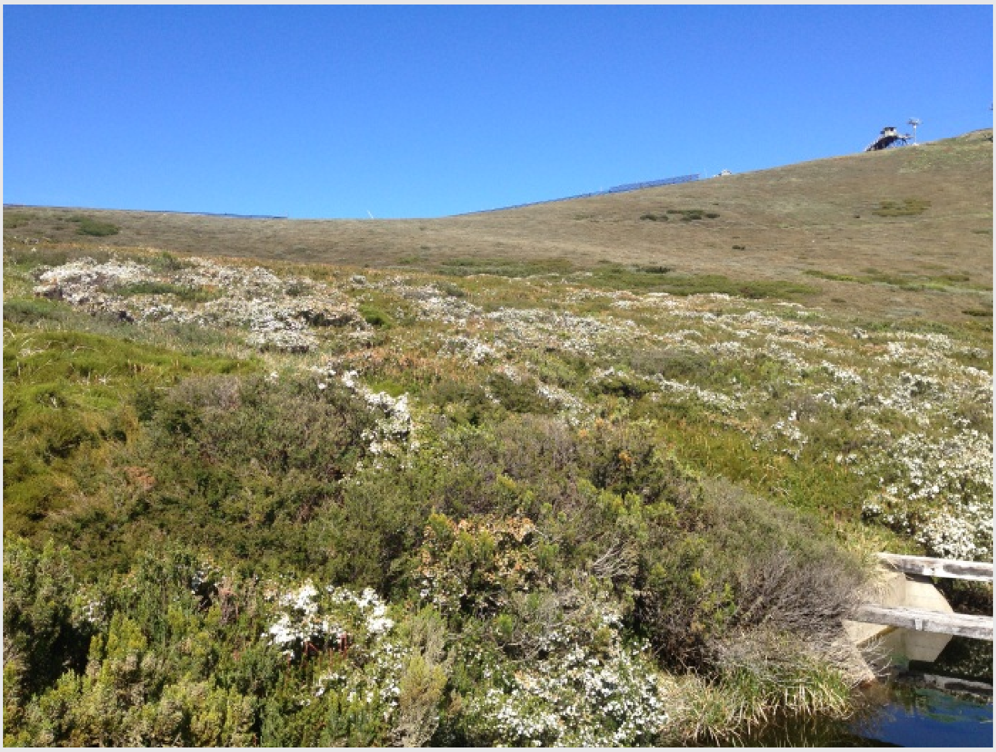


Photo taken from the aqueduct weir looking up towards Mt Buller Summit. Interpreted area of historical landslip to right of view. Springs emanating in this area. Proposed Storage far left of view (from horizon).

Photo taken from aqueduct weir looking uphill (south) towards bore BH6 (outside of proposed Storage area footprint).

Appendix G – Groundwater Management Plan

Groundwater Management Plan

G.1 Environmental Management Framework

An Environmental Management Framework would be developed for the Mt Buller works based on the principles of AS/NZS ISO 14001: 2004. The major elements of the environmental management strategy and framework are described in the SEMP compiled for the project.

A Construction Environmental Management Plan (CEMP) would be developed by the appointed lead construction contractor for the project. The CEMP would comprise schedules that set out procedures, measures and obligations for managing and mitigating potential environmental impacts. The schedules would also have specific commitments, actions and conditions necessary to ensure that environmental protection requirements are identified and managed effectively. Performance measures, monitoring and reporting requirements and corrective actions for each schedule would also be documented.

A Monitoring and Management Plan would be developed for the project. This plan would integrate a variety of groundwater, surface water and ecological monitoring and management aspects and would be developed and commenced in advance of construction. An important component of the Monitoring and Management Plan is the Groundwater Management Plan.

G.2 Requirement for a Groundwater Management Plan

Background

Based on the current hydrogeological understanding of the proposed storage site, there is a potential risk that construction of the storage could result in a reduction in groundwater recharge, and dislocation of surface water recharge. Alpine bogs identified hydraulically down-gradient of the proposed storage may consequently be detrimentally impacted.

There is significant uncertainty in assessing the resultant impact to the Alpine bogs as a result of the reduction in recharge. It is surmised that the Alpine bogs and their associated ecosystem rely upon groundwater (springflow) during the drier, summer periods. It is noted that there were episodes during the recent Millennium drought where bogs were exposed to significant reductions in rainfall recharge, e.g. 2006, however in these instances groundwater (storage) may potentially be an important aspect for bog survival.

A reduction in direct recharge may reduce groundwater spring flow, but it may not necessarily result in decreased water levels at the bog, i.e. access to water is maintained. There is currently a lack of detailed information on how the estimated groundwater recharge reductions might translate into changes in Alpine bog condition and whether there is a threshold groundwater level at which bog impacts are experienced from groundwater drawdown (as a result of recharge reductions). Beyond this threshold active management may be necessary for the protection of the GDE.

G.3 Groundwater Management Plan Scope

The purpose of a GMP is to describe the means by which the proponent would aim to prevent, manage and control or minimise the groundwater impacts associated with the construction (and ongoing operation) of the development at the Mt Buller Resort.

The GMP would be integrated with ecological assessments, specifically to assess the health of vegetation (and associated ecosystems) that may be detrimentally impacted by changes in groundwater flow regimes.

The GMP would be split into two phases. The first phase would have the objective of characterising groundwater level behaviour and its relationship with Alpine bog condition. This would be used to inform the design of the artificial recharge system, for example:

- Optimal locations for recharge;
- Recharge depths (soil profile at the bogs);
- Water quality; and
- Anticipated recharge rates.

This may require additional monitoring bore installation, groundwater sampling, groundwater monitoring (e.g. minimum 12 months) and possibly tracer testing. Geotechnical testing is required to ensure that any drainage diversion, or artificial recharge systems do not jeopardise the stability of embankments, stability of thin residual soil profiles, or reactive historical landslip surfaces.

The second phase of the GMP would focus on characterising the long term condition of the Alpine bogs and the efficacy of the artificial recharge. It is anticipated that frequent monitoring would be initially required, however monitoring would be reviewed periodically as risks are better characterised i.e. the performance of the system determined. Monitoring reviews would also determine whether contingency actions are required, i.e. application of additional recharge or alternative locations.

G.4 Objectives

The objective of the GMP would be to minimise the impact on groundwater and associated ecosystems during and post construction.

G.4.1 Pre-construction

Objectives include:

- Establish baseline information regarding seasonal water level behaviour and Alpine bog health prior to construction. A minimum 12 months (encapsulating a season) is recommended.
- Obtaining sufficient information to enable detailed design and construction of an effective irrigation system.

G.4.1 During and Post-construction

The objectives are to:

- avoid or minimise the impact on groundwater availability to the GDEs;
- avoid or minimise the impact on groundwater quality to the GDEs;
- define the commencement data, duration, frequency of development activities and anticipated impact to quality and quantity of groundwater;

- determine via scientific modelling, the radius of influence and profile of any potential impact on groundwater levels from development activities (i.e. water table drawdown cone of depression, if any);
- model the potential for recharge/discharge between surface water and groundwater; and
- include an assessment of the receiving environment (before development activities), including the seasonal variability of water flow, if applicable.

G.5 Authorisation and approval

The GMP would be authorised by the various proponents and approval obtained from the relevant referral agencies prior to construction of the proposed storage

G.6 Monitoring Program components

G.6.1 Extraction use and metering

Metering and monitoring may include:

- If groundwater is pumped for construction water supplies, or for construction dewatering, records (including metering of extraction/dewatering bores) are to be maintained regarding bore use.
- Metering of application rates to the bog / source water supply to the artificial recharge system.
- Changes in flow in the aqueduct
- Weather data.

G.6.2 Groundwater level

The GMP would provide reasonable spatial coverage of the study area, but also specifically where infrastructure components would ultimately be located. This includes:

- Monitoring bores installed as part of the groundwater investigations, specifically bores BH04, BH06, BH07, BH09 and BH19;
- These aforementioned bores should be equipped with automated groundwater level loggers. Other site bores should be gauged during site visitation; and
- To support construction, or data collection pre-construction , additional bores in the existing monitoring network should be considered, e.g. control bores outside of the construction area.

This would be achieved through a groundwater observation bore network. The network would include:

- Monitoring bores constructed to the minimum standards (LWBC 2003);
- Nested monitoring bores, i.e. monitoring of multiple aquifers within specific parts of the study area;
- Monitoring bores to be surveyed (level to m AHD and location); and
- Monitoring bores which are:
  - maintained in operational conditions;

  - kept secure from unauthorised access; and
  - clearly identified on the bore casing or headworks.

The network may be updated with improved hydrogeological understanding (for example, ongoing geotechnical information), and numerical modelling outcomes.

The frequency of groundwater level monitoring would vary between the pre-, during, and post construction phases of the project. A base monthly frequency would be adopted for the monitoring network prior to construction, however the frequency (and included bores) would be tailored to specific objectives within the study area during the construction phase, for example, monitoring bores near proposed construction dewatering may be more frequently sampled.

Intensive water level (and water quality) monitoring using automated equipment (for example, data loggers) would be used in parts of the study area to inform both the hydrogeological understanding and facilitate linkages with ecological investigations and hydrologic studies of waterways, i.e. surface and groundwater interactions.

G.6.3 Groundwater quality

Groundwater samples would be collected from monitoring bores. Groundwater monitoring would be in accordance with EPA guidelines (ANZECC/ARMCANZ (2000)). Analytes to be incorporated into the monitoring program would include major cations and anions, organic and inorganic constituents and physical parameters (pH, TDS).

Similarly to groundwater level monitoring, the frequency of groundwater quality monitoring would vary between the pre-, during, and post construction phases of the project. A base quarterly frequency would be adopted for the monitoring network prior to construction, however the frequency (and Sampling and Analytical Program) would be tailored to specific objectives within the study area during the construction phase. For example monitoring bores near proposed construction dewatering may be more frequently sampled, or the Analytical Program adapted to suite the likely contaminants. The analytical program would consider the ANZECC/ARMCANZ (2000) water quality guidelines, and any identified naturally elevated constituent concentrations.

G.6.4 Flora and Fauna Monitoring

Ecological monitoring of the condition of the Alpine bogs and adjoining aquatic environments would be undertaken as part of the Monitoring and Management Plan. Specific factors that would be monitored would be formulated through consultation with appropriately qualified ecological specialists (refer GHD 2014c).

G.6.4 QA/QC

The GMP would include a quality assurance/quality control (QA/QC) program as part of its field procedures, based on relevant Australian Standards (Standards Australia 2005) and industry common practice. The QA/QC program undertaken could include the following:

- Implementation of standard procedures including sampling equipment decontamination between sampling points;
- Field measurement of groundwater quality parameters and purging records;

- Field equipment calibration records
- Preservation of samples with ice during transport from the field to the laboratory;
- Use of laboratories certified by the National Association of Testing Authorities (NATA);
- Transportation of samples with accompanying chain of custody (COC) documentation;
- Collection of blind and split duplicate samples and calculated review of Relative Percent Difference (RPDs);
- Comparison of field and analytical data;
- Compliance with sample holding times; and
- Review of internal analysis of QC and laboratory duplicates.

G.6.5 Bore condition

The proponent would be responsible for maintaining operational bores and observation bores, if required. This would include periodical inspection, and repair or re-survey where required, of monitoring bores. Maintenance would be prompted from visual inspection and assessment during a site visit, but also where anomalous monitoring results (for example, water level or groundwater quality) are noted.

The recharge system would be designed with inspection / maintenance access to ensure its long term operation.

G.6.6 Data storage

Monitoring data would be stored (and backed-up) in a digital format, which facilitates simple information handling and transfer. Monitoring data would include:

- Water levels;
- Sampling purge details;
- Metering data;
- Field and laboratory water quality;
- Bore condition; and
- QA/QC records (instrument calibration, laboratory program).

Digital records of bore construction and location would also be maintained.

G.6.7 Reporting

Periodical reviews would be undertaken, with the review having the objective to interpret the data to determine:

- Trends:
  - water level, quality and flow behaviour;
  - comparison against predicted water level trends and the radius of influence estimations;
- Detailed review of pump failures (if such have occurred), supply or dewatering issues;

- Recommendations regarding improvements or refinements to the monitoring system, for example, network, frequencies, analytical scope;
- Review of monitoring procedures, data collection and quality, training;
- Collation and reporting for management and administration review; and
- Data distribution, for example, community groups, public access, education and further research.

G.6.8 Trigger levels

Triggers for management response are required to enable intervention to protect the study area biodiversity. This would likely comprise a tiered approach, with the amount of intervention increasing with the risk of adverse impact. Information from reference (control) sites would also be utilised.

Groundwater quality triggers would be established based on maintaining the baseline groundwater quality. The groundwater baseline would be established through a pre-construction phase monitoring program, taking into consideration the ANZECC/ARMCANZ (2000) water quality guidelines and any identified naturally elevated constituent concentrations.

The groundwater level baseline would be established through a pre-construction phase monitoring program, however the establishment of groundwater level triggers would be based on a number of factors given the seasonal variability and climate influences on groundwater. Groundwater level triggers could be established to:

- Maintain the condition of Alpine bog communities;
- Mitigate against the impacts of construction dewatering; and
- Preserve flow directions and hydraulic gradients.

The development of trigger levels would need to consider subtle and long term trends. Where the GMP identifies changes to groundwater levels or quality, a trigger action could be to initiate additional ecological investigations.

The monitoring methods would be designed to collect data in an efficient way to record key biodiversity parameters, and should be based on industry established protocols.

G.7 Response plan and contingencies

The Response and Contingencies Plan, should a trigger level be reached, may include the following elements noted below. In addition to implementing appropriate responses, notification and reporting to other agencies may be required.

G.7.1 Changes to groundwater quality

Changes to groundwater quality would prompt trigger actions and some may include:

- Re-testing or repeat monitoring as a QA/QC check;
- Hydrogeological review;
- Bore performance testing;
- Geophysical testing; and/or,

- Sampling of other nearby monitoring bores.

The trigger actions would be expected to inform appropriate interventions.

G.7.2 Changes to groundwater level

In response to a groundwater level trigger being reached, some identified actions may include:

- For dewatering / drainage:
  - Irrigation of impacted vegetation;
  - Changes to irrigation / recharge rates

G.7.3 Changes to Alpine bog condition

Specific triggers would be determined through consultation with appropriately qualified ecological specialists (refer GHD 2014c). These may be linked to groundwater levels, or environmental indicators.

GHD

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	J Learmonth	T Anderson		G Jones		4/07/2014
0	T Anderson	G Jones		G Jones		21/07/2014

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