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Upper Barwon River Investigation 2019/2020

- Final Report
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Upper Barwon River Investigation 2019/2020

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Contents

Executive Summary

Austral Research and Consulting investigated the extent of impacts from Big Swamp on surface water, sediments and the macroinvertebrate community structure in Boundary Creek and the upper Barwon River in Spring 2019 and Autumn 2020. Water samples were collected for analysis with a specific focus on metals and the impacts of pH on these analytes from the East and West Barwon Rivers, Boundary Creek downstream of Big Swamp, and the Barwon River down to Winchelsea. Surface water and sediment results from Spring sampling suggested that the drying and wetting of Big Swamp has mobilised Aluminium, Cadmium, Iron, Lead and Zinc in the Barwon River but this impact is not recorded downstream of Birregurra. Autumn and Spring/ Autumn analysis suggested reduced flows over Summer decreased the concentration of most metals in water in Boundary Creek and the continuing poor macroinvertebrate diversity in Boundary Creek is most likely affected by low pH. Whilst Boundary Creek remains impacted by Big Swamp, overall waterway health indices suggest the Barwon River downstream of Boundary Creek is healthy with an average Aquatic Life index of 8 out of 10. Continued monitoring of Boundary Creek and the upper Barwon River during the remediation process is recommended to provide feedback as to the success of remediation works.

1. Introduction

Austral Research and Consulting (Austral) were contracted by Barwon Water to undertake an investigation into the sediment and water quality and macroinvertebrate condition of the upper Barwon River with regard to the extent of impact of low pH inflows from Boundary Creek.

The survey determined a baseline for ongoing monitoring of the Barwon River as part of a remediation plan required by a section 78 Ministerial Notice by:

- Assessing the spatial extent of surface water effects resulting for acidic discharge from Boundary Creek in the Barwon River,
- Determining if acidic discharge from Boundary Creek has affected sediment in the Barwon River and if so, the spatial extent and depth of accumulation, and;
- Assess the potential impact of acidic discharge from Big Swamp at Yeodene on the macroinvertebrate community structure in Boundary Creek and the Barwon River.

This report should be read in conjunction with that produced in 2019 by Austral Research and Consulting 'Investigation of Sediments and Macroinvertebrates in the Upper Barwon River'.

1.1. Background

Studies have confirmed that past water extractions from the Barwon Downs borefield by Barwon Water to boost Geelong's water supply in conjunction with a dry climate lead to reductions in flows in lower Boundary Creek (Jacobs, 2017). This in turn caused Big Swamp to dry out activating naturally occurring acid sulfate soils that when rewetted have released acidic water into the lower reaches of Boundary Creek. Boundary Creek joins the Barwon River 3.7km downstream of Big Swamp.

2. Methods

A total of twelve sites were surveyed along East Barwon, West Barwon, and Barwon Rivers in addition to Boundary Creek (Figure 1).

Figure 1: Barwon River and Boundary Creek (base map from Waterwatch Victoria)

2.1. Site Selection

Sites were selected in consultation with Barwon Water to best give an indication of the impact of water coming from Big Swamp on Boundary Creek and particularly the Barwon River. Two sites are on the East Barwon River, one site is on the West Barwon River, one site is on Boundary Creek and eight sites are on the mainstem Barwon River. They incorporate existing Waterwatch sites, upstream sites that are unimpacted by Boundary Creek (sites 1-4) and sites focused on any impacts from Boundary Creek (Table 1).

Site no.	Existing number	Site description	Lat	Long
1	CO_BAR004 (inact.)	East Barwon River @ Kents Road, Yaugher	-38.512196	143.732530
2	New	East Barwon River @ Dewings Bridge Road	-38.434878	143.747933
3	CO_WES010	West Barwon River @ 7 bridges Road	-38.474669	143.689396
4	New	Barwon River immediately u/s of Boundary Ck conf.	-38.418236	143.742025
5	CO_BOU009	Boundary Creek, Colac-Forrest Road	-38.421122	143.710475
6	New	Barwon River immediately d/s of Boundary conf.	-38.416717	143.742383
7	New	Barwon River u/s CO_BAR016	-38.402291	143.757554
8	CO_BAR016	Barwon River @ Colac-Lorne Road	-38.388771	143.768956
9	CO_BAR020	Barwon River @ Birregurra	-38.339105	143.790971

10	CO_BAR030	Barwon River @ Conns Lane	-38.325134	143.832385
11	CO_BAR040	Barwon River @ Winchelsea Deans Marsh Road	-38.278018	143.978382
12	CO_BAR060	Barwon River @ Princes Hwy bridge, Winchelsea	-38.240445	143.989326

- **Table 1: Site locations and descriptions**

2.2. Sampling methodology

Macroinvertebrates and *in situ* water quality, vegetation, site descriptions and photos were collected in October, 2019 (Spring) and March/ April, 2020 (Autumn) and sediments in Spring only. Specific sampling methods are detailed below.

2.2.1. In-situ water quality

In-situ water quality parameters were measured at each site including dissolved oxygen (mg/L), temperature (ºC), specific conductivity (µS/cm) and pH using a YSI ProPlus water quality meter. Turbidity (NTU) and alkalinity (mg/L) were measured using HACH meters and test kits respectively.

2.2.2. Metals in water

Water samples were collected for metals analysis, filtered in the field and kept refrigerated prior to delivery to the NATA accredited Eurofins Laboratory.

2.2.3. Macroinvertebrates

The benefit of monitoring the biological community is that it is affected by numerous types of toxicants and disturbances and the impacts can be evident over months or years (if two seasons are sampled) unlike chemical testing which may not capture an event.

Macroinvertebrates were collected at each site and photos and site assessment sheets were completed as per Victorian EPA guidelines (EPA, 2003b). In the absence of riffle habitats, two edge samples were collected (L. Metzling 2019 pers. comm. August 12) using a 250µm mesh dip net to sample ten meters of representative habitat at two locations at each site between 2nd and 4th October, 2019 and 31st March-2nd April 2020. The contents of the net was placed into a white tray to be picked through for 30 minutes with the aim of picking over 100 animals into 70% ethanol for later identification to family level following the Rapid Bioassessment Methodology for Rivers and Streams (EPA, 2003b). Macroinvertebrates were identified in the laboratory in accordance with the guidelines; to class for Oligochaeta and Mites, chironomids to sub-family and all other taxa to family except those that are not included in EPA Victoria biotic calculations (EPA, 2003b).

2.2.4. Site descriptions

EPA Victoria field sampling and habitat assessment sheets were filled out at each site and site photos taken (EPA, 2003b). These have been summarised in Appendix 1.

3. Results

3.1. Water quality

Water samples were collected and *in situ* readings taken at all 12 sites at the same time as macroinvertebrates were collected giving an indication of conditions at the time of sampling.

Table 2: In-situ water quality data- Spring 2019/ Autumn 2020

Site	Waterway	Season	Temp. (°C)	pH	Conductivity (µS/cm)	Specific Conductivity (µS/cm@25°C)	Dissolved oxygen (mg/L)	DO %	Alkalinity	Turbidity
Site 1	East Barwon Rv	Spring	13.2	6.2	186.7	240	13.07	123	5	9.09
		Autumn	14	8.67	161.8	210.16	4.42	47.5	5	2.6
Site 2	East Barwon Rv	Spring	15.5	6.3	544	664	6.8	66.8	10	9.97
		Autumn	16	7.71	180.7	218.2	5.85	59.9	10	9.49
Site 3	West Barwon Rv	Spring	14.7	5.26	473.4	590.6	7.3	73.5	10	16.3
		Autumn	14.4	8.23	179.6	224.0	4.45	42.9	10	3.28
Site 4	Barwon Rv	Spring	17.9	7.4	575	664	9.15	96.4	10	8.01
		Autumn	17	6.60	211.2	248.4	6.08	64.3	10	41.5
Site 5	Boundary Ck	Spring	12.1	3.94	777	1030	7.43	67.6	0	2.92
		Autumn	10.4	4.05	680	944	2.05	18.5	0	260
Site 6	Barwon Rv	Spring	14.4	7.34	608	756	7.3	71.3	10	9.43
		Autumn	15.8	6.88	207.7	250.6	6.58	66.1	10	31.7
Site 7	Barwon Rv	Spring	13.4	7.9	599	770	7.2	71.7	5	10
		Autumn	15.4	6.46	207.9	256.2	7.46	75.6	5	21.8
Site 8	Barwon Rv	Spring	16.2	7.8	660	795	8.8	87.9	10	13.5
		Autumn	15.9	6.79	234.8	284.8	3.22	32	10	5.13
Site 9	Barwon Rv	Spring	15.4	7.8	1049	1288	9.7	98	15	16.6
		Autumn	16.2	6.79	494.4	600.6	6.65	69.8	15	11.1
Site 10	Barwon Rv	Spring	14.6	7.9	1252	1561	8.1	86.1	15	18
		Autumn	16.2	5.56	511	613	3.96	40.2	15	19.2

Site	Waterway	Season	Temp. (°C)	pH	Conductivity (µS/cm)	Specific Conductivity (µS/cm@25°C)	Dissolved oxygen (mg/L)	DO %	Alkalinity	Turbidity
Site 11	Barwon Rv	Spring	13	7.9	1707	2227	9.23	87	15	26.1
		Autumn	15.6	6.26	762	929	3.62	35.2	15	13.3
Site 12	Barwon Rv	Spring	12.4	8	1788	2364	8.4	82.1	15	19.9
		Autumn	15.9	6.69	924	1117	52.5	54.5	15	20.7

Temperature was similar between seasons, pH at the downstream sites is slightly more acidic in Autumn than it was in Spring, conductivity and dissolved oxygen levels are lower in Autumn than in Spring, and there isn't a clear pattern in turbidity levels between season though levels are very high in Boundary Creek in Autumn.

- **Table 3: Metal results for water samples (mg/L) and ANZECC water quality guidelines (2000, Table 3.4.1) for trigger values applying to typical *slightly–moderately disturbed systems.***

mg/L	Season	Aluminium	Antimony	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Selenium	Silver	Zinc
Site 1	Spring	< 0.05*	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.33	< 0.001	0.04	< 0.0001	< 0.001	< 0.005	0.032
	Autumn	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.21	< 0.001	0.007	< 0.0001	< 0.001	< 0.005	< 0.005
Site 2	Spring	< 0.05*	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.4	< 0.001	0.15	< 0.0001	< 0.001	< 0.005	0.008
	Autumn	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.08	< 0.001	0.037	< 0.0001	0.001	< 0.005	< 0.005
Site 3	Spring	< 0.05*	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.31	< 0.001	0.31	< 0.0001	< 0.001	< 0.005	0.051
	Autumn	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	< 0.05	0.004	0.015	< 0.0001	< 0.001	< 0.005	< 0.005
Site 4	Spring	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.33	< 0.001	0.15	< 0.0001	< 0.001	< 0.005	0.017
	Autumn	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.14	< 0.001	0.35	< 0.0001	< 0.001	< 0.005	< 0.005
Site 5	Spring	10*	< 0.005	< 0.001	0.0002	< 0.001	< 0.001	5.4	< 0.001	0.06	< 0.0001	< 0.001	< 0.005	0.34
	Autumn	< 0.05*	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	17	< 0.001	0.18	< 0.0001	< 0.001	< 0.005	0.015
Site 6	Spring	0.09	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.13	< 0.001	0.17	< 0.0001	< 0.001	< 0.005	0.057
	Autumn	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.17	< 0.001	0.16	< 0.0001	< 0.001	< 0.005	< 0.005
Site 7	Spring	0.07	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.15	< 0.001	0.08	< 0.0001	< 0.001	< 0.005	0.013
	Autumn	< 0.05*	< 0.005	< 0.001	< 0.0002	< 0.001	0.001	0.09	< 0.001	0.01	< 0.0001	< 0.001	< 0.005	0.006

mg/L	Season	Aluminium	Antimony	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Selenium	Silver	Zinc
Site 8	Spring	0.1	< 0.005	< 0.001	< 0.0002	< 0.001	0.001	0.23	< 0.001	0.066	< 0.0001	< 0.001	< 0.005	0.015
	Autumn	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	< 0.05	< 0.001	< 0.005	< 0.0001	< 0.001	< 0.005	< 0.005
Site 9	Spring	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.22	< 0.001	0.098	< 0.0001	< 0.001	< 0.005	0.01
	Autumn	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	< 0.05	< 0.001	0.016	< 0.0001	< 0.001	< 0.005	< 0.005
Site 10	Spring	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.22	< 0.001	0.09	< 0.0001	< 0.001	< 0.005	< 0.005
	Autumn	< 0.05*	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	< 0.05	< 0.001	0.027	< 0.0001	< 0.001	< 0.005	0.008
Site 11	Spring	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.42	< 0.001	0.1	< 0.0001	< 0.001	< 0.005	< 0.005
	Autumn	< 0.05*	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	< 0.05	< 0.001	0.082	< 0.0001	< 0.001	< 0.005	< 0.005
Site 12	Spring	0.07	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	0.56	< 0.001	0.1	< 0.0001	< 0.001	< 0.005	< 0.005
	Autumn	< 0.05	< 0.005	< 0.001	< 0.0002	< 0.001	< 0.001	< 0.05	< 0.001	0.044	< 0.0001	< 0.001	< 0.005	0.015
ANZECC		0.05 (>6.5pH) *ID (<6.5pH)	ID	0.013	0.0002	0.001	0.0014	ID	0.0034	1.2	0.00006	0.005	0.00005	0.008

ID= insufficient data
Shaded exceeds trigger values
**aluminium results where pH is <6.5*

Overall, metal concentrations in the water decreased between Spring and Autumn, presumably due to lower flows and resuspension from sediments. Exceptions were Iron at Site 5 (Boundary Creek) where there is noticeable impact in the water column, increasing the turbidity at this site (Table 2). Iron levels continued to be higher in Autumn than in Spring at Site 6 below the Barwon River/ Boundary Creek confluence but had decreased to undetectable levels by Site 8 at the Colac-Lorne Road. Manganese is higher in Autumn than in Spring at Site 4 (above the Boundary Creek confluence), Site 5 on Boundary Creek and Site 6 below the Barwon River/ Boundary Creek confluence but below ANZECC trigger levels in all instances. Zinc concentrations are reduced at every site except for Site 12 in Winchelsea where they have exceeded ANZECC trigger levels. Zinc concentrations also exceeded ANZECC trigger levels at Site 5 on Boundary Creek in Autumn but were lower than in Spring.

3.2. Macroinvertebrate results

Biotic indices such as AusRivAS, SIGNAL, SIGNAL2, EPT (Ephemoptera, Plecoptera, Trichoptera) and taxa richness (number of families and key families) scores were calculated in accordance with EPA Victoria biological objectives (EPA Victoria, 2004). A multi dimensional scaling (MDS) plot was also produced and SIMPER analysis to give an indication of how similar the macroinvertebrate community compositions are to each other. A full list of macroinvertebrate families found at each site is in Appendix 2.

AusRivAS scores and bands are considered to give the most accurate assessment of the health of a site as the program compares the test site to a number of reference sites that have similar physical and chemical characteristics but are relatively free of environmental impacts. The score indicates how many macroinvertebrate families were found compared to those found at reference sites. The statewide model for edge habitat over two seasons was applied to these samples.

- **Table 4: AusRivAS Bands, Observed/Expected scores and descriptions (AusRivAS Macroinvertebrate Predictive Modelling Version 3.2.2)**

Band	OE 50 score	Description
X	1.15+	More biologically diverse than reference sites
A	0.85-1.14	Reference condition
B	0.56-0.84	Significantly impaired
C	0.27-0.55	Severely impaired
D	0-0.26	Extremely impaired

SIGNAL and SIGNAL2 are biotic indices based on the tolerance or intolerance of biota (macroinvertebrates) to water pollution. Sites with high scores are likely to have low nutrient, salinity and turbidity levels and high oxygen levels. EPA biological objectives use the SIGNAL score but SIGNAL2 is also calculated as it uses updated, refined scores (Chessman, 2003).

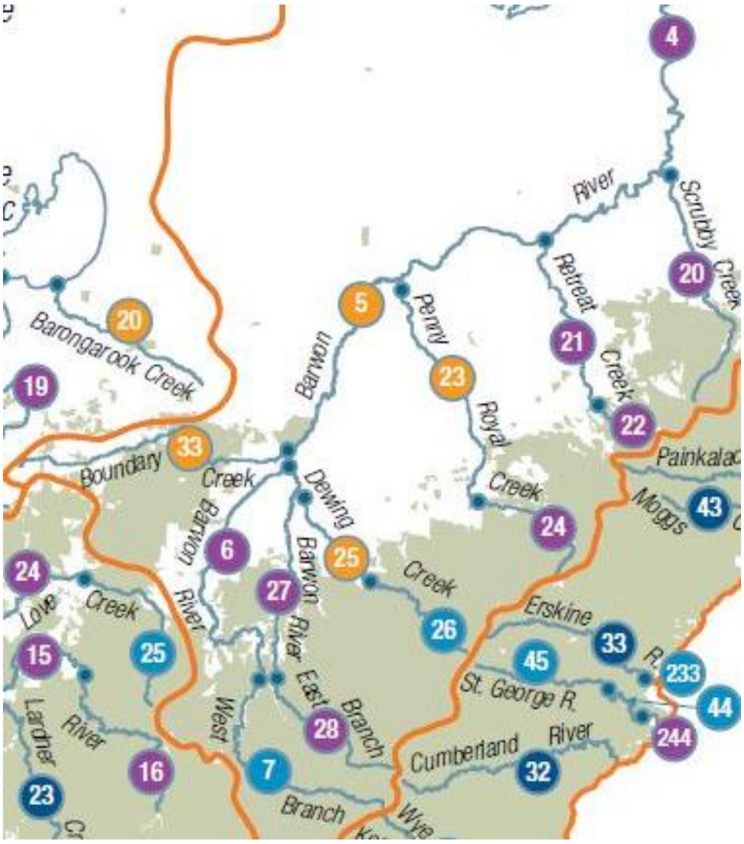
- **Table 5: Key to SIGNAL scores**

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

The EPT score indicates the number of families that are sensitive to pollution that are present at the site with a low score usually indicating that there has been some type of disturbance. Together, these scores give a good picture of the health of the waterway at a site and potentially what is causing any disturbance.

Taxa richness, measured by the number of macroinvertebrate families collected, can give a good overview of the health of a waterway. High numbers are associated with diverse habitats present at the site but can also be influenced by mild nutrient enrichment which can increase the food supply. The score can be combined with SIGNAL2 scores as in Figure 2 to help interpret results.

Every six years the Department of Environment and Primary Industries conducts Index of Stream Condition (ISC) assessments using information collected from a range of sources to give a benchmark of river condition in Victoria. The five sub-indices measured are Hydrology, Physical Form, Streamside Zone, Water quality and Aquatic Life and are reported in reaches (10-30km river lengths with similar characteristics). Figure 2 has been taken from the latest Index of Stream Condition data and shows the extent of the reaches in the study area. Table 7 identifies which sites are in each reach. Aquatic Life sub-index is a score out of 10 and is calculated by adding three Aquatic Life indicator scores according to the formula found in the Aquatic Life sub-index fact sheet (DEPI, 2014). The Aquatic Life sub-index was included in this report as it was included as a target in the recent discussion paper by Baldwin (2018).



- **Figure 2: ISC reaches in the upper Barwon catchment. Taken from Index of Stream Condition ISC3 Corangamite Region. https://www.water.vic.gov.au/water-reporting/third-index-of-stream-condition-report**

Care should be taken when comparing Aquatic Life scores as whilst it is anticipated that reaches are similar along their length, sites can vary in their quality, influenced by riparian and instream vegetation condition, inputs by tributaries and stock access. The sites and the year sampled to form the ISC3 Aquatic Life score is also unknown. In ISC3 (2004-2010) Reach 6 (West Barwon Rv) scored 9, Reach 27 (East Barwon Rv) scored 6, Reach 33 (Boundary Ck) scored 4, Reach 5 (Barwon River to Retreat Creek confluence) scored 6 and Reach 4 (Barwon River to Native Hut Creek confluence) scored 8 (DEPI, 2019). Aquatic Life scores for this study are in Table 7 below.

The study area crosses two biological regions. Site 1 (East Barwon River at Yaugher) is in Forests B; characterised by upland reaches in the Otway Ranges where there is some clearing for forestry, grazing and some intensive agriculture. Sites 2 to 12 are in Cleared Hills and Coastal Plains; incorporating the lower reaches of the Barwon River where the region has been substantially cleared for intensive agriculture (EPA, 2004).

- **Table 6: Biological Objectives (EPA, 2004)**

Objective	Number of Families	SIGNAL Index score	EPT Index score	AusRivAS O/E score	AusRivAS Band
Forests B (Region 3)	24	5.8	9	0.87-1.13	A
Cleared Hills & Coastal Plains (Region 4)	26	5.5	-	0.85-1.15	A

The pollution sensitive Ephemeroptera, Plecoptera and Tricoptera (EPT) macroinvertebrate families are seldom found in waterways within the Cleared Hills and Coastal Plains region, therefore no objectives have been set but numbers have been reported in Table 7.

- **Table 7: Biotic index results.**

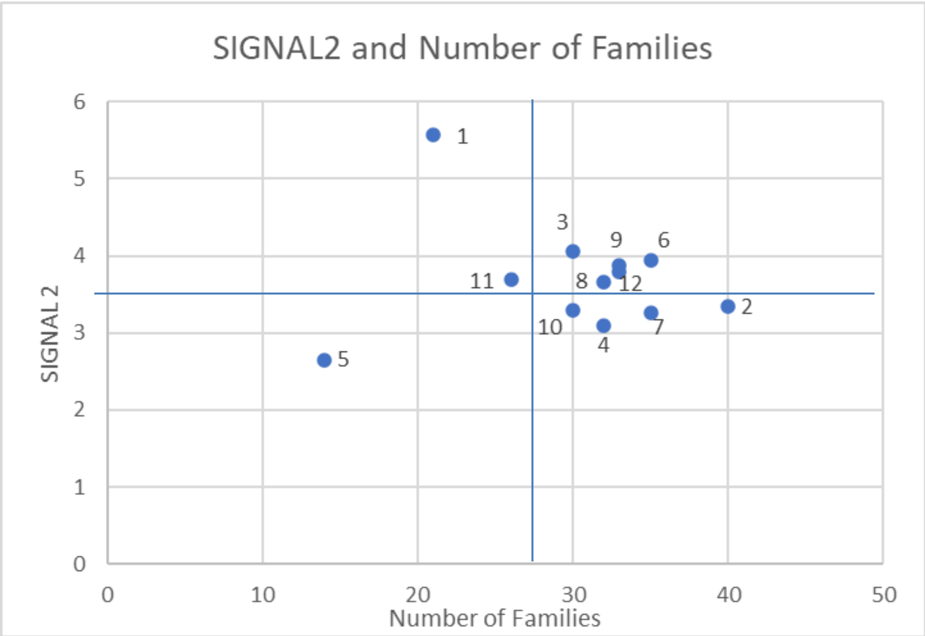
Site	ISC reach	Number of Families	SIGNAL	SIGNAL2#	EPT Index score#	AusRivAS O/E score	AusRivAS Band	Aquatic Life subindex
1	6	21	5.30	5.57	4	0.7	B	4
2	27	40	5.51	3.35	4	0.82	B	7
3	6	30	5.90	4.07	7	0.75	B	8
4	27	32	5.10	3.09	4	0.71	B	6
5	33	14	5.21	2.64	0	0.26	D	2
6	5	35	5.61	3.94	7	1.18	X	8
7	5	35	5.29	3.26	6	0.82	B	7
8	5	32	5.27	3.66	6	0.85	A	8
9	5	33	5.55	3.88	8	0.87	A	8
10	5	30	5.52	3.30	4	0.83	B	8
11	4	26	5.29	3.69	4	0.72	B	5
12	4	33	5.56	3.79	7	1.06	A	9

 # No objective.
Objective met

Sites 9 and 12 meet the most objectives for ecosystem protection (EPA, 2004) and are in the 'reference condition' AusRivAS band, indicating that they are the healthiest sites within the upper Barwon River. Site 6 has more taxa present than would be expected by the AusRivAS model (Band X). There may be mild organic enrichment present or it might be a biological hotspot but given that this site also has high SIGNAL scores and EPT scores its likely that the varied habitat present, with deep fast flowing sections, shallow slow sections and abundant instream vegetation is contributing to the varied macroinvertebrate taxa present.

The average Aquatic Life score for Spring/ Autumn 2019/20 in Reach 6 (West Barwon Rv) is 6, Reach 27 (East Barwon Rv) is 7, Reach 33 (Boundary Creek) is 2, Reach 5 (upper Barwon River) is 8 and Reach 4 (Barwon River from Retreat Creek to Native Hut Creek) is 7. These scores are similar to ICS3 scores in Reach 27 and Reach 4, improved for Reach 5 and lower for Reaches 33 and 6 but as is evident from our results in Table 9, the condition of sites within a reach is variable.

Whilst SIGNAL2 scores give an indication of water quality in the river from which the sample was collected, combining the score with the richness score (how many different macroinvertebrate families are present), can provide an indication of the types of pollution and other physical and chemical factors that are affecting the macroinvertebrate community. This is shown in the plot in Figure 3 where quandrant boundaries are defined according to Chessman (2003) with the top right quadrant (Quadrant 1) containing the healthiest sites. As all sites are subject to human disturbance, those sites that met or were close to meeting EPA biological objectives for number of families and SIGNAL scores were included in Quadrant 1 and a cross check of which sites had the most EPT families (Table 5) confirmed the quadrant borders.



- **Figure 3 SIGNAL2 index plotted against number of families recorded for each site.**

Sites 3 (West Barwon Rv), 6 (Barwon Rv immediately d/s of Boundary Ck), 8 (Colac-Lorne Road), 9 (Birregurra) and 12 (Winchelsea) have high SIGNAL2 and number of macroinvertebrate families suggesting the habitat and water quality are favorable and stress factors are low. Sites 2 (East Barwon Rv) and 7 (Barwon Rv u/s Colac- Lorne Rd) in the bottom right quadrant have slightly lower SIGNAL2 scores, possibly due to water quality influences but the high number of families present suggest that any toxicants are not present in large amounts. Sites 11 (Barwon Rv above Winchelsea) and 1 (East Barwon Rv, Yaugher) in the top left quadrant have high SIGNAL2 scores but fewer number of families. These sites are possibly affected by pollution other than what SIGNAL scores are based on (organic, nutrient enrichment or salinity). Site 5 (Boundary Creek) has lower SIGNAL2 scores and low numbers of families suggesting that they are subject to a number of impacts such as low pH and high metal concentrations.

The MDS (Multidimensional Scaling) plot (Figure 4) shows how similar, or dissimilar, the macroinvertebrate community compositions at each site are to one another based on presence absence data.

- **Figure 4: MDS plot of families over two seasons at twelve sites.**

The Multi Dimensional Scaling plot in Figure 4 shows a large seasonal effect on the macroinvertebrate community composition with Site 5 being the outlier in both seasons. SIMPER (Similarity Percentages) showed that 53% of macroinvertebrate families are shared between the sites in Autumn and macroinvertebrate community composition is slightly less variable in spring (60% similarity) as illustrated by the tighter cluster in Figure 4.

4. Discussion & Conclusion

4.1. Metals

Metal concentrations in the surface water have generally decreased between Spring and Autumn, most likely due to reductions in flow over Summer which would reduce the opportunity for the resuspension of metals from the sediments. Iron is the exception to this, with concentrations more than 3 times higher in Autumn than in Spring and the iron-oxidising bacteria that thrive in pools such as present in Boundary Creek contributing to the nearly 100 times increase in turbidity. This is a naturally occurring process in acidic, iron rich waters where there is mixing of de-oxygenated and oxygenated water (Earhart, 2009). Whilst iron levels were also elevated at the site immediately below the Boundary Creek/ Barwon River confluence this does not appear to extend to the Colac-Lorne Road, Yeodene and nor does it appear to have impacted the macroinvertebrate community composition downstream of the Boundary Creek confluence.

The increase in Zinc levels at Site 12, immediately downstream of Winchelsea is likely a result of stormwater runoff from the township. Whilst the concentration of 0.015mg/L is above ANZECC water quality guidelines (0.08mg/L) it is well below reported acute toxicity (0.14 mg/L) to macroinvertebrates in Australian freshwater systems (ANZECC, 2000).

4.2. Macroinvertebrates

Big Swamp continues to impact the macroinvertebrate community composition in Boundary Creek as measured at Site 5, Colac-Forrest Road. In comparison with a 2014/15 study of Boundary Creek (Austral Research and Consulting, 2015), the site at Colac-Forrest Road recorded more families in 2019/20 (14 compared to 10), higher SIGNAL scores (5.21 to 4.5), equivalent SIGNAL2 scores and lower AusRivAS banding (0.26 D to 0.38 C). The reduction in AusRivAS score between 2014/2015 and 2019/20 was due to single individuals of Oligochaeta (worms) and Veliidae (water striders) being expected by the model and recorded in the earlier study but not in this study. The high iron concentrations in the water at this site in Autumn (17mg/L) may be affecting macroinvertebrates with acute toxicity reported at iron concentrations ranging from 0.32 to 16 mg/L (ANZECC, 2000) but it is more likely that the continuing low pH is having more of a long term effect on populations.

Biological scores for sites along the Barwon River above and below the confluence with Boundary Creek suggest that severe impacts are limited to the Creek at this time. The absence of taxa such as snails from Site 6 directly downstream of the confluence in Spring was not evident in Autumn and this site recorded more taxa than what was expected by the AusRivAS model. Sites 8 (Colac-Lorne Road), 9 (Biregurra), and 12 (Winchelsea) all have reference condition macroinvertebrate assemblages and Site 6 (immediately downstream of Boundary Ck confluence) has more macroinvertebrate families than expected. Fish bycatch from macroinvertebrate sampling included southern pygmy perch, smelt and a galaxid at Site 6 in Autumn (Appendix 1). These results suggest that the Barwon River may have recovered from the 2016 fish kill event (Ryan, 2016) and is not currently being adversely impacted by inflows from Boundary Creek.

4.3. Recommendations

Sampling of metals in the water along the Barwon River during the Boundary Creek remediation works should give an indication of whether they are still being mobilised by the low pH water coming into the system. Sampling at the same time as macroinvertebrates will give an indication of any impacts during higher flow (Spring) and lower flow (Autumn) conditions. Sediments should be sampled for metals periodically (3-5 years) to track whether they are moving downstream or are remaining bound at the site.

Monthly water quality samples from Boundary Creek and seasonal macroinvertebrate sampling will give an excellent indication as to its recovery during remediation works. Continuation of annual macroinvertebrate sampling in Autumn and Spring on the Barwon River during the remediation works on Boundary Creek should give an accurate picture of the health of the Barwon River.

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Appendix 1:

5.1. Site 1- East Barwon River@ Kents Road


Site 1: upstream Spring 2019


Site 1: downstream Spring 2019


Site 1: upstream Autumn 2020


Site 1: upstream Autumn 2020

The East Barwon at Kents Road has diverse habitat with large deep pools and some riffle/ run areas although in Autumn these runs had dried to trickles. The average stream width at was eight meters and bank full in Spring but had contracted to five meters in Autumn. Willows dominate the riparian zone and are growing within the stream channel. The substrate is a mix of clay and silt with a number of aquatic macrophytes growing in the margins and shallow pool areas. The majority of the riparian zone is exotic vegetation, dominated by blackberries, willows and pasture grass. One larval fish was collected as bycatch during macroinvertebrate sampling. A concurrent snapshot study by EnviroDNA (2019) found evidence of platypus at this site. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 74 out of 140.

5.2. Site 2- East Barwon River@ Dewings Bridge Road


Site 2: upstream Spring 2019


Site 2: downstream Spring 2019


Site 2: upstream Autumn 2020


Site 2: downstream Autumn 2020

The East Barwon at Dewings Bridge Road consists of a slow flowing channel with extensive backwaters. There is very little riparian zone present but a number of submerged and emergent macrophytes provide good habitat and one larval fish was found in the sample net in Autumn. The substrate is a mix of clay and silt with some sand. The average stream width at this site was seven meters and was bank full during both Spring and Autumn sampling. The majority of the riparian zone is pasture grass with stock access on both sides. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 59 out of 140.

5.3. Site 3- West Barwon River@ Seven Bridges Road


Site 3: upstream Spring 2019


Site 3: downstream Autumn 2019


Site 3: upstream autumn 2020


Site 3: downstream autumn 2020

The West Barwon River at Seven Bridges Road has large deep pools with a number of large deep backwaters. The average stream width at this site is seven meters, narrow at the top of the surveyed reach and widening into a large pool near the bridge. The substrate is clay and silt mixed with 20% sand. There are some macrophytes present along with trailing bank vegetation, roots and instream large woody debris (primarily willow branches). Willows dominate the riparian zone a mix of shrubs and native and pasture grasses in the understory. Four larval fish were collected as bycatch during macroinvertebrate sampling in Spring 2019. A concurrent snapshot study by EnviroDNA (2019) found evidence of platypus at this site in Spring 2019. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 85 out of 140.

5.4. Site 4- Barwon River upstream of Boundary Creek confluence


Site 4: upstream Spring 2019


Site 4: downstream Spring 2019


Site 4: upstream Autumn 2020


Site 4: downstream Autumn 2020

The Barwon River immediately upstream of the Boundary Creek confluence is a large slow flowing channel with shallow side sections that support a number of macrophyte beds. The average stream width at this site is nine meters. The substrate is clay and black silt with some large woody debris and filamentous algae present in addition to the macrophytes. Juncus, Typha, Triglochin and Polygonum are all present instream though riparian vegetation is limited to some isolated trees, a narrow native plantation and pasture grass with stock access. The introduced Gambusia (mosquito fish) were collected as bycatch during macroinvertebrate sampling in Spring. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 79 out of 140.

5.5. Site 5- Boundary Creek @ Colac- Forrest Road

Site 5: upstream Spring 2019

Site 5: downstream Spring 2019

Site 5: upstream Autumn 2020

Site 5: downstream Autumn 2020

Boundary Creek at Colac- Forrest Road has a mix of large deep pools, a large shallow pool at the bridge and shallow runs. It was bankfull at the time of Spring sampling with an average stream width of four meters, narrow at the top of the surveyed reach and widening into a large pool upstream of the bridge. During Autumn sampling, Boundary Creek at this site had contracted to a pool approximately 4 meters long by 2.5 meters wide. The pooled water was stagnant, with low oxygen concentrations and very high turbidity. The substrate is a mix of cobble, pebble, gravel, sand, clay and silt. There are no macrophytes but there is some filamentous algae and trailing bank vegetation present. The riparian zone is wide and a mix of native and exotic vegetation except the ground cover which is dominated by *Convolvulus* sp. and pasture grasses. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 81 out of 140.

5.6. Site 6- Barwon River downstream of Boundary Creek confluence

Site 6: upstream Spring 2019

Site 6 : downstream Spring 2019

Site 6: upstream Autumn 2020

Site 6: downstream Autumn 2020

The Barwon River immediately downstream of the Boundary Creek confluence is a narrow deep channel with wide shallow edges dominated by grasses and aquatic macrophytes. The average stream width at this site is five meters and was bank full in Spring. It is wide but still with a narrow channel at the top of the surveyed reach and narrowing to a confined channel downstream. The river had contracted to the main channel but remained flowing, leaving the fringes to dry out. The substrate consists of clay and silt with filamentous algae tangled through the macrophyte beds. Macrophyte species are varied with Triglochin, Polygonum, Phragmites, and Juncus all present in addition to trailing grasses. Three different fish species were collected at this site as bycatch; southern pygmy perch, smelt and a galaxid. The riparian zone is limited to grasses and scattered native trees and shrubs with stock access to the site. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 70 out of 140.

5.7. Site 7- Barwon River upstream of CO_BAR16

 Site 7: upstream Spring 2019	 Site 7: downstream Spring 2019
 Site 7: upstream Autumn 2020	 Site 7: downstream Autumn 2020

The Barwon River upstream of CO_BAR16 adjacent to the northern boundary of the pine plantation has a large deep channel with any shallow areas dominated by beds of Phragmites. The average stream width at this site is seven meters. The substrate is clay and silt. In addition to the Phragmites beds there are beds of Triglochin, and scattered Polygonum, Juncus and other grasses. The riparian zone has a good mix of trees, shrubs and understory with a majority of native trees and shrubs. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 90 out of 140.

5.8. Site 8- Barwon River @ Colac- Lorne Road

Site 8: upstream Spring 2019

Site 8: downstream Spring 2019

Site 8: upstream Autumn 2020

Site 8: downstream Autumn 2020

The Barwon River at Colac- Lorne Road has large deep pools with a shallow areas at the sides and willow trees growing in the channel and some substrate exposed. The average stream width at this site is eight meters with a predominantly clay and silt substrate mixed with some sand. There are beds of Triglochin and Phragmites in addition to trailing grasses and large willows. The riparian zone consists of willow trees, pasture grasses and blackberries and allows stock access. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 69 out of 140.

5.9. Site 9- Barwon River @ Birregurra


Site 9: upstream Spring 2019


Site 9: downstream Spring 2019


Site 9: upstream Autumn 2020


Site 9: downstream Autumn 2020

The Barwon River at Birregurra consists of a large deep slow flowing pool. The average stream width at this site is five meters with steep clay banks. The substrate is clay and silt with willow roots, some snags and Triglochin beds scattered along the edges of the channel. There have been recent willow removal works and replanting of the riparian zone in amongst the pasture grass and blackberry groundcover. Rakali footprints were evident in the soft sediment edge. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 67 out of 140.

5.10. Site 10- Barwon River @ Conns Lane

 Site 10: upstream Spring 2019	 Site 10: downstream Spring 2019
 Site 10: upstream Autumn 2020	 Site 10: downstream Autumn 2020

The Barwon River at Conns Lane has large deep pools with some small deep backwaters and a narrow deep run at the top of the reach. The average stream width at this site is six meters. The substrate is clay and silt mixed with some sand and gravel. Phragmites beds line the channel and there are isolated patches of Triglochin in addition to Polygonum and trailing grasses along the waters edge. The riparian zone consists of relatively new and older native revegetation with pasture grass understory. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 98 out of 140.

5.11. Site 11- Barwon River@ Winchelsea- Deans Marsh Road


Site 11: upstream Spring 2019


Site 11: downstream Spring 2019


Site 11: upstream Autumn 2020


Site 11: downstream Autumn 2020

The Barwon River at Winchelsea- Deans Marsh Road has large deep pools with a shallow run at the top of the reach. The average stream width at this site is five meters and the substrate is clay and silt mixed with some sand and gravel. Triglochin is growing in the shallow areas of the channel and there are roots, large woody debris and trailing grasses. The riparian zone is predominately native trees and understory with a mix of grasses as groundcover. Rakali footprints were spotted at the waters edge. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 90 out of 140.

5.12. Site 12- Barwon River @ Winchelsea


Site 12: upstream Spring 2019


Site 12: downstream Spring 2019


Site 12: upstream Autumn 2020


Site 12: downstream Autumn 2020

The Barwon River at Winchelsea has large deep pools with a large shallow pool at the top of the reach. The average stream width at this site is twelve meters. The substrate is clay and silt mixed with sand and some gravel. In addition to the Phragmites beds at the top of the reach and along some edges there are also patches of Triglochin. Large woody debris, trailing grasses and emergent vegetation such as Polygonum are also present. Riparian vegetation is predominantly native with many established eucalypts and groundcover is pasture grass. A concurrent snapshot study by EnviroDNA (2019) in Spring found evidence of platypus at this site. Overall analysis of the health of the waterway using EPA habitat parameters for Low Gradient Streams gives this site a score of 88 out of 140.

Appendix 2- Macroinvertebrates

Site Code	Taxa Name	Autumn	Spring
1	Atyidae		3
1	Ceinidae	45	13
1	Ceratopogonidae	1	
1	Chironominae	75	5
1	Corixidae	10	12
1	Dugesiidae	1	10
1	Dytiscidae	1	1
1	Dytiscidae (Larva)	1	
1	Glossiphoniidae	2	
1	Gripopterygidae		33
1	Hydrobiosidae	2	
1	Leptoceridae	24	2
1	Leptophlebiidae	20	1
1	Lymnaeidae	1	
1	Mites	10	1
1	Notonectidae		1
1	Oligochaeta	9	1
1	Orthocladiinae	8	65
1	Physidae	29	30
1	Planorbidae	1	1
1	Simuliidae	2	2
1	Sphaeriidae	8	
1	Tanypodinae	28	
2	Aeshnidae	2	
2	Ancylidae	2	
2	Atyidae	3	
2	Baetidae	1	14
2	Belostomatidae	4	
2	Ceinidae	21	22
2	Ceratopogonidae		52
2	Chironominae	22	12
2	Coenagrionidae	33	36
2	Corduliidae	1	
2	Corixidae	38	16
2	Dixidae	1	
2	Dugesiidae		1
2	Dytiscidae	5	19
2	Dytiscidae (Larva)		2
2	Glossiphoniidae	4	1
2	Gyrinidae	2	
2	Gyrinidae (Larva)		1

2	Hydrochidae	3	4
2	Hydrophilidae	1	1
2	Leptoceridae	36	18
2	Leptophlebiidae	15	45
2	Lestidae		2
2	Libellulidae		1
2	Lymnaeidae		1
2	Mites	1	4
2	Naucoridae	7	2
2	Nemertea		1
2	Notonectidae	7	6
2	Oligochaeta	12	11
2	Oniscigastridae		1
2	Orthocladiinae	2	21
2	Paramelitidae	3	3
2	Perthiidae	6	
2	Physidae	9	28
2	Planorbidae	1	1
2	Pleidae		1
2	Sphaeriidae	3	2
2	Stratiomyidae	1	
2	Tanypodinae	5	10
2	Veliidae		9
3	Atriplectididae	3	
3	Caenidae		1
3	Ceratopogonidae		5
3	Chironomidae (Pupa)		7
3	Chironominae	53	8
3	Coenagrionidae		2
3	Conoesucidae		1
3	Corixidae	28	2
3	Dixidae	2	
3	Dugesiidae		2
3	Dytiscidae	9	
3	Dytiscidae (Larva)		1
3	Glossiphoniidae	1	
3	Gripopterygidae		4
3	Hydrophilidae		2
3	Hydroptilidae		3
3	Janiridae		1
3	Leptoceridae	18	21
3	Leptophlebiidae	4	6
3	Mites	20	14

3	Notonectidae	3	
3	Oligochaeta	4	1
3	Orthocladiinae		6
3	Paramelitidae	7	3
3	Perthiidae		1
3	Physidae	8	5
3	Planorbidae	1	17
3	Scirtidae sp.		9
3	Sphaeriidae	3	
3	Synlestidae		1
3	Tanypodinae	24	5
3	Veliidae	4	31
4	Atyidae	10	
4	Baetidae		24
4	Ceinidae	15	5
4	Ceratopogonidae	1	14
4	Chironomidae (Pupa)		1
4	Chironominae	32	9
4	Coenagrionidae	7	22
4	Corixidae	37	33
4	Culicidae	1	
4	Curculionidae		1
4	Dugesiidae	1	
4	Dytiscidae	13	6
4	Dytiscidae (Larva)		2
4	Ecnomidae	3	
4	Glossiphoniidae	1	
4	Haliplidae		4
4	Hydrobiidae		1
4	Hydrochidae	2	
4	Leptoceridae	7	15
4	Leptophlebiidae	5	7
4	Lymnaeidae	1	4
4	Mesoveliidae	5	
4	Mites	14	1
4	Naucoridae	9	4
4	Notonectidae	2	
4	Oligochaeta	30	5
4	Orthocladiinae	1	29
4	Paramelitidae	8	1
4	Physidae	4	17
4	Planorbidae	11	4
4	Sphaeriidae	2	

4	Tanypodinae	11	23
5	Chironominae	43	30
5	Corixidae	12	1
5	Culicidae	12	2
5	Culicidae (Pupa)		1
5	Dugesiidae		1
5	Dytiscidae	38	2
5	Dytiscidae (Larva)	2	1
5	Glossiphoniidae	1	
5	Hydrophilidae	3	
5	Janiridae		11
5	Naucoridae	1	
5	Notonectidae		1
5	Orthocladiinae		1
5	Scirtidae sp.	9	20
5	Tanypodinae		1
6	Atyidae	13	
6	Baetidae	2	7
6	Caenidae		1
6	Ceinidae	2	3
6	Ceratopogonidae		6
6	Chironomidae (Pupa)		1
6	Chironominae	17	1
6	Coenagrionidae	4	1
6	Corixidae	50	1
6	Dytiscidae	3	4
6	Glossiphoniidae	1	3
6	Gripopterygidae		44
6	Gyrinidae	4	
6	Gyrinidae (Larva)	7	
6	Hydraenidae	1	
6	Hydrobiosidae	3	1
6	Hydrochidae		1
6	Hydrophilidae	1	1
6	Hydroptilidae		26
6	Leptoceridae	9	3
6	Leptophlebiidae		1
6	Lymnaeidae	8	
6	Mites	1	2
6	Notonectidae	3	
6	Oligochaeta	11	1
6	Orthocladiinae	7	33
6	Paramelitidae	23	56

6	Parastacidae		1
6	Perthiidae	2	
6	Physidae	26	
6	Sialidae	2	
6	Simuliidae	44	2
6	Sphaeriidae	2	
6	Tanypodinae	17	2
6	Telephlebiidae	1	
6	Veliidae	1	2
7	Aeshnidae		2
7	Atyidae	16	3
7	Baetidae		3
7	Ceinidae	11	6
7	Ceratopogonidae		6
7	Chironomidae (Pupa)		2
7	Chironominae	27	4
7	Coenagrionidae	4	25
7	Corduliidae		4
7	Corixidae	38	9
7	Dugesiidae		10
7	Dytiscidae		6
7	Dytiscidae (Larva)	2	
7	Ecnomidae	3	
7	Gripopterygidae		1
7	Gyrinidae (Larva)	5	1
7	Hydraenidae		1
7	Hydrophilidae		2
7	Hydroptilidae		1
7	Janiridae		1
7	Kokiriidae		1
7	Leptoceridae		7
7	Lestidae		1
7	Lymnaeidae	2	
7	Mites	3	3
7	Naucoridae	1	1
7	Notonectidae	17	16
7	Oligochaeta	4	4
7	Orthocladiinae	2	1
7	Paramelitidae	13	16
7	Perthiidae	4	1
7	Physidae	11	6
7	Planorbidae		1
7	Scirtidae sp.		1

7	Tanypodinae	10	8
7	Veliidae		8
8	Aeshnidae	4	
8	Atyidae	25	
8	Baetidae		13
8	Belostomatidae	1	
8	Caenidae		3
8	Ceinidae		2
8	Ceratopogonidae		4
8	Chironominae	37	19
8	Coenagrionidae	24	52
8	Corduliidae	1	2
8	Corixidae	38	15
8	Crambidae	3	
8	Dugesiidae	9	2
8	Dytiscidae	6	4
8	Dytiscidae (Larva)	1	
8	Gripopterygidae		21
8	Gyrinidae (Larva)		1
8	Hydrochidae	1	
8	Hydrophilidae	6	
8	Hydroptilidae		1
8	Leptoceridae	5	47
8	Leptophlebiidae	9	13
8	Mites	3	1
8	Nepidae		1
8	Notonectidae	17	2
8	Oligochaeta	7	4
8	Orthocladiinae		16
8	Paramelitidae	17	8
8	Physidae	14	14
8	Planorbidae	4	
8	Sialidae	5	
8	Simuliidae		1
8	Sphaeriidae	1	
8	Tanypodinae	23	4
8	Veliidae	5	9
9	Aeshnidae	1	
9	Atyidae	6	1
9	Belostomatidae	1	
9	Calamoceratidae		2
9	Ceinidae	50	29
9	Ceratopogonidae	1	3

9	Chironomidae (Pupa)		2
9	Chironominae	2	53
9	Coenagrionidae	23	35
9	Corixidae	46	49
9	Crambidae	7	
9	Dugesiidae	25	5
9	Dytiscidae		1
9	Dytiscidae (Larva)	4	3
9	Ecnomidae	1	
9	Glossiphoniidae	1	1
9	Gripopterygidae		28
9	Hydrobiidae		18
9	Hydrochidae		5
9	Hydroptilidae	1	1
9	Janiridae	1	17
9	Kokiriidae		1
9	Leptoceridae		4
9	Leptophlebiidae	1	10
9	Lymnaeidae		1
9	Mites	1	7
9	Naucoridae		1
9	Notonectidae	5	
9	Oligochaeta	3	10
9	Oniscigastridae		2
9	Orthocladiinae		2
9	Paramelitidae	11	35
9	Physidae	10	17
9	Sialidae	3	
9	Tanypodinae		4
9	Telephlebiidae	1	
9	Tipulidae		1
9	Veliidae		9
10	Atyidae	34	19
10	Baetidae	6	2
10	Ceinidae	29	37
10	Ceratopogonidae	2	6
10	Chironominae		53
10	Coenagrionidae		36
10	Corixidae	18	1
10	Dixidae	2	
10	Dugesiidae	21	9
10	Dytiscidae	2	
10	Glossiphoniidae	2	

10	Gyrinidae	3	1
10	Gyrinidae (Larva)	1	4
10	Hydraenidae	1	
10	Hydrophilidae	1	
10	Hydroptilidae	9	
10	Janiridae		1
10	Leptoceridae		2
10	Leptophlebiidae	1	6
10	Lestidae	1	
10	Lymnaeidae		3
10	Mites	29	6
10	Naucoridae	1	
10	Notonectidae	3	2
10	Oligochaeta		3
10	Orthocladiinae		12
10	Paramelitidae	1	3
10	Physidae	2	43
10	Scirtidae sp.		1
10	Tanypodinae	12	
10	Veliidae	1	4
11	Atyidae	20	22
11	Baetidae		15
11	Ceinidae	2	22
11	Ceratopogonidae	1	
11	Chironomidae (Pupa)		1
11	Chironominae	1	39
11	Coenagrionidae	2	17
11	Corixidae	15	18
11	Dugesiidae	23	18
11	Dytiscidae	1	
11	Empididae		1
11	Glossiphoniidae	7	
11	Gripopterygidae		34
11	Gyrinidae		8
11	Hydrochidae	1	1
11	Janiridae	21	31
11	Leptoceridae		4
11	Leptophlebiidae		2
11	Lymnaeidae	1	
11	Mites	45	2
11	Notonectidae	18	1
11	Oligochaeta	2	
11	Orthocladiinae		15

11	Paramelitidae	27	2
11	Physidae	3	31
11	Scirtidae sp.	1	
11	Simuliidae		11
11	Veliidae	8	4
12	Atyidae		13
12	Baetidae		4
12	Calamoceratidae	5	1
12	Ceinidae	15	37
12	Chironominae	62	36
12	Coenagrionidae	2	49
12	Corduliidae		1
12	Corixidae	3	12
12	Dugesiidae	7	8
12	Dytiscidae	3	1
12	Ecnomidae	3	
12	Elmidae	1	1
12	Elmidae (Larva)		1
12	Glossiphoniidae	4	
12	Gripopterygidae		26
12	Gyrinidae	2	
12	Gyrinidae (Larva)	9	6
12	Hydraenidae	1	
12	Hydrophilidae	2	
12	Hydroptilidae		1
12	Isostictidae		4
12	Janiridae	1	2
12	Leptoceridae	4	15
12	Leptophlebiidae	13	6
12	Mites	38	12
12	Notonectidae		2
12	Oligochaeta	1	2
12	Orthocladiinae	1	10
12	Paramelitidae	1	
12	Physidae	2	29
12	Scirtidae sp.	7	11
12	Stratiomyidae	3	2
12	Tanypodinae	6	11
12	Tipulidae	1	
12	Veliidae	2	8