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Anglesea Borefield Ecological Monitoring and Assessment Program 2019

Prepared for: Barwon Water

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Ethics and Permits

All surveys were undertaken under the following ethics and research permits granted to Ecology Australia:

- Wildlife and Small Institutions Animal Ethics Committee (WSIAEC) projects 06.19 and 07.19;
- Fisheries Research Permit 1142;
- *Wildlife Act 1975*, *Flora and Fauna Guarantee Act 1988*, and *National Parks Act 1975* Research Permit 10007806; and
- Scientific Procedures Fieldwork Licence 20097.

Summary

Introduction

Under the *Bulk Entitlement (Anglesea Groundwater) 2009* (BE) (Victorian Government 2009), Barwon Water is permitted to extract water to supplement the water supply to Geelong and surrounding areas when required. The BE requires data to be collected to monitor the impacts of water drawdown under a Monitoring and Assessment Program (MAP) established in 2009. The MAP includes groundwater and surface water monitoring, acid sulfate investigations, land level surveying and aquatic and terrestrial ecological monitoring.

The MAP was last revised and updated in 2014 (Victorian Government 2014). The MAP currently requires monitoring of aquatic components (macroinvertebrates and fish) to be undertaken annually, and monitoring of terrestrial components (vegetation and frogs) to be undertaken biennially in the absence of groundwater pumping and annually during periods of groundwater extraction. With the exception of the second frog survey (December 2019), all sampling conducted for this report was completed prior to the operation of the borefield. Barwon Water made the decision to operate the Anglesea borefield to supplement urban water supplies in November 2019.

Ecology Australia was commissioned to undertake both the aquatic and terrestrial ecological monitoring in 2019 and has undertaken the terrestrial monitoring (vegetation and frogs) since 2009 and the aquatic ecology monitoring since 2017.

Methods

Vegetation monitoring was undertaken along six permanent transects in the Anglesea Swamp and four permanent transects in the Anglesea Estuary. The data collected included:

- Plant species lists;
- Ecological Vegetation Class (EVC);
- Plant Functional Group;
- Bare ground cover; and
- Water depth (in the swamp only).

Frog survey data was collected at eight sites in the Anglesea Swamp and four sites in the Anglesea Estuary and included:

- Species richness;
- Abundance;
- Water quality; and
- Habitat attributes.

Aquatic monitoring consisted of targeted survey for Southern Pygmy Perch at two sites, and macroinvertebrate sampling at three sites. Since the detection of Otway Bush Yabby *Geocharax tasmanicus* (formerly *G. gracilis*) in 2017, this species has been monitored opportunistically via the existing monitoring regime for fish and macroinvertebrates. Fish and macroinvertebrate monitoring included:

- Taxonomic diversity (macroinvertebrates);
- Abundance;
- Biometrics (fish);
- Water quality; and
- Habitat attributes.

Findings

Vegetation

Ecological Vegetation Classes, plant Functional Groups, plant species numbers and frequency remain largely unchanged in the Anglesea Swamp and Anglesea Estuary.

Standing water was again recorded at all sites in the swamp and algal mats were present at three sites and at one site in the estuary.

Bare ground cover has fluctuated in the Anglesea Swamp but is considered to be within the normal limits of seasonal variation.

Rainfall records indicate average annual rainfall has been highly variable since 2014.

Vehicle tracks were observed in the swamp at site ASP7_2014 and it is recommended that vehicle access be prevented in future to reduce substrate disturbance and vegetation damage.

Frogs

Frogs were not recorded at any of the Anglesea Swamp survey sites during either survey, although Southern Brown Tree Frogs *Litoria ewingii* and Southern Bullfrogs *Limnodynastes dumerilii* were heard calling at least 100 m away from several sites during the first survey. A single Southern Bullfrog was observed near one of the Anglesea Estuary sites during the second survey; otherwise no frogs were heard calling or observed at the estuary survey sites. However, frogs were heard calling at least 100 m from nine of the twelve survey sites, suggesting that they do occur in the broader area. The 2019 results are consistent with previous surveys, where low numbers and diversity of frogs have been recorded across the survey sites.

Southern Pygmy Perch

Southern Pygmy Perch were detected from one of the two monitoring sites, SC1, which is consistent with the results of the most recent survey. No recruitment was detected at site SC1, a spring sampling result that has not occurred previously. With two successive surveys failing to detect Southern Pygmy Perch at BCT1, it would be advisable to determine if there is a source population elsewhere in the Breakfast Creek catchment.

Macroinvertebrates

Macroinvertebrate community indices comparison against State Environment Protection Policy (SEPP)(Waters) objectives was consistent with previous years, with low abundance and diversity, but occasional samples meeting SIGNAL2 score objectives.

Otway Bush Yabby was again detected at BCT1 and SC1, and there was evidence of recent recruitment. This species has been consistently detected since 2017, and based on earlier reports, there is evidence of the species presence within the study area prior to 2017.

1 Introduction

Barwon Water is permitted to extract groundwater from the Anglesea Borefield, under the *Bulk Entitlement (Anglesea Groundwater) 2009* (BE), to supplement the water supply to Geelong and surrounding areas when required. Groundwater pumping under the BE is permitted as long as it does not adversely affect environmental values and ground water dependent ecosystems in the Jan Juc Groundwater Management Area.

The BE requires data to be collected to monitor the impacts of water drawdown. At the commencement of the BE a Monitoring and Assessment Program (MAP) was developed. The MAP includes groundwater and surface water monitoring, acid sulfate investigations, land-level surveying and aquatic and terrestrial ecological monitoring. The MAP has been revised and updated once, in September 2014.

Ecology Australia has undertaken the terrestrial (vegetation and frogs) monitoring component of the MAP since 2009 and the aquatic component (fish and macroinvertebrates) since 2017 (Ecology Australia 2009–2017).

The current MAP requires aquatic ecological monitoring to be undertaken annually, and terrestrial ecological monitoring to be undertaken biennially in the absence of ground water pumping and annually during periods of ground water extraction. With the exception of the second frog survey (undertaken in December 2019), all sampling conducted for this report was completed prior to the operation of the borefield. Barwon Water made the decision to operate the Anglesea borefield to supplement urban water supplies in November 2019. The terrestrial ecological monitoring was last undertaken in 2017 and was due again in 2019.

The 2019 ecological monitoring includes the Aquatic Ecology and Terrestrial Ecology components as detailed below.

1.1 Aquatic Ecology

The Aquatic Ecological monitoring component included spring monitoring of macroinvertebrates at three sites:

- Breakfast Creek tributary (BCT1);
- Salt Creek (SC1); and
- Lower Anglesea River wetland (Wetland 3).

Additionally, this component included spring sampling of Southern Pygmy Perch *Nannoperca australis* at two sites:

- Breakfast Creek tributary (BCT1); and
- Salt Creek (SC1).

1.2 Terrestrial Ecology

The Terrestrial Ecological monitoring component included spring monitoring of vegetation along established transects at six sites and frog monitoring at eight sites in the Anglesea Swamp (Figure 1):

- AS1_2014 (vegetation and frog monitoring);
- AS2 (vegetation and frog monitoring);

- AS3 (vegetation and frog monitoring);
- AS4 (vegetation and frog monitoring);
- AS5 (frog monitoring only);
- AS6 (frog monitoring only);
- ASP7_2014 (vegetation and frog monitoring); and
- AGP2_2014 (vegetation and frog monitoring).

Additionally, spring monitoring of vegetation along was undertaken at established transects at four sites and frog monitoring was undertaken at the same sites in the Anglesea Estuary (Figure 1):

- LAR1;
- LAR2;
- LAR3; and
- LAR4.

Vegetation data collection included: floristic species lists, Ecological Vegetation Classes (EVCs), plant Functional Groups, and other structural attributes (water depth, bare ground and algal mats).

The frog monitoring data collection included: species richness, abundance, water quality, and habitat attributes.

This report presents the monitoring methods and results, along with a discussion including a comparison of the 2019 data with annual data collected since the MAP review and update in 2014.

Figure 1 Anglesea Borefield ecological Monitoring and Assessment Program survey sites, 2019.

2 Methods

The aquatic and terrestrial ecology monitoring methods that are provided here follow the revised MAP requirements and remain unchanged since the last round of monitoring conducted in 2017 (Ecology Australia 2017). They are repeated in this report for ease of reference.

2.1 Vegetation

Field work was carried out in the last week of October 2019. Vegetation monitoring was conducted at the following sites in the Anglesea Swamp: AS1_2014, AS2, AS3, AS4, ASP7_2014 and, AGP2_2014 and the following sites in the Anglesea Estuary: LAR1, LAR2, LAR3, and LAR4.

2.1.1 Floristic composition

At each of the sites, plant species and Ecological Vegetation Classes (EVCs) following the Department of Environment, Land, Water and Planning (DELWP) benchmarks (DELWP 2019a) were recorded in sequential 1 m^2 quadrats located along established 100 m transects. The start and end of all transects are marked by steel pickets. The quadrats are located every second meter along the left hand side of the transect looking from start to end, with the first quadrat placed at 1–2 m, the second quadrat placed at 3–4 m and so on to 99–100 m.

There are 50 quadrats along each transect in the swamp, 15 quadrats along LAR2, LAR3 and LAR4 transects and 7 quadrats along LAR1 in the estuary.

Field staff walk the right hand side of the transect to avoid trampling vegetation within the quadrats.

Plant species were placed into respective plant Functional Groups (FGs) (see Table 1). The FGs and composition of EVCs were analysed to assess hydroecology (Section 2.1.2) and structure (Section 2.1.3).

2.1.2 Hydroecology

The FGs and EVCs were used to assess the degree of groundwater dependent vegetation across the swamp and estuary and the sensitivity of sites to groundwater drawdown.

FGs (Table 1) are based on the hydroecology (known or likely water requirements) of plant species, modified from Cassanova (2011) and Doeg et.al. (2012) as detailed in Ecology Australia (2013b).

FG data is presented in two forms for each of the sites:

- Frequency and FG of the three most dominant species along the transect; and
- Frequency of each broad FG along the transect.

2.1.3 Structural attributes

Vegetation structure was documented through the recorded EVCs, dominant plant species and photo points. Photo points are located at 0 m, 25 m, 50 m, and 75 m along each transect in the swamp and at the start of each transect in the estuary. Photos were taken looking toward the end of the transect.

2.1.4 Other attributes

Other transect attributes recorded were water depth (in the swamp only) and percentage cover of bare ground, rounded to the nearest 5%.

Water depth is a snap shot in time (one day of the year) and will vary considerably over time depending on rainfall. Hydroperiod is a fundamental driver of wetland condition (e.g. Foti et al. 2012).

Bare ground provides space for plant recruitment. This can provide an indication of potential change at a site, for example — are the extant FGs recruiting, or are conditions favouring the recruitment of drier or wetter groups?

In 2016, large amounts of 'algal mat' (consisting of filamentous algae) were observed in quadrats for the first time since the revised MAP monitoring commenced in 2014. The presence of an algal mat was noted again in 2019, with presence being recorded for each quadrat.

2.1.5 Wetland boundaries

Wetland boundaries in the Anglesea Swamp were confirmed as far as practicable by mapping the interface between Swamp Scrub and Aquatic Sedgeland using aerial imagery and ground-truthing. This mapping should detect significant boundary shifts in response to any longer term hydrological change.

Table 1 Anglesea Borefield, ecological Monitoring and Assessment Program, Plant Functional Groups (modified from Cassanova (2011) and Doeg et.al. (2012))

Functional group code	Definition	Example species	Broad category
Tdr	*Terrestrial dry.* This species group does not require flooding and will persist in damper parts of the landscape because of localised high rainfall. Species in this group can invade or persist in riparian zones and the edges of wetlands, but are essentially terrestrial.	Messmate, Brown Stringybark, Prickly Moses, Silver Banksia	Dry
Tda	*Terrestrial damp*. These species germinate and establish on saturated or damp ground, but cannot tolerate flooding in the vegetative state. They require the soil profile to remain damp for at least several months.	Swamp Gum, Variable Sword-sedge, Manuka , Slender Bog-sedge	
ATl	*Amphibious fluctuation tolerator - low-growing.* This species group can germinate either on saturated soil or under water and grow submerged, as long as they are exposed to air by the time they start to flower and set seed. They require or tolerate shallow flooding for approximately 3 months.	Austral Brookline, Swamp Club-sedge, Spotted Knotweed	Amphibious
ATe	*Amphibious fluctuation tolerator-emergent*. This species group consists of emergent monocots and dicots that survive in saturated soil or shallow water but require most of their photosynthetic parts to remain above the water (emergent). They tolerate fluctuations in the depth of water, as well as water presence. They need water or soil moisture to be present for 8-12 months of the year.	Tall Sedge, Red Fruit Saw-sedge, Pouched Coral-fern, Scrambling Coral-fern	
ATw	*Amphibious fluctuation tolerator- woody*. This species group consists of woody perennial species that may hold their fruits (and seeds) in the canopy and require water to be present in the root zone all year round, but will germinate in shallow water or on a drying substrate.	Woolly Tea-tree, Scented Paperbark	
ARp	*Amphibious fluctuation responder- plastic.* This species group occupies a similar zone to the ATI group, except that they have a morphological response to water level changes such as rapid shoot elongation or a change in leaf form. They can persist on damp and drying soil because of their morphological flexibility but can flower even if the site does not dry out. They occupy a slightly deeper/wet-for-longer site than the ATI group.	Creeping Cotula, Monkey Flower, River Buttercup	
Se	*Perennial-emergent.* This category refers to monocotyledonous species that require permanent water in the root zone, but remain emergent. They occur where water levels do not fluctuate or fluctuate with relatively little drawdown in the dry part of the year.	Cumbungi, Sea Rush, Southern Water-ribbons	Aquatic

2.2 Frogs

Zoologists undertook two repeat surveys for frogs at 12 sites, on 29–30 October (before operation of the borefield) and 9–10 December 2019 (after operation of the borefield):

- AS1_2014, AS2, AS3, AS4, AS5, AS6, ASP7_2014 and AGP2_2014 in the Anglesea Swamp; and
- LAR1, LAR2, LAR3 and LAR4 in the Anglesea Estuary (Figure 1).

Survey sites comprise the ten sites required by the MAP, as well as two additional sites (AS5 and AS6), which are surveyed in the event that very low frog activity is observed in the Anglesea Swamp.

2.2.1 Habitat assessment and water quality

To supplement the habitat data collected as part of vegetation monitoring, the following variables were recorded in relation to frog habitat:

- Wetland permanence (i.e. ephemeral, semi-permanent or permanent);
- Water quality parameters:
  - Temperature (° C);
  - pH;
  - Electrical Conductivity (EC);
  - Dissolved Oxygen (DO); and
  - Turbidity (NTU).
- A general habitat description, including levels of cover of fringing, emergent, submergent and floating vegetation where present.

Photos were also taken showing characteristic frog habitat at each survey site.

2.2.2 Frog surveys

Zoologists used both diurnal and nocturnal visual encounter surveys to detect frogs at the survey sites. Nocturnal surveys also included call playback and spotlighting. Weather conditions at the time of survey were recorded using a Kestrel weather meter. However, high rainfall, aseasonally low Spring temperatures, and high winds, resulted in the final frog sampling event being delayed until the site could be safely accessed and weather conditions were suitable in early Summer 2019.

Visual encounter surveys

Visual and aural encounter surveys were undertaken at each site during the diurnal habitat assessment and at the beginning of each nocturnal survey. Surveys comprised two zoologists listening for a period of approximately five minutes for the distinctive calls of male frogs. The species heard, and estimation of the number of frogs calling for each species, were recorded. In addition, zoologists looked for frogs at each site, by traversing the sites and scanning vegetation and the water surface for the presence of frogs. Visual encounter during nocturnal surveys was aided by the use of headtorches and/or hand-held spotlights, to look for the distinctive eye-shine of frogs.

Nocturnal call playback

Call playback was used after the nocturnal aural survey, to elicit calling by male frogs that were not calling independently onsite. This involved the broadcast of pre-recorded calls of each species through a speaker, followed by a period of quiet listening. Frog calls broadcast during call playback, based on previous records included:

- Southern Brown Tree Frog *Litoria ewingii*;
- Southern Bullfrog *Limnodynastes dumerilii*;
- Spotted Marsh Frog *Limnodynastes tasmaniensis*;
- Striped Marsh Frog *Limnodynastes peronii*;
- Common Spadefoot Toad *Neobatrachus sudellae*;
- Victorian Smooth Froglet *Geocrinia victoriana*; and
- Common Froglet *Crinia signifera*.

Call response data were used to estimate frog species richness and abundance within each site across the Anglesea Catchment and Estuary.

2.3 Aquatic ecology

2.3.1 Macroinvertebrate surveys

Macroinvertebrate surveys were undertaken at three sites on 29–30 October 2019. Site BCT1 was again relocated downstream to stream gauge SV3, consistent with previous years (Ecology Australia 2019) however for consistency it will be referred to as BCT1. Wetland 2 and Wetland 3 were combined into a single site, as they act as a single waterbody due to connectivity between the two sites, and as there was insufficient water in either one to collect three samples, but sufficient water once the two sites were combined.

As per the established methods (GHD 2016), triplicate edge samples were collected at each site where sufficient surface water was present following the methods outlined in the Victorian Rapid Bioassessment (RBA) Methodology for Rivers and Streams (EPA 2003). A 0.25 mm mesh net with a 30 cm x 30 cm opening was used to collect each sample. Edge ('sweep') samples were collected from water bodies with little to no flow. The sampling objective was to subsample all types of habitats present, which can include overhanging vegetation, coarse woody debris, backwaters, bare edges, leaf packs and macrophytes. Each sample consisted of 10 m of habitat, which was not necessarily contiguous. The water and habitat was agitated to dislodge macroinvertebrates and suspend them within the water column. Additional macroinvertebrates which were observed but not collected (e.g. fast moving) were noted on the sample label.

Samples were live-sorted ('picked') following the standard RBA procedures and preserved in 70% ethanol. In summary, the procedures entail:

- Picking for 30 minutes from a white tray, aiming to collect 200 animals from as many different taxa as possible;
- If less than 200 animals are collected within 30 minutes then picking continues for an additional 10 minutes;

- If 200 animals are collected within 40 minutes and no new taxa are detected, then picking ceases; otherwise picking continues for an additional 10 minutes. This continues until a maximum of 60 minutes of picking has been completed; and
- Avoidance of favouring large and abundant taxa over smaller, more cryptic taxa, by picking a maximum of approximately 30 of each taxa, with the exception of animals which may superficially appear to be the same but typically require microscopic examination to identify the additional taxa (e.g. taxa which are to be identified to a lower taxonomic resolution).

At each site, RBA field sampling and habitat assessment sheets were completed, including in situ water quality measurements using a calibrated U-52 Horiba water quality meter.

Upon detection of Otway Bush Yabby in 2017 it was requested by Mark Dodgshun of Barwon Water that this species be monitored concurrently with the effort that was being employed for fish and macroinvertebrates (Ecology Australia 2018).

Macroinvertebrate identification

Macroinvertebrates were identified and enumerated with a stereo microscope using keys outlined in MDFRC (2013), which provides an update on those outlined in Hawking (2000). The majority of taxa were identified to family level with the following exceptions as per the RBA protocols (EPA 2003):

- Chironomidae are identified to sub-family;
- Oligochaeta and Acarina are not identified below these taxonomic levels;
- Adult and larval beetles are listed separately;
- Taxa excluded from the recommended indices were discarded
- Specimens of the orders Ephemeroptera, Plecoptera, Trichoptera and Odonata were identified to genus level, as per GHD (2015–2017) and Ecology Australia (2018–2019).

2.3.2 Macroinvertebrate data analyses

Macroinvertebrate data were analysed both as individual samples, and on a site basis using the combined data from three samples. Where available, the results were compared against indices objectives outlined in State Environment Protection Policy – Waters (SEPP-W) (Victorian Government Gazette 2018).

The following indices were used to analyse macroinvertebrate data:

- Number of taxa — total number of taxa based on taxonomic resolution levels described above;
- Abundance — total number of individuals collected excluding those that were discarded (e.g. Collembolla, Staphlinidae beetles);

SIGNAL2 score — average SIGNAL score for taxa collected in each sample, based on methods of Chessman (2003).

- Table 2 provides the corresponding water quality categories;

- Number of EPT taxa — number of taxa from the orders of Ephemeroptera, Plecoptera and Trichoptera (EPT), which are considered more sensitive to pollution and disturbance and hence are considered an indicator of ecosystem health;
- Number of EPTO taxa — number of taxa from the orders of Ephemeroptera, Plecoptera, Trichoptera and Odonata (EPTO). This index is used for waterways in 'Mediterranean climate' regions, and aids in interpreting the health of lentic (still water) systems, where the numbers of Plecoptera are diminished while Odonata, which are also relatively sensitive to pollutants and disturbance, are more abundant and diverse (Pinto et al. 2004)

Table 2 SIGNAL score classifications (Chessman 1995)

SIGNAL score	Water quality
>7	Excellent
6-7	Clean water
5-6	Mild pollution
4-5	Moderate pollution
<4	Severe pollution

2.3.3 Fish surveys

Surveys targeting Southern Pygmy Perch *Nannoperca australis* were undertaken at two sites; SC1 and BCT1 on 29–30 October 2019. As with the macroinvertebrate surveys, site BCT1 was relocated downstream due to insufficient surface water (see section 3.3.1).

Ten bait traps (mesh size of 2 mm and funnel entrances of 4 cm) with 10 cm yellow glow sticks were set in the afternoon and retrieved the following morning at both sites. This is a modification of the methods used by GHD (2015–2017), where it is believed that five bait traps were set each year during surveys conducted from 2012–2016 (GHD 2013–2017), but is consistent with monitoring in recent years (Ecology Australia 2018–2019). The number of traps was increased to increase the likelihood of collecting 30 Southern Pygmy Perch per site.

The first 30 Southern Pygmy Perch were required to be measured (total length) to the nearest millimetre, and weighed to the nearest 0.1 gram. Subsequent Southern Pygmy Perch were also measured to increase the accuracy of population structure estimates. Additional taxa of interest detected in bait traps or observed at each site were recorded, with a particular focus on threatened crayfish Otway Bush Yabby *Geocharax tasmanicus* (formerly *G. gracilis*).

Instream habitat assessment was undertaken at all sites surveyed. The habitat assessment included notes on existing sources of disturbance, notes and estimates of biological and physical attributes (e.g. wetted instream cover, riparian shading, aquatic vegetation, substrate composition, flow and depth) and in situ water quality measurement. An outline of some of these habitat descriptors is provided below:

- The percentage cover of various forms of instream habitat (based on the proportion of the wetted area that they covered at the time of assessment).
- The shading estimate as per the EPA Rapid Bioassessment method (EPA 2003). This is an estimate based on a plan view as it would appear with the sun directly overhead (i.e. midday).
- The flow status estimate is as per the USEPA field sheets that are incorporated into the latest iteration of the Victorian EPA Rapid Bioassessment field sheets (Version: September 2012). This is an estimate based on the proportion of the channel filled and/or substrate exposed.
- The disturbance rating estimate is based on identification of a number of disturbance sources including levels of bank erosion, riparian vegetation clearance, parallel or adjacent roads, bridges/culverts/fords, rubbish, drain input, water extraction points, stock access, sedimentation, invasive exotic vegetation, barriers to fish passage, channelization and hydrological alterations; together with a severity rating (i.e. high, medium, low) applied to the disturbance sources that were identified at a given site.

Water quality measurements (dissolved oxygen (mg/L), pH, temperature (degrees Celsius), conductivity (mS/cm) and turbidity (NTU)) were made with a calibrated Horiba U-52 water quality meter.

2.4 Conservation status

Threatened species of State and/or National conservation significance were determined by reference to the Victorian Government Advisory Lists (DSE 2009, 2013, DEPI 2014) including listings under the Victorian *Flora and Fauna Guarantee Act 1988* (FFG Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

2.5 Nomenclature and taxonomy

The scientific names, common names and systematic orders of flora and fauna taxa follow the Victorian Biodiversity Atlas (DELWP 2019b). Common names are generally used for fauna in the text.

Where an asterisk (*) precedes a plant name it is used to signify non-indigenous taxa, those species which have been introduced to Victoria or Australia. A hash (#) is used to denote Victorian plant species that are not indigenous to the region or local area.

3 Results

Vegetation and frog monitoring were undertaken at the same sites (with two additional sites for frogs). Findings for each site are presented below followed by site summaries in Section 4.2.3.

The aquatic ecology monitoring was carried out at sites in different locations to the terrestrial monitoring sites and as such the site summaries are presented separately in Sections 4.3–4.7.

3.1 Vegetation

Site summaries displaying the results of the vegetation monitoring area provided in Figures 2, 4, 6, 8, 10, 12, 16, 18, 20 and 22.

3.1.1 Floristic composition

A total of 28 indigenous plant species was recorded across all sites in the Anglesea swamp (Appendix 1), while in the Anglesea estuary a total of 16 indigenous plant species, three exotic plant species and two native Victorian species not indigenous to the location were recorded (Appendix 2).

Native species richness at any one site ranged from 8–16 in the swamp and 8–13 in the estuary (Table 3).

Table 3 Anglesea Borefield ecological Monitoring and Assessment Program, number of native plant species recorded across monitoring sites and Functional Groups, October 2019.

Transect/Site	Total number of native plant species	Number of plant species in a dry Functional Group (Tdr, Tda)	Number of plant species in an Amphibious Functional Group (Ate, ATw, ARp)	Number of plant species in an Aquatic Functional Group (Se)
Anglesea Swamp				
AS2	15	9	4	2
AS3	10	2	7	1
AS4	16	4	9	3
ASP7_2014	15	3	10	2
AS1_2014	12	6	4	2
AGP2_2014	8	1	5	2
Anglesea Estuary				
LAR1	10	3	4	3
LAR2	9	3	4	2
LAR3	13	7	4	2
LAR4	8	3	3	2

No weeds were recorded in 2019 in the swamp and there was little sign of disturbance with the exception of site ASP7_2014 where there was evidence of vehicle access and obvious vegetation and substrate disturbance (Plates 1–2).

Plate 1 Site ASP7_2014, Anglesea Swamp, evidence of vehicle access, October 2019.

Plate 2 Site ASP7_2014, Anglesea Swamp, evidence of vehicle access, October 2019.

The vegetation in the estuary remains relatively healthy. Although non-indigenous plants were recorded in all transects, there were comparatively greater numbers of native species in each transect (Appendix 2), and indigenous plants were recorded more frequently than weeds in all transects (Figures 16, 18, 20 and 22).

3.1.2 Hydroecology

In the Anglesea swamp five FGs were represented (Tda, Tdr, Se, Ate and ATw) (Table 3). No plants from the ATI or ARp FG's were recorded. Plants from five FG's were also recorded in the Anglesea estuary (Tda, Tdr, Se, Ate and ARp) and no plants from the ATI or ATw FGs were recorded (Table 3).

3.1.3 Structural attributes

Three EVCs recorded in the swamp in 2019 were: Swamp Scrub, representing an open to closed shrubland to 4 m high, Aquatic Sedgeland, characterised by a variably dense cover of sedges to 1.3 m, and Heathy Woodland generally bordering the swamp which has a eucalypt canopy over a shrubby understory. The wetland vegetation was dominated by plants in the Amphibious and Aquatic FGs (Figures 2, 4, 6, 8, 10 and 12).

In the estuary two EVCs were recorded: Swampy Riparian Woodland which consisted of a low open eucalypt canopy to 8 m tall with an understory of scattered woody shrubs and small herbs, and Estuarine Wetland consisting of a dense cover of reeds and rushes to 1 m, with scattered tussock grasses and small herbs. The wetland vegetation was dominated by plants in the Amphibious and Aquatic FGs (Figures 16, 18, 20 and 22).

3.1.4 Other attributes

Water was present at all six sites in the swamp and the average depth ranged from 1–22 cm (Figures 2, 4, 6, 8, 10 and 12).

Bare ground was recorded at one site in the swamp (AGP2_2014) in 2019 and included a 5% cover in two quadrats (an average of 0.2%) (Figures 2, 4, 6, 8, 10 and 12). No bare ground was recorded within the estuary transects (Figures 16, 18, 20 and 22).

Algal mat was recorded at three sites in the swamp and the number of quadrats it was recorded in ranged from 1 (ASP7_2014) to 44 (AS1_2014) (Figures 2, 4, 6, 8, 10 and 12). Algal mat was recorded in one quadrat at one site in the estuary (LAR1).

3.1.5 Wetland boundaries

No changes were observed in the wetland boundaries between the Aquatic Sedgeland and the Swamp Scrub, or between these two EVCs and the adjoining Heathy Woodland (Figures 24–25).

3.2 Frogs

3.2.1 Survey conditions

During the first round of frog surveys on 29–30 October 2019, three of the eight Anglesea Swamp monitoring sites had open standing water and three had very shallow pools. By the second survey, four sites in the swamp had very shallow standing water in small pools, with water levels sufficient to

measure water quality only present at two sites. Water levels were similar to those observed in previous years.

The second frog survey was delayed until early December, due to inclement weather, including low temperatures that are outside the prescribed survey methodology for frog detection, in addition to high rainfall and winds, which presented potential safety issues associated with site access. Conditions during both frog surveys were suitable for detecting frogs, with low wind, moderate temperatures, relatively high humidity and rain falling during the second survey (Table 4).

Table 4 Weather conditions during frog surveys, Anglesea revised ecological Monitoring and Assessment Program, 2019.

Variable	Survey 1	Survey 2
Temperature (°C)	10.5–18.7	12–17
Humidity (%)	61.3–88.1	69.4–80.4
Cloud cover (0–8)	0–6	1–8
Moon light (0–4)	0–1	0–4
Wind speed (0–3)	0–1	0–1
Rainfall during survey (0–3)	0	0–2
Rain in past 24 hours (None–heavy)	None	Low

3.2.2 Frog species richness and abundance

Anglesea Swamp

No frogs were detected at long-term survey points during either survey at the Anglesea Swamp. During the first survey, Southern Brown Tree Frogs were heard calling from near two sites, at least 100 m away, and Southern Bullfrogs were heard near four sites (Table 5). Both species were heard calling near AS3, on Harrison Track North. A maximum of five individuals of each species were heard calling near the survey sites.

Anglesea Estuary

No frogs were heard calling at long-term survey points during either survey at the Anglesea Estuary. One Southern Bullfrog was observed beside a walking track near LAR3 during the second survey (Plate 3). Frogs were heard calling at least 100 m from each of the survey sites during the first survey, and at least 100 m from LAR2 and LAR4 during the second survey (Table 5). Larger numbers of frogs, between 12 and 20, were heard calling in the estuary.

Table 5 Anglesea Borefield revised ecological Monitoring and Assessment Program, frog species detected during surveys and estimated abundances, 2019. The number of frogs heard calling at least 100 m from the survey sites are listed in parentheses.

Site	Southern Brown Tree Frog		Southern Bullfrog		Species Richness
	1	2	1	2	
Anglesea Swamp					
AS2	0	0	0 (1)	0	0
AS3	0 (1–5)	0	0 (1–5)	0	0
AS4	0	0	0	0	0
AS5	0	0	0	0	0
ASP7_2014	0	0	0 (1–5)	0	0
AS1_2014	0	0	0 (1)	0	0
AS6	0	0	0	0	0
AGP2_2014	0 (1–5)	0	0	0	0
Anglesea Estuary					
LAR1	0 (1–5)	0	0	0	0
LAR2	0 (6–10)	0	0 (6–10)	0	0
LAR3	0 (1–5)	0	0	1	1
LAR4	0 (6–10)	0	0 (6–10)	0	0

Plate 3 Southern Bullfrog *Limnodynastes dumerilii* observed beside a walking track at the Anglesea Estuary, near LAR3. Photo: Brett Goodman.

3.2.3 Habitat assessment and water quality

Anglesea Swamp

The Anglesea Swamp monitoring sites mostly support dense shrub cover of Scented Paperbark *Melaleuca squarrosa* and Prickly Teatree *Leptospermum continentale*, which opens up into clearings of emergent aquatic vegetation, largely sedges such as Zig-zag Bog-sedge *Schoenus brevifolius*, Square Twig-sedge *Baumea tetragona* and Fine Twig-sedge *B. arthrophylla.* Swards of dead and live sedges occasionally form thick mats across the site. Fringing vegetation sometimes includes shorter Pink Swamp-heath *Sprengelia incarnata* or Pouched Coral-fern *Gleichenia dicarpa*. Where monitoring sites support standing water, Southern Water-ribbons *Cycnogeton alcockiae* and filamentous algae may be present as submergent and floating vegetation. Some sites also include small patches of bare ground and low cover of woody debris, especially at the interface between emergent and fringing vegetation.

All monitoring sites are considered intermittent except for AS3 (semi-permanent) and AS4 (semi-permanent to permanent). Five sites had sufficient standing water to allow at least some water quality parameters to be measured during the first survey, declining to two sites by the second survey. AS4, AS5 and AS6 had no standing water in either survey and water quality could not be measured. Most sites were acidic (pH of 2.56–3.83) and electric conductivity was moderate, ranging from 801 to 4,540 µs/cm, with all but one measurement above 1,000 µs/cm. Water temperatures were relatively high, with all but two measurements above 15 °C (range: 11.7–26.7 °C). Turbidity and dissolved oxygen could not be measured at some sites due to low water levels. Where measurements were possible, dissolved oxygen levels were variable (range: 1.25–7.5 mg/L) and turbidity was relatively low, with all but one reading below 11 NTU (range: 2–131 NTU).

Anglesea Estuary

The Anglesea Estuary is relatively deep, with slow-moving water. Apart from filamentous algae, cover of aquatic vegetation was generally low, particularly cover of floating and submergent vegetation. Common Reed *Phragmites australis* provides sparse emergent vegetation at most sites. Fringing vegetation occurs at higher levels of cover, dominated by grasses, sedges, rushes and herbs including Coast Tussock-grass, *Poa poiformis* var. *poiformis*, Common Blown-grass *Lachnagrosits filiformis*, Sea Rush *Juncus kraussii* ssp. *australiensis* and Shiny Swamp-mat *Selliera radicans*. LAR1 also supports Narrow-leaf Cumbungi *Typha domingensis* and Southern Water-ribbons. Scattered shrubs of Hop Goodenia *Goodenia ovata* and Manuka *Leptospermum scoparium* and stands of Swamp Gum *Eucalyptus ovata* var. *ovata* were recorded near the water's edge.

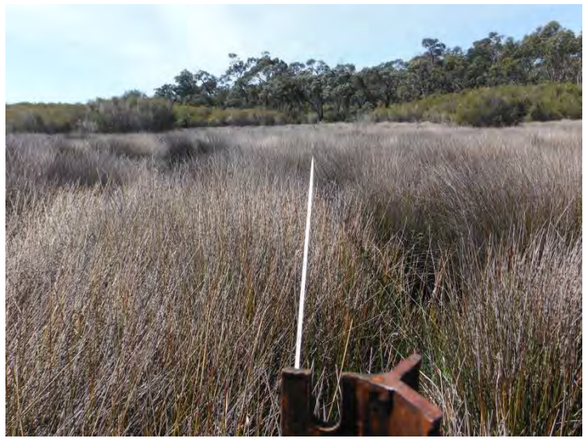
All estuary monitoring sites are considered permanent, with stream widths ranging from 2–3 m to approximately 9 m wide, and up to 2 m deep. Water quality could be measured at all sites, and values were consistent between sites within surveys, compared to measurements taken in the Anglesea Swamp. All sites had very low pH (3.32–3.94), and water temperature was generally around 20 °C, apart from cooler readings at LAR1 in the first survey (15.2 °C). Electrical conductivity readings were moderately high, particularly in the second survey, with slightly lower recordings obtained at LAR1, further upstream. Conductivity jumped from a mean of 8,328 µs/cm in the first survey, to 14,275 µs/cm in the second survey. Turbidity was low (0–11 NTU) and dissolved oxygen concentrations varied from 4.82 to 9.54 mg/L.

3.2.4 Vegetation and frog site summaries

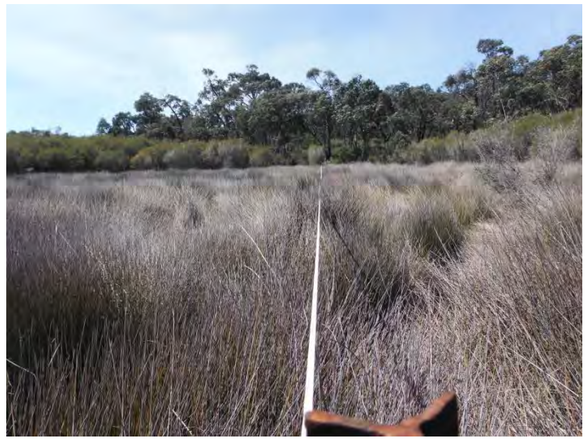
The following site summaries include:

- transect photos at 25 m intervals;
- the proportion of each EVC and each FG recorded at each site;
- the top three dominant plant species and their FG;
- other attributes including average bare ground cover, water depth and algal mat;
- a habitat description;
- frog species occurrence and abundance;
- water quality data; and
- relevant comments.

0—25m



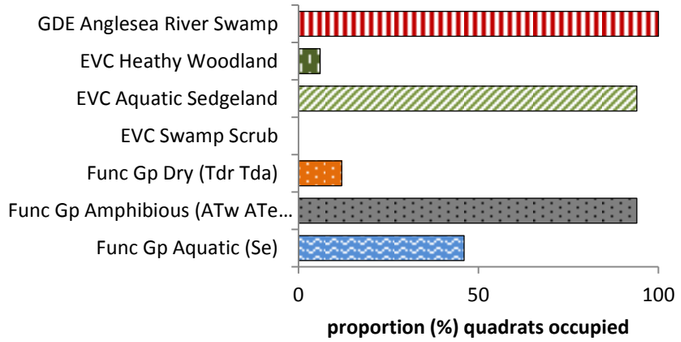
25—50m



50—75m

75—100m

Proportion of ECVs and broad FGs, Site AS2



Dominant Plant Species		Broad FG	Quadrats occupied (% frequency)
Schoenus brevifolius	Zig-zag Bog-sedge	Amphibious	86
Baumea tetragona	Square Twig-sedge	Aquatic	26
Cycnogeton alcockiae	Southern Water-ribbons	Aquatic	26

Other attributes		
Average % bare ground cover	0	(bare ground recorded in 0 quadrats)
Average water depth along transect (cm)	5	Water recorded in 36 quadrats
Algal mat (quadrats occupied)	0	

Key:

GDE: Groundwater Dependent Ecosystem

EVC: Ecological Vegetation Class

FG: Functional Group

Figure 2 Anglesea Borefield Monitoring and Assessment Program, Anglesea Swamp, Site AS2, vegetation summary data, 2019.

AS2: General habitat description	
Ecological Vegetation Class (EVC)	Aquatic Sedgeland
Wetland permanence	Ephemeral
Swamp dominated by emergent dead and live sedges, interspersed with patches of clear open water at varying depth up to c. 15 cm. Open water contains 10–20% floating and submergent vegetation, as well as floating debris. The swamp is fringed with 70–100% shrub vegetation and small amounts of bare wet soil. Macropod and predator scats noted at the swamp.	

AS2: Frog abundance and richness			
Southern Brown Tree Frog	**Common Froglet**	**Southern Bullfrog**	**Species Richness**
0	0	0	0

AS2: Water quality parameters					
Survey 1					
pH	3.57	**Turbidity**	4 NTU	**Water temperature**	14.6 °C
EC	3190 µs/cm	**Salinity**	0.16%	**Dissolved Oxygen**	1.25 mg/L
Survey 2					
pH	NA	**Turbidity**	NA	**Water temperature**	NA
EC	NA	**Salinity**	NA	**Dissolved Oxygen**	NA

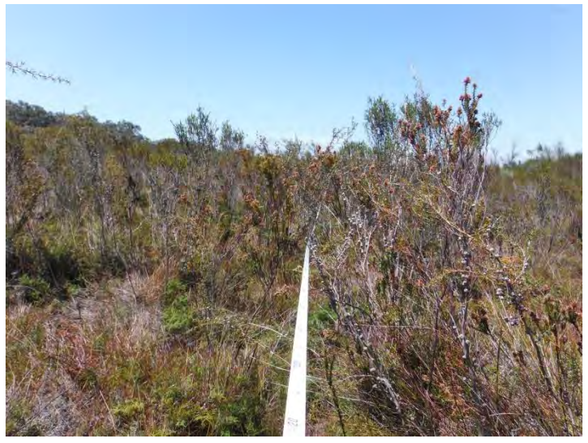
Comments
Patches of open water had dried out at the time of the second survey but were still moist underfoot. One Southern Bullfrog calling at least 100 m from observers.

Figure 3 Anglesea Borefield terrestrial revised ecological Monitoring and Assessment Program, Anglesea Swamp site AS2, 2019 frog summary data.

0—25m

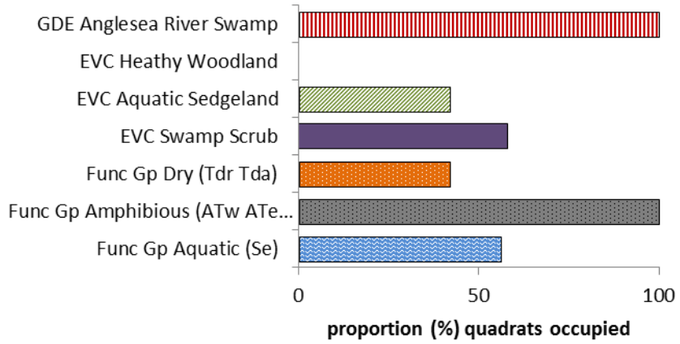
25—50m

50—75m



75—100m

Proportion of EVCs and FGs, Site AS3



Dominant Plant Species	Broad FG	Quadrats occupied (% frequency)
Melaleuca squarrosa	Scented Paperbark	Amphibious	66
Schoenus brevifolius	Zig-zag Bog-sedge	Amphibious	64
Baumea tetragona	Square Twig-sedge	Aquatic	56
Sprengalia incarnata	Pink Swamp-heath	Amphibious	56

Other attributes		
Average % bare ground cover	0	(bare ground recorded in 0 quadrats)
Average water depth along transect (cm)	1	Water recorded in 25 quadrats
Algal mat (quadrats occupied)	0	

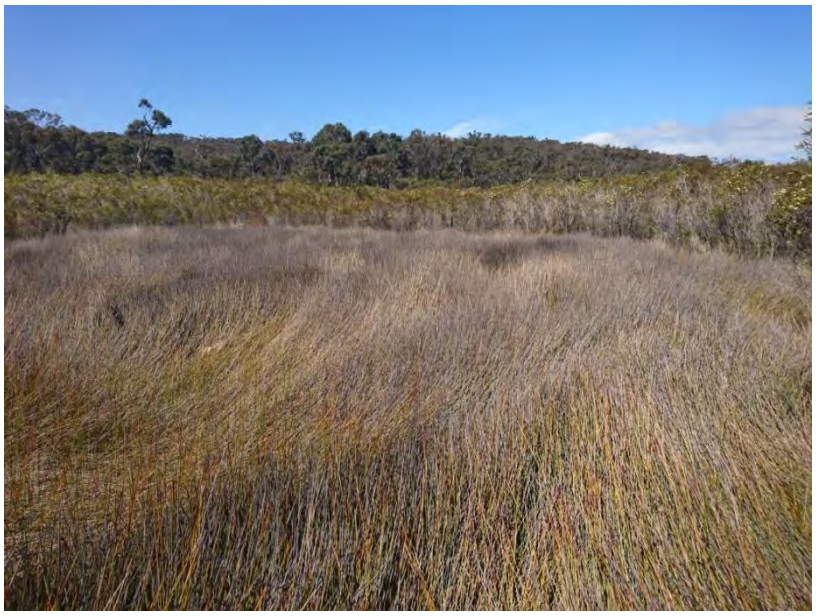
Key:

GDE: Groundwater Dependent Ecosystem

EVC: Ecological Vegetation Class

FG: Functional Group

Figure 4 Anglesea Borefield Monitoring and Assessment Program, Anglesea Swamp, Site AS3, vegetation summary data, 2019.



AS3: General habitat description	
Ecological Vegetation Class (EVC)	Swamp Scrub
Wetland permanence	Semi-permanent
Small (c. 0.25 ha) clearing in shrub vegetation (Swamp Paperbark, Prickly Tea-tree and Pink Swamp-heath) with c. 100% cover of emergent dead and live sedges and small amounts of Pouched Coral-fern. Less than 5% cover of fallen branches was observed under fringing vegetation. Pools of standing water up to 15 cm deep during the first survey had dried out by the second survey. Shallow water up to 4 cm deep was present in the swamp in the second survey, but no pools.	

AS3: Frog abundance and richness			
Southern Brown Tree Frog	**Common Froglet**	**Southern Bullfrog**	**Species Richness**
0	0	0	0

AS3: Water quality parameters					
Survey 1					
pH	3.43	**Turbidity**	131 NTU	**Water temperature**	11.7 °C
EC	801 µs/cm	**Salinity**	0.03%	**Dissolved Oxygen**	NA
Survey 2					
pH	3.83	**Turbidity**	8 NTU	**Water temperature**	17.8 °C
EC	1440 µs/cm	**Salinity**	0.06%	**Dissolved Oxygen**	NA

Comments
Southern Brown Tree Frogs (1–5 individuals) and Southern Bullfrogs (1–5 individuals) calling at least 100 m from observers.

Figure 5 Anglesea Borefield terrestrial revised ecological Monitoring and Assessment Program, Anglesea Swamp site AS3, 2019 frog summary data.

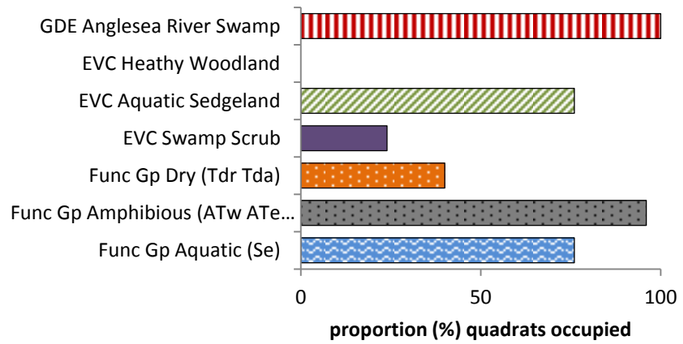
0—25m

25—50m

50—75m

75—100m

Proportion of EVCs and FGs, Site AS4



Dominant Plant Species		Broad FG	Quadrats occupied (% frequency)
Melaleuca squarrosa	Scented Paperbark	Amphibious	92
Cycnogeton procerum sp. aff.	Common Water-ribbons	Aquatic	76
Empodisma minus	Spreading Rope-rush	Amphibious	72

Other attributes		
Average % bare ground cover	0	(bare ground recorded in 0 quadrats)
Average water depth along transect (cm)	2	Water recorded in 30 quadrats
Algal mat (quadrats occupied)	0	

Key:

GDE: Groundwater Dependent Ecosystem

EVC: Ecological Vegetation Class

FG: Functional Group

Figure 6 Anglesea Borefield Monitoring and Assessment Program, Anglesea Swamp, Site AS4, vegetation summary data, 2019.

AS4: General habitat description	
Ecological Vegetation Class (EVC)	Aquatic Sedgeland
Wetland permanence	Semi-permanent
Survey site located on the perimeter of the swamp in fringing vegetation. Soil was dry and solid underfoot during both surveys. Thick ground cover of Pouched Coral-fern to c. 1 m, with emergent Pink Swamp-heath and Scented Paperbark. Less than 10% cover of fallen branches, and small (5–10%) amounts of bare ground. Macropod scats observed.	

AS4: Frog abundance and richness			
Southern Brown Tree Frog	**Common Froglet**	**Southern Bullfrog**	**Species Richness**
0	0	0	0

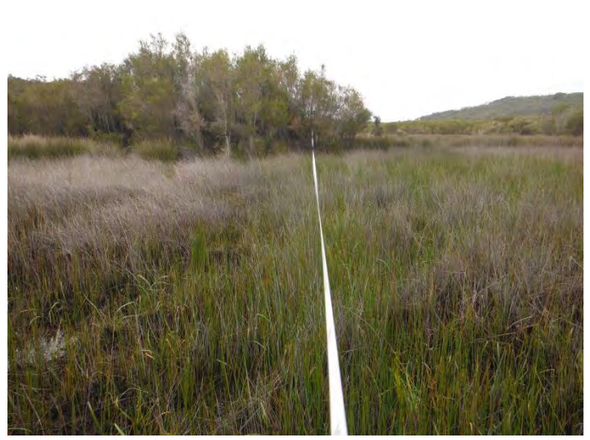
AS4: Water quality parameters					
Survey 1					
pH	NA	**Turbidity**	NA	**Water temperature**	NA
EC	NA	**Salinity**	NA	**Dissolved Oxygen**	NA
Survey 2					
pH	NA	**Turbidity**	NA	**Water temperature**	NA
EC	NA	**Salinity**	NA	**Dissolved Oxygen**	NA

Comments
No water quality measurements could be taken given the lack of water at the survey site.

Figure 7 Anglesea Borefield terrestrial revised ecological Monitoring and Assessment Program, Anglesea Swamp site AS4, 2019 frog summary data.

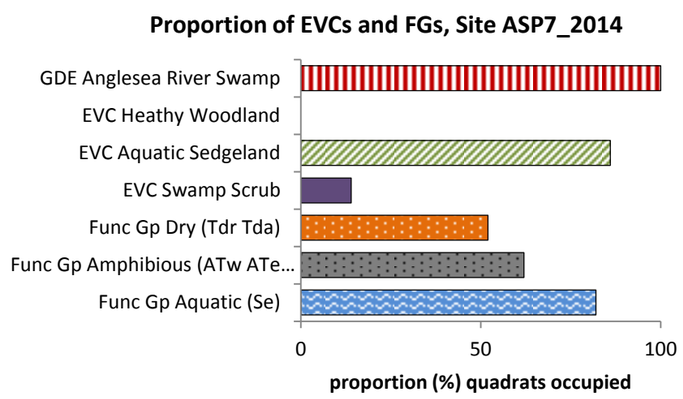
0—25m

25—50m



50—75m

75—100m



Dominant Plant Species		Broad FG	Quadrats occupied (% frequency)
Cycnogeton procerum sp. aff.	Common Water-ribbons	Aquatic	76
Baumea arthrophylla	Fine Twig-sedge	Aquatic	72
Schoenus brevifolius	Zig-zag Bog-sedge	Amphibious	58

Other attributes		
Average % bare ground cover	0	(bare ground recorded in 0 quadrats)
Average water depth along transect (cm)	1	Water recorded in 16 quadrats
Algal mat (quadrats occupied)	1	

Key:

GDE: Groundwater Dependent Ecosystem

EVC: Ecological Vegetation Class

FG: Functional Group

Figure 8 Anglesea Borefield Monitoring and Assessment Program, Anglesea Swamp, Site ASP7_2014, vegetation summary data, 2019.

ASP7_2014: General habitat description	
Ecological Vegetation Class (EVC)	Aquatic Sedgeland
Wetland permanence	Ephemeral
Relatively large (c. 3 ha) clearing in the swamp, comprising c. 90% emergent sedges, fringed with c. 90% cover of mostly Scented Paperbark. At time of second survey, the swamp was mostly dry, with only small pools of up to 5–10 cm deep water remaining. The surface of the swamp was damp and covered in dead and decomposing vegetation. Vehicles had been accessing the site, leaving visible disturbance in the form of numerous tyre tracks.	

ASP7_2014: Frog abundance and richness			
Southern Brown Tree Frog	**Common Froglet**	**Southern Bullfrog**	**Species Richness**
0	0	0	0

ASP7_2014: Water quality parameters					
Survey 1					
pH	2.6	**Turbidity**	11 NTU	**Water temperature**	21.7 °C
EC	3400 µs/cm	**Salinity**	0.17%	**Dissolved Oxygen**	NA
Survey 2					
pH	3.34	**Turbidity**	NA	**Water temperature**	26.7 °C
EC	2280 µs/cm	**Salinity**	0.11%	**Dissolved Oxygen**	NA

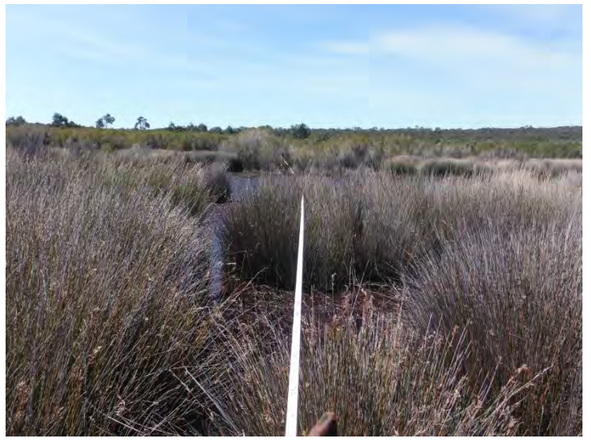
Comments
Pools of up to 20 cm depth were present during the first survey, but water too shallow for turbidity or dissolved oxygen measurements during the second survey. Southern Bullfrog (1–5 individuals) heard calling at least 100 m from observers.

Figure 9 Anglesea Borefield terrestrial revised ecological Monitoring and Assessment Program, Anglesea Swamp site ASP7_2014, 2019 frog summary data.

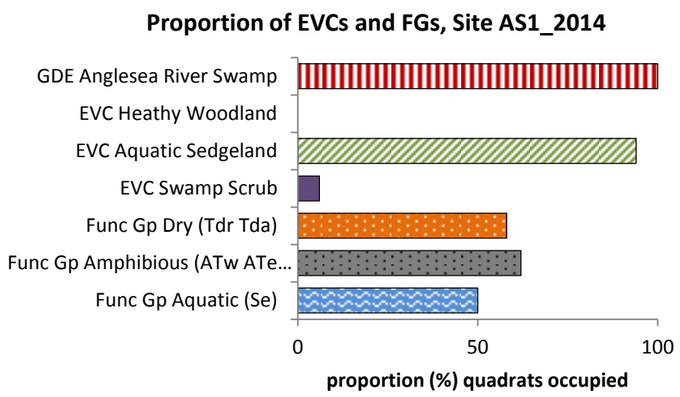
0—25m

25—50m

50—75m



75—100m



Dominant Plant Species		Broad FG	Quadrats occupied (% frequency)
Cycnogeton procerum sp. aff.	Common Water-ribbons	Aquatic	50
Baumea arthrophylla	Fine Twig-sedge	Aquatic	50
Schoenus brevifolius	Zig-zag Bog-sedge	Amphibious	48

Other attributes		
Average % bare ground cover	0	(bare ground recorded in 0 quadrats)
Average water depth along transect (cm)	9	Water recorded in 46 quadrats
Algal mat (quadrats occupied)	44	

Key:

GDE: Groundwater Dependent Ecosystem

EVC: Ecological Vegetation Class

FG: Functional Group

Figure 10 Anglesea Borefield Monitoring and Assessment Program, Anglesea Swamp, Site AS1_2014, vegetation summary data, 2019.

AS1_2014: General habitat description	
Ecological Vegetation Class (EVC)	Aquatic Sedgeland
Wetland permanence	Ephemeral
Mostly open swamp almost completely fringed with Scented Paperbark and Prickly Tea-tree. During the first survey, the swamp supported up to 10 cm of water, containing 70–100% cover of floating red filamentous algae, which had dried to a black crust in drier areas. Some emergent rushes (20–50%) occurred in patches through the swamp, with sporadic submergent cover of Common Water-ribbons (c. 5%). Small amounts of bare soil and dead branches were observed around the edges of the swamp. Some wallaby tracks and scats were also observed.	

AS1_2014: Frog abundance and richness			
Southern Brown Tree Frog	**Common Froglet**	**Southern Bullfrog**	**Species Richness**
0	0	0	0

AS1_2014: Water quality parameters					
Survey 1					
pH	8.1	**Turbidity**	8 NTU	**Water temperature**	23.7 °C
EC	4540 µs/cm	**Salinity**	0.23%	**Dissolved Oxygen**	7.5 mg/L
Survey 2					
pH	NA	**Turbidity**	NA	**Water temperature**	NA
EC	NA	**Salinity**	NA	**Dissolved Oxygen**	NA

Comments
AS1_2014 did not support standing water at the time of the second survey. The swamp surface was soft and wet underfoot. One Southern Bullfrog was calling very infrequently during the first survey, at least 100 m from observers.

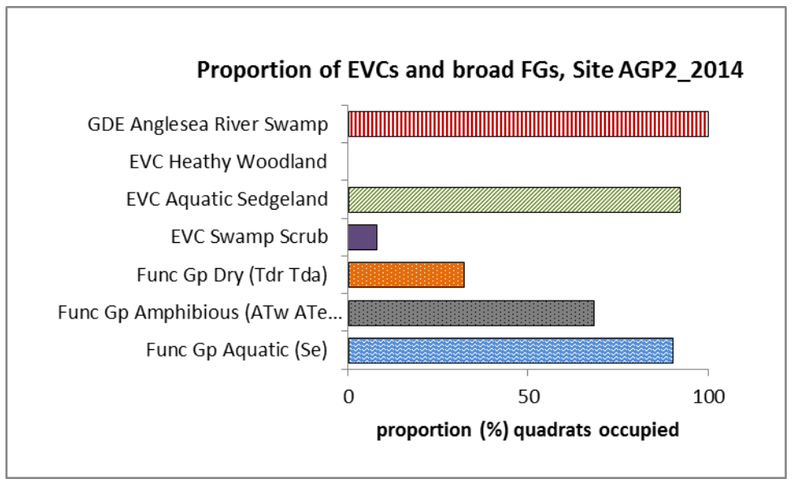
Figure 11 Anglesea Borefield terrestrial revised ecological Monitoring and Assessment Program, Anglesea Swamp site AS1_2014, 2019 frog summary data.

0—25m

25—50m

50—75m

75—100m



Dominant Plant Species		Broad FG	Quadrats occupied (% frequency)
Cycnogeton procerum sp. aff.	Common Water-ribbons	Aquatic	90
Juncus procerus	Tall Rush	Amphibious	62
Melaleuca squarrosa	Scented Paperbark	Amphibious	56

Other attributes		
Average % bare ground cover	0	(bare ground recorded in 0 quadrats)
Average water depth along transect (cm)	0.2	Water recorded in 48 quadrats
Algal mat (quadrats occupied)	32	

Key:

GDE: Groundwater Dependent Ecosystem

EVC: Ecological Vegetation Class

FG: Functional Group

Figure 12 Anglesea Borefield Monitoring and Assessment Program, Anglesea Swamp, Site AGP2_2014, vegetation summary data, 2019.

AGP2_2014: General habitat description	
Ecological Vegetation Class (EVC)	Aquatic Sedgeland
Wetland permanence	Ephemeral
Small (c. 0.25 ha) clearing in tall (up to 4 m) fringing vegetation of Scented Paperbark and Prickly Tea-tree. Approximately 40% open water with c. 20–50% cover of floating Common Water-ribbons, interspersed with emergent rushes and patches of Scented Paperbark. Water at time of first survey was clear, with decomposing Water-ribbons, leaves and woody debris present. Pools up to 20 cm at time of first survey had dried out to less than 5 cm at time of second survey.	

AGP2_2014: Frog abundance and richness			
Southern Brown Tree Frog	**Common Froglet**	**Southern Bullfrog**	**Species Richness**
0	0	0	0

AGP2_2014: Water quality parameters					
Survey 1					
pH	2.84	**Turbidity**	2 NTU	**Water temperature**	20.1 °C
EC	4010 µs/cm	**Salinity**	0.2%	**Dissolved Oxygen**	6.8 mg/L
Survey 2					
pH	NA	**Turbidity**	NA	**Water temperature**	NA
EC	NA	**Salinity**	NA	**Dissolved Oxygen**	NA

Comments
Insufficient water was present for water quality measurements during second survey. Southern Brown Tree Frogs (1–5 individuals) were calling during the first survey, at least 100 m from observers, towards the south-east.

Figure 13 Anglesea Borefield terrestrial revised ecological Monitoring and Assessment Program, Anglesea Swamp site AGP2_2014, 2019 frog summary data.

AS5: General habitat description	
Ecological Vegetation Class (EVC)	Aquatic Sedgeland
Wetland permanence	Ephemeral
Dry swamp, less than 0.25 ha in size, with complete cover of vegetation, comprising sedges and Pouched Coral-fern, surrounded by 100% cover of fringing Prickly Tea-tree and Scented Paperbark. Swamp dry underfoot, with thick cover of dead sedges and 5–10% cover of fallen branches around the perimeter of the swamp.	

AS5: Frog abundance and richness			
Southern Brown Tree Frog	**Common Froglet**	**Southern Bullfrog**	**Species Richness**
0	0	0	0

AS5: Water quality parameters					
Survey 1					
pH	NA	**Turbidity**	NA	**Water temperature**	NA
EC	NA	**Salinity**	NA	**Dissolved Oxygen**	NA
Survey 2					
pH	NA	**Turbidity**	NA	**Water temperature**	NA
EC	NA	**Salinity**	NA	**Dissolved Oxygen**	NA

Comments
The swamp was dry during both surveys; hence no water quality measurements were taken.

Figure 14 Anglesea Borefield terrestrial revised ecological Monitoring and Assessment Program, Anglesea Swamp site AS5, 2019 frog summary data.

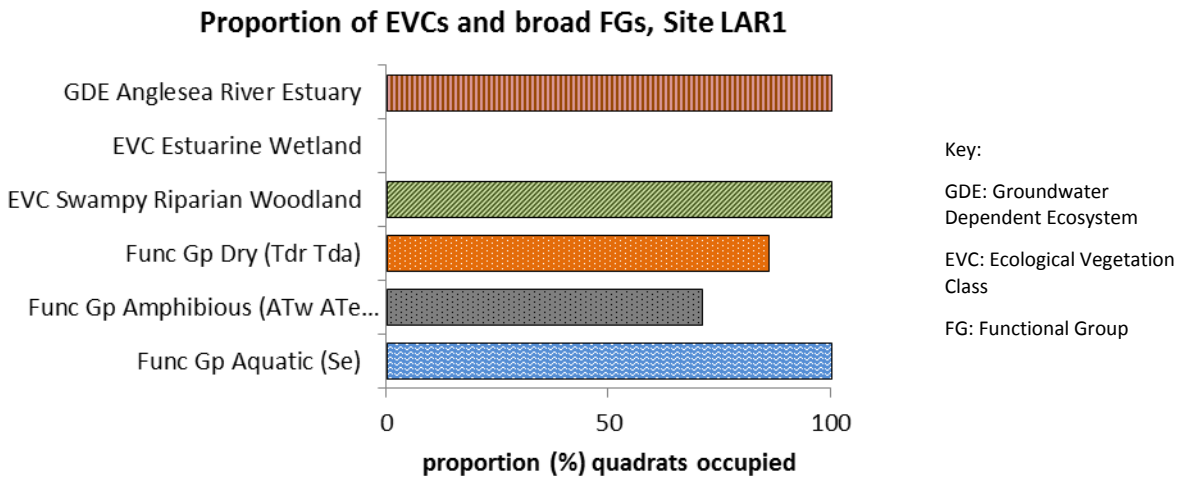
AS6: General habitat description	
Ecological Vegetation Class (EVC)	Aquatic Sedgeland
Wetland permanence	Ephemeral
Swamp clearing, damp underfoot with maximum 5 cm of water in small pools. Swamp vegetation mostly comprises 70–100% cover of decomposing sedges, with small clumps of live sedges and Scented Paperbark. The swamp is fringed by 70–100% cover of Scented Paperbark. Runnels through the swamp contain dead vegetation, small amounts of water, algae and sprouting sedges. The perimeter of the swamp supports <5% cover of fallen branches and 5–10% cover of bare soil. Some macropod scats observed at the site.	

AS6: Frog abundance and richness			
Southern Brown Tree Frog	**Common Froglet**	**Southern Bullfrog**	**Species Richness**
0	0	0	0

AS6: Water quality parameters					
Survey 1					
pH	NA	**Turbidity**	NA	**Water temperature**	NA
EC	NA	**Salinity**	NA	**Dissolved Oxygen**	NA
Survey 2					
pH	NA	**Turbidity**	NA	**Water temperature**	NA
EC	NA	**Salinity**	NA	**Dissolved Oxygen**	NA

Comments
Water quality was not measured during either survey due to insufficient depth.

Figure 15 Anglesea Borefield terrestrial revised ecological Monitoring and Assessment Program, Anglesea Swamp site AS6, 2019 frog summary data.



Dominant native plant species		Broad FG	Quadrats occupied (% frequency)
Cycnogeton alcockiae	Southern Water-ribbons	Aquatic	86
Eucalyptus ovata var. *ovata*	Swamp Gum	Dry	86
Leptospermum scoparium	Manuka	Dry	57

Other attributes	
Average % bare ground cover	0
Algal mat	1

Figure 16 Anglesea Borefield Monitoring and Assessment Program, Anglesea Estuary, Site LAR1, vegetation summary data, 2019.

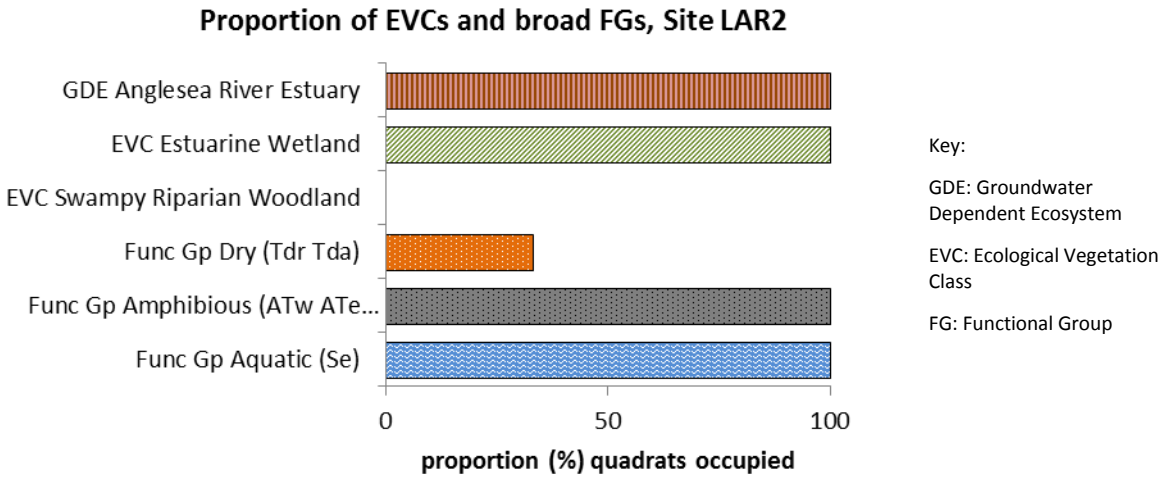
LAR1: General habitat description	
Ecological Vegetation Class (EVC)	Swampy Riparian Woodland
Wetland permanence	Permanent
Slow-flowing creek between 30–100 cm deep and up to 3 m wide, with 20–50% cover of submergent algae and Southern Water-ribbons and 10–20% floating cover of water-ribbons. Creek fringed with young Common Reeds, water-ribbons and revegetation including Prickly Tea-tree, Eucalypts and Goodenia. Common Reeds also present as emergent vegetation on the banks.	

LAR1: Frog abundance and richness			
Southern Brown Tree Frog	**Common Froglet**	**Southern Bullfrog**	**Species Richness**
0	0	0	0

LAR1: Water quality parameters					
Survey 1					
pH	3.32	**Turbidity**	1 NTU	**Water temperature**	15.2 °C
EC	4810 µs/cm	**Salinity**	0.24%	**Dissolved Oxygen**	4.82 mg/L
Survey 2					
pH	3.84	**Turbidity**	0 NTU	**Water temperature**	21.2 °C
EC	13800 µs/cm	**Salinity**	0.79%	**Dissolved Oxygen**	6.97 mg/L

Comments
Southern Brown Tree Frogs (1–5 individuals) were heard calling during the first survey, more than 100 m upstream from the site.

Figure 17 Anglesea Borefield terrestrial revised ecological Monitoring and Assessment Program, Anglesea Estuary site LAR1, 2019 frog summary data.



Dominant native plant species		Broad FG	Quadrats occupied (% frequency)
Juncus kraussii ssp. *australiensis*	Sea Rush	Aquatic	100
Phragmites australis	Common Reed	Amphibious	80
Selliera radicans	Shiny Swamp-mat	Amphibious	80

Other attributes	
Average % bare ground cover	0
Algal mat	0

Figure 18 Anglesea Borefield Monitoring and Assessment Program, Anglesea Estuary, Site LAR2, vegetation summary data, 2019.

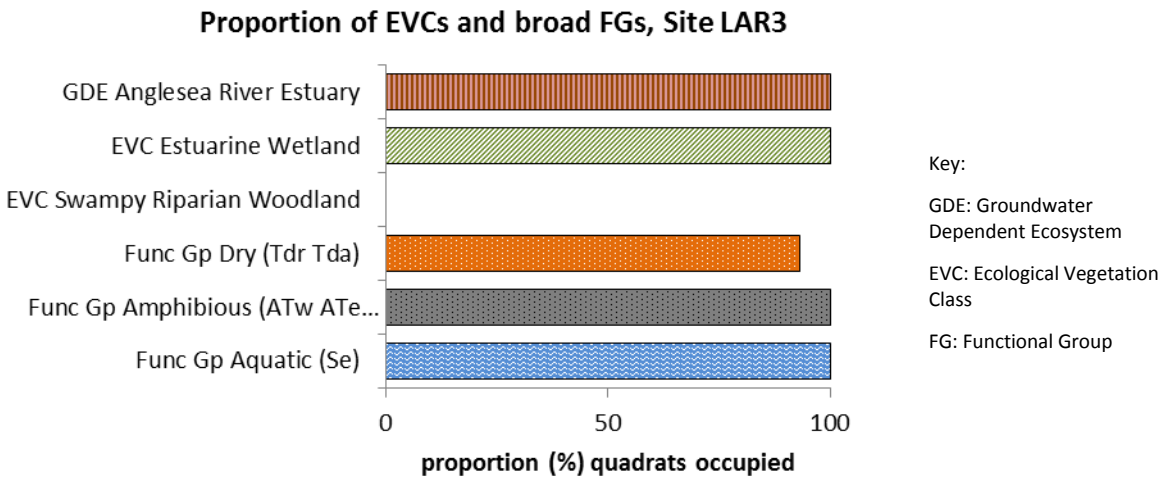
LAR2: General habitat description	
Ecological Vegetation Class (EVC)	Estuarine Woodland
Wetland permanence	Permanent
Slow-moving creek in estuary, up to 2 m deep and 7 m wide, fringed with 70–100% cover of Coastal Tussock-grass, Sea Rush and Common Reed. Submergent vegetation comprises 5–10% cover of dead reeds and algae. The site is mostly open, supporting less than 5% cover of emergent vegetation.	

LAR2: Frog abundance and richness			
Southern Brown Tree Frog	**Common Froglet**	**Southern Bullfrog**	**Species Richness**
0	0	0	0

LAR2: Water quality parameters					
Survey 1					
pH	3.67	**Turbidity**	6 NTU	**Water temperature**	19.9 °C
EC	9500 µs/cm	**Salinity**	0.53%	**Dissolved Oxygen**	9.3 mg/L
Survey 2					
pH	3.86	**Turbidity**	0 NTU	**Water temperature**	21.2 °C
EC	14400 µs/cm	**Salinity**	0.84%	**Dissolved Oxygen**	7.89 mg/L

Comments
Southern Brown Tree Frogs (1–5) and Southern Bullfrogs (1–5) were heard calling during the first survey, more than 100 m from observers.

Figure 19 Anglesea Borefield terrestrial revised ecological Monitoring and Assessment Program, Anglesea Estuary site LAR2, 2019 frog summary data.



Dominant native plant species		Broad FG	Quadrats occupied (% frequency)
Juncus kraussii ssp. *australiensis*	Sea Rush	Aquatic	100
Cycnogeton procerum sp. aff.	Common Water-ribbons	Aquatic	87
Poa poiformis var. *poiformis*	Coast Tussock-grass	Dry	87

Other attributes	
Average % bare ground cover	0
Algal mat	0

Figure 20 Anglesea Borefield Monitoring and Assessment Program, Anglesea Estuary, Site LAR3, vegetation summary data, 2019.

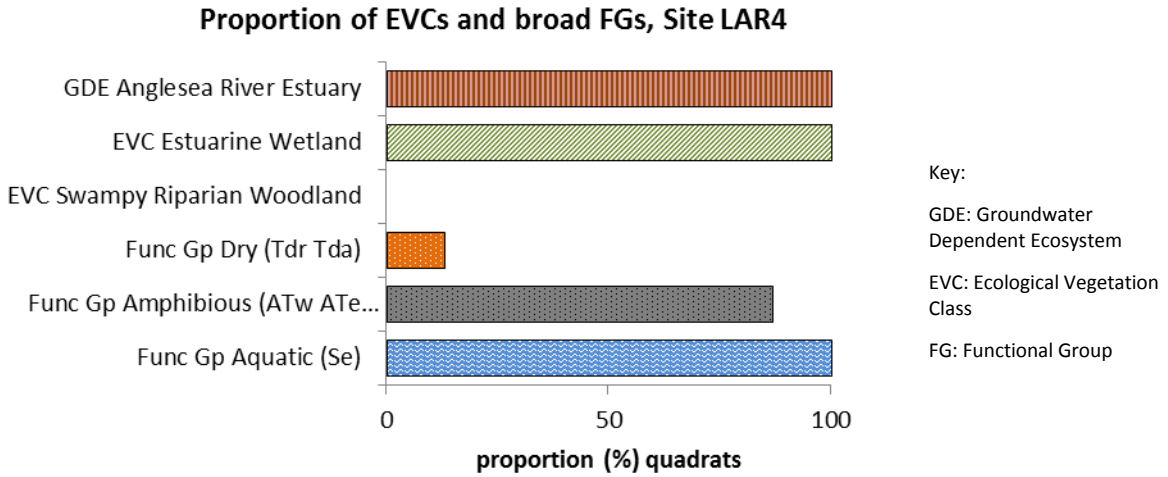
LAR3: General habitat description	
Ecological Vegetation Class (EVC)	Estuarine Woodland
Wetland permanence	Permanent
Slow-flowing creek c. 8 m wide and up to 2 m deep. Water is relatively clear, with 5–10% floating and 5–10% submergent vegetation, comprising Common Water-ribbons, Common Reed, Sedges and algae. Low (5–10%) cover of emergent reeds and water-ribbons emerge near the banks. Bare soil, debris and fallen branches occur on the banks, and the site is fringed by 70–100% cover of vegetation including Sea Rush, Common Water-ribbons and Shiny Swamp-mat.	

LAR3: Frog abundance and richness			
Southern Brown Tree Frog	**Common Froglet**	**Southern Bullfrog**	**Species Richness**
0	0	1	1

LAR3: Water quality parameters					
Survey 1					
pH	3.7	**Turbidity**	7 NTU	**Water temperature**	20.0 °C
EC	9300 µs/cm	**Salinity**	0.52%	**Dissolved Oxygen**	9.54 mg/L
Survey 2					
pH	3.94	**Turbidity**	0 NTU	**Water temperature**	21.1 °C
EC	14400 µs/cm	**Salinity**	0.84%	**Dissolved Oxygen**	8.47 mg/L

Comments
Southern Brown Tree Frogs (1–5) were heard calling during the first survey, more than 100 m from observers. One Southern Bullfrog observed near on the path near the site during the second survey.

Figure 21 Anglesea Borefield terrestrial revised ecological Monitoring and Assessment Program, Anglesea Estuary site LAR3, 2019 frog summary data.



Dominant native plant species		Broad FG	Quadrats occupied (% frequency)
Juncus kraussii ssp. *australiensis*	Sea Rush	Aquatic	100
Cycnogeton procerum sp. aff.	Common Water-ribbons	Aquatic	100
Selliera radicans	Shiny Swamp-mat	Amphibious	73

Other attributes	
Average % bare ground cover	0
Algal mat	0

Figure 22 Anglesea Borefield Monitoring and Assessment Program, Anglesea Estuary, Site LAR4, vegetation summary data, 2019.

LAR4: General habitat description	
Ecological Vegetation Class (EVC)	Heathy Woodland
Wetland permanence	Permanent
Wide (up to 9 m) creek, up to 2 m deep, fringed by 70–100% cover of revegetation on the west bank (Prickly Tea-tree, Goodenia etc) and by Sea Rush, dead Common Reed and Coastal Tussock-grass on the east bank. Algae forms dense submerged mats on the bank, with decomposing and emergent sedges and reeds. Low (<5%) submergent and floating cover of Common Water-ribbons, Sea Rush, algae and dead vegetation.	

LAR4: Frog abundance and richness			
Southern Brown Tree Frog	**Common Froglet**	**Southern Bullfrog**	**Species Richness**
0	0	0	0

LAR4: Water quality parameters					
Survey 1					
pH	3.74	**Turbidity**	11 NTU	**Water temperature**	20.2 °C
EC	9700 µs/cm	**Salinity**	0.54%	**Dissolved Oxygen**	9.38 mg/L
Survey 2					
pH	3.93	**Turbidity**	0 NTU	**Water temperature**	21.2 °C
EC	14500 µs/cm	**Salinity**	0.84%	**Dissolved Oxygen**	8.3 mg/L

Comments
Southern Brown Tree Frogs (6–10) and Southern Bullfrogs (6–10) were heard calling during the first survey, at least 100 m from observers.

Figure 23 Anglesea Borefield terrestrial revised ecological Monitoring and Assessment Program, Anglesea Estuary site LAR4, 2019 frog summary data.

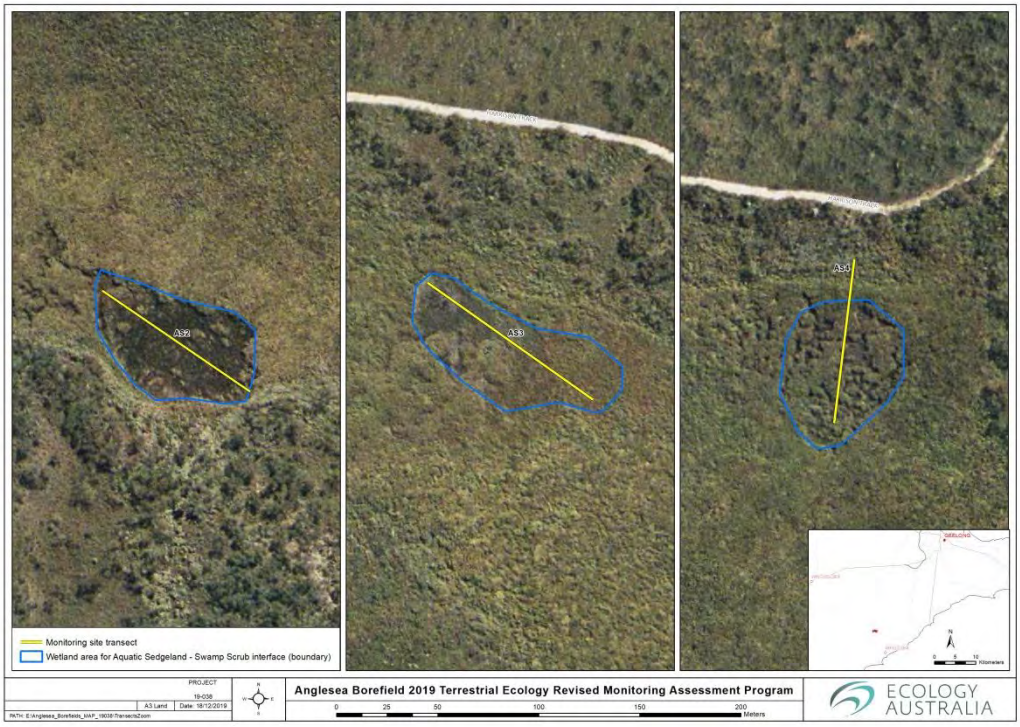


Figure 24 Anglesea Borefield ecological Monitoring and Assessment Program, wetland boundaries, sites AS2, AS3 and AS4, Anglesea Swamp 2019.

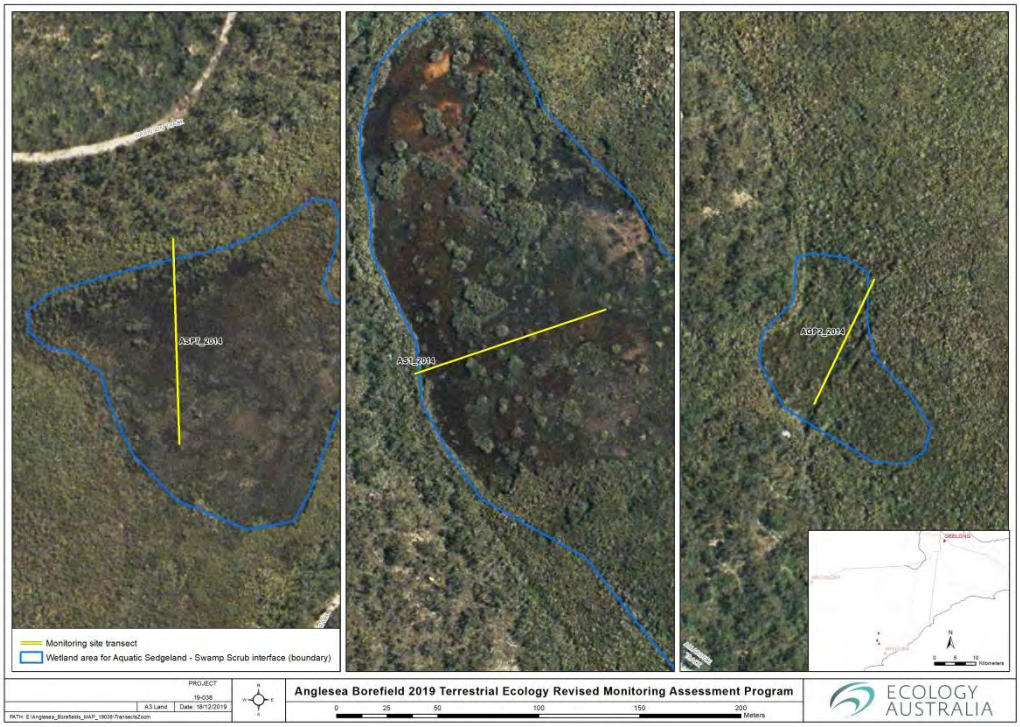


Figure 25 Anglesea Borefield ecological Monitoring and Assessment Program, wetland boundaries, sites ASP7_2014, AS1_2014 NS AGP2_2014, Anglesea Swamp 2019.

3.3 Macroinvertebrates

The macroinvertebrate site results based on combined data from each site sampled are provided in Table 6, for comparison against previous results (GHD 2010–2017, Ecology Australia 2018, 2019).

None of the samples collected contained sufficient macroinvertebrates to enable the sample to be picked in 30 minutes (each one had considerably less than 200 macroinvertebrates). BCT1 had insufficient surface water for three samples to be collected. Two sites were so depauperate that the combined data from all samples did not add up to 200 macroinvertebrates.

Site W2/3 had the fewest taxa present, with only nine taxa detected across the three samples, and in one sample only four taxa were detected. This is substantially less than the State Environmental Protection Policy (SEPP) – Waters of Victoria (WoV) objective (Vic. Gov. 2003) of 24 taxa. No samples attained SEPP objectives for number of taxa, and even as combined samples by site there were no sites that achieved this objective.

None of the sites attained SEPP–WoV objectives for EPA key families, despite being triplicate rather than dual samples, with W2/3 again performing considerably worse than all other sampled sites. As combined sample sites, the highest number of taxa detected was 19, which occurred at SC1.

Two sites attained SEPP–WoV objectives for SIGNAL scores when the three samples were combined, with BCT1 attaining the highest score. BCT1 and SC1 attained the highest diversity for EPT and EPTO, but still failed to meet the SEPP–WoV objectives.

Table 6 Site macroinvertebrate indices results (non-attainment of SEPP WoV objectives indicated by shading)

Indices	W2/3	SC1	BCT1	SEPP objective*
# taxa	9	19	13	24
Abundance	174	223	102	N/A
EPA key families	6	13	8	26*
SIGNAL score	5.1	5.8	5.9	5.8
EPT	0	4	4	9
EPTO	0	4	4	N/A

3.4 Southern Pygmy Perch

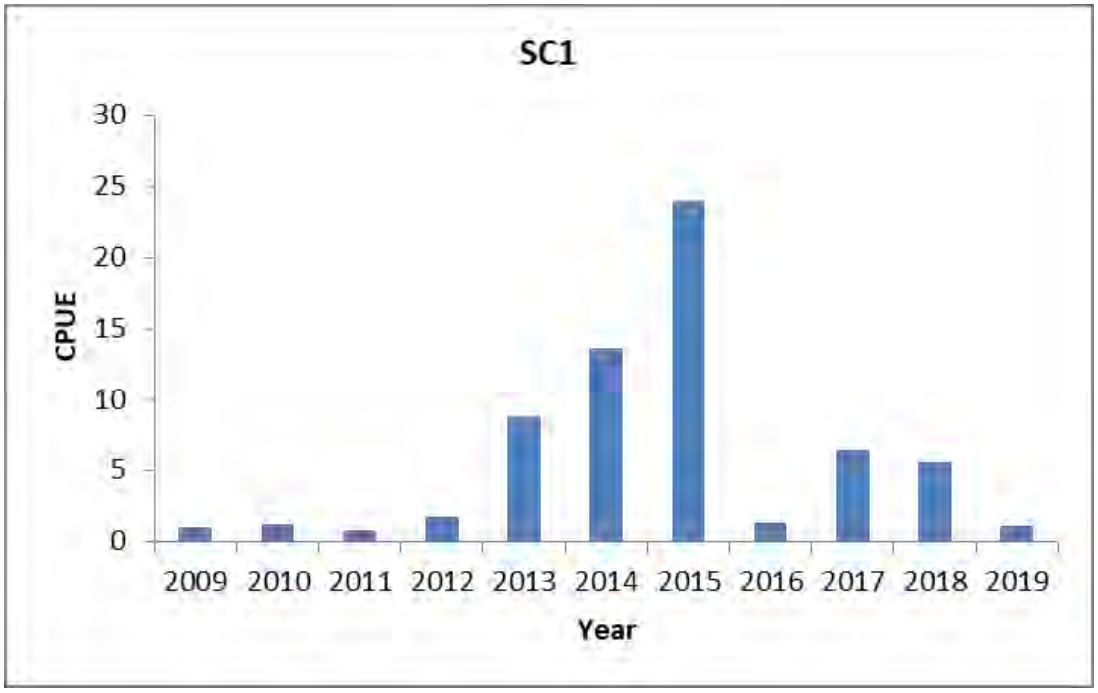
A total of 11 Southern Pygmy Perch were captured from Salt Creek (SC1), and none were captured from Breakfast Creek tributary (BCT1) (Figure 26 and Figure 27, Plate 4). These represent the third lowest and equal lowest spring Catch Per Unit Effort (CPUE) since 2009, respectively. CPUE was calculated using number of traps deployed, based on the assumption that five bait traps were utilised each spring from 2009–2016, and ten traps were utilised from 2017–2019. It is unclear how many of the fish were detected via electrofishing versus bait traps in 2009 and 2010, or how many bait traps were used between 2012 and 2016 as it is not specified in the methods (GHD 2010–2017). While CPUE is typically

measured by units of time, this was not feasible due to the lack of data from previous years, so catch per trap was used instead.

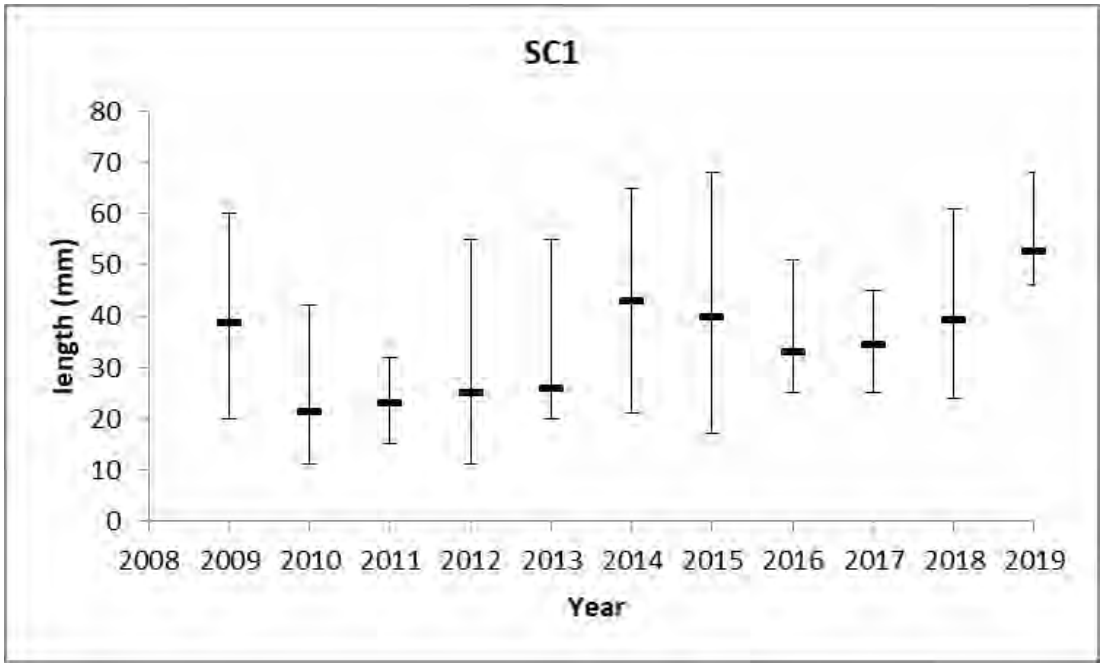
Higher total abundances had been noted from BCT1 in 2015–2017, followed by a reduction to zero fish detected in 2018 and 2019. Recruitment was last detected in spring 2016 (GHD 2017), which means there have been three successive spring sampling events where recruitment has not been detected. However, the detection of recent recruitment for this and most Victorian freshwater fish species is more reliably detected by sampling fish in autumn, rather than spring. Although no fish were detected at this site during the two most recent rounds of monitoring, it should be noted that none were detected in spring 2012, and the population was redetected at the site the following autumn.

The abundance of Southern Pygmy Perch in SC1 appears to have been highly variable over the 11 years of monitoring. Recruitment appears to have occurred annually at SC1 from 2009–2018; however, no recruitment was detected in 2019.

Plate 4 Southern Pygmy Perch from SC1

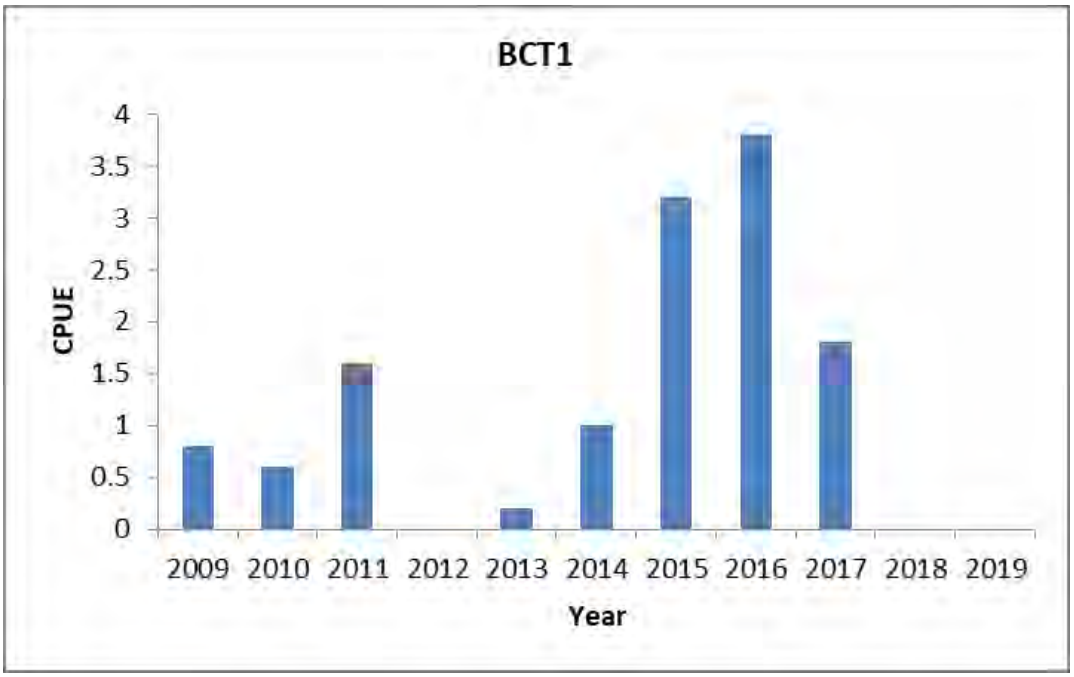


a) Fish Catch Per Unit Effort (CPUE)(fish per trap) at SC1.

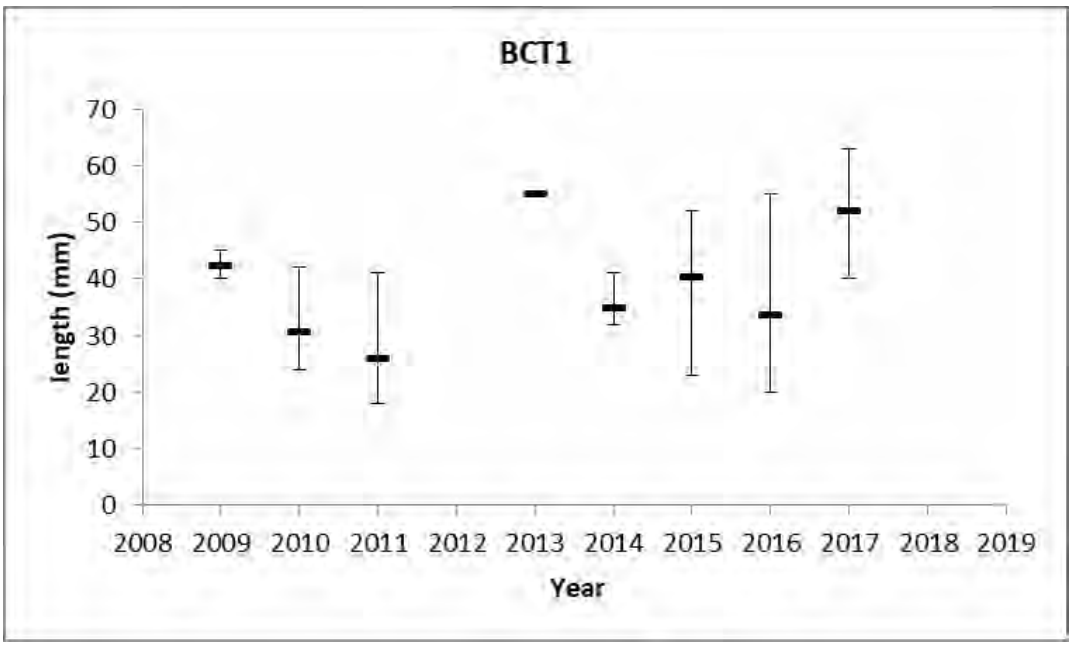


b) Mean (black bars), together with minimum and maximum lengths (TL) of Southern Pygmy Perch. n= CPUE x5 from Figure 27a), with the exception of 2017–2019 where n=CPUEx10

Figure 26 Site SC1 Southern Pygmy Perch spring CPUE a), and length (TL) b) summary 2009–2019



a) Fish Catch Per Unit Effort (CPUE)(fish per trap) at BCT1



b) Mean (black bars), together with minimum and maximum lengths (TL) of Southern Pygmy Perch. n= CPUE x5 from Figure 27a), with the exception of 2017–2019 where n=CPUEx10

Figure 27 Site BCT1 Southern Pygmy Perch spring CPUE a), and length (TL) b) summary 2009–2019

3.5 Water quality

Water quality results were fairly consistent with results from previous years (GHD 2010–17, Ecology Australia 2018, 2019) (Table 7). It should be noted that to accurately assess against SEPP-WoV indices, a minimum of 11 data points are required from a single year, hence snap-shot measurements are incapable of providing an indication of compliance. The SEPP-W objectives are compared against the results only to provide context.

Table 7 In situ water quality results and SEPP-W objectives

	Temperature (°C)	Conductivity (µs/cm)	Dissolved oxygen		pH
			mg/L	%Sat	
SEPP-W objective		<200 (75th percentile)		>85 (25th percentile	6.5-7.5 (25th -75th percentile)
BCT1	11.16	394	7.20	67.8	4.30
SC1	11.87	341	4.71	45.1	4.78
W2&3	10.99	5310	5.07	48.3	2.36

3.6 Otway Bush Yabby

Otway Bush Yabby *Geocharax tasmanicus* (formerly *G. gracilis*) is a small freshwater crayfish listed as Endangered on the Victorian Advisory List of threatened invertebrates (DSE 2009). Otway Bush Yabby was detected at two of the three surveys locations where the species has been detected annually since 2017 (Ecology Australia 2018, 2019). Otway Bush Yabby were detected during both the fish survey (bait trapping), and the macroinvertebrate survey (dip netting) (Table 8). A total of 61 individuals were detected. There is a published record from Salt Creek c.2007 (Schultz et al. 2007).

Table 8 Records of Otway Bush Yabby (spring 2019)

Site	Macroinvertebrate sampling	Bait trapping
BCT1	37	20 (male, female, juveniles)
SC1	3	1 (female)
W2&3	0	

Plate 5 Otway Bush Yabby, mature and juvenile specimens – Breakfast Creek tributary (BCT1)

Plate 6 Otway Bush Yabby – Breakfast Creek tributary (BCT1)

3.7 Aquatic monitoring sites

Wetland 2 and 3

Plate 7 Wetland 2 and 3

At the time of survey, Wetlands 2 and 3 were very shallow, contracted, and dominated by dense stands of Paperbark and Tea-tree. These two wetlands are connected and hence do not constitute independent sites. Additionally, at the time of survey there was insufficient surface water present in either wetland to collect three samples, so Wetlands 2 and 3 were converted to a single site, which is consistent with the previous two years of monitoring.

The substrate was predominantly clay/silt, with a gravel track running adjacent to the site and presenting a potential point source of pollutants and sediment. Filamentous algae was abundant, and macrophytes and coarse particulate organic matter were present in moderate abundance. The majority of the site exhibited no obvious flow, with the exception of slow flow being evident within a small channel crossing under the track. Despite combining the two wetlands, this site had very limited standing water. At the time of sampling, the in situ water quality measurements appeared poor relative to SEPP objectives.

The macroinvertebrate results for the wetland site were poor for all indices (Table 9). Site W2/3 has regularly been dry at the time of survey, or an alternative wetland site has been surveyed. Macroinvertebrate sampling results from Wetland 2/3 were broadly similar with the most recent survey in 2018 (Ecology Australia 2019).

Table 9 Individual macroinvertebrate sample results at W2/3, showing SEPP-W objectives (shading indicates non-attainment of SEPP objectives)

	W2/3-1	W2/3-2	W2/3-3	SEPP-W objective
# taxa	5	6	4	17
Abundance	81	38	55	-
SIGNAL2	3.0	3.2	2.8	4.2
EPT	0	0	0	6
EPTO	0	0	0	-

Salt Creek (SC1)

Plate 8 Salt Creek at SC1

Salt Creek at SC1 had the largest areas of surface water available for sampling, and appeared permanent. The substrate was silt/clay, and the site was dominated by lentic (still) habitats. The main instream cover available for fish and macroinvertebrates, in decreasing order of prevalence, consisted of loose silt lying on the surface, Coarse Particulate Organic Matter (CPOM)(e.g. leaves, branches and other organic debris), overhanging terrestrial vegetation, aquatic vegetation, overhanging bank and logs. The dominant aquatic vegetation taxa were *Juncus* spp., *Carex* spp. and *Blechnum nudum*.

Salt Creek failed to attain SEPP objectives for all macroinvertebrate indices with the exception of the SIGNAL2 score for two of the three samples (Table 10). SC1 has been surveyed annually, and was last surveyed in 2018 (Ecology Australia 2019). The pH, conductivity, and dissolved oxygen levels have deteriorated slightly since 2018, while the macroinvertebrate results are comparable or showed slight improvements against all indices.

Table 10 Individual macroinvertebrate sample results at SC1, showing SEPP-W objectives (shading indicates non-attainment of SEPP objectives)

	SC1-1	SC1-2	SC1-3	SEPP-W objective
# taxa	14	7	14	17
Abundance	67	30	51	-
SIGNAL2	4.8	4.3	3.6	4.2
EPT	4	1	1	6
EPTO	4	1	1	-

Total abundance of Southern Pygmy Perch was lower than it has been since 2016 and CPUE was lower than it has been since 2011. The length-frequency histogram shows a population dominated by older fish and indicates possible recruitment failure or very low levels of recruitment in the past 12 months. Southern Pygmy Perch reach maturity at approximately 30–33 mm (Knight 2008), and the smallest length detected was 46 mm (Figure 28). It should be noted that fish growth rates can be influenced by a number of factors including temperature and resource availability, hence using recruitment or length at maturity cut-off lengths provide only a coarse indication.

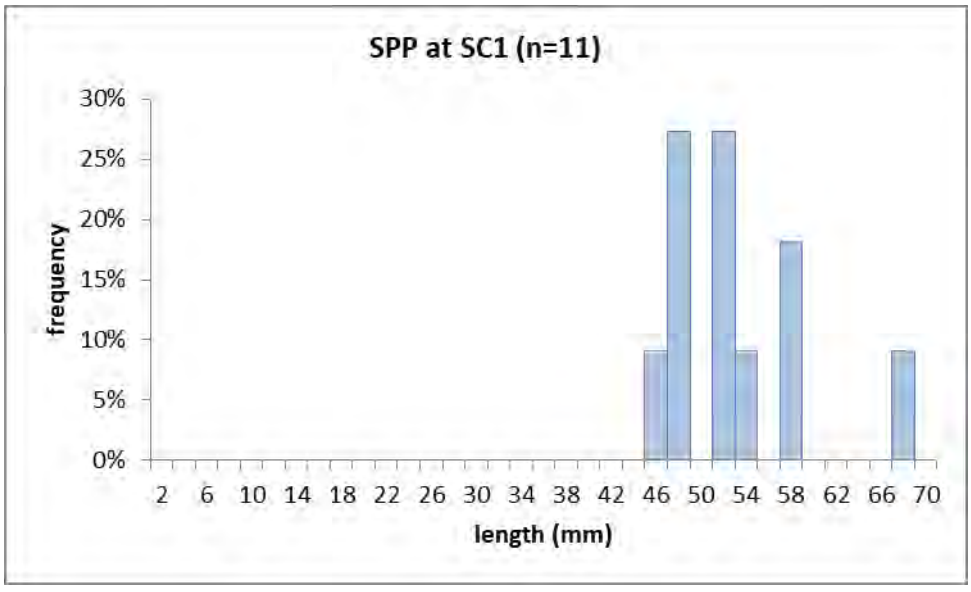


Figure 28 Length-frequency histogram of Southern Pygmy Perch at SC1.

Breakfast Creek tributary 1 (BCT1) at SV3

Plate 9 Breakfast Creek tributary (BCT1) at SV3, showing stream gauge

Breakfast Creek tributary at SV3 (relocated BCT1) consisted of a narrow, shallow stream, with a maximum width of 1.5 m. The substrate was predominantly silt/clay, with some sand, pebble and gravel present, and the lentic or pool (still) hydraulic habitats were dominant, with less than 10% glide (i.e. gentle flow) evident within the surveyed reach. The main instream cover available for fish and macroinvertebrates, in decreasing order of prevalence, consisted of coarse particulate organic matter (e.g. leaves and other organic debris), overhanging terrestrial vegetation, loose silt lying on the surface, overhanging bank, woody debris, filamentous algae, roots, and moss. The dominant aquatic vegetation type was *Blechnum* sp. The water level was slightly lower than in 2018, based on the site photographs, and stream gauge SV3 (235274A) data provided by Tom Scarborough of Barwon Water. During the sampling period in 2018, the water level ranged from 0.1–0.11 m and discharge ranged from 0.11–0.17 ML/day, whereas in 2019 the water level was 0.08–0.09 m and discharge was <0.05 ML/day.

Similarly to SC1, the macroinvertebrate results for the Breakfast Creek tributary site 1 failed to attain SEPP objectives for every index with the exception of SIGNAL2 score, of which both of the individual samples met the required score (Table 11). Whilst failing to meet all objectives, BCT1 SIGNAL2 scores were superior to those at other sites, while BCT1 EPT taxa scores were comparable to SC1. BCT1 showed slight declines against calculated macroinvertebrate indices compared with 2017 (Ecology Australia 2018), but were comparable with those from 2018 (Ecology Australia 2019). Site BCT1 has been sampled annually. The results from the past few years are fairly consistent, with some indices improving and others declining marginally.

Table 11 Individual macroinvertebrate sample indices results at BCT1, showing SEPP-W objectives (shading indicates non-attainment of SEPP objectives)

	BCT1-1	BCT1-2	BCT1-3	SEPP-W objective
# taxa	10	7		17
Abundance	48	54		-
SIGNAL2	4.7	5.3		4.2
EPT	2	4		6
EPTO	2	4		-

No Southern Pygmy Perch were detected at BCT1 during this round of monitoring. The length-frequency histogram from 2017, when the species was last detected, suggests that recruitment failure may have occurred, however detection of recruitment has been inconsistent at this site throughout the 11 years of monitoring. Southern Pygmy Perch reach maturity at approximately 30–33 mm TL (Knight 2008), and none of the fish detected in 2017 were below this threshold. However, recruitment is more reliably detected by autumn rather than spring sampling, and fish length provides only a coarse measurement of fish age/recruitment.

4 Discussion

4.1 Vegetation

Overall there appeared to be little change in vegetation health in the swamp and estuary in 2019 compared with previous years under the current MAP.

The recorded EVCs at each site did not vary from previous years in the Anglesea Swamp and Estuary (see Ecology Australia 2014–2017). Similarly, plant functional groups showed little change and continued to be dominated by aquatic and amphibious Functional Groups at every site in the Anglesea Swamp and Estuary (see Ecology Australia 2014–2017).

Total plant species numbers varied little from previous years in the swamp (Table 12) and the estuary (Table 13) and the differences are within the expected range of natural seasonal variation.

Table 12 Total plant numbers and number of plant species in Functional Groups at study sites in the Anglesea Swamp, Anglesea Borefield Monitoring and Assessment Program, 2019.

Anglesea Swamp Transect/ Site	Year	Total plant numbers	Number of plant species in Functional Group Dry (Tdr, Tda)	Number of plant species in Functional Group Amphibious (ATl, ATe, ATw; and Arp)	Number of plant species in Functional Group Aquatic (Se)
AS2	2014	13	9	2	2
	2015	13	8	2	3
	2016	15	9	2	4
	2017	16	10	2	4
	2019	15	9	4	2
AS3	2014	13	3	8	2
	2015	13	3	8	2
	2016	11	3	7	1
	2017	11	3	7	1
	2019	10	2	7	1
AS4	2014	21	9	9	3
	2015	22	9	9	4
	2016	21	8	10	3
	2017	20	8	9	3
	2019	16	4	9	3

Anglesea Swamp Transect/ Site	Year	Total plant numbers	Number of plant species in Functional Group Dry (Tdr, Tda)	Number of plant species in Functional Group Amphibious (ATl, ATe, ATw; and Arp)	Number of plant species in Functional Group Aquatic (Se)
ASP7_2014	2014	16	2	10	4
	2015	16	1	10	5
	2016	17	3	10	4
	2017	17	3	10	4
	2019	15	3	10	2
AS1_2014	2014	14	4	7	3
	2015	14	4	7	3
	2016	12	3	7	2
	2017	12	3	6	3
	2019	12	6	4	2
AGP2_2014	2014	9	2	5	2
	2015	7	2	3	2
	2016	6	1	3	2
	2017	7	1	4	2
	2019	8	1	5	2

Table 13 Total plant numbers and number of plant species in Functional Groups at study sites in the Anglesea Estuary, Anglesea Borefield Monitoring and Assessment Program, 2019.

Anglesea Estuary Transect/ Site	Year	Total plant numbers	Number of plant species in Functional Group Dry (Tdr, Tda)	Number of plant species in Functional Group Amphibious (ATl, ATe, ATw; and Arp)	Number of plant species in Functional Group Aquatic (Se)
LAR1	2015	8	3	2	3
	2017	8	3	2	3
	2019	10	3	4	3
LAR2	2015	11	4	4	3

Anglesea Estuary Transect/ Site	Year	Total plant numbers	Number of plant species in Functional Group Dry (Tdr, Tda)	Number of plant species in Functional Group Amphibious (ATl, ATe, ATw; and Arp)	Number of plant species in Functional Group Aquatic (Se)
	2017	10	4	4	2
	2019	9	3	4	2
LAR3	2015	13	6	4	3
	2017	14	7	4	3
	2019	13	7	4	2
LAR4	2015	12	3	6	3
	2017	8	2	4	2
	2019	8	3	3	2

No weed species were recorded in the swamp. Weed species continue to be recorded in the estuary (Appendix 2) in 2019. Native plant species were recorded in higher numbers and higher frequencies than weeds in 2015, 2017 and 2019 (see Ecology Australia 2015 and 2017).

The higher weed cover in the estuary likely reflects the vastly increased accessibility of the site, the disturbance history and various recreational activities that occur in and around the estuary (e.g. fishing, boating, dog walking, etc.).

Aside from vehicle tracks at one site (ASP7_2014) there appears to be little sign of disturbance in the swamp. It is recommended that vehicle access is prevented to reduce incidents and severity of future disturbance.

In the swamp, greater areas of bare ground were recorded in 2014 and 2015 compared with 2016–2019. These differences coincided with lower water levels in 2014 and 2015 (leaving exposed bare ground) and higher water levels in 2016 and 2017 (see Ecology Australia 2014–2017).

These observations are taken at one point in time and may not reflect annual average water levels or areas of bare ground so should be interpreted with caution. At present the dominance of Aquatic and Amphibious plant FGs and stable plant species numbers suggests that plants are tolerant of this variability in water levels. No bare ground was recorded in the Estuary in any years.

Algal mats continue to be recorded in the Anglesea Swamp (first recorded in 2016) (Figure 29). While algae are a normal part of wetland ecosystems, the growth of algae can also be associated with low flows (Mitrovic and Bowling 2013, Davie and Mitrovic 2014) and might suggest reduction of overbank flows in the swamp. At this stage there are no obvious impacts on the vegetation.

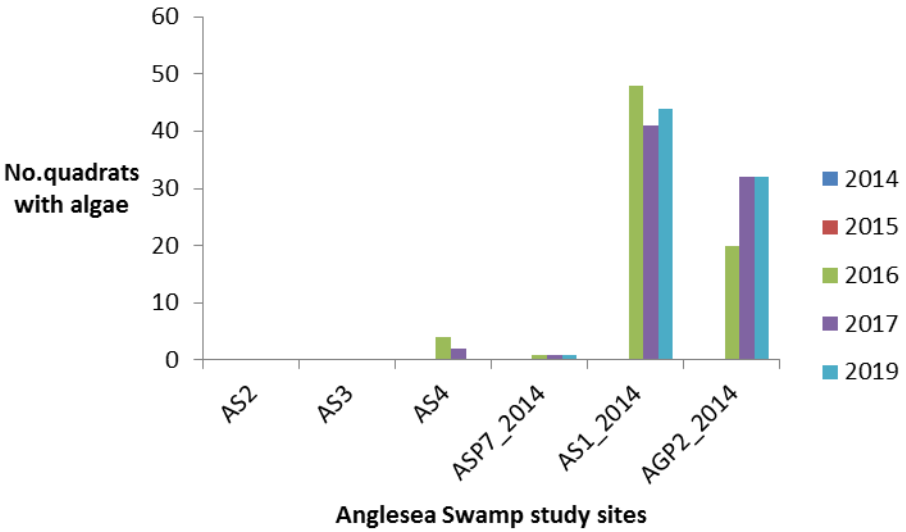


Figure 29 Algae records at study sites in the Anglesea Estuary, Anglesea Borefield Monitoring and Assessment Program, 2019

The 2019 climate data from the nearest weather station (Aireys Inlet ~ 10km away from Anglesea township) shows a mean annual rainfall of 624 mm from 1994—2019 (BOM 2020). Records indicate that the years with below average rainfall relative to the period above were 2014 (498 mm), 2015 (489 mm), 2017 (607 mm) and 2019 (525 mm). The 2016 annual rainfall (714 mm) was higher than the 1994–2019 mean (624 mm). Rainfall data was not available for 2018 (BOM 2020). The relevance of the rainfall data should be interpreted with caution given the weather station is some distance from the study sites. However, the rainfall data is useful for the purposes of demonstrating regional climatic changes which are likely to have direct influences on vegetation and algal mats.

4.2 Frogs

Results of the 2019 frog surveys as part of the Anglesea MAP are consistent with previous years, with low numbers and diversity of frogs recorded across both the Anglesea Swamp and Anglesea Estuary (Table 14, Figure 27). Although only one frog was observed at or near a survey site, frogs were heard calling at least 100 m from survey sites, indicating that frogs occur in the broader area. The low recorded diversity and abundance of frogs is likely to be correlated with the quality of frog habitat in the survey area.

The presence of water is essential for the reproduction of most Australian frog species, to allow tadpoles to mature (Hazell et al. 2003), although hydroperiod requirements will differ depending on the species' reproductive strategy. Southern Bullfrog tadpoles take up to six months to mature; hence this species needs standing water over half the year for successful reproduction (Anstis 2013). In contrast,

Common Eastern Froglet tadpoles can reach maturity in only four to six weeks, and as a result can survive in small, highly intermittent waterbodies with less stable conditions (Lane and Mahony 2002; Hazell et al. 2003; Anstis 2013). While three sites in the Anglesea Swamp supported standing water during the first frog survey, they had largely dried out by the second survey. As such, the hydroperiod at these sites may have been too short for frog reproduction during the current survey. Frogs were recorded at four of the eight sites in 2016, when winter/spring rainfall was above average (587.6 mm compared to 367.6 mm on average) and 7 of the 8 sites had standing water during the first survey (Ecology Australia 2017). Although a similar number of sites had some standing water in 2019 (5 of 8), the average water depth was lower. This may have affected frogs in several ways, including; increasing both the temperature and rate at which water evaporated, which would have further reduced the quality and/or area of frog habitat at survey sites. Taken together, these effects would have reduced options for frogs to breed and the likelihood that any eggs or tadpoles could hatch and successfully metamorphose, respectively.

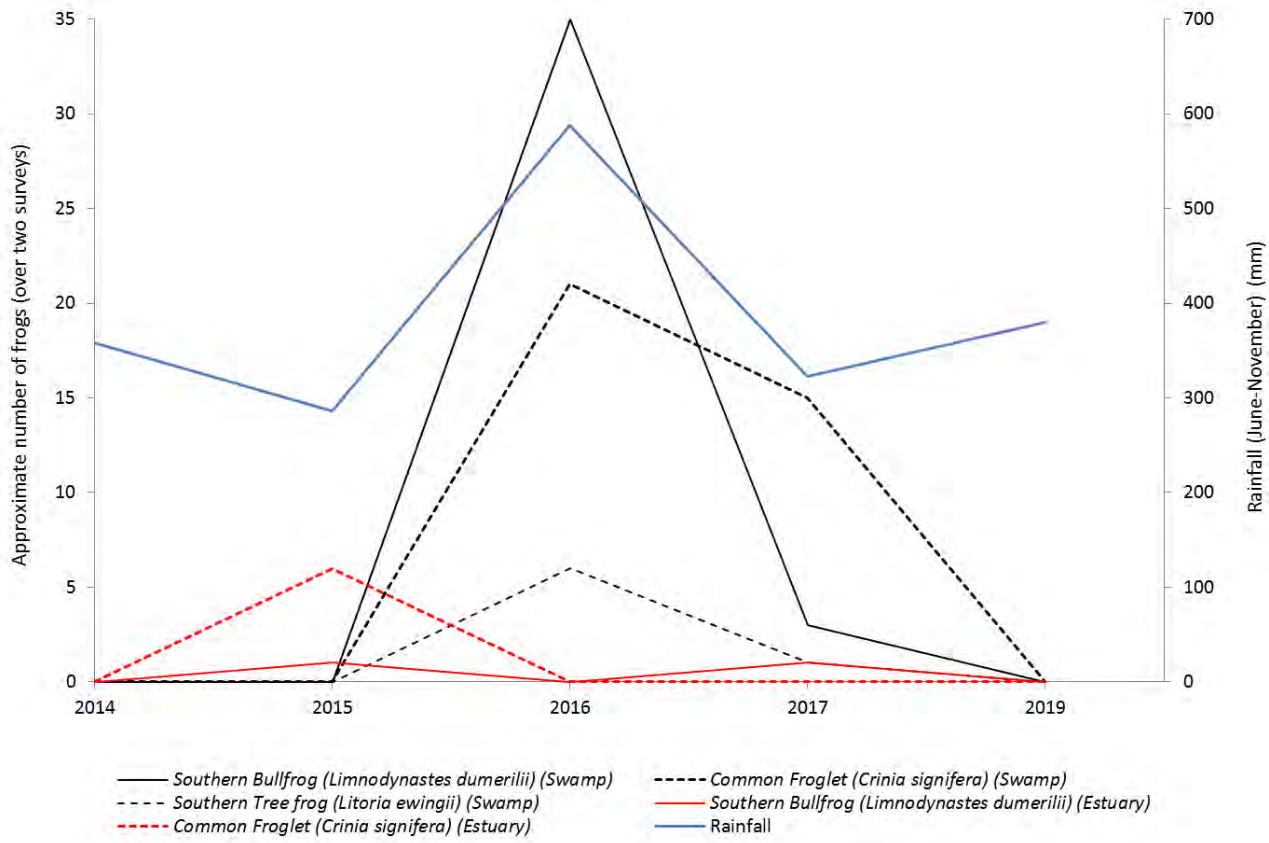


Figure 30 Approximate number of frogs recorded in spring surveys at the Anglesea Swamp and Anglesea Estuary, as part of the Anglesea Borefield Monitoring and Assessment Program, and average winter and spring rainfall, 2014–19[1]. Two surveys were undertaken in each year, except for 2014, when sites were surveyed once.

[1] Rainfall data drawn from Wensleydale (station no. 87119), except for August 2014, when data were not collected at this station, and data drawn instead from Aireys Inlet (no. 90180).

Water quality metrics also influence the quality of frog habitat. Acidity can negatively impact the survival and growth of eggs and tadpoles, with 100% mortality of Striped Marsh Frog eggs below pH of 4.0 (Barth and Wilson 2010). While different species will exhibit different acidity tolerance thresholds, the very acidic conditions in those areas surveyed within the Anglesea Catchment are unlikely to be conducive to frog reproduction. However, whether this is a long-term situation is impossible to answer in the absence of long-term data.

High levels of salinity can also have a negative impact on frog populations. The survival of Southern Brown Tree Frogs is reduced in saline conditions (Chinathamby et al. 2006), and fewer Southern Bullfrogs have been recorded in stormwater ponds with elevated salinity (Hamer et al. 2012). Moderately high salinity/electrical conductivity levels were recorded at both the Swamp (1.44–4.54 ms/cm) and Estuary (4.81–14.5 ms/cm), which may further reduce the potential for frogs to reproduce in these areas.

Table 14 Number of survey sites in the Anglesea Swamp and Anglesea Estuary at which frogs were recorded during spring surveys of the Anglesea MAP, 2014–19.

Area	Common name	Species	2014	2015	2016	2017	2019
Anglesea Swamp	Southern Tree Frog	*Litoria ewingii*	0	0	2	1	0
	Southern Bullfrog	*Limnodynastes dumerilii*	0	0	2	1	0
	Common Froglet	*Crinia signifera*	0	0	3	1	0
		Any species	**0**	**0**	**4**	**1**	**0**
Anglesea Estuary	Southern Tree Frog	*Litoria ewingii*	NA	0	NA	0	0
	Southern Bullfrog	*Limnodynastes dumerilii*	NA	1	NA	1	0
	Common Froglet	*Crinia signifera*	NA	2	NA	0	0
		Any species	**NA**	**3**	**NA**	**1**	**0**

4.3 Aquatic Ecology

The macroinvertebrate survey results were relatively consistent with previous years, with sites demonstrating slight improvements for some indices, and minor reductions in others. The low abundance and diversity of macroinvertebrates detected, and poor performance against SEPP objectives could be attributed to a few different factors. Due to the limited surface water present at all sites, all, or nearly all available surface water was sampled at every suitable site. This is likely to impact upon the results, as this reduces the degree of selectiveness that can be employed in sampling all microhabitats present; and it is possible that some sites may not have been wetted for a sufficient period for colonisation/re-colonisation by the full complement of potential species. Additionally, the reduction in connectivity between sites influences colonisation, and is further influenced by the motility of each taxa. The impacts of acid sulphate soils and/or acid events can result in low pH levels, most notably in Wetland 2/3. Reductions in surface water as a result of evaporation and evapotranspiration further reduce the suitability for macroinvertebrates and other aquatic life, as physicochemical parameters (such as salinity and temperature) become more extreme; as is potentially demonstrated by the high electrical conductivity noted at site W2/3.

The Southern Pygmy Perch population in the Anglesea catchment was identified as genetically distinct from surrounding catchments, and at the time of genetic assessment, the historically abundant populations from the Anglesea River and surrounding wetlands were not detected (Cesar 2012). If further surveys of Southern Pygmy Perch in the broader catchment area were to be undertaken and yield similar results to that found previously (Cesar 2012), then the populations present in Salt Creek and Breakfast Creek tributary may be important source populations for recolonisation lower in the catchment. Southern Pygmy Perch has not been detected at BCT1 since 2017, however the population at BCT1 has previously persisted despite three successive spring sampling events where no recruits were detected (2012–14) (GHD 2013–2015). Appearance and reappearance at BCT1 may indicate that the site does not encompass the local Breakfast Creek source population. In Salt Creek, the population appears to have had successful annual recruitment at SC1 with the exception of 2019. It should be noted that as a species that breeds predominantly in spring, the timing of sampling (spring) hampers the reliability of recruitment detection. While the review of the MAP (GHD 2013b) suggested the BCT1 population was relatively stable, the more recent surveys have detected many more individuals and much more consistent evidence of recruitment at SC1.

The most notable result from the aquatic ecological monitoring in recent years was the detection of the endangered Otway Bush Yabby. This species has previously been recorded in Salt Creek in 2007 (Schultz 2007), however 2017 was the first time it was recorded as part of this monitoring program. Based on the abundance and size ranges encountered, the population appears to be stable.

Recommendations in regards to the aquatic monitoring were proposed after the 2018 monitoring event (Ecology Australia 2019). These recommendations remain current and are reproduced and expanded upon below:

- Due to the limited presence of surface water, it may be beneficial to reduce the number of macroinvertebrate samples per site from three down to two, to avoid oversampling which likely results in poorer results per sample. As the new SEPP-W indices for macroinvertebrates are based on single samples, there is a greater importance in collecting higher quality individual samples. The trade-offs of this approach in terms of reduced replication and reduced data compatability also require consideration. This change would best be considered as part of a review of the MAP.
- Given the recent failure to detect Southern Pygmy Perch at BCT1, it would be beneficial to reassess the catchment for additional populations. This has not been done since 2012, and would ideally focus on historic records from Anglesea River and associated wetlands and Breakfast Creek in addition to known refuge pools throughout Salt Creek and Anglesea River (as identified in GHD 2010), and an investigation into refuge pools in the Breakfast Creek catchment. As a genetically distinct population in an isolated catchment, it is of concern that the species may have retracted to a single remnant population. This results in a high level of vulnerability for this genetic lineage. This assessment can be undertaken at any time, but would ideally be undertaken in late summer/autumn.
- Consideration should be given to the inclusion of Otway bush yabby in the monitoring program in future years, including investigations into the extent of the population throughout the study area. The inclusion of this species as a target of the monitoring program was undertaken in 2019. This required no modification to the methods other than collecting biometric data from the specimens collected. Investigating the extent of the population

distribution can be undertaken at any time, but would ideally be undertaken in late summer/autumn, and would most cost effectively be undertaken in conjunction with the catchment-based investigation into detecting additional Southern Pygmy Perch populations.

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Appendix 1 Anglesea Borefield, terrestrial ecology, Monitoring and Assessment Program, Anglesea Swamp, native plant species and Functional Groups (native plant species only) spring 2019

Status	Scientific name	Common name	Functional group	AS2	AS3	AS4	ASP7_2014	AS1_2014	AGP2_2014
	Banksia marginata	Silver Banksia	Tdr	✓		✓		□	
	Baumea arthrophylla	Fine Twig-sedge	Se	□		✓	✓		✓
	Baumea juncea	Bare Twig-sedge	Tda			□	✓	✓	
	Baumea tetragona	Square Twig-sedge	Se	✓	✓	✓		□	
	Cassytha glabella	Slender Dodder-laurel	Tdr	□	✓	✓	✓	✓	
	Cassytha pubescens	Downy Dodder-laurel	Tdr	✓		□	□	□	
	Cycnogeton alcockiae	Southern Water-ribbons	Se	✓		✓	✓	✓	✓
	Eleocharis sphacelata	Tall Spike-sedge	Se	□				✓	
	Empodisma minus	Spreading Rope-rush	ATe	□	✓	✓	✓	✓	✓
	Epacris obtusifolia	Blunt leaf-Heath	ATw		✓	✓	✓	□	
	Eucalyptus falciformis	Western Peppermint	Tdr	✓	□				
	Gahnia radula	Thatch Saw-sedge	Tdr	✓				✓	
	Gahnia sieberiana	Red-fruit Saw-sedge	ATe	✓	□	✓	✓		✓
	Gleicheinia dicarpa	Pouched Coral-fern	ATe	□	✓	✓	✓	✓	
	Gleicheinia microphylla	Scrambling Coral-fern	ATe			✓		□	
	Juncus procerus	Tall Rush	ATe	✓		□	□		✓
	Lepidosperma longitudinale	Pithy Sword-sedge	ATe	□	□	✓	✓		✓
	Leptospermum continentale	Prickly Tea-tree	Tdr		✓	✓	✓	✓	
	Leptospermum lanigerum	Woolly Tea-tree	ATw				✓		
	Leptospermum scoparium	Manuka	Tda	✓		✓		✓	✓
	Melaleuca squarrosa	Scented Paperbark	ATw	✓	✓	✓	✓	✓	✓
	Opercularia varia	Variable Stinkweed	Tdr	✓		□	□		□
	Platylobium obtusangulum	Common Flat-pea	Tdr	✓		□			
	Pteridium esculentum	Bracken	Tdr	✓	□		□	✓	□
	Rhytidosporum	White Marianth	Tdr	✓	□	□	□	□	□

Status	Scientific name	Common name	Functional group	AS2	AS3	AS4	ASP7_ 2014	AS1_ 2014	AGP2_ 2014
	procumbens								
	Schoenus brevifolius	Zig-zag Bog-sedge	ATe	✓	✓	✓	✓	✓	
	Sprengalia incarnata	Pink Swamp-heath	ATw		✓	✓	✓	☐	
	Xyris operculata	Tall Yellow-eye	ATe		✓		✓	☐	

Appendix 2 Anglesea Borefield, terrestrial ecology, Monitoring and Assessment Program, Anglesea Estuary, plant species and Functional Groups (native plant species only) spring 2019

Key:

= Victorian species not indigenous to the region, location or local area
*= Species not native to Victoria

Status	Scientific name	Common name	Functional group	LAR1	LAR2	LAR3	LA R4
#	*Acacia longifolia* subsp. *longifolia*	Sallow Wattle	NA			✓	
#	*Acacia longifolia* subsp. *sophorae*	Coast Wattle	NA	✓			
*	*Aira elegantissima*	Delicate Hair-grass	NA			✓	
	Cycnogeton procerum sp. aff.	Common Water-ribbons	Se	✓	✓	✓	✓
	Eucalyptus ovata. var. *ovata*	Swamp Gum	Tda	✓		✓	
	Ficinia nodosa	Knobby Club-sedge	Tdr			✓	✓
	Gahnia sieberiana	Red-fruit Saw-sedge	Ate	✓			
	Goodenia ovata	Hop Goodenia	Tdr	✓		✓	✓
	Juncus kraussii ssp. *australiensis*	Sea Rush	Se	✓	✓	✓	✓
	Leptinella longipes	Coast Cotula	ARp		✓	✓	✓
	Leptospermum continentale	Prickly Tea-tree	Tdr			✓	
	Leptosperumum scoparium	Manuka	Tda	✓	✓	✓	
	Lobelia anceps	Angled Lobelia	ATe	✓	✓	✓	✓
	Myoporum insulare	Common Boobialla	Tda		✓		
	Phragmites australis	Common Reed	ARp	✓	✓	✓	
	Poa poiformis var. *poiformis*	Coast Tussock-grass	Tdr		✓	✓	✓
	Selliera radicans	Shiny Swamp-mat	ARp	✓	✓	✓	✓
	Senecio glomeratus s.l.	Annual Fireweed	Tdr			✓	
*	*Symphotrichum subulatum*	Aster-weed	NA		✓		✓
	Typha domingensis	Narrow-leaf Cumbungi	Se	✓			
*	*Vulpia* sp.	Fescue	NA		✓		

Appendix 3 Results by sample of macroinvertebrate sampling

Taxa	BCT1 E1	BCT1 E2	BCT1 Total	SC1 E1	SC1 E2	SC1 E3	SC1 Total	W2/3 E1	W2/3 E2	W2/3 E3	W2/3 Total	Total
Acarina	6		**6**	4	2	6	**12**					**18**
Carabidae (adult)				1			**1**					**1**
Ceratopogonidae									2		**2**	**2**
Chironominae				2		3	**5**					**5**
Crambidae		1	**1**									**1**
Culicidae	8		**8**			30	**30**	63		26	**89**	**127**
Curculionidae (adult)								1	1		**2**	**2**
Dytiscidae (adult)				1	8	9	**18**	1	2	1	**4**	**22**
Dytiscidae (larvae)		1	**1**	5		13	**18**					**19**
Gripopterygidae *Dinatoperla/Leptoperla*				6			**6**					**6**
Gripopterygidae *Leptoperla*		4	**4**									**4**
Gyrinidae (adult)								1			**1**	**1**
Hydraenidae (adult)						2	**2**		1		**1**	**3**
Hydrobiosidae *Taschorema* complex				1			**1**					**1**
Hydrochidae (adult)						1	**1**					**1**
Hydrophilidae (adult)				1		2	**3**		7		**7**	**10**
Janiridae	1		**1**									**1**
Koonungidae					2	4	**6**					**6**
Leptoceridae *Triplectides*	13	2	**15**									**15**
Leptophlebiidae (a mix of damaged and immature specimens)				3			**3**					**3**
Leptophlebiidae *Nousia*		2	**2**									**2**
Leptophlebiidae *Thraulophlebia*	7	8	**15**	29	1	18	**48**					**63**
Oligochaeta	2		**2**	7			**7**			1	**1**	**10**
Orthocladiinae	2		**2**	5		5	**10**					**12**
Paramelitidae				17		6	**23**					**23**
Parastacidae *Geocharax tasmanicus*	4	33	**37**	1	1	1	**3**					**40**
Polycentropodidae *Plectrocnemia*	1	3	**4**	4			**4**					**8**
Scirtidae (larvae)	4		**4**	1	7	1	**8**	15	25	27	**67**	**79**
Veliidae					1	12	**13**					**13**
Total	**48**	**54**	**102**	**88**	**22**	**113**	**223**	**81**	**38**	**55**	**174**	**499**