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Sustainability and Healthy Country
Barwon Water
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Dear Will,

Re: Rationale behind changes to the Monitoring and Assessment Program for the Anglesea Borefield

1 Introduction and Purpose

BlueSphere Environmental Pty Ltd (BlueSphere), in conjunction with Sage Environmental Pty Ltd (Sage), Senversa Pty Ltd (Senvversa) and PSK Environmental Pty Ltd (PSK), was engaged by Barwon Region Water Corporation (Barwon Water) to update the Monitoring and Assessment Program (MAP) for the Anglesea Borefield based on the outcomes of the recent Bulk Entitlement Review (BlueSphere, 2024).

The purpose of this letter is to provide the rationale behind changes to the MAP for the Anglesea Borefield.

2 Changes to Routine Environmental Monitoring Requirements

2.1 Rainfall

Barwon Water has established a number of local rainfall gauges within the catchment. These were not previously included in the MAP but provide important data with which to interpret the monitoring results. As such these have been included in the updated MAP.

2.2 Groundwater

Due to the presence of naturally occurring acid sulfate soils within the catchment and ongoing acid generation risks, metals / metalloids analysis has been added into the MAP to monitor the concentrations of metals / metalloids within the Alluvial Swamp Aquifer (ASA). This will enable further refinement of the potential acid generation risks and potential downstream effects.

2.3 Surface Water

An additional three surface water monitoring locations have been added to the MAP, with monitoring at one existing location expanded, for the following purposes:

- Monitoring requirements at location SGP2-B have been revised to include bi-annual water quality monitoring to provide greater understanding of the surface water conditions along Salt Creek Swampland given that there are no surface water quality monitoring locations between SV4 and SV2. This additional water quality monitoring location will also assist in understanding the drivers of the decline in water quality that occurs between these two existing monitoring locations.
- Additional monitoring sites AV4, AV5 and AV6 have been located along the Anglesea River to provide greater insight into the surface water quality and availability across the catchment. Additionally, AV4 has also been positioned to better assess the potential acid generation risks in the Anglesea River Swampland, which has high concentrations of Reduced Inorganic Sulfur and thus a high acid generation potential.

These locations are all designed to be co-located with other monitoring locations such as groundwater bores and ecological monitoring locations. This will enable a direct comparison of the measured

parameters and improve the rigour with which causative processes and risk outcomes can be linked (e.g. water availability and species abundance).

Analysis of metals / metalloids has also been added to the MAP to better understand the acid generation and mobilisation processes, and the potential flow on effects to the flora and fauna that rely on these surface water features.

2.4 Ecology

The monitoring activities undertaken to date have established a baseline of data with regard to conditions in the catchment. However, as the condition of these ecological receptors is influenced by a number of factors, especially climate, ecological monitoring alone does not provide data upon which risks can be interpreted. As such, based on the previous monitoring results and outcomes of the recent Bulk Entitlement Review, changes to the number of ecological monitoring locations along Anglesea River and Salt Creek have been undertaken to better target the identified potential high-risk areas, and co-locate monitoring sites with surface water or groundwater monitoring locations to support improved data interpretation. This includes:

- Inclusion of one (1) new (at existing surface water location SGP2-B), and one (1) historic (SCP15) vegetation monitoring location along Salt Creek to support an understanding of ecosystem conditions along this waterway.
- Inclusion of two (2) new ecological monitoring locations (AS2 and AS8) within the Upper Anglesea River to support an understanding of ecosystem conditions along this portion of the waterway.
- Inclusion of one (1) previous monitoring location within the Upper Anglesea River (AGP1).
- Inclusion of frog monitoring at existing ecological monitoring location UAR2.
- A reduction in the number of aquatic ecology and frog monitoring locations for the following reasons:
 - The monitoring locations on the Upper Anglesea River (UAR1), Breakfast Creek (BC) and Breakfast Creek Tributary (BCT) are outside of the identified risk areas and are not considered at risk of being impacted by Barwon Water's groundwater pumping activities on this basis. Therefore, no further ecological monitoring is considered necessary in these areas;
 - Reduced number of vegetation and frog survey locations on Anglesea River due to changes in the estimated areas of impact and a need to co-locate the Anglesea River monitoring locations with other elements of the MAP. This will support an improved ability to interpret data with regard to pumping and groundwater drawdown impacts; and
 - LAR2, LAR3 and LAR4, located within the Anglesea River Estuary, have been removed from the MAP as Barwon Water's groundwater pumping activities do not have a direct impact on the estuary. The risks to the estuary stem from secondary effects associated with changes in water availability and quality upstream. However, the most upstream vegetation monitoring location (LAR1) has been maintained to monitor the quality of the water and ecological response to water discharging from the catchment into the estuary. Annual macroinvertebrate and water quality monitoring and an additional vegetation transect has also been added to LAR1 to support improved data interpretation.
- The frequency of ecological monitoring has been adjusted to increase the frequency and make monitoring activities more consistent between pumping and non-pumping periods. This accounts for the forecast lag time for groundwater pumping impacts to migrate through to surface environments and will provide greater insight into the climatic influences and potential trends over time.

2.5 Land Level Surveying

The land level surveying program is largely consistent with the previous MAP (2014). However, the following minor changes have been made to the MAP:

- The survey points have been split to reflect which borefield they relate to (i.e. the southern or northern borefield); and

- The subsidence thresholds and triggers for further work have been clarified to remove the ambiguity in the previous wording and ensure this focuses on subsidence and not soil moisture variability.

3 Assessment Program

In addition to updating the routine monitoring requirements, the following additional work has been built into the MAP to address the uncertainties and data gaps outlined in the groundwater pumping impact assessment (BlueSphere, 2025) and BE review (BlueSphere, 2024b) and provide further information to assess ongoing risks associated with operation of the Anglesea Borefield.

3.1 Groundwater

3.1.1 Installation of Additional Groundwater Monitoring Bores in the Alluvial Swamp Aquifer

Two (2) additional Alluvial Swamp Aquifer (ASA) groundwater monitoring bores are planned to be installed under the revised MAP (one within the mid-section of Salt Creek Swampland and one within the Mid Anglesea River (Upstream)) to:

- Fill the data gap that currently exists within these two locations;
- Provide an understanding of the groundwater level and quality in these areas and help corroborate the groundwater-surface water interactions and acid generation risks; and
- Facilitate Acid Sulfate Soil sampling at both bore locations to enable an assessment of the interactions between soil and groundwater chemistry.

These two new ASA groundwater monitoring bores are intended to provide additional monitoring points within the potential risk areas identified as part of the 2024 BE review (BlueSphere, 2024) and provide greater insight into the groundwater-surface water interactions within the potential risk areas.

However, given the planned locations are within a National Park, the installation of these additional bores is dependent on the ability to obtain the relevant permits and/or approvals. An effort has been made to position these bores close to existing access tracks to minimise disturbance to the extent practicable.

3.1.2 Groundwater Bore Data Value Assessment

While all the data collected to date has been integral in the development of the Anglesea Groundwater Model, ongoing monitoring of a significant number of bores outside of the potential areas of impact may not be providing any further value. As such, a data value assessment has been built into the revised MAP to identify whether there is an opportunity to reduce the number of monitoring locations, whilst ensuring sufficient bores remain to facilitate future review and calibration of the groundwater model.

3.2 Acid Sulfate Soil Sampling and Analysis

Previously, acid sulfate soil (ASS) investigations were undertaken to a maximum depth of 1.4 m bgl at the Anglesea River, Anglesea River Swamplands and Salt Creek Swampland. The Upper Anglesea River Swamplands reported very high concentrations of reduced inorganic sulfur (RIS) at the vertical extent of the investigation, suggesting that the layer may extend to a greater depth.

Given the scenario forecast modelling work indicates that in the absence of suitable management controls drawdown could be greater than 1.4 m bgl, additional ASS sampling and analysis has been built in to the revised MAP to enable further refinement of the understanding of the potential acid generation risks.

3.2.1 Acid Sulfate Soil Sampling Locations

Given the potential risk areas are isolated to the use of individual borefields (i.e. the Northern or Southern borefield), the nature of these investigations is dependent on how each borefield will be used. The locations of interest for each borefield are provided in **Section 3.2.1.1** and **Section 0** below.

However, given the planned investigation locations are within a National Park, these investigations are dependent on the ability to obtain the relevant permits and/or approvals.

3.2.1.1 Northern Borefield

In the event that the northern borefield is to be utilised by Barwon Water, additional investigations within the potential risk areas outlined in Table 1 have been built into the revised MAP. Noting that the recommended investigation depth has been based on the outcomes of the Groundwater Pumping Impact Assessment (BlueSphere 2025).

Table 1 Northern borefield - ASS investigation areas

Investigation Area	Recommended Investigation Depth (m bgl)
Upper Anglesea River (Upstream)	7 (or base of ASA if shallower)
Mid Anglesea River (Upstream)	7 (or base of ASA if shallower)
Upper Anglesea River (Downstream)	9 (or base of ASA if shallower)
Mid Anglesea River (Midstream Trib East)	6 (or base of ASA if shallower)

3.2.1.2 Southern Borefield

Given Barwon Water preference the use of the Southern Borefield, and some uncertainty remains as to the amount of acid that could be released if groundwater levels fall below the maximum extent of previous investigations, additional ASS investigations within the potential risk areas outlined in Table 2 have been built into the revised MAP. Noting that the recommended investigation depth has been based on the outcomes of the Groundwater Pumping Impact Assessment (BlueSphere 2025).

Table 2 Southern borefield - ASS investigation areas

Investigation Area	Recommended Investigation Depth (m bgl)
Upper Salt Creek (Downstream Breakfast Creek2)	3 (or base of ASA if shallower)
Upper Salt Creek (Downstream Breakfast Creek1)	4 (or base of ASA if shallower)

3.2.2 ASS Analysis

ASS samples are to be collected and analysed in accordance with the requirements of the *National Acid Sulfate Soils guidance: National acid sulfate soils sampling and identification methods manual* (Sullivan *et al.* 2018a). Sampling should be conducted at 100 m intervals, subject to access from within the zones nominated above. Samples should be analysed for the following:

- pH_F (soil field pH), pH_{Fox} (soil pH following H₂O₂ oxidation);
- The Chromium Suite method;
- Sequential Metals and Metalloid Extraction for metal and metalloid mobility analysis; and
- Incubation tests, to assess the rates of acidification of the sulfidic soils and sediments.

The proposed analysis does not include Acid Volatile Sulfur (AVS) analysis as investigations undertaken by Wong *et al.* (2020) indicated low levels of monosulfides.

Sequential Metals and Metalloid Extraction is an accepted method for assessing the metal and metalloid mobilisation hazard in the *National Acid Sulfate Soils Guidance: National acid sulfate soils identification and laboratory methods manual* (Sullivan *et al.* 2018b). Incubation testing has been selected to assess the rate of soil acidification to remain consistent with testing undertaken by Sullivan *et al.* (2016).

It is expected that the additional ASS data collected will be able to be combined with the findings of the soil moisture investigation (**Section 3.3**), particularly capillary rise and rates of soil moisture decline following water level reductions, to provide greater insight into the following:

- Estimates of acid runoff from the swamplands; and
- Additional monitoring requirements and management options to mitigate or manage any risks of pumping-induced acid generation.

3.3 Soil Moisture Investigation

The installation of soil moisture probes has also been built into the revised MAP to provide an understanding of the linkage between no measurable water and retention of soil moisture. This will also consider factors such as capillary rise and retention of soil moisture following water level declines to overarching water availability. The proposed soil moisture probes have been located to target areas of greatest predicted drawdown (BlueSphere, 2025) and areas with elevated potential for acid generation:

- The greatest predicted drawdown occurs in the following ASA zones (BlueSphere, 2025):
 - Upper Anglesea River (Downstream);
 - Mid Anglesea River (Upstream);
 - Mid Anglesea River (Midstream Trib East);
 - Upper Salt Creek (Downstream Breakfast Creek2); and
 - Upper Salt Creek (Downstream Breakfast Creek1).
- The highest concentration of RIS occurs within the unsaturated zone at the following ASA zones and previous acid sulfate soil sampling locations (BlueSphere, 2024a and 2025):
 - Lower Salt Creek (Upstream1; STC15);
 - Mid Anglesea River (Midstream2; MSC9);
 - Mid Anglesea River (Downstream1; MSC26); and
 - Mid Anglesea River (Midstream Trib East; MSC14).

These soil moisture probes have also been positioned to allow co-location with other monitoring locations such as groundwater bores, surface water locations and ecological monitoring points.

It is intended for the soil moisture probes to be installed for a period of one year to allow for a full cycle of weather conditions.

However, given the planned investigation locations are within a National Park, these investigations are dependent on the ability to obtain the relevant permits and/or approvals.

3.4 Investigation Into the Use of Remote Sensing Techniques

Whilst a comprehensive monitoring and assessment program has been in place for over 10 years, the most recent Impact Assessment (BlueSphere, 2025) highlighted some data gaps that would benefit from an improved understanding of the linkage between groundwater levels, surface water availability and/or connectivity, and ecological condition in the broader environment (away from the main channels). Resolving these data gaps would help better quantify the potential risks, assess the adequacy of the monitoring network into the future, or potentially, identify new areas of interest.

Given the dense vegetation and access limitations along Anglesea River and Salt Creek, an investigation into the use of remote sensing techniques has been built into the revised MAP to:

- Identify permanent or largely-permanent standing water or pools, where populations of aquatic organisms may be found across seasons/years; and
- Identify the areas that are most reliant on groundwater-surface water interactions (e.g., use of aerial imagery and/or plant water stress metrics to identify the areas that remained 'healthy' during previous drought periods).

Ground truthing could then be undertaken to best inform the future monitoring requirements and target the communities that are most likely to be impacted by changes in groundwater-surface water interactions.

3.5 Implementation Timeline

As these additional investigations are subject to permits and/or approvals that can have lengthy turnaround times, or are intended to better quantify the potential risks associated with future groundwater extraction activities, the following schedule has been built into the revised MAP to allow the outcomes of these assessments to be considered as part of the next Bulk Entitlement Review.

Table 3 Implementation timeline

Item	Timeline
Installation of Additional Groundwater Monitoring Bores in the Alluvial Swamp Aquifer	As soon as practicable, pending relevant permits and/or approvals, to allow collection of data prior to next Bulk Entitlement Review (Due July 2030)
Groundwater Bore Data Value Assessment	Complete as part of next Bulk Entitlement Review (Due July 2030)
Acid Sulfate Soil Sampling and Analysis	Before next Bulk Entitlement Review (Due July 2030)
Soil Moisture Investigation	Before next Bulk Entitlement Review (Due July 2030)
Investigation Into the Use of Remote Sensing Techniques	Before next Bulk Entitlement Review (Due July 2030)

4 Closure

This document has been prepared for Barwon Water for the Anglesea Borefield. Should you have any questions please contact the undersigned.

Yours sincerely,

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The report has been prepared with the objectives and scope of work outlined in the proposal 1 September 2023. The work was carried out in accordance with the existing contract between BlueSphere and Barwon Water.

The conclusions and recommendations provided in this report are based on available information and it is possible that different conclusions and recommendations could be made should new information become available, or with changing site conditions over time. These opinions, conclusions and recommendations are subject to uncertainty given the potentially complex nature of any subsurface environment. Variation in soil and groundwater conditions may vary significantly between the specific sampling and testing locations and other locations at the site.

The report will not be updated if anything occurs after the date of this report and BlueSphere Environmental Pty Ltd will not be obliged to inform any person of any matter arising or coming to its attention after that date.

References:

BlueSphere Environmental, 2024, *Bulk Entitlement Review, Anglesea Borefield*, 31 October 2024

BlueSphere Environmental Pty Ltd, 2025, *Groundwater Pumping Impact Assessment, Anglesea Borefield Bulk Entitlement Review*, Doc No. 31313.01, dated 23 May 2025

Government of Victoria, 2014. *Water Act 1989: Bulk Entitlement (Anglesea Groundwater) Order 2009 Monitoring and Assessment Program*. Melbourne: State Government of Victoria.

Sullivan L.A., Reeves, J.M. & Trewarn, A., 2016. Investigation into the acid generation potential of soils at Coogoorah Park, Anglesea, Report commissioned for DELWP, Federation University Australia, Mt Helen, Victoria, Australia, Dated 30 June 2016.

Sullivan, L, Ward, N, Toppler, N and Lancaster, G. 2018a. National Acid Sulfate Soils guidance: National acid sulfate soils sampling and identification methods manual, Department of Agriculture and Water Resources, Canberra ACT. CC BY 4.0.

Sullivan, L, Ward, N, Toppler, N and Lancaster, G 2018b, National Acid Sulfate Soils Guidance: National acid sulfate soils identification and laboratory methods manual, Department of Agriculture and Water Resources, Canberra, ACT. CC BY 4.0. ('National ASS Laboratory Guidelines 2018')

Wong, V. N., Claff, S. R. & Driscoll, J., 2020. Anglesea Acid Sulfate Soil Investigation (Draft), Melbourne: School of Earth, Atmosphere and Environment, Monash University.