Appendix 5

Aquatic Monitoring Report: Autumn 2015 and Spring 2015*

(No. of pages including blank pages = 46)

*Note: A copy of this Appendix is available on the Project CD

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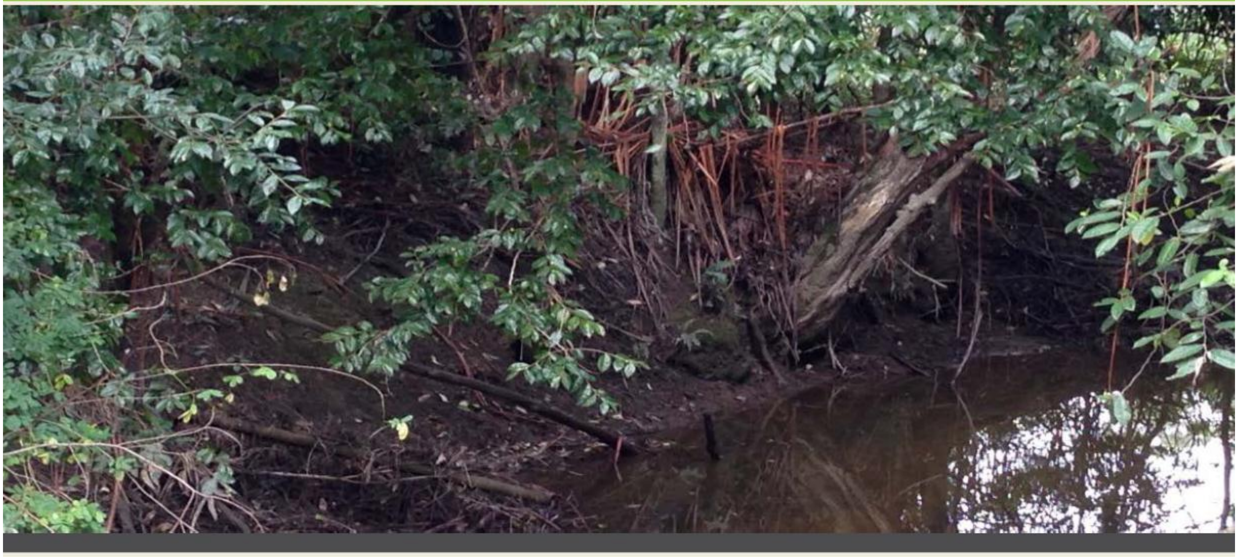

Tasman Coal Aquatic Monitoring Report

Autumn 2015

Prepared for Donaldson Coal Pty Ltd

July 2015

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Cover photograph: Blue Gum Creek

Executive summary

Context

Tasman Coal ceased production in July 2013 and was subsequently rehabilitated finishing in September 2014. As part of environmental monitoring for the Tasman Coal mine, Blue Gum Creek aquatic ecological health was investigated. The program includes methods for measuring macroinvertebrates as well as water quality and catchment-riparian conditions.

Aims

The aim of the aquatic monitoring program is to assess river health of Blue Gum Creek. The monitoring aims to:

- Assess stream condition using RCE.
- Assess habitat condition using AUSRIVAS proforma.
- Assess water quality against default ANZECC trigger values.
- Assess the macroinvertebrate community condition using SIGNAL.
- Discuss the results in context to past survey and rehabilitation of these streams.
- Suggest management actions designed to improve the condition of aquatic environs.

Results

Aquatic environments downstream of Tasman Coal rehabilitation works have moderate riparian and channel morphology condition. The macroinvertebrate community is in reasonable health despite moderate weighted Signal scores. This is supported by the presence of pollution sensitive taxa (Leptophlebiidae) within the streams. Moderate Signal scores may indicate some stream impairment which is likely to be the result of several contributing factors such as roadways, weeds, agriculture and past high flow events. The report did identify raised electrical conductivity as a potential concern to stream health, however, this was observed prior to the mines operation. Temporal comparisons to past data were limited as past methods employed an old system to calculate Signal.

Recommendations

Niche recommends that previous macroinvertebrate monitoring data be reviewed for quality control. In performing this review, it is recommended that previous Signal results be updated using Chessman (2003) Signal2 methods to provide greater accuracy of stream health assessment and to ensure that data is comparable for future monitoring assessments.

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Glossary and abbreviations

ANZECC	Australian and New Zealand Environment and Conservation Council
Anthropogenic	Caused or produced by humans
Aquatic macroinvertebrates	Animals that have no backbone, are visible with the naked eye and spend all or part of their life in water
AUSRIVAS	Australian Rivers Assessment system
CMA	Catchment management area
Drainage	Natural or artificial means for the interception and removal of surface or subsurface water.
Ecology	The study of the relationship between living things and the environment.
Ephemeral	Existing for a shot amount of time
Habitat	The place where a species, population or ecological community lives (whether permanently, periodically or occasionally).
Pollution	A technical term (Source: Gooderham J and Tsyrlin E 2002). SIGNAL2 scores are indicative only and that pollution does not refer to just anthropogenic sources. Environmental stress may result in poor water quality occurring naturally in waterways such as those conditions found in ephemeral streams. Low family richness and the occurrence of pollution tolerant invertebrates can give a low SIGNAL score even though they are natural condition.
RCE Inventory	Riparian and Channel and Environment inventory assessment
Riparian	Relating to the banks of a natural waterway.
SIGNAL	Stream Invertebrate Grade Number Average Level
Stress	response to a stressor such as an environmental condition or a stimulus

1. Introduction

1.1 Background

Tasman Coal ceased production in July 2013 and was subsequently rehabilitated finishing in September 2014. As part of environmental monitoring for the Tasman Coal mine, the aquatic ecological health of Blue Gum Creek was investigated. The program includes methods for measuring macroinvertebrates as well as water quality and catchment-riparian conditions. These measures are used to evaluate the effectiveness of water quality protection measures during development of the area for mining, and catchment rehabilitation.

1.2 Catchment characteristics

Blue Gum Creek has its source at Mount Sugarloaf. Prior to Pambalong Nature Reserve, it drains a catchment area of approximately $16km^2$. Catchment landuse at the upstream site at George Booth Drive is predominantly bushland as well as the rehabilitated mine site and the Hunter expressway. Stockrington Quarry is also located in the catchment to the north of the site. By the second site (Dog Hole Road crossing), the catchment also includes grazing activity.

1.3 Aim

The aim of the aquatic monitoring program is to assess river health of Blue Gum Creek to determine if water quality protection measures and catchment rehabilitation are having a positive influence on the environment. The monitoring aims to:

- Assess stream condition using RCE.
- Assess habitat condition using AUSRIVAS proforma.
- Assess water quality against default ANZECC trigger values.
- Assess the macroinvertebrate community condition using SIGNAL.
- Discuss the results in context to past survey and rehabilitation of these streams.
- Identify management actions designed to improve the condition of aquatic environs.

2. Methods

2.1 Location of sampling sites

Two sites were sampled on Blue Gum Creek (Figure 2, Table 1). Two sites were located downstream of Tasman Coal rehabilitation works. There is no upstream site to determine reference condition for these streams.

Table 1 Location of sampling sites

Site name	Stream	Location	Easting	Northing
BGC@SR	Blue Gum Creek	Blue Gum Creek upstream of Stockrington Road	368006	6362135
BGC@DHB	Blue Gum Creek	Blue Gum Creek downstream at Dog Hole Bridge	369275	6363473

2.2 Field methods

The field methods were consistent with standardised techniques in field sampling as prescribed by AUSRIVAS (Turak et al. 2000). The AUSRIVAS methods of sampling both pools and riffles were modified as no suitable in-stream riffle features were present.

2.2.1 Aquatic habitat and stream condition

Riparian, Channel and Environment Inventory assessment (RCE)

The RCE Inventory (Chessman et al. 1997) provides a comparative measure of stream condition by assessing both the stream and its riparian environment in terms of habitat diversity, habitat condition and the degree of human-induced disturbance. Thirteen categories each receive a score between 1 and 4 based their condition, resulting in an accumulated score of between 13 and 52. The maximum score (52) indicates a stream with little or no obvious physical disruption and the lowest score (13) indicates a heavily channelled stream without any riparian vegetation. This assessment provided a score the general condition of the stream and must be interpreted accordingly.

Habitat description

A description of aquatic habitat was also produced using the AUSRIVAS (Australian River Assessment System) proforma. The survey is a rapid visual assessment used to describe the habitat based on the following parameters:

- geomorphology
- channel diversity
- bank stability
- riparian vegetation and adjacent land use
- water quality
- macrophytes
- local impacts and land use practices.

Regional location of study area
Tasman Coal - Aquatic Monitoring

FIGURE 1

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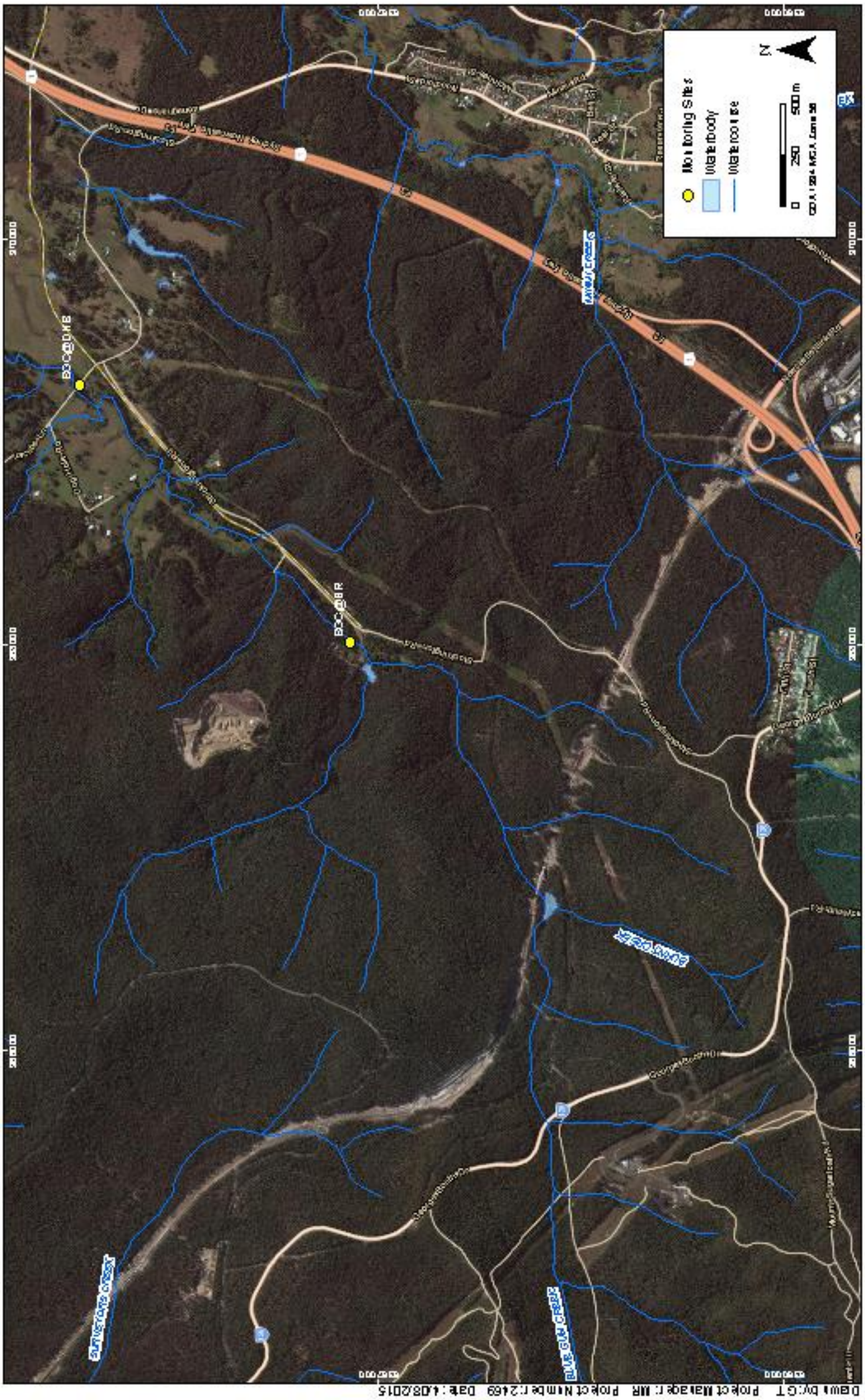

Location of study sites
Tasman Coal - Aquatic Monitoring
FIGURE 2

2.2.2 Water quality

Surface water quality was measured in situ using a calibrated Yeokal 611 water quality probe at each site. The following variables were recorded:

- temperature (°C)
- conductivity (µS/cm)
- pH
- oxidation – reduction potential (ORP) (mV)
- dissolved oxygen (DO)(% saturation and mg/L)
- turbidity (NTU).

Alkalinity (mg $CaCa_3$/L) was measured with a standard titration kit. Water quality data were compared with the ANZECC (2000) default trigger values to physical and chemical stressors for protection of slightly upland aquatic ecosystems in south-eastern Australia.

2.2.3 Macroinvertebrates

Samples were collected from pool edges for a length of 10 metres either as a continuous line or in disconnected segments. Sampling in segments was often undertaken to ensure the sampling of sub-habitats such as macrophyte beds, bank overhangs, submerged branches and root mats. Segmented sampling was also employed where pool length was short and it was logistically difficult to sample in a continuous line (e.g. in-stream logs). A 250 µm dip net was drawn through the water with short sweeps towards the bank to dislodge benthic fauna while scraping submerged rocks and debris, sides of the stream bank and the bed substrate (Plate 1). Further sweeps in the water column targeted the suspended fauna.

Plate 1 Sampling method

Each sample was rinsed from the net onto a white sorting tray from which animals were picked using forceps, pipettes and or paint brushes. Each tray was picked for a minimum period of forty minutes, after which they were picked at ten minute intervals for either a total of one hour or until no new specimens had been found. Care was taken to collect cryptic and fast moving animals in addition to those that were conspicuous or slow. The animals collected at each site were placed into a labelled jar containing 70% ethanol.

Laboratory methods-invertebrate identification

Macroinvertebrate samples were identified to family level with the exception of Oligochaeta (to class), Polychaeta (to class), Ostracoda (to subclass), Nematoda (to phylum), Nemertea (to phylum), Acarina (to order) and Chironomidae (to subfamily). Keys used include:

- Dean, J., Rosalind, M., St Clair, M., and Cartwright, D. (2004) Identification keys to Australian families and genera of caddis-fly larvae (Trichoptera) Cooperative Research Centre for Freshwater Ecology.
- Gooderham, J. and Tsyrlin, E. (2002). The Waterbug Book: A guide to the Freshwater Macroinvertebrates of Temperate Australia, CSIRO Publishing.
- Hawking and Theischinger (1999) A guide to the identification of larvae of Australian families and to the identification of ecology of larvae from NSW.
- Madden, C. (2010) Key to genera of Australian Chironomidae. Museum Victoria Science Reports 12,1-31.
- Madden, C. (2011) Draft identification key to families of Diptera larvae of Australian inland waters La Trobe University.
- Smith, B. (1996) Identification keys to the families and genera of bivalve and gastropod molluscs found in Australian inland waters Murray Darling Freshwater Research Centre.
- Website - http://www.mdfrc.org.au/bugguide/.

2.3 Data analysis

2.3.1 SIGNAL2: (Stream Invertebrate Grade Number Average Level) scores

The revised SIGNAL2 biotic index developed by Chessman (2003a, b) was used to determine the "environmental quality" of sites. This method assigns grade numbers to each macroinvertebrate family or taxa found, based largely on their response to a range of environmental conditions (Table 2). The sum of all grade numbers for that habitat is then divided by the total number of families recorded in each habitat to calculate the SIGNAL2 index. A weighted Signal2 score was also calculated (see Chessman 2003). The SIGNAL2 index therefore uses the average sensitivity of macroinvertebrate families to present a snapshot of biotic integrity at a site. Table 3 provides a broad guide for interpreting the health of the site according to the SIGNAL 2 score of the site.

Table 2 SIGNAL Grade and the Level of Pollution Tolerance

SIGNAL Grade	Pollution Tolerance
10-8	Indicates a greater sensitivity to pollution
7-5	Indicates a sensitivity to pollution
4-3	Indicates a tolerance to pollution
2-1	Indicates a greater tolerance to pollution

Table 3 Guide to interpreting the SIGNAL 2 scores

SIGNAL 2 Score	Habitat quality
Greater than 6	Healthy habitat
Between 5 and 6	Mild pollution
Between 4 and 5	Moderate pollution
Less than 4	Severe pollution

(Source: Gooderham J and Tsyrlin E 2002)

*Note that SIGNAL2 scores are indicative only and that pollution does not refer to just anthropogenic pollution. Environmental stress may result in poor water quality occurring naturally in waterways. Low family richness and the occurrence of pollution tolerant invertebrates can give a low SIGNAL score even though they are natural condition.

2.3.2 Opportunistic observations

Opportunistic visual observations of aquatic fauna were recorded.

3. Results

3.1 Weather Conditions

Surveys were conducted on the 12th June 2015. The weather was fine with light winds at the time of sampling. There was a high rainfall event 6 weeks prior to sampling, while there is evidence of some disturbance to the stream morphology it is expected that any changes to invertebrate assemblages are likely to have recovered from this event.

3.2 Aquatic habitat

The aquatic habitat of the study area comprises pools with no riffles present. Sites generally had moderate riparian and channel health (RCE 20-40). Most sites had fine sand/silt substrate with very little cobble/boulder habitat evident. Stream banks were mostly stabilised by riparian vegetation, and showed some evidence of erosion and siltation. Macrophyte occurrence varied between sites, with Typha being predominant at the BGC@SR site. There was evidence (fallen vegetation and debris) of a high flow event occurring at both sites.

Table 4 shows the RCE inventory scores of each site. An RCE score greater than 40 indicates a stream considered to be in good condition with potential for higher biodiversity values. RCE Scores of 20-40 indicate a stream is in moderate condition and below 20 indicates that the stream is in very poor condition.

Table 4 RCE inventory scores

	Site	
	Blue Gum Creek at Dog Hole Bridge	**Blue Gum Creek at Stockrington Rd**
RCE Score	33	36

3.2.1 Blue Gum Creek at Stockrington Road

The site is located is most upstream site on Blue gum Creek. Catchment landuse at the upstream site at George Booth Drive is predominantly bushland as well as the rehabilitated mine site and Stockrington Quarry to the north and the Hunter Expressway to the south (Figure 2, Plate 2). The stream was in moderate condition (RCE 33), and showed some disturbance through the presence of weeds Lantana (*Lantana camara*), Tobacco Bush (*Solanum mauritianum*) and Crofton Weed (*Ageratina adenophora*) as well as significant erosion. Canopy vegetation included Blue Gum (*Eucalyptus saligna*). The mid-storey was dominated by Lantana, Tobacco Bush, Cheese Tree (*Glochidion ferdinandi*) and the ground cover by native and exotic grasses and herbs. The vegetation provided low shading of the stream.

Plate 2 Blue Gum Creek at Stockrington Road

This stream was mostly shallow (<1 m depth) and had a 5 m modal width. The stream substrate consisted of predominately silt. The macrophytes Typha and Duckweed (Lemnaceae) were observed at this site. There were pools present with some flow at the time of sampling. The water also appeared turbid and extensive stream bank erosion from a recent flood.

3.2.2 Blue Gum Creek at Dog Hole Bridge

The site is located downstream of site BGC@SR and upstream of Dog Hole bridge (Figure 2, Plate 3). The stream was in moderate condition (RCE 36), and showed some disturbance (i.e. presence of weeds such as Lantana). Canopy vegetation included Blue Gum, Lilly Pilly (*Syzygium smithii*) and Cheese Tree. The mid-storey was dominated by Lantana and Cheese Tree and the ground cover by native grasses and herbs. The vegetation provided moderate shading of the stream.

Plate 3 Blue Gum Creek at Dog Hole Bridge

This stream was mostly shallow (<1 m depth) with some deep sections and had a 2.5 m modal width. The stream substrate consisted of predominately silt, with some bedrock and cobbles. No macrophytes were observed at this site. There were pools present; however there was little flow at the time of sampling. The water appeared turbid. There was an anoxic odour present and signs of grazing on both side of the creek.

3.3 Water quality

Water quality results (Table 5), showed that temperature was consistent 13.9 – 13.13 °C. Conductivity was relatively high at both sites 906-1068 µ/cm; exceeding default ANZECC guidelines for upland streams; the highest in site BG@DHB. Although the water appeared turbid, turbidity measurements ranged between 9.1-39.7 NTU; within ANZECC guidelines. Dissolved Oxygen (DO) ranged 53.3 -79.5% saturation below ANZECC guidelines. The pH readings ranged between 6.61-6.79; within ANZECC guidelines. Alkalinity ranged 120-170 mg $CaCa_3$/L; showing that Blue Gum Creek has a high buffering capacity; that is has a high resistance to changes in pH. Despite exceedences in conductivity, dissolved oxygen and pH these are likely within the natural variability of these streams.

Table 5 Water quality results

Site number	Temp (C°)	Conductivity (µS/cm)	Turbidity (NTU)	Dissolved Oxygen (% sat)	pH	Alkalinity (mg $CaCa_3$/L)
BGC@ SR	13.9	**906**	39.7	**79.5**	6.79	160
BGC@DHB	13.13	**1068**	9.1	**53.3**	6.61	120

ANZECC guidelines for upland streams: Electrical conductivity (30-350 µS/cm), Turbidity (6-50 NTU), pH (6.5-8), Dissolved Oxygen (80-110%). Text in bold indicate those variables that exceed the default trigger values.

Note: For some waterways, default ANZECC guidelines do not reflect typical background water quality and chemistry Therefore an assessment of water quality monitoring data against default values can suggest the condition of the waterway is outside the normal range, or polluted, when in fact it is 'clean', or vice versa

3.4 Macroinvertebrates

Signal results for the two sampled sites are provided in Table 6. Raw data is provided in Annex 1.

Table 6 Macroinvertebrate results

Site number	Number of Taxa	SIGNAL2	SIGNAL2 weighted
BGC@SR	17	3.35	4.45
BGC@DHB	16	3.31	4.1

Number of taxa were relatively consistent between sites (Table 6), both having a moderate diversity. Signal2 scores indicate that both sites have severe pollution (<4 Signal), however the weighted scores (taking into account relative abundance) showed the stream was moderately polluted (4-5 Signal).

Pollution sensitive mayflies (i.e. Leptophlebiidae (Signal 8)) are known to be sensitive to sedimentation, salinity, and poor water quality in general (Horigan et al. 2005, Johnson and Ritchie 2003; Wellnitz et al.1994; Rassmussan and Lindegaard 1988; Peters et al. 2011). These mayflies were observed at both sites, providing some evidence of good stream health.

3.5 Other fauna

Introduced pest fish species Plague Minnow (*Gambusia holbrooki*) were observed in both Blue Gum Creek sites.

4. Discussion

4.1 RCE Scores

RCE score were similar to previous results with scores 20-40, indicating moderate condition. These scores are with in the range of scores experienced throughout the life of the monitoring program (Tuft 2013).

4.2 Signal Scores and stream health

The moderate signal scores (4-5 Signal) maybe the result of pollution as the creek show signs of disturbance (erosion, siltation, weed, and elevated salinity). Despite some moderate Signal scores, the streams appear to be in reasonable health particularly with the presence of sensitive mayfly taxa Leptophlebiidae (Signal 8) as well as beetle Scirtidae (Signal 6) and caddis fly Leptoceridae (Signal 6) (Annex 1). This is consistent with conclusions from spring 2014 monitoring report (Tuft 2014) that found both sites showed a predominance of moderately tolerant families but also included some sensitive taxa and indicated sedimentation disturbance within Blue Gum Creek.

This report identified elevated electrical conductivity (EC) within Blue Gum Creek. Although relatively high and exceeding ANZECC default guidelines, these levels were observed prior to the commencement of the mine operations (Newcastle Coal 2002).

4.2.1 Signal vs. Signal2

Comparison of Signal to past monitoring results is limited as previous monitoring was based upon preliminary Signal methods (Chessman 1995; et al 1997). These preliminary Signal methods and scores for each taxon was later updated (Chessman 2003), and have not been used in latter monitoring assessments. This has led to assessments prior to this report having consistently higher Signal scores than what would be otherwise calculated with updated Signal methods and scores.

Originally Signal scores were derived subjectively from only 12 published case studies (Chessman 1995). The development of Signal later saw the scores improved in accuracy and the development of techniques to objectively set Signal scores (Chessman 1997). Signal2 is the culmination of these earlier studies and data gathered from 15,000 samples and 4,000 sites from across the state (Chessman 2003a). Signal2 is the most up to date version of this index and is considered a more versatile and reliable version of Signal (Chessman 2003b).

5. Conclusion and Recommendations

5.1 Conclusions

Blue Gum Creek is categorised as having moderate riparian and channel morphology condition. The macroinvertebrate community is in reasonable health; however, does show signs of disturbance that maybe contributing to moderate Signal scores. This is likely to be to the result of several contributing factors such as roadways, weeds, agriculture, and past high flow events also potentially important. A temporal comparison with past results to evaluate changes in condition, over time, was limited due to data incompatibilities (i.e. Signal scores were previously calculated using an old, preliminary Signal approach (Chessman 1995).

5.2 Recommendations

Niche recommends that previous macroinvertebrate monitoring data be reviewed for quality control. In performing this review, it is recommended that previous Signal results be updated using Chessman (2003) Signal2 methods to provide greater accuracy of stream health assessment and to ensure that data is comparable for future monitoring assessments.

6. References

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Websites

http://ausrivas.ewater.com.au/

http://www.mdfrc.org.au/bugguide/

Annex 1 Macroinvertebrate survey results

	Blue Gum Creek at Stockrington Road	Blue Gum Creek at Dog Hole Bridge
Turbellaria	1	
Hydrobiidae	7	
Physidae	1	1
Oligochaeta	5	
Acarina		1
Atyidae	1	
Parastacidae	1	
Dytiscidae	1	5
Hydrophilidae	1	
Hydraenidae	1	
Scirtidae	14	5
Simuliidae	7	
Stratiomiyidae		1
Ceratopogonidae	2	
Tanypodinae		5
Orthocladiinae	3	
Chironominae	1	14
Baetidae		5
Leptophlebiidae	20	11
Caenidae		4
Veliidae		3
Pleidae		2
Coenagrionidae		2
Hemicorduliidae		1
Leptoceridae	4	18

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Tasman Coal Aquatic Monitoring Report

Spring 2015

Prepared for Donaldson Coal Pty Ltd

October 2015

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Cover photograph: Blue Gum Creek

Executive summary

Context

Tasman Coal ceased production in July 2013 and the site has subsequently been under rehabilitation since September 2014. As part of environmental monitoring requirements for the Tasman Coal mine, Blue Gum Creek aquatic ecological health was investigated. The program includes methods for measuring macroinvertebrates as well as water quality and catchment-riparian conditions.

Aims

The aim of the aquatic monitoring program is to assess river health of Blue Gum Creek. The monitoring aims to:

- Assess stream condition using RCE.
- Assess habitat condition using AUSRIVAS proforma.
- Assess water quality against default ANZECC trigger values.
- Assess the macroinvertebrate community condition using SIGNAL.
- Discuss the results in context to past survey and rehabilitation of these streams.
- Suggest management actions designed to improve the condition of aquatic environs.

Results and conclusions

Aquatic environments downstream of Tasman Coal rehabilitation works have moderate riparian and channel morphology condition. Assessment of macroinvertebrates using weighted Signal scores showed that Blue Gum Creek was in poor stream health, however there were some pollution sensitive taxa (Leptophlebiidae) located at the lower Blue Gum Creek site on Stockrington Road. The Signal scores indicate stream impairment, which is likely to be the result of several contributing factors such as roadways, weeds, agriculture and past high flow events. The report did identify raised electrical conductivity as a potential concern to stream health, however, this was observed prior to the mines operation. Signal scores indicated a deterioration in stream health from the autumn sampling, however this change is likely unrelated to any stream management actions by Tasman Coal.

Recommendations

Niche recommends that the monitoring program for Tasman Coal be reviewed as there are several confounding anthropogenic disturbances affecting macroinvertebrate communities and stream health downstream of the mine. The review should assess: whether the sites are appropriate to monitor stream health and catchment protection measures, whether additional sites are required in closer proximity to Tasman Coal and the value of continuing the program in its current form.

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AUSRIVAS	Australian Rivers Assessment system
CMA	Catchment management area
Drainage	Natural or artificial means for the interception and removal of surface or subsurface water.
Ecology	The study of the relationship between living things and the environment.
Ephemeral	Existing for a shot amount of time
Habitat	The place where a species, population or ecological community lives (whether permanently, periodically or occasionally).
Pollution	A technical term (Source: Gooderham J and Tsyrlin E 2002). SIGNAL2 scores are indicative only and that pollution does not refer to just anthropogenic sources. Environmental stress may result in poor water quality occurring naturally in waterways such as those conditions found in ephemeral streams. Low family richness and the occurrence of pollution tolerant invertebrates can give a low SIGNAL score even though they are natural condition.
RCE Inventory	Riparian and Channel and Environment inventory assessment
Riparian	Relating to the banks of a natural waterway.
SIGNAL	Stream Invertebrate Grade Number Average Level
Stress	response to a stressor such as an environmental condition or a stimulus

1. Introduction

1.1 Background

Tasman Coal ceased production in July 2013 and the site has subsequently been under rehabilitation since September 2014. As part of environmental monitoring requirements for the Tasman Coal mine, the aquatic ecological health of Blue Gum Creek was investigated. The program includes monitoring macroinvertebrates, water quality and catchment-riparian condition. These measures are used to evaluate the effectiveness of water quality protection measures during development of the area for mining, and success of catchment rehabilitation.

1.2 Catchment characteristics

Blue Gum Creek has its source at Mount Sugarloaf. Prior to Pambalong Nature Reserve, it drains a catchment area of approximately 16km^2. Catchment land use at the upstream site at George Booth Drive is predominantly bushland as well as the rehabilitated mine site and the Hunter Expressway. Stockrington Quarry is also located in the catchment to the north of the site. The catchment also includes rural land use with grazing activity common (See Figure 1).

1.3 Aim

The aim of the aquatic monitoring program is to assess river health of Blue Gum Creek to determine if water quality protection measures and catchment rehabilitation are having a positive influence on the environment. The monitoring aims to:

- Assess stream condition using RCE.
- Assess habitat condition using AUSRIVAS proforma.
- Assess water quality against default ANZECC trigger values.
- Assess the macroinvertebrate community condition using SIGNAL.
- Discuss the results in context to past survey and rehabilitation of these streams.
- Identify management actions designed to improve the condition of aquatic environs.

2. Methods

2.1 Location of sampling sites

Two sites were sampled on Blue Gum Creek (Figure 2, Table 1). Two sites were located downstream of Tasman Coal rehabilitation works. There is no upstream site to determine reference condition for these streams.

Table 1 Location of sampling sites

Site name	Stream	Location	Easting	Northing
BGC@SR	Blue Gum Creek	Blue Gum Creek upstream of Stockrington Road	368006	6362135
BGC@DHB	Blue Gum Creek	Blue Gum Creek downstream at Dog Hole Bridge	369275	6363473

2.2 Field methods

The field methods were consistent with standardised techniques in field sampling as prescribed by AUSRIVAS (Turak et al. 2000). The AUSRIVAS methods of sampling both pools and riffles were modified as no suitable in-stream riffle features were present.

2.2.1 Aquatic habitat and stream condition

Riparian, Channel and Environment Inventory assessment (RCE)

The RCE Inventory (Chessman et al. 1997) provides a comparative measure of stream condition by assessing both the stream and its riparian environment in terms of habitat diversity, habitat condition and the degree of human-induced disturbance. Thirteen categories each receive a score between 1 and 4 based their condition, resulting in an accumulated score of between 13 and 52. The maximum score (52) indicates a stream with little or no obvious physical disruption and the lowest score (13) indicates a heavily channelled stream without any riparian vegetation. This assessment provided a score the general condition of the stream and must be interpreted accordingly.

Habitat description

A description of aquatic habitat was also produced using the AUSRIVAS (Australian River Assessment System) proforma. The survey is a rapid visual assessment used to describe the habitat based on the following parameters:

- geomorphology
- channel diversity
- bank stability
- riparian vegetation and adjacent land use
- water quality
- macrophytes
- local impacts and land use practices.

Regional location of study area
Tasman Coal - Aquatic Monitoring

FIGURE 1

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Drawn by: GT Project Manager: MR Project Number: 2469 Date: 5/08/2015

Location of study sites
Tasman Coal - Aquatic Monitoring

FIGURE 2

Imagery: (c) Nearmap (May 2015)

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2.2.2 Water quality

Surface water quality was measured in situ using a calibrated Yeokal 611 water quality probe at each site. The following variables were recorded:

- temperature (°C)
- conductivity (µS/cm)
- pH
- oxidation – reduction potential (ORP) (mV)
- dissolved oxygen (DO)(% saturation and mg/L)
- turbidity (NTU).

Alkalinity (mg $CaCa_3$/L) was measured with a standard titration kit. Water quality data were compared with the ANZECC (2000) default trigger values to physical and chemical stressors for protection of slightly upland aquatic ecosystems in south-eastern Australia.

2.2.3 Macroinvertebrates

Samples were collected from pool edges for a length of 10 metres either as a continuous line or in disconnected segments. Sampling in segments was often undertaken to ensure the sampling of sub-habitats such as macrophyte beds, bank overhangs, submerged branches and root mats. Segmented sampling was also employed where pool length was short and it was logistically difficult to sample in a continuous line (e.g. in-stream logs). A 250 µm dip net was drawn through the water with short sweeps towards the bank to dislodge benthic fauna while scraping submerged rocks and debris, sides of the stream bank and the bed substrate (Plate 1). Further sweeps in the water column targeted the suspended fauna.

Plate 1 Sampling method

Each sample was rinsed from the net onto a white sorting tray from which animals were picked using forceps, pipettes and or paint brushes. Each tray was picked for a minimum period of 40 minutes, after which they were picked at 10 minute intervals for either a total of one hour or until no new specimens had been found. Care was taken to collect cryptic and fast moving animals in addition to those that were conspicuous or slow. The animals collected at each site were placed into a labelled jar containing 70% ethanol.

Laboratory methods-invertebrate identification

Macroinvertebrate samples were identified to family level with the exception of Oligochaeta (to class), Polychaeta (to class), Ostracoda (to subclass), Nematoda (to phylum), Nemertea (to phylum), Acarina (to order) and Chironomidae (to subfamily). Keys used include:

- Dean, J., Rosalind, M., St Clair, M., and Cartwright, D. (2004) Identification keys to Australian families and genera of caddis-fly larvae (Trichoptera) Cooperative Research Centre for Freshwater Ecology.
- Gooderham, J. and Tsyrlin, E. (2002). The Waterbug Book: A guide to the Freshwater Macroinvertebrates of Temperate Australia, CSIRO Publishing.
- Hawking and Theischinger (1999) A guide to the identification of larvae of Australian families and to the identification of ecology of larvae from NSW.
- Madden, C. (2010) Key to genera of Australian Chironomidae. Museum Victoria Science Reports 12,1-31.
- Madden, C. (2011) Draft identification key to families of Diptera larvae of Australian inland waters La Trobe University.
- Smith, B. (1996) Identification keys to the families and genera of bivalve and gastropod molluscs found in Australian inland waters Murray Darling Freshwater Research Centre.
- Website - http://www.mdfrc.org.au/bugguide/.

2.3 Data analysis

2.3.1 SIGNAL2: (Stream Invertebrate Grade Number Average Level) scores

The revised SIGNAL2 biotic index developed by Chessman (2003a, b) was used to determine the "environmental quality" of sites. This method assigns grade numbers to each macroinvertebrate family or taxa found, based largely on their response to a range of environmental conditions (Table 2). The sum of all grade numbers for that habitat is then divided by the total number of families recorded in each habitat to calculate the SIGNAL2 index. A weighted Signal2 score was also calculated (see Chessman 2003b). The SIGNAL2 index therefore uses the average sensitivity of macroinvertebrate families to present a snapshot of biotic integrity at a site. Table 3 provides a broad guide for interpreting the health of the site according to the SIGNAL 2 score of the site.

Table 2 SIGNAL Grade and the Level of Pollution Tolerance

SIGNAL Grade	Pollution Tolerance
10-8	Indicates a greater sensitivity to pollution
7-5	Indicates a sensitivity to pollution
4-3	Indicates a tolerance to pollution
2-1	Indicates a greater tolerance to pollution

Table 3 Guide to interpreting the SIGNAL 2 scores

SIGNAL 2 Score	Habitat quality
Greater than 6	Healthy habitat
Between 5 and 6	Mild pollution
Between 4 and 5	Moderate pollution
Less than 4	Severe pollution

(Source: Gooderham J and Tsyrlin E 2002)

*Note that SIGNAL2 scores are indicative only and that pollution does not refer to just anthropogenic pollution. Environmental stress may result in poor water quality occurring naturally in waterways. Low family richness and the occurrence of pollution tolerant invertebrates can give a low SIGNAL score even though they are natural condition.

2.3.2 Opportunistic observations

Opportunistic visual observations of aquatic fauna were recorded.

3. Results

3.1 Weather Conditions

Surveys were conducted on the 7th October 2015. The weather was mild and overcast with light winds and some light rain at the times during sampling.

3.2 Aquatic habitat

The aquatic habitat of the study area comprises pools with no riffles present. Sites generally had moderate riparian and channel health (RCE 20-40). Most sites had fine sand/silt substrate with very little cobble/boulder habitat evident. Stream banks were mostly stabilised by riparian vegetation, and showed some evidence of erosion and siltation. Macrophyte occurrence varied between sites, with *Typha sp*. being predominant at the upstream site.

Table 4 shows the RCE inventory scores of each site. An RCE score greater than 40 indicates a stream considered to be in good condition with potential for higher biodiversity values. RCE Scores of 20-40 indicate a stream is in moderate condition and below 20 indicates that the stream is in very poor condition.

Table 4 RCE inventory scores

	Site	
	Blue Gum Creek at Stockrington Rd upstream	Rd Blue Gum Creek at Dog Hole Bridge downstream
RCE Score	36	36

3.2.1 Blue Gum Creek at Stockrington Road

The site is located is most upstream site on Blue gum Creek. Catchment landuse at the upstream site at George Booth Drive is predominantly bushland as well as the rehabilitated mine site and Stockrington Quarry to the north and the Hunter Expressway to the south (Figure 2, Plate 2). The stream was in moderate condition (RCE 33), and showed some disturbance through the presence of weeds Lantana (*Lantana camara*), Tobacco Bush (*Solanum mauritianum*) and Crofton Weed (*Ageratina adenophora*) as well as significant erosion. Canopy vegetation included Blue Gum (*Eucalyptus saligna*). The mid-storey was dominated by Lantana, Tobacco Bush, Cheese Tree (*Glochidion ferdinandi*) and the ground cover by native and exotic grasses and herbs. The vegetation provided low shading of the stream.

Plate 2 Blue Gum Creek at Stockrington Road

This stream was mostly shallow (<1 m depth) and had a 5 m modal width. The stream substrate consisted of predominately silt. The macrophytes *Typha sp.* and Duckweed (Lemnaceae) were observed at this site. There were pools present with some flow at the time of sampling. The water also appeared turbid and extensive stream bank erosion was observed, likely from a past flood event.

3.2.2 Blue Gum Creek at Dog Hole Bridge

The site is located downstream of site BGC (along Stockrington Road) and upstream of Dog Hole Bridge (Figure 2, Plate 3). The stream was in moderate condition (RCE 36), and showed some disturbance (i.e. presence of weeds such as Lantana). Canopy vegetation included Blue Gum (*Eucalyptus sp.)*, and Lilly Pilly (*Syzygium smithii*). The mid-storey was dominated by *Lantana camara* and Cheese Tree (*Glochidion ferdinandi*) and the ground cover by native grasses and herbs. The riparian vegetation provided moderate shading of the stream.

Plate 3 Blue Gum Creek at Dog Hole Bridge

This stream was mostly shallow (<1 m depth) with some deep sections and had a 2.5 m modal width. The stream substrate consisted of predominately silt, with some bedrock and cobbles. No macrophytes were observed at this site. There were pools present; however there was little flow at the time of sampling. The water appeared turbid. There was an anoxic odour present and signs of grazing on both side of the creek.

3.3 Water quality

Water quality results (Table 5), showed that temperature was consistent 17.85 – 19.45 °C. Conductivity was relatively high at both sites 1230-1474 µ/cm; exceeding the default ANZECC guideline of 350 µ/cm but below the EPL limit of 2000 µ/cm. Turbidity measurements ranged between 16.8-44.4 NTU and were within ANZECC guidelines. Dissolved Oxygen (DO) ranged 28.8 -44% saturation and was outside the ANZECC guideline of 80-110%. The pH readings were abnormally high and for this reason are not reported, however monthly sampling conducted by Abel Coal recorded pH 7 (upstream of BGC@SR) and pH 7.7 (at BGC@DHB) on 29/9/2015; both within ANZECC guidelines. Alkalinity ranged 80-300 mg $CaCa_3$/L showing that Blue Gum Creek has a high buffering capacity; that is has a high resistance to changes in pH. Despite exceedences in conductivity and dissolved oxygen these results are likely within the natural variability of these streams.

Table 5 Water quality results

Site number	Temp (C°)	Conductivity (µS/cm)	Turbidity (NTU)	Dissolved Oxygen (% sat)	pH	Alkalinity (mg $CaCa_3$/L)
BGC@ SR	19.45	**1230**	44.4	**44**	--	80
BGC@DHB	17.85	**1474**	16.8	**28.8**	--	300

ANZECC guidelines for upland streams: Electrical conductivity (30-350 µS/cm), Turbidity (6-50 NTU), pH (6.5-8), Dissolved Oxygen (80-110%). Text in bold indicate those variables that exceed the default trigger values.

Note: For some waterways, default ANZECC guidelines do not reflect typical background water quality and chemistry Therefore an assessment of water quality monitoring data against default values can suggest the condition of the waterway is outside the normal range, or polluted, when in fact it is 'clean', or vice versa

3.4 Macroinvertebrates

Signal2 results for the two sampled sites are provided in Table 6. Raw data is provided in Annex 1.

Table 6 Macroinvertebrate results

Site number	Number of Taxa	SIGNAL2	SIGNAL2 weighted
BGC@SR	15	3.27	3.29
BGC@DHB	2	3.50	3.17

BGC@SR had the highest number of families (15) (Table 6); BGC@DHB was depauperate with only two families observed. Signal2 and weighted Signal 2 scores indicated that both sites have severe pollution (<4 Signal), indicating dominance of pollution tolerant macroinvertebrate families.

Pollution sensitive mayflies (i.e. Leptophlebiidae (Signal 8)) are known to be sensitive to sedimentation, salinity, and poor water quality in general (Horigan et al. 2005, Johnson and Ritchie 2003; Wellnitz et al.1994; Rassmussan and Lindegaard 1988; Peters et al. 2011). These mayflies were observed at BGC@SR however not at BGC@DHB. While the presence of Leptophlebiidae may indicate that BGH@SR can support some sensitive taxa, overall it can be concluded that Blue Gum Creek is in poor stream health.

3.5 Other fauna

Introduced pest fish species Plague Minnow (*Gambusia holbrooki*) were observed at both BGC@SR sites, while Coxs Gudgeon (*Gobiomorphus coxii*) was observed at BGC@DHC.

4. Discussion

4.1 RCE Scores

RCE score were similar to previous results with scores 20-40, indicating moderate condition. These scores are similar to those calculated in autumn 2015 (Niche 2015) and are within the range of scores experienced throughout the life of the monitoring program (Tuft 2013).

4.2 Signal Scores and stream health

The poor signal scores (<4) is potentially the result of pollution from creek disturbances by erosion, siltation, weeds, and elevated salinity. Despite some poor Signal scores, BGC@SR, show some indication of good stream health with the presence of sensitive mayfly taxa Leptophlebiidae (Signal 8) as well as the beetle Scirtidae (Signal 6) (Annex 1). This is consistent with conclusions from spring 2014 monitoring report (Tuft 2014) that found both sites showed a predominance of pollution tolerant families as well as some sensitive taxa. The report also identified sedimentation as a potential source of disturbance within Blue Gum Creek. On this sampling occasion the downstream site BGC@DHB contained only two pollution tolerant families indicative of poor stream health.

The spring results show a decrease in weighted signal scores from the previous monitoring period (Table 7), however this is unrelated to rehabilitation of Tasman Coal or to any specific management actions. As previously discussed there are likely several factors contributing to the stream health of Blue Gum Creek.

Table 7 Autumn and spring 2015 weighted signal scores

Site number	Autumn 2015 Weighted Signal 2	Spring 2015 Weighted Signal 2
BGC@SR	4.45	3.29
BGC@DHB	4.1	3.17

This report identified elevated electrical conductivity (EC) within Blue Gum Creek. Although relatively high and exceeding ANZECC default guidelines, these levels were observed in autumn 2015 (Niche 2015) and prior to the commencement of the mine operations (Newcastle Coal 2002).

5. Conclusion and Recommendations

5.1 Conclusions

Blue Gum Creek is categorised as having moderate riparian and channel morphology condition. The macroinvertebrate community particularly BGC@DHB indicates poor stream health. Blue Gum Creek shows signs of disturbance that maybe contributing to low Signal scores. These include several contributing factors such as roadways, weeds, agriculture, and past high flow events also potentially important. The ability of sampling sites to monitor changes to mine rehabilitation and water quality protection measures are complicated by these disturbances.

5.2 Recommendations

Niche recommends that the monitoring program for Tasman Coal be reviewed as there are several confounding anthropogenic disturbances affecting macroinvertebrate communities and stream health downstream of the mine. The review should assess: whether the sites are appropriate to monitor stream health and catchment protection measures, whether additional sites are required in closer proximity to Tasman Coal and the value of continuing the program in its current form.

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Websites

http://ausrivas.ewater.com.au/

http://www.mdfrc.org.au/bugguide/

Annex 1 Macroinvertebrate survey results

	Blue Gum Creek at Stockrington Road	Blue Gum Creek at Dog Hole Bridge
Turbellaria	5	
Lymnaeidae	2	
Hydrobiidae		1
Physidae	4	
Corbiculidae	1	
Oligochaeta	4	
Acarina	2	
Dytiscidae	21	
Hydrophilidae	1	
Scirtidae	2	
Tanypodinae	1	
Orthocladiinae	1	
Chironominae	119	40
Leptophlebiidae	14	
Corixidae	7	
Coenagrionidae	1	

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