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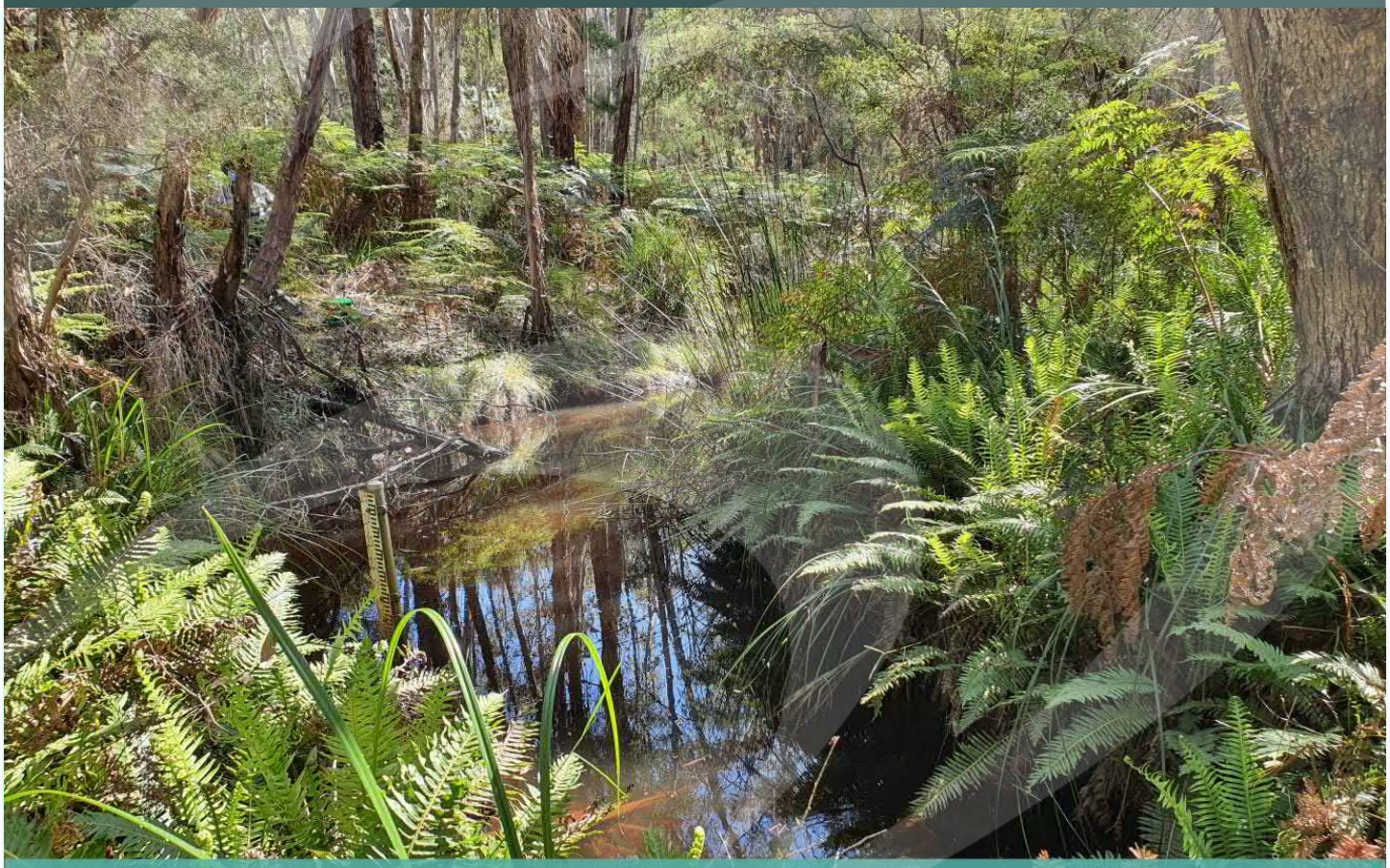
Anglesea Borefield Ecological Monitoring and Assessment Program 2020



Prepared for: Barwon Water

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Summary

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 (Victorian Government 2009). The BE requires data to be collected to monitor the impacts of water drawdown under a Monitoring and Assessment Program (MAP) established in 2009.

Per the updated MAP (revised in 2014; Victorian Government 2014), Ecology Australia was commissioned to undertake both the aquatic and terrestrial ecological monitoring in 2020. The terrestrial monitoring, which is typically biennial and last conducted in 2019, was required again in 2020 as the borefield was operated in 2020 triggering the requirement for the terrestrial monitoring. Ecology Australia has undertaken terrestrial monitoring (vegetation and frogs) since 2009 and aquatic 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 presence;
- Ecological Vegetation Class (EVC);
- Plant Functional Group (FG);
- Bare ground cover; and
- Water depth (in the swamp only).

Frog survey data were 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 a targeted survey for Southern Pygmy Perch and Otway Bush Yabby at two sites and macroinvertebrate sampling at three sites. Fish and macroinvertebrate monitoring included:

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

Findings

Vegetation

Ecological Vegetation Classes, functional groups and species richness at each site have remained largely unchanged in the Anglesea swamp and Anglesea estuary. The frequency of dominant species in the Anglesea Estuary remains similar to previous years. Within four of the Anglesea Swamp sites, several dominant species from the aquatic (Se) and amphibious (Ate) functional group are beginning to show trends of decline in frequency.

Standing water remains present at all the swamp sites. Algal mats were again recorded at three swamp sites where they have been present since 2016. The abundance of these mats appears to be stable.

Bare ground cover across years is highly variable mostly due to changes in seasonal water height variation rather than other variables such as increased soil disturbance. Where vehicle disturbance was noted at site ASP7_2014 the tracks are still evident however the vegetation appears to be recovering.

Frogs

No frogs were recorded at any of the Anglesea Swamp survey sites during either survey. However, Southern Brown Tree Frogs *Litoria ewingii* and/or Southern Bullfrogs *Limnodynastes dumerilii* were calling at least 100 m from four of the eight Anglesea Swamp sites. Two Common Froglets *Crinia signifera* were heard at one site during the diurnal habitat survey. All four estuary sites had Southern Brown Tree Frogs and Southern Bullfrogs calling at least 100 m away and Southern Bullfrogs were present at two sites. The 2020 results are consistent with previous surveys, where low numbers and low diversity of frogs have been recorded across the survey sites.

Southern Pygmy Perch & Otway Bush Yabby

Southern Pygmy Perch were detected from one of the two monitoring sites, SC1, which is consistent with the results of the most recent survey. Recruitment was detected at site SC1, which indicates that fish are continuing to recruit within this system, despite a lack of recruitment evident in 2019. This year's sampling (2020) was the third consecutive year that Southern Pygmy Perch were not recorded at the BCT1. Based on this result it would be advisable to determine if there is a source population elsewhere in the Breakfast Creek catchment as the population at BCT1 appears to be locally extirpated.

Otway Bush Yabby was recorded at both SC1 and BCT1. This species has been detected at these sites annually since 2017 (Ecology Australia 2018–2020). The population of this species appears to be increasing with nearly three times as many Otway Bush Yabby captured in 2020 compared with 2019.

Macroinvertebrates

Macroinvertebrate community indices comparison against State Environmental Protection Policy – Waters objective (SEPP (W); Vic. Gov. 2018) was overall poor and typically consistent with previous surveys. Overall, only two of the possible 12 objectives were met during the 2020 macroinvertebrate monitoring, both for SIGNAL2 score, at sites SC1 and BCT1.

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 (Victorian Government 2009). Groundwater pumping under the BE is permitted as long as it does not adversely affect environmental values and groundwater-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 has been revised and updated once, in September 2014 under the *Bulk Entitlement (Anglesea Groundwater) 2014* (henceforth to be referred to as the "BE" succeeding the previous version; Victorian Government 2014). The MAP includes groundwater and surface water monitoring, acid sulfate investigations, land-level surveying and aquatic and terrestrial ecological monitoring (Victorian Government 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 groundwater pumping, and annually during periods of groundwater extraction (Victorian Government 2014). Barwon Water operated the borefield between August 2019 and June 2020 with a total of 2177.3 ML extracted from the borefield during operation (Barwon Water, 2021). As borefield extraction occurred during 2020 (i.e. during this present reporting period) the MAP requirement for terrestrial ecological monitoring was triggered (this would not have been required in 2020 if the borefield was not operated).

The 2020 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* and Otway Bush Yabby *Geocherax tasmanicus* (formerly *Geocharax gracilis*) 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 was undertaken at established transects at four sites and frog monitoring was undertaken at the same sites in the Anglesea Estuary

- 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 2020 data with annual data collected since the MAP review and update in 2014.

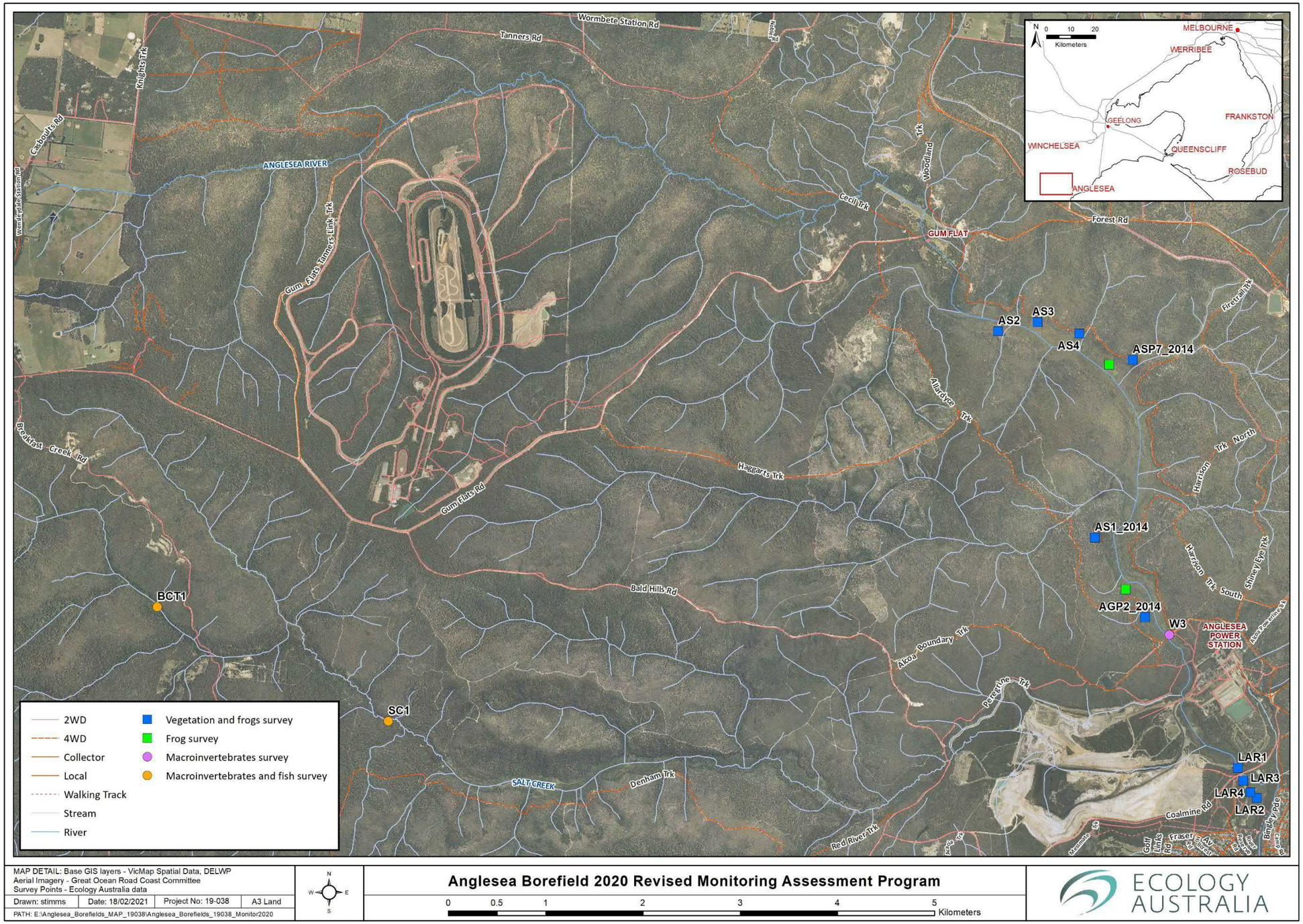


Figure 1 Anglesea Borefield ecological Monitoring and Assessment Program survey sites, 2020

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 second week of November 2020. 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 on 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 hydro-ecology (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) is based on the hydro-ecology (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 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%. Bare ground was estimated differently from previous surveys and

results should be interpreted considering this. In 2020 if there was standing water it was also recorded as bare ground for the quadrat.

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 indicate 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 2020, 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 a 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 4 and 5 November and again on 25 and 26 November (before 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 if 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 about 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 the survey were recorded using a Kestrel weather meter. In 2020, all frog sampling events were completed during suitable weather in Spring.

Visual encounter surveys

Visual and aural encounter surveys were undertaken at each site during the diurnal habitat assessment and the beginning of each nocturnal survey. Surveys comprised two zoologists listening for approximately five minutes for the distinctive calls of male frogs. The species heard, and an estimation of the number of frogs calling for each species was 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 head-torches and/or hand-held spotlights, to look for the distinctive eye-shine of frogs.

Nocturnal call playback

Call playback was used following the nocturnal aural survey, in an attempt to elicit calling behaviour by male frogs that were not calling independently onsite. This approach uses 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 5–6 November 2020. The relocated Site BCT1 was sampled, consistent with previous years (Ecology Australia, 2019) and will continue to be referred to as BCT1. Wetland 2 and Wetland 3 were again 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.

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 250 µm 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 were agitated to dislodge macroinvertebrates and suspend them within the water column.

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, except groups that typically require microscopic examination to identify to the taxonomic resolution of family (e.g. Amphipoda) or taxa which are to be identified to a lower taxonomic resolution than family (e.g. Chironomidae, and families of Odonata, Ephemeroptera, Plectoptera and Trichoptera).

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.

Since the detection of Otway Bush Yabby in 2017, this species has been monitored concurrently with the effort that was being employed for fish and macroinvertebrates (Ecology Australia 2018–2020).

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 (2018–2020).

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) about surface water in the Central Foothills and Coastal Plains geographic region. Where there is no relevant index available in the SEPP (W) the results were compared against the indices used in previous reports.

The following indices were used to analyse macroinvertebrate data:

- Number of taxa — total number of taxa based on taxonomic resolution levels described above;
- 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). These taxa are typically considered more sensitive to pollution and disturbance and hence the index is an indicator of ecosystem health; and

- Number of EPTO taxa — number of taxa from the orders of Ephemeroptera, Plecoptera, Trichoptera and Odonata (EPTO). This modified version of the EPT index is used for waterways in 'Mediterranean climate' regions, and aid 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* and Otway Bush Yabby *Geocharax tasmanicus* were undertaken at two sites; SC1 and BCT1 on 5–6 November 2020. As with the macroinvertebrate surveys, site BCT1 was relocated downstream due to insufficient surface water.

Ten bait traps (stretched mesh size of 2 mm and funnel entrances of 4 cm diameter) with 10 cm long yellow glow sticks were set in the afternoon and retrieved the following morning at both sites. This is consistent with the monitoring approach used in recent years (Ecology Australia 2018–2020), where the number of traps per site was increased to increase the number of Southern Pygmy Perch.

The first 30 Southern Pygmy Perch captured at each site were required to be measured (total length) to the nearest millimetre and weighed to the nearest 0.1 gram. All remaining Southern Pygmy Perch was recorded as a total number of individuals per site.

All captures of Otway Bush Yabby were recorded per sampling method and per replicate (with individuals captured both within the bait traps and within sweep samples). All Otway Bush Yabbies captured using the latter method were picked out of the sample and returned to the point of capture before macroinvertebrate samples were live-picked as described above (see: section 2.3.1).

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 the identification of several 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) in addition to 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

All scientific names, common names and systematic orders of flora and fauna species follow the Victorian Biodiversity Atlas (DELWP 2019b), with common names referring to fauna within the text of the report.

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.

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 27 indigenous plant species were recorded across all sites in the Anglesea swamp (Appendix 1), while in the Anglesea estuary a total of 19 indigenous plant species, eight 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 8–15 in the swamp and 9-14 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, November 2020.

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	13	7	4	2
AS3	10	2	7	1
AS4	15	3	9	3
ASP7_2014	14	3	9	2
AS1_2014	12	5	4	3
AGP2_2014	8	1	5	2
Anglesea Estuary				
LAR1	9	3	4	2
LAR2	12	6	4	2
LAR3	14	9	4	1
LAR4	9	4	3	2

No weeds were recorded in 2020 in the swamp and there was little sign of recent disturbance.

3.1.2 Hydro-ecology

In the Anglesea Swamp, five FGs were represented (Tda, Tdr, Se, Ate and ATw) by at least one species recorded for each functional group(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).

The percentage frequency of species at each site (occurring across 50 quadrats) was recorded during each survey period between 2014 and 2020 at Anglesea Swamp. Table 4 shows a summary of the plants and their associated functional (hydro-ecological) groups that appeared to show trends of change over time in the percentage frequency.

Table 4 Plant species, and the associated functional group, that showed trends of change for each site over time at Anglesea Swamp.

Sites	Functional Group	Scientific Name	Quadrats Occupied (% frequency)					
			2014	2015	2016	2017	2019	2020
AGP2_2014	Se	*Cycnogeton procerum* sp. aff.	82	80	96	92	90	96
	ATe	*Juncus procerus*	70	74	74	72	62	36
AS1_2014	Se	*Eleocharis sphacelata*	20	10	4	4	4	8
	Se	*Machaerina arthrophylla*	58	52	52	54	0	4
AS2	Se	*Cycnogeton procerum* sp. aff.		12	44	44	26	26
	Se	*Machaerina tetragona*	46	52	46	50	26	34
ASP7_2014	Se	*Cycnogeton procerum* sp. aff.	18	16	88	90	76	80
	Se	*Machaerina arthrophylla*	80	78	76	78	72	58

There were five wetland plant species across two main functional groups (Table 4) that showed trends of change over time, for the percentage frequency, of the number of quadrats occupied between 2014 and 2020 surveys.

Site AGP2_2014 has shown a 50% decline in the frequency of occurrence of Tall Rush *Juncus procerus* in 2020 with 36% from 72% in 2017. The functional group of this plant is described as an Amphibious Fluctuation Tolerator- emergent (ATe). Table 1 describes this functional group as including plants that require 8-12 months per year of flooding as long as a proportion of the plant is emergent from the water throughout the year.

Site AS1_2014 showed downward trends in two species from the Perennial Emergent (Se) functional group. This functional group is described in Table 1 as monocotyledonous species requiring permanent water within the root zones of the plant, without water drawing down totally throughout the dry part of the year. Tall Spike-rush *Eleocharis sphacelata* showed a large decrease of percentage frequency between 2014 (20%) and 2016 (4%) with the 2020 result being 8% frequency. The percentage frequency of Fine Twig-sedge *Machaerina arthrophylla* was relatively stable between 2014 and 2017 monitoring years, ranging from 52-58% frequency. After 2017 this species dropped to the point that it was not recorded in 2019 and only 4% frequency in 2020.

Site AS2 showed trends of change over time of the percentage frequency in two wetland species from the Perennial Emergent (Se) functional group. Water Ribbons *Cycnogeton procerum* sp. aff. showed an initial increase in percentage frequency from 0% in 2014 to 44% in 2017. In 2019 and 2020 there was a decrease to 26% frequency. Square Twig-sedge *Machaerina tetragona* was relatively stable between 2014 and 2017 monitoring years, ranging from 46-50% frequency. After 2017 this species dropped to 26% frequency in 2019 and 24% in 2020.

Site AS2 showed trends of change over time of the percentage frequency in two wetland species from the Perennial Emergent (Se) functional group. Water Ribbons showed an initial increase in percentage frequency from 0% in 2014 to 44% in 2017. In 2019 and 2020 there was a decrease to 26% frequency. The percentage frequency of Fine Twig-sedge was relatively stable between 2014 and 2017 monitoring years, ranging from 76-80% frequency. After 2017 this species has trended down to 72% frequency in 2019 and only 58% frequency in 2020.

The vegetation in the estuary remains relatively healthy. Non-indigenous plants were recorded in all estuary sites except in LAR4. In sites LAR1, LAR2 and LAR3, indigenous plants were recorded in comparatively greater numbers in each transect (Appendix 2), and indigenous plants were recorded more frequently than weeds in all transects (Figures 16, 18, 20 and 22).

3.1.3 Structural attributes

Three EVCs recorded in the swamp in 2020 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 2.5 – 16.5 cm (Figures 2, 4, 6, 8, 10 and 12).

Bare ground was recorded in all sites at the swamp in 2020 and ranged from an average of 3% in transect AS3 to 68% in transect AS1_2014 (Figures 2, 4, 6, 8, 10 and 12). Bare ground was only recorded at transect LAR2 in the estuary at an average of 1% (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 5 (AS4) to 38 (AS1_2014) (Figures 2, 4, 6, 8, 10 and 12). Algal mat was recorded in two quadrats 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

The first round of frog surveys was conducted on 4–5 November 2020, seven of the eight Anglesea Swamp monitoring sites had open standing water, with AS5 being mostly moist with shallow (ca. 0.1 m) pools of water located near the centre of the survey site. By the second survey, AS5 had become too shallow to provide reliable water quality measurements. Overall, water levels were similar to those observed in previous years. However, due to a strong winds event, it was not possible to complete the first frog survey at site AS2.

The second frog survey was conducted on 25-26 November 2020. Conditions during both frog surveys were suitable for detecting frogs, with low wind, moderate temperatures, and relatively high humidity; no rain fall occurred during or immediately before either survey (Table 5).

Table 5 Weather conditions during frog surveys, Anglesea revised ecological Monitoring and Assessment Program, 2020.

Variable	Survey 1	Survey 2
Temperature (°C)	13.75	13.15
Humidity (%)	78.1	81.61
Cloud cover (0–8)	2.90	1.25
Moon light (0–4)	0	2.5
Wind speed (0–3)	0	0
Rainfall during survey (0–3)	0	0
Rain in past 24 hours (None–heavy)	None	None

3.2.2 Frog species richness and abundance

Anglesea Swamp

There were no frogs were observed during either survey at any of the long-term survey points located within the Anglesea Swamp. During the second survey, Southern Brown Tree Frogs were heard calling from near two sites more than 100 m away, while Southern Bullfrogs were heard near one site (Table 6). Both species were heard calling near AS3, on Harrison Track North. A maximum of five individuals of each species was heard calling near the survey sites. In addition, two Common Froglet were detected calling during the vegetation assessment at AS2.

Anglesea Estuary

Frogs were heard calling in the vicinity (<100 m) of the long-term survey points during each of the surveys at the Anglesea Estuary. One Southern Bullfrog was observed active beside the walking track between LAR4 and LAR2 (Plate 3), with another two individuals observed floating and calling within the creek near LAR2 during the first survey. Typically, Southern Brown treefrogs and Southern bullfrog were

heard calling from within 100 m of each of the survey sites during both surveys (Table 6), often in large numbers of both species of frogs (between 10 and 20 individuals) around the estuary.

Table 6 Anglesea Borefield revised ecological Monitoring and Assessment Program, frog species detected during nocturnal surveys and estimated abundances, 2020. 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	0 (1-5)	0
AS3	0	0 (1-5)	0	0 (1-5)	0
AS4	0 (1-5)	0	0	0	0
AS5	0	0	0	0	0
ASP7_2014	0	0	0	0	0
AS1_2014	0	0	0	0	0
AS6	0	0 (1-5)	0	0	0
AGP2_2014	0	0	0	0	0
Anglesea Estuary					
LAR1	0 (1–5)	0 (1–5)	0 (1-5)	0 (1-5)	0
LAR2	0 (1–5)	0 (1–5)	2 (6–10)	0 (6–10)	1
LAR3	0 (5–10)	0 (1–5)	0 (6–10)	0 (1–5)	1
LAR4	0 (6–10)	0 (6–10)	1 (6–10)	0 (1–5)	0

Plate 1 Southern Bullfrog *Limnodynastes dumerilii* observed beside walkway at the Anglesea Estuary, near LAR4. Photo: Ruth Marr.

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 open up into clearings of emergent aquatic vegetation, largely sedges such as Zig-zag Bog-sedge *Schoenus brevifolius*, Square Twig-sedge *Machaerina tetragona* and Fine Twig-sedge *M. 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, Common Water-ribbons *Cycnogeton procerum* sp. aff. 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). During the 2020 surveys, all sites had sufficient standing water to allow for all water quality parameters to be measured during the first survey. This had declined by the second survey such that three sites (AS5, AS6 and ASP7) had insufficient standing water to allow reliable water quality measurement. Most sites were acidic (pH of 3.41–8.31) and electric conductivity was low, ranging from 0.02 to 3.93 µs/cm. Water temperatures were relatively high, with all but three measurements above 15 °C (range: 13.1–21.8 °C). Turbidity was more variable across sites, being generally low (range: 0 – 66 NTU) with most values being under 15 NTU. Similarly, dissolved oxygen levels were variable (range: 1.55–9.17 mg/L).

Anglesea Estuary

The Anglesea Estuary is relatively deep, with slow-moving water. Apart from filamentous algae, the cover of aquatic vegetation was generally low, particularly the 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 *Goodenia 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 – 3 m deep. As such water quality could be measured at all sites, and values were generally 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 over 20 °C, apart from a cooler reading obtained at LAR1 in the second survey (18.4 °C). Electrical conductivity readings were relatively low, particularly in the second survey, with slightly lower recordings obtained at LAR1, further upstream. Conductivity remained constant with a mean of 7.82 µs/cm in the first survey, to 7.85 µs/cm in the second survey. Turbidity was low (0–5 NTU) and dissolved oxygen concentrations varied from 2.56 to 22.2 mg/L.

3.2.4 Vegetation and frog site summaries

The following site summaries include:

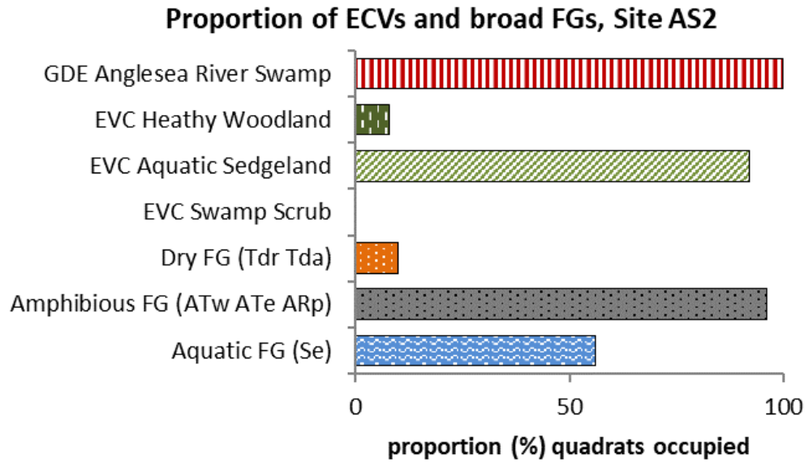
- transect photos at 25 m intervals;
- the proportion of each EVC and each FG recorded at each site;
- the top three dominant plant species and their FG;
- other attributes including average bare ground cover, water depth and algal mat;
- a habitat description;
- frog species occurrence and abundance;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

0—25m

25—50m

50—75m

75—100m



Dominant Plant Species		Broad FG	Quadrats occupied (% frequency)
Schoenus brevifolius	Zig-zag Bog-sedge	Amphibious	88
Machaerina tetragona	Square Twig-sedge	Aquatic	34
Cycnogeton procerum sp. aff.	Common Water-ribbons	Aquatic	26

Other attributes		
Average % bare ground cover	20	(bare ground recorded in 34 quadrats)
Average water depth along transect (cm)	9	Water recorded in 35 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, 2020.

AS2: General habitat description					
Ecological Vegetation Class (EVC)	Aquatic Sedgeland				
Wetland permanence	Ephemeral				
Swamp dominated by emergent dead and live sedges, with patches of clear open water at varying depth to c. 20 cm. Open water contains 5% floating, 5-10% submergent vegetation and 70-100% emergent and floating debris and vegetation. The swamp is fringed with 70–100% shrub vegetation with small amounts of bare wet soil. Macropod and predator scats observed in 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	4.12	**Turbidity**	42 NTU	**Water temperature**	15.5 °C
EC	1.28 µs/cm	**Salinity**	0.05%	**Dissolved Oxygen**	9.08 mg/L
Survey 2					
pH	6.61	**Turbidity**	104 NTU	**Water temperature**	19.1°C
EC	1.75 µs/cm	**Salinity**	0.08%	**Dissolved Oxygen**	4.32 mg/L
Comments					
Pools of up to 20 cm depth were present during the first survey. Site was not surveyed during the first frog survey event. Two Common froglets calling during vegetation assessment in the week following first frog survey. Southern bullfrog where detected calling in the distance on the second frog survey.					

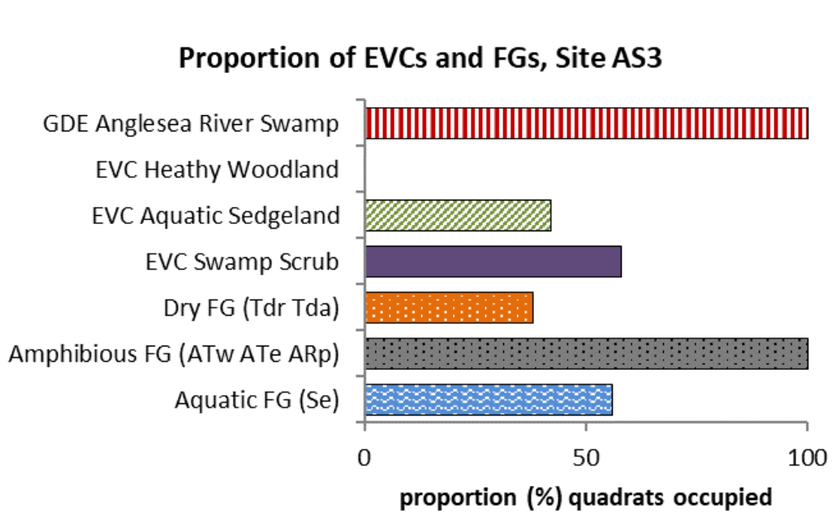
Figure 3 Anglesea Borefield terrestrial revised ecological Monitoring and Assessment Program, Anglesea Swamp site AS2, 2020 frog summary data.

0—25m

25—50m

50—75m

75—100m



Dominant Plant Species	Broad FG		Quadrats occupied (% frequency)
Schoenus brevifolius	Zig-zag Bog-sedge	Amphibious	80
Melaleuca squarrosa	Scented Paperbark	Amphibious	70
Sprengalia incarnata	Pink Swamp-heath	Amphibious	68

Other attributes		
Average % bare ground cover	5	(bare ground recorded in 14 quadrats)
Average water depth along transect (cm)	2.5	Water recorded in 31 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, 2020.

AS3: General habitat description	
Ecological Vegetation Class (EVC)	Swamp Scrub
Wetland permanence	Semi-permanent
Site consists of a small (c. 0.25 ha) clearing in shrub vegetation (Swamp Paperbark, Prickly Tea-tree and Pink Swamp-heath) with 70–100% 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 15 cm depth in the first survey had declined to 5–10 cm deep by the second survey. There was shallow water < 5 cm deep present in the swamp in the second survey, but no pools. Macropod tracks present around the site.	

AS3: Frog abundance and richness					
Southern Brown Tree Frog		**Common Froglet**		**Southern Bullfrog**	**Species Richness**
1-5		0		1-5	2
Survey 1					
pH	3.86	**Turbidity**	15 NTU	**Water temperature**	13.1 °C
EC	1.38 µs/cm	**Salinity**	0.06%	**Dissolved Oxygen**	7.83 mg/L
Survey 2					
pH	4.66	**Turbidity**	66 NTU	**Water temperature**	15.0 °C
EC	1.36 µs/cm	**Salinity**	0.06%	**Dissolved Oxygen**	NA
Comments					
Southern Brown Tree Frogs (1-5 individuals) and Southern Bullfrogs (1-5 individuals) could be heard calling more than 100 m from observers. A male Koala was calling from nearby.					

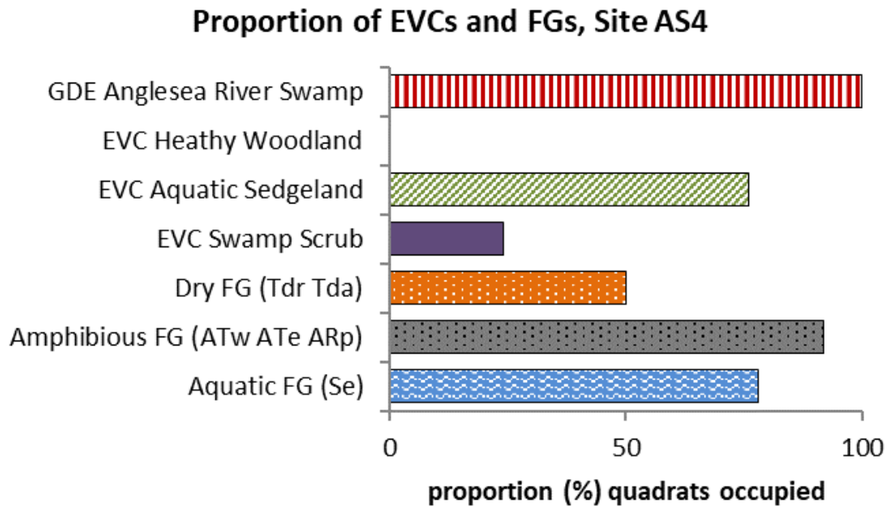
Figure 5 Anglesea Borefield terrestrial revised ecological Monitoring and Assessment Program, Anglesea Swamp site AS3, 2020 frog summary data.

0—25m

25—50m

50—75m

75—100m



Dominant Plant Species		Broad FG	Quadrats occupied (% frequency)
Melaleuca squarrosa	Scented Paperbark	Amphibious	90
Cycnogeton procerum sp. aff.	Common Water-ribbons	Aquatic	76
Machaerina arthrophylla	Fine Twig-sedge	Aquatic	68

Other attributes		
Average % bare ground cover	35	(bare ground recorded in 40 quadrats)
Average water depth along transect (cm)	6	Water recorded in 39 quadrats
Algal mat (quadrats occupied)	5	

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, 2020.

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. Thick ground cover of Pouched Coral-fern to c. 1 m, with emergent (20-50%) Pink Swamp-heath and Scented Paperbark. Submergent vegetation (10-20%), with less than 5-10% cover of fallen branches, and small (5–10%) amounts of bare ground. Macropod tracks and scats observed at site.					
Southern Brown Tree Frog		**Common Froglet**		**Southern Bullfrog**	**Species Richness**
0		0		0	0
AS4: Water quality parameters					
Survey 1					
pH	3.60	**Turbidity**	8 NTU	**Water temperature**	15.3 °C
EC	2.20 µs/cm	**Salinity**	0.10%	**Dissolved Oxygen**	6.93 mg/L
Survey 2					
pH	4.82	**Turbidity**	9 NTU	**Water temperature**	13.8 °C
EC	2.41 µs/cm	**Salinity**	0.12%	**Dissolved Oxygen**	NA
Comments					
Water depth was adequate for water quality measurements, with the exception of dissolved oxygen. Southern Brown tree-frogs were detected calling in the direction of AS3. Two Southern Boobook owls were calling nearby < 200 m.					

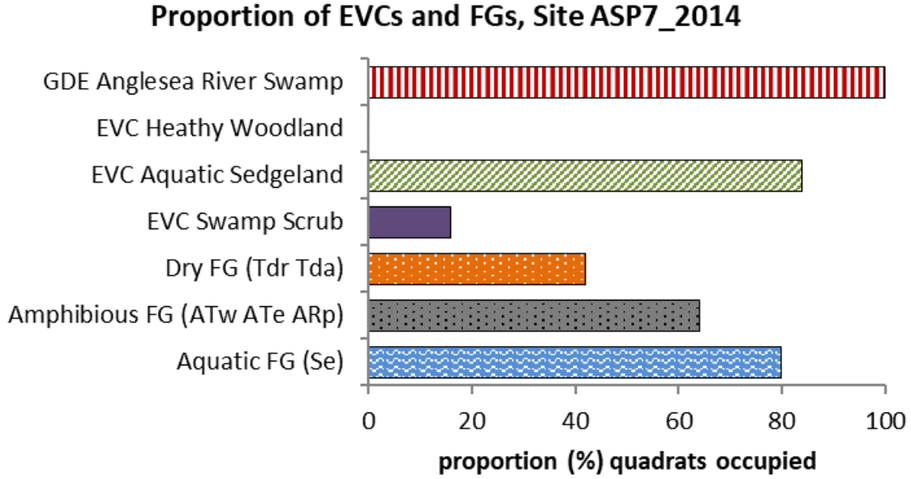
Figure 7 Anglesea Borefield terrestrial revised ecological Monitoring and Assessment Program, Anglesea Swamp site AS4, 2020 frog summary data.

0—25m

25—50m

50—75m

75—100m



Dominant Plant Species	Broad FG	Quadrats occupied (% frequency)
Cycnogeton procerum sp. aff.	Common Water-ribbons	Aquatic	80
Machaerina arthrophylla	Fine Twig-sedge	Aquatic	58
Schoenus brevifolius	Zig-zag Bog-sedge	Amphibious	58

Other attributes		
Average % bare ground cover	35	(bare ground recorded in 47 quadrats)
Average water depth along transect (cm)	6.5	Water recorded in 46 quadrats
Algal mat (quadrats occupied)	0	

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, 2020.

ASP7_2014: General habitat description	
Ecological Vegetation Class (EVC)	Aquatic Sedgeland
Wetland permanence	Ephemeral
Site consists of a large (c. 3 ha) clearing within the swamp, comprising c. 70% emergent sedges, fringed with c. 70-90% cover of mostly Scented Paperbark. During the first survey the swamp had an average depth of 0.2 m. The reduced depth observed during the second survey revealed a substrate of dead and decomposing vegetation. Vehicles tracks present at the southern edge of the site first observed in 2019 remain clearly visible as numerous wheel ruts.	

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

Survey 1					
pH	3.41	**Turbidity**	1 NTU	**Water temperature**	17.8 °C
EC	2.56 µs/cm	**Salinity**	0.12%	**Dissolved Oxygen**	4.26 mg/L
Survey 2					
pH	NA	**Turbidity**	NA	**Water temperature**	NA
EC	NA	**Salinity**	NA	**Dissolved Oxygen**	NA

Comments
Pools of up to 20 cm depth were present during the first survey, had become too shallow (<0.05 m) for water quality measurements during the second survey. There were no frogs detected during either survey.

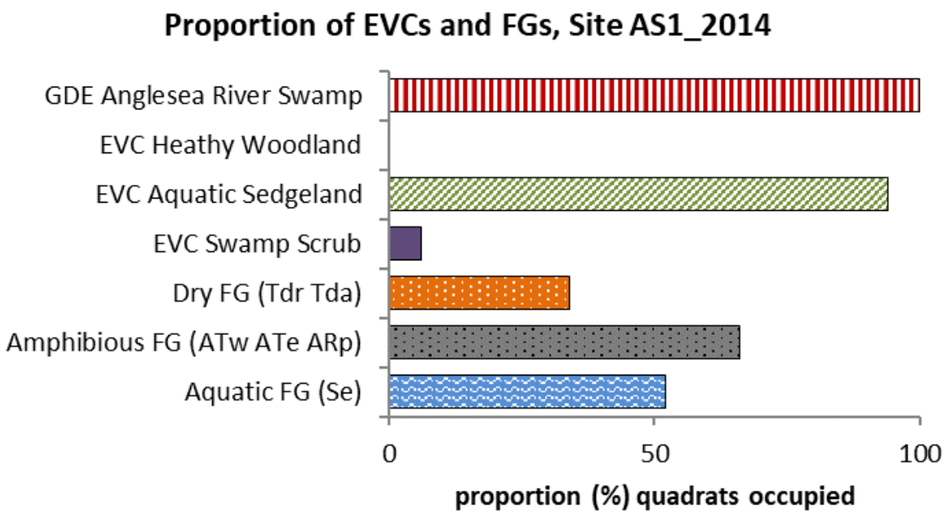
Figure 9 Anglesea Borefield terrestrial revised ecological Monitoring and Assessment Program, Anglesea Swamp site ASP7_2014, 2019 frog summary data.

0—25m

25—50m

50—75m

75—100m



Dominant Plant Species		Broad FG	Quadrats occupied (% frequency)
Schoenus brevifolius	Zig-zag Bog-sedge	Amphibious	62
Cycnogeton procerum sp. aff.	Common Water-ribbons	Aquatic	50
Melaleuca squarrosa	Scented Paperbark	Amphibious	32

Other attributes		
Average % bare ground cover	70	(bare ground recorded in 43 quadrats)
Average water depth along transect (cm)	9	Water recorded in 42 quadrats
Algal mat (quadrats occupied)	38	

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, 2020.

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 consisting of 70–100%. Considerable amounts of floating filamentous algae. Emergent rushes (20–50%) are located throughout the swamp, and submergent thin water ribbon (< 5%). Some evidence of wallaby tracks and carnivore scats also present.	

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

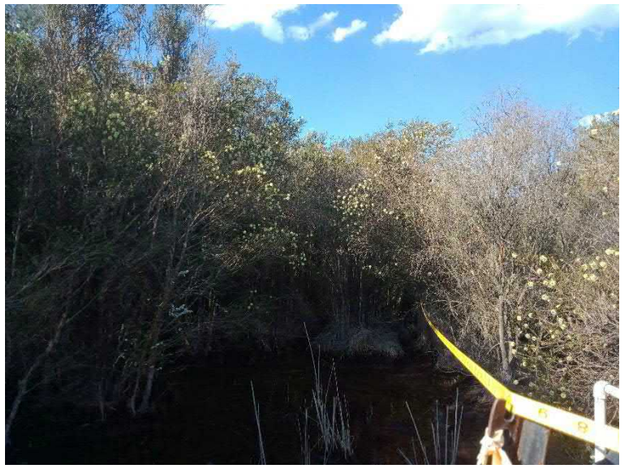
AS1_2014: Water quality parameters					
Survey 1					
pH	5.05	**Turbidity**	0 NTU	**Water temperature**	19.8 °C
EC	3.40 µs/cm	**Salinity**	0.17%	**Dissolved Oxygen**	9.17 mg/L
Survey 2					
pH	8.31	**Turbidity**	0 NTU	**Water temperature**	21.8 °C
EC	0.02 µs/cm	**Salinity**	3.93%	**Dissolved Oxygen**	7.23 °C

Comments
The depth of the swamp by the second frog survey was still suitable for water quality measurements. One Southern Bullfrog was calling very infrequently during the first survey, at least 100 m from observers. An Owlet nightjar and Southern boobook heard calling during second frog survey. There were no frogs detected in either survey.

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

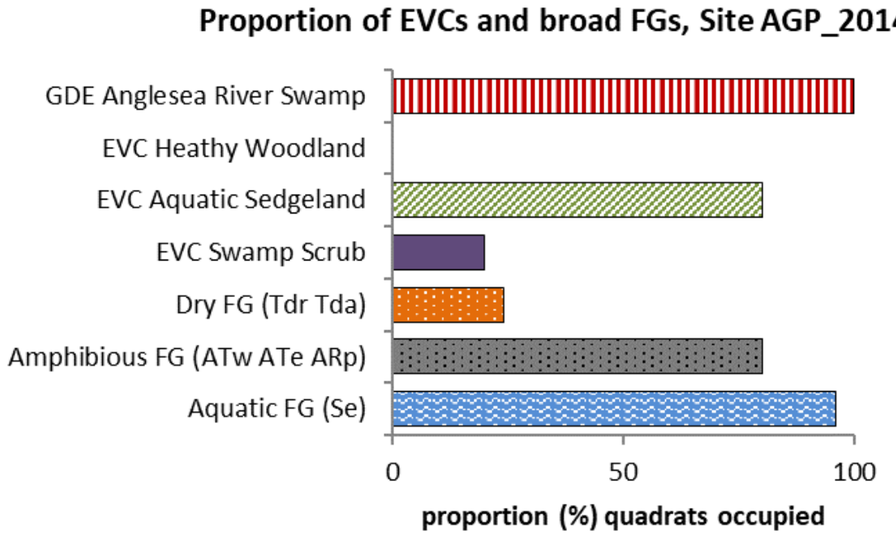
0—25m

25—50m



50—75m

75—100m



Dominant Plant Species		Broad FG	Quadrats occupied (% frequency)
Cycnogeton procerum sp. aff.	Common Water-ribbons	Aquatic	96
Melaleuca squarrosa.	Scented Paperbark	Amphibious	50
Juncus procerus	Tall Rush	Amphibious	36

Other attributes		
Average % bare ground cover	40	(bare ground recorded in 50 quadrats)
Average water depth along transect (cm)	16.5	Water recorded in 50 quadrats
Algal mat (quadrats occupied)	30	

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, 2020.

AGP2_2014: General habitat description					
Ecological Vegetation Class (EVC)	Aquatic Sedgeland				
Wetland permanence	Ephemeral				
This is a small (c. 0.25 ha) clearing in tall (up to 4 m) fringing vegetation of Scented Paperbark and Prickly Tea-tree (70-100%). Approximately 40% open water with 50–70% cover of floating Common Water-ribbons, interspersed with emergent rushes (*Juncus* spp.) and patches of Scented Paperbark. Emergent vegetation consisted of *Gahnia*, Common Water-ribbon, and rushes (50-70%), with submergent Common Water-ribbon.					
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	5.38	**Turbidity**	2 NTU	**Water temperature**	17.7 °C
EC	3.27 µs/cm	**Salinity**	0.16%	**Dissolved Oxygen**	6.02 mg/L
Survey 2					
pH	5.35	**Turbidity**	0 NTU	**Water temperature**	19.7 °C
EC	3.41 µs/cm	**Salinity**	0.17%	**Dissolved Oxygen**	2.56 mg/L
Comments					
No frogs were detected calling in either survey.					

Figure 12 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
The small (0.25 ha) section of swamp was generally moist with occasional deeper depressions. The vegetation, consists sedges and Pouched Coral-fern, surrounded by 70-100% cover of fringing Prickly Tea-tree and Scented Paperbark. There is a thick cover of emergent dead sedges and 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	3.84	**Turbidity**	0 NTU	**Water temperature**	13.3°C
EC	2.58 µs/cm	**Salinity**	0.12%	**Dissolved Oxygen**	1.55 mg/L
Survey 2					
pH	NA	**Turbidity**	NA	**Water temperature**	NA
EC	NA	**Salinity**	NA	**Dissolved Oxygen**	NA

Comments
The swamp was mostly moist throughout with the occasional deeper depression (0.05 m) during the first frog survey. Depth had declined by the second frog survey precluding water quality measurements. A Southern boobook owl was heard calling during the first frog survey. No frogs were detected in either nocturnal survey.

Figure 13 Anglesea Borefield terrestrial revised ecological Monitoring and Assessment Program, Anglesea Swamp site AS5, 2020 frog summary data.

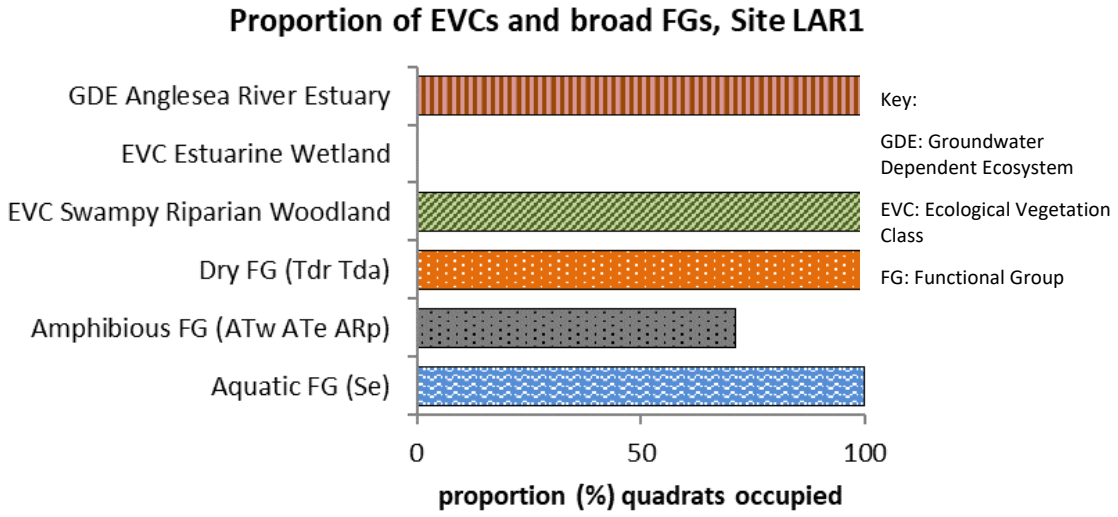
AS6: General habitat description	
Ecological Vegetation Class (EVC)	Aquatic Sedgeland
Wetland permanence	Ephemeral
Swamp relatively shallow (to 0.1 m) consisting of emergent (20–50%) vegetation consisting of decomposing sedges, small clumps of live sedges and Scented Paperbark. There are small (10-20%) amounts of submergent and floating vegetation consisting of sedges and algae. The swamp is fringed by 70–100% cover of Scented Paperbark. The swamp perimeter supports <5% cover of fallen branches and 5–10% cover of bare soil. Small runnels contain dead vegetation, algae and live sedges.	

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	5.14	**Turbidity**	7 NTU	**Water temperature**	18.8°C
EC	3.25 µs/cm	**Salinity**	0.17%	**Dissolved Oxygen**	4.65 mg/L
Survey 2					
pH	NA	**Turbidity**	NA	**Water temperature**	NA
EC	NA	**Salinity**	NA	**Dissolved Oxygen**	NA

Comments
Water quality was not measured during the second survey event due to insufficient depth. Southern brown tree-frog was detected calling about 200 m from the site during the second frog survey.

Figure 14 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 procerum sp. aff.	Common Water-ribbons	Aquatic	100
Eucalyptus ovata var. *ovata*	Swamp Gum	Dry	100
Juncus kraussii ssp. australiensis	Sea Rush	Aquatic	57
Leptospermum scoparium	Manuka	Dry	57

Other attributes	
Average % bare ground cover	0
Algal mat	2

Figure 15 Anglesea Borefield Monitoring and Assessment Program, Anglesea Estuary, Site LAR1, vegetation summary data, 2020

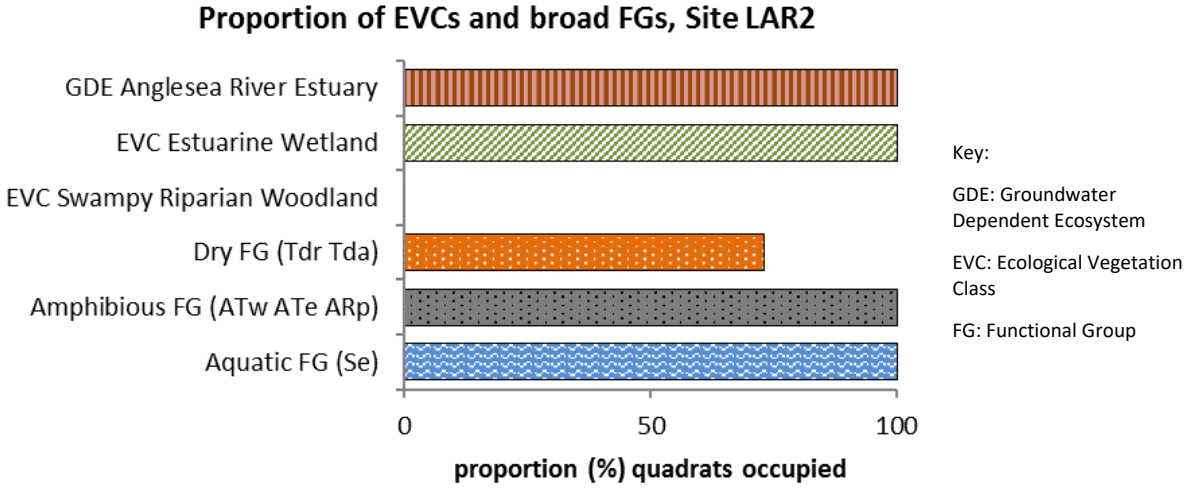
LAR1: General habitat description	
Ecological Vegetation Class (EVC)	Swampy Riparian Woodland
Wetland permanence	Permanent
This site is a section of slow-flowing creek 30–100 cm deep and 3-4 m wide, with 50–70% presence of submergent vegetation consisting of algae and Southern Water-ribbons and 20-50% cover of floating water-ribbons. The creek is fringed with young Common Reeds, water-ribbons and revegetation in the form of Prickly Tea-tree, Eucalypts and Goodenia. Common Reeds are an emergent vegetation along 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	5.36	**Turbidity**	3 NTU	**Water temperature**	15.2 °C
EC	4.04 µs/cm	**Salinity**	0.2%	**Dissolved Oxygen**	5.76 mg/L
Survey 2					
pH	4.11	**Turbidity**	1 NTU	**Water temperature**	18.4 °C
EC	4.04 µs/cm	**Salinity**	0.2%	**Dissolved Oxygen**	5.56 mg/L

Comments
During the second frog survey Common froglet (1-5 individuals), Pobblebonk (1-5 individuals), and Southern Brown Tree Frogs (1–5 individuals) were detected calling from more than 100 m upstream of the site.

Figure 16 Anglesea Borefield terrestrial revised ecological Monitoring and Assessment Program, Anglesea Estuary site LAR1, 2020 frog summary data.



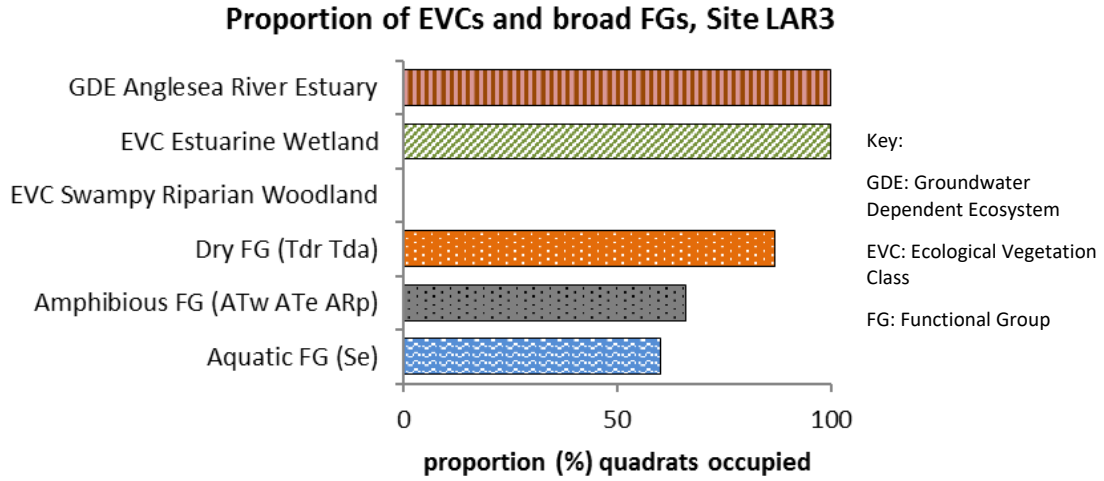
Dominant native plant species		Broad FG	Quadrats occupied (% frequency)
Juncus kraussii ssp. *australiensis*	Sea Rush	Aquatic	100
Lobelia anceps	Angled Lobelia	Amphibious	93
Phragmites australis	Common Reed	Amphibious	93

Other attributes	
Average % bare ground cover	1
Algal mat	0

Figure 17 Anglesea Borefield Monitoring and Assessment Program, Anglesea Estuary, Site LAR2, vegetation summary data, 2020.

LAR2: General habitat description					
Ecological Vegetation Class (EVC)	Estuarine Woodland				
Wetland permanence	Permanent				
Slow-moving creek in estuary 2 – 3 m deep and 7 m wide, fringed with 50–70% cover of Angled Lobelia, Coastal Tussock-grass, Sea Rush and Common Reed. The submergent vegetation comprises 5–10% cover at edge of channel consisting of dead reeds and algae. Floating vegetation consists of 5–10% water ribbon. 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		1	1
LAR2: Water quality parameters					
Survey 1					
pH	3.68	**Turbidity**	4 NTU	**Water temperature**	21.2 °C
EC	10.9 µs/cm	**Salinity**	0.59%	**Dissolved Oxygen**	9.3 mg/L
Survey 2					
pH	3.78	**Turbidity**	5 NTU	**Water temperature**	22.8 °C
EC	9.8 µs/cm	**Salinity**	0.55%	**Dissolved Oxygen**	7.26 mg/L
Comments					
Southern Bullfrogs (5–10) were heard and observed calling during both surveys, with distant individual heard calling up to 100 m from observers.					

Figure 18 Anglesea Borefield terrestrial revised ecological Monitoring and Assessment Program, Anglesea Estuary site LAR2, 2020 frog summary data.



Dominant native plant species		Broad FG	Quadrats occupied (% frequency)
Poa poiformis var. poiformis	Coast Tussock-grass	Dry	73
Juncus kraussii ssp. australiensis	Sea Rush	Aquatic	60
Leptosperumum scoparium	Manuka	Dry	60

Other attributes	
Average % bare ground cover	0
Algal mat	0

Figure 19 Anglesea Borefield Monitoring and Assessment Program, Anglesea Estuary, Site LAR3, vegetation summary data, 2020.

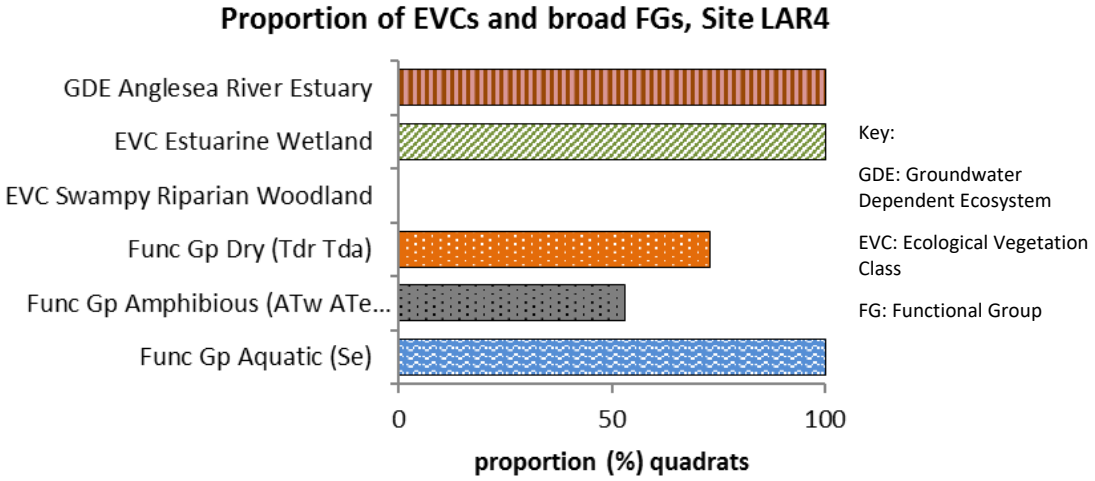
LAR3: General habitat description	
Ecological Vegetation Class (EVC)	Estuarine Woodland
Wetland permanence	Permanent
Slow-flowing creek up to 10 m wide and up to 2–3 m deep. There is 5–10% floating and 5–10% submergent vegetation, comprising of mainly Sedges and algae, Common Water-ribbons and Common Reeds. There is a nominal (5–10%) cover of emergent reeds and water-ribbons along the banks. The banks also contain a cover of bare soil, debris and fallen branches. 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**
1	0	1	2

LAR3: Water quality parameters					
Survey 1					
pH	4.53	**Turbidity**	3 NTU	**Water temperature**	18.6 °C
EC	5.96 µs/cm	**Salinity**	0.34%	**Dissolved Oxygen**	7.36 mg/L
Survey 2					
pH	3.61	**Turbidity**	4 NTU	**Water temperature**	21.9 °C
EC	9.2 µs/cm	**Salinity**	0.51%	**Dissolved Oxygen**	8.84 mg/L

Comments
Southern Brown Tree Frogs (1–5) were heard calling from within 100 m of observers. Southern Bullfrog were observed floating in the creek and heard calling along the path during both surveys.

Figure 20 Anglesea Borefield terrestrial revised ecological Monitoring and Assessment Program, Anglesea Estuary site LAR3, 2020 frog summary data.



Dominant native plant species		Broad FG	Quadrats occupied (% frequency)
Poa poiformis var. poiformis	Coast Tussock-grass	Dry	73
Juncus kraussii ssp. australiensis	Sea Rush	Aquatic	60
Leptosperumum scoparium	Manuka	Dry	60

Other attributes	
Average % bare ground cover	0
Algal mat	0

Figure 21 Anglesea Borefield Monitoring and Assessment Program, Anglesea Estuary, Site LAR4, vegetation summary data, 2020.

LAR4: General habitat description	
Ecological Vegetation Class (EVC)	Heathy Woodland
Wetland permanence	Permanent
This wide (<10 m) section of creek is up to 3 m deep and is fringed by revegetation (70–100%) along the west bank consisting of: Goodenia, Prickly Tea-tree, etc. The east bank is revegetated with Sea Rush, dead Common Reed and Coastal Tussock-grass. There are dense submerged algal mats along the bank and decomposing and emergent sedges and reeds. Low floating submergent vegetation (5–10%) consists 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**
1	0	1	2

LAR4: Water quality parameters					
Survey 1					
pH	3.83	**Turbidity**	4 NTU	**Water temperature**	20.8 °C
EC	10.4 µs/cm	**Salinity**	0.58%	**Dissolved Oxygen**	10.63 mg/L
Survey 2					
pH	3.73	**Turbidity**	4 NTU	**Water temperature**	22.4 °C
EC	8.39 µs/cm	**Salinity**	0.46%	**Dissolved Oxygen**	6.53 mg/L

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

Figure 22 Anglesea Borefield terrestrial revised ecological Monitoring and Assessment Program, Anglesea Estuary site LAR4, 2020 frog summary data.

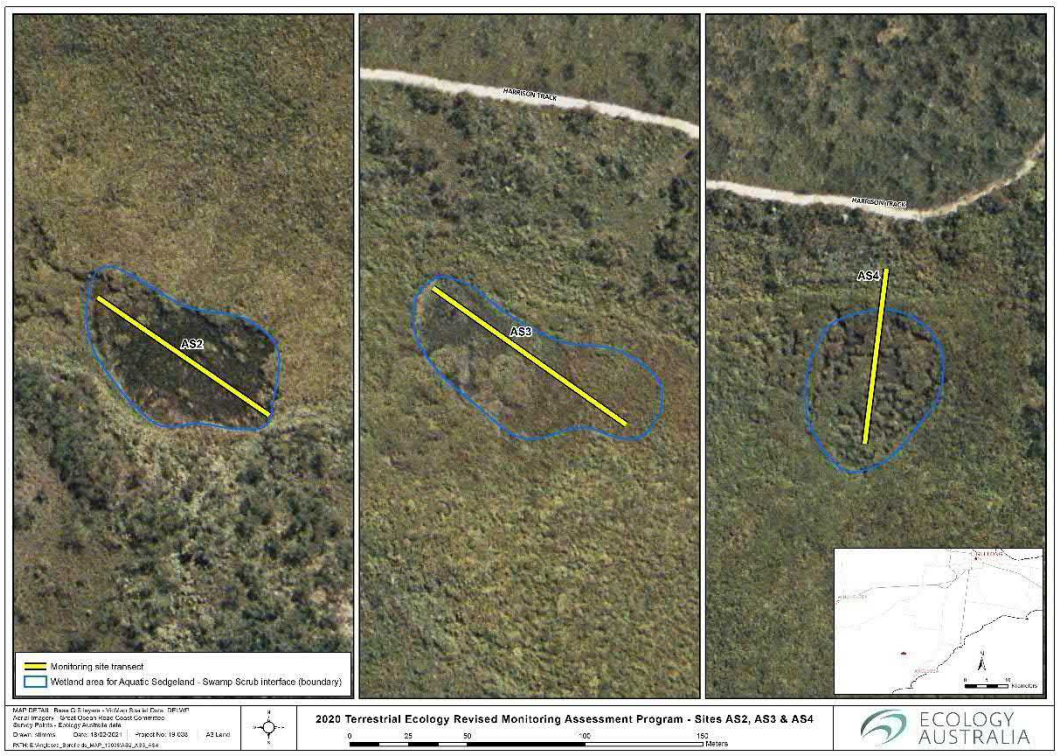


Figure 23 Anglesea Borefield ecological Monitoring and Assessment Program, wetland boundaries, sites AS2, AS3 and AS4, Anglesea Swamp 2020.

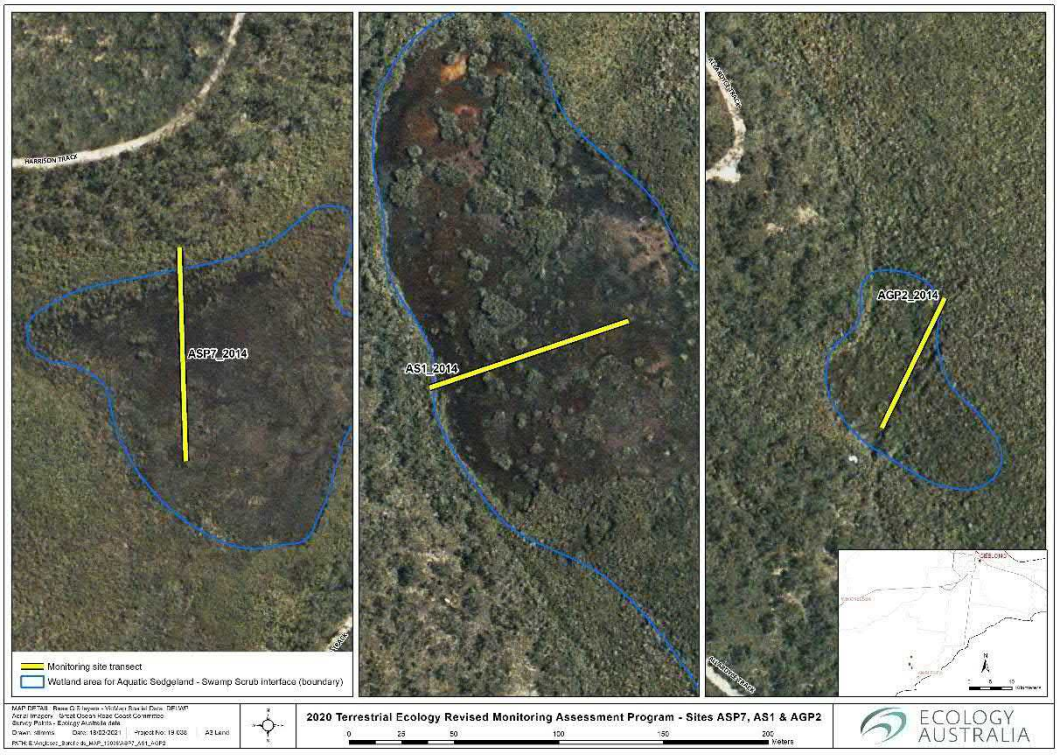


Figure 24 Anglesea Borefield ecological Monitoring and Assessment Program, wetland boundaries, sites ASP7_2014, AS1_2014 NS AGP2_2014, Anglesea Swamp 2020.

3.3 Macroinvertebrates

The macroinvertebrate results based on combined sample data from each site are provided in Table 7, 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 less than 200 macroinvertebrates in total across all three edge samples). At the time of sampling, BCT1 had very low surface water, however, three edge samples were still collected.

Site SC1 was considerably more diverse (i.e. a higher number of taxa) than sites W2/3 and BCT1 (Table 7). However, all three sites detected fewer taxa than the objective listed in the State Environmental Protection Policy – Waters objective (SEPP (W); Vic. Gov. 2018; Table 7). Sites SC1 and BCT1 achieved the SEPP (W) goal for SIGNAL score, however, site W2/3 did not. Both SC1 and BCT1 recorded a total of five EPT taxa, which is one short of the SEPP (W) objective, while no EPT taxa were detected at site W2/3 (Table 7). Overall, only two of a possible 12 objectives were met during the 2020 macroinvertebrate monitoring, with the overall objective attainment result being comparable to the 2019 result (Ecology Australia, 2020). Individual sample results from each site are presented in section 3.7.

Table 7 Site macroinvertebrate indices result from combined samples (non-attainment of SEPP (W) objectives indicated by shading)

Index	W2/3	SC1	BCT1	SEPP (W) objective*
# taxa	6	19	9	20
SIGNAL score	3.0	4.3	4.8	3.4
EPT	0	5	5	6*
EPTO	0	5	5	-

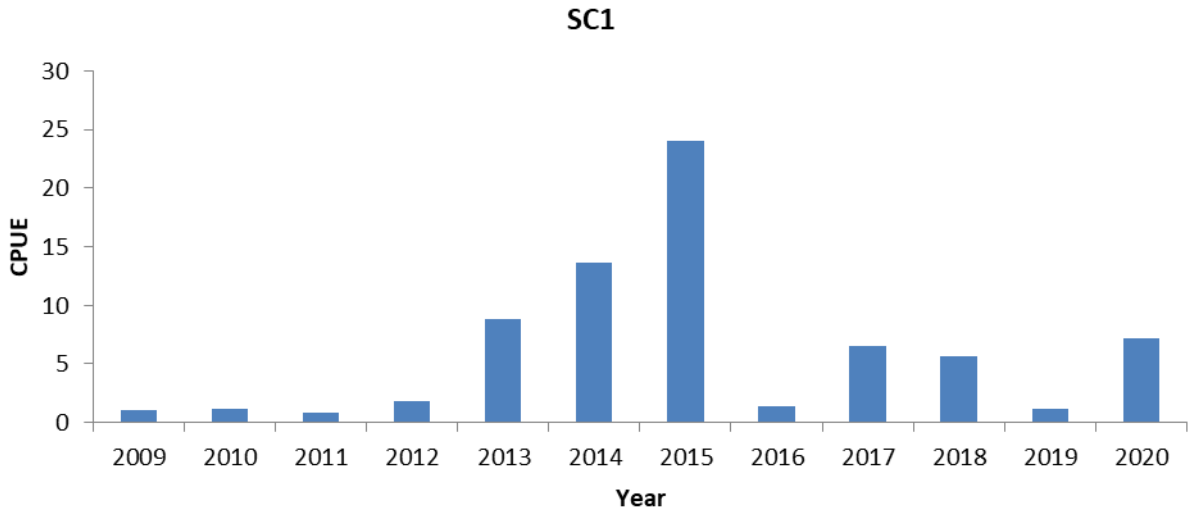
*Indicates an objective that was sourced from the previous report (Ecology Australia 2020) because no applicable objective exists in the current SEPP (W).

Plate 2 Leptoceridae (*Lectrides* sp.) outside its case, collected from site SC1 during the 2020 survey.

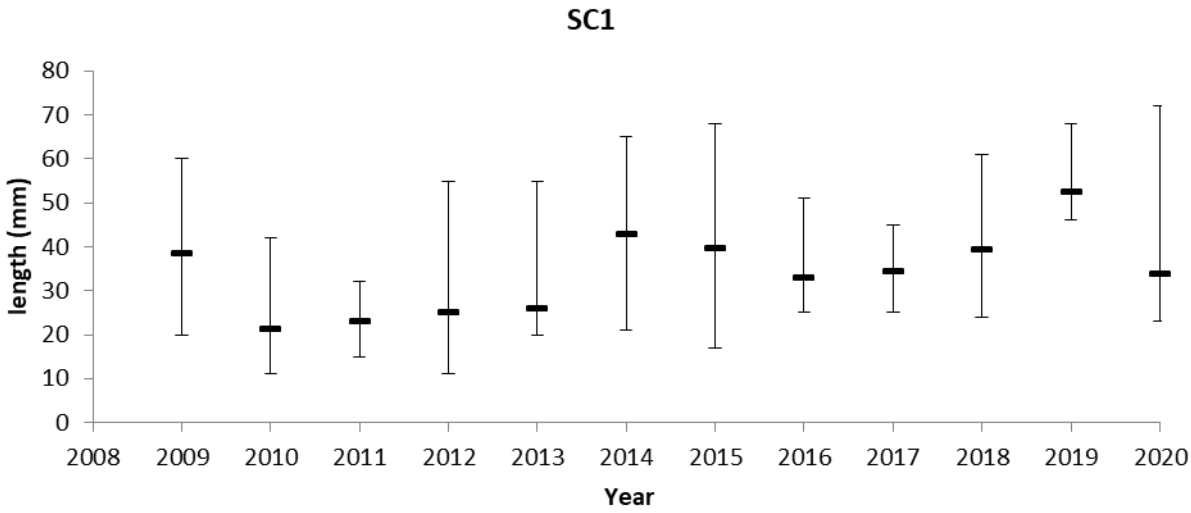
3.4 Southern Pygmy Perch

A total of 72 Southern Pygmy Perch were captured from Salt Creek (SC1), and none were captured from Breakfast Creek tributary (BCT1; Figure 25; Figure 26; and Plate 4). The Southern Pygmy Perch Catch Per Unit Effort (CPUE) from Salt Creek was the highest since 2015 (the highest year recorded) and represents the fourth-highest rate since 2009. Young of year fish (i.e. fish considered to be less than one year of age) were also detected at SC1, which indicates that fish are continuing to recruit within this system, despite a lack of recruitment evident in 2019. This year's sampling (2020) was the third consecutive year that Southern Pygmy Perch were not recorded at the Breakfast Creek tributary site.

Plate 3 Southern Pygmy Perch from SC1.

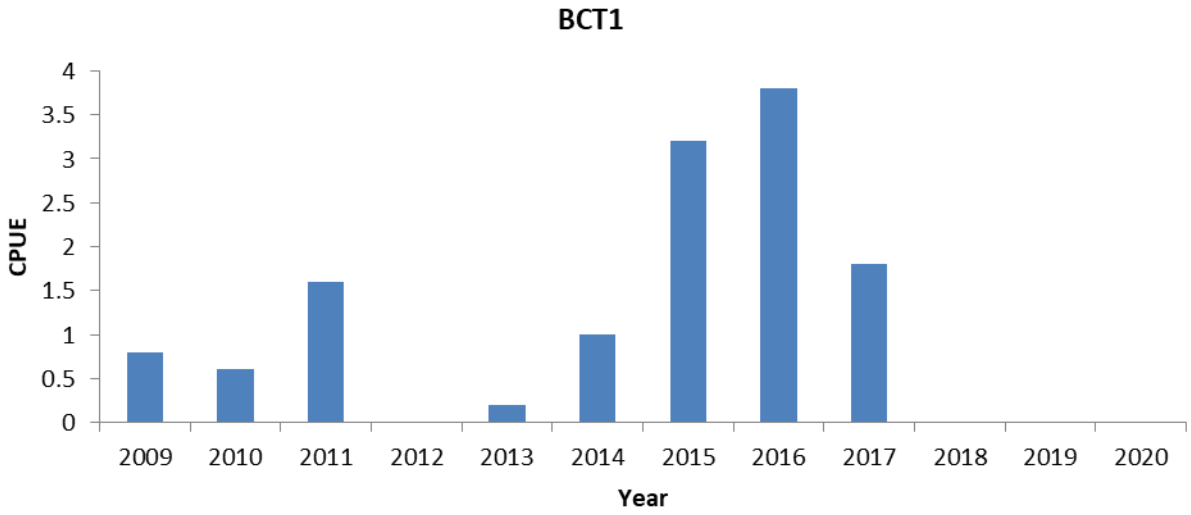


a) Fish Catch Per Unit Effort (CPUE; fish per trap) at site SC1.

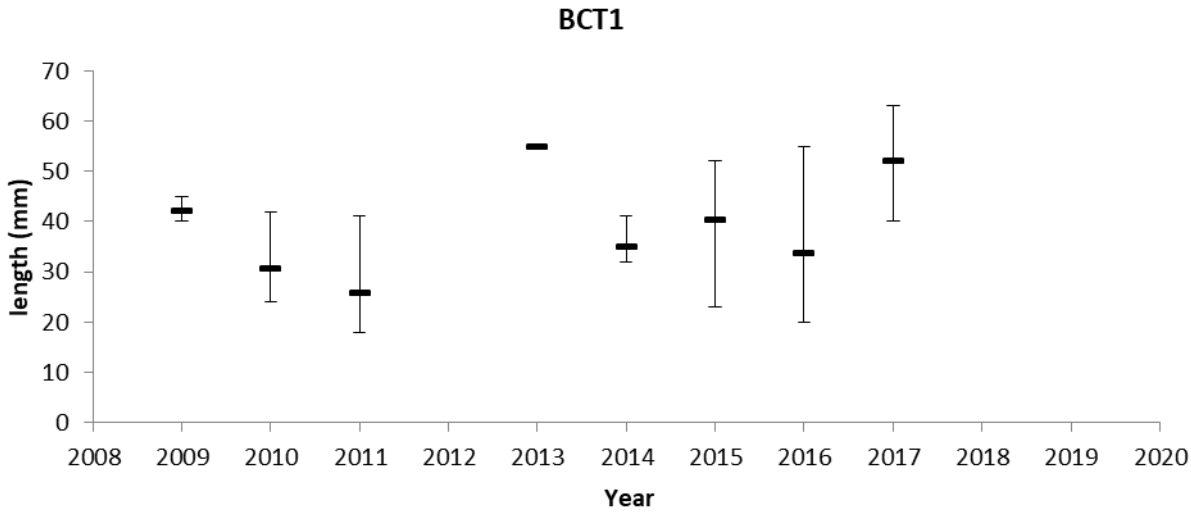


b) Mean (black bars), together with minimum and maximum lengths (TL) of Southern Pygmy Perch.

Figure 25 Site SC1 Southern Pygmy Perch spring CPUE (a), and length (b) summary 2009–2020.



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.

Figure 26 Site BCT1 Southern Pygmy Perch spring CPUE (a), and length (b) summary 2009–2020.

3.5 Water quality

Water quality results were fairly consistent with results from previous years (GHD 2010–17, Ecology Australia 2018–2020; Table 8). It should be noted that to accurately assess against SEPP (W) indices, a minimum of 11 data points are required from a single year, hence snap-shot measurements are incapable of indicating compliance. The SEPP (W) objectives are compared against the results only to provide context. For sites BCT1 and SC1, the SEPP (W) was potentially met for conductivity but not for dissolved oxygen or pH, while site W2/3 possibly did not meet any objective.

Table 8 In situ water quality results and SEPP (W) objectives (potential non-attainment of SEPP (W) objectives indicated by shading).

	Temperature (°C)	Conductivity (µs/cm)	Dissolved oxygen		pH
			mg/L	%Sat	
SEPP (W) objective		≤2000 (75th percentile)		≥70 (25th percentile	6.8-8 (25th -75th percentile)
BCT1	11.2	310	4.3	40.2	4.2
SC1	12.5	285	3.7	35.6	4.9
W2/3	12.9	4130	6.1	60.5	2.4

3.6 Otway Bush Yabby

Otway Bush Yabby *Geocharax tasmanicus* 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 2018–2020). Otway Bush Yabby was detected during both the fish survey (bait trapping) and the macroinvertebrate sampling (sweep sampling; Table 9). A total of 86 Otway Bush Yabbies were detected at site BCT1 and 94 at site SC1 during the 2020 sampling. This represents a total of 180 Otway Busy Yabbies, nearly three times the amount detected in 2019. As in previous years, Otway Bush Yabby was not detected at site W2/3.

Table 9 Records of Otway Bush Yabby (spring 2020).

Site	Macroinvertebrate sampling	Bait trapping
BCT1	81	5
SC1	20	74
W2&3	0	

Plate 4 Otway Bush Yabby – Salt Creek (SC1)

Plate 5 Otway Bush Yabbies – Breakfast Creek tributary (BCT1)

3.7 Aquatic monitoring sites

Wetland 2 and 3

Plate 6 Wetland 2 and 3

At the time of the survey, Wetlands 2 and 3 were very shallow, contracted, and dominated by dense stands of Paperbark and Tea-tree. The dominant aquatic vegetation taxa were *Triglochin* spp.

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 were highly abundant, and macrophytes and coarse particulate organic matter were present in moderate abundance. The majority of the site exhibited no obvious flow, with only a small area of slow flow being evident within a small channel crossing under the track. Despite combining the two wetlands (ref to section 2.3.1), this site had very limited standing water.

The macroinvertebrate results for the wetland site were poor (See Table 6 and Table 10). Overall, the macroinvertebrate abundance and diversity was very low, however, edge sample two and three achieved the desired SIGNAL score. Despite this, the overall SIGNAL score for W2/3 did not achieve the SIGNAL score goal (refer to Table 6). Macroinvertebrate sampling results from Wetland 2/3 were broadly similar to the most recent survey in 2019 (Ecology Australia 2020). No Otway Bush Yabby was detected at W2/3 in 2020 (Note: they have not been previously detected at this site).

Table 10 Individual macroinvertebrate sample results at W2/3, showing SEPP (W) objectives (shading indicates non-attainment of SEPP (W) objectives)

Metric	W2/3			SEPP (W) objective
	Edge sample 1	Edge sample 2	Edge sample 3	
# taxa	5	1	3	20
Abundance	35	6	38	-
SIGNAL2	3.0	6.0	3.7	3.4
EPT	0	0	0	6*
EPTO	0	0	0	-

*Indicates where the metric from the previous report and not the SEPP (W) was used.

Salt Creek (SC1)

Plate 7 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. and *Carex* spp.

Salt Creek attained SEPP (W) objectives for SIGNAL score for all three edge samples, however, did not attain SEPP (W) goals for all other indices (Table 11). Snapshot water quality appeared to be suitable for fish and crayfish although the results may potentially fail to meet the dissolved oxygen and pH goals. Strong numbers of Otway Bush Yabby were detected at SC1 with a total of 94 individuals detected across the two sampling methods used. This represents a significant increase in the number of Otway Bush Yabby detected at SC1 compared with the 4 detected in 2019.

Table 11 Individual macroinvertebrate sample results at SC1, showing SEPP (W) objectives (shading indicates non-attainment of SEPP (W) objectives)

Metric	SC1			SEPP (W) objective
	Edge sample 1	Edge sample 2	Edge sample 3	
# taxa	11	5	14	20
Abundance	40	21	112	-
SIGNAL2	4.9	5.0	4.0	3.4
EPT	3	1	4	6*
EPTO	3	1	4	-

The abundance of Southern Pygmy Perch at SC1 was the highest recorded since 2015. The length frequency histogram shows two distinct cohorts, those larger and older fish, around 70–75 mm and those younger fish around 25–40 mm. During the 2019 sampling only older and larger fish were detected, a potential indication of short term recruitment failure. However, the 2020 length data clearly shows that strong recent recruitment in the system has occurred and that the population size may now be slightly larger than it has been over the last five years. Southern Pygmy Perch typically reach maturity at approximately 30–33 mm (conservatively set at 30 mm for the histogram; Knight 2008) with the smallest length detected being smaller than 30 mm, indicating that young of year fish are likely to be present within the system.

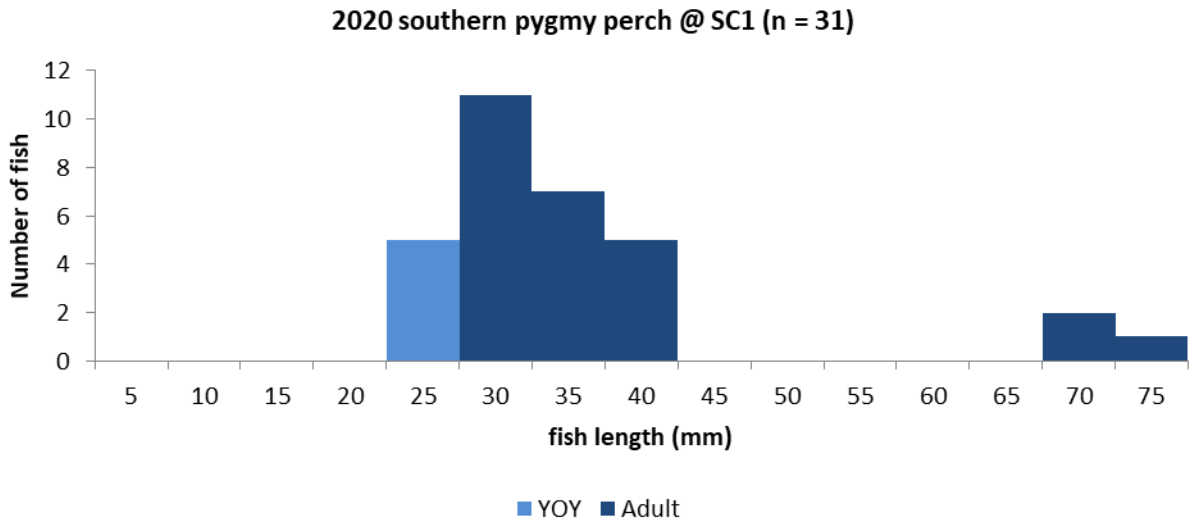


Figure 27 Length-frequency histogram of Southern Pygmy Perch at SC1 showing two distinct cohorts.

Breakfast Creek tributary 1 (BCT1) at SV3

Plate 8 Breakfast Creek tributary BCT1, showing stream gauge

Breakfast Creek tributary at site BCT1 consisted of a narrow, shallow stream, with a maximum width of 1.5 m. During the 2020 surveys, BCT1 was near dry with very slow flow only occurring adjacent to the stream gauge (over the small weir). Longitudinally the steam was a series of disconnected and/or poorly connected pools along the length of the surveyed reach. During the 2020 survey, 10 bait traps were set and three macroinvertebrate sweeps were taken. However, the length of reach was extended from that described in the 2019 report to account for the shallow, near dry prevailing habitat. The substrate was predominantly silt/clay, with some sand, pebble and gravel present. 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 macroinvertebrate survey of BCT1 showed that this site attained SEPP (W) objectives for SIGNAL scores for two of three edge samples (Table 12). No other SEPP (W) objectives were achieved at BCT1 either on a sample basis or site/combined sample basis (see Table 6). The overall abundance of macroinvertebrates during the 2020 survey was low, however, it is a promising sign that EPT taxa remain and make up a large proportion of the taxa present. Snapshot water quality appeared to be suitable for fish and crayfish although the results may potentially fail to meet the dissolved oxygen and pH objectives. Strong numbers of Otway Bush Yabby were detected at BCT1 with a total of 86

individuals detected across the two sampling methods used. This represents an increase in the 57 Otway Bush Yabbies detected at BCT1 in 2019 (Ecology Australia 2020).

Table 12 Individual macroinvertebrate sample indices result at BCT1, showing SEPP (W) objectives (shading indicates non-attainment of SEPP (W) objectives)

Metric	BCT1			SEPP (W) objective
	Edge sample 1	Edge sample 2	Edge sample 3	
# taxa	5	1	6	20
Abundance	14	1	20	-
SIGNAL2	6.2	6.0	3.3	3.4
EPT	4	1	2	6*
EPTO	4	1	2	-

No Southern Pygmy Perch were detected at BCT1 during this round of monitoring. This is the third year in a row that this species has not been detected at BCT1. Previous reports have highlighted that there may have been a recruitment failure at this site in 2017.

4 Discussion

4.1 Vegetation

Overall, there appeared to be little change in vegetation health in the swamp and estuary in 2020 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 2014–2019). Similarly, plant diversity across 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 2014–2019). However there does appear to be an emerging trend of change in percentage frequency of five wetland species across four of the Anglesea Swamp sites. The two hydro-ecological functional groups that are represented in this trend are ATe represented by Tall Rush at site AGP_2014 and Se represented by Fine Twig-sedge, Square Twig-sedge, Tall Spike-sedge and Water Ribbons.

The observable decline in health of one species in the ATe functional group at site AGP_2014 would suggest that the growth tolerance of the species at the site has been exceeded. Using the descriptions of the functional group (Table 1) this could indicate that the site has received less than 8 months of inundation of water on an annual basis since. This appears to generally coincide with a number of very dry years for rainfall. It is important to note that there are other variables that can affect plant health such as soil and water salinity and acidity.

The general trend of decline across multiple species, in particular Tall Spike-sedge, Fine Twig-sedge and Square Twig-sedge from the Se functional group suggests that there has been an increased drying out of the root-zones of these plants during the dry periods over multiple years. Again, this is consistent with the more recent lower rainfall years. One species Water Ribbons from the same functional group (Se) showed a more variable (temporal and spatial) changes in percentage frequency which could be a function of the plant's biology differences.

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 13 Total plant numbers and number of plant species in Functional Groups at study sites in the Anglesea Swamp, Anglesea Borefield Monitoring and Assessment Program, 2020.

Anglesea Swamp Transect/ Site	Year	Total number of native species	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

Anglesea Swamp Transect/ Site	Year	Total number of native species	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)
	2016	15	9	2	4
	2017	16	10	2	4
	2019	15	9	4	2
	2020	13	7	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
	2020	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
	2020	15	3	9	3
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
	2020	14	3	9	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

Anglesea Swamp Transect/ Site	Year	Total number of native species	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)
	2020	12	5	4	3
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
	2020	8	1	5	2

Table 14 Total plant numbers and number of plant species in Functional Groups at study sites in the Anglesea Estuary, Anglesea Borefield Monitoring and Assessment Program, 2020.

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
	2020	9	3	4	2
LAR2	2015	11	4	4	3
	2017	10	4	4	2
	2019	9	3	4	2
	2020	12	6	4	2
LAR3	2015	13	6	4	3
	2017	14	7	4	3
	2019	13	7	4	2
	2020	14	9	4	1

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)
LAR4	2015	12	3	6	3
	2017	8	2	4	2
	2019	8	3	3	2
	2020	9	4	3	2

No weed species were recorded in the swamp. Weed species continue to be recorded in all estuary sites except LAR4 (Appendix 2). Native plant species continue to be recorded in higher numbers and higher frequencies than weeds since monitoring in the estuary began (see Ecology Australia 2015, 2017 and 2019).

There was little sign of recent disturbance in the swamp. Where the vehicle disturbance was noted at site ASP7_2014 in 2019, the aquatic vegetation appears to be re-growing and recovering.

In the swamp, the large increase in bare ground in 2020 compared to previous surveys is due to the inclusion of soil below the water surface to the total bare ground. Therefore, this increase is not comparable to previous surveys. Due to the lack of disturbance across all sites, the amount of bare ground is likely similar to that observed in 2019.

Algal mats continue to be recorded in the Anglesea Swamp (first recorded in 2016) (Figure 28). 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.

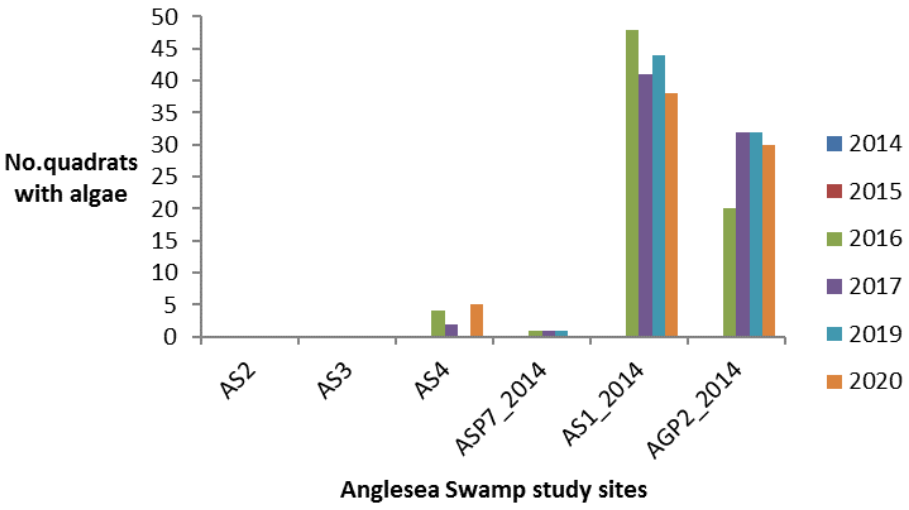


Figure 28 Algae records at study sites in the Anglesea Swamp, 2020

The 2020 climate data from the nearest weather station (Aireys Inlet ~ 10km away from Anglesea township) shows a mean annual rainfall of 620 mm from 1994—2020 (BOM 2021). Relative to this average, years with below average rainfall were 2014 (498 mm), 2015 (489 mm), 2017 (607 mm) and 2019 (525 mm). The 2016 annual rainfall (714 mm) was higher than the 1994–2020 mean (620 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 2020 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 15, Figure 27). Although there were several individual frogs observed at the estuary sites, frogs were heard calling from more than 100 m from several survey sites, indicating that frogs occur in the greater area. The low recorded species diversity and abundance of frog species is likely correlated with the quality of frog habitat in the study area.

While hydroperiod requirements differ among the different frog species, due to specific reproductive characteristics, the presence of suitable quality water is a basic requirement for successful reproduction and tadpole metamorphosis (Hazell et al. 2003). For instance, Southern Bullfrog tadpoles typically require a period for development of up to six months to reach maturity. Hence, this species needs standing water for more than half a year for successful reproduction (Anstis 2013).

Conversely, 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). During the 2020 surveys, most of the Anglesea Swamp supported standing water during the first frog survey, and while some sites reduced water levels by the second survey they had not dried out as in 2019. As such, the hydro-period at most sites should have been suitable for frog reproduction during the current survey. Frogs were recorded at four of the eight sites in 2016, a year that had above average winter/spring rainfall (587.6 mm compared to 408.1 mm on average) and 7 of the 8 sites had standing water during the first survey (Ecology Australia 2017). During the 2020 surveys a similar number of sites had standing water (8 of 8), with a similar average depth to that observed in 2016. The reduced number of frogs detected during the 2020 surveys is intriguing and is likely suggestive of the influence of a suite of long-term factors that may be impacting frog reproduction and subsequent recruitment. For instance, while conditions during the 2020 season were more conducive for frog reproduction and recruitment the low number of frogs detected across many of the survey long-term survey sites may be indicative of a lag in the rate of recovery of frogs in the greater Anglesea swamp and estuary system. Indeed, I must be acknowledged that the last couple of surveys only detected low numbers of frog number at a small number of sites. The previous surveys have consistently cited the role of reduced hydro-period for the low numbers of frogs detected, which has ultimately resulted in reproductive failure of frogs in the Anglesea swamp and estuary. Low hydro-period would affect frogs by 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. Ultimately, these effects would have reduced options for frogs to breed and the likelihood that any eggs or tadpoles could hatch and successfully reach metamorphose.

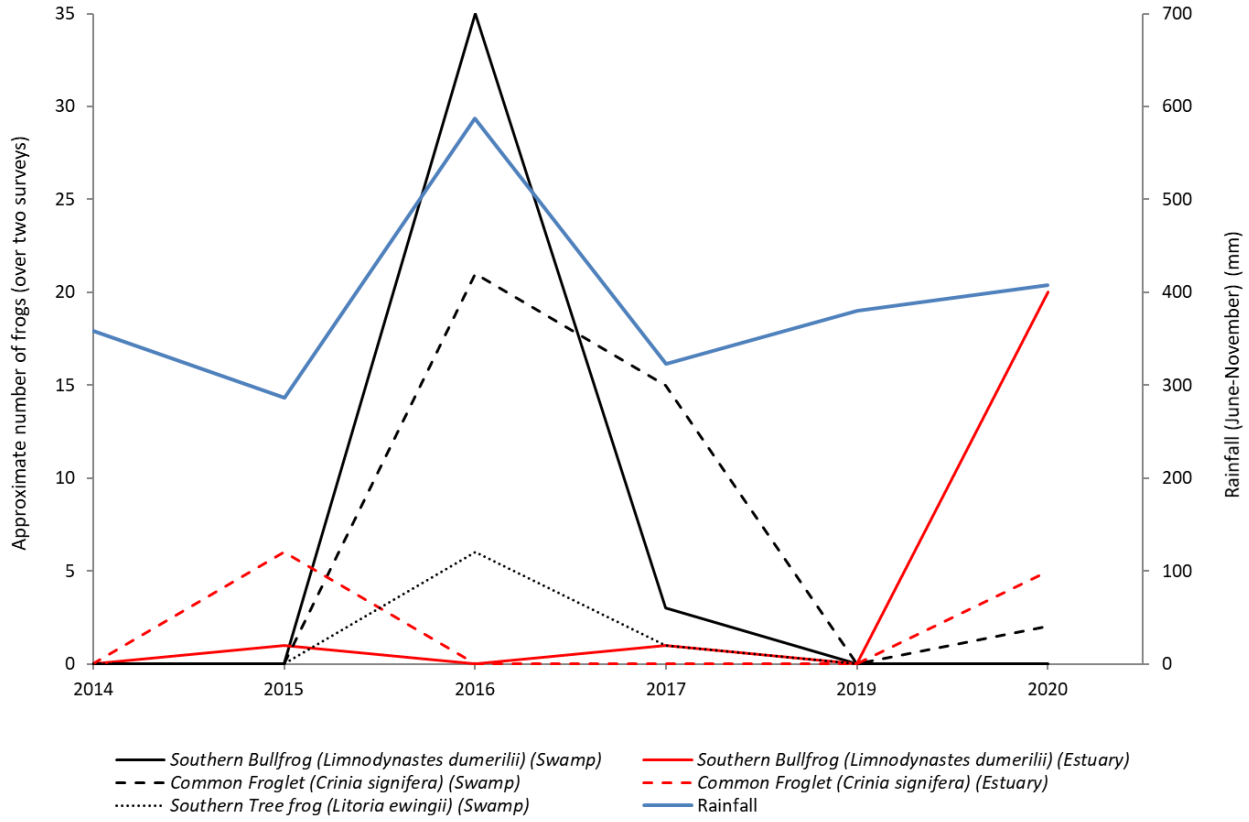


Figure 29 Approximate number of frogs recorded in spring surveys at the Anglesea Swamp and Anglesea Estuary, as part of the Anglesea Borefield Monitoring and Assessment Program, and average winter and spring rainfall, 2014–20[1]. Two surveys were undertaken in each year, except for 2014, when sites were surveyed once.

Further, evidence from the water quality data suggests key water quality metrics may be impacting the quality of frog habitat. For instance, acidic water can negatively impact the survival and growth of both frog eggs and developing tadpoles. Striped Marsh Frog egg s experience 100% mortality at pH below 4.0 (Barth and Wilson 2010). Many of the sites in the Anglesea catchment exhibited acidic water metrics. While there may be species-specific differences in acidic tolerance levels, the very acidic conditions in those areas surveyed may be negatively affecting frog reproduction. Nonetheless, whether this is the case over the long-term is difficult to address in the absence of long-term water quality data.

Similarly, the survival of Southern Brown Tree Frogs declines in elevated saline conditions (Chinathamby et al. 2006), with lower numbers of Southern Bullfrogs have been recorded in stormwater ponds with

[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).

elevated salinity (Hamer et al. 2012). High saline levels may also have a negative impact on adult frog populations, making them more prone to desiccation. Moderately high salinity/electrical conductivity levels were recorded at both the Swamp (0.02–3.93 ms/cm) and Estuary (4.04–10.90 ms/cm), which may further reduce the potential for frogs to successfully reproduce in these areas. As such, the combination of these factors could act to further reduce the likelihood of successful reproduction of amphibians at sites within the Anglesea swamp and estuary.

Table 15 Number of survey sites in the Anglesea Swamp and Anglesea Estuary at which frogs were recorded during spring surveys of the Anglesea MAP, 2014–20.

Area	Common name	Species	2014	2015	2016	2017	2019	2020
Anglesea Swamp	Southern Tree Frog	*Litoria ewingii*	0	0	2	1	0	0
	Southern Bullfrog	*Limnodynastes dumerilii*	0	0	2	1	0	0
	Common Froglet	*Crinia signifera*	0	0	3	1	0	1
		Any species	**0**	**0**	**4**	**1**	**0**	**1**
Anglesea Estuary	Southern Tree Frog	*Litoria ewingii*	NA	0	NA	0	0	0
	Southern Bullfrog	*Limnodynastes dumerilii*	NA	1	NA	1	0	2
	Common Froglet	*Crinia signifera*	NA	2	NA	0	0	0
		Any species	**NA**	**3**	**NA**	**1**	**0**	**2**

4.3 Aquatic Ecology

The macroinvertebrate monitoring results were relatively consistent with previous years, although almost all indices showed a marginal reduction compared with the 2019 results. The exception was for EPT at sites BCT1 and SC1, which were higher, and the number of taxa at SC1 (identical to 2019). The low abundance and diversity of macroinvertebrates detected, and poor performance against SEPP (W) objectives could be attributed to a few different factors. In particular, the low water levels and limited surface water at BCT1 and W2/3 resulted in a corresponding scarcity of habitat to sample. The site SC1 showed the best result in terms of macroinvertebrate community and also the largest volume of water and habitat available, as expected. A combination of low level of surface water and poor habitat is likely to affect the results by both limiting the area/habitat available during sampling and reducing the likelihood that the full suite of macroinvertebrates can persist within those sites. Moreover, consecutive years at a low water level and reduced habitat have now been recorded at BCT1 and W2/3, likely worsening these effects. Whereas, site SC1 habitat suitability has remained relatively consistent over the past few years, and relatively similar in terms of the macroinvertebrate community. Overall, it appears that the macroinvertebrate community within SC1 has been fairly stable through time, whereas the community at sites BCT1 and W2/3 are showing diminishing signs. The additional sampling (i.e. a greater number of sites sampled) that is undertaken triennially as per the MAP (Victorian Government, 2014) is due to be completed in 2021. This more comprehensive sampling will provide an improved understanding of long term macroinvertebrate community changes.

The Southern Pygmy Perch population at site SC1 has shown a sizeable increase in catch between 2019 and 2020 which may indicate a substantial increase in population size to levels not seen since 2015. The increase appears driven by strong recent recruitment resulting in a dominant cohort of juvenile and

young of year fish. Conversely, this was the third year in a row that no Southern Pygmy Perch have been detected at BCT1. This result is alarming as it may indicate the extirpation of the species population in the local area. However, previous reports for this species have noted that populations can reappear after several years of no recruitment (GHD 2013–2015). This suggests that the site surveyed during this project is possibly not the Breakfast Creek 'source population' and is a site where extirpation and subsequent re-colonisation from a nearby source population have occurred previously. If so, more consistent and representative monitoring results are likely to be obtained from an additional or alternative site in the Breakfast Creek catchment. Given the population of Southern Pygmy Perch in the Anglesea catchment is genetically distinct when compared to nearby catchments (Cesar 2012), it is important to maintain the population within both Salt Creek and Breakfast creek. The persistence of suitable habitat within drought refuge pools is expected to be the key to ensuring the persistence of source populations. Identification and monitoring of such sites should therefore form an important component of the monitoring program.

Otway Bush Yabby populations within both SC1 and BCT1 were the highlight of the 2020 survey, with more than triple the number detected in 2020 compared with 2019. They were abundant in both the deeper and more stable SC1 as well as in the shallow and poorly connected pools of BCT1, meaning that with this species able to complete its life cycle in both permanent and more intermittent habitats, with a large proportion of small individuals detected at both sites (indicative of good recruitment). This species was first detected in Salt Creek in 2007 (Schultz 2007) but was likely misidentified as Common Yabby *Cherax destructor* or unidentified Parastacidae (from the macroinvertebrate samples) until 2017, as all Parastacidae recorded since 2017 have been Otway Bush Yabbies. Since 2017 the Otway Bush Yabby population appears to be increasing further, with 2020 being the highest catch rate recorded, and more than triple that recorded in the previous year. Based on both the abundance and broad size range detected, it appears that a healthy population occurs at sites BCT1 and SC1. The apparent boom in the recruitment of Otway Bush Yabby may also be a sign of increasing intermittency and a reduction in the quality of habitat for fish (including eels) within the borefields.

Recommendations regarding the aquatic monitoring component were proposed after the 2018 monitoring event (Ecology Australia 2019). These recommendations remain current and are reproduced and expanded upon following the 2020 event 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 greater importance in collecting higher quality individual samples. The trade-off of this approach in terms of reduced replication and reduced data compatibility also requires consideration. It should be noted that to overcome the issue of low surface water availability in 2020, the site BCT1 was slightly expanded compared with the site boundary in 2019 (when only two samples were successfully taken). The suitability of this change being made permanent would best be considered as part of a review of the MAP.
- Given the recent failures to detect Southern Pygmy Perch at BCT1, it would be beneficial to survey additional/alternative locations on Breakfast Creek to establish if the population of Southern Pygmy Perch persists. In addition, it would be beneficial to reassess the catchment as a whole 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, identification of refuge pools in the Breakfast Creek catchment, and investigation of known refuge pools throughout Salt Creek and Anglesea River (as identified in GHD 2010). 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 in terms of maximising capture rates.

- The 2019 and 2020 surveys have now both included Otway Bush Yabby as a target species and the population has shown signs of stability and growth in the area. Including investigations into the extent of the population throughout the study area should be included in the triennial macroinvertebrate survey. This requires no modification to the methods other than collecting data from the specimens collected. This additional effort could further be expanded by including this species in an expanded Southern Pygmy Perch catchment assessment, as the survey methodology would be similar and cost-effective.
    - In addition, we recommend that occipital carapace length (OCL) for up to 30 individuals per site per method to the nearest mm be recorded for Otway Bush Yabby for all future monitoring targeting this species. This data may then be used and present in a similar way to the lengths present for the Southern Pygmy Perch (i.e. length-frequency histograms) and OCL data will allow for a greater understanding of the size classes present within the borefields for this species.

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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 2020

Status	Scientific name	Common name	Functional group	AS2	AS3	AS4	ASP7_2014	AS1_2014	AGP2_2014
	Banksia marginata	Silver Banksia	Tdr			✓			
	[1]*Machaerina arthrophylla*	Fine Twig-sedge	Se			✓	✓	✓	✓
	Machaerina juncea	Bare Twig-sedge	Tda				✓	✓	
	Machaerina tetragona	Square Twig-sedge	Se	✓	✓	✓			
	Cassytha glabella	Slender Dodder-laurel	Tdr		✓	✓	✓	✓	
	Cycnogeton procerum sp. aff.	Common Water-ribbons	Se	✓		✓	✓	✓	✓
	Eleocharis sphacelata	Tall Spike-sedge	Se					✓	
	Empodisma minus	Spreading Rope-rush	ATe		✓	✓	✓	✓	✓
	Epacris obtusifolia	Blunt leaf-Heath	ATw		✓	✓	✓		
r	*Eucalyptus falciformis*	Western Peppermint	Tdr	✓					
	Gahnia radula	Thatch Saw-sedge	Tdr	✓					
	Gahnia sieberiana	Red-fruit Saw-sedge	ATe	✓		✓	✓		✓
	Gleicheinia dicarpa	Pouched Coral-fern	ATe		✓	✓	✓	✓	
	Gleichenia 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	✓					

Status	Scientific name	Common name	Functional group	AS2	AS3	AS4	ASP7_2014	AS1_2014	AGP2_2014
	Pteridium esculentum	Bracken	Tdr	✓				✓	
	Rytidosporum procumbens	White Marianth	Tdr	✓					
	Schoenus brevifolius	Zig-zag Bog-sedge	ATe	✓	✓	✓	✓	✓	
	Sprengalia incarnata	Pink Swamp-heath	ATw		✓	✓	✓		
	Xyris operculata	Tall Yellow-eye	ATe		✓				

[1] *Machaerina* is synonymous with *Baumea* recorded in previous surveys.

Appendix 2 Anglesea Borefield, terrestrial ecology, Monitoring and Assessment Program, Anglesea Estuary, plant species and Functional Groups (native plant species only) spring 2020

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	LAR4
#	*Acacia longifolia subsp. longifolia*	Sallow Wattle	NA			✓	
#	*Acacia longifolia subsp. sophorae*	Coast Wattle	NA	✓			
	Acacia verticillata	Prickly Moses	Tdr			✓	
*	*Aira elegantissima*	Delicate Hair-grass	NA			✓	
*	*Anthoxanthum odoratum*	Sweet Vernal-grass	NA			✓	
	Cassytha melantha	Coarse Dodder-laurel	Tdr				✓
	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	✓	✓	✓	✓
	Goodenia radicans	Shiny Swamp-mat	ARp			✓	
*	*Holcus lanatus*	Yorkshire Fog	NA	✓		✓	
*	*Hypochaeris radicata*	Cat's Ears	NA			✓	
	Juncus kraussii ssp. australiensis	Sea Rush	Se	✓	✓	✓	✓
	Lachnagrostis filiformis	Common Blown-grass	Tdr		✓	✓	
	Leptinella longipes	Coast Cotula	ARp		✓	✓	✓
	Leptosperumum scoparium	Manuka	Tda	✓	✓	✓	✓
	Lobelia anceps	Angled Lobelia	ATe	✓	✓	✓	✓
*	*Lotus sp.*	Lotus	NA			✓	
	Myoporum insulare	Common Boobialla	Tda		✓	✓	
	Phragmites australis	Common Reed	ARp	✓	✓	✓	
*	*Plantago coronopus*	Buck's-horn Plantain	NA		✓	✓	
	Poa poiformis var. poiformis	Coast Tussock-grass	Tdr		✓	✓	✓
	[1]*Goodenia radicans*	Shiny Swamp-mat	ARp	✓	✓		✓

Status	Scientific name	Common name	Functional group	LAR1	LAR2	LAR3	LAR4
	Senecio glomeratus	Annual Fireweed	Tdr		✓		
*	*Sonchus oleraceus*	Sow Thistle	NA			✓	
*	*Vulpia bromoides*	Squirrel-tail Fescue	NA			✓	

[1]*Goodenia radicans* is synonymous with *Selliera radicans* recorded in previous surveys

Appendix 3 Results by sample of macroinvertebrate sampling in 2020. (E1 = Edge sample 1, E2 = Edge sample 2 and E3 = Edge sample 3)

Taxa	W2/3				BCT1				SC1				**Total**
	E1	E2	E3	Total	E1	E2	E3	Total	E1	E2	E3	Total	
Acarina				**0**				**0**	1			**1**	**1**
Amphipoda				**0**				**0**	4			**4**	**4**
Ceratopogonidae	1			**1**				**0**				**0**	**1**
Chironominae			7	**7**			2	**2**	3	1	28	**32**	**41**
Culicidae	19			**19**			4	**4**			1	**1**	**24**
Curculionidae				**0**				**0**			1	**1**	**1**
Dytiscidae	4		4	**8**	8		1	**9**	3		36	**39**	**56**
Gripopterygidae				**0**	1			**1**				**0**	**1**
Hydrochidae				**0**				**0**		1	1	**2**	**2**
Hydrophilidae	1			**1**				**0**			1	**1**	**2**
Koonungidae				**0**				**0**			4	**4**	**4**
Leptoceridae (*Lectrides*)				**0**				**0**			1	**1**	**1**
Leptoceridae (*Leptorussa*)				**0**			6	**6**				**0**	**6**
Leptoceridae (*Triplectides*)				**0**	2	1	6	**9**			1	**1**	**10**
Leptophlebiidae				**0**				**0**	1		2	**3**	**3**
Leptophlebiidae (*Ulmerophlebia*)				**0**	1			**1**	1	4	2	**7**	**8**
Oligochaeta				**0**			1	**1**				**0**	**1**
Paramelitidae				**0**				**0**	4	14	24	**42**	**42**
Polycentropodidae (*Plectrocnemia*)				**0**	2			**2**	1			**1**	**3**
Scirtidae	10	6	27	**43**				**0**		1	1	**2**	**45**
Tanypodinae				**0**				**0**	3			**3**	**3**
Tipulidae				**0**				**0**	1			**1**	**1**
Veliidae				**0**				**0**	18		9	**27**	**27**
Total	**35**	**6**	**38**	**79**	**14**	**1**	**20**	**35**	**40**	**21**	**112**	**173**	**287**