2019-10-10 NWE-MYS-3702

Ms. Kimberly D. Bose
Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

October 10, 2019

Re: NorthWestern Energy filing Mystic Lake Hydroelectric Project No. 2301 10-Year (2010-2019) Water Quality Monitoring Report and 20-Year (2020-2040) Water Quality Monitoring Plan

Dear Secretary Bose:

By Order dated May 3, 2011, the Commission approved NorthWestern Energy's Mystic Lake Hydroelectric Project (No. 2301) Water Quality Management Plan (2010 to 2019). This plan was developed to address the Montana Department of Environmental Quality water quality certification condition 3 in Appendix A of the December 17, 2007 Commission order issuing the new license. The Commission directed NorthWestern Energy to submit a 10-year report on this plan by December 31, 2019 with a prior 30 day review period by Montana Fish Wildlife and Parks, the U.S. Forest Service, and the Montana Department of Environmental Quality.

NorthWestern proposes a 20-year water quality monitoring plan for the years 2020-2040. Under this updated monitoring plan, NorthWestern will collect water quality data on West Rosebud Creek once every 5 years and Mystic Lake once every 3 years. Data summaries will be provided to the Mystic Technical Advisory Committee (TAC) in years when water quality monitoring occurs, and a 20-year water quality monitoring report will be submitted to the Commission by December 31, 2041.

Herein attached is the Mystic Lake Hydroelectric Project No. 2301 10-Year (2010-2019) Water Quality Monitoring Report and 20-Year (2020-2040) Water Quality Monitoring Plan. Attached to this letter is the consultation record with Montana Fish Wildlife and Parks, the U.S. Forest Service, and the Montana Department of Environmental Quality in regards to review and approval of this plan. Approval signatures from the U.S. Forest Service, and the Montana Department of Environmental Quality are included on the second page of this letter.

Sincerely,

Mary Gail Sullivan
Director, Environmental and Lands

CC: Andy Welch, NWE
Jordan Tollefson, NWE
Jon Hanson, NWE
Kristen Dawes, NWE
Eric Sivers, MT DEQ
Don Skaar, MT FWP
Mike Ruggles, MT FWP
Clint Sestrich, USFS-CGNF
Ken Coffin, USFS-CGNF

Northwestern Energy has consulted with agencies in the preparation and filing of the Mystic Lake Hydroelectric Project No. 2301 10-Year (2010-2019) Water Quality Monitoring Report and 20-Year (2020-2040) Water Quality Monitoring Plan. As signed below, the following agencies agree with the content described above and in the attached report:

By: ____________________

Title: CWA Section 401 Coordinator
Representing Montana Department of Environmental Quality

Date: 6/13/2019

By: ____________________

Title: ____________________
Representing Montana Department of Fish, Wildlife and Parks

Date: ____________________

By: ____________________

Title: District Ranger
Representing U.S. Forest Service

Date: 8 Oct 2019

Tollefson, Jordan

From:	Garber, Jason <JGarber2@mt.gov>
Sent:	Thursday, June 13, 2019 11:17 AM
To:	Tollefson, Jordan
Subject:	RE: Mystic Water Quality Report and
Attachments:	DEQ_Signed_10yr_report_20yr_plan.pdf
Follow Up Flag:	Follow up
Flag Status:	Flagged

Jordan,

See attached.

Jason

From: Tollefson, Jordan [mailto:Jordan.Tollefson@northwestern.com]
Sent: Wednesday, May 22, 2019 10:52 AM
To: Garber, Jason <JGarber2@mt.gov>; Skaar, Donald <dskaar@mt.gov>; Ruggles, Mike <mikeruggles@mt.gov>; Rhoten, Jason <jrhoten@mt.gov>; 'kcoffin@fs.fed.us' <kcoffin@fs.fed.us>; 'csestrich@fs.fed.us' <csestrich@fs.fed.us>; 'James Boyd (James_Boyd@fws.gov)' <James_Boyd@fws.gov>
Cc: Dawes, Kristen <Kristen.Dawes@northwestern.com>; 'Kristi Webb' <kwebb@nw-enviro.com>; Sullivan, Mary Gail <MaryGail.Sullivan@northwestern.com>; Hanson, Jonathan (Jon) <Jon.Hanson@northwestern.com>; Welch, Andrew <Andrew.Welch@northwestern.com>
Subject: Mystic Water Quality Report and

Mystic TAC Members,

The Mystic 10 year water quality report and 20 year water quality plan have been completed and are ready for your review and approval. Please take a few minutes to review the attached document and if you have any comments, you can send them to me and I will incorporate them into the final document. Also attached is the FERC filing letter for this report, so please have the appropriate representative from your agency sign this letter in the signature blocks provided and return a copy to me. The deadline for the review period is Monday, June 24th, so try to have your comments and signatures back to me before then. Thank you for taking the time to review this report.

Jordan

Jordan Tollefson
Hydro Compliance Professional
Jordan.Tollefson@NorthWestern.com
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C (406) 565-3879

1315 N Last Chance Gulch
Helena, MT 59601

NorthWestern Energy
Delivering a Bright Future

Connect With Us:

Tollefson, Jordan

From:	Ruggles, Mike on behalf of Ruggles, Mike <mikeruggles@mt.gov>
Sent:	Monday, July 08, 2019 12:02 PM
To:	Tollefson, Jordan; Garber, Jason; Skaar, Donald; Rhoten, Jason; 'kcoffin@fs.fed.us'; 'csestrich@fs.fed.us'
Cc:	Welch, Andrew; Hanson, Jonathan (Jon)
Subject:	RE: Mystic Water Quality Report and Plan

Hi Jordan,

Thanks for the reminder. Don Skaar will be signing for FWP. I was able to review the report and plan last week and it looks fine from my perspective.

Mike

From: Tollefson, Jordan <Jordan.Tollefson@northwestern.com>
Sent: Monday, July 08, 2019 12:00 PM
To: Garber, Jason <JGarber2@mt.gov>; Skaar, Donald <dskaar@mt.gov>; Ruggles, Mike <mikeruggles@mt.gov>; Rhoten, Jason <jrhoten@mt.gov>; 'kcoffin@fs.fed.us' <kcoffin@fs.fed.us>; 'csestrich@fs.fed.us' <csestrich@fs.fed.us>
Cc: Welch, Andrew <Andrew.Welch@northwestern.com>; Hanson, Jonathan (Jon) <Jon.Hanson@northwestern.com>
Subject: RE: Mystic Water Quality Report and Plan

Good morning everyone,

This is a quick reminder about the Mystic Water Quality Report and Water Quality Plan approvals. To date I have only received signature approval from DEQ, and am still looking for FWP and USFS approvals. Attached is the FERC filing letter with the signature approval blocks on the second page. If you have any questions, please let me know. Thanks.

Jordan

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Cc: Dawes, Kristen <Kristen.Dawes@northwestern.com<mailto:Kristen.Dawes@northwestern.com>>; 'Kristi Webb' <kwebb@nw-enviro.com<mailto:kwebb@nw-enviro.com>>; Sullivan, Mary Gail <MaryGail.Sullivan@northwestern.com<mailto:MaryGail.Sullivan@northwestern.com>>; Hanson, Jonathan (Jon) <Jon.Hanson@northwestern.com<mailto:Jon.Hanson@northwestern.com>>; Welch, Andrew <Andrew.Welch@northwestern.com<mailto:Andrew.Welch@northwestern.com>>
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____

Attachments:

image001.jpg (7 KB)

Tollefson, Jordan

From: Coffin, Ken W -FS <ken.coffin@usda.gov>
Sent: Tuesday, October 08, 2019 1:38 PM
To: Tollefson, Jordan
Subject: RE: Mystic Water Quality Report and Plan
Attachments: NWE Mystic Lake water quality report FS signature.pdf

Follow Up Flag: Follow Up
Flag Status: Flagged

Hi Jordan,

Attached is the signature page for the Mystic Lake water quality report.

kwc

Ken Coffin
District Ranger
Forest Service
Beartooth Ranger District
Custer Gallatin National Forest
p: 406-446-4529
ken.coffin@usda.gov
6811 Hwy 212 South
Red Lodge, MT 59068
www.fs.fed.us

Caring for the land and serving people

From: Tollefson, Jordan [mailto:Jordan.Tollefson@northwestern.com]
Sent: Monday, July 8, 2019 12:00 PM
To: 'Garber, Jason' <JGarber2@mt.gov>; 'Don Skaar (dskaar@mt.gov)' <dskaar@mt.gov>; 'mikeruggles@mt.gov' <mikeruggles@mt.gov>; 'jrhoten@mt.gov' <jrhoten@mt.gov>; Coffin, Ken W -FS <ken.coffin@usda.gov>; Sestrich, Clint -FS <clint.sestrich@usda.gov>
Cc: Welch, Andrew <Andrew.Welch@northwestern.com>; Hanson, Jonathan (Jon) <Jon.Hanson@northwestern.com>
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Cc: Dawes, Kristen <Kristen.Dawes@northwestern.com>; 'Kristi Webb' <kwebb@nw-enviro.com>; Sullivan, Mary Gail <MaryGail.Sullivan@northwestern.com>; Hanson, Jonathan (Jon) <Jon.Hanson@northwestern.com>; Welch, Andrew <Andrew.Welch@northwestern.com>
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Mystic Lake Hydroelectric Project
FERC Project Number 2301

10-Year (2010–2019) Water Quality Monitoring Report
and
20-Year (2020-2040) Water Quality Monitoring Plan

Public
March 2019

Prepared by:
NorthWestern Energy
Butte, Montana

With Assistance From:
New Wave Environmental Consulting, LLC
Missoula, Montana

GEI Consultants, Inc.
Portland, Oregon

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Acronyms

Above Powerhouse	APH
above mean sea level	amsl
Administrative Rules of Montana	ARM
Allen Grade Bridge	AGB
below detection	BD
Below Powerhouse	BPH
Below West Rosebud Lake	BWRL
Celsius	C
centimeter	cm
cubed	^{3}
cubic feet per second	cfs
degrees	°
dissolved oxygen	DO
Ephemeroptera, Plecoptera, Trichoptera (composition of taxa)	EPT
Environmental Protection Agency	EPA
Fahrenheit	F
Federal Energy Regulatory Commission	FERC or Commission
liter	L
7-day average of the daily maxima	7DADM
meter	m
micro	µ
micrometer	µm
milligrams	mg
milliliter	mL
Montana Department of Environmental Quality	MDEQ
Mystic Lake Hydroelectric Project No. 2301	Project
natural counting units	NCU
nephelometric turbidity unit	NTU
NorthWestern Energy Corporation	NorthWestern or Licensee
number	No. or #
percent	%
Pine Grove Campground	PGC
PPL Montana, LLC	PPL Montana
Rhithron Associates, Inc.	Rhithron
saturation	Sat
Shannon Diversity Index	H'
specific conductivity	µS
squared	^{2}
Technical Advisory Committee	TAC
total dissolved solids	TDS
total suspended solids	TSS
U.S. Geological Survey	USGS
United States	U.S.

Executive Summary

The Mystic Lake Hydroelectric Project No. 2301 (Project) is owned and operated by the Licensee, NorthWestern Energy Corporation (NorthWestern). The Federal Energy Regulatory Commission (FERC or Commission) issued a new license (40-year-term) on December 17, 2007 that was effective January 1, 2010. The new License requires NorthWestern to implement a 10-year Water Quality Monitoring Plan for the Project area (from Mystic Lake downstream to below the Re-regulation dam). The License also requires compliance with the terms and conditions specified in the Section 401 Water Quality Certification issued by the Montana Department of Environmental Quality (MDEQ) on February 5, 2007.

2010-2019 Water Monitoring Summary

In compliance with the FERC License, and in consultation with MDEQ, the Licensee developed and submitted a long-term monitoring plan, *Mystic Lake Hydropower Project FERC Project Number 2301 Water Quality Monitoring Plan (2010-2019)*, to the Commission on November 9, 2010. In compliance with the monitoring plan submitted in 2010, NorthWestern prepared this report presenting the fourth year (2018) of water quality monitoring for the 2010 to 2019 monitoring period. This report summarizes the 2018 results and provides a comprehensive review of the sampling events over the last 10-years (2010-2019).

This report provides the analysis and summary of water chemistry and biology data collected in 2018 from Mystic Lake and West Rosebud Creek. One site in Mystic Lake (mid-lake) was sampled in August to analyze physical and chemical properties of the lake as well as biological characteristics, including chlorophyll *a* and plankton species composition and relative abundance. In West Rosebud Creek, three sites [above powerhouse (APH), below powerhouse (BPH), and below West Rosebud Lake (BWRL)] were sampled in April, July, and October and analyzed for chemical and biological (chlorophyll *a* and periphyton) properties. In addition, macroinvertebrate samples were collected in October 2018 at five sites in West Rosebud Creek, including APH, BPH, and BWRL plus two additional sites located further downstream, Pine Grove Campground (PGC) and Allen Grade Bridge (AGB).

Water chemistry parameters collected from Mystic Lake and West Rosebud Creek included temperature, pH, specific conductivity, dissolved oxygen, total alkalinity, arsenic, bicarbonate, cadmium, calcium, chloride, copper, iron, lead, magnesium, manganese, nitrogen (nitrate + nitrite), total nitrogen (persulfate), orthophosphate, total phosphorus, potassium, sodium, sulfate, total dissolved solids, total suspended solids, and zinc. In addition, turbidity was also measured in West Rosebud Creek.

As in previous sample years (2010, 2012, 2015), no water quality parameters analyzed in 2018 in Mystic Lake or West Rosebud Creek were detected above Montana's numeric water quality standards as outlined in the Circular DEQ-7 (MDEQ, 2017) or above B-1 classification standards outlined in the Administrative Rules of Montana (ARM) 17.30.623. Detection limits for analyzing water samples for heavy metals (arsenic, cadmium, copper, iron, lead, zinc) were consistent with the limits provided in the Circular DEQ-7 (MDEQ 2017). No heavy metals were detected in Mystic Lake. All heavy metals were near or below the detection limit in West Rosebud Creek.

Biological parameters collected in Mystic Lake included phytoplankton and zooplankton species composition and relative abundance, and chlorophyll *a*. Mystic Lake is a cold, nutrient poor (oligotrophic) lake with minimal phytoplankton biomass and low species diversity, low chlorophyll *a* concentrations, and low zooplankton species diversity primarily comprised of Cladocera and Cyclopoida.

Biological parameters evaluated in West Rosebud Creek included macroinvertebrate species composition, relative abundance, and metrics, as well as periphyton species composition and benthic algae measured as chlorophyll *a*.

Diatoms (a type of algae) provide an assessment of stream health. In this report, three indices, including the Shannon diversity index (species richness and evenness), pollution index, and siltation index were assessed. The pollution and siltation indices for diatom samples taken at the three stream sites (APH, BPH, BWRL) between 2006 and 2018, indicate an "excellent" and non-stressed mountain stream. The Shannon diversity index, indicative of species richness and evenness, revealed more variability among years and sites with results ranging from "fair" to "excellent" classifications. The variability in the Shannon diversity index is common in mountain streams with low species diversity and likely related to natural stress typical of a cold-water, steep-gradient, and low-nutrient stream.

Macroinvertebrate metrics such as taxa richness, EPT richness (a standard community composition metric used to evaluate water and habitat quality [Bukantis, 1997]), and biotic index were also used to assess stream health. All macroinvertebrate metrics analyzed at five sites (APH, BPH, BWRL, PGC, AGB) sampled in West Rosebud Creek met the stream-quality assessment criteria for non-impacted site since sampling began in 2010. The overall macroinvertebrate assemblages were characteristic of good environmental conditions in all stream reaches. Changes in species composition among sites reflected the longitudinal gradient within the study area and localized influences of West Rosebud and Emerald lakes. Overall, West Rosebud Creek supports a healthy assemblage of aquatic macroinvertebrates. The community is typical of a soft-water (low alkalinity), low-nutrient mountain stream and there are few indications of environmental stress.

In summary, the data collected in 2018 were comparable with water quality results from prior years. The water quality data collected in 2018 from Mystic Lake and West Rosebud Creek were consistent with expectations of an high elevation, oligotrophic mountain system at temperate latitude with minimal anthropogenic inputs.

2020-2040 Water Quality Monitoring Plan

NorthWestern proposes a 20-year (2020-2040) and to continue implementing a 3-year sampling interval in Mystic Lake and a 5-year sampling interval in West Rosebud Creek. Stream temperature monitoring will be discontinued. Water chemistry and biological parameters will remain the same, sampling methods will remain the same, and the time of year for sampling will remain the same. NorthWestern will provide a summary of results to the TAC within 1 year of each sampling event. A comprehensive 20-year (2020-2040) monitoring report will be prepare for TAC approval prior to submittal to the Commission by December 31, 2041.

1. Introduction

Mystic Lake is located at the head of a high mountain canyon in the upper reaches of West Rosebud Creek. Lands surrounding Mystic Lake are in the Absaroka-Beartooth Wilderness Area. Within West Rosebud Creek drainage (213.4 square miles), Mystic Lake is the fourth and largest lake in a chain of six hydrologically-connected lakes (listed in order going downstream: Star, Silver, Island, Mystic, West Rosebud, and Emerald lakes). Mystic Lake has a maximum pool elevation of 7,673.5 feet amsl and a minimum useable pool elevation of 7,612 feet amsl. The present License allows Mystic Lake to fluctuate 10 feet between recreational pool level and full pool level between July 10 and September 15.

West Rosebud Creek is a tributary to the Stillwater River located in Beartooth Ranger District of the Custer Gallatin National Forest. Headwaters of West Rosebud Creek are within the Absaroka-Beartooth Wilderness Area. West Rosebud Creek drains an area of 213.4 square miles and flows about 30 miles to the northeast where it joins the Stillwater River near the town of Absarokee. The Stillwater River joins the Yellowstone River at the town of Columbus.

1.1 Project Description and Monitoring Requirements

The Mystic Lake Hydroelectric Project No. 2301 (Project) is operated and owned by the Licensee (NorthWestern). On December 17, 2007, the Federal Energy Regulatory Commission (FERC or Commission) issued a new 40-year License for the Project effective January 1, 2010. The License requires the Licensee to implement a 10-year Water Quality Monitoring Plan (Monitoring Plan) for Mystic Lake and West Rosebud Creek as specified in Appendix A of the Final License Application submitted to FERC on December 15, 2006. The Licensee must also comply with the terms and conditions specified in the Section 401 Water Quality Certification issued by the Montana Department of Environmental Quality (MDEQ) on February 5, 2007 (presented in Appendix A of the December 17, 2007 FERC Order Issuing New License).

In compliance with the FERC License and in consultation with MDEQ, the former owner, PPL Montana, developed and submitted the Monitoring Plan (PPL Montana, 2010), to the Commission on November 9, 2010.

The Monitoring Plan included a summary of water quality (chemistry and biological) sampling results from 2006 to 2009, to establish a baseline. Water quality data collected during the baseline period indicate that the drainage (from Mystic Lake downstream to West Rosebud Creek below the Re-regulation Dam) is representative of an oligotrophic system (PPL Montana, 2010).

The objective for the Monitoring Plan was to continue monitoring water quality (chemistry and biology) trends and variability in Mystic Lake and West Rosebud Creek. Water quality data was sampled in 2010, 2012, 2015, and 2018. Stream temperature monitoring in West Rosebud Creek was sampled in 2010, 2012, 2014, 2016, and 2018 in conjunction with fisheries population evaluations in West Rosebud and Emerald lakes.

Water quality monitoring reports were prepared following each sampling season. Reports for 2010, 2012, and 2015 sampling years (PPL Montana, 2011 and 2013; NorthWestern, 2016) were distributed to the Mystic Fisheries, Aquatic Habitat, and Water Quality Technical Advisory Committee (TAC) and posted on the Project website (http://www.mysticlakeproject.com/com-orders.htm). Stream temperature data collected in conjunction with fisheries data were summarized in the 2014 and 2016 annual fisheries reports (NorthWestern, 2015; 2017).

The Monitoring Plan outlines water quality parameters evaluated, and the sampling schedule implemented between 2010 and 2019. At the end of the 10-year monitoring period, the Licensee is required to re-evaluate water quality data and determine the need to modify and/or continue the Monitoring Plan.

This report provides the results of the water quality monitoring based on sampling events in 2010, 2012, 2015, and 2018 in Mystic Lake and in West Rosebud Creek. The 2018 sampling event marks the completion of the monitoring period described in the Monitoring Plan.

2. Water Quality Monitoring Program

2.1 Sampling Sites

The Licensee identified one sampling site in Mystic Lake and three primary sampling locations in West Rosebud Creek, including West Rosebud Above the Powerhouse (APH), West Rosebud Creek Below the Powerhouse (BPH), and West Rosebud Creek Below West Rosebud Lake (BWRL) for collection of long-term water quality data (Figure 2-1).

Macroinvertebrate sampling was completed in the APH, BPH, and BWRL sites in compliance with the Monitoring Plan (PPL Montana, 2010) and in two additional sites, Pine Grove Campground (PGC) and Allen Grade Bridge (AGB) (Figure 2-1), located downstream in compliance with the *2010-2015 Fisheries Monitoring Plan* (PPL Montana, 2010a).

Stream temperature monitoring was scheduled in conjunction with fisheries monitoring in West Rosebud and Emerald lakes (NorthWestern, 2016). Stream monitoring stations were established at for locations in West Rosebud Creek including the upper bypass reach, APH, BPH, and BWRL sites (Figure 2-1).

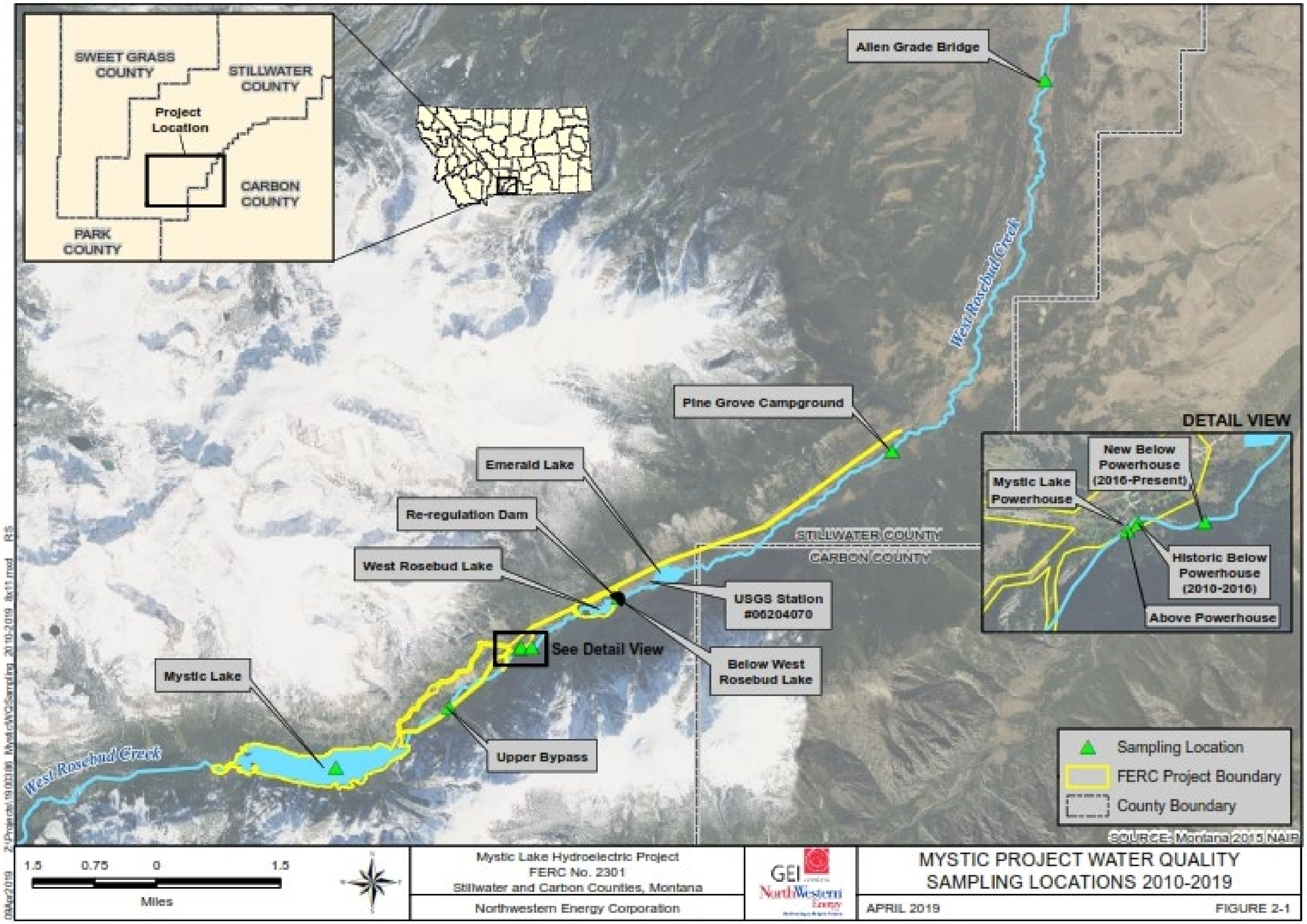
2.2 Sampling Parameters

Water quality data were collected in the middle of Mystic Lake in early August and in April, July, and October, in West Rosebud Creek. Macroinvertebrate samples were collected in October. Water quality data were collected within the same 2-week period each year, when feasible. Water chemistry and biological parameters monitored in Mystic Lake and West Rosebud Creek are listed in Table 2-1.

Table 2-1: Summary of water chemistry and biological parameters analyzed from three sites in West Rosebud Creek and one site in Mystic Lake, 2010 – 2019 monitoring period.

	West Rosebud Creek (APH, BPH, BWRL)				Mystic Lake (Mid-lake)			
Parameters	**2010**	**2012**	**2015**	**2018**	**2010**	**2012**	**2015**	**2018**
Hydrolab	x	x	x	x	x	x	x	x
Total Alkalinity	x	x	x	x	x	x	x	x
Arsenic	x	x	x	x	x	x	x	x
Bicarbonate	x	x	x	x	x	x	x	x
Cadmium	x	x	x	x	x	x	x	x
Calcium	x	x	x	x	x	x	x	x
Chloride	x	x	x	x	x	x	x	x
Copper	x	x	x	x	x	x	x	x
Iron	x	x	x	x	x	x	x	x
Lead	x	x	x	x	x	x	x	x
Magnesium	x	x	x	x	x	x	x	x
Manganese	x	x	x	x	x	x	x	x
Nitrogen, Nitrate +Nitrite	x	x	x	x	x	x	x	x
Nitrogen, Total (persulfate)	x	x	x	x	x	x	x	x
Orthophosphate	x	x	x	x	x	x	x	x
Total Phosphorus	x	x	x	x	x	x	x	x
Potassium	x	x	x	x	x	x	x	x
Sodium	x	x	x	x	x	x	x	x
Sulfate	x	x	x	x	x	x	x	x
TDS	x	x	x	x	x	x	x	x
TSS	x	x	x	x	x	x	x	x
Turbidity	x	x	x	x	x	x	x	x
Zinc	x	x	x	x	x	x	x	x
Chlorophyll *a*	x	x	x	x	x	x	x	x
Periphyton	x	x	x	x				
Macroinvertebrates	x	x	x	x				
Phytoplankton					x	x	x	x
Zooplankton					x	x	x	x

Figure 2-1: Mystic Project Water Quality Monitoring 2010–2019 Sampling Locations.



Hydrolab-brand multiparameter water quality instruments were used to measure temperature, pH, specific conductivity, and dissolved oxygen. A Hach turbidimeter was used to measure turbidity. Water samples were analyzed for chemical composition and various biological parameters as listed in Table 2-1.

The Licensee also made a visual assessment for the presence of *Didymosphenia geminata* (*Didymosphenia*) in West Rosebud Creek. These observations were done concurrent with water quality sampling efforts implemented in April, July, and October in West Rosebud Creek and included a visual observation from bank-to-bank.

2.3 Sampling Methods

2.3.1 *Mystic Lake*

Mystic Lake water samples were collected with a Van Dorn water sampler. The mid-lake water chemistry samples were drawn from a composite of four sub-samples taken from depths of 0 (surface), 25, 50, and 100 feet. Samples were sent to Energy Laboratories for chemical analysis.

Multiparameter sondes by Hydrolab were used to measure the following parameters: water temperature (°C), pH, specific conductivity (µS/cm), and dissolved oxygen (% saturation and milligrams per liter [mg/L]). These parameters were recorded at various intervals from the surface to approximately 140 to 159-foot depth.

2.3.1.1 Phytoplankton Samples

Phytoplankton samples were drawn from a composite of several sub-samples collected from a zone of three times the Secchi depth or the top of the thermocline (the depth at which the water temperature declines most rapidly; determined from a Hydrolab profile when temperature changes were greater than 1.0. °C per meter), whichever was shallower.

Phytoplankton samples were collected by NorthWestern personnel and delivered to Rhithron Associates, Inc. (Rhithron) laboratory facility in Missoula, Montana for analysis. Rhithron's reports (2011; 2012; 2015; 2018) summarizing results from each sampling event over the last 10-years (2010-2018) and respective methods are provided in Appendix B.

Phytoplankton samples taken in 2012 and earlier were sent to Karl Bruun, Nostoca Algae Laboratory for sample analysis. Details of the methods implemented in 2012 are provided in the 2012 Water Quality Monitoring Report (PPL Montana, 2013).

2.3.1.2 Zooplankton Samples

Zooplankton samples were collected from individual vertical tows from 100-foot depth to the surface and were collected with an 80-micrometer (µm) mesh net. Samples were taken by

Licensee personnel and delivered to Rhithron for analysis. Processing and identification methods are provided in Appendix B.

Prior to 2015, zooplankton samples were sent to Alex Salki, Salki Consultants, Inc. for processing and identification. Details of methods implemented prior to 2015 are provided in previous water quality reports (PPL Montana, 2010; 2011; 2013).

2.3.1.3 Chlorophyll *a* Samples

Chlorophyll *a* samples were drawn from a composite of several sub-samples collected from a zone of three times the Secchi depth or the top of the thermocline (determined from a Hydrolab profile when temperature changes were greater than 1.0°C per meter), whichever was more shallow. Composite water samples were filtered on site through a 0.7-µm glass fiber filter (GF/F). A total sample volume of approximately 2,000 milliliters (mL) was taken for the chlorophyll analysis.

2.3.2 *West Rosebud Creek*

West Rosebud Creek water samples were taken using sample bottles that were rinsed three times with native water prior to sampling. Samples were taken in the upstream direction to avoid entrainment of sediment disturbed by wading. During sampling, the sampling device was lowered and raised at a constant rate through the water column, carefully avoiding any disturbance of bottom sediments.

Samples were transferred to a decontaminated Teflon churn splitter and sealed in a secure container (wrapped in plastic in a soft cooler) until processing. Processing and splitting of sample aliquots into sample bottles was done in the field and occurred as soon as all samples for the day had been taken. Filtration was performed with a 0.45-µm filter for dissolved parameters by Energy Laboratories. All sample bottles were virgin polyethylene bottles supplied by Energy Laboratories.

Samples were clearly labeled with a waterproof marker or preprinted labels, indicating site identification, date and time, sample type, preservative, and sampler’s initials. Field notebooks were completed for each location along with appropriate chain-of-custody forms. All samples were immediately placed in a cooler chilled to 4 °C (39.2 °F) for transport to the lab.

Quality control samples were analyzed for water quality parameters. These samples consisted of one replicate for every 10 samples and one equipment blank for each sampling event. The replicate was a sequential sample taken at one of the locations as a control measure of field variability, sample processing procedures, and laboratory methodology. The equipment blank was a deionized water sample run through the DH 59 sampler and churn splitter and analyzed for the full suite of water quality parameters. The blank represents a quality control measure of lab methodology, but also integrates procedural aspects such as decontamination and sample handling.

Multiparameter sondes by Hydrolab were used to measure the following parameters: water temperature (°C), pH, specific conductivity, and dissolved oxygen. Turbidity was measured with a Hach Model 2100P turbidimeter.

2.3.2.1 Macroinvertebrate Samples

Northwestern contracted with David Stagliano, Montana Biological Survey/Stag Benthics to sample, process (identification and enumeration), and analyze aquatic macroinvertebrates in West Rosebud Creek in October 2018. In previous years, Dan McGuire, McGuire Consulting had completed the survey and analyses. Methods and results from each year (2010, 2012, 2015, 2018) are provided in Appendix A.

There were three replicate Hess samples (0.1 m^2, 390 micron mesh) collected from each of the five sites in West Rosebud Creek in riffle habitats less than 30 centimeter (cm) in depth. The sample sites include APH, BPH, BWRL, PGC, and AGB.

Processing of the benthic macroinvertebrate samples was consistent with the techniques and procedures used for Licensee's annual macroinvertebrate monitoring on the Madison and Missouri rivers (McGuire, 1992), using the U.S. Environmental Protection Agency (EPA) Rapid Bioassessment Protocols (Plafkin et al., 1989) to obtain a 300-organism fixed-count subsample. The use of a fixed-count subsample standardizes kick sample data and allows quantitative comparisons to a reference condition (Barbour and Gerritsen, 1996).

For processing, a sample was first emptied into a U.S. Standard #30 sieve and rinsed with water. The entire sample was then evenly distributed within a gridded enamel pan ranging from 9- by 12-inch to 14- by 20-inch, depending on the sample's volume. All macro-invertebrates in a randomly selected grid square were removed. This process was repeated until 270 to 330 organisms (300 ± 10 percent) had been picked. Rare taxa that were missed by subsampling were removed from the remainder of the sample and included in the taxa list for the site.

Macroinvertebrates were identified to taxonomic levels specified in the MDEQ's 1998 *Rapid bioassessment macroinvertebrate protocols: Sampling and sample analysis SOP's* using the most recent published taxonomic literature. The total number of macroinvertebrates per sample was extrapolated from the percentage of the sample used to obtain approximately 300 organisms.

2.3.2.2 Periphyton Samples

Periphyton species composition and enumeration samples were collected by Licensee personnel from all habitats within the sampling site in amounts proportional to the occurrence of different habitats at the site. Samples were preserved with Lugol's solution. Periphyton samples were delivered to Rhithron for analysis. Methods of analysis are available in Rhithron's Technical Summary of Methods and Quality Assurance Procedures (2018). There was some slight variation of methods prior to 2015 and these are described in Appendix B.

2.3.2.3 Periphyton Chlorophyll Samples

Periphyton chlorophyll samples used the whole rock sampling method. A minimum of five stones were collected for each replicate. Four replicates (each replicate containing five stones) were collected at each site. The samples were transported to Energy Laboratories in a cooler with ice, and then stored in a freezer until analyzed.

2.3.2.4 Stream Temperature

West Rosebud Creek temperature monitoring occurred concurrently with West Rosebud Lake and Emerald Lake fish surveys in 2010, 2012, 2014, 2016, and 2018 (PPL Montana, 2010a; NorthWestern, 2016a). The water temperature monitoring period extends from April to late October at four designated sites, including the upper bypass in West Rosebud Creek (located immediately below Mystic Lake), APH, BPH, and BWRL (Figure 2-1). Stream temperature data were collected using HOBO water temperature Pro v2 Data Loggers (temperature loggers).

3. Mystic Lake Results

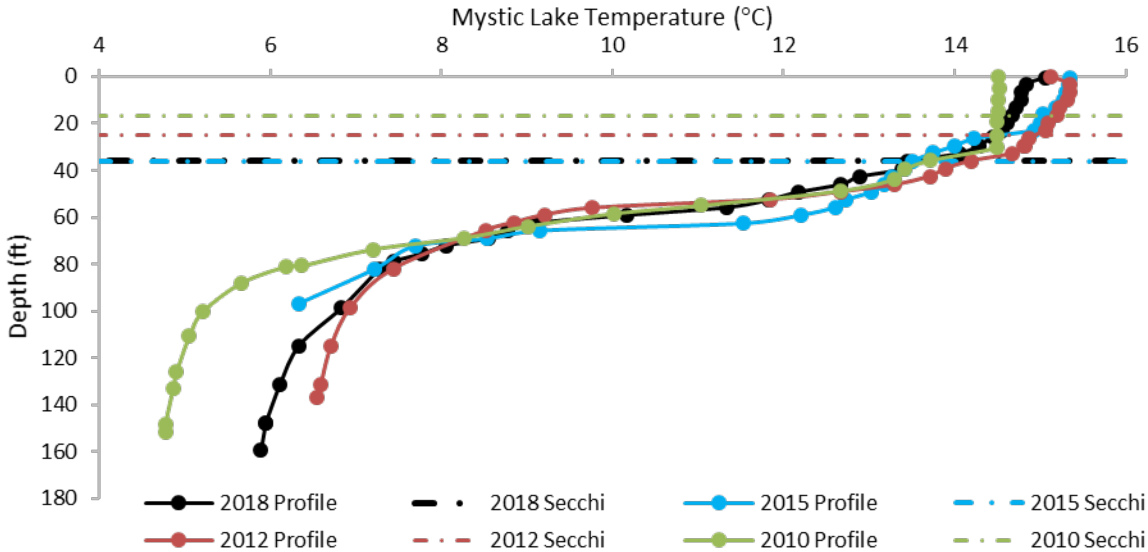
In 2018, water temperature, transparency (secchi depth), pH, specific conductivity, and dissolved oxygen profiles in Mystic Lake were collected on August 7. Water quality data collected in 2018 for Mystic Lake has been analyzed and the results and comparisons to previous years of data are summarized and presented in Sections 3.1 to 3.4. Since 2010, these same limnological parameters were measured in early August, between August 4 and 13.

3.1 Temperature and Transparency

As in previous years, the 2018 temperature profile for Mystic Lake shows a well-defined thermal stratification developed by August (Figure 3-1). In August 2018, the lake temperature dropped from approximately 15 °C near the surface to about 6 °C (59–43 °F) at depth of approximately 160 feet below the surface. The depth at which the water temperature declined most rapidly (also referred to as the thermocline) in 2018 was comparable to previous years, around 60 feet below the surface (Figure 3-1).

Clarity or transparency of the lake water was measured via a secchi disc. The depth of water in which the secchi disc is still visible has ranged from 17 feet in 2010 to 36 feet in 2015 and 2018. The clear-blue water as measured by the secchi depths indicate high transparency in the lake, typical of cold, nutrient-poor (oligotrophic) systems (Horne and Goldman, 1994).

Figure 3-1: Thermal profile (°C) and secchi depth (ft) in Mystic Lake during August sampling completed in 2010, 2012, 2015, 2018.



3.2 Dissolved Oxygen

In August 2018, dissolved oxygen concentrations (mg/L) in Mystic Lake remained between 6.3 and 6.9 mg/L from the surface to approximately 160 feet below the surface (Figure 3-2). Concentrations of dissolved oxygen from 2018 and previous years (2010–2015) are indicative of an orthograde curve (Figure 3-2), which is representative of an unproductive, or oligotrophic, lake (Horne and Goldman, 1994). An orthograde curve is characterized as showing no "appreciable decrease or increase in oxygen concentrations" (Horne and Goldman, 1994).

The dissolved oxygen profile measured as percent saturation is provided in Figure 3-3. Dissolved oxygen dissolves more easily as temperatures decrease, therefore the percent saturation (dissolved oxygen) decreases with temperature and depth, as illustrated in Figure 3-3. Between 2010 and 2018, percent saturation has ranged from approximately 84 percent or greater at the surface to around 40 feet below the surface. Between 40 and 60 feet below water surface, dissolved oxygen concentrations declined to 65 to 86 percent saturation (Figure 3-3).

3.3 Specific Conductivity

Specific conductivity is measured in micro Siemens per centimeter (μS/cm). Specific conductivity is a measure of the resistance of a solution to electrical flow and is used as an index for total dissolved solids (TDS). The resistance of water to an electrical current is reduced with increasing content of ions. Therefore, a higher specific conductance allows for electrical current to pass more freely and low specific conductance resists electrical current. Low specific conductance is often related to a low amount of TDS in the water column.

Figure 3-2: Dissolved oxygen (mg/L) profile for Mystic Lake measured in August 2010, 2012, 2015, and 2018.

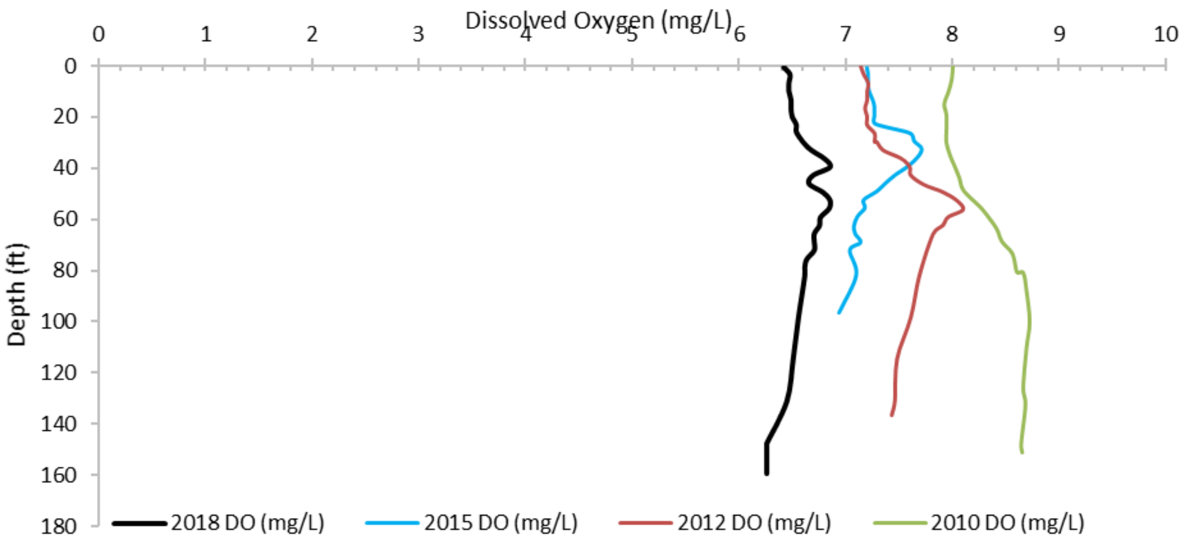
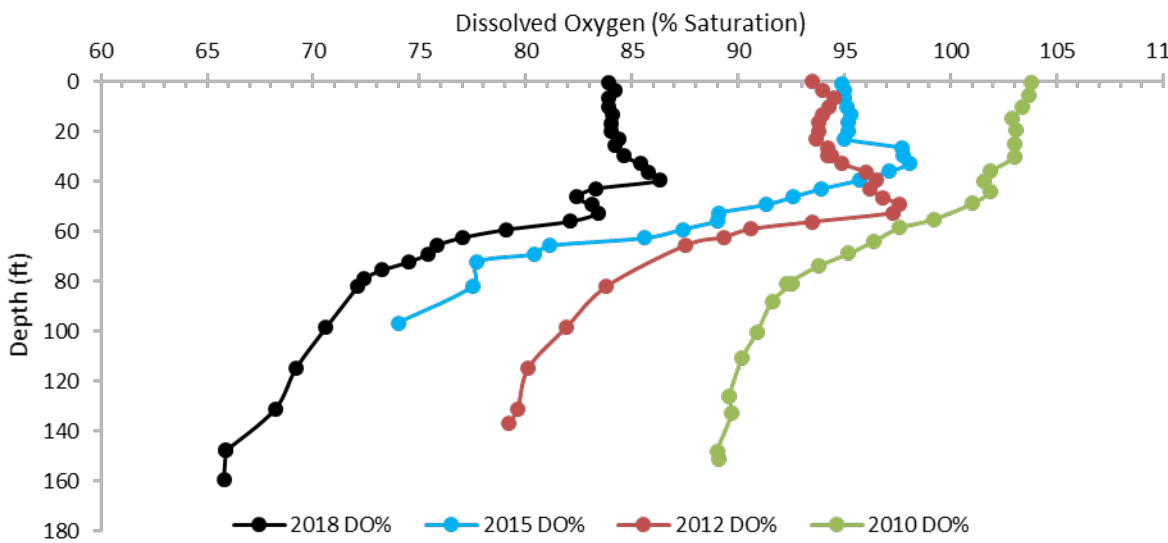
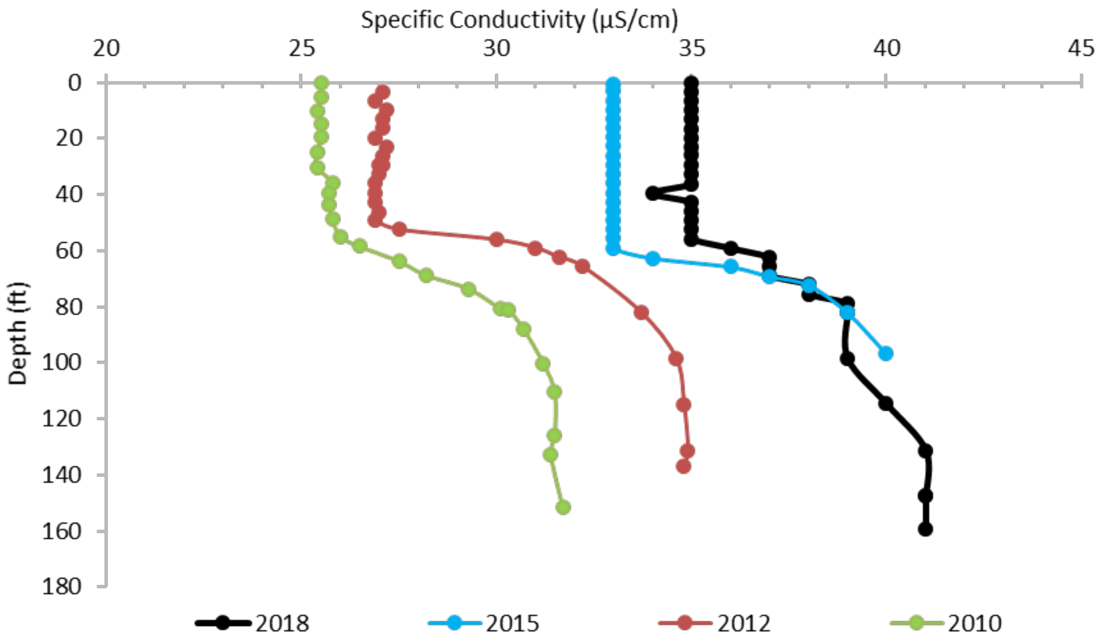


Figure 3-3: Dissolved oxygen (DO) profile, measured as % saturation for Mystic Lake measured in August 2010, 2012, 2015, and 2018.



Specific conductivity recorded in August 2018 in Mystic Lake ranged between 34 and 41 μS/cm and increased once 56 feet below the surface (Figure 3-4). The 2018 data indicate that Mystic Lake continues to have relatively low conductivity. At the thermocline, around 60 feet below the surface, conductivity values increased as observed in previous years (Figure 3-4).

Figure 3-4. Specific conductivity (µS/cm) profile for Mystic Lake 2010, 2012, 2015, 2018.



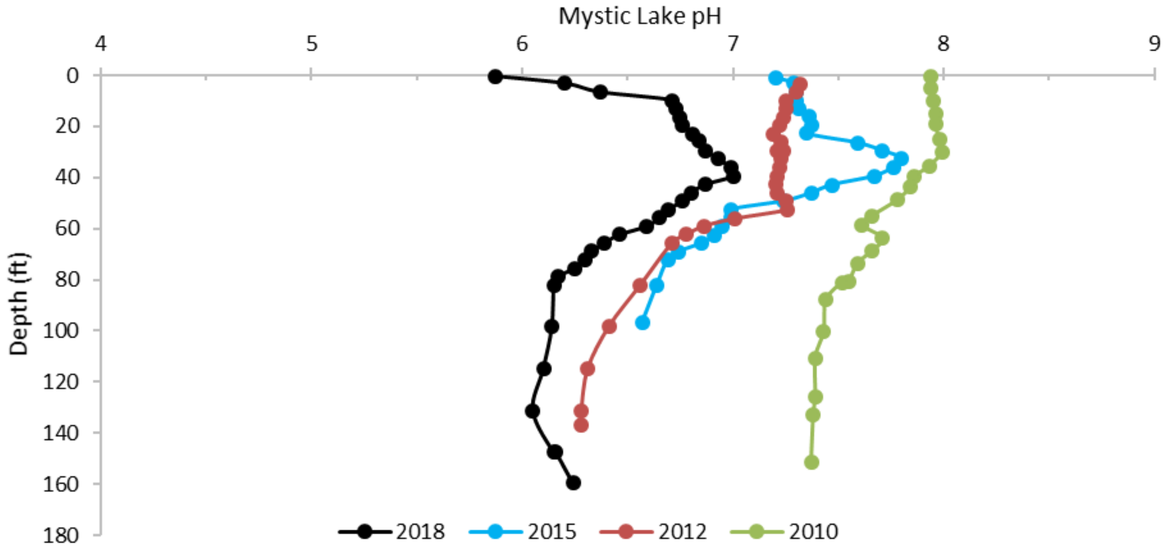
3.4 pH

The profile of pH was also measured at various depths during the August sampling in Mystic Lake in 2010, 2012, 2015, and 2018 (Figure 3-5). The pH measurements ranged between 7.3 and 8.0 in 2010; between 6.3 and 7.3 in 2012; between 6.6 and 7.8 in 2015; and between 5.9 and 7.0 in 2018. All measurements of pH are within the typical range for lakes, pH of 6 to 9 (Horne and Goldman, 1994).

3.5 Water Chemistry

Mystic Lake water chemistry results are presented in Table 3-1 for August 2010 through 2018. Many of the parameters analyzed were below detection, while others were near detection limits or low in concentration (Table 3-1). The 2018 results were similar previous years and consistent with an oligotrophic system that has minimal anthropogenic inputs and an unpolluted state.

Figure 3-5. pH profile for Mystic Lake 2010, 2012, 2015, 2018.



3.6 Phytoplankton

In August 2018 phytoplankton samples were taken from a composite of a whole water sample collected via a Van Dorn sampler from the upper 50 feet of the water column in Mystic Lake.

In 2018, Mystic Lake phytoplankton density measured by total biovolume ($\mu m^3/mL$) and by cell density (cells/mL) was dominated by Bacillariophyta. The phytoplankton taxa composition (% total biovolume) for Mystic Lake in 2010 through 2018 is shown in Figure 3-6 while phytoplankton density measured by cell density (cells/mL) is shown in Figure 3-7.

Table 3-1: Water chemistry results for Mystic Lake in August from 2010, 2012, and 2015. (BD=below detection).

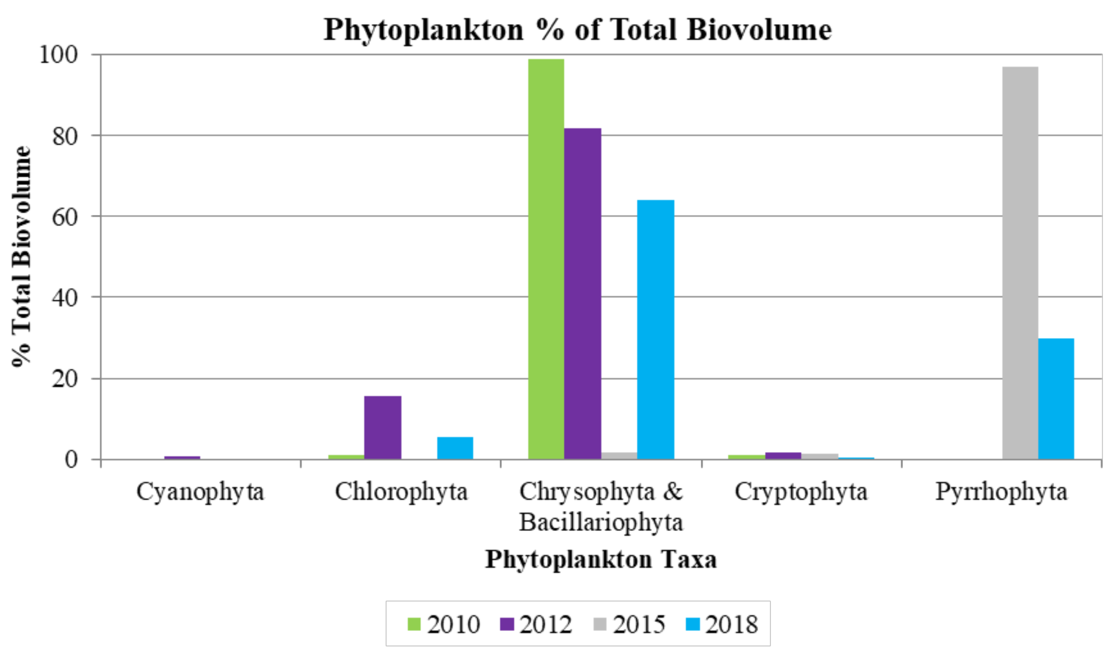
Parameters	Units	Detection Limit[a]	August			
			2010	2012	2015	2018
Total Alkalinity ($CaCO_3$)	mg/L	4	10	10	11	13
Arsenic	mg/L	0.001	BD	BD	BD	BD
Bicarbonate	mg/L	4	12	13	14	16
Cadmium	mg/L	0.00008 (2006-2015) 0.0001 (2018)	BD	BD	BD	BD
Calcium	mg/L	1	4	3	4	5
Chloride	mg/L	1	BD	BD	BD	BD
Copper	mg/L	0.001	BD	BD	BD	BD
Iron	mg/L	0.05 (2006-2010) 0.003 (2012-2018)	BD	BD	BD	BD
Lead	mg/L	0.0005 (2006-2010) 0.001 (2012-2018)	BD	BD	BD	BD

Parameters	Units	Detection Limit[a]	August			
			2010	2012	2015	2018
Magnesium	mg/L	1	BD	BD	1	1
Manganese	mg/L	0.005 (2006-2010) 0.001 (2012-2018)	BD	BD	0.002	BD
Nitrogen, Nitrate+Nitrite	mg/L	0.05 (2006-2010) 0.01 (2012-2018)	0.1	0.07	0.11	0.09
Total Nitrogen (persulfate)	mg/L	0.1 (2006-2010) 0.01 (2012) 0.03 (2015, 2018)	0.2	0.22	0.16	0.15
Orthophosphate	mg/L	0.01 (2006-2010) 0.005 (2012-2018)	BD	BD	BD	BD
Total Phosphorus	mg/L	0.01 (2006-2010) 0.005 (2012-2018)	BD	BD	BD	BD
Potassium	mg/L	1	BD	BD	BD	BD
Sodium	mg/L	1	BD	BD	BD	BD
TDS	mg/L	1 (2006-2010) 10 (2012-2018)	17	18	16	10
TSS	mg/L	10	BD	BD	BD	BD
Sulfate	mg/L	1	2	2	4	3
Turbidity	NTU[b]	0.2 (2006-2010, 2018) 0.1 (2012-2015)	0.5	0.5	0.3	0.4
Zinc	mg/L	0.01	BD	BD	BD	BD

[a]Some methodologies and detections limits improved overtime, thus the applicable detection limit is indicated in parentheses.

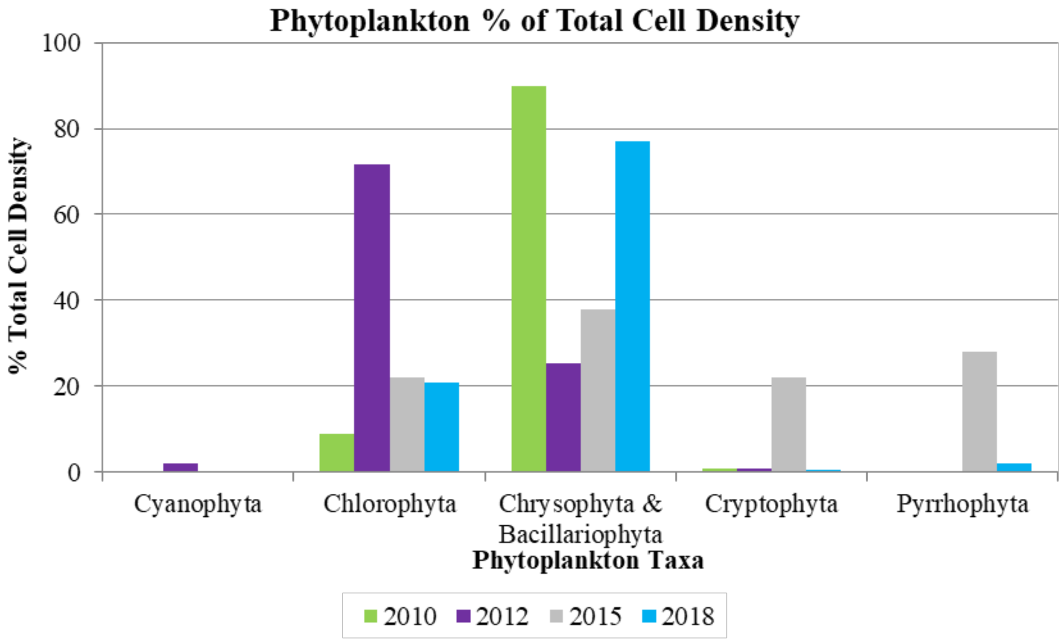
[b]nephelometric turbidity unit

Figure 3-6: Phytoplankton taxa composition (% of total biovolume) in August in 2010, 2012, 2015, and 2018 in Mystic Lake, Montana.



../2010-2018 Mystic Lake Phytoplankton 190129.xlsx?web=1

Figure 3-7: Phytoplankton taxa composition (% of total cell density) in August in 2010, 2012, 2015, and 2018 in Mystic Lake, Montana.



The phytoplankton assemblages observed in 2018 and in previous sample years (Figures 3-6 and 3-7) are typical of the species diversity observed in oligotrophic lakes (Watson et al., 1997). Phytoplankton communities are influenced by water column stability and stratification, which determine the mixing regime, nutrient levels, and nutrient availability to organisms. With only one-sample taken in one-point in time per year, variability in phytoplankton composition and densities is expected, but types of phytoplankton observed are anticipated to remain similar as observed in Mystic Lake. In general, oligotrophic systems provide minimal support to phytoplankton biomass due to low levels of nutrients, specifically total phosphorus, which also results in low species diversity (Watson et al., 1997). Nutrient levels in Mystic Lake were below detection limits for total phosphorus and low for total nitrogen (0.15 mg/L), thus likely a limiting factor for phytoplankton productivity.

3.7 Zooplankton

For all years of data, zooplankton were classified into two phylum: crustacean and rotifera. Crustaceans were further classified by order, including Calanoida, Cyclopoida, and Cladocera. Densities of the various crustaceans display fluctuations among years (Figure 3-8). Calanoida were the predominate zooplankton present between 2007 and 2012, but were less common in 2015 (Figures 3-8, 3-9). Zooplankton abundance often varies spatially, seasonally, and annually due to environmental and biological factors (Wetzel, 1983). Additionally, some variability would be expected in the zooplankton densities as a result of sampling one point-in-time each year.

Figure 3-8: Density of crustaceans (Calanoida, Cyclopoida, Cladocera) in August in 2010, 2012 2015, and 2018 in Mystic Lake, Montana

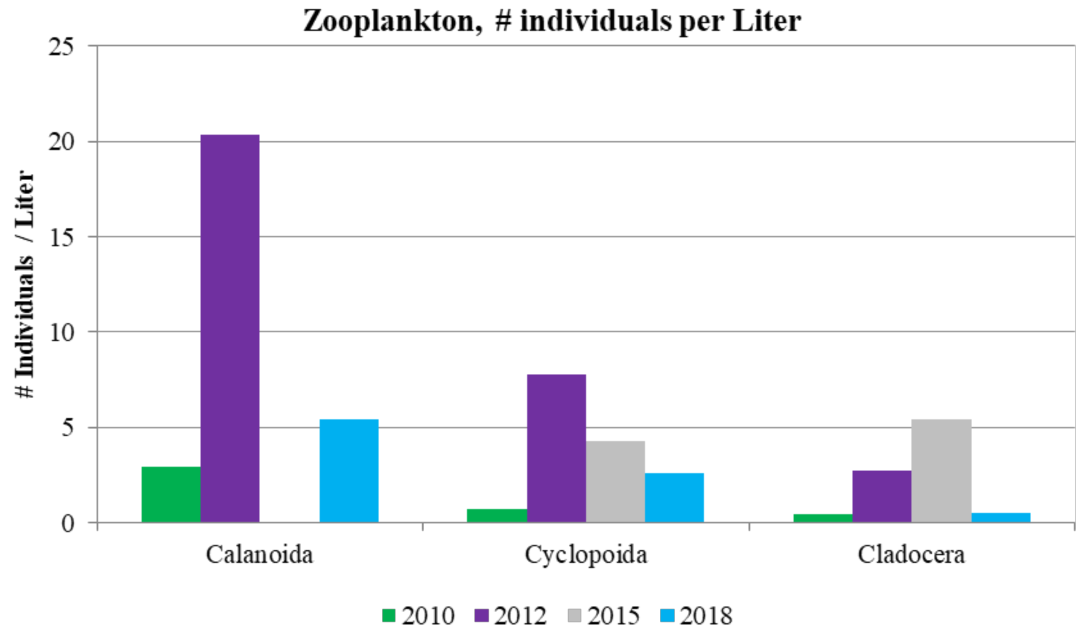
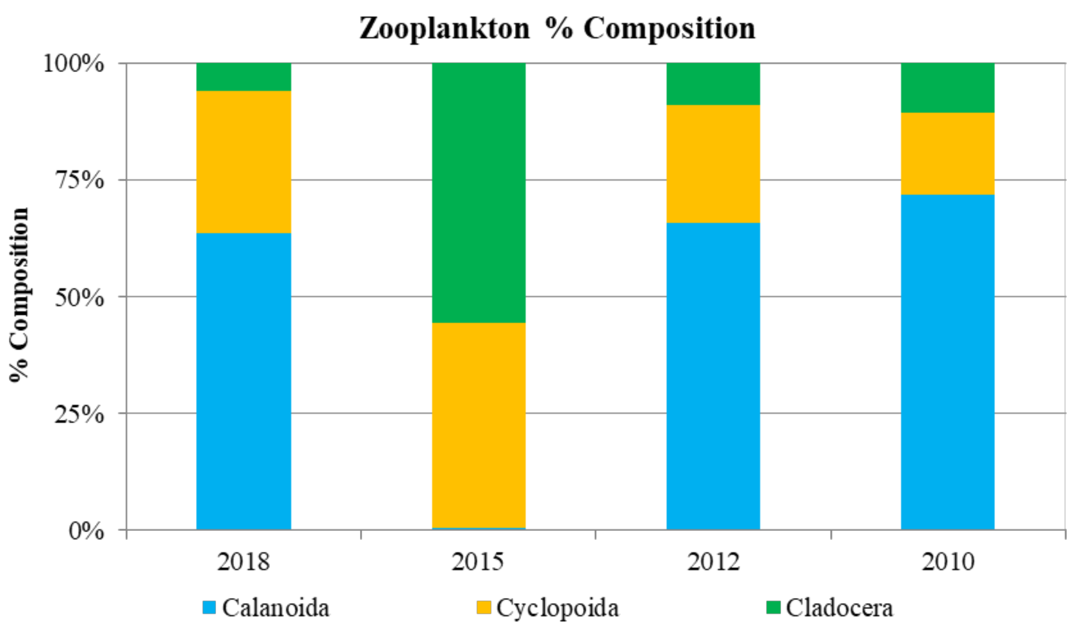


Figure 3-9: Composition of crustacean (Calanoida, Cyclopoida, Cladocera) in August 2010, 2012, 2015, and 2018 in Mystic Lake, Montana



Rotifera were not identified in previous samples taken in 2010 (Rhithron, 2011), but were identified in 2012 (PPL Montana, 2013), 2015 (NorthWestern, 2016b), and in 2018 (this report). The species composition of Rotifera from 2012, 2015, 2018 samples in Mystic Lake is presented in Table 3-2. The rotifer assemblage varied among years (2012, 2015, and 2018) but the most common genera was Conochilus in all years.

Table 3-2. Rotifera species composition in Mystic Lake, August 2012, 2015, 2018.

Mystic Lake	% of Total Rotifera		
Rotifera	**2012**	**2015**	**2018**
Conochilus	84.6%	44.7%	86.0%
Filinia	10.9%	0.7%	0.8%
Gastropus	3.6%	-	1.4%
Kellicotia	0.9%	11.4%	2.4%
Keratella	0.1%	11.3%	7.4%
Polyarthra	0.1%	-	0.1%
Synchaeta	-	29.3%	0.5%
Asplanchna	-	2.5%	0.6%
Rotifera	-	-	0.5%

Overall the species assemblage of rotifera identified in Mystic Lake in 2012, 2015, and 2018 are common for oligotrophic montane lakes (Larson et al., 1999; 2009). Rotifera have short generation times, and species often display extreme rates of population growth and decline in response to their environment (Neill, 1984). The abundance of rotifera may be related to presence of predator crustaceans or exploitative resource competition between rotifera and crustaceans (Larson et al., 2007).

3.8 Chlorophyll a

Chlorophyll *a* is the photosynthetic pigment that causes the green color in algae and plants. The concentration of chlorophyll *a* present in the water is directly related to the amount of algae living in the water. Chlorophyll *a* samples were taken from Mystic Lake in August 2018; the concentration was estimated to be approximately 3.2 milligrams per cubic meter (mg/m^3). These results are consistent with the typical chlorophyll *a* concentrations found in oligotrophic lakes (Carlson, 1977; Wetzel, 1983) and with chlorophyll *a* concentrations measured in Mystic Lake since 2006 (NorthWestern, 2016). Chlorophyll *a* concentrations measured in Mystic Lake since 2010 is provided in Table 3-3.

Table 3-3: Summary of Chlorophyll *a* concentration (mg/m^3) measured in Mystic Lake in August 2010, 2012, 2015, and 2018. (Detection limit 0.1 mg/m^3 2010–2015, detection limit 1.0 mg/m^3 in 2018).

Year	Mystic Lake Chlorophyll *a* (mg/m^3)
2010	3.4
2012	1.3
2015	2.4
2018	3.2

3.9 Mystic Lake Summary

Mystic Lake temperature profile and transparency, as well as water chemistry results in 2018 were similar to previous years. However, there appears to be a shift in pH, specific conductivity, and dissolved oxygen values and concentrations over the years. Although the values and concentrations measured in 2018 remain within normal ranges for an oligotrophic lake, we suspect there may be drift in the probe or barometric sensor and the shift in values does not reflect any change in limnological characteristics. NorthWestern will be reviewing the calibration history and potential need to replace the probes on the sonde.

4. West Rosebud Creek Results

West Rosebud Creek is sampled three times a year and the results are summarized below. Stream temperature monitoring occurs between April and October, depending on accessibility to the monitoring sites. Temperature data are summarized in Section 4.2.

4.1 Temperature, pH, Specific Conductivity, Dissolved Oxygen, and Turbidity

A Hydrolab was used to measure water temperature, pH, specific conductivity, and dissolved oxygen, while turbidity was measured using a Hach turbidimeter. In 2018, these parameters were evaluated at three locations in West Rosebud Creek (APH, BPH, BWRL), once on April 10, July 2, and October 10. There was no dissolved oxygen (DO) value available in October 2018 for any site due to an instrument error. A summary of the 2010 through 2018 data from West Rosebud Creek (APH, BPH, BWRL) is presented in Table 4-1.

The Hydrolab data collected between 2010 and 2018 show consistent values of seasonal stream temperature, pH values, specific conductivity, and dissolved oxygen. West Rosebud Creek continues to be a cold stream (max temperature recorded was 13.3 °C, or 56 °F) with near neutral pH (6.7 to 7.8), low amounts of total dissolved solids (specific conductivity values 26.2 to 49.0 µS/cm), and dissolved oxygen concentrations near or above saturation (Table 4-1).

Turbidity remains minimal in West Rosebud Creek at all sites and seasons throughout the monitoring period (Figure 4-1). Turbidity values measured since 2006 in West Rosebud Creek indicate minimal to no turbidity in the system with all values less than 3 NTUs (PPL Montana, 2010).

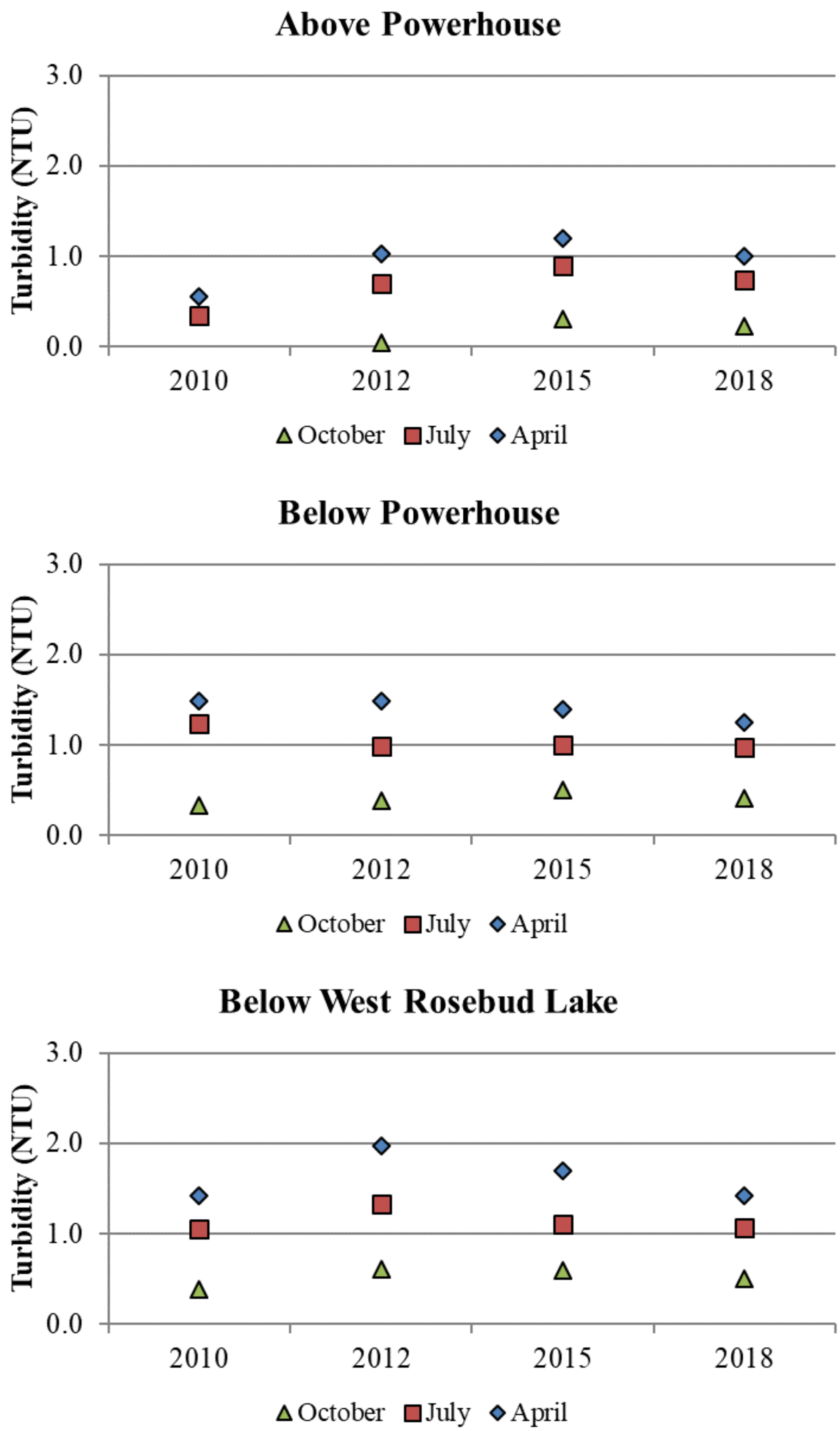
Table 4-1: **Summary of stream temperature (°C), pH, Specific Conductivity [µS/cm], DO (% saturation) collected APH, BPH, and BWRL in West Rosebud Creek in April, July, and October in 2010, 2012, 2015, and 2018.**

APH	April				July				October			
Year	2010	2012	2015	2018	2010	2012	2015	2018	2010	2012	2015	2018
Stream Temp (°C)	0.2	5.2	1.3	4.1	8.8	12.2	13.3	10.8	6.9	5.4	7.1	6.6
pH	7.8	7.6	7.3	7.5	7.7	6.9	7.2	7.1	7.8	7.6	7.2	7.0
Specific Conductivity (µS/cm)	42.9	44.0	46.1	52.0	26.4	29.8	33.8	35.0	46.1	40.8	49.0	44.0
Dissolved Oxygen (% Sat)	98.7	100.9	88.3	103.8	No Value	93.9	90.6	82.2	96.3	89.4	88.7	No Value

BPH	April				July				October			
Year	2010	2012	2015	2018	2010	2012	2015	2018	2010	2012	2015	2018
Stream Temp (°C)	1.2	3.4	1.8	2.5	9.1	11.8	12.4	9.6	10.3	10.3	10.1	9.3
pH	7.7	7.5	7.2	7.2	7.7	7.0	7.1	6.7	7.6	7.6	7.1	6.2
Specific Conductivity (µS/cm)	37.6	37.9	41.4	45.0	26.2	29.9	33.0	35.0	33.1	32.3	No Value	37.8
Dissolved Oxygen (% Sat)	98.7	100.3	87.3	103.4	No Value	94.0	91.0	82.8	95.0	89.0	89.7	No Value

BWRL	April				July				October			
Year	**2010**	**2012**	**2015**	**2018**	**2010**	**2012**	**2015**	**2018**	**2010**	**2012**	**2015**	**2018**
Stream Temp (°C)	6.9	5.7	4.0	2.2	8.0	11.6	12.1	10.6	10.3	10.2	9.1	7.5
pH	7.8	7.8	7.0	7.5	7.6	6.9	7.3	6.9	7.6	7.6	6.9	6.7
Specific Conductivity (µS/cm)	46.1	38.0	41.8	45.0	25.5	29.2	32.8	34.0	33.1	32.7	40.0	37.0
Dissolved Oxygen (% Sat)	96.3	106.7	90.1	104.8	No Value	92.4	94.3	85.0	95.0	89.4	89.1	No Value

Figure 4-1: Turbidity measurements in April, July, and October at each West Rosebud Creek site (APH – top graph, BPH – middle graph, BWRL – bottom graph) in 2010, 2012, 2015, and 2018.



4.2 Stream Temperature

Continuous stream temperature data were collected in three locations in West Rosebud Creek every 2 years from 2010 through 2018 (Table 4-2). The majority of the temperature loggers recorded stream temperatures from early April through October, but in some instances the data collection periods in 2010 and 2012 were reduced in some sites due to equipment issues and in 2018 loggers were removed at the end of September. In 2010, stream temperature data were collected in 30-minute increments, while in 2012, 2014, 2016, and 2018 stream temperature data were collected in 15-minute increments.

Table 4-2: Duration of water temperature analyzed at the West Rosebud Creek monitoring sites in 2010, 2012, 2014, 2016, and 2018.

West Rosebud Creek Sites	Start Date	End Data
Upper Bypass	April 12, 2018 April 5, 2016 May 29, 2014 April 4, 2012 May 4, 2010	September 30, 2018 November 14, 2016 October 31, 2014 October 31, 2012 October 29, 2010
APH	April 12, 2018 April 5, 2016 April 3, 2014 April 4, 2012	September 30, 2018 November 14, 2016 June 30, 2014 October 31, 2012
BPH	April 12, 2018 April 5, 2016 April 3, 2014 April 4, 2012 April 7, 2010	September 30, 2018 November 14, 2016 July 17, 2014 October 31, 2012 July 17, 2010
BWRL	April 12, 2018 April 5, 2016 April 3, 2014 April 4, 2012	September 30, 2018 November 14, 2016 October 31, 2014 October 31, 2012
Below Emerald Lake (USGS Gauge)	April 7, 2010	October 31, 2010

In 2010, there were some technical issues with the temperature loggers used to collect temperature data from APH and BWRL. Thus, the upper bypass and the U.S. Geological Survey (USGS) gage station #06204070 in West Rosebud Creek downstream of Emerald Lake were used to best represent these stream reaches. Licensee-collected data were only available from three sites (upper bypass, BPH, and below Emerald Lake).

In 2016, the BPH site was re-located to address safety concerns associated with the historic site. The difference in temperatures in 2016 at the historic and new BPH site were minimal (NorthWestern, 2017). Detailed temperature data and analysis of the 2016 season are presented in the *2016 Annual Fisheries Monitoring Report* (NorthWestern, 2017). Since 2016, BPH temperature data has been collected from the new BPH site (Figure 2-1).

Water temperature monitoring occurred concurrently with past fisheries surveys in West Rosebud and Emerald lakes as outlined in the 10-year (2010-2019) Water Quality Monitoring Plan and previous 6-Year (2010-2015) Fisheries Monitoring Plan (PPL Montana, 2010). Water temperature in West Rosebud Creek is of interest primarily because of its potential to influence salmonids' behavior and survival.

4.2.1 *Maximum 7-Day Average of the Daily Maxima (7DADM)*

The EPA Region 10 has published "Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards" (EPA 2003). In this guidance document, EPA recommends a 16 °C (60.8 °F) as the maximum 7-day average of the daily maxima (7DADM) criterion to:

> *(1) safely protect juvenile salmon and trout from lethal temperatures;*
> *(2) provide upper optimal conditions for juvenile growth under limited food during the period of summer maximum temperatures and optimal temperatures for other times of the growth season;*
> *(3) avoid temperatures where juvenile salmon and trout are at a competitive disadvantage with other fish;*
> *(4) protect against temperature-induced elevated disease rates; and*
> *(5) provide temperatures that studies show juvenile salmon and trout prefer and are found in high densities* (EPA 2003).

Although EPA (2003) suggests warmer maximum 7DADM limits in some circumstances such as migratory corridors with low density mid-summer juvenile rearing, the 16 °C (60.8 °F) standard would be appropriate for a non-degraded, headwater habitat such as West Rosebud Creek.

The maximum 7DADM is often used as a standard because it reflects an average of maximum temperatures that fish are exposed to over a week-long period and is not biased by one daily maximum (EPA, 2003). An annual summary of the maximum 7DADM in West Rosebud Creek from 2010 to 2018 is provided in Table 4-3.

The maximum 7DADM in West Rosebud Creek remained less than 16 °C (60.8 °F) at all sites and all years of monitoring, 2010-2018 (Table 4-3). West Rosebud Creek maximum 7DADM did not exceed the recommended threshold of 16 °C provided by EPA (2003). Stream temperatures in West Rosebud Creek appear to be within the preferred range for salmonids.

Table 4-3: Seasonal maximum 7DADM stream temperature recorded at the four West Rosebud Creek monitoring sites in 2010, 2012, 2014, 2016, and 2018. (NA – not applicable)

Year	Maximum of the 7DADM Temperature (°C)				
	Upper Bypass	APH	BPH (Historic)[1]	BPH (New)	BWRL
2010	15.0	No Data	12.0**	NA	14.4*
2012	15.7	15.9	14.6	NA	14.8
2014	14.5	10.2**	12.5**	NA	13.1
2016	15.2	14.9	15.4	15.3	15.6
2018	15.4	15.2	NA	14.1	14.5

[1]BPH site changed in 2016 (NorthWestern, 2017)
*2010 Data is from USGS Gage #06204070
**Data only available through June/July

4.2.2 *Maximum Daily Stream Temperature*

A summary of the maximum daily stream temperatures for each site at West Rosebud Creek and year monitored since 2010 is provided in Table 4-4. The maximum daily stream temperature recorded at all the sites was 16.3 °C (61.3 °F) in the BPH in 2016.

Table 4-4: Seasonal maximum daily water temperature recorded at the four West Rosebud Creek monitoring sites in 2010, 2012, 2014, 2016, and 2018.

Year	Maximum Daily Temperature (°C)				
	Upper Bypass	APH	BPH (Historic)[1]	BPH (New)	BWRL
2010	15.9	No Data	12.6**	NA	14.8*
2012	16.1	16.2	15.2	NA	15.6
2014	15.3	10.5**	13.3**	NA	13.8
2016	16.0	15.8	16.3	16.3	16.1
2018	16.0	15.8	NA	14.6	14.9

[1]BPH site changed in 2016 (NorthWestern, 2017)
*2010 Data is from USGS Gage #06204070
**Data only available through June/July

Daily maximum stream temperatures for each year 2010, 2012, 2014, 2016, and 2018 are illustrated in Figures 4-2 through 4-6, respectively. Maximum daily stream temperatures varied annually, but in generally trends remained consistent with a greater variance in spring maximum daily temperatures between monitoring locations than in the summer months and maximum temperatures occurring in late July and early August.

Figure 4-2: Maximum daily stream temperatures recorded in West Rosebud Creek monitoring sites in 2010.

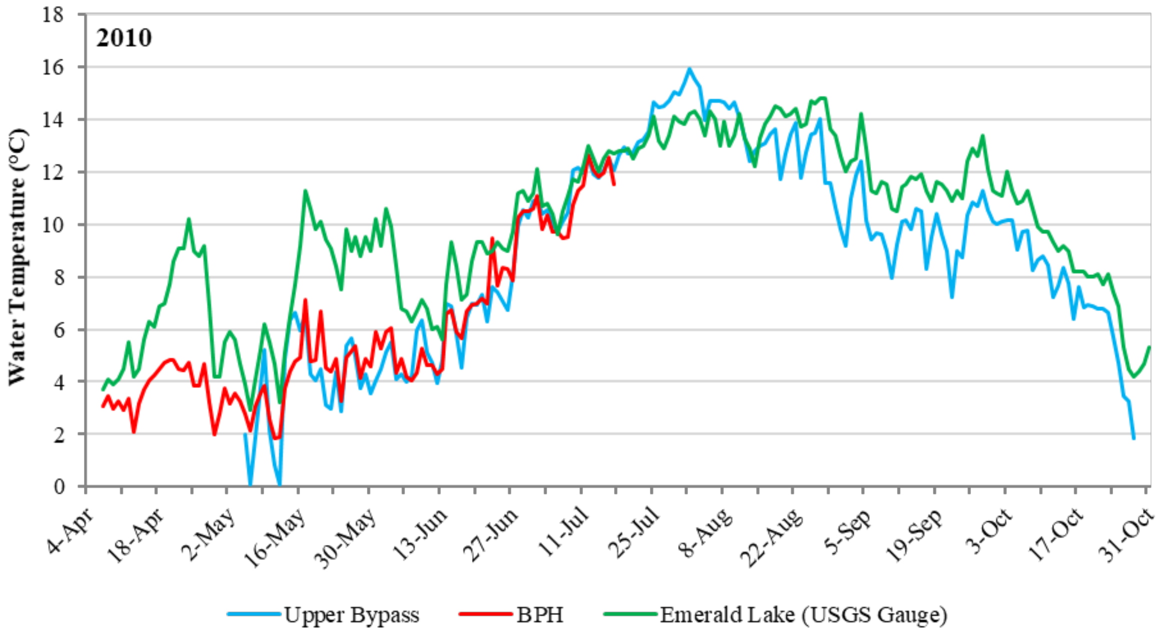


Figure 4-3: Maximum daily stream temperatures recorded in West Rosebud Creek monitoring sites in 2012.

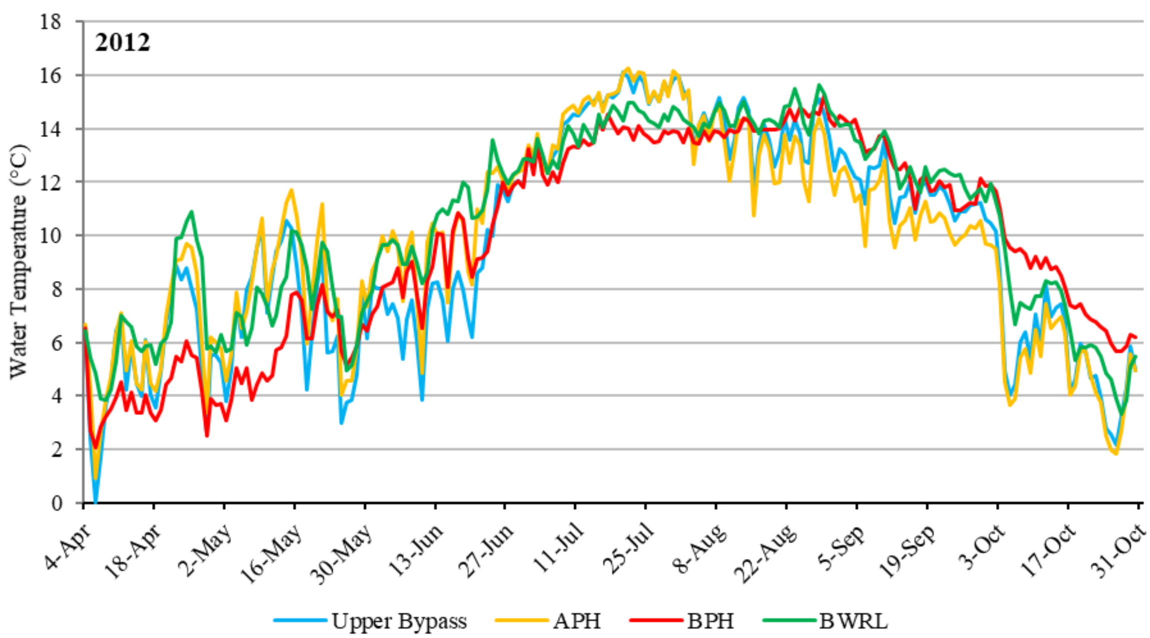


Figure 4-4: Maximum daily stream temperatures recorded in West Rosebud Creek monitoring sites in 2014.

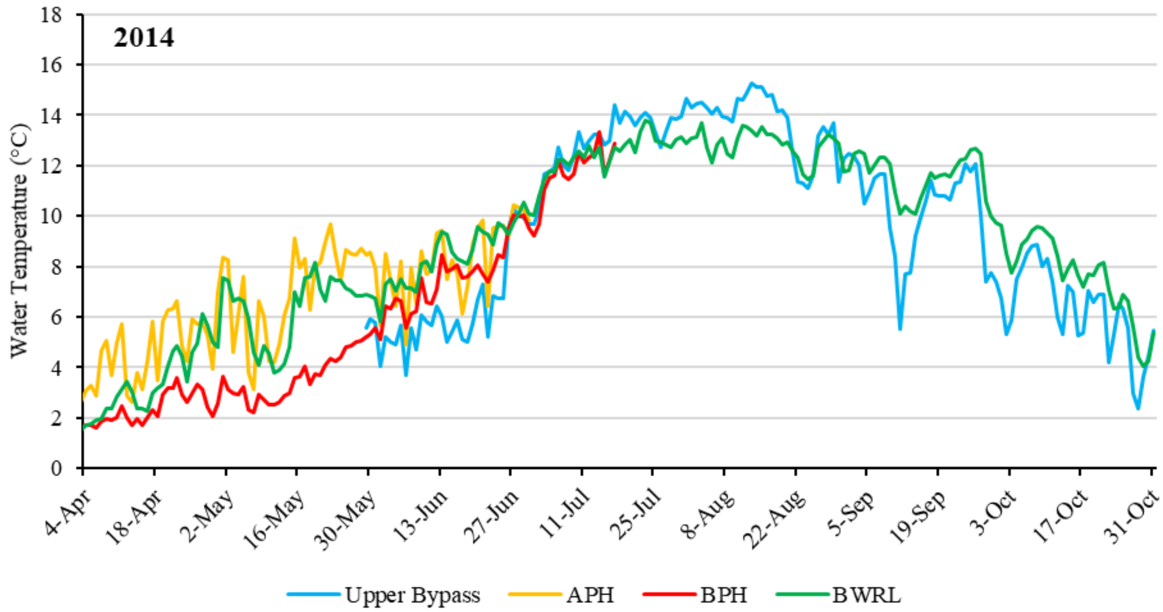


Figure 4-5: Maximum daily stream temperatures recorded in West Rosebud Creek monitoring sites in 2016.

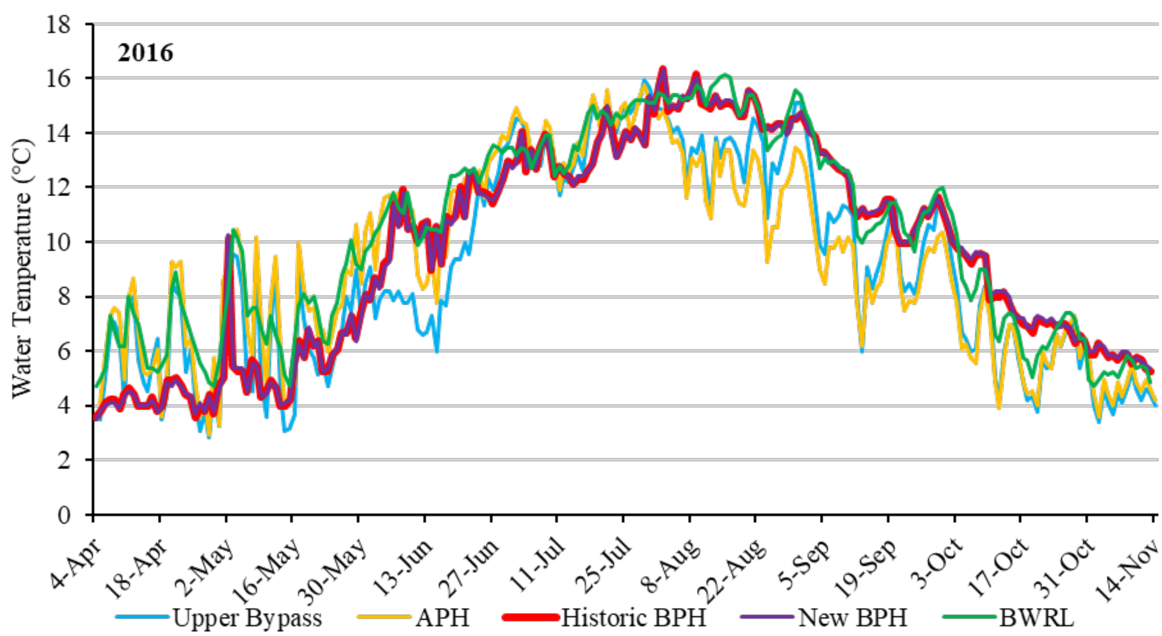
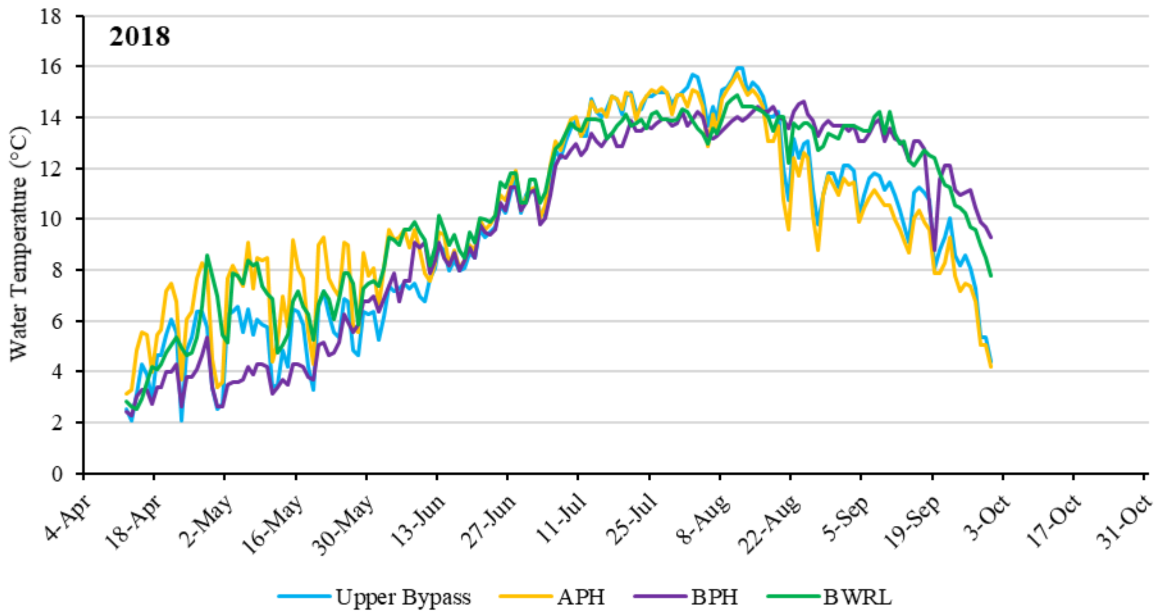


Figure 4-6: Maximum daily stream temperatures recorded in West Rosebud Creek monitoring sites in 2018. BPH = New Site selected in 2016.



4.2.3 *Stream Temperature Discussion*

Salmonids are cold-water fish with specific temperature requirements. Although some populations of salmonids have adapted to warmer temperatures, in general salmonids are not present if summer water temperatures consistently exceed 22 °C (71.6 °F) (Griffith, 1999). There is variation in temperature preferences between salmonid species. Brown trout can survive in warmer waters, 18 to 24 °C, compared to other species of trout (Wydoski and Whitney, 2003). Optimal growth for brown trout has been reported at temperatures ranging between 14 and 17 ºC (Forseth and Jonsson, 1994). Rainbow trout generally prefer temperatures less than 21 °C (Wydoski and Whitney, 2003) and achieve optimal growth around 13.1 °C (Bear, 2005; Bear et al. 2007).

In all years of monitoring, stream temperatures in West Rosebud Creek remained well below thermal limits of rainbow and brown trout. During the warmest portion of the summer (July – August), stream temperatures in West Rosebud Creek were often within the optimum range (14–17 °C) for brown trout while sometimes exceeding the optimum growth temperature for rainbow trout (13.1 °C).

4.3 Water Chemistry

West Rosebud Creek water chemistry results were very similar over the course of the year (April, July, and October 2018) and among the three sites (Table 4-5). Results from the 10-year monitoring period show the parameters with measurable concentrations remained consistent through the seasons and years (detailed results from 2010, 2012, and 2015 provided in Appendix C):

- alkalinity ranged between 12–20 mg/L
- bicarbonate ranged between 16–24 mg/L
- calcium ranged between 4–7 mg/L
- nitrogen (nitrate + nitrite) ranged between 0.05–0.15 mg/L
- total nitrogen ranged between 0.10–0.31 mg/L
- TDS ranged between 16–44 mg/L
- sulfate ranged between 2–6 mg/L

In general, other parameters were either below detection or at detection levels in 2018 and previous years. These data support that the conditions in West Rosebud Creek represent an oligotrophic stream system, low in productivity and receiving minimal nutrient input.

Table 4-5: Water chemistry results for West Rosebud Creek taken from Above the Powerhouse, Below the Powerhouse, and Below West Rosebud Lake on April 10, July 2, and October 1, 2018. BD indicates below detection limit.

Parameters	Units	Detection Limit	Above Powerhouse			Below Powerhouse			Below West Rosebud Lake		
			10-Apr	2-Jul	1-Oct	10-Apr	2-Jul	1-Oct	10-Apr	2-Jul	1-Oct
Total Alkalinity	mg/L	4	20	13	18	16	13	16	18	16	13
Arsenic	mg/L	0.001	BD	BD	BD	BD	BD	BD	BD	BD	BD
Bicarbonate	mg/L	4	24	16	21	20	16	19	22	19	16
Cadmium	mg/L	0.0001	BD	BD	BD	BD	BD	BD	BD	BD	BD
Calcium	mg/L	1	7	4	6	6	4	5	6	4	4
Chloride	mg/L	1	BD	BD	BD	1	BD	BD	BD	BD	BD
Copper	mg/L	0.001	BD	BD	BD	BD	BD	BD	BD	BD	BD
Iron	mg/L	0.03	BD	0.04	BD	BD	0.04	BD	0.03	BD	0.03
Lead	mg/L	0.001	BD	BD	BD	BD	BD	BD	BD	BD	BD
Magnesium	mg/L	1	2	1	1	2	1	1	2	1	1
Manganese	mg/L	0.001	BD	0.001	BD	0.001	0.002	BD	0.002	0.001	0.002
Nitrogen, Nitrate + Nitrite	mg/L	0.01	0.13	0.11	0.1	0.14	0.12	0.07	0.12	0.05	0.12
Nitrogen, Total (persulfate)	mg/L	0.3	0.15	0.18	0.12	0.19	0.18	0.13	0.16	0.14	0.18
Orthophosphate	mg/L	0.005	BD	BD	0.008	BD	BD	0.005	BD	0.005	BD
Total Phosphorus	mg/L	0.005	BD	BD	BD	BD	BD	BD	BD	BD	BD
Potassium	mg/L	1	BD	BD	BD	BD	BD	BD	BD	BD	BD
Sodium	mg/L	1	1	BD	BD	BD	BD	BD	BD	BD	BD
TDS	mg/L	10	41	24	35	41	23	26	34	27	22
TSS	mg/L	10	BD	BD	BD	BD	BD	BD	BD	BD	BD
Sulfate	mg/L	1	5	3	5	4	3	4	4	4	3
Zinc	mg/L	0.01	BD	BD	BD	BD	BD	BD	BD	BD	BD

4.4 Macroinvertebrates

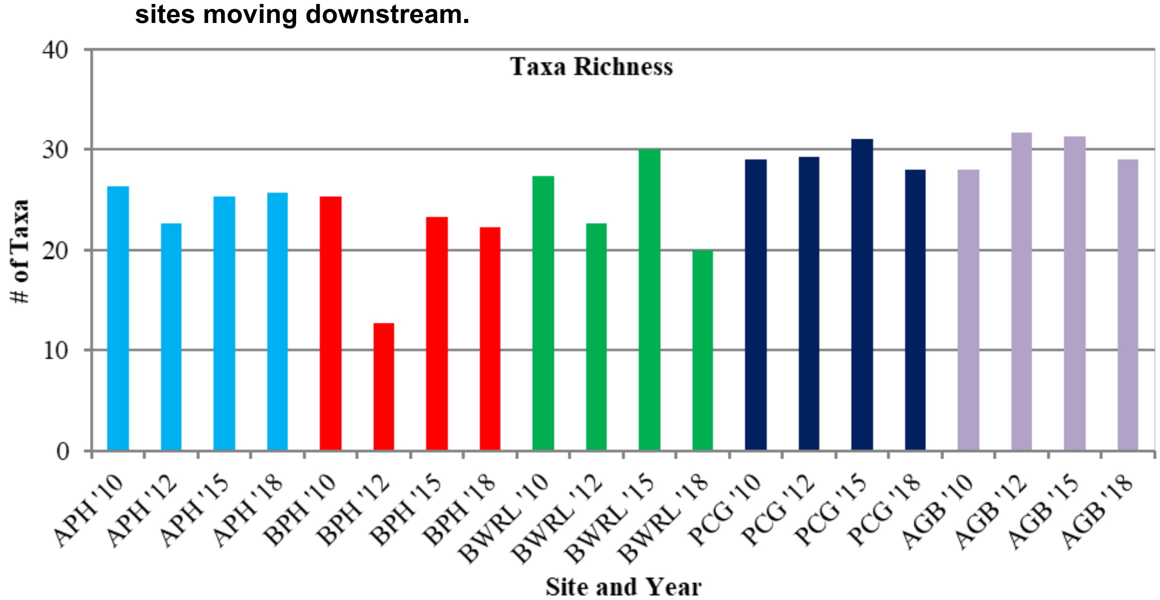
A summary of the October 2018 macroinvertebrate results and comparisons to 2010, 2012, and 2015 sampling years for five West Rosebud Creek sites (APH, BPH, BWRL, PGC, and AGB) sampled is provided in the following text. The sample locations listed in order from upstream to downstream include APH, BPH, BWRL, PGC, and AGB (*see* Figure 2-1). Stagliano (2019) collected and analyzed macroinvertebrates in 2018 and provided a summary report available in Appendix A.

In 2018, there was a total of 71 unique macroinvertebrate taxa (63 insect taxa; 8 non-insect taxa) identified from the five West Rosebud Creek sampling sites (Table 4-6). Each site had between 33 and 38 unique taxa identified in 2018. Between 2010 and 2018, the number of unique taxa identified by site has ranged 33 to 40 in APH; 24 to 35 in BPH; 34 to 42 in BWRL, 38 to 41 in PGC; and 38 to 42 in AGB (Figure 4-7).

Table 4-6: Number of unique taxa sampled in October 2018 for each West Rosebud Creek site (APH, BPH, BWRL, PGC, AGB) and all West Rosebud Creek sites combined.

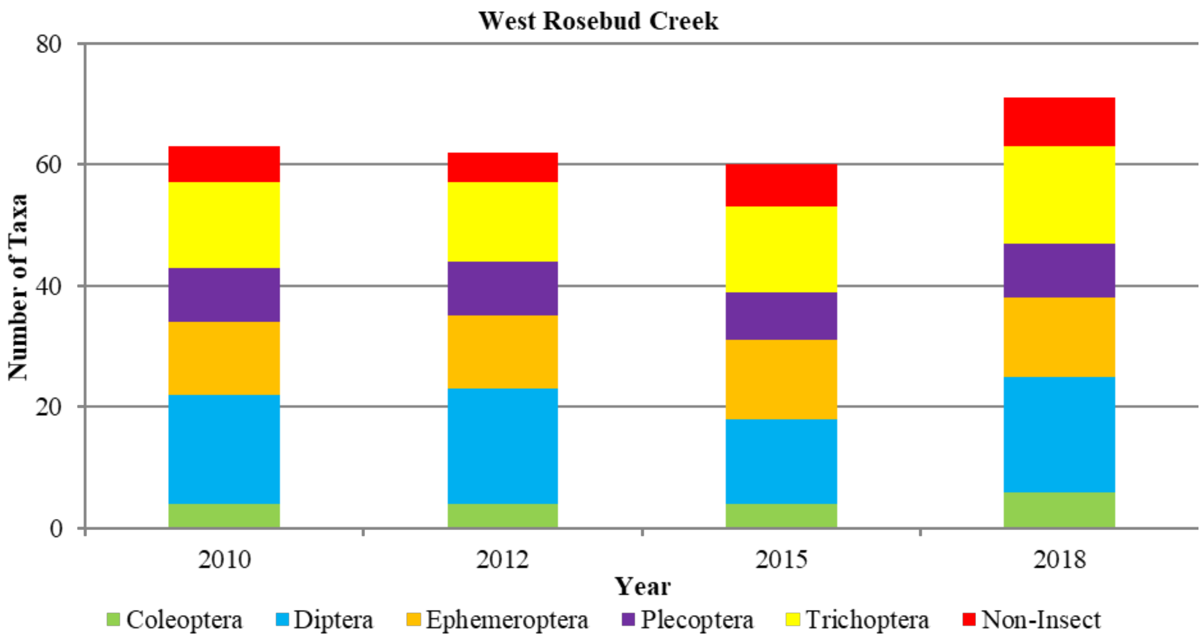
Taxonomic Group	APH	BPH	BWRL	PGC	AGB	West Rosebud Creek
Coleoptera (beetles)	1	1	2	2	4	6
Diptera (flies)	7	9	11	13	13	19
Ephemeroptera (mayflies)	11	9	9	8	7	13
Plecoptera (stoneflies)	5	5	4	5	5	9
Trichoptera (caddisflies)	7	5	2	9	10	16
Non-Insect	2	4	6	1	3	8
EPT Total	23	19	15	22	22	38
Total	33	33	34	38	42	71

Figure 4-7: Total number of unique macroinvertebrate taxa per sample location in West Rosebud Creek in 2010, 2012, 2015, and 2018. Each year illustrates the five sample sites moving downstream.



A summary of the total number of macroinvertebrate taxa, including the taxonomic groups, for the five sample locations in West Rosebud Creek since 2010 is presented in Figure 4-8. The total number of taxa and the taxa composition have remained consistent since 2010.

Figure 4-8: Cumulative number of macroinvertebrate taxa at the five West Rosebud Creek sites in October 2010, 2012, 2015, and 2018.



4.4.1 *Community Composition and Density*

The percent composition of macroinvertebrate taxonomic groups (five West Rosebud Creek sites combined) remained similar over time (Figure 4-9). Diptera relative abundance varied the greatest between sample events compared to other taxonomic groups, ranging from 23 to 31 percent. The composition of macroinvertebrates between 2010 and 2018 consisted of (in approximate percentages) Coleoptera (6–8%); Diptera (23–31%); Ephemeroptera (18–22%); Plecoptera (13–15%); Trichoptera (21–23%); and non-insect (8–12%).

When evaluating by individual sites *versus* all sites combined at West Rosebud Creek, greater fluctuation among the macroinvertebrate taxa groups were observed. The relative abundance of each macroinvertebrate taxa across sites in West Rosebud Creek between 2010 and 2018 has ranged from 3 to 21 percent Coleoptera; 10 to 50 percent Diptera; 6 to 38 percent Ephemeroptera; 6 to 46 percent Plecoptera; 4 to 29 percent Trichoptera; and 0 to 17 percent non-insect.

Variation among the relative abundance of macroinvertebrate taxa at the five sites sampled in 2018 is shown in Figure 4-10. The greatest difference among the sites in 2018 was the increased percentage of Diptera in AGB (50%) and decline in Ephemeraptera (6%).

Figure 4-9: Relative abundance of macroinvertebrate taxa in West Rosebud Creek (APH, BPH, BWRL, PGC, and AGB combined) in 2010, 2012, 2015, and 2018.

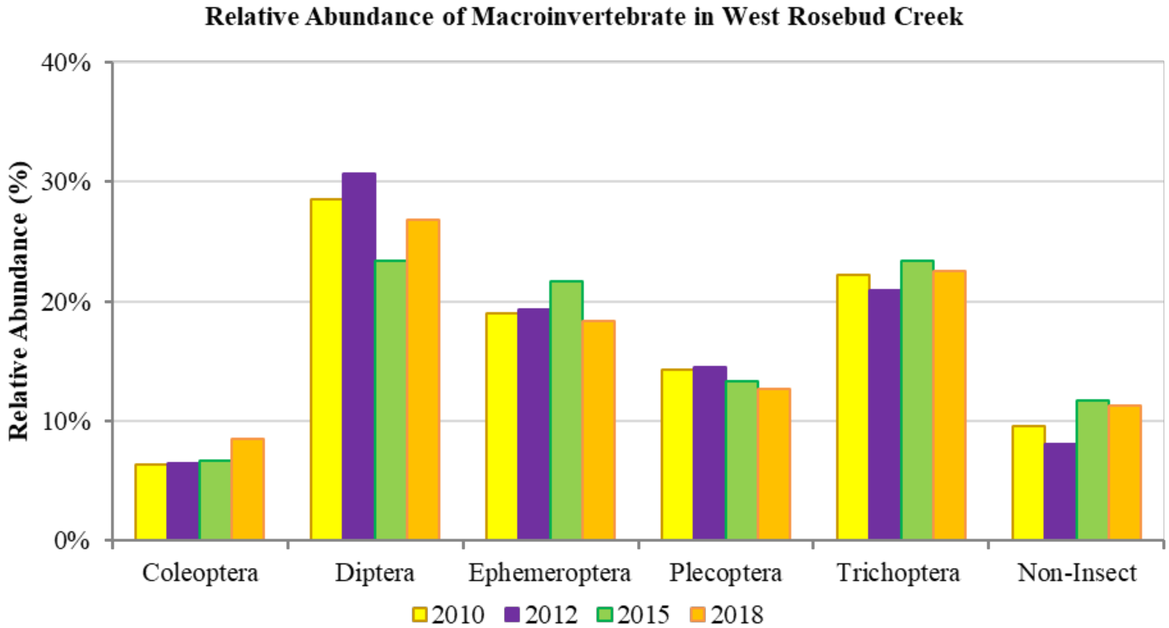
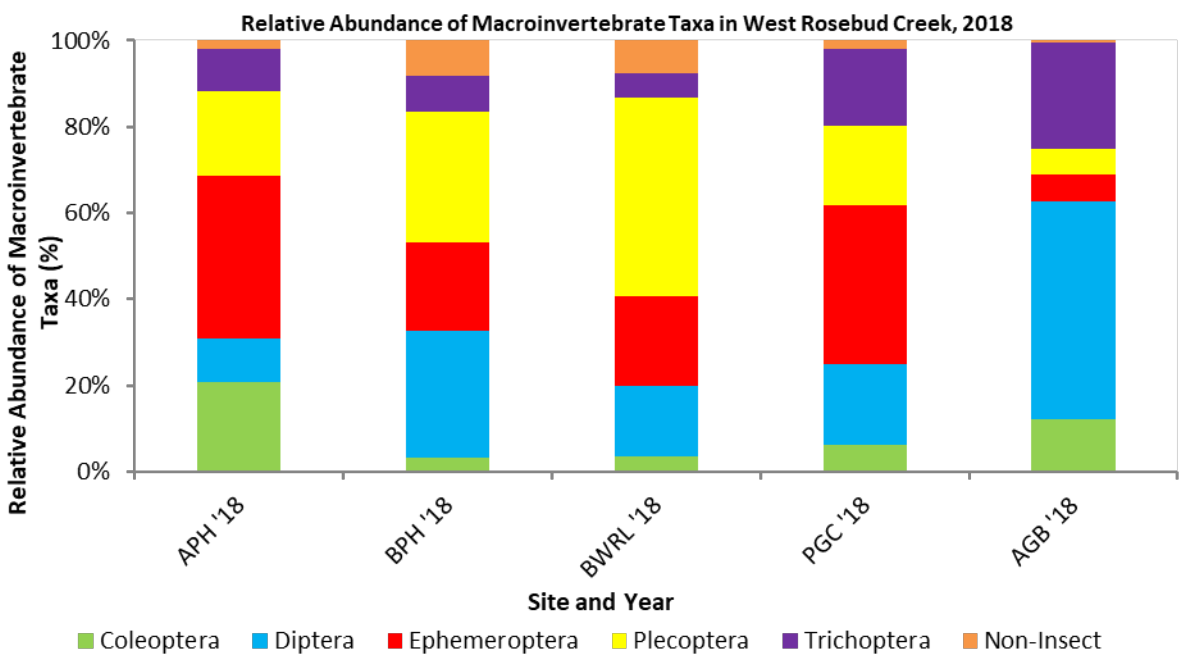


Figure 4-10: Relative abundance of macroinvertebrate taxa in each sample site (APH, BPH, BWRL, PGC, AGB) in West Rosebud Creek, 2018.



Mean macroinvertebrate community density for all sites in West Rosebud Creek in the previous sample years (2010, 2012, 2015) ranged from 174 to 631 organisms per 0.1-square meter (m^2). In general, the mean density of macroinvertebrates has remained lower in the upper most sample sites (APH, BPH) compared to the more downstream sample sites

(BWRL, PGC, AGB) since 2010. However, in 2015 and 2018 the mean density BPH was greater than BWRL.

In 2018, the mean macroinvertebrate community density ranged from 96 to 410 organisms per 0.1 m^2 (Table 4-7). The density of macroinvertebrates in BPH, BWRL, PGC, and AGB were lower in 2018 than previous sample years. Overall, each site demonstrated large range of values and various degrees of fluctuation between sample events.

Table 4-7: Mean number of organisms per Hess sample (0.1 m^2) encountered per site in West Rosebud Lake in October 2010, 2012, 2015 (McGuire, 2016); and 2018 (Stagliano, 2019).

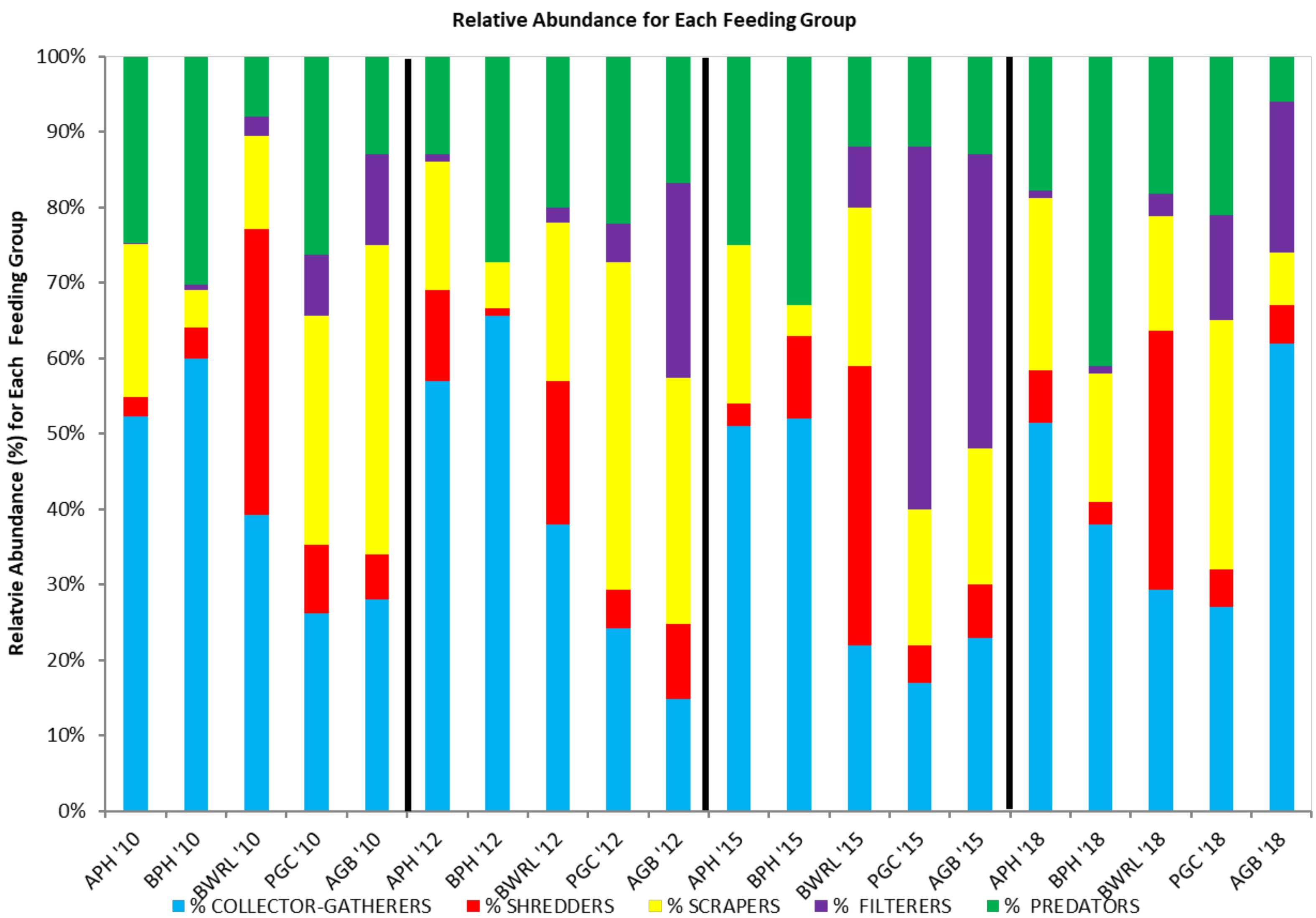
Site	Mean 2010 (# per 0.1 m^2)	Mean 2012 (# per 0.1 m^2)	Mean 2015 (# per 0.1 m^2)	Mean 2018 (# per 0.1 m^2)	2010-2015 Range of Mean Values
APH	206	195	177	200	177-206
BPH	279	174	451	122	174-451
BWRL	380	544	323	96	323-544
PGC	563	341	631	207	341-631
AGB	360	448	480	410	360-480

4.4.2 *Functional Feeding Groups*

Functional feeding groups provide information regarding the balance of feeding strategies within the benthic macroinvertebrate community. Organisms sampled in West Rosebud Creek were classified into the five major functional feeding groups, including 1) scrapers that consume algae and associated material; 2) shredders that consume leaf litter or other coarse particulate organic matter, including wood; 3) collector-gatherers that collect fine particulate matter from the stream bottom; 4) filterers that collect fine particulate organic matter from the water column using a variety of filters; and 5) predators that feed on other consumers. The mean composition of the functional feeding groups observed at each site (APH, BPH, BWRL, PGC, AGB) and each sample year since 2010 is shown in Figure 4-11.

Collector-gatherers were consistently the most predominant functional feeding group (greater than 50%) in each of the upstream sites, APH and BPH with one exception in BPH in in 2018, only representing 38 percent of the functional feeding group (Figure 4-11). In all years a combination of shredders and collector-gatherers were most dominant in the BWRL site (77% in 2010; 57% in 2012; 59% in 2015; 63% in 2018). Further downstream at PGC, scrapers were the predominant functional feeding group (33-43%) except in 2015 (18%) when filterers were the most dominant group in the both downstream sites PGC (48%) and AGB (39%). The furthest downstream site, AGB revealed the most variability among the relative abundance of the functional feeding groups between years. In 2010, scrapers were most dominant (41%), in 2012 and 2018 collector-gatherers were most dominant (57% and 62%, respectively), in 2015 filterers were the most dominant (39%).

Figure 4-11: Relative abundance of feeding groups: collector-gatherers, shredders, scrapers, filterers, and predators at APH, BPH, BWRL, PGC, and AGB sites in 2010, 2012, 2015, and 2018.



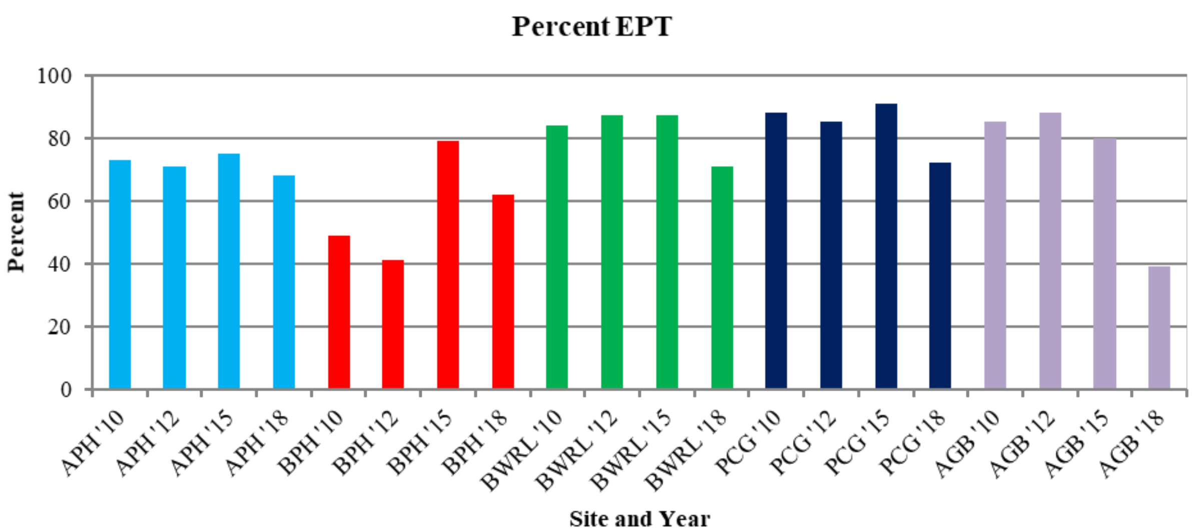
4.4.3 *Percent EPT and EPT Taxa Richness*

EPT taxa richness refers to the composition of taxa in "pollution sensitive" orders, including, mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera). These three orders are typically the most dominate macroinvertebrate faunas found in mountain streams and are strong indicators of aquatic ecosystem health. The percent EPT, or relative abundance, is the total number of EPT individuals divided by the total number of individuals in the sample. The percent EPT is a standard community composition metric used to evaluate water and habitat quality (Bukantis, 1997). Environmental stress (natural or human-caused) or pollution may be indicated when EPT comprise less than about 50 percent of the fauna.

EPT taxa richness represents the number of taxa within the orders. Streams that are classified as low or non-impacted will typically have 10 or more EPT taxa present. Streams that are classified as severely impacted may have 0 (zero) to 1 EPT taxa present (Bode, 1993). Percent EPT and EPT taxa richness will decrease with decreasing water quality (Weber, 1973). Therefore, EPT indices such as the percent EPT (Figure 4-12) and EPT taxa richness are commonly used to assess the biological condition of a stream.

The relative abundance (or percent) of EPT in West Rosebud Creek in 2018 ranged between 39 and 72 percent (Figure 4-12). The lowest abundance was at the lowermost sample site (AGB) while the other sites were relatively consistent (62–72%). EPT abundance was above 50 percent at all sites in all years except AGB in 2018 and BPH in 2010 and 2012 (Figure 4-12). BPH values improved in following years while the decline in AGB is unknown. The surrounding area around AGB is privately owned and the decline in EPT abundance may indicate negative impacts associated with surrounding land use or response to other environmental stressors.

Figure 4-12: EPT percent composition in the five West Rosebud Creek sites, in order from upstream to downstream in 2010, 2012, 2015, and 2018.

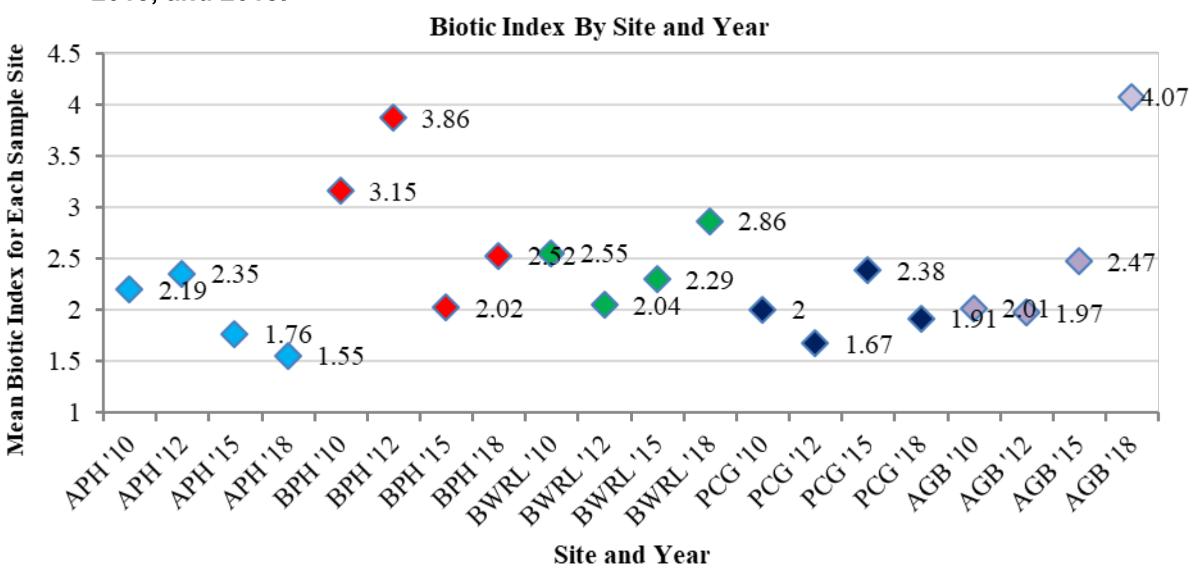


EPT richness in West Rosebud Creek has averaged 16 EPT taxa at all sites between 2010 and 2018. EPT richness has typically exceeded 10 EPT taxa per site for all sample years since 2010 except for BPH in 2012.

4.4.4 *Biotic Index*

The biotic index was developed as a measure of organic pollution (Hilsenhoff, 1987). The Montana-specific version of this index (Bukantis, 1997) is an excellent indicator of a stream's trophic status and tends to be correlated with water temperature, substrate embeddedness, and the percentage of fine sediments (Bollman, 1998). On a scale of 0 (zero) to 10, with higher values indicating increasingly eutrophic conditions, healthy mountain streams in Montana typically have biotic index values of 4 or less (McGuire, 1992). In general, since 2010, the biotic index values at all five locations in West Rosebud Creek, except for AGB in 2018 were less than 4 (Figure 4-13).

Figure 4-13: Summary of the mean biotic index for each West Rosebud Creek site in 2010, 2012, 2015, and 2018.



4.4.5 *Summary*

A non-impacted site refers to a stream of high quality that has a diverse macroinvertebrate community that is dominated by "pollution sensitive" organisms and that the macroinvertebrate community is not limited by water quality or habitat conditions. Criteria for a healthy/non-impacted site include taxa richness greater than 30, EPT taxa richness greater than 10, and a biotic index between 0 (zero) and 4.5 (Bode, 1993).

The macroinvertebrate metrics for the 2018 results are summarized in Table 4-8. The criteria for a healthy/non-impacted site based on taxa richness, EPT richness, and biotic index were met at all five sample sites. However, relative abundance of EPT at AGB (39%) and the increase in the biotic index from around 2.0 in 2010 to 4.1 may indicate factor(s) influencing the macroinvertebrate community and stream health at this site. Continued monitoring will assist in determining if the data derived in 2018 represent natural variability or a decline in health.

Table 4-8: Summary of macroinvertebrate metrics (mean density, total unique taxa for each site, mean EPT richness, mean biotic index) collected in West Rosebud Creek (APH, BPH, BRWL, PGC, AGB) in 2018.

Metrics	APH	BPH	BWRL	PGC	AGB
Mean Community Density (organisms/0.1 m^2)	200	122	96	207	410
Taxa Richness	26	22	20	28	29
EPT Richness	18	12	10	17	17
Biotic Index	1.6	2.5	2.9	1.9	4.1

4.5 Didymosphenia geminata

A visual survey for *Didymosphenia geminata* (*Didymosphenia*) was completed in West Rosebud Creek (APH, BPH, BWRL, PGC, AGB) in October 2018. Although *Didymosphenia* was observed at each sample site in October, *Didymosphenia* was primarily located along the channel margins where flows were slower and canopy cover was absent. *Didymosphenia* was lighter in density where stream currents were stronger. In 2018, *Didymosphenia* was most extensive at BPH and AGB in 2018.

4.6 Chlorophyll a

Chlorophyll *a* (benthic algae) was measured at three sites in West Rosebud Creek (APH, BPH, BWRL) in October 2018. Five samples were taken from each site for analysis. In all years with the exception of 2012, the chlorophyll *a* concentration represents an average of the five samples taken at each site. In 2012, the samples were compiled as one composite sample with composite concentrations for the three sites in West Rosebud Creek. The mean value of chlorophyll *a* and range of values (except for 2012 sample year) from samples taken at each site since 2010 is summarized in Table 4-9.

In 2018, the average chlorophyll *a* concentration at each site in West Rosebud Creek ranged between 22.7 to 51.9 mg/m^2 with similar concentrations APH and BWRL and the highest concentration BPH. Chlorophyll *a* concentrations in 2018 were within the range of values observed since 2006 (NorthWestern, 2016).

Table 4-9: Summary of chlorophyll *a* concentrations (mg/m²) in West Rosebud Creek based on five rock samples taken at each site (APH, BPH, and BWRL) in October 2018, 2015, 2012, 2010.

Year	Parameter	Chlorophyll *a* (mg/m^2)		
		APH	BPH	BWRL
2010	Average	35	41	28
	Range	25-50	23-60	17-43
2012	Average	8.4	9.3	6.6
	Range	samples were compiled as one composite sample		
2015	Average	56	97	121
	Range	28-141	57-164	40-163
2018	Average	22.7	51.9	20.7
	Range	17-30	36-73	7-50

Benthic algae growth, measured as chlorophyll *a* is often related to nutrients in the system (Suplee and Watson, 2013; Dodds et al., 2002) as well as other factors such as streamflow and habitat (Maret et al., 2010). In West Rosebud Creek, nutrient (phosphorus and nitrogen) inputs via anthropogenic sources are minimal and nutrient concentrations remain at low levels and/or below detection limits. In October 2018 nutrient levels analyzed for all three sites in West Rosebud Creek were below the detection limit (0.005 mg/L) for total phosphorus and ranged between 0.12 mg/L and 0.14 mg/L for total nitrogen. Other factors such as streamflow and/or habitat (e.g., substrate and/or temperature) may be contributing to benthic algae growth.

4.7 Periphyton

West Rosebud Creek was sampled at three sites (APH, BPH, BWRL) for periphyton, including diatom and non-diatom algae. Rhithron (2018) completed the diatom and non-diatom analysis for the August 2018 samples, which is summarized below. Rhithron's technical summary of the 2018 results is provided in Appendix B.

4.7.1 *Diatom Algae*

Diatom diversity metrics are used as general indicators of river health and ecological integrity (Stevenson et al., 2010). Bahls (1993) provided a summary of diatom associated indices, including Shannon diversity (H') index, pollution index, and siltation index from reference mountain streams in Montana that were analyzed using various metrics for assessing stream health.

The H' index is a metric that represents both species richness and evenness. The H' index value by itself must be interpreted cautiously because the H' value does not evaluate species composition and may not identify other ecological/biological influences to the system. The

H’ index (based on a $\log_2$) can range from 0 (zero) indicating all species are the same and no diversity, to 5.0 indicating high species richness and even distribution among species.

The pollution index provides a quick interpretation with a numeric expression of pollution sensitivity or tolerances of diatoms present in the stream. The pollution index value ranges between 1.00 (most-tolerant diatoms) to 3.0 (sensitive diatoms) (Bahls, 1993).

The siltation index evaluates the relative abundance of motile diatoms (*Navicula, Nitzschia, Cylindrotheca, and Surirella*) that are classified as more tolerant of sedimentation and values can, in theory, range between 0 (zero) indicating totally different communities and 100 indicating identical communities (Bahls, 1993).

A summary of the impairment ratings for mountain streams in Montana (Bahls, 1993) is provided in Table 4-10. West Rosebud Creek has consistently been classified as a non-stressed mountain stream based on the pollution and siltation indices over the years (Table 4-11). In contrast, the H’ index has shown more variability among the sites and from year to year (Table 4-11). Overall the H’ index results indicate some minor to moderate stress exists in West Rosebud Creek (APH, BPH, BWRL). However, the lower H’ value may be attributed to natural stress in the environment *versus* an anthropogenic contribution. Bahls (1993) mentions diatom diversity in mountain streams was often less than in plains streams and that the natural stress in mountain streams may result in low diversity (H’) index values or low diversity in diatom flora. Natural stress may be attributed to cold water, steep gradients, and low levels of nutrients and light.

Table 4-10: Summary of index values, including Shannon diversity index (H’), pollution index, and siltation index (motile taxa %), in mountain streams (Bahls 1993).

Classifications for Mountain Streams				
Rating	**Shannon Diversity Index (H’)**	**Pollution Index**	**Siltation Index (Motile Taxa %)**	**Overall Biological Integrity**
Non-Stressed Mountain Streams	Greater than 2.50	Greater than 2.5	Less than 20	Excellent
Minor Stress Mountain Streams	Between 1.76 and 2.50	Between 2.01 and 2.50	Between 20 and 39	Good
Moderate Stress Mountain Streams	Between 1.00 and 1.75	Between 1.50 and 2.00	Between 40 and 60	Fair
High Stress Mountain Streams	Less than 1.0	Less than 1.50	Greater than 60	Poor

Table 4-11: Summary of Shannon diversity index (H'), pollution index, and siltation index (motile taxa %) values in West Rosebud Creek samples (APH, BPH, BWRL), 2010, 2012, 2015, 2018. Colored boxes correlate to Table 4-10, Bahls (1993) classification for mountain streams.

Location	Shannon Diversity Index (H')				Pollution Index				Siltation Index (Motile Taxa %)			
	2018	2015	2012	2010	2018	2015	2012	2010	2018	2015	2012	2010
APH	1.19	2.37	2.00	2.39	2.95	2.79	2.91	2.81	2.9	6.7	2.3	4.0
BPH	1.67	2.88	1.80	1.39	2.91	2.79	2.92	2.94	3.2	5.1	1.8	1.5
BWRL	1.31	3.29	1.90	3.40	2.97	2.83	2.91	2.71	0.4	9.1	2.3	12.6

The diatom flora in oligotrophic mountain streams is often dominated by *Achnanthes minutissima* (Bahls 1993) as was observed in most years in West Rosebud Creek (Table 4-12). The diatom flora was primarily dominated by *A. minutissima* in West Rosebud Creek over the years with the exception of BPH in 2015 and BWRL in 2010 and 2018 (Table 4-12). The dominance (>50%) of *A. minutissima* at a site in any given year coincided with a lower H' index value less than 2.5 (Tables 4-11; 4-12). In contrast, when *A. minutissima* represented 50 percent or less of the diatom flora in West Rosebud Creek (BPH in 2015, BWRL in 2010 and 2018), the H' index was higher, above 2.5 (non-stressed).

Table 4-12: Summary of the percent composition of *A. minutissima* at each sample site in 2006, 2007, 2008, and 2010, 2012, and 2015.

Location	% Composition of *A. minutissima*						
	2018	2015	2012	2010	2008	2007	2006
APH	83%	63%	65%	60%	63%	74%	74%
BPH	77%	50%	71%	79%	81%	80%	72%
BWRL	79.5	46%	70%	38%	62%	67%	76%

In summary, West Rosebud Creek 2018 diatom results are comparable to previous years' data with the exception of H' values. H's values have shown some variability among years with the lowest values recorded at the BPH and BWRL sites. The variability and lower H' values identified through the years may be attributed to natural stress in the environment *versus* an anthropogenic contribution. Bahls (1993) suggests that the lower diatom diversity observed in mountain streams may be the result of natural stressors like cold-water, steep gradient, and low nutrient and light these systems experience, thus may result in low diversity (H') values. The other indices (pollution and siltation) measured in West Rosebud Creek indicate a non-stressed environment thus further supporting the conclusion that diatom diversity may be more related to the natural environmental conditions in West Rosebud Creek.

4.7.2 *Non-Diatom Algae*

Rhithron's non-diatom algae determinations from samples taken at each site (APH, BPH, BWRL) in West Rosebud Creek since 2010 are provided in Appendix B. The most common (highest relative abundance) non-diatom algae in West Rosebud Creek included Chlorophyta (green algae) and Cyanophyta (blue-green algae), which are common in oligotrophic waters (Watson et al., 1997). Other non-diatom algae identified in West Rosebud Creek, but less common (identified as rare in sample) included Chrysophyta (golden algae) and Rhodophyta (red algae). These rare occurring red and golden algae were only identified in APH and BWRL in samples collected since 2010. The non-diatom algae composition appeared consistent with data analyzed from previous years of data collected since 2010 (PPL Montana, 2011; 2013 and

NorthWestern, 2016). However, Bacillariophyta (a type of diatom) remained the most abundant or dominant algae observed at all three sites in all years

Green algae, blue-green algae, and diatoms were present at all three sites in West Rosebud Creek in all years of sampling (2010–2018). Green and blue-green algae represented the majority of the non-diatom biomass at each site (Rhithron, 2015). Bahls (1993) found blue-green algae dominated the non-diatom flora of the Northern Rockies reference streams. Other studies (*cited in* Huszar and Caraco, 1998) have also documented blue-green algae dominance in low-nutrient, specifically total phosphorus, systems. The blue-green algae dominance may be a function of the low availability of inorganic nitrogen. Blue-green algae can “fix” atmospheric or molecular nitrogen when bioavailable nitrogen (nitrogen or ammonia) is limited, which creates a competitive advantage. Factors causing blue-green algae dominance may also be dependent on morphometric diversity within divisions of phytoplankton (Huszar and Caraco, 1998). Huszar and Caraco (1998) evaluated the morphological-functional framework that divides phytoplankton into three major strategies: competitive, stress tolerant, and ruderal. Their study (1998) suggests size and shape of phytoplankton may be a better predictor of their response to physical and chemical environmental compared to taxonomy at the division level (e.g., cyanobacteria, chlorophytes, diatoms, chrysophytes, etc.).

West Rosebud Creek is an oligotrophic stream, which indicates the system is most likely to have clear water, low biomass, and nutrient-limited conditions (Reynolds et al., 2002). The water chemistry analysis and periphyton data (diatom and non-diatom) from West Rosebud Creek (2010–2018 sampling) indicate the system is a nutrient-poor system with nutrient concentrations (nitrogen and total phosphorus) low or below detection, which supports the oligotrophic classification.

5. Discussion

The water quality data collected between 2010 and 2018 from Mystic Lake and West Rosebud Creek were consistent with expectations of an unpolluted, high elevation, oligotrophic mountain system at temperate latitude with minimal anthropogenic inputs.

5.1 Water Quality Standards

The MDEQ has several water-use classifications for surface water quality standards. West Rosebud Creek Drainage is classified in the Administrative Rules of Montana (ARM) 17.30.623 (2017) as a B-1 stream which means the waters

> *…are to be maintained suitable for drinking, culinary, and food processing purposes, after conventional treatment; bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply*.

Montana numeric water quality standards are specified in the Circular DEQ-7 (October 2012 edition, MDEQ 2017) and Circular DEQ-12A (July 2014 edition, MDEQ). No water quality parameter in Mystic Lake or West Rosebud Creek was detected above Montana water quality standards (Circular DEQ-7; DEQ-12A) over the 10-year monitoring period (2010–2018). Detection limits for analyzing water samples for heavy metals (arsenic, cadmium, copper, iron, lead, zinc) were consistent with the limits provided in the Circular DEQ-7 (2017). All heavy metals were near or below the detection limit in West Rosebud Creek and Mystic Lake.

Data collected in 2018 are consistent with water quality results from studies completed since 2006 (PPL Montana 2004, 2010, 2011, 2013; NorthWestern, 2016). Water chemistry characteristics among the three West Rosebud Creek sites (APH, BPH, BWRL) are similar and do not indicate any significant differences among the creek sites. Overall, the water quality data collected in 2018 and in past studies from Mystic Lake and West Rosebud Creek represent an oligotrophic system with no indication of impairment.

5.2 Mystic Lake

The water chemistry data analysis between 2010 and 2018 from samples taken from Mystic Lake were representative of an unimpaired, oligotrophic lake with minimal/non-measurable anthropogenic inputs. Oligotrophic lakes such as Mystic Lake are nutrient-poor and typically support minimal phytoplankton biomass with low species diversity (Watson et al., 1997). Phytoplankton biomass is often regulated by nutrient levels, specifically total phosphorus (Watson et al., 1997). In Mystic Lake, the phytoplankton community was dominated by Bacillariophyta (diatoms) with less common species present including Chlorophyta, Chrysophyta, Cryptophyta, and Pyrrhophyta (dinoflagellates). Nutrient levels in Mystic Lake were below detection limits for total phosphorus in all years (2010–2018) and low for total nitrogen (≤0.22 mg/L) in all years (*refer to* Table 3-1), thus likely a limiting factor for phytoplankton productivity.

During the 10-year monitoring period, chlorophyll *a* concentrations ranged from 1.3 to 3.4 mg/m^3 in Mystic Lake (*refer to* Table 3-3), consistent with the typical chlorophyll *a* concentrations (< 8 mg/m^3) found in oligotrophic lakes (Wetzel, 1983).

Zooplankton in Mystic Lake primarily consisted of Cladocera, Cladocera, Cyclopoida, and Rotifera with densities fluctuating year to year. Zooplankton abundance often varies spatially, seasonally, and annually due to environmental and biological factors (Wetzel, 1983). Some variability is expected in the zooplankton densities as a result of sampling one point-in-time each sample year.

5.3 West Rosebud Creek

The water chemistry data analysis of West Rosebud Creek over the last 10-year monitoring period was representative of an unimpaired, oligotrophic stream system with minimal anthropogenic inputs. West Rosebud Creek water chemistry results since 2010 were very similar between years and among the three stream sites (APH, BPH, BWRL). Parameters measured from the water samples were either in low concentrations or near detection limits or below the detection limit.

In April 2012, arsenic was detected in West Rosebud (0.002 mg/L) with concentrations slightly above the detection limit of 0.001 mg/L. Arsenic was not detected in the July or October 2012 samples, or in any samples from previous years, or in subsequent samples taken in 2015 and 2018.

The mean chlorophyll *a* concentrations were within an acceptable range (less than 150 mg chlorophyll *a* per m^2) recommended by MDEQ to avoid a nuisance to the public (Suplee and Watson, 2013; Suplee et al., 2009; Suplee, 2017).

Maximum daily stream temperatures in all sites along West Rosebud Creek remained less than 16.3 °C (61.3 °F) during each of the 5-years monitored since 2010. These temperatures are in the preferred range for salmonid species (Eaton et al., 1995) present in West Rosebud Creek.

In addition to the chemical analysis of West Rosebud Creek, other biological studies including an analysis of periphyton (diatom and non-diatom algae) and macroinvertebrates were completed. The majority of sampling only occurred at three sites, APH, BPH, and BWRL. Macroinvertebrates were sampled at five sites, including the two most downstream sites, PGC and AGB.

Diatoms provide an assessment of stream health. Stream health can be evaluated using several indices. In this report, three indices, including the Shannon diversity (H') index, pollution index, and siltation index were assessed. The pollution and siltation indices for samples taken at all three stream sites from 2010 to 2018, indicate an "excellent" and non-stressed mountain stream. The H' index revealed more variability among years and sites and indicated low species richness and evenness. The less than excellent classification (H' index) for sites over the years is likely attributed to natural stress such as cold water, steep gradients, and low level of nutrients and light of a mountain stream (Bahls, 1993).

The diatom and non-diatom algae species compositions were generally low in species diversity and results were similar among the sample years. The diatom flora was dominated by *Achnanthes minutissima,* typical for an oligotrophic mountain stream (Bahls 1993). The non-diatom taxa composition in West Rosebud Creek was dominated by green and blue-green algae, which are common in oligotrophic systems (Watson et al., 1997).

Macroinvertebrate metrics such as taxa richness, EPT richness, and biotic index were used to assess stream health. All macroinvertebrate metrics analyzed at all five sites sampled in West Rosebud Creek (APH, BPH, BWRL, PGC, AGB) met the stream-quality assessment criteria for non-impacted site. The overall macroinvertebrate assemblages were characteristic of good environmental conditions in all stream reaches. The benthic community is typical of a soft-water (low alkalinity), low-nutrient mountain stream and there are few indications of environmental stress. Mayflies, stoneflies, and caddisflies dominated the benthic community. Changes in species composition among sites reflected the longitudinal gradient within the study area and localized influences of West Rosebud and Emerald lakes.

6. 2020-2040 Water Quality Monitoring Plan

As part of the FERC license for Mystic Lake Hydroelectric Project No. 2301. NorthWestern (Licensee) is required to implement a water quality monitoring plan and update the plan every 10-years. The monitoring plan includes a schedule and a format for submitting water quality data collected to Montana Department of Environmental Quality (MDEQ). As specified in the Project 2301 license, the water quality monitoring plan includes the following compliance requirements.

> *At a minimum of a ten year intervals of the license date, review and evaluate the data collected for water quality trends, temperature effects on the fish assemblage and conditions of aquatic resources within Mystic Lake, West Rosebud Lake and West Rosebud Creek form the Mystic Lake Dam to the outlet of West Rosebud Lake and based upon this review and evaluation, modify the monitoring plan as appropriate with Department [MDEQ] approval.*

Baseline data gathered from 2006-2009 provided a foundation of water quality conditions in the Project area (Mystic Lake and West Rosebud Creek). The primary monitoring objective of the subsequent 10-year (2010-2019) monitoring plan was to monitor chemistry and biology trends and variability in Mystic Lake and West Rosebud Creek.

NorthWestern implemented the 10-year (2010-2019) Water Quality Monitoring Plan developed by PPL Montana (2010), which is summarized in this report. Results from the baseline data (2006-2009) and 10-year (2010-2019) monitoring period continue to indicate the Project waters remain oligotrophic (this report).

NorthWestern has reviewed the 2010-2019 monitoring data and proposes a 20-year (2020-2040) Water Quality Monitoring Plan with minor modifications to sampling interval in West Rosebud Creek and discontinuation of the stream temperature monitoring. Details of the sampling parameters and intervals are presenting in Table 6-1. NorthWestern consulted with USFSS, MFWP, and MDEQ regarding the modifications and received support an agreement in the changes.

6.1 Methods

NorthWestern will implement the sampling procedures for water quality data collection (chemistry and biology) as was described in the Standard Operating Procedures (SOPs) presented in Appendix D.

6.2 Sampling Locations

For the next 20-year (2020-2040) monitoring period, the Licensee proposes to continue water chemistry and biological sampling at the established four sites (mid-lake, APH, BPH, and BWRL) as shown in Figure 2-1.

6.3 Sampling Parameters

NorthWestern proposes to continue implementing a 3-year sampling interval in Mystic Lake and modify the West Rosebud Creek sampling interval to every 5-years. Water chemistry and biological parameters will remain the same with the exception of stream temperature (Table 6-1). NorthWestern proposes to discontinue water temperature monitoring. NorthWestern will also continue to record observations of *Didymosphenia* in West Rosebud Creek during the sampling events.

Sampling efforts in West Rosebud Creek will continue to be completed three times a year (April, July, October) and when feasible, within the same 2-week period, as was completed between 2010 and 2019. Mystic Lake water chemistry and biological data will be collected in August. Macroinvertebrate data will only be collected in October.

Table 6-1: Water quality monitoring parameters in West Rosebud Creek and Mystic Lake, 2020-2040. West Rosebud Creek sampling will occur every 5-years and Mystic Lake sampling will occur every 3-years.

	West Rosebud Creek (APH, BPH, BWRL)	Mystic (Mid-lake)
Parameters	2020, 2025, 2030, 2035, 2040	2021, 2024, 2027, 2030, 2033, 2036, 2039
Hydrolab	x	x
Total Alkalinity	x	x
Arsenic	x	x
Bicarbonate	x	x
Cadmium	x	x
Calcium	x	x
Chloride	x	x
Copper	x	x
Iron	x	x
Lead	x	x
Magnesium	x	x
Manganese	x	x
Nitrogen, Nitrate +Nitrite	x	x
Nitrogen, Total (persulfate)	x	x
Orthophosphate	x	x
Total Phosphorus	x	x
Potassium	x	x

Parameters	West Rosebud Creek (APH, BPH, BWRL)	Mystic (Mid-lake)
	2020, 2025, 2030, 2035, 2040	2021, 2024, 2027, 2030, 2033, 2036, 2039
Sodium	x	x
Sulfate	x	x
TDS	x	x
TSS	x	x
Turbidity	x	x
Zinc	x	x
Chlorophyll *a*	x	x
Periphyton	x	
Macroinvertebrates	x	
Phytoplankton		x
Zooplankton		x

6.4 Reporting

NorthWestern will summarize monitoring results within 1-year of each sampling year for TAC members. These annual summaries will be posted to the Project website but not be submitted to the Commission.

Following the completion of the 20-year monitoring period (2020-2040), NorthWestern will prepare a comprehensive report for the TAC approval prior to submittal to the Commission. The 20-year report will be submitted to the Commission by December 31, 2041.

Following analysis of the 2020 to 2040 data, NorthWestern will consult with the TAC to determine the need to continue monitoring water quality in the Mystic Lake Project area and/or modifications to the water quality monitoring plan for the future. Any future water quality monitoring plan (post 2040) will be included in the report submitted to the Commission by December 31, 2041.

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Appendix A – Macroinvertebrate Reports, 2010-2018

WEST ROSEBUD CREEK, MONTANA
AQUATIC MACROINVERTEBRATE SURVEY
OCTOBER, 2006

prepared for
PPL-Montana
Butte, MT

prepared by
Daniel L. McGuire
McGuire Consulting

September, 2007

MACROINVERTEBRATE SURVEY – WEST ROSEBUD CREEK – OCTOBER 2006

PPL Montana owns and operates the Mystic Lake hydroelectric facility on West Rosebud Creek, Stillwater County, Montana. Aquatic macroinvertebrate surveys have been conducted annually since 2004. The pilot study (August 2004) included macroinvertebrate samples from 7 sites (McGuire 2005). In 2005, macroinvetebrates were collected from 2 downstream sites (McGuire 2006). During October of 2006, PPL surveyed macroinvertebrates above and below the Mystic Powerhouse and below West Rosebud Lake. A Hess sampler (0.1 m^2, 390 micron mesh) was used to collect macroinvertebrates. Three samples were collected from each reach. Collection sites tended to be widely spaced, especially in the upper reach, where suitable habitats were limited.

RESULTS

The 2006 data (identifications, enumerations and metric values for each sample), along with summary statistics for each site, are presented in Appendix A.

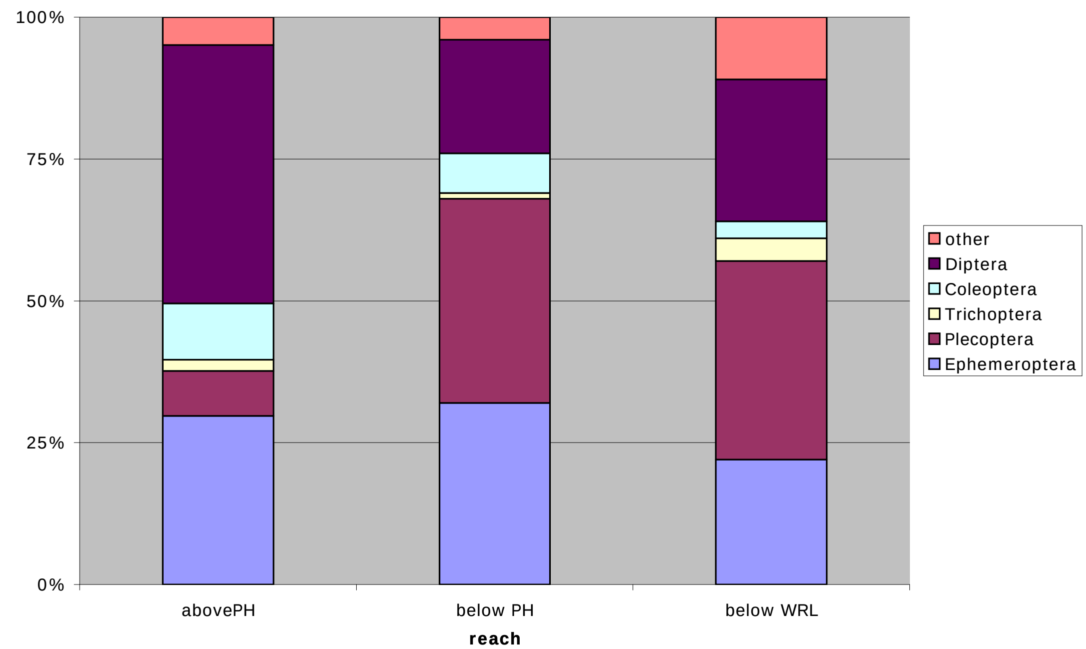
Community composition

West Rosebud Creek supports a diverse macroinvertebrate fauna and is typical of mountain streams in the region. A total of 107 taxa have been identified from the study area since 2004 (Table 1). Insects accounted for 95 taxa while 12 noninsect taxa were identified. Dipterans were the most diverse group with 43 taxa, including 31 genera of midges. Mayflies, stoneflies, and caddisflies were each represented by 14 to 17 species. Noninsect taxa included segmented worms, leeches, flatworms, crustaceans, fingernail clams and freshwater sponge. The 9 samples collected during October 2006 contained a total of 67 taxa,

Changes in species composition among sites reflected localized influences of West Rosebud and Emerald Lakes and the altitudinal gradient within the study area. A few diptera, caddisflies and stoneflies usually found in small mountain streams were confined to the upper reach (Mystic Dam to Powerhouse) while several taxa more characteristic of larger streams were limited to the lower reach. Most noninsect taxa were confined to reaches below West Rosebud Lake.

Mayflies, stoneflies and midges were the most numerous macroinvertebrates in October samples (Figure 1). Chironomids were the predominant (46%) macroinvertebrates collected above the powerhouse in early October. Stoneflies were numerically dominant in stream reaches below the powerhouse and West Rosebud Lake. These were primarily early instar (recently hatched) chloroperlids and nemourids. Early instar mayflies, primarily Ephemerella and Paraleptophlebia, were also abundant in each reach.

Figure 1. Percent relative abundance of major macroinvetebrate groups in West Rosebud Creek Hess samples- Oct., 2006.

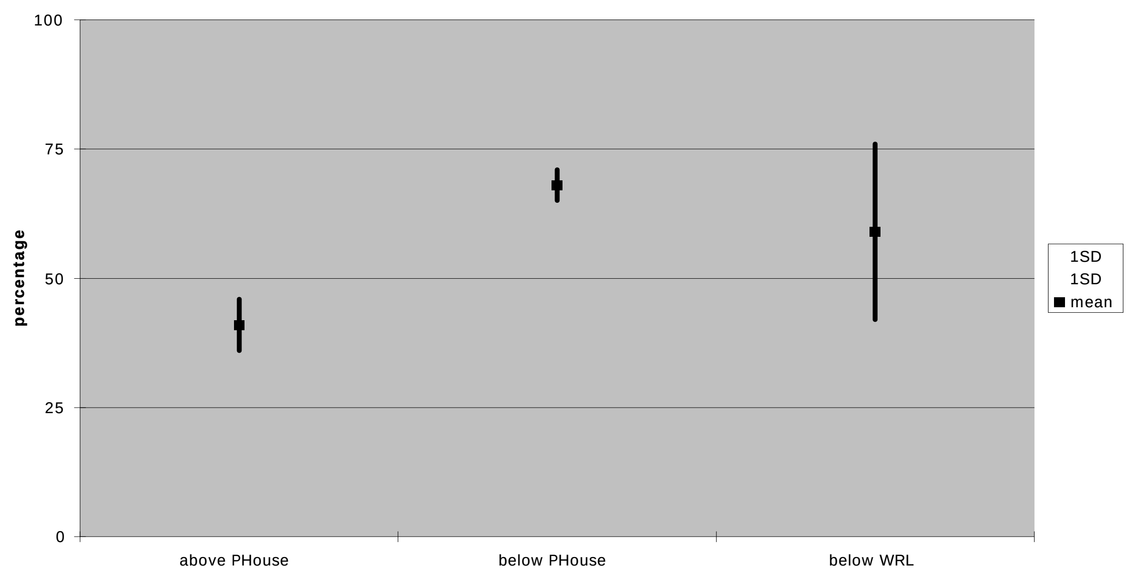


<u>Percent EPT</u>

Mayflies, stoneflies, and caddisflies (Ephemeroptera, Plecoptera, and Trichoptera, respectively) typically dominate macroinvertebrate faunas in mountain streams. The combined relative abundance of these 3 groups (percent EPT) is a standard metric of water and habitat quality (Bukantus 1997). Environmental stress may be indicated when EPT comprise less than about 50% of the fauna.

Mean EPT relative abundance ranged from 41% to 68% among West Rosebud sites (Figure 2). The lowest value (41%) was for the stream reach above the powerhouse. While this value is consistent with slight environmental stress, it may have been an anomaly caused by a high number of chironomids in 1 replicate. Mean EPT relative abundance for this reach was 58% in August 2004. Due to substantial variance within dates, EPT relative abundance was not significantly different.

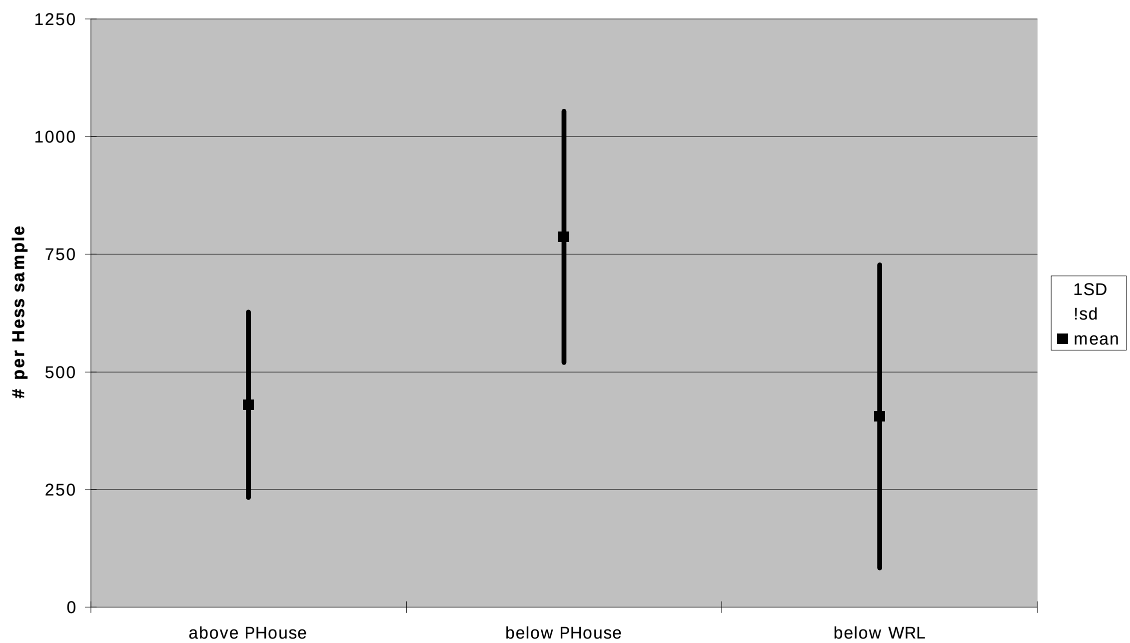
Figure 2. Mean percentage (+- 1 SD) of EPT (mayflies, stoneflies and caddisflies) in Hess samlples from 3 reaches of West Rosebud Creek, Oct. 2006.



Community Density

Mean community density ranged from approximately 400 to 800 organisms per 0.1 m^2 Hess sample (Figure 3). Total density was not significantly different among sites. Mean macroinvertebrate densities were significantly higher in reaches above and below the powerhouse during October 2006 than in August 2004 (mean ~ 110 organisms per sample, McGuire 2005). This increase is probably a seasonal pattern that reflects fall recruitment of newly hatched organisms.

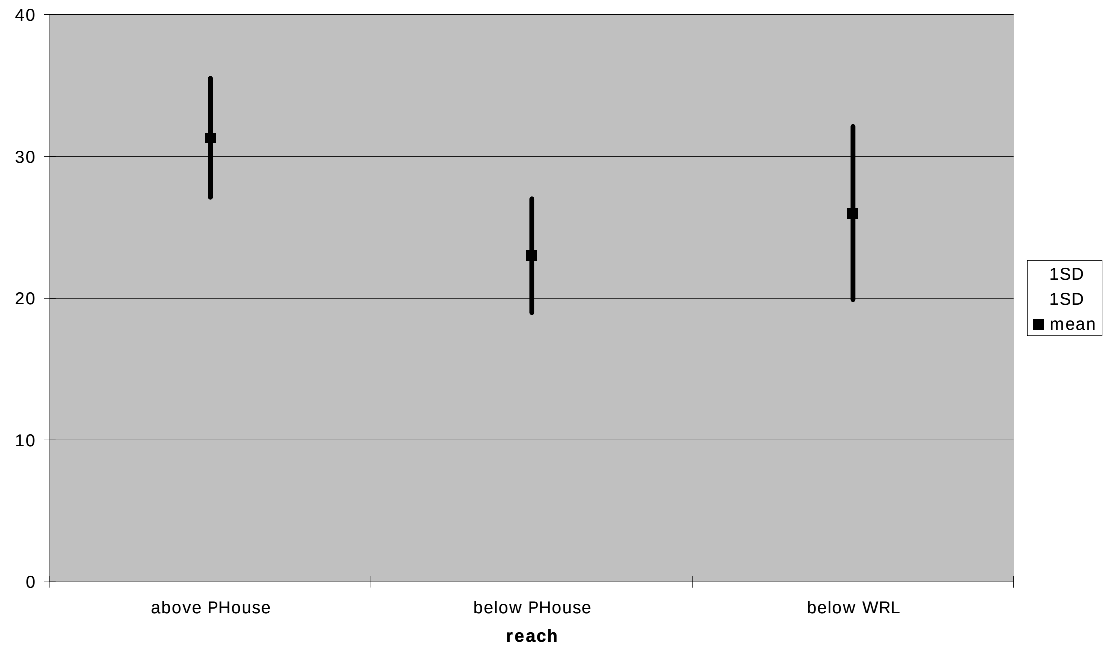
Figure 3. Mean macroinvertebrate densities (+- 1 SD) per Hess sample in 3 reaches of West Rosebud Creek, Oct 2006.



Taxa Richness

Mean taxa richness ranged from 23 to 31 taxa per sample and was similar for each site. These values were slightly higher than those recorded for these reaches in August 2004.

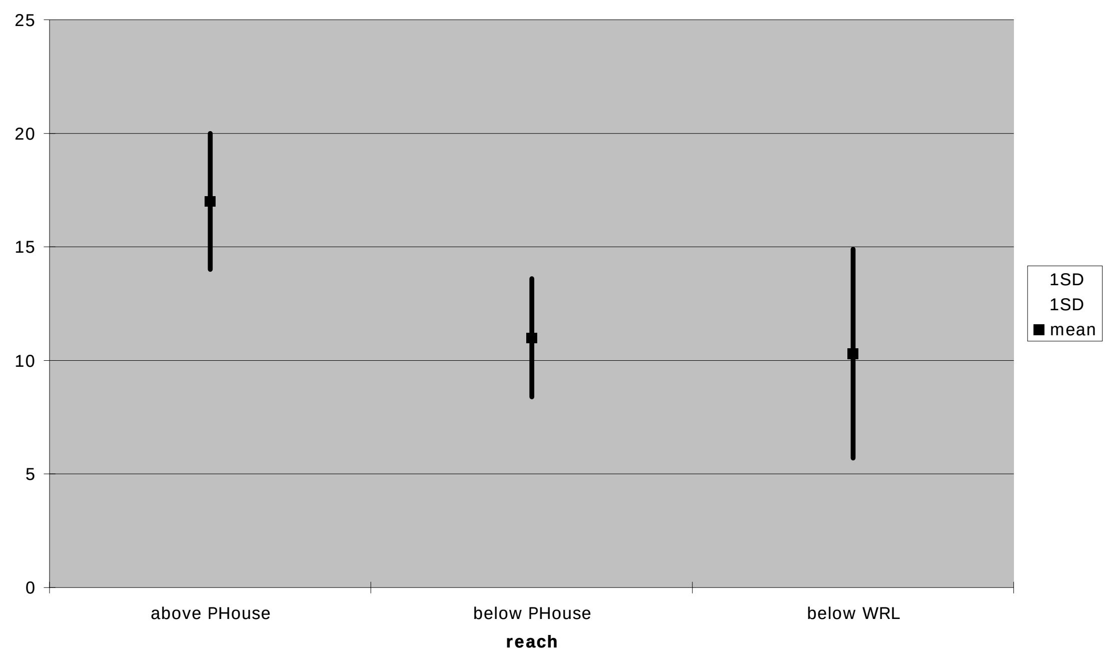
Figure 4. Mean taxa richness per Hess sample in 3 reaches of West Rosebud Creek, October 2006.



EPT Richness

The mean number of mayfly, stonefly and caddisfly taxa per sample ranged from 8 to 15 (Figure 4). EPT richness was highest in the reach above the powerhouse. Values for all 3 stream reaches were near 10 in August 2004.

Figure 5. Mean EPT taxa richness (+-1SD) per Hess sample in 3 reaches of West Rosebud Creek, October 2006.



Biotic Index

The biotic index was developed as a measure of organic pollution (Hilsenhoff 1987). The Montana version of this index (Bukantis 1997) is an excellent indicator of a streams trophic status and also tends to be correlated with water temperature, substrate embeddedness, and the percentage of fine sediments (Bolman 1998). On a scale of 0 to 10, with higher values indicating increasingly eutrophic conditions, healthy mountain streams in Montana typically have biotic index values of 4 or less (McGuire 1993).

Biotic index values were generally indicative of excellent water quality in all 3 reaches of West Rosebud Creek (Figure 6). Values were slightly elevated below West Rosebud Lake compared to upstream reaches. This pattern was also evident during previous surveys. A seasonal pattern associated with changes in primary production and organic loading (leaf litter) was also evident in the data set. Biotic index values were slightly higher in October 2005 and 2006 than in August 2004 for all 3 reaches.

Figure 6. Mean biotic index values (+-1SD) for 3 reaches of West Rosebud Creek, October 2006.

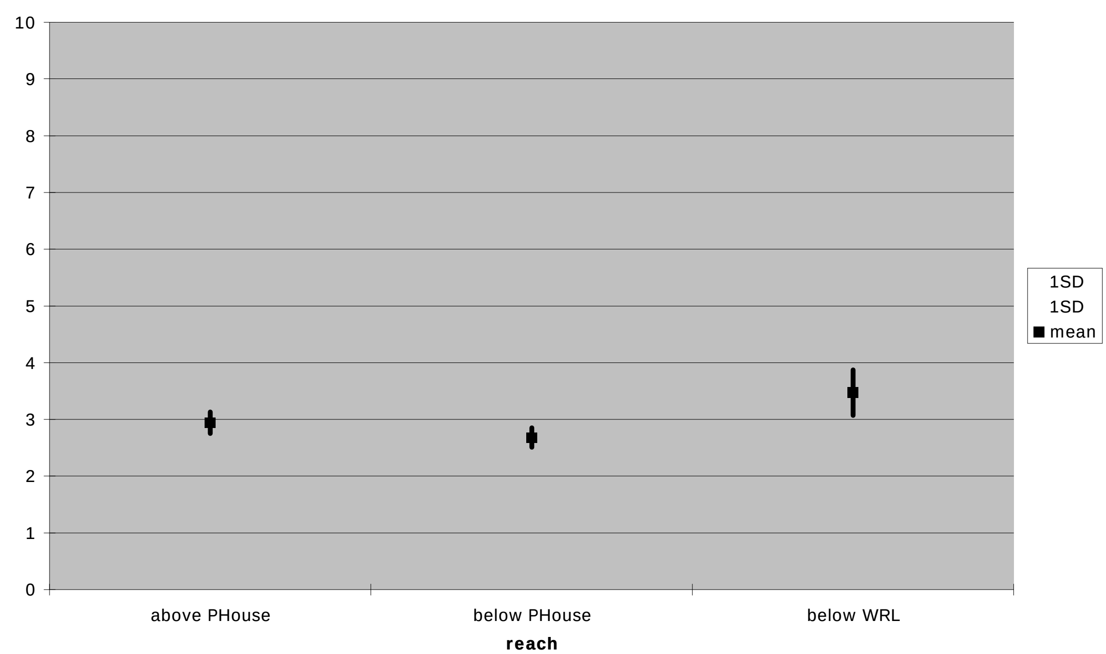


Table 1. A checklist of aquatic macroinvertebrates collected from West Rosebud Creek,Stillwater County, Montana during August, 2004 and 2005.

Order Family		genus/species	reach:	upper	lower	lower	upper
DIPTERA (two-winged flies)			year:	2004	2004	2005	2006
Athericidae		*Atherix sp.*		x			
Blephariceridae		*Agathon sp.*			x		
Ceratopgonidae		Ceratopogoninae			x	x	
Chironomidae							
	(Podonominae)	*Boreochlus sp.*		x			
	(Tanypodinae)	*Thienemannimyia gp.*		x	x	x	x
	(Diamesinae)	*Diamesa sp.*				x	x
		Pagastia sp.		x	x	x	x
		Potthastia sp.					x
		Pseudodiamesa sp.		x			
	(Prodiamsinae)	*Prodiamesia sp.*			x		
	(Orthocladinae)	*Brillia sp.*		x	x	x	
		Corynoneura sp.		x	x	x	
		Cricotopus spp.			x		x
		Eukiefferiella spp.		x	x	x	x
		Heterotrissocladius sp.					x
		Hydrobaenus sp.		x	x		x
		Krenosmittia sp.		x	x		
		Lopescladius sp.					x
		Orthocladius sp.		x	x	x	x
		Nanocladius sp.			x		
		Parametriocnemus sp.			x	x	x
		Paraphaenocladius sp.				x	
		Rheocricotopus sp.		x	x	x	x
		Synorthocladius sp.		x	x		x
		Tvetenia sp.		x	x	x	x
	(Chironomini)	*Microtendipes sp.*			x		
		Paracladopelma sp.			x	x	
		Polypedilum sp.		x	x	x	
	(Tanytasini)	*Cladotanytarsus sp.*			x	x	
		Sublettia sp.			x		
		Stempellinella sp.		x			
		Krenopsectra sp.		x	x	x	x
		Micropsectra sp. (poss. early instar Krenopsectra)				x	
		Tanytarsus sp.			x		x
Deuterophlebiidae		*Deuterophlebia sp.*		x	x	x	
Empididae		*Chelifera sp.*		x	x	x	x
		Clinocera sp.		x	x	x	x
Tipulidae		*Antocha sp.*			x	x	x
		Dicranota sp.		x	x		x
		Hexatoma sp.		x	x	x	x

	Hesperoconopa sp.	x		x	
	Limnophila sp.		x	x	
Simuliidae	*Simulium sp. (Eusimulium)*	x	x	x	x
EPHEMEROPTERA					
Ameletidae	*Ameletus sp.*	x	x	x	x
Baetidae	*Acentrella sp.*	x	x	x	
	Baetis tricaudatus	x	x	x	x
	Diphetor hageni	x	x	x	
Ephemerellidae	*Caudatella hystrix*		x		
	Drunella coloradensis		x		
	Drunella doddsi	x	x	x	x
	Drunella grandis	x	x	x	x
	Drunella spinifera				x
	Ephemerella sp.	x		x	x
	Seratella tibialis	x	x	x	x
Heptageniidae	*Cinygmula sp.*	x	x	x	x
	Epeoris grandis		x	x	
	Epeorus longimanus	x	x	x	x
	Rhithrogena sp.	x	x	x	x
Leptophlebiidae	*Paraleptophlebia sp.*	x	x	x	x
PLECOPTERA					
Capniidae		x			
Leuctridae		x		x	x
Nemouridae	*Malenka sp.*		x	x	
	Podmosta sp.	x			
	Visoka cataractae	x			x
	Zapada oregenensis gp.		x		
	Zapada cinctipes	x	x	x	x
Chloroperlidae	Chloroperlinae*	x	x	x	x
	*(Swelta spp and Suwallia sp.)				
	Kathroperla sp.	x	x	x	x
Perlodidae	*Skwala sp.*		x	x	x
	Cultus sp.			x	
	Unident. early instar	x	x		x
Perlidae	*Claassina sabulosa*		x	x	
	Doroneuria theodora	x			x
	Hesperoperla pacifica	x	x	x	x
TRICHOPTERA					
Hydropsychidae	*Arctopsyche sp.*	x	x	x	x
	Hydropsyche (C) oslari		x	x	
Philopotamidae	*Dolophilodes sp.*		x	x	x
Limnephilidae	*Apatania sp.*				x
	Ecclisomyia sp.	x			x
	Psychoglypha sp.		x		
Hydroptilidae	*Agraylea sp.*		x		
Brachycentridae	*Brachycentrus americanus*	x		x	x

	Micrasema sp.		x	x	x
Lepidostomatidae	*Lepidostoma sp.*		x	x	x
Glossosomatidae	*Glossosoma sp.*		x	x	x
Uenoidae	*Neophylax sp.*		x		
Rhyacophilidae	*Rhyacophila betteni gp.*	x			x
	Rhyacophila brunnea gp.		x	x	x
	Rhyacophila hyalinata gp.			x	x
	Rhyacophila coloradensis gp.			x	x
	Rhyacophila sibirica gp.		x		x
COLEOPTERA (beetles)					
Dytiscidae	*Stictotarsus sp.*		x		
Elmidae	*Heterlimnius corpulentus*	x	x	x	x
	Narpus concolor		x	x	
	Optioservus sp.	x	x	x	x
	Ziatzevia parvula			x	x
ANNELIDA					
Enchytraeidae		x	x	x	x
Megadrilli		x	x	x	x
Naididae	*Nais sp.*		x		x
Tubificidae	immature wo/capilliform chaetae (prob Limnodrilus)		x	x	
	immature w/capilliform chaetae (prob Rhyacodrilus)		x	x	
Glossophoniidae	*Helobdella stagnalis*		x		
CRUSTACEA					
Isopoda	*Caecidotea sp.*		x		x
Ostracoda		x	x		x
MOLLUSCA					
Planorbidae	*Gyraulus sp.*				x
Sphaeriidae	*Pisidium sp.*	x	x	x	x
TURBELLARIA		x	x	x	x
PORIFERA			x	x	x

CONCLUSIONS

West Rosebud Creek supported a relatively sparse but healthy assemblage of aquatic macroinvertebrates. The community was generally typical of a soft-water mountain stream. Based on the 2006 survey, there was only 1 indicator of slight environmental stress. EPT relative abundance was slightly lower than expected in the stream reach above the powerhouse. However, the measured shift in community composition was primarily driven by a high number of midges in 1 sample. Other metrics were consistent with a healthy benthic community.

Macroinvertebrate monitoring will provide a more powerful and relaliable assessment of environmental conditions as the datebase grows.

LITERATURE CITED

Bollman, W. 1998. Improving stream bioassessment methods for the Montana Valleys and Foothills Ecoregion. Masters Thesis. University of Montana. Missoula, MT.

Bukantis, R. 1997. Rapid bioassessment macroinvertebrate protocols: sampling and sample analysis SOP's. Montana Dept. of Health & Environmental Sciences. Helena, Montana.

McGuire, D.L. 1992. Montana Reference Streams Project: 1991 aquatic macroinvertebrate surveys. Prepared for the Montana Water Quality Bureau. Helena, Montana.

McGuire, D.L. 2005. West Rosebud Creek, Montana - aquatic macroinvertebrate survey. Prepared for PPL-Montana. Butte, Montana.

McGuire, D.L. 2006. West Rosebud Creek, Montana – 2005 aquatic macroinvertebrate survey. Prepared for PPL-Montana. Butte, Montana.

APPENDIX A:

West Rosebud Creek:
Aquatic Macroinvertebrate Data
August, 2004

1. Mystic Dam - Powerhouse section - upper site.

2. Mystic Dam - Powerhouse section - middle site.

3. Mystic Dam - Powerhouse section - lower site.

4. Emerald Lake Campground 2 (at bridge above lake).
   N 45^0 15.260 - W 109^0 41.959

5. Below Emerald Lake.

6. Pine Grove Campground.
   N 45^0 16.801 - W 109^0 38.240

7. Allen Grade Bridge.
   N 45^0 20.572 - W 109^0 36.090

AQUATIC MACROINVERTEBRATE SURVEY RESULTS
WEST ROSEBUD CREEK, MONTANA, OCTOBER, 2008

prepared for
PPL-Montana
Butte, MT

prepared by
Daniel L. McGuire
McGuire Consulting

June, 2009

INTRODUCTION

PPL Montana owns and operates the Mystic Lake hydroelectric facility on West Rosebud Creek, Stillwater County, Montana. Aquatic macroinvertebrate surveys of West Rosebud Creek (WRC) have been conducted annually since 2004. The pilot study (August 2004) included seven sites (McGuire 2005). In 2005, macroinvetebrates were collected from the two downstream sites (McGuire 2006). Since 2006, sampling has occurred in October (McGuire 2007 and 2008). This report incorporates data from October 2008 into the database.

METHODS

Three Hess samples (0.1 m^2, 390 micron mesh) are generally collected from each site. Samples tend to be widely spaced, especially at the upper site, where suitable substrates are limited. Additional macroinvertebrate samples were taken in conjunction with spawning gravel substrate samples in 2005 and 2007.

STUDY AREA

Active WRC monitoring sites, from upstream to downstream:

Station 1	Above Powerhouse	APH
Station 2	Below Powerhouse	BPH
Station 3	Below West Rosebud Lake	BWRL
Station 4	Pine Grove Campground	PGCG
Station 5	Allen Grade Bridge	AGB

RESULTS

The 2008 data (identifications, enumerations, and metric values for each sample), along with summary statistics for each site, are presented in Appendix A (separate file).

Community composition

West Rosebud Creek supports a diverse macroinvertebrate fauna that is typical of mountain streams in the region. Since 2004. 117 taxa have been identified from the stream (Table 1). Insects accounted for 103 taxa while 14 noninsect taxa were identified. Dipterans were the most diverse group with 46 taxa, including 33 genera of midges. Mayflies, stoneflies, and caddisflies were each represented by 15 to 17 species. Noninsect taxa included segmented worms, leeches, flatworms, crustaceans, fingernail clams and freshwater sponge. The 15 samples obtained during October 2008 contained 64 taxa, including four previously uncollected taxa.

Table 1. A checklist of aquatic macroinvertebrates collected from West Rosebud Creek, Stillwater County, Montana during August, 2004 and 2005 and Oct. 2006 -08.

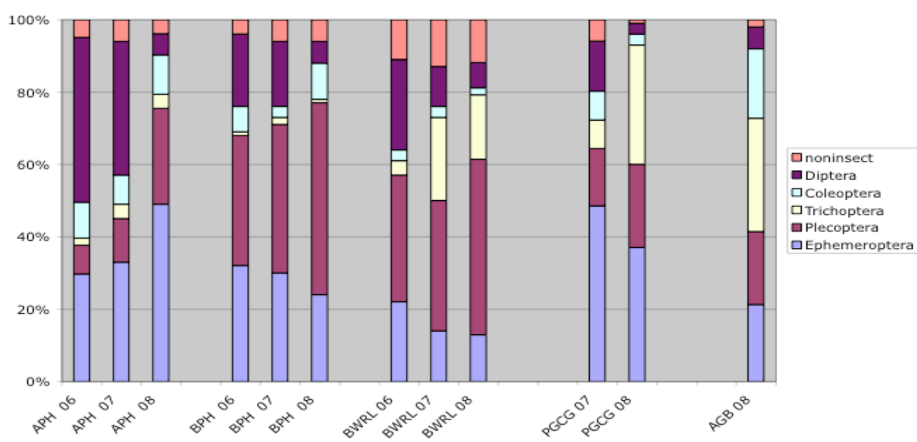
Orde Family	genus/species	year: 2004	2005	2006	2007	2008
	sites:samples	4:12	2:14	3:09	4:17	5:17
DIPTERA (two-winged flies)						
Athericidae	*Atherix sp.*	x				
Blephariceridae	*Agathon sp.*	x				
Ceratopgonidae	Ceratopogoninae	x	x		x	
Chironomidae						
(Podonominae)	*Boreochlus sp.*	x				
(Tanypodinae)	*Thienemannimyia gp.*	x	x	x	x	x
(Diamesinae)	*Diamesa sp.*		x	x	x	
	Pagastia sp.	x	x	x	x	x
	Potthastia sp.			x	x	x
	Pseudodiamesa sp.	x				
(Prodiamsinae)	*Prodiamesia sp.*	x				
(Orthocladinae)	*Brillia sp.*	x	x			x
	Corynoneura sp.	x	x			
	Cricotopus spp.	x		x		
	Eukiefferiella spp.	x	x	x	x	x
	Heterotrissocladius sp.			x		
	Hydrobaenus sp.	x		x	x	
	Krenosmittia sp.	x			x	
	Lopescladius sp.			x		
	Orthocladius sp.	x	x	x	x	x
	Nanocladius sp.	x				
	Parachaetocladius sp.				x	
	Parametriocnemus sp.	x	x	x	x	x
	Paraphaenocladius sp.		x			
	Rheocricotopus sp.	x	x	x	x	x
	Synorthocladius sp.	x		x	x	x
	Thienemanniella sp.				x	
	Tvetenia sp.	x	x	x	x	x
(Chironomini)	*Microtendipes sp.*	x				
	Paracladopelma sp.	x	x			
	Polypedilum sp.	x	x			
(Tanytasini)	*Cladotanytarsus sp.*	x	x		x	
	Sublettia sp.	x				
	Stempellinella sp.	x				
	Krenopsectra sp.	x	x	x	x	
	Micropsectra sp. (poss. early instar Kren		x			x
	Tanytarsus sp.	x		x		
Deuterophlebiidae	*Deuterophlebia sp.*	x	x			
Empididae	*Chelifera sp.*	x	x	x	x	x
	Clinocera sp.	x	x	x	x	
Tipulidae	*Antocha sp.*	x	x	x	x	
	Dicranota sp.	x		x	x	x
	Hexatoma sp.	x	x	x	x	x
	Hesperoconopa sp.	x	x			
	Limnophila sp.	x	x		x	
	Rhabdomastix sp.					x
Simuliidae	*Simulium sp. (Eusimulium)*	x	x	x	x	x
EPHEMEROPTERA						
Ameletidae	*Ameletus sp.*	x	x	x	x	x
Baetidae	*Acentrella sp.*	x	x			x
	Baetis bicaudatus				x	x
	Baetis tricaudatus	x	x	x	x	x
	Diphetor hageni	x	x			
Ephemerellidae	*Caudatella hystrix*	x			x	x
	Drunella coloradensis	x				
	Drunella doddsi	x	x	x	x	x
	Drunella grandis	x	x	x	x	x
	Drunella spinifera			x		
	Ephemerella sp.	x	x	x	x	x
	Seratella tibialis	x	x	x		x
Heptageniidae	*Cinygmula sp.*	x	x	x	x	x
	Epeoris grandis	x	x			
	Epeorus longimanus	x	x	x	x	x
	Rhithrogena sp.	x	x	x	x	x
Leptophlebiidae	*Paraleptophlebia sp.*	x	x	x	x	x

Orde Family	genus/species	year: 2004	2005	2006	2007	2008
	sites:samples	4:12	2:14	3:09	4:17	5:17
PLECOPTERA						
Capniidae		x			x	x
Leuctridae		x	x	x	x	x
Nemouridae	*Malenka sp.*	x	x			
	Podmosta sp.	x				
	Visoka cataractae	x		x		
	Zapada oregenensis gp.	x				x
	Zapada cinctipes	x	x	x	x	x
Chloroperlidae	Chloroperlinae*	x	x	x	x	x
	*(Swelta spp and Suwallia sp.)					
	Kathroperla sp.	x	x	x	x	x
Perlodidae	*Skwala sp.*	x	x	x	x	x
	Cultus sp.		x		x	
	Unident. early instar	x		x	x	
Perlidae	*Claassina sabulosa*	x	x		x	x
	Doroneuria theodora	x		x	x	x
	Hesperoperla pacifica	x	x	x	x	x
TRICHOPTERA						
Hydropsychidae	*Arctopsyche sp.*	x	x	x	x	x
	Hydropsyche (C) oslari	x	x		x	x
Philopotamidae	*Dolophilodes sp.*	x	x	x	x	
Limnephilidae	*Apatania sp.*			x		
	Ecclisomyia sp.	x		x		
	Psychoglypha sp.	x				
Hydroptilidae	*Agraylea sp.*	x			x	x
Brachycentridae	*Brachycentrus americanus*	x	x	x	x	x
	Brachycentrus occidentalis					x
	Micrasema sp.	x	x	x	x	x
Lepidostomatidae	*Lepidostoma sp.*	x	x	x	x	x
Glossosomatidae	*Glossosoma sp.*	x	x	x	x	x
Uenoidae	*Neophylax sp.*	x				
Rhyacophilidae	*Rhyacophila betteni gp.*	x		x	x	
	Rhyacophila brunnea gp.	x	x	x	x	x
	Rhyacophila hyalinata gp.		x	x	x	x
	Rhyacophila coloradensis gp.		x	x	x	x
	Rhyacophila sibirica gp.	x		x	x	x
COLEOPTERA (beetles)						
Dytiscidae	*Stictotarsus sp.*	x				
Elmidae	*Heterlimnius corpulentus*	x	x	x	x	x
	Lara sp.					x
	Microcylloepus sp.					x
	Narpus concolor	x	x		x	x
	Optioservus sp.	x	x	x	x	x
	Ziatzevia parvula		x	x	x	
Haliplidae	*Brychius sp.*				x	
ANNELIDA						
Enchytraeidae		x	x	x	x	x
Megadrilli		x	x	x	x	x
Naididae	*Nais sp.*	x		x		x
Tubificidae	immature wo/capilliform chaetae (prob Li	x	x		x	
	immature w/capilliform chaetae (prob Rhy	x	x			
Glossophoniidae	*Helobdella stagnalis*	x			x	
CRUSTACEA						
Isopoda	*Caecidotea sp.*	x		x	x	x
Ostracoda		x		x	x	
MOLLUSCA						
Physidae	*Physella sp.*				x	x
Planorbidae	*Gyraulus sp.*			x		
Sphaeriidae	*Pisidium sp.*	x	x	x	x	x
TURBELLARIA	*Polycelis sp.*	x	x	x	x	x
HYDRA					x	x
PORIFERA		x	x	x		

Changes in species composition among sites reflected localized influences of West Rosebud and Emerald Lakes and the altitudinal gradient within the study area. A few diptera, caddisflies and stoneflies usually found in small mountain streams were confined to the upper reach (Mystic Dam to Powerhouse) while several taxa more characteristic of larger streams were limited to the lower reach. Most noninsect taxa were confined to reaches below West Rosebud Lake.

Mayflies, stoneflies, caddisflies, and midges were the most numerous macroinvertebrates in October samples (Figure 1). Early instar (recently hatched) mayflies, primarily Baetis, Cingymula, Ephemerella and Paraleptophlebia, were abundant in each reach. Stoneflies were numerically dominant in stream reaches below the powerhouse and West Rosebud Lake. These were primarily early instar chloroperlids and nemourids. Caddisflies were abundant at sites downstream from West Rosebud Lake. Chironomids were less abundant in 2008 then in previous years.

Figure 1. Relative abundance (%) of major macroinvertebrate groups at 5 sites on West Rosebud Creek during October, 2006 - 2008.

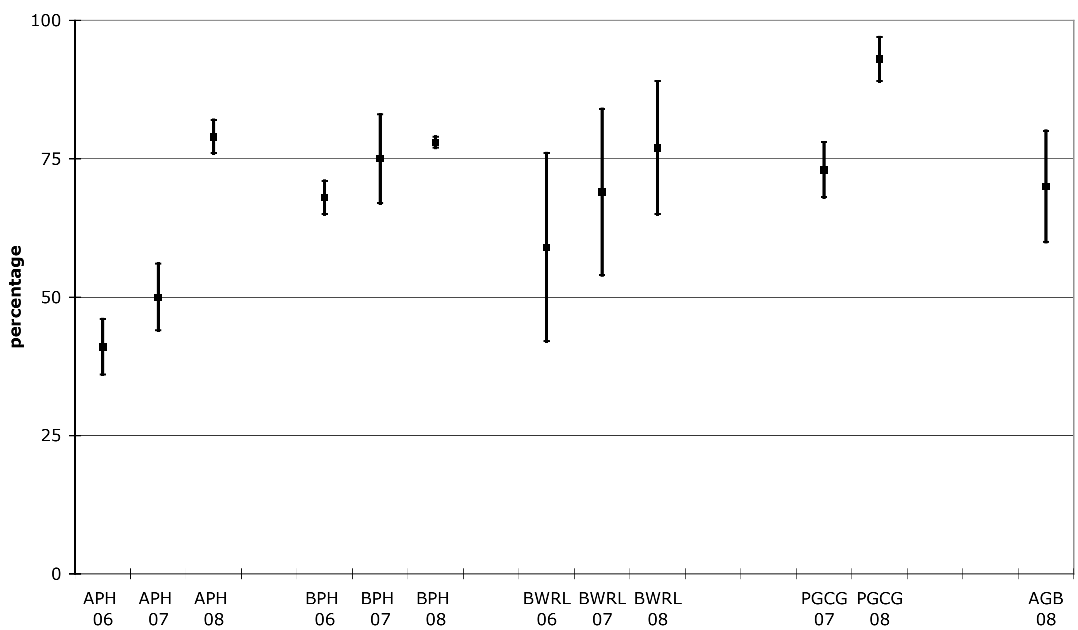


Percent EPT

Mayflies, stoneflies, and caddisflies (Ephemeroptera, Plecoptera, and Trichoptera, respectively) typically dominate macroinvertebrate faunas in mountain streams. The combined relative abundance of these 3 groups (percent EPT) is a standard metric of water and habitat quality (Bukantus 1997). Environmental stress may be indicated when EPT comprise less than about 50% of the fauna.

Mean EPT relative abundance ranged from 41% to 93% among WRC sites (Figure 2). Values were higher at each site in 2008 than in previous years.

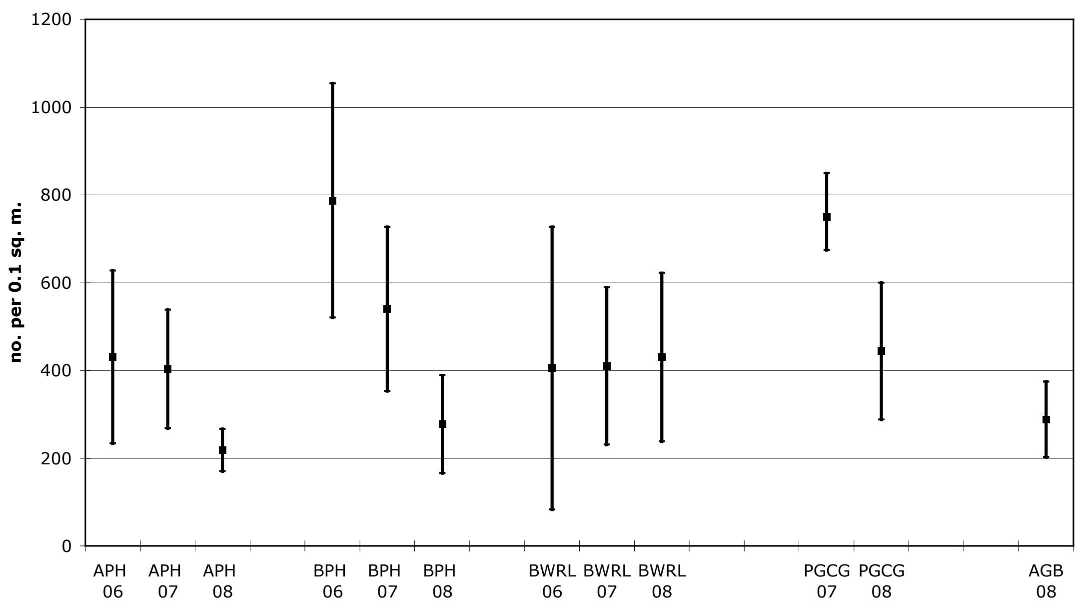
Figure 2. Mean percentage (+ or - 1 SD) of EPT in Hess samples from 5 sites on West Rosebud Creek during October, 2006 - 2008.



Community Density

Macroinvertebrate abundance was low in West Rosebud Creek. Mean community density was generally similar among sites and ranged from approximately 200 to 800 organisms per 0.1 m^2 Hess sample (Figure 3). Community density was lower at most sites in 2008 then in previous years.

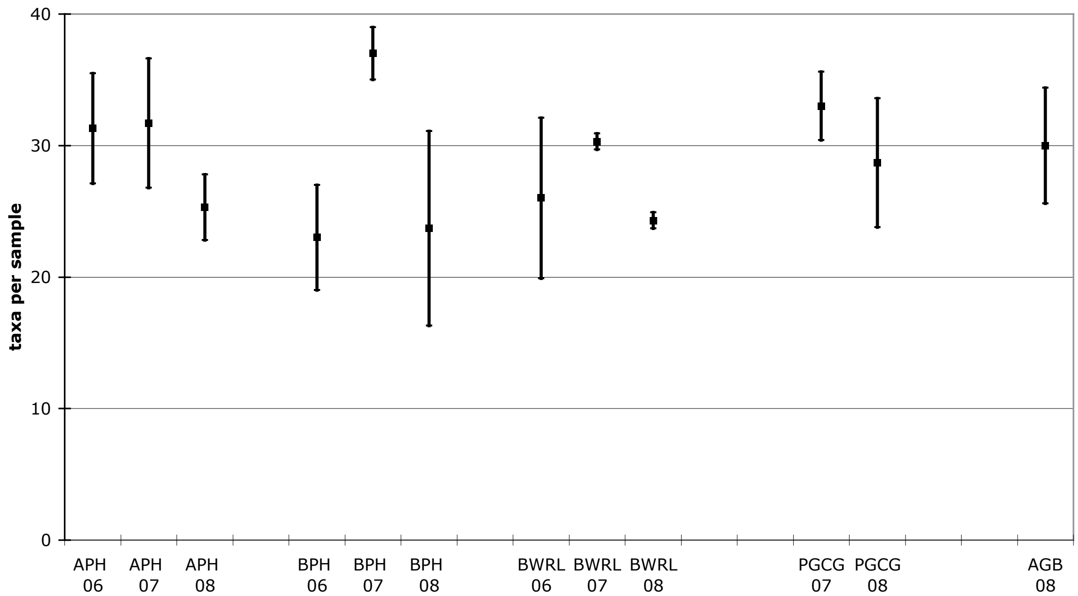
Figure 3. Mean number of macroinvertebrates (+ or - 1SD) per Hess sample at 5 sites on West Rosebud Creek during October, 2006 - 2008.



Taxa Richness

The number of taxa collected per sample is a basic measure of biological integrity that is sensitive to most environmental stresses. Hess samples from healthy mountain streams typically contain 30 or more taxa. The study area mean over the past 3 years was 30 taxa per Hess sample (Figure 4). Mean taxa richness was generally lower in 2008 than in previous years.

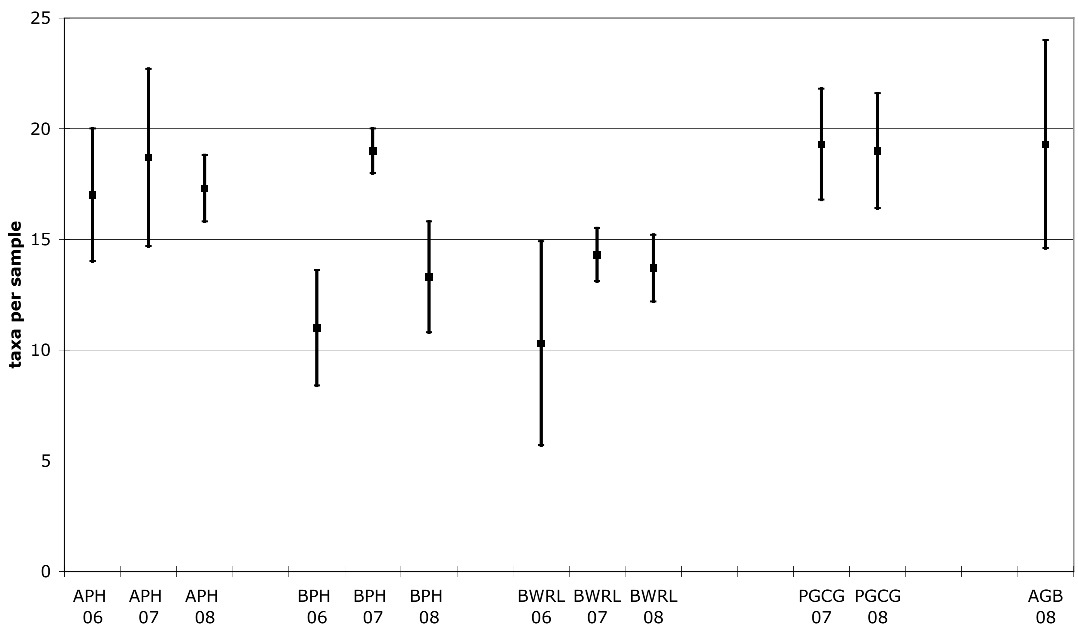
Figure 4. Mean taxa richness (= or - 1 SD) of macroinvertebrates in Hess samples from 5 sites on West Rosebud Creek during October, 2006 -2008.



EPT Richness

The mean number of mayfly, stonefly and caddisfly taxa per sample ranged from 10 to 19 over the three sampling periods (Figure 4). EPT richness tended to be lowest below the powerhouse and West Rosebud Lake.

Figure 5. Mean EPT richness (= or - 1 SD) per Hess sample at 5 sites on West Rosebud Creek during August, 2006 - 2008.

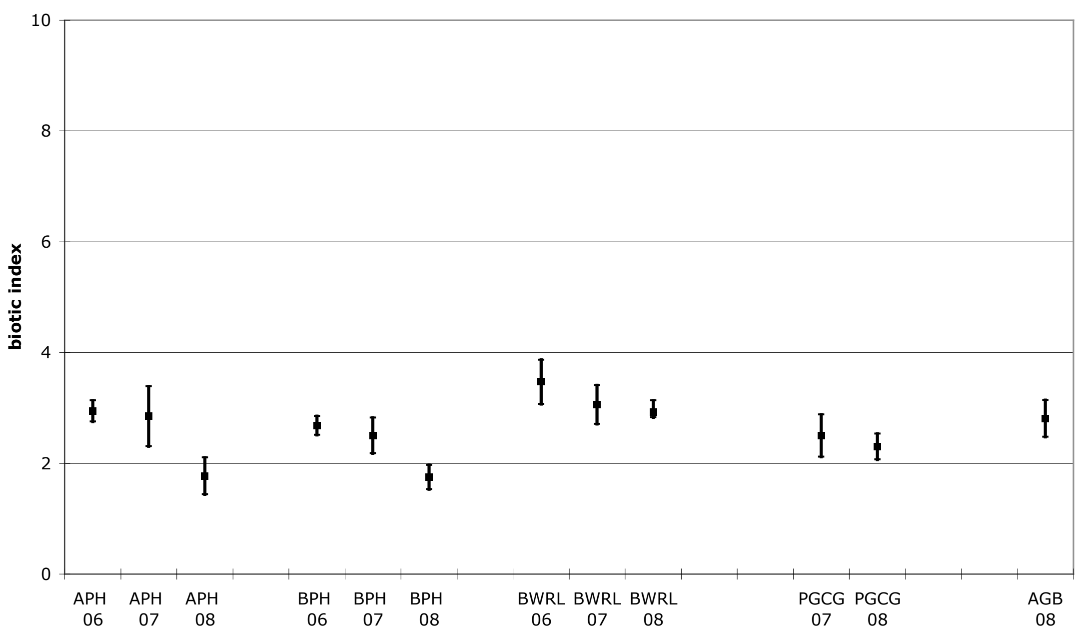


Biotic Index

The biotic index was developed as a measure of organic pollution (Hilsenhoff 1987). The Montana version of this index (Bukantis 1997) is an excellent indicator of a streams trophic status and also tends to be correlated with water temperature, substrate embeddedness, and the percentage of fine sediments (Bolman 1998). On a scale of 0 to 10, with higher values indicating increasingly eutrophic conditions, healthy mountain streams in Montana typically have biotic index values of 4 or less (McGuire 1993).

Biotic index values indicated excellent water quality throughout WRC (Figure 6). The study area mean was 2.6. Annual site estimates ranged from 1.8 to 3.5. Values were slightly elevated below West Rosebud Lake compared to other reaches.

Figure 6. Mean Biotic index values for 5 sites on West Rosebud Creek during October, 2006 - 2008.



CONCLUSIONS

West Rosebud Creek supported a sparse but generally healthy assemblage of aquatic macroinvertebrates. The community was typical of a soft-water mountain stream. There were few indications of environmental stress. EPT relative abundance was slightly lower than expected above the powerhouse in 2006 and 2007. Taxa richness and EPT richness were slightly below optimal at sites below the powerhouse and below West Rosebud Lake.

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AQUATIC MACROINVERTEBRATE SURVEY RESULTS
WEST ROSEBUD CREEK, MONTANA, OCTOBER, 2012

prepared for
PPL-Montana
Butte, MT

prepared by
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McGuire Consulting

March, 2013

INTRODUCTION

PPL Montana owns and operates the Mystic Lake hydroelectric facility on West Rosebud Creek, Stillwater County, Montana. Aquatic macroinvertebrate surveys of West Rosebud Creek (WRC) have been conducted since 2004. The pilot study (August 2004) included seven sites (McGuire 2005). Since 2006, sampling has occurred in October. This report incorporates data from October 2010 and 2012 into the database. Prevous monitoring reports are included in the literature cited.

STUDY AREA

Current WRC monitoring sites, from upstream to downstream:

Above Powerhouse	APH
Below Powerhouse	BPH
Below West Rosebud Lake	BWRL
Pine Grove Campground	PGCG
Allen Grade Bridge	AGB

METHODS

Three Hess samples (0.1 m^2, 390 micron mesh) are generally collected from each site. Samples tend to be widely spaced, especially at the upper site, where suitable substrates are limited.

RESULTS

Appendix A (separate file) contains the complete data set for the macroinvertebrate monitoring program (2004 through 2012). Raw data (identifications and enumerations) as well as metric values and summary statistics are included in this file.

Community composition

West Rosebud Creek supports a diverse macroinvertebrate fauna that is typical of mountain streams in the region. Since 2004, 122 taxa have been identified from the stream (Table 1). Insects accounted for 108 taxa while 14 noninsect taxa were identified. Dipterans were the most diverse group with 48 taxa, including 35 genera of midges. Mayflies, stoneflies, and caddisflies were each

Table 1. A checklist of aquatic macroinvertebrates collected from West Rosebud Creek, Stillwater County, Montana during August, 2004 and 2005 and Oct. 2006 -08.

Orde Family	genus/species	year: 2004	2005	2006	2007	2008
	sites:samples	4:12	2:14	3:09	4:17	5:17
DIPTERA (two-winged flies)						
Athericidae	*Atherix sp.*	x				
Blephariceridae	*Agathon sp.*	x				
Ceratopgonidae	Ceratopogoninae	x	x		x	
Chironomidae						
(Podonominae)	*Boreochlus sp.*	x				
(Tanypodinae)	*Thienemannimyia gp.*	x	x	x	x	x
(Diamesinae)	*Diamesa sp.*		x	x	x	
	Pagastia sp.	x	x	x	x	x
	Potthastia sp.			x	x	x
	Pseudodiamesa sp.	x				
(Prodiamsinae)	*Prodiamesia sp.*	x				
(Orthocladinae)	*Brillia sp.*	x	x			x
	Corynoneura sp.	x	x			
	Cricotopus spp.	x		x		
	Eukiefferiella spp.	x	x	x	x	x
	Heterotrissocladius sp.			x		
	Hydrobaenus sp.	x		x	x	
	Krenosmittia sp.	x			x	
	Lopescladius sp.			x		
	Orthocladius sp.	x	x	x	x	x
	Nanocladius sp.	x				
	Parachaetocladius sp.				x	
	Parametriocnemus sp.	x	x	x	x	x
	Paraphaenocladius sp.		x			
	Rheocricotopus sp.	x	x	x	x	x
	Synorthocladius sp.	x		x	x	x
	Thienemanniella sp.				x	
	Tvetenia sp.	x	x	x	x	x
(Chironomini)	*Microtendipes sp.*	x				
	Paracladopelma sp.	x	x			
	Polypedilum sp.	x	x			
(Tanytasini)	*Cladotanytarsus sp.*	x	x		x	
	Sublettia sp.	x				
	Stempellinella sp.	x				
	Krenopsectra sp.	x	x	x	x	
	Micropsectra sp. (poss. early instar Kren		x			x
	Tanytarsus sp.	x		x		
Deuterophlebiidae	*Deuterophlebia sp.*	x	x			
Empididae	*Chelifera sp.*	x	x	x	x	x
	Clinocera sp.	x	x	x	x	
Tipulidae	*Antocha sp.*	x	x	x	x	
	Dicranota sp.	x		x	x	x
	Hexatoma sp.	x	x	x	x	x
	Hesperoconopa sp.	x	x			
	Limnophila sp.	x	x		x	
	Rhabdomastix sp.					x
Simuliidae	*Simulium sp. (Eusimulium)*	x	x	x	x	x
EPHEMEROPTERA						
Ameletidae	*Ameletus sp.*	x	x	x	x	x
Baetidae	*Acentrella sp.*	x	x			x
	Baetis bicaudatus				x	x
	Baetis tricaudatus	x	x	x	x	x
	Diphetor hageni	x	x			
Ephemerellidae	*Caudatella hystrix*	x			x	x
	Drunella coloradensis	x				
	Drunella doddsi	x	x	x	x	x
	Drunella grandis	x	x	x	x	x
	Drunella spinifera			x		
	Ephemerella sp.	x	x	x	x	x
	Seratella tibialis	x	x	x		x
Heptageniidae	*Cinygmula sp.*	x	x	x	x	x
	Epeoris grandis	x	x			
	Epeorus longimanus	x	x	x	x	x
	Rhithrogena sp.	x	x	x	x	x
Leptophlebiidae	*Paraleptophlebia sp.*	x	x	x	x	x

Orde Family	genus/species	year: 2004	2005	2006	2007	2008
	sites:samples	4:12	2:14	3:09	4:17	5:17
PLECOPTERA						
Capniidae		x			x	x
Leuctridae		x	x	x	x	x
Nemouridae	*Malenka sp.*	x	x			
	Podmosta sp.	x				
	Visoka cataractae	x		x		
	Zapada oregenensis gp.	x				x
	Zapada cinctipes	x	x	x	x	x
Chloroperlidae	Chloroperlinae*	x	x	x	x	x
	*(Swelta spp and Suwallia sp.)					
	Kathroperla sp.	x	x	x	x	x
Perlodidae	*Skwala sp.*	x	x	x	x	x
	Cultus sp.		x		x	
	Unident. early instar	x		x	x	
Perlidae	*Claassina sabulosa*	x	x		x	x
	Doroneuria theodora	x		x	x	x
	Hesperoperla pacifica	x	x	x	x	x
TRICHOPTERA						
Hydropsychidae	*Arctopsyche sp.*	x	x	x	x	x
	Hydropsyche (C) oslari	x	x		x	x
Philopotamidae	*Dolophilodes sp.*	x	x	x	x	
Limnephilidae	*Apatania sp.*			x		
	Ecclisomyia sp.	x		x		
	Psychoglypha sp.	x				
Hydroptilidae	*Agraylea sp.*	x			x	x
Brachycentridae	*Brachycentrus americanus*	x	x	x	x	x
	Brachycentrus occidentalis					x
	Micrasema sp.	x	x	x	x	x
Lepidostomatidae	*Lepidostoma sp.*	x	x	x	x	x
Glossosomatidae	*Glossosoma sp.*	x	x	x	x	x
Uenoidae	*Neophylax sp.*	x				
Rhyacophilidae	*Rhyacophila betteni gp.*	x		x	x	
	Rhyacophila brunnea gp.	x	x	x	x	x
	Rhyacophila hyalinata gp.		x	x	x	x
	Rhyacophila coloradensis gp.		x	x	x	x
	Rhyacophila sibirica gp.	x		x	x	x
COLEOPTERA (beetles)						
Dytiscidae	*Stictotarsus sp.*	x				
Elmidae	*Heterlimnius corpulentus*	x	x	x	x	x
	Lara sp.					x
	Microcylloepus sp.					x
	Narpus concolor	x	x		x	x
	Optioservus sp.	x	x	x	x	x
	Ziatzevia parvula		x	x	x	
Haliplidae	*Brychius sp.*				x	
ANNELIDA						
Enchytraeidae		x	x	x	x	x
Megadrilli		x	x	x	x	x
Naididae	*Nais sp.*	x		x		x
Tubificidae	immature wo/capilliform chaetae (prob Li	x	x		x	
	immature w/capilliform chaetae (prob Rhy	x	x			
Glossophoniidae	*Helobdella stagnalis*	x			x	
CRUSTACEA						
Isopoda	*Caecidotea sp.*	x		x	x	x
Ostracoda		x		x	x	
MOLLUSCA						
Physidae	*Physella sp.*				x	x
Planorbidae	*Gyraulus sp.*			x		
Sphaeriidae	*Pisidium sp.*	x	x	x	x	x
TURBELLARIA	*Polycelis sp.*	x	x	x	x	x
HYDRA					x	x
PORIFERA		x	x	x		

Table 1. A checklist of aquatic macroinvertebrates collected from West Rosebud Creek, Stillwater County, Montana during August, 2004 and 2005 and Oct. 2006,2007, 2008, 2010 and 2012.

Orde Family	genus/species year:	2004	2005	2006	2007	2008	2010	2012
	# sites.samples	4 .12	2. 14	3. 9	4. 17	5. 15	5. 15	5. 15
DIPTERA (two-winged flies)								
Athericidae	*Atherix sp.*	x						
Blephariceridae	*Agathon sp.*	x						
Ceratopgonidae	Ceratopogoninae	x	x		x		x	x
Chironomidae								
(Podonominae)	*Boreochlus sp.*	x						
(Tanypodinae)	*Thienemannimyia gp.*	x	x	x	x	x	x	
(Diamesinae)	*Diamesa sp.*		x	x	x		x	
	Pagastia sp.	x	x	x	x	x	x	x
	Potthastia sp.			x	x	x	x	x
	Pseudodiamesa sp.	x						
(Prodiamsinae)	*Prodiamesia sp.*	x						
(Orthocladinae)	*Brillia sp.*	x	x			x	x	
	Corynoneura sp.	x	x					
	Cricotopus spp.	x		x				
	Eukiefferiella spp.	x	x	x	x	x	x	x
	Heterotrissocladius sp.			x				
	Hydrobaenus sp.	x		x	x			x
	Krenosmittia sp.	x			x			
	Lopescladius sp.			x				
	Orthocladius sp.	x	x	x	x	x	x	x
	Nanocladius sp.	x					x	x
	Parachaetocladius sp.				x			
	Parametriocnemus sp.	x	x	x	x	x		
	Paraphaenocladius sp.		x					
	Rheocricotopus sp.	x	x	x	x	x	x	x
	Symposiocladius (Orthocladius)							x
	Synorthocladius sp.	x		x	x	x	x	x
	Thienemanniella sp.				x			
	Tvetenia sp.	x	x	x	x	x	x	x
(Chironomini)	*Microtendipes sp.*	x						
	Paracladopelma sp.	x	x					
	Polypedilum sp.	x	x					
(Tanytasini)	*Cladotanytarsus sp.*	x	x		x			
	Rheotanytarsus sp.							x
	Sublettia sp.	x						
	Stempellinella sp.	x						x
	Krenopsectra sp.	x	x	x	x			
	Micropsectra sp. (poss. early instar Kren		x			x	x	x
	Tanytarsus sp.	x		x				
Deuterophlebiidae	*Deuterophlebia sp.*	x	x					
Empididae	*Chelifera sp.*	x	x	x	x	x		x
	Clinocera sp.	x	x	x	x		x	
Tipulidae	*Antocha sp.*	x	x	x	x		x	x
	Dicranota sp.	x		x	x	x	x	
	Hexatoma sp.	x	x	x	x	x	x	x
	Hesperoconopa sp.	x	x					
	Limnophila sp.	x	x		x			
	Rhabdomastix sp.					x		x
Simuliidae	*Simulium sp. (Eusimulium)*	x	x	x	x	x	x	x
EPHEMEROPTERA								
Ameletidae	*Ameletus sp.*	x	x	x	x	x	x	x
Baetidae	*Acentrella sp.*	x	x			x		x
	Baetis bicaudatus				x	x	x	x
	Baetis tricaudatus	x	x	x	x	x	x	x
	Diphetor hageni	x	x					
Ephemerellidae	*Caudatella hystrix*	x			x	x	x	x
	Drunella coloradensis	x						
	Drunella doddsi	x	x	x	x	x	x	x
	Drunella grandis	x	x	x	x	x	x	x
	Drunella spinifera			x				
	Ephemerella sp.	x	x	x	x	x	x	x
	Seratella tibialis	x	x	x		x		
Heptageniidae	*Cinygmula sp.*	x	x	x	x	x	x	x
	Epeoris grandis	x	x				x	
	Epeorus longimanus	x	x	x	x	x	x	x
	Rhithrogena sp.	x	x	x	x	x	x	x
Leptophlebiidae	*Paraleptophlebia sp.*	x	x	x	x	x	x	x

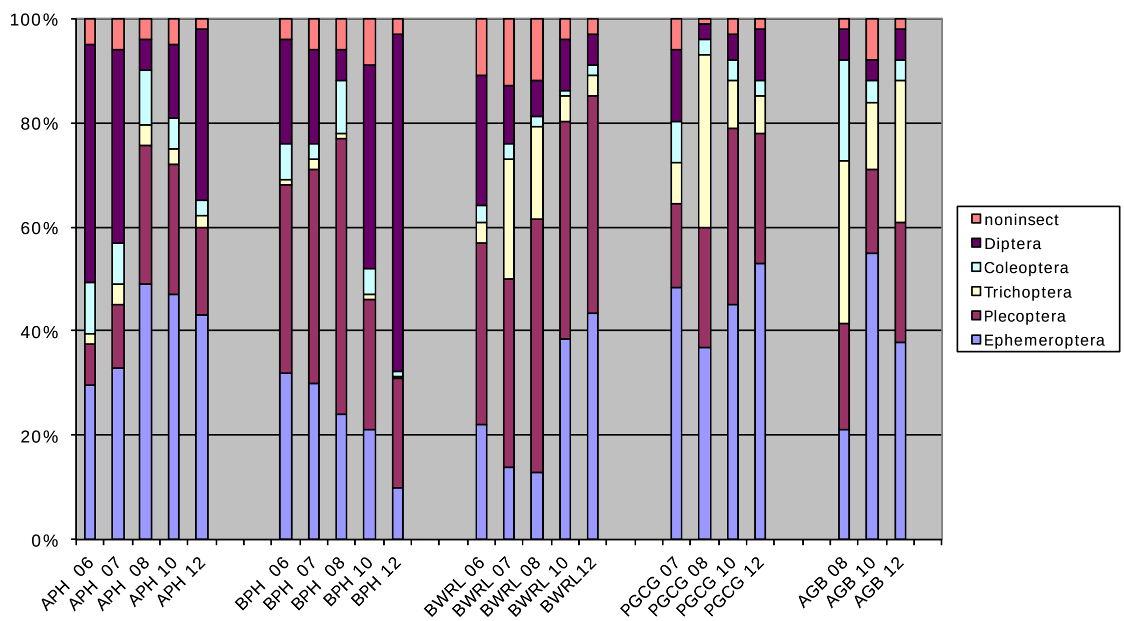
Table 1. Checklist concluded.

Orde	Family	genus/species	2004	2005	2006	2007	2008	2010	2012
		sites/samples	4. 12	2. 14	3. 9	4. 17	5. 15	5. 15	5. 15
PLECOPTERA									
	Capniidae		x			x	x	x	
	Leuctridae		x	x	x	x	x	x	x
	Nemouridae	*Malenka sp.*	x	x					
		Podmosta sp.	x						
		Visoka cataractae	x		x				
		Zapada oregenensis gp.	x				x		
		Zapada cinctipes	x	x	x	x	x	x	x
	Chloroperlidae	Chloroperlinae*	x	x	x	x	x	x	x
		*(Swelta spp and Suwallia sp.)							
		Kathroperla sp.	x	x	x	x	x	x	x
	Perlodidae	*Skwala sp.*	x	x	x	x	x	x	x
		Cultus sp.		x		x			
		Isoperla sp.							x
		Unident. early instar	x		x	x			
	Perlidae	*Claassenia sabulosa*	x	x		x	x	x	x
		Doroneuria theodora	x		x	x	x	x	x
		Hesperoperla pacifica	x	x	x	x	x	x	x
TRICHOPTERA									
	Hydropsychidae	*Arctopsyche sp.*	x	x	x	x	x	x	x
		Hydropsyche (C) oslari	x	x		x	x	x	x
	Philopotamidae	*Dolophilodes sp.*	x	x	x	x		x	x
	Limnephilidae	*Apatania sp.*			x				
		Neothremma sp.	x		x			x	
		Ecclisomyia sp.	x					x	
		Psychoglypha sp.	x			x	x		
	Hydroptilidae	*Agraylea sp.*	x	x	x	x	x	x	x
	Brachycentridae	*Brachycentrus americanus*					x	x	x
		Brachycentrus occidentalis	x	x	x	x	x		
		Micrasema sp.	x	x	x	x	x	x	x
	Lepidostomatidae	*Lepidostoma sp.*	x	x	x	x	x	x	x
	Glossosomatidae	*Glossosoma sp.*	x					x	x
	Uenoidae	*Neophylax sp.*	x		x	x			
	Rhyacophilidae	*Rhyacophila betteni gp.*	x	x	x	x	x	x	x
		Rhyacophila brunnea gp.		x	x	x	x	x	x
		Rhyacophila hyalinata gp.		x	x	x	x		x
		Rhyacophila coloradensis gp.	x		x	x	x	x	x
		Rhyacophila sibirica gp.	x					x	x
COLEOPTERA (beetles)									
	Dytiscidae	*Stictotarsus sp.*	x	x	x	x	x		
	Elmidae	*Heterlimnius corpulentus*					x	x	x
		Lara sp.					x		
		Microcylloepus sp.	x	x		x	x		
		Narpus concolor	x	x	x	x	x	x	x
		Optioservus sp.		x	x	x		x	x
		Ziatzevia parvula				x		x	x
	Haliplidae	*Brychius sp.*							
ANNELIDA									
	Enchytraeidae		x	x	x	x	x	x	x
	Megadrilli		x		x		x		x
	Naididae	*Nais sp.*	x	x		x		x	
	Tubificidae	immature wo/capilliform chaetae (prob Lir	x	x					
		immature w/capilliform chaetae (prob Rhy	x			x			
	Glossophoniidae	*Helobdella stagnalis*				x			
			x		x	x	x		
CRUS	Isopoda	*Caecidotea sp.*	x		x	x		x	
	Ostracoda								
						x	x		
MOLI	Physidae	*Physella sp.*			x				
	Planorbidae	*Gyraulus sp.*	x	x	x	x	x		
	Sphaeriidae	*Pisidium sp.*	x	x	x	x	x	x	x
		Polycelis sp.				x	x	x	x
TURBELLARIA			x	x	x			x	x
HYDRA									
PORIFERA									

Changes in species composition among sites reflected the longitudinal gradient within the study area and localized influences of West Rosebud and Emerald Lakes. A few diptera, caddisflies and stoneflies typically found in small mountain streams were confined to the upper reach (Mystic Dam to Powerhouse) while several taxa more characteristic of larger streams were limited to the lower reach. Most noninsect taxa were confined to reaches below West Rosebud Lake.

Mayflies, stoneflies, caddisflies, and midges were the most numerous macroinvertebrates in October samples (Figure 1). Early instar (recently hatched) mayflies, primarily Baetis, Cingymula, Ephemerella and Paraleptophlebia, were abundant in each reach. Stoneflies were typically numerically dominant in stream reaches below the powerhouse and West Rosebud Lake. These were primarily early instar chloroperlids and nemourids. However, chironomids dominated the fauna below the Powerhouse in 2012. Caddisflies were most abundant at sites downstream from West Rosebud Lake.

Figure 1. Relative abundance (%) of major macroinvertebrate groups at 5 sites on West Rosebud Creek during October, 2006 - 2012.

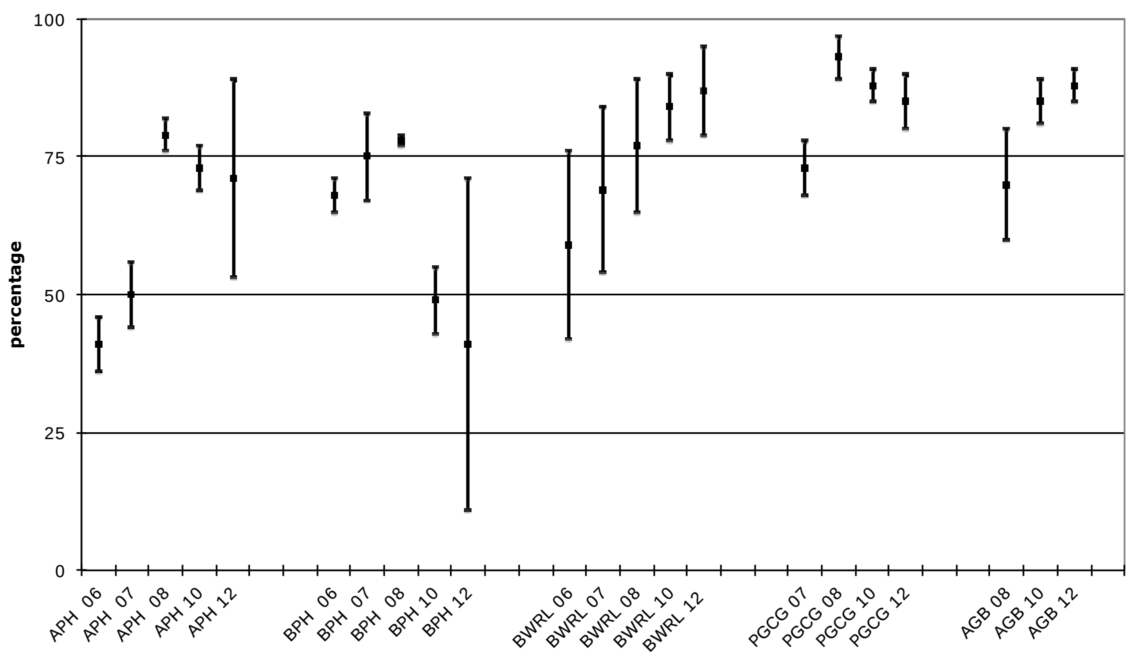


Percent EPT

Mayflies, stoneflies, and caddisflies (Ephemeroptera, Plecoptera, and Trichoptera, respectively) typically dominate macroinvertebrate faunas in mountain streams. The combined relative abundance of these 3 groups (percent EPT) is a standard metric of water and habitat quality (Bukantus 1997). Environmental stress may be indicated when EPT comprise less than about 50% of the fauna.

Mean EPT relative abundance ranged from 41% to 95% among WRC sites (Figure 2). Most vlaues were indicative of healthy stream environments. Relatively low values above (2006 and 2007) and below (2010 and 2012) the Powerhouse were consistent with slight environmental stress. The relatively low mean value below the Powerhouse in 2012 was associated with high variability.

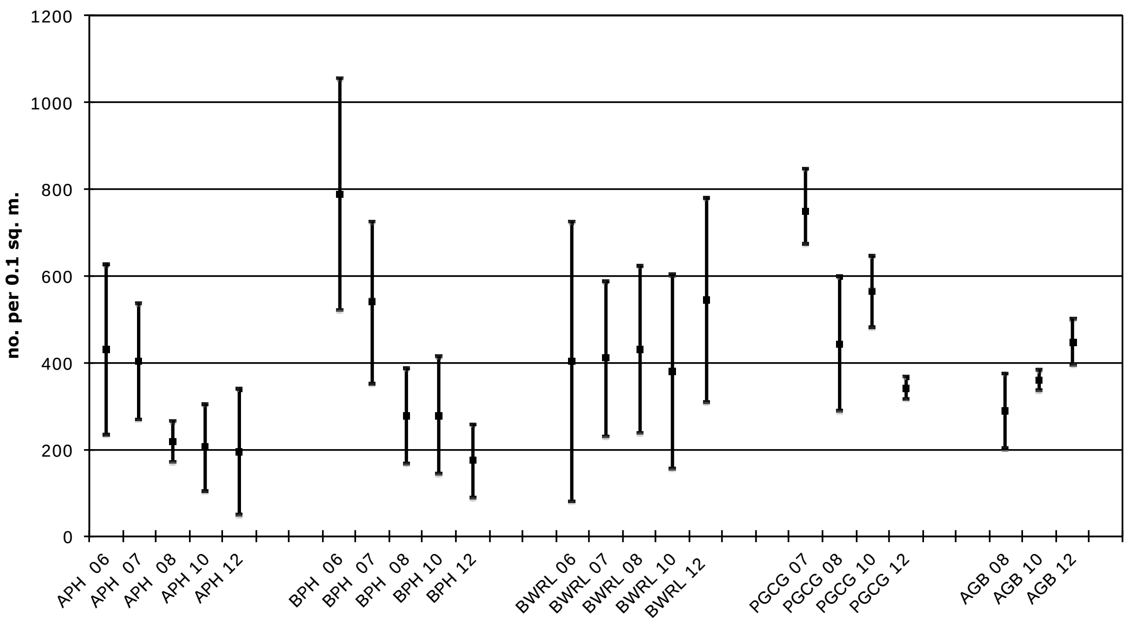
Figure 2. Mean percentage (+ - 1 SD) of EPT in Hess samples from 5 sites on West Rosebud Creek during October, 2006 - 2012.



<u>Community Density</u>

Macroinvertebrate abundance was low in West Rosebud Creek. Mean community density was generally similar among sites and ranged from approximately 200 to 800 organisms per 0.1 m^2 Hess sample (Figure 3). Community density has declined below the Powerhouse over the monitoring period.

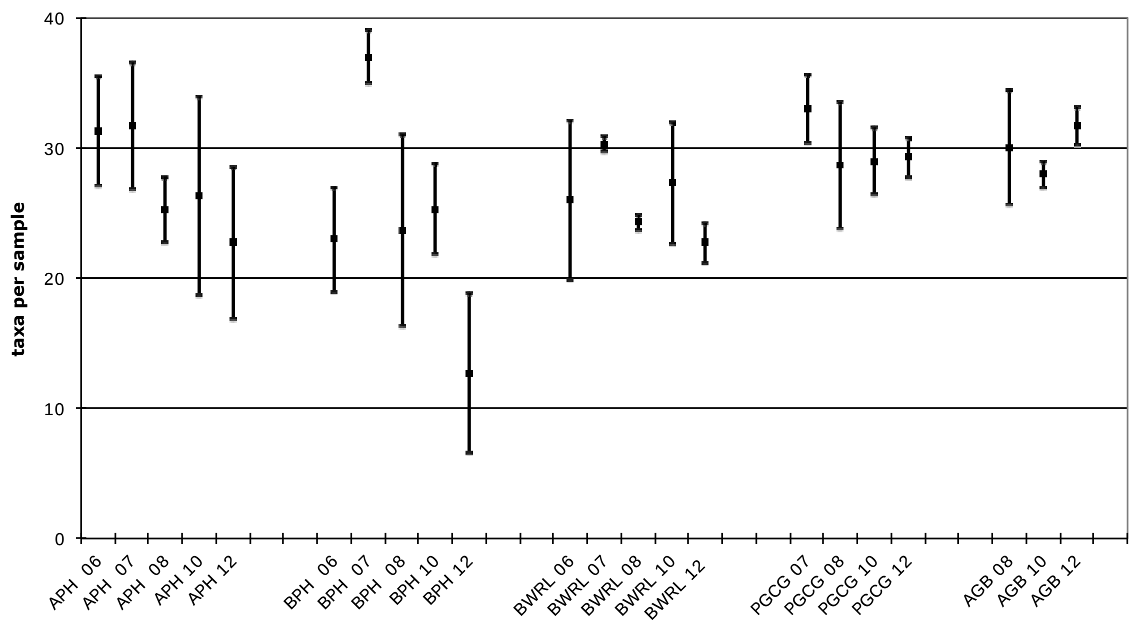
Figure 3. Mean number of macroinvertebrates (+ or - 1SD) per Hess sample at 5 sites on West Rosebud Creek during October, 2006 - 2012.



Taxa Richness

The number of taxa collected per sample is a basic measure of biological integrity that is sensitive to most environmental stresses. Hess samples from healthy mountain streams typically contain 30 or more taxa. The study area mean over the past 7 years was 27 taxa per Hess sample (Figure 4). Mean values have generally indicated stress in stream reaches above the Powerhouse, below the Powerhouse, and below West West Rosebud Lake.

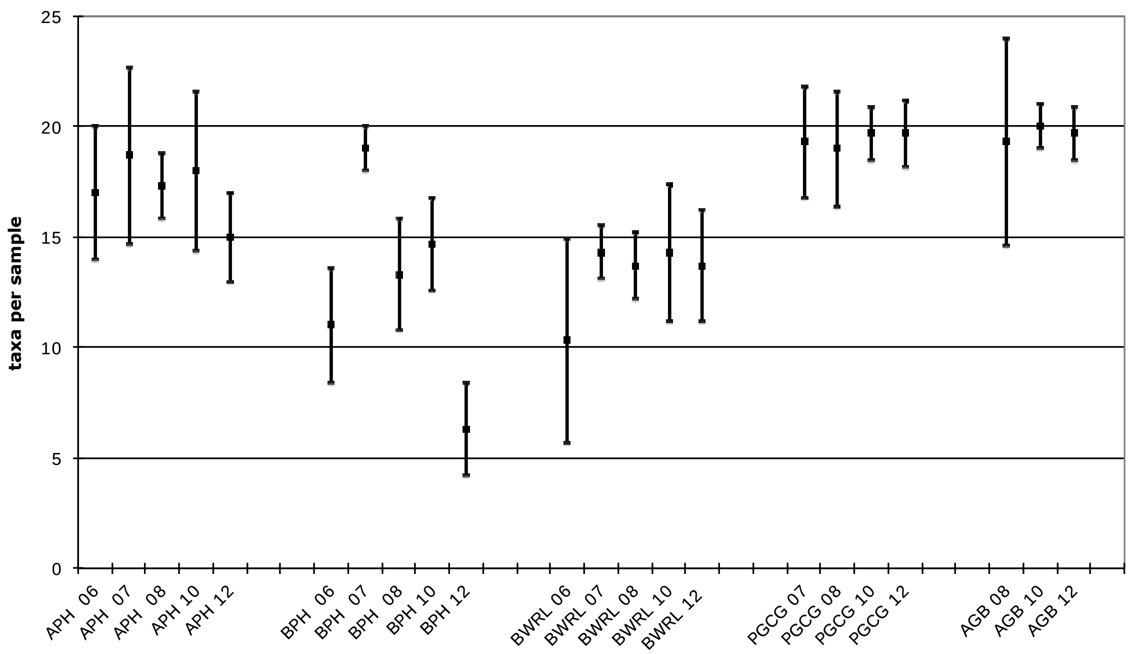
Figure 4. Mean taxa richness (+ or - 1 SD) of macroinvertebrates in Hess samples from 5 sites on West Rosebud Creek during October, 2006 -2012.



EPT Richness

The mean number of mayfly, stonefly and caddisfly taxa per sample ranged from 6 to 20 over the five sampling periods (Figure 5). EPT richness tended to be lowest below the Powerhouse and West Rosebud Lake. Significant environmental stress was indicated below the Powerhouse in 2012.

Figure 5. Mean EPT richness (+ or - 1 SD) per Hess sample at 5 sites on West Rosebud Creek during August, 2006 - 2012.

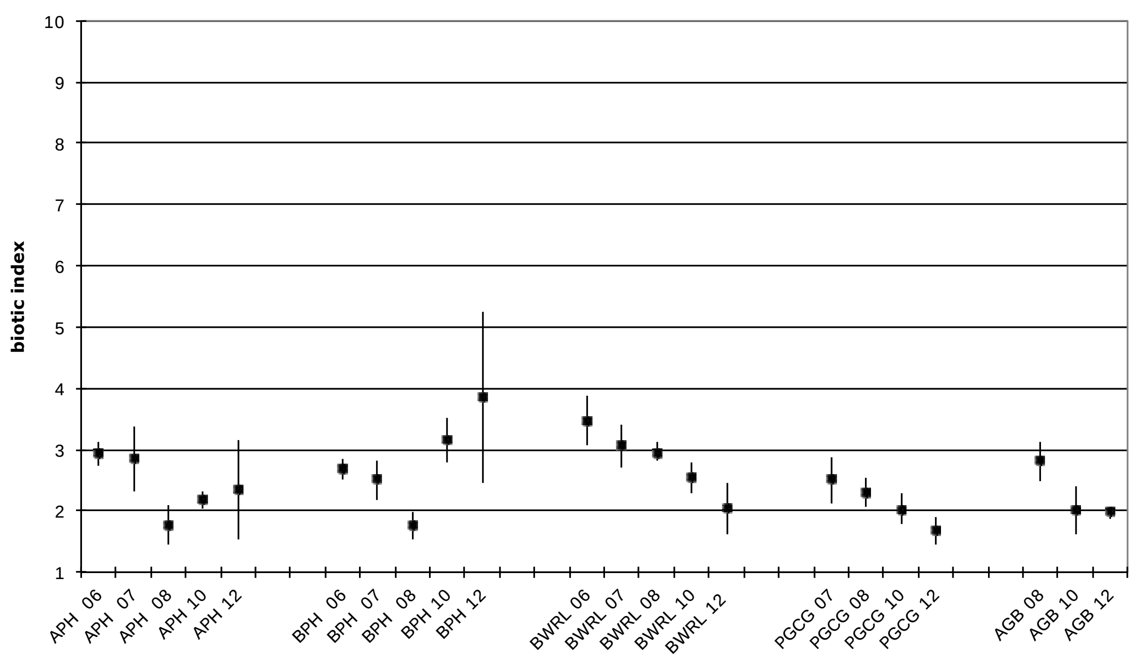


Biotic Index

The biotic index was developed as a measure of organic pollution (Hilsenhoff 1987). The Montana version of this index (Bukantis 1997) is an excellent indicator of a streams trophic status and also tends to be correlated with water temperature, substrate embeddedness, and the percentage of fine sediments (Bolman 1998). On a scale of 0 to 10, with higher values indicating increasingly eutrophic conditions, healthy mountain streams in Montana typically have biotic index values of 4 or less (McGuire 1993).

Biotic index values indicated excellent water quality throughout WRC (Figure 6). The study area mean was 2.5. Annual site estimates ranged from 1.7 to 3.9. Values were slightly elevated below the Powerhouse in 2012. Biotic index values have trended lower in the three downstream reaches since monitoring began.

Figure 6. Mean biotic index values (+-1SD) for 5 sites on West Rosebud Creek during October, 2006 - 2012.



CONCLUSIONS

West Rosebud Creek supported a sparse but generally healthy assemblage of aquatic macroinvertebrates. Benthic assemblages were typical of a soft-water mountain streams. However, the macroinvertebrate assemblage below the Powerhouse clearly indicated increased environmental stresses during 2012. This reach supported a simple macroinvertebrate assemblage dominated by one genus of chironomidae. Community density, composition, and taxa richness were reduced, while the biotic index was elevated, compared to other stations and dates. Cobble habitat is limited in this reach and may have been negatively affected by high stream flows in 2011. Moreover, extensive growths of the filamentous diatom, *Didymosphenia*, further reduced benthic habitat heterogeniety in this reach. While *Didymosphenia* is generally present throughout the study area, the most extensive growths during 2012 were in the stream reach below the Powerhouse. There were few indications of environmental stress at other sites.

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AQUATIC MACROINVERTEBRATE SURVEY RESULTS
WEST ROSEBUD CREEK, MONTANA, OCTOBER, 2015

prepared for
Northwestern Energy
Butte, MT

prepared by
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August , 2016

INTRODUCTION

Northwestern Energy owns and operates the Mystic Lake hydroelectric facility on West Rosebud Creek, Stillwater County, Montana. Aquatic macroinvertebrate surveys of West Rosebud Creek (WRC) have been conducted since 2004. The pilot study (August 2004) included seven sites (McGuire 2005). Since 2006, sampling has occurred in October. This report incorporates data from October 2015 into the database. Previous monitoring reports are included in the literature cited.

STUDY AREA

Current WRC monitoring sites, from upstream to downstream:

Above Powerhouse	APH
Below Powerhouse	BPH
Below West Rosebud Lake	BWRL
Pine Grove Campground	PGCG
Allen Grade Bridge	AGB

METHODS

Three Hess samples (0.1 m^2, 390 micron mesh) are generally collected from each site. Samples tend to be widely spaced, especially at the upper site, where suitable substrates are limited.

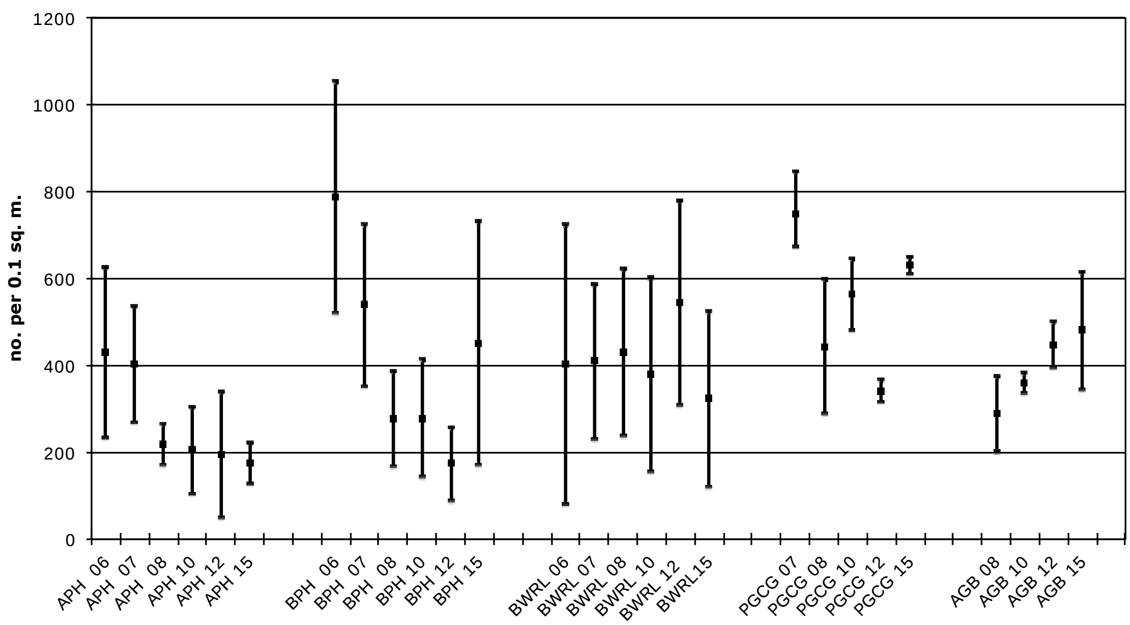
RESULTS

Appendix A (separate file) contains the complete data set for the macroinvertebrate monitoring program (2004 through 2015). Raw data (identifications and enumerations) as well as metric values and summary statistics are included in this file.

Community Density

Macroinvertebrate abundance was low in West Rosebud Creek. Mean community density was generally similar among sites and ranged from approximately 200 to 800 organisms per 0.1 m^2 Hess sample (Figure 1). Community densities tended to be higher at most sites during drought (2000-2007) than during years with higher stream flow.

Figure 1. Mean number of macroinvertebrates (+ or - 1SD) per Hess sample at 5 sites on West Rosebud Creek during October, 2006 - 2015.



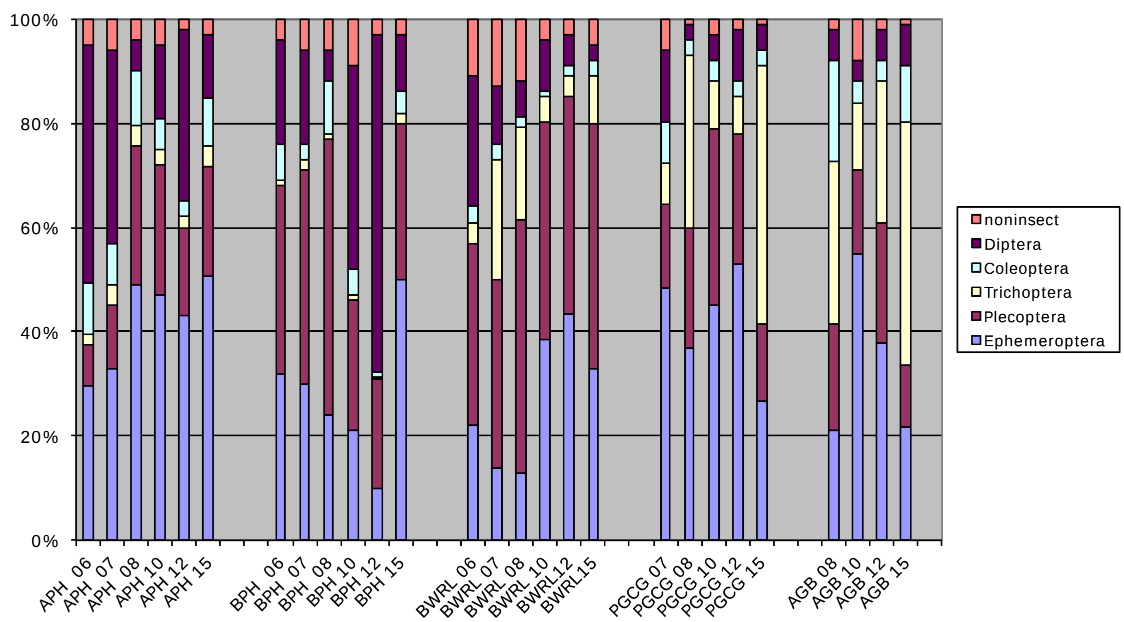
Community Composition

West Rosebud Creek supports a diverse macroinvertebrate fauna that is typical of mountain streams in the region. The 2015 samples contained 60 taxa, including 35 EPT taxa area. Since 2004, 123 taxa have been identified from the stream (Appendix B). Insects accounted for 109 taxa while 14 noninsect taxa were identified. Dipterans were the most diverse group with 48 taxa, including 35 genera of midges. Mayflies, stoneflies, and caddisflies were each represented by 16 to 20 species. Noninsect taxa included segmented worms, leeches, flatworms, crustaceans, fingernail clams and freshwater sponge.

Changes in species composition among sites reflected the longitudinal gradient within the study area and localized influences of West Rosebud and Emerald Lakes. A few dipterans, caddisflies and stoneflies typically found in small mountain streams were confined to the upper reach (Mystic Dam to Powerhouse) while several taxa more characteristic of larger streams were limited to the lower reach. . Hydropsyche cockerelli, a caddisfly common in lower elevation streams, was collected for the first time in 2015 at the lower monitoring site (AGB). Most noninsect taxa were confined to reaches below West Rosebud Lake.

Mayflies, stoneflies, caddisflies, and midges were the most numerous macroinvertebrates in October samples (Figure 2). Early instar (recently hatched) mayflies, primarily *Baetis*, *Cingymula*, *Ephemerella* and *Paraleptophlebia*, were abundant in each reach. Stoneflies were typically numerically dominant in stream reaches below the powerhouse and West Rosebud Lake. These were primarily early instar chloroperlids and nemourids. However, chironomids dominated the fauna below the Powerhouse in 2012. Caddisflies were more numerous abundant at sites downstream from West Rosebud Lake and were the most abundant macroinvertebrates at the two lower sites (PGCG and AGB) in 2015.

Figure 2. Relative abundance (%) of major macroinvertebrate groups at 5 sites on West Rosebud Creek during October, 2006 - 2015.

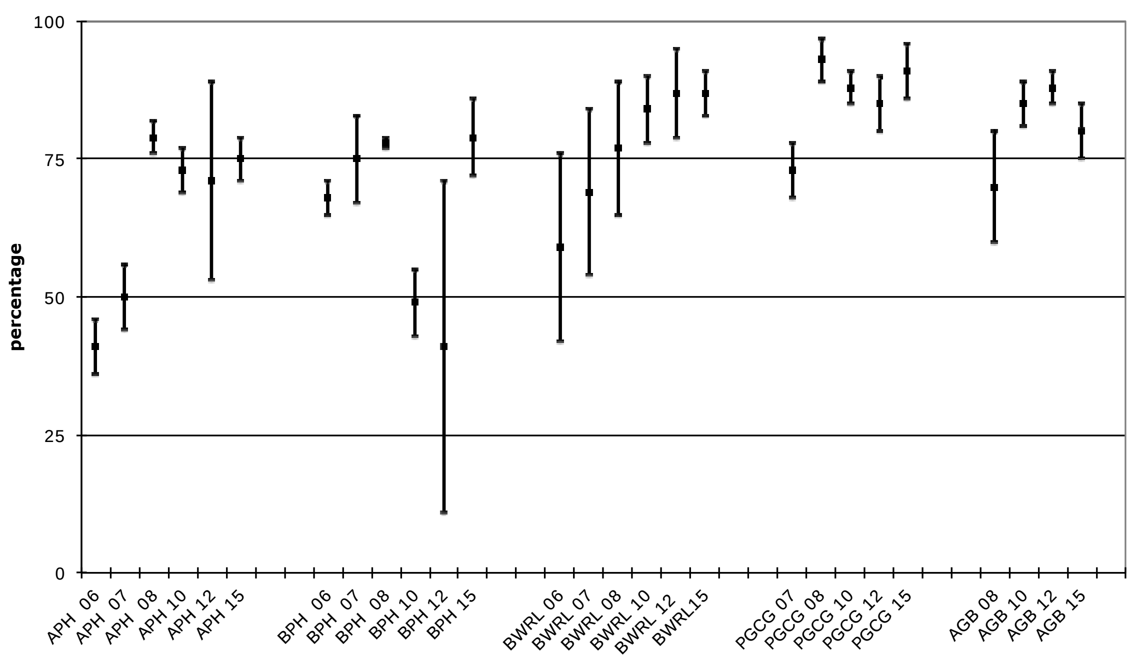


Percent EPT

Mayflies, stoneflies, and caddisflies (Ephemeroptera, Plecoptera, and Trichoptera, respectively) typically dominate macroinvertebrate faunas in mountain streams. The combined relative abundance of these 3 groups (percent EPT) is a standard metric of water and habitat quality (Bukantus 1997). Environmental stress may be indicated when EPT comprise less than about 50% of the fauna.

Mean EPT relative abundance ranged from 41% to 95% among WRC sites (Figure 3). Most values were indicative of healthy stream environments. However, relatively low values above the Powerhouse (2006 and 2007) and below the Powerhouse (2010 and 2012) were consistent with slight environmental stress.

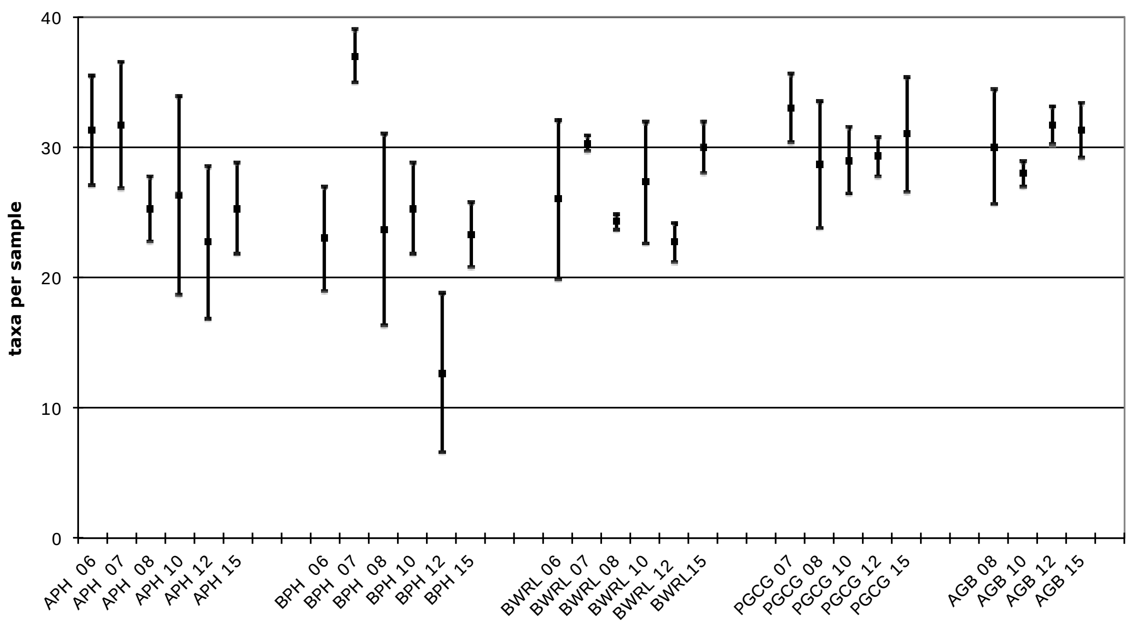
Figure 2. Mean percentage (+ - 1 SD) of EPT in Hess samples from 5 sites on West Rosebud Creek during October, 2006 - 2015.



Taxa Richness

The number of taxa collected per sample is a basic measure of biological integrity that is sensitive to most environmental stresses. Hess samples from healthy mountain streams typically contain 30 or more taxa. The study area mean over the past 10 years was 27 taxa per Hess sample (Figure 4). Mean values have usually indicated stress in stream reaches above the Powerhouse, below the Powerhouse, and below West Rosebud Lake.

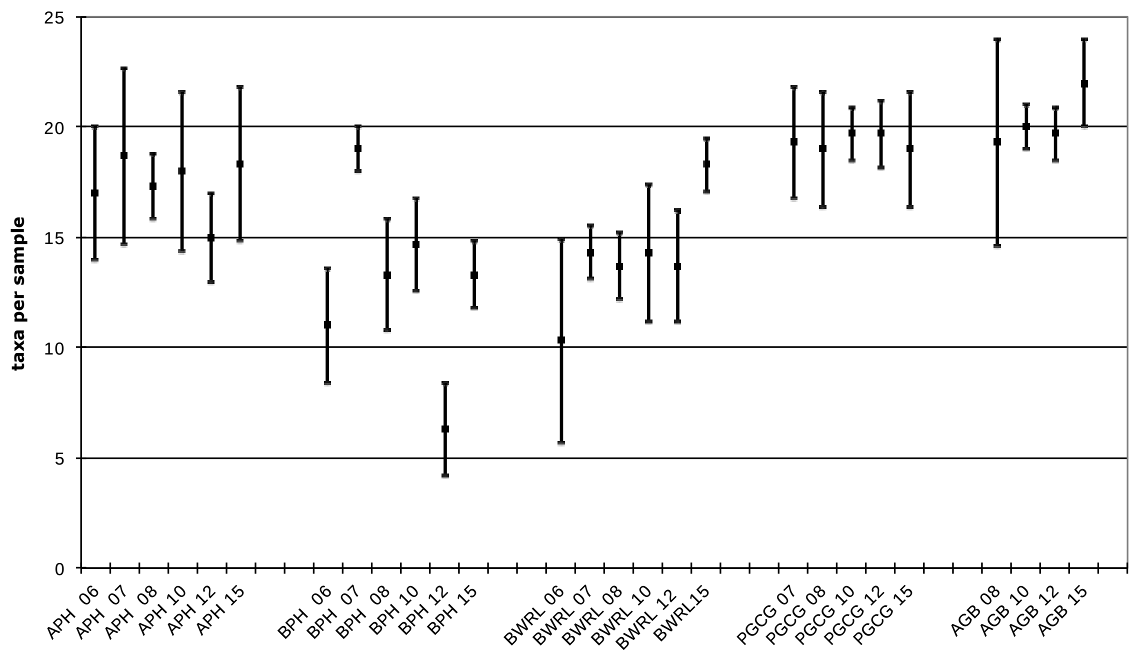
Figure 4. Mean taxa richness (+ or - 1 SD) of macroinvertebrates in Hess samples from 5 sites on West Rosebud Creek during October, 2006 -2015.



<u>EPT Richness</u>

The mean number of mayfly, stonefly and caddisfly taxa per sample ranged from 6 to 20 over the six sampling periods (Figure 5). EPT richness tended to be lowest below the Powerhouse and West Rosebud Lake. Significant environmental stress was indicated below the Powerhouse in 2012.

Figure 5. Mean EPT richness (+ or - 1 SD) per Hess sample at 5 sites on West Rosebud Creek during August, 2006 - 2015.

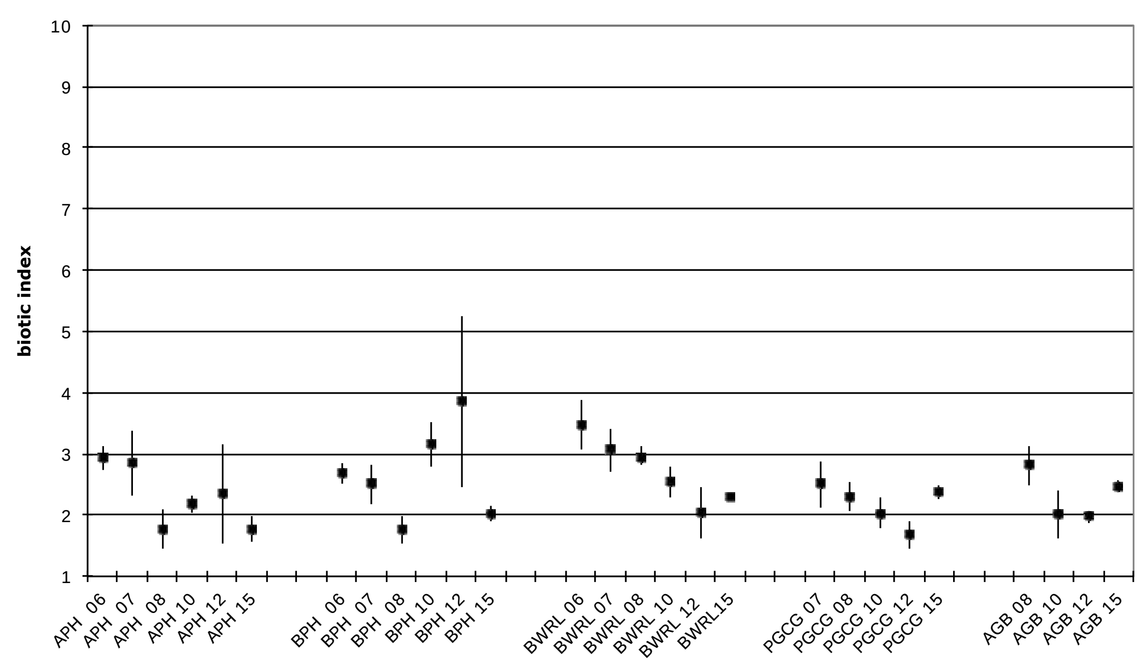


Biotic Index

The biotic index was developed as a measure of organic pollution (Hilsenhoff 1987). The Montana version of this index (Bukantis 1997) is an excellent indicator of a streams trophic status and also tends to be correlated with water temperature, substrate embeddedness, and the percentage of fine sediments (Bolman 1998). On a scale of 0 to 10, with higher values indicating increasingly eutrophic conditions, healthy mountain streams in Montana typically have biotic index values of 4 or less (McGuire 1993).

Biotic index values indicated excellent water quality throughout WRC (Figure 6). The study area mean was 2.5. Annual site estimates ranged from 1.7 to 3.9. Values were slightly elevated below the Powerhouse in 2012.

Figure 6. Mean biotic index values (+-1SD) for 5 sites on West Rosebud Creek during October, 2006 - 2015.



CONCLUSIONS

Macroinvertebrate assemblages were characteristic of good environmental conditions in all stream reaches during 2015. Mayflies, stoneflies and caddisflies dominated the benthic community. Changes in species composition among sites reflected the longitudinal gradient within the study area and localized influences of West Rosebud and Emerald Lakes. Metric values indicated improved biological integrity compared to 2012. Relatively sparse growths of *Didymosphenia* were present at all sites during 2015.

West Rosebud Creek supported a sparse but generally healthy assemblage of aquatic macroinvertebrates. Benthic assemblages were typical of a soft-water mountain streams. However, the macroinvertebrate assemblage below the Powerhouse clearly indicated increased environmental stresses during 2012. This reach supported a simple macroinvertebrate assemblage dominated by one genus of Chironomidae. Community density, composition, and taxa richness were reduced, while the biotic index was elevated compared to other stations and dates. Cobble habitat is limited in this reach and may have been negatively affected by high stream flows in 2011. Moreover, extensive growths of the filamentous diatom, *Didymosphenia,* further reduced benthic habitat heterogeneity in this reach. While *Didymosphenia* is generally present throughout the study area, more extensive growths were evident during 2012, especially below the Powerhouse.

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Appendix A – 2015 Results

AQUATIC MACROINVERTEBRATE DATA

Northweste Stillwater County, MT

West Rosel above Powerhouse Powerhouse

6-Oct-15 HESS SAMPLES 0.1 M2

ple (0.1m2):	1	2	3	MEAN	ST. DEV.	TOT #	%RA
Taxon							
COLEOPTERA				16		49	9%
Heterlimnius	18	14	17	16.3	2.1	49	9.2%
DIPTERA				21		63	12%
Pagastia sp.	2	1	3	2.0	1.0	6	1.1%
Eukiefferiell	0	1	7	2.7	3.8	8	1.5%
Orthocladius	13	12	17	14.0	2.6	42	7.9%
Synorthocla	1	1	0	0.7	0.6	2	0.4%
Micropsectr	0	3	1	1.3	1.5	4	0.8%
Ceratopogo	1	0	0	0.3	0.6	1	0.2%
EPHEMEROPTERA				89		268	50%
Acentrella ir	1	0	0	0.3	0.6	1	0.2%
Baetis bicau	1	7	9	5.7	4.2	17	3.2%
Baetis tricau	6	6	15	9.0	5.2	27	5.1%
Caudatella h	0	9	37	15.3	19.3	46	8.7%
Drunella doc	0	12	9	7.0	6.2	21	4.0%
Drunella gra	8	2	3	4.3	3.2	13	2.4%
Ephemerella	21	6	17	14.7	7.8	44	8.3%
Cinygmula s	11	9	13	11.0	2.0	33	6.2%
Epeorus spp	0	4	5	3.0	2.6	9	1.7%
Rhithrogena	4	8	10	7.3	3.1	22	4.1%
Paraleptoph	6	9	10	8.3	2.1	25	4.7%
Ameletus sp	5	3	2	3.3	1.5	10	1.9%
PLECOPTERA				38		113	21%
Leuctridae	0	2	3	1.7	1.5	5	0.9%
Zapada cinc	3	2	7	4.0	2.6	12	2.3%
Chloroperlin	23	24	13	20.0	6.1	60	11.3%
Doroneuria	3	19	10	10.7	8.0	32	6.0%
Hesperoper	1	1	2	1.3	0.6	4	0.8%
TRICHOPTERA				7		22	4%
Arctopsyche	0	0	2	0.7	1.2	2	0.4%
Ecclisomyia	1	0	0	0.3	0.6	1	0.2%
Brachycentr	0	0	1	0.3	0.6	1	0.2%
Glossosoma	0	0	1	0.3	0.6	1	0.2%

Rhyacophila	1	5	8		4.7	3.5	14	2.6%
Rhyacophila	0	1	1		0.7	0.6	2	0.4%
Rhyacophila	0	0	1		0.3	0.6	1	0.2%
ANNELIDA					5		15	3%
Enchytraeid	3	4	7		4.7	2.1	14	2.6%
Megadrilli	1	0	0		0.3	0.6	1	0.2%
OTHER					0		1	0%
Polycelis sp	0	0	1		0.3	0.6	1	0.2%
IDs by D. McGuire								
TOTAL ORG	134	165	232		177	50.1	531	
TAXA RICH	22	25	29		25.3	3.5	34	
EPT RICHN	15	18	22		18.3	3.5	24	
BIOTIC IND	1.96	1.54	1.78		1.76	0.21	1.75	
% DOMINAI	17%	15%	16%		16%	1%		
% COLLECT	54%	41%	58%		51%	9%	52%	
% SCRAPE	18%	28%	25%		24%	5%	24%	
%EPT	71%	78%	77%		75%	4%	76%	
SHANNON	3.72	4.13	4.29		4.05	0.29	4.32	
EPT/(EPT +	0.86	0.88	0.86		0.87	0.01	0.90	
% COLLECT	54%	41%	57%		51%	9%	51%	
% SHREDD	2%	2%	4%		3%	1%	3%	
% SCRAPE	16%	25%	21%		21%	5%	21%	
% FILTERE	0%	0%	1%		0%	1%	1%	
% PREDAT	28%	32%	17%		25%	8%	24%	
% CHIRONO	12%	11%	12%		12%	1%	12%	
% TANYTAI	0%	2%	0%		1%	1%	1%	
Baetidae/EF	13%	17%	18%		16%	3%	17%	
METALS TO	2.31	1.90	2.12		2.11	0.21	2.10	

notes: Chloroperlinae mostly early instar- both Sweltsa and Suwallia present.

notes:Didymo visual estimate: scale: 0 not evident, 5 extensive clumps >50 coverage on cobbles

Didymo	1	1	2

AQUATIC MACROINVERTEBRATE DATA

Northweste Stillwater County, MT

West Rosel below Powerhouse

6-Oct-15 HESS SAMPLES 0.1 M2

ple (0.1m2):	1	2	3	MEAN	ST. DEV.	TOT #	%RA
Taxon							
COLEOPTERA				19		58	4%
Heterlimnius	27	10	21	19.3	8.6	58	4.3%
DIPTERA				48		145	11%
Thienemanr	0	2	1	1.0	1.0	3	0.2%
Diamesa sp	0	2	2	1.3	1.2	4	0.3%
Pagastia sp.	0	3	0	1.0	1.7	3	0.2%
Eukiefferiell	0	1	1	0.7	0.6	2	0.1%
Orthocladius	16	59	14	29.7	25.4	89	6.6%
Synorthocla	5	8	4	5.7	2.1	17	1.3%
Tvetenia sp.	1	1	0	0.7	0.6	2	0.1%
Antocha sp.	0	6	8	4.7	4.2	14	1.0%
Dicranota sp	0	0	1	0.3	0.6	1	0.1%
Hexatoma s	2	7	1	3.3	3.2	10	0.7%
EPHEMEROPTERA				227		682	50%
Baetis bicau	1	0	0	0.3	0.6	1	0.1%
Baetis tricau	1	3	2	2.0	1.0	6	0.4%
Caudatella h	2	0	8	3.3	4.2	10	0.7%
Drunella gra	0	20	0	6.7	11.5	20	1.5%
Ephemerella	45	485	75	201.7	245.8	605	44.7%
Cinygmula s	2	0	0	0.7	1.2	2	0.1%
Epeorus lon	0	3	7	3.3	3.5	10	0.7%
Rhithrogena	2	0	3	1.7	1.5	5	0.4%
Paraleptoph	8	8	7	7.7	0.6	23	1.7%
PLECOPTERA				134		402	30%
Leuctridae	0	1	1	0.7	0.6	2	0.1%
Zapada cinc	23	15	70	36.0	29.7	108	8.0%
Chloroperlin	61	105	79	81.7	22.1	245	18.1%
Skwala sp.	0	2	0	0.7	1.2	2	0.1%
Doroneuria .	0	0	1	0.3	0.6	1	0.1%
Hesperoper	13	6	25	14.7	9.6	44	3.3%
TRICHOPTERA				7		20	1%
Brachycentr	1	0	1	0.7	0.6	2	0.1%
Lepidostom	1	4	0	1.7	2.1	5	0.4%

Rhyacophila	0	0	5	1.7	2.9	5	0.4%
Rhyacophila	0	3	3	2.0	1.7	6	0.4%
Rhyacophila	0	0	1	0.3	0.6	1	0.1%
Rhyacophila	1	0	0	0.3	0.6	1	0.1%
ANNELIDA				0		1	0%
Enchytraeid	1	0	0	0.3	0.6	1	0.1%
OTHER				15		45	3%
Polycelis sp	11	11	21	14.3	5.8	43	3.2%
Pisidium sp.	1	0	1	0.7	0.6	2	0.1%
IDs by D. McGuire							
TOTAL ORG	225	765	363	451	280.5	1353	
TAXA RICH	21	23	26	23.3	2.5	35	
EPT RICHN	13	12	15	13.3	1.5	21	
BIOTIC IND	2.11	1.87	2.08	2.02	0.13	1.97	
% DOMINAN	27%	63%	22%	37%	23%		
% COLLECT	45%	76%	38%	53%	20%	60%	
% SCRAPE	16%	4%	24%	15%	10%	11%	
%EPT	72%	86%	79%	79%	7%	82%	
SHANNON	3.21	2.09	3.36	2.89	0.69	2.89	
EPT/(EPT +	0.88	0.90	0.93	0.90	0.03	0.93	
% COLLECT	44%	76%	37%	52%	20%	60%	
% SHREDD	11%	3%	20%	11%	8%	8%	
% SCRAPE	5%	1%	5%	4%	2%	3%	
% FILTERE	1%	0%	1%	0%	0%	0%	
% PREDAT	39%	20%	38%	33%	11%	28%	
% CHIRONO	10%	10%	6%	9%	2%	9%	
% TANYTAR	0%	0%	0%	0%	0%	0%	
Baetidae/EP	3%	1%	2%	2%	1%	1%	
METALS TO	2.47	2.28	2.48	2.41	0.11	2.37	

notes: Chloroperlinae mostly early instar- both Sweltsa and Suwallia present.

notes:Didymo visual estimate: scale: 0 not evident, 5 extensive clumps >50 coverage on cobbles

Didymo	2	3	4

AQUATIC MACROINVERTEBRATE DATA

Northweste Stillwater County, MT

West Rosel below West Rosebud Lake

6-Oct-15 HESS SAMPLES 0.1 M2

ple (0.1m2):	1	2	3	MEAN	ST. DEV.	TOT #	%RA
Taxon							
COLEOPTERA				8		25	3%
Heterlimnius	6	8	5	6.3	1.5	19	2.0%
Optioservus	4	1	0	1.7	2.1	5	0.5%
Zaitzevia sp	0	1	0	0.3	0.6	1	0.1%
DIPTERA				10		31	3%
Thienemanr	1	2	0	1.0	1.0	3	0.3%
Pagastia sp.	3	3	5	3.7	1.2	11	1.1%
Eukiefferiell	1	0	2	1.0	1.0	3	0.3%
Orthocladius	3	0	0	1.0	1.7	3	0.3%
Nanocladius	0	3	1	1.3	1.5	4	0.4%
Rheocricoto	0	0	1	0.3	0.6	1	0.1%
Antocha sp.	1	2	2	1.7	0.6	5	0.5%
Simulium sp	0	1	0	0.3	0.6	1	0.1%
EPHEMEROPTERA				108		323	33%
Baetis bicau	0	0	2	0.7	1.2	2	0.2%
Baetis tricau	12	34	5	17.0	15.1	51	5.3%
Caudatella h	0	4	15	6.3	7.8	19	2.0%
Drunella doo	4	4	0	2.7	2.3	8	0.8%
Drunella gra	1	0	0	0.3	0.6	1	0.1%
Ephemerella	19	12	9	13.3	5.1	40	4.1%
Cinygmula s	5	12	7	8.0	3.6	24	2.5%
Epeorus gra	0	0	1	0.3	0.6	1	0.1%
Epeorus lon	1	5	4	3.3	2.1	10	1.0%
Rhithrogena	2	1	1	1.3	0.6	4	0.4%
Paraleptoph	37	110	15	54.0	49.7	162	16.7%
Ameletus sp	1	0	0	0.3	0.6	1	0.1%
PLECOPTERA				151		454	47%
Zapada cinc	46	257	85	129	112.3	388	40.0%
Chloroperlin	10	17	9	12.0	4.4	36	3.7%
Skwala sp.	0	2	1	1.0	1.0	3	0.3%
Hesperoper	4	15	8	9.0	5.6	27	2.8%
TRICHOPTERA				29		86	9%
Arctopsyche	0	16	11	9.0	8.2	27	2.8%

Hydropsych	7	4	1		4.0	3.0	12	1.2%
Dolophilode	3	11	5		6.3	4.2	19	2.0%
Agraylea sp	1	0	1		0.7	0.6	2	0.2%
Lepidostoma	3	4	0		2.3	2.1	7	0.7%
Rhyacophila	0	2	6		2.7	3.1	8	0.8%
Rhyacophila	2	2	6		3.3	2.3	10	1.0%
Rhyacophila	0	1	0		0.3	0.6	1	0.1%
ANNELIDA					6		18	2%
Enchytraeid	2	2	5		3.0	1.7	9	0.9%
Megadrilli	0	6	2		2.7	3.1	8	0.8%
Nais sp.	0	0	1		0.3	0.6	1	0.1%
OTHER					11		33	3%
Polycelis sp	1	12	7		6.7	5.5	20	2.1%
Pisidium sp.	4	2	4		3.3	1.2	10	1.0%
Caecidotea	0	1	0		0.3	0.6	1	0.1%
Physella sp	2	0	0		0.7	1.2	2	0.2%

IDs by D. McGuire

TOTAL ORG	186	557	227		323	203.4	970
TAXA RICH	28	32	30		30.0	2.0	42
EPT RICHN	17	19	19		18.3	1.2	24
BIOTIC IND	2.29	2.33	2.24		2.29	0.04	2.30
% DOMINAI	25%	46%	37%		36%	11%	
% COLLECT	35%	20%	33%		30%	8%	26%
% SCRAPE	54%	71%	50%		58%	11%	63%
%EPT	85%	92%	85%		87%	4%	89%
SHANNON	3.72	2.94	3.71		3.46	0.45	3.45
EPT/(EPT +	0.95	0.98	0.96		0.96	0.02	0.98
% COLLECT	28%	14%	24%		22%	7%	19%
% SHREDD	26%	47%	37%		37%	10%	41%
% SCRAPE	28%	24%	13%		21%	8%	22%
% FILTERE	8%	6%	9%		8%	2%	7%
% PREDAT	10%	10%	16%		12%	4%	11%
% CHIRONO	4%	1%	4%		3%	2%	3%
% TANYTAI	0%	0%	0%		0%	0%	0%
Baetidae/EF	15%	19%	12%		15%	3%	16%
METALS TO	2.60	2.51	2.48		2.53	0.06	2.52

notes: Chloroperlinae mostly early instar- both Sweltsa and Suwallia present.

notes:Didymo visual estimate: scale: 0 not evident, 5 extensive clumps >50 coverage on cobbles

Didymo	0	0	1

AQUATIC MACROINVERTEBRATE DATA

Northweste Stillwater County, MT

West Rosel Pine Grove Campground

6-Oct-15 HESS SAMPLES 0.1 M2

ple (0.1m2):	1	2	3	MEAN	ST. DEV.	TOT #	%RA
Taxon							
COLEOPTERA				18		53	3%
Heterlimnius	8	2	2	4.0	3.5	12	0.6%
Narpus conc	1	0	0	0.3	0.6	1	0.1%
Optioservus	11	14	15	13.3	2.1	40	2.1%
DIPTERA				30		89	5%
Thienemanr	0	2	1	1.0	1.0	3	0.2%
Diamesa sp	0	1	0	0.3	0.6	1	0.1%
Pagastia sp.	0	1	2	1.0	1.0	3	0.2%
Eukiefferiell	1	7	2	3.3	3.2	10	0.5%
Orthocladius	1	42	14	19.0	21.0	57	3.0%
Rheocricoto	0	0	1	0.3	0.6	1	0.1%
Tvetenia sp.	0	1	0	0.3	0.6	1	0.1%
Antocha sp.	1	1	1	1.0	0.0	3	0.2%
Hexatoma s	0	3	4	2.3	2.1	7	0.4%
Ceratopogo	0	1	1	0.7	0.6	2	0.1%
Simulium sp	1	0	0	0.3	0.6	1	0.1%
EPHEMEROPTERA				170		509	27%
Baetis tricau	13	24	3	13.3	10.5	40	2.1%
Caudatella h	5	17	12	11.3	6.0	34	1.8%
Drunella doc	16	19	8	14.3	5.7	43	2.3%
Drunella gra	0	2	1	1.0	1.0	3	0.2%
Ephemerella	23	39	49	37.0	13.1	111	5.9%
Cinygmula s	23	20	18	20.3	2.5	61	3.2%
Epeorus lon	0	1	0	0.3	0.6	1	0.1%
Rhithrogena	30	16	9	18.3	10.7	55	2.9%
Paraleptoph	70	47	44	53.7	14.2	161	8.5%
PLECOPTERA				92		275	15%
Leuctridae	0	1	0	0.3	0.6	1	0.1%
Zapada cinc	48	28	15	30.3	16.6	91	4.8%
Chloroperlin	37	43	75	51.7	20.4	155	8.2%
Skwala sp.	0	0	1	0.3	0.6	1	0.1%
Claassenia	0	0	2	0.7	1.2	2	0.1%
Doroneuria	0	0	1	0.3	0.6	1	0.1%
Hesperoper	7	7	10	8.0	1.7	24	1.3%

TRICHOPTERA				315		944	50%
Arctopsyche	2	14	5	7.0	6.2	21	1.1%
Hydropsych	319	221	328	289.3	59.3	868	45.9%
Dolophilode	5	5	1	3.7	2.3	11	0.6%
Brachycentr	0	4	4	2.7	2.3	8	0.4%
Lepidostoma	2	0	0	0.7	1.2	2	0.1%
Glossosoma	3	5	7	5.0	2.0	15	0.8%
Rhyacophila	3	8	2	4.3	3.2	13	0.7%
Rhyacophila	0	3	3	2.0	1.7	6	0.3%
ANNELIDA				3		10	1%
Enchytraeid	4	4	2	3.3	1.2	10	0.5%
OTHER				4		13	1%
Polycelis sp	4	4	2	3.3	1.2	10	0.5%
Pisidium sp.	1	2	0	1.0	1.0	3	0.2%
IDs by D. McGuire							
TOTAL ORG	639	609	645	631	19.3	1893	
TAXA RICH	26	34	33	31.0	4.4	41	
EPT RICHN	16	20	21	19.0	2.6	24	
BIOTIC IND	2.30	2.51	2.33	2.38	0.11	2.38	
% DOMINAI	50%	36%	51%	46%	8%		
% COLLECT	62%	66%	68%	65%	3%	65%	
% SCRAPE	30%	22%	16%	23%	7%	23%	
%EPT	95%	86%	93%	91%	5%	91%	
SHANNON	2.83	3.62	2.87	3.11	0.44	3.20	
EPT/(EPT +	1.00	0.91	0.97	0.96	0.05	0.97	
% COLLECT	10%	25%	16%	17%	7%	17%	
% SHREDD	8%	5%	2%	5%	3%	5%	
% SCRAPE	22%	18%	13%	18%	4%	18%	
% FILTERE	51%	40%	52%	48%	7%	48%	
% PREDAT	8%	12%	16%	12%	4%	12%	
% CHIRON(	0%	9%	3%	4%	4%	4%	
% TANYTAI	0%	0%	0%	0%	0%	0%	
Baetidae/EF	7%	13%	2%	7%	5%	8%	
METALS TC	3.97	3.76	4.11	3.95	0.17	3.95	

notes: Chloroperlinae mostly early instar- both Sweltsa and Suwallia present.

notes:Didymo visual estimate: scale: 0 not evident, 5 extensive clumps >50 coverage on cobbles

Didymo	1	1	1

AQUATIC MACROINVERTEBRATE DATA

Northweste Stillwater County, MT

West Rosel Allen Grade Bridge

6-Oct-15 HESS SAMPLES 0.1 M2

ple (0.1m2):	1	2	3	MEAN	ST. DEV.	TOT #	%RA
Taxon							
COLEOPTERA				52		157	11%
Narpus conc	2	1	1	1.3	0.6	4	0.3%
Optioservus	55	40	58	51.0	9.6	153	10.6%
DIPTERA				37		111	8%
Pagastia sp.	1	3	0	1.3	1.5	4	0.3%
Eukiefferiell	1	1	0	0.7	0.6	2	0.1%
Orthocladius	9	15	29	17.7	10.3	53	3.7%
Rheocricoto	0	1	0	0.3	0.6	1	0.1%
Tvetenia sp.	5	2	2	3.0	1.7	9	0.6%
Micropsectr	4	0	0	1.3	2.3	4	0.3%
Antocha sp.	4	3	4	3.7	0.6	11	0.8%
Hexatoma s	9	13	4	8.7	4.5	26	1.8%
Ceratopogo	0	0	1	0.3	0.6	1	0.1%
EPHEMEROPTERA				106		318	22%
Acentrella ir	0	0	1	0.3	0.6	1	0.1%
Baetis tricau	8	11	7	8.7	2.1	26	1.8%
Caudatella h	0	1	1	0.7	0.6	2	0.1%
Drunella doc	2	8	6	5.3	3.1	16	1.1%
Drunella gra	5	3	13	7.0	5.3	21	1.5%
Ephemerella	12	15	25	17.3	6.8	52	3.6%
Cinygmula s	10	5	7	7.3	2.5	22	1.5%
Rhithrogena	16	29	48	31.0	16.1	93	6.5%
Paraleptoph	30	17	38	28.3	10.6	85	5.9%
PLECOPTERA				58		175	12%
Zapada cinc	6	40	38	28.0	19.1	84	5.8%
Chloroperlin	34	14	17	21.7	10.8	65	4.5%
Isoperla sp.	1	0	1	0.7	0.6	2	0.1%
Claassenia s	6	7	5	6.0	1.0	18	1.3%
Hesperoper	1	3	2	2.0	1.0	6	0.4%
TRICHOPTERA				223		670	47%
Arctopsyche	9	4	11	8.0	3.6	24	1.7%
Hydropsych	71	167	248	162.0	88.6	486	33.8%
Hydropsych	0	1	0	0.3	0.6	1	0.1%

Dolophilode	0	0	2	0.7	1.2	2	0.1%
Brachycentr	22	21	36	26.3	8.4	79	5.5%
Micrasema s	1	1	1	1.0	0.0	3	0.2%
Lepidostoma	4	3	1	2.7	1.5	8	0.6%
Glossosoma	17	19	8	14.7	5.9	44	3.1%
Rhyacophila	3	1	1	1.7	1.2	5	0.3%
Rhyacophila	7	2	7	5.3	2.9	16	1.1%
Rhyacophila	0	1	1	0.7	0.6	2	0.1%
ANNELIDA				1		4	0%
Enchytraeid	0	4	0	1.3	2.3	4	0.3%
OTHER				2		5	0%
Polycelis sp	0	4	1	1.7	2.1	5	0.3%
IDs by D. McGuire							
TOTAL ORG	355	460	625	480	136.1	1440	
TAXA RICH	29	33	32	31.3	2.1	38	
EPT RICHN	20	22	24	22.0	2.0	25	
BIOTIC IND	2.34	2.55	2.52	2.47	0.11	2.49	
% DOMINAI	20%	36%	40%	32%	11%		
% COLLECT	57%	63%	68%	62%	6%	63%	
% SCRAPE	25%	27%	24%	25%	2%	25%	
%EPT	75%	81%	84%	80%	5%	81%	
SHANNON	3.97	3.62	3.35	3.64	0.31	3.69	
EPT/(EPT +	0.93	0.94	0.94	0.94	0.01	0.96	
% COLLECT	28%	21%	20%	23%	4%	22%	
% SHREDD	4%	10%	7%	7%	3%	7%	
% SCRAPE	21%	17%	17%	18%	2%	18%	
% FILTERE	29%	42%	48%	39%	10%	41%	
% PREDAT	19%	10%	8%	13%	5%	12%	
% CHIRONO	6%	5%	5%	5%	0%	5%	
% TANYTAI	1%	0%	0%	0%	1%	0%	
Baetidae/EF	10%	12%	5%	9%	3%	8%	
METALS TC	3.45	4.06	4.10	3.87	0.37	3.93	

notes: Chloroperlinae mostly early instar- both Sweltsa and Suwallia present.

notes:Didymo visual estimate: scale: 0 not evident, 5 extensive clumps >50 coverage on cobbles

Didymo	1	1	3

Appendix B. A checklist of aquatic macroinvertebrates collected from West Rosebud Creek, Stillwater County, Montana during August, 2004 and 2005 and Oct. 2006,2007, 2008, 2010, 2012 and 2015.

Order	Family	genus/species	year:	2004	2005	2006	2007	2008	2010	2012	2015
			# sites/ samples	4 .12	2. 14	3. 9	4. 17	5. 15	5. 15	5. 15	5. 15
DIPTERA (two-winged flies)											
	Athericidae	*Atherix sp.*		x							
	Blephariceridae	*Agathon sp.*		x							
	Ceratopgonidae	Ceratopogoninae		x	x		x		x	x	x
	Chironomidae										
	(Podonominae)	*Boreochlus sp.*		x							
	(Tanypodinae)	*Thienemannimyia gp.*		x	x	x	x	x	x		x
	(Diamesinae)	*Diamesa sp.*			x	x	x		x		x
		Pagastia sp.		x	x	x	x	x	x	x	x
		Potthastia sp.				x	x	x	x	x	
		Pseudodiamesa sp.		x							
	(Prodiamsinae)	*Prodiamesia sp.*		x							
	(Orthocladinae)	*Brillia sp.*		x	x			x	x		
		Corynoneura sp.		x	x						
		Cricotopus spp.		x		x					
		Eukiefferiella spp.		x	x	x	x	x	x	x	x
		Heterotrissocladius sp.				x					
		Hydrobaenus sp.		x		x	x			x	
		Krenosmittia sp.		x			x				
		Lopescladius sp.				x					
		Orthocladius sp.		x	x	x	x	x	x	x	x
		Nanocladius sp.		x					x	x	x
		Parachaetocladius sp.					x				
		Parametriocnemus sp.		x	x	x	x	x			
		Paraphaenocladius sp.			x						
		Rheocricotopus sp.		x	x	x	x	x	x	x	x
		Symposiocladius (Orthocladius)								x	
		Synorthocladius sp.		x		x	x	x	x	x	x
		Thienemanniella sp.					x				
		Tvetenia sp.		x	x	x	x	x	x	x	x
	(Chironomini)	*Microtendipes sp.*		x							
		Paracladopelma sp.		x	x						
		Polypedilum sp.		x	x						
	(Tanytasini)	*Cladotanytarsus sp.*		x	x		x				
		Rheotanytarsus sp.								x	
		Sublettia sp.		x							
		Stempellinella sp.		x						x	
		Krenopsectra sp.		x	x	x	x				
		Micropsectra sp. (poss. early instar Krenopsectra)			x			x	x	x	x
		Tanytarsus sp.		x		x					
	Deuterophlebiidae	*Deuterophlebia sp.*		x	x						
	Empididae	*Chelifera sp.*		x	x	x	x	x		x	

Appendix B. A checklist of aquatic macroinvertebrates collected from West Rosebud Creek, Stillwater County, Montana during August, 2004 and 2005 and Oct. 2006,2007, 2008, 2010, 2012 and 2015.

Order	Family	genus/species	year:	2004	2005	2006	2007	2008	2010	2012	2015
		Clinocera sp.		x	x	x	x		x		
	Tipulidae	*Antocha sp.*		x	x	x	x		x	x	x
		Dicranota sp.		x		x	x	x	x		
		Hexatoma sp.		x	x	x	x	x	x	x	x
		Hesperoconopa sp.		x	x						
		Limnophila sp.		x	x		x				
		Rhabdomastix sp.						x		x	
	Simuliidae	*Simulium sp. (Eusimulium)*		x	x	x	x	x	x	x	x
EPHEMEROPTERA											
	Ameletidae	*Ameletus sp.*		x	x	x	x	x	x	x	x
	Baetidae	*Acentrellainsignificans*		x	x			x		x	x
		Baetis bicaudatus					x	x	x	x	x
		Baetis tricaudatus		x	x	x	x	x	x	x	x
		Diphetor hageni		x	x						
	Ephemerellidae	*Caudatella hystrix*		x			x	x	x	x	x
		Drunella coloradensis		x							
		Drunella doddsi		x	x	x	x	x	x	x	x
		Drunella grandis		x	x	x	x	x	x	x	x
		Drunella spinifera				x					
		Ephemerella sp.		x	x	x	x	x	x	x	x
		Seratella tibialis		x	x	x		x			
	Heptageniidae	*Cinygmula sp.*		x	x	x	x	x	x	x	x
		Epeoris grandis		x	x				x		x
		Epeorus longimanus		x	x	x	x	x	x	x	x
		Rhithrogena sp.		x	x	x	x	x	x	x	x
	Leptophlebiidae	*Paraleptophlebia sp.*		x	x	x	x	x	x	x	x
PLECOPTERA											
	Capniidae			x			x	x	x		
	Leuctridae			x	x	x	x	x	x	x	x
	Nemouridae	*Malenka sp.*		x	x						
		Podmosta sp.		x							
		Visoka cataractae		x		x					
		Zapada oregenensis gp.		x				x			
		Zapada cinctipes		x	x	x	x	x	x	x	x
	Chloroperlidae	Chloroperlinae*		x	x	x	x	x	x	x	x
		*(Swelta spp and Suwallia sp.)									
		Kathroperla sp.		x	x	x	x	x	x	x	
	Perlodidae	*Skwala sp.*		x	x	x	x	x	x	x	x
		Cultus sp.			x		x				
		Isoperla sp.								x	x
		Unident. early instar		x		x	x				
	Perlidae	*Claassenia sabulosa*		x	x		x	x	x	x	x
		Doroneuria theodora		x		x	x	x	x	x	x
		Hesperoperla pacifica		x	x	x	x	x	x	x	x
TRICHOPTERA											
	Hydropsychidae	*Arctopsyche sp.*		x	x	x	x	x	x	x	x
		Hydropsyche (C) oslari		x	x		x	x	x	x	x
		Hydropsyche cockerelli									x
	Philopotamidae	*Dolophilodes sp.*		x	x	x	x		x	x	x

Appendix B. A checklist of aquatic macroinvertebrates collected from West Rosebud Creek, Stillwater County, Montana during August, 2004 and 2005 and Oct. 2006,2007, 2008, 2010, 2012 and 2015.

Order	Family	genus/species	year:	2004	2005	2006	2007	2008	2010	2012	2015
	Limnephilidae	*Apatania sp.*				x					
		Neothremma sp.		x		x			x		
		Ecclisomyia sp.		x					x		x
		Psychoglypha sp.		x			x	x			
	Hydroptilidae	*Agraylea sp.*		x	x	x	x	x	x	x	x
	Brachycentridae	*Brachycentrus americanus*						x	x	x	x
		Brachycentrus occidentalis		x	x	x	x	x			
		Micrasema sp.		x	x	x	x	x	x	x	x
	Lepidostomatidae	*Lepidostoma sp.*		x	x	x	x	x	x	x	x
	Glossosomatidae	*Glossosoma sp.*		x					x	x	x
	Uenoidae	*Neophylax sp.*		x		x	x				
	Rhyacophilidae	*Rhyacophila betteni gp.*		x	x	x	x	x	x	x	
		Rhyacophila brunnea gp.			x	x	x	x	x	x	x
		Rhyacophila hyalinata gp.			x	x	x	x		x	x
		Rhyacophila coloradensis gp.		x		x	x	x	x	x	x
		Rhyacophila sibirica gp.		x					x	x	x
COLEOPTERA (beetles)											
	Dytiscidae	*Stictotarsus sp.*		x	x	x	x	x			
	Elmidae	*Heterlimnius corpulentus*						x	x	x	x
		Lara sp.						x			
		Microcylloepus sp.		x	x		x	x			
		Narpus concolor		x	x	x	x	x	x	x	x
		Optioservus sp.			x	x	x		x	x	x
		Ziatzevia parvula					x		x	x	x
	Haliplidae	*Brychius sp.*									
ANNELIDA											
	Enchytraeidae			x	x	x	x	x	x	x	x
	Megadrilli			x		x		x		x	x
	Naididae	*Nais sp.*		x	x		x		x		x
	Tubificidae	immature wo/capilliform chaetae (prob Limnodrilus)		x	x						
		immature w/capilliform chaetae (prob Rhyacodrilus)		x			x				
	Glossophoniidae	*Helobdella stagnalis*					x				
CRUSTACEA	Isopoda	*Caecidotea sp.*		x		x	x	x			x
	Ostracoda			x		x	x		x		
MOLLUSCA	Physidae	*Physella sp.*					x	x			x
	Planorbidae	*Gyraulus sp.*				x					
	Sphaeriidae	*Pisidium sp.*		x	x	x	x	x			x
TURBELLARIA		*Polycelis sp.*		x	x	x	x	x	x	x	x
HYDRA							x	x	x	x	
PORIFERA				x	x	x			x	x	

AQUATIC MACROINVERTEBRATE SURVEY RESULTS FOR WEST ROSEBUD CREEK, STILLWATER COUNTY, MONTANA

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Prepared for:

NorthWestern Energy
Delivering a Bright Future

Submitted to:

Jordan Tollefson
Hydro Compliance Professional
February 2019

INTRODUCTION

Northwestern Energy, Inc. (NWE) owns and operates the Mystic Lake hydroelectric facility on West Rosebud Creek, Stillwater County, Montana. Aquatic macroinvertebrate surveys of West Rosebud Creek (WRC) have been conducted since 2004. The pilot study (August 2004-2005) included seven sites (McGuire 2005). Since 2008, sampling has occurred consistently at five of these sites in October (see Appendix B). This report incorporates data from October 2018 sampling into the long-term monitoring database. Previous monitoring reports are included in the literature cited.

STUDY AREA

Current WRC macroinvertebrate monitoring sites sampled from the furthest upstream to downstream are:

Above Powerhouse	APH
Below Powerhouse	BPH
Below West Rosebud Lake	BWRL
Pine Grove Campground	PGCG
Allen Grade Bridge	AGB

METHODS

Three replicate Hess samples (0.1 m^2, 390 micron mesh) were collected from each site in riffle habitats <30 cm in depth. Samples tended to be widely spaced, especially at the upper sites, where boulder/bedrock dominates the stream bottom and suitable cobble/gravel substrates are limited. At each sampling point, the Hess sampler was pushed into the stream bottom to form an effective seal and all cobbles (>64 mm) within the sampling frame were scrubbed clean of organisms and removed; then the entire area within the Hess sampler frame was raked (disturbed) until all organic matter and macroinvertebrates were washed into the collection net of the Hess sampler. Macroinvertebrates, organic and inorganic matter were composited into a 40 liter bucket and transferred to 1 liter Nalgene bottles with 95% ETOH for transport to the Helena Laboratory. Samples were processed following protocols used by McGuire (2015).

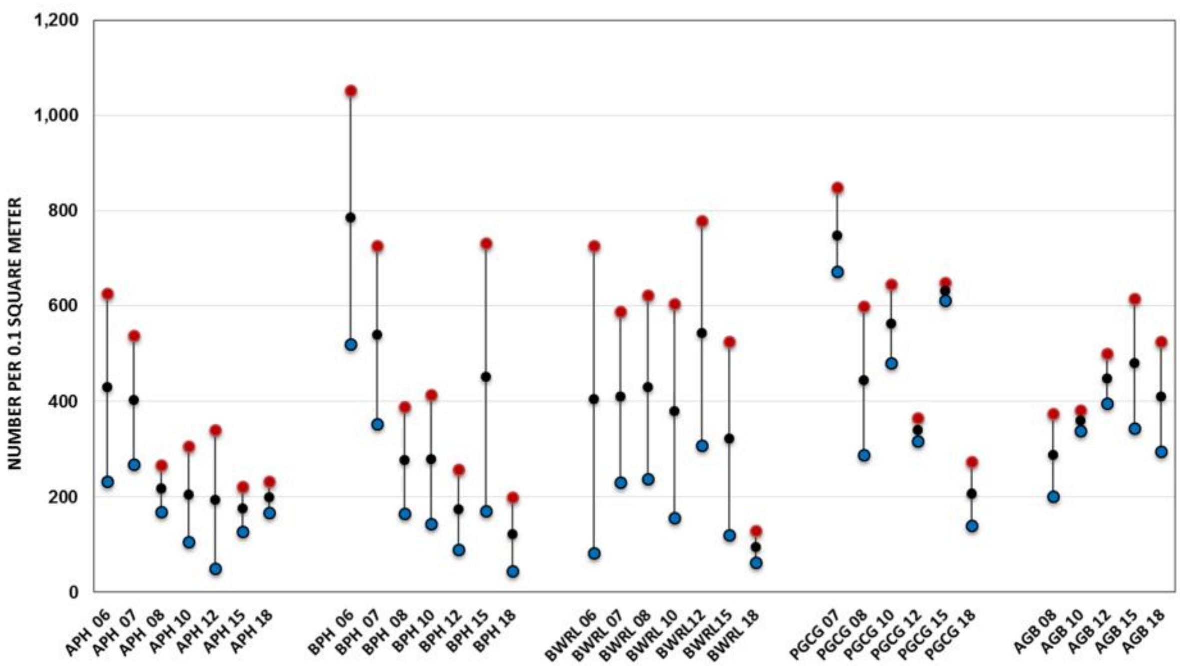
RESULTS

West Rosebud Creek supports a diverse macroinvertebrate fauna that is typical of oligotrophic mountain streams in the region. The 2018 samples contained 74 total taxa, including 37 mayfly, stonefly and caddisfly (EPT) taxa (Appendices **A & B**). Since 2004, 131 taxa have been identified from WRC (**Appendix B**). Appendix A contains the complete data set for the macroinvertebrate monitoring sampling in 2018. Raw macroinvertebrate data (identifications and enumerations) as well as metric values and summary statistics are included in this file.

Community Density

Macroinvertebrate abundance in 2018 was generally lower across all West Rosebud Creek sites (stable at APH) than in previous years. Mean community density was generally similar among sites and ranged from approximately 100 to 400 organisms per 0.1 m^2 Hess sample (**Figure 1**). Community densities tended to be higher at most sites during drought years (2000-2007) than during years with higher stream flow. Likewise, high stream flows of 2018 may have contributed to lower than average densities at the WRC sites BPH, BWRL and PGCG (**Figure 1**).

Figure 1. Mean number of macroinvertebrates (± 1 SD) per Hess sample at 5 sites on West Rosebud Creek during October, 2006 - 2018.



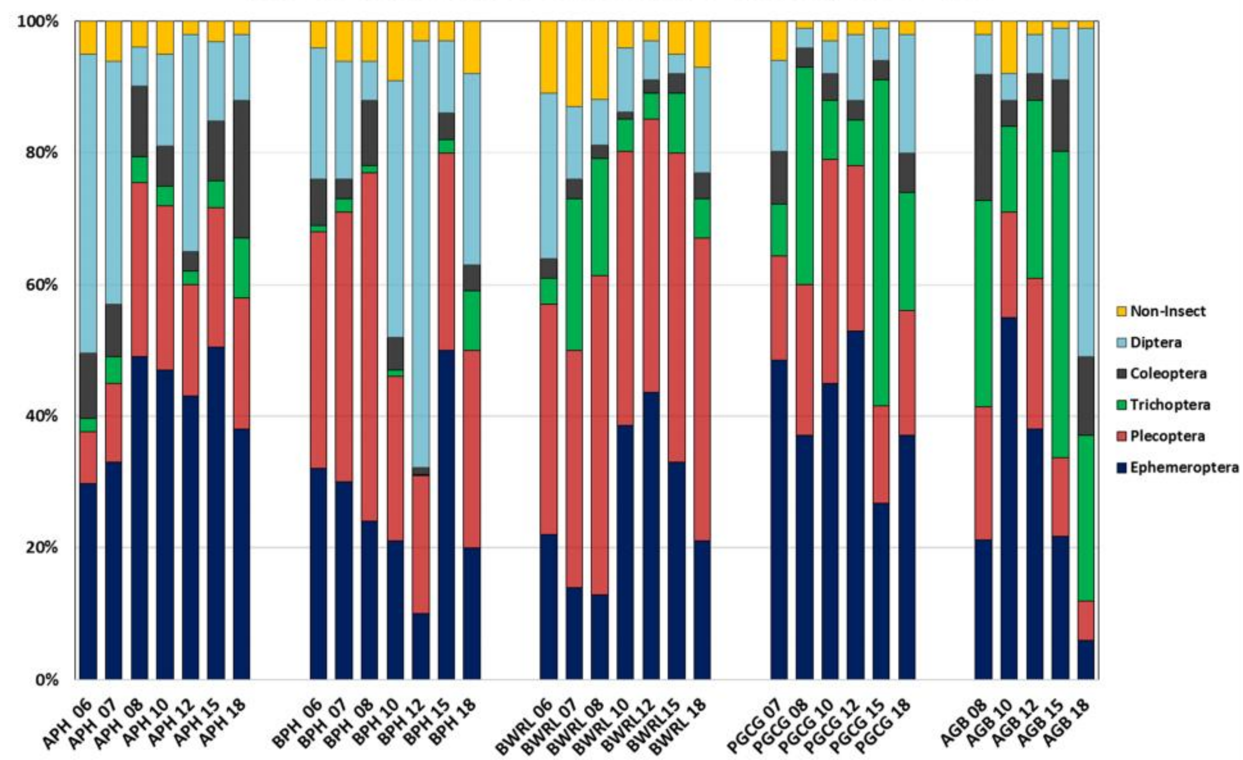
Macroinvertebrate Community Composition

West Rosebud Creek supports a diverse macroinvertebrate fauna that is typical of oligotrophic mountain streams in the region. The 2018 samples contained 74 taxa and included 37 EPT taxa. Since 2004, 131 taxa have been identified from this stream (**Appendix B**). Insects accounted for 117 taxa while 14 non-insect taxa were identified. Dipterans were the most diverse group with 48 taxa, including 35 genera of midges. Mayflies, stoneflies, and caddisflies were each represented by 17, 17 and 21 species, respectively (**Appendix B**). Non-insect taxa included segmented worms, leeches, flatworms, crustaceans, fingernail clams and freshwater sponge. Most non-insect taxa, except aquatic worms and the Turbellarian, *Polycelis*, were confined to BWRL.

Changes in species composition among sites reflects the longitudinal and altitudinal gradient within the study area and localized influences of West Rosebud and Emerald Lakes. A few unique dipterans, caddisflies and stoneflies (*Boreochlus* sp., *Neothremma alicia*, *Visoka cataractae*) typically found in headwater mountain streams were confined to the APH reach, while several taxa more characteristic of larger streams were limited to the sites downstream of the powerhouse (BPH, BWRL, PGCG, AGB). *Hydropsyche cockerelli,* a caddisfly common in lower elevation streams, was collected for the first time in 2015 at the lower monitoring site (AGB), but was not observed in 2018. Two riffle beetles, *Cleptelmis addenda* and *Helichus striatus*, were newly reported at the AGB site in 2018 (**Appendix B**).

Mayflies, stoneflies, caddisflies, and midges were the most numerous macroinvertebrates in October samples (**Figure 2**). Early instar (recently hatched) mayflies, primarily *Baetis*, *Cinygmula*, *Ephemerella* and *Paraleptophlebia*, were abundant in each reach. Stoneflies were typically numerically dominant in the stream BPH and BWRL reaches. These were primarily early instar chloroperlids and nemourids. However, chironomids (Diptera) dominated the fauna below the Powerhouse in 2012, and at AGB in 2018. Diptera abundance has substantially increased at BPH and AGB in 2018 compared to 2015, while mayflies and caddisflies at these sites, respectively, have substantially decreased (**Figure 2**). Caddisflies were more abundant at sites downstream from West Rosebud Lake and were the most abundant macroinvertebrates at the two lower sites (PGCG and AGB) in 2015, but not in 2018 (**Figure 2**).

FIGURE 2. RELATIVE ABUNDANCE (%) OF MAJOR MACROINVERTEBRATE GROUPS AT 5 SITES ON WEST ROSEBUD CREEK DURING OCTOBER, 2006 - 2018.

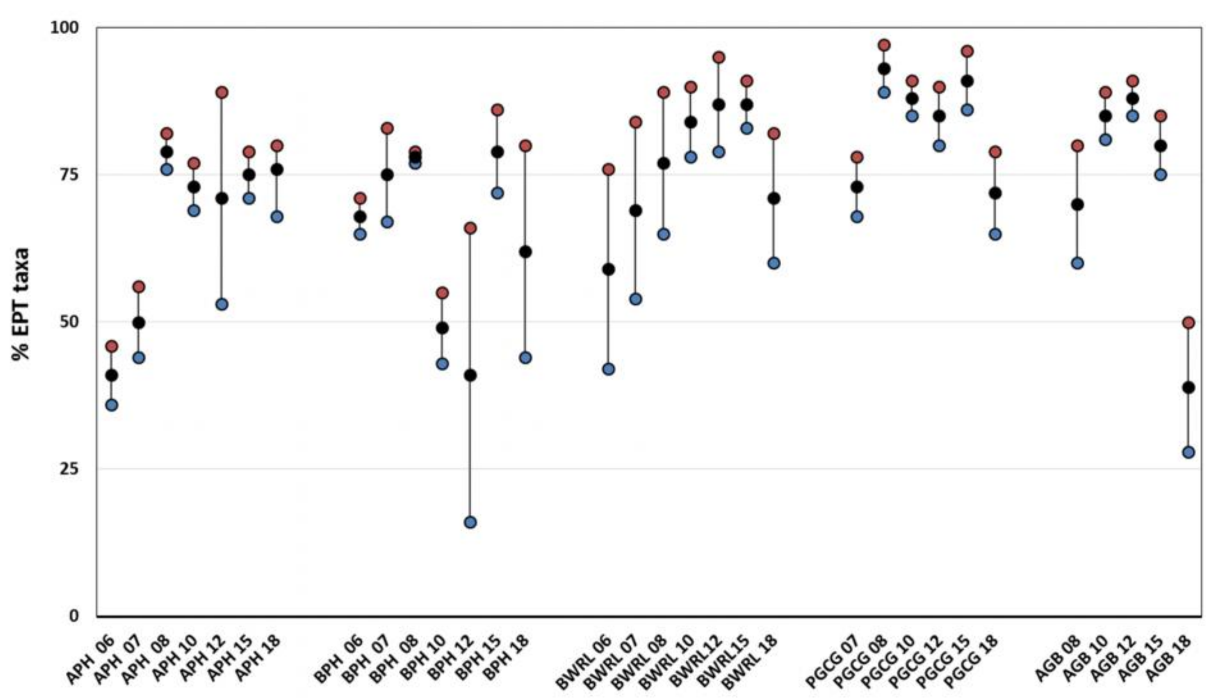


Percentage of EPT Taxa

Mayflies, stoneflies, and caddisflies (Ephemeroptera, Plecoptera, and Trichoptera, respectively) typically dominate macroinvertebrate faunas in mountain streams. The combined relative abundance of these 3 groups (percent EPT) is a standard metric of water and habitat quality (Bukantus 1997). Environmental stress is typically indicated when EPT comprise less than about 50% of the fauna.

Mean EPT relative abundance ranged from 41% to 95% among WRC sites from 2006 to 2015, but the AGB site reported the lowest % EPT ever reported (39%) in 2018 (**Figure 3**). Most sites had values that were indicative of healthy stream environments. However, relatively low values APH (2006 and 2007) and BPH (2010 and 2012) were consistent with slight environmental stress. Reductions in % EPT across most sites in 2018 (except APH) may be due to sustained high flows and/or increased coverage of *Didymo* at some sites (**Figure 3**).

FIGURE 3. MEAN PERCENTAGE OF EPT (± 1 SD)IN HESS SAMPLES FROM 5 SITES ON WEST ROSEBUD CREEK DURING OCTOBER, 2006 - 2018.



Taxa Richness

The number of taxa collected per sample is a basic measure of biological integrity that is sensitive to most environmental stresses. Hess samples from healthy mountain streams typically contain 30 or more taxa. The study area mean over the past 12 years was 27 taxa per Hess sample (**Figure 4**). Mean taxa richness values have usually indicated slight stresses in stream reaches APH, BPH, and BWRL, while values in 2012 at BPH indicated significant stresses (**Figure 4**). Declines in total taxa richness compared to earlier monitoring samples (2006-2007) continued for the upper 3 sites in 2018, but this is not significant (**Figure 4**). The lower 2 sites reported similar taxa richness scores in 2018, as in the previous decade (**Figure 4**).

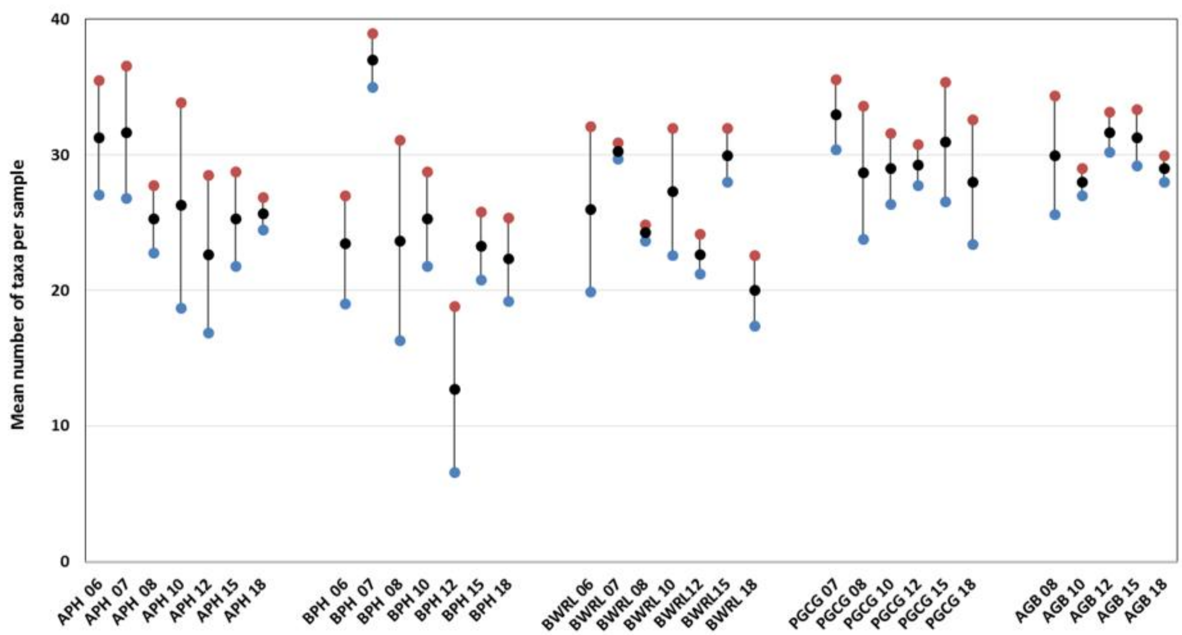
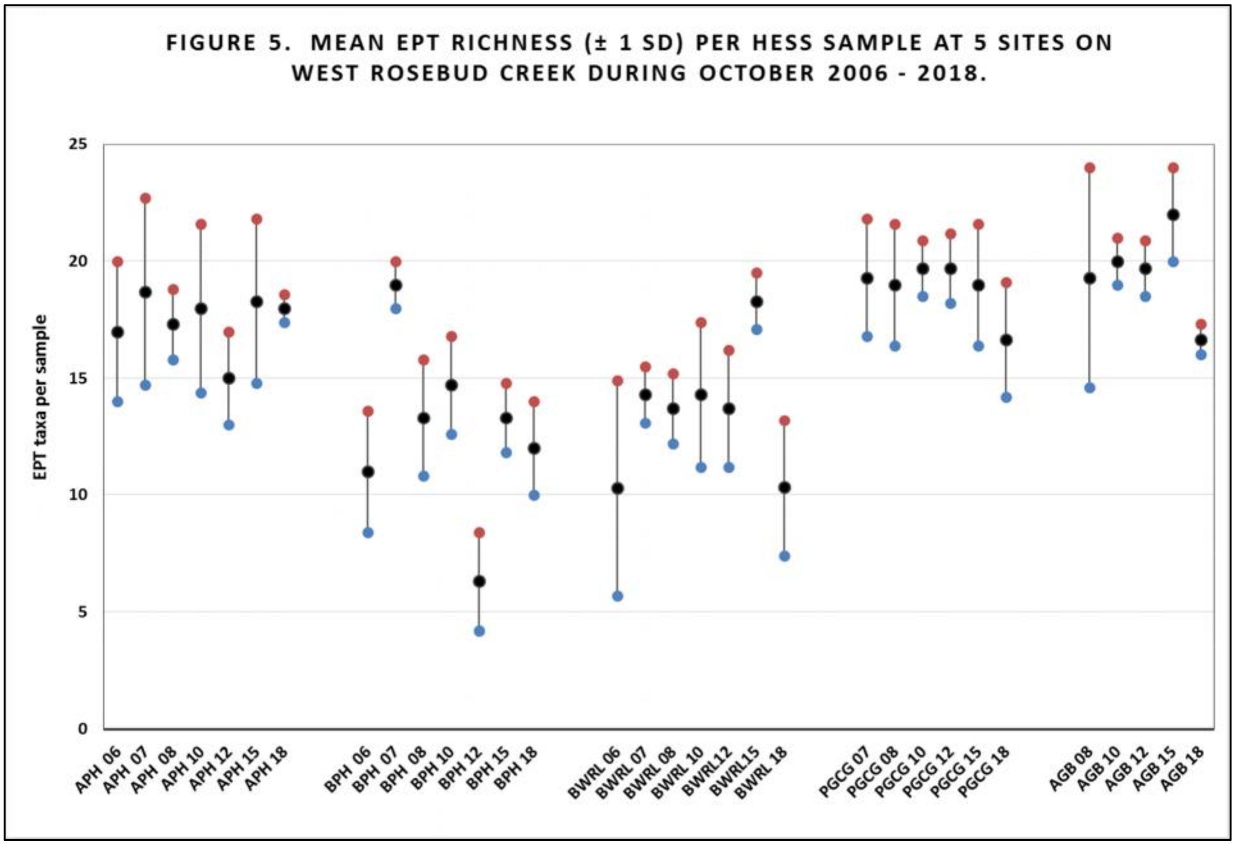


FIGURE 4. MEAN TAXA RICHNESS (± 1 SD) OF MACROINVERTEBRATES IN HESS SAMPLES FROM 5 SITES ON WEST ROSEBUD CREEK DURING OCTOBER 2006-2018.

EPT Richness

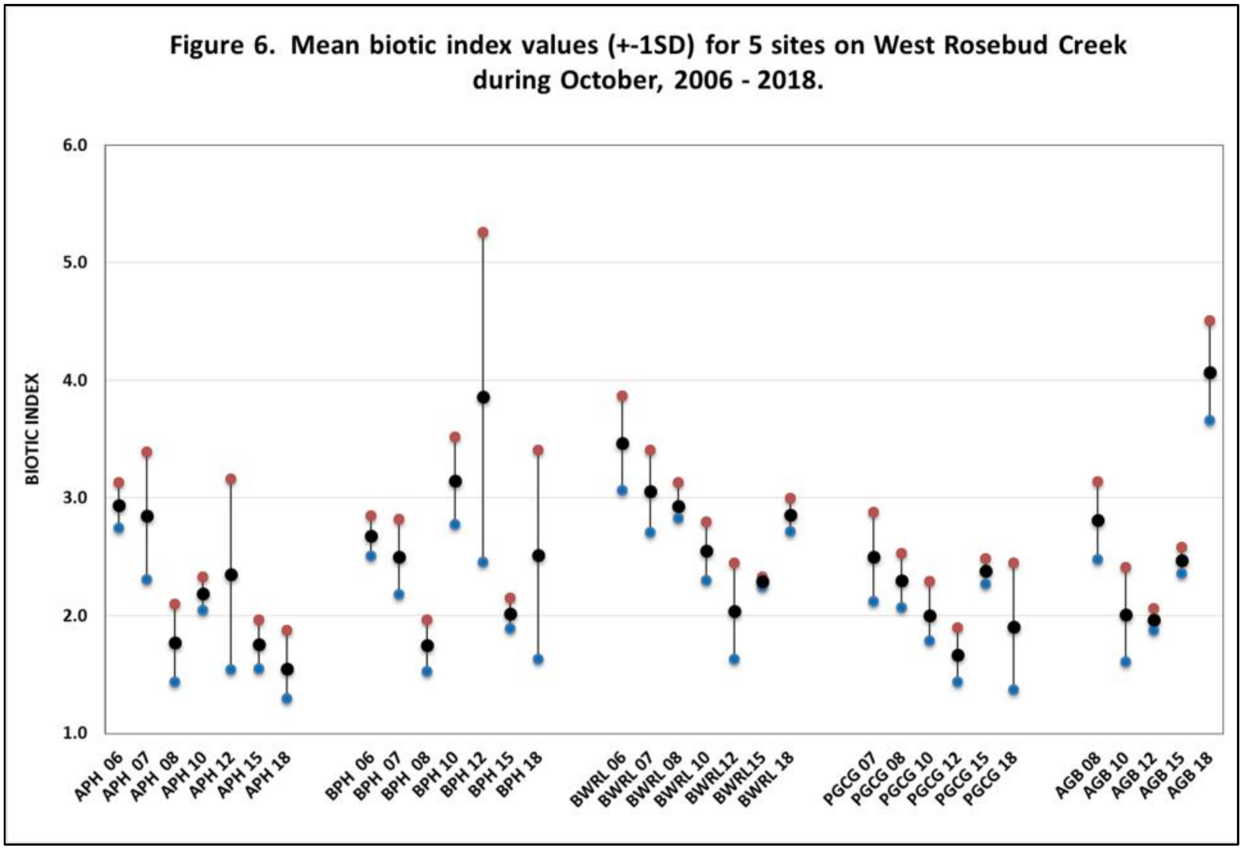
The mean number of mayfly, stonefly and caddisfly taxa per sample ranged from 6 to 22 over the seven sampling periods (**Figure 5**). The combined richness of these 3 groups (EPT richness) is a standard metric of water and habitat quality (Bukantus 1997). Environmental stress is typically indicated when EPT richness is less than about 15 taxa for mountain streams. EPT richness has tended to be lowest at BPH and BWRL; this was the case again in 2018 with declines from 2015 values. EPT richness declines are reported in all sites (except APH) since the last sampling period (2015). Significant declines in EPT were reported at BPH in 2012 and BWRL in 2018 (**Figure 5**).



Biotic Index

The Hilsenhoff biotic index (HBI) was developed as a measure of organic pollution (Hilsenhoff 1987). The Montana version of this index (Bukantis 1997) is an excellent indicator of a streams trophic status and also tends to be correlated with water temperature, substrate embeddedness, and the percentage of fine sediments (Bollman 1998). On a scale of 0 to 10, with higher values indicating increasingly eutrophic conditions; HBI values of 0-3.0 in mountain streams indicate no organic pollution (excellent condition), and 3.0-4.0 slight organic pollution (very good) (Hilsenhoff 1987, McGuire 1993).

Biotic index values have indicated excellent to very good water quality throughout WRC over the monitoring period (**Figure 6**). The multi-year study area mean was 2.42. Annual site estimates have ranged from 1.6 to 4.1. Values were slightly elevated BPH in 2012 and at AGB in 2018 (**Figure 6**).



CONCLUSIONS

Overall, 2018 WRC macroinvertebrate assemblages were characteristic of good environmental conditions in most stream reaches, except at the Allen Grade Bridge (AGB). The biotic index at AGB (>4.0) in 2018 was the highest ever reported across all sites and years, indicating declining biological integrity and a continuation (2012 to 2015) of an increasingly tolerant macroinvertebrate community. Mayflies, stoneflies and caddisflies dominated the benthic communities at all WRC sites, except for midges dominating the AGB samples. Previous changes in species composition among sites reflected the longitudinal gradient within the study area and localized influences of West Rosebud and Emerald Lakes, but the large deviations observed in metric values at AGB indicate a decline in biological integrity compared to 2015. Moderate to abundant growth of *Didymosphenia* were present on the cobbles of some sites during 2018 (especially at BPH and AGB), and may be a causal factor to the declining community health. Increases in benthic sediment input at AGB from erosion and trampled banks downstream from USFS lands can also cause similar responses in the macroinvertebrate community.

WRC supports a sparse, but generally healthy assemblage of aquatic macroinvertebrates. Benthic assemblages are typical of headwater, oligotrophic mountain streams transitioning to a lower elevation stream community at AGB. However, the macroinvertebrate assemblages at the BPH and BWRL sites are clearly susceptible to increased environmental stresses, as witnessed in 2012 and 2018. Community density, composition, EPT and total taxa richness have been reduced at these sites following a relatively high flow year, while the biotic index was elevated in 2018 compared to other stations and dates. Cobble habitat is limited in this reach and may have been negatively affected by high stream flows in 2011 and 2018. Moreover, extensive growths of the stalked, filamentous diatom, *Didymosphenia,* has further reduced benthic habitat heterogeneity in this reach. While *Didymosphenia* has generally been present throughout the study area, more extensive growths were evident during 2018, especially at the BPH and AGB sites.

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AQUATIC MACROINVERTEBRATE DATA
Northwestern Energy; Mystic Rosebud Creek, Stillwater County, MT
West Rosebud Creek, above Powerhouse
1-Oct-18 HESS SAMPLES 0.1 m^2

Hess sample (0.1m^2):	1	2	3	MEAN	ST. DEV.	TOT #	%RA
Taxon							
COLEOPTERA				41		124	21%
Heterlimnius corpulentus	22	74	28	41.3	28.4	124	20.6%
DIPTERA				20		61	10%
Pagastia sp.	3	12	16	10.3	6.7	31	5.2%
Eukiefferiella spp.	1	4	4	3.0	1.7	9	1.5%
Orthocladius sp.	0	2	2	1.3	1.2	4	0.7%
Synorthocladius sp.	0	0	2	0.7	1.2	2	0.3%
Micropsectra spp.	4	0	2	2.0	2.0	6	1.0%
Hexatoma	1	4	2	2.3	1.5	7	1.2%
Chelifera	0	2	0	0.7	1.2	2	0.3%
Ceratopogoninae	0	0	0	0.0	0.0	0	0.0%
EPHEMEROPTERA				75		226	38%
Acentrella insignificans	0	0	0	0.0	0.0	0	0.0%
Baetis bicaudatus	3	4	4	3.7	0.6	11	1.8%
Baetis tricaudatus	7	2	6	5.0	2.6	15	2.5%
Caudatella hystrix	20	20	52	30.7	18.5	92	15.3%
Drunella doddsi	8	6	2	5.3	3.1	16	2.7%
Drunella grandis	0	0	0	0.0	0.0	0	0.0%
Ephemerella sp.	1	2	4	2.3	1.5	7	1.2%
Serratella tibialis	0	2	0	0.7	1.2	2	0.3%
Cinygmula spp.	1	2	4	2.3	1.5	7	1.2%
Epeorus longimannus	13	0	18	10.3	9.3	31	5.2%
Epeorus grandis	4	0	2	2.0	2.0	6	1.0%
Rhithrogena sp.	3	12	20	11.7	8.5	35	5.8%
Paraleptophlebia sp.	4	0	0	1.3	2.3	4	0.7%
Ameletus sp.	0	0	0	0.0	0.0	0	0.0%

AQUATIC MACROINVERTEBRATE DATA
Northwestern Energy; Mystic Rosebud Creek, Stillwater County, MT
West Rosebud Creek, above Powerhouse
1-Oct-18 HESS SAMPLES 0.1 m^2

Hess sample (0.1m^2):	1	2	3	MEAN	ST. DEV.	TOT #	%RA
PLECOPTERA				39		118	20%
Leuctridae	0	0	0	0.0	0.0	0	0.0%
Visoka cataractae	1	0	0	0.3	0.6	1	0.2%
Zapada cinctipes	19	16	2	12.3	9.1	37	6.2%
Chloroperlinae*	13	12	8	11.0	2.6	33	5.5%
Doroneuria sp.	0	24	2	8.7	13.3	26	4.3%
Hesperoperla pacifica	13	6	2	7.0	5.6	21	3.5%
TRICHOPTERA				19		58	10%
Arctopsyche sp.	1	2	2	1.7	0.6	5	0.8%
Ecclisomyia sp.	0	0	1	0.3	0.6	1	0.2%
Brachycentrus americanus	0	2	0	0.7	1.2	2	0.3%
Micrasema bactro	5	4	2	3.7	1.5	11	1.8%
Neothremma alicia	15	2	4	7.0	7.0	21	3.5%
Rhyacophila betteni gp.	0	0	0	0.0	0.0	0	0.0%
Rhyacophila brunnea gp.	2	2	2	2.0	0.0	6	1.0%
Rhyacophila coloradensis gp.	0	10	2	4.0	5.3	12	2.0%
ANNELIDA				4		12	2%
Enchytraeidae	0	0	0	0.0	0.0	0	0.0%
Megadrilli	4	6	2	4.0	2.0	12	2.0%
			0				
OTHER				1		2	0%
Polycelis sp.	2	0	0	0.7	1.2	2	0.3%

IDs by D. Stagliano

	1	2	3	MEAN	ST. DEV.	TOT #
TOTAL ORGANISMS	170	234	197	200.3	32.1	601
TAXA RICHNESS	25	25	27	25.7	1.2	33
EPT RICHNESS	18	18	19	18.3	0.6	23
BIOTIC INDEX	1.53	1.89	1.24	1.55	0.33	1.57
% DOMINANT TAXON	13%	32%	26%	24%	10%	
% COLLECTORS (g+f)	39%	56%	63%	53%	13%	54%
% SCRAPER+SHREDDER	43%	18%	27%	29%	13%	28%
%EPT	78%	56%	71%	68%	12%	67%

AQUATIC MACROINVERTEBRATE DATA
Northwestern Energy; Mystic Rosebud Creek, Stillwater County, MT
West Rosebud Creek, above Powerhouse
1-Oct-18 HESS SAMPLES 0.1 m^2

Hess sample ($0.1m^2$):	1	2	3	MEAN	ST. DEV.	TOT #	%RA
SHANNON DIVERSITY	4.03	3.68	3.74	3.82	0.19	4.12	
EPT/(EPT + Chironomidae)	0.94	0.88	0.84	0.89	0.05	0.92	
% COLLECTOR-GATHERERS	38%	55%	62%	52%	12%	53%	
% SHREDDERS	12%	7%	1%	7%	5%	6%	
% SCRAPERS	31%	11%	26%	23%	10%	22%	
% FILTERERS	1%	2%	1%	1%	1%	1%	
% PREDATORS	18%	26%	9%	18%	8%	18%	
% CHIRONOMIDAE	5%	8%	13%	9%	4%	9%	
% TANYTARSINI	2%	0%	1%	1%	1%	1%	
Baetidae/EPHEMEROPTERA	16%	12%	9%	12%	3%	12%	
METALS TOLERANCE INDEX	2.00	2.70	2.30	2.33	0.35	2.33	

notes: Chloroperlinae mostly early instar- both Sweltsa and Suwallia present.
notes:Didymo visual estimate: scale: 0 not evident, 5 extensive clumps >50 coverage on cobbles

Didymo	**1**	**1**	**2**				

	Avg.
EPHEMEROPTERA	37.6%
PLECOPTERA	19.6%
TRICHOPTERA	9.7%
COLEOPTERA	20.6%
DIPTERA	10.1%
ANNELIDA	2.0%

AQUATIC MACROINVERTEBRATE DATA
Northwestern Energy; Mystic Rosebud Creek, Stillwater County, MT
West Rosebud Creek: below Powerhouse
1-Oct-18 HESS SAMPLES 0.1 m^2

Hess sample (0.1m2):	1	2	3	MEAN	ST. DEV.	TOT #	%RA
Taxon							
COLEOPTERA				4		12	3%
Heterlimnius corpulentus	8	0	4	4.0	4.0	12	3.3%
DIPTERA				35		106	29%
Thienemannimyia gp.	0	0	1	0.3	0.6	1	0.3%
Diamesa sp.	2	0	3	1.7	1.5	5	1.4%
Pagastia sp.	8	0	2	3.3	4.2	10	2.7%
Eukiefferiella spp.	24	1	18	14.3	11.9	43	11.8%
Orthocladius sp.	10	1	2	4.3	4.9	13	3.6%
Synorthocladius sp.	4	1	0	1.7	2.1	5	1.4%
Micropsectra	9	2	3	4.7	3.8	14	3.8%
Antocha sp.	8	0	5	4.3	4.0	13	3.6%
Dicranota sp.	0	0	0	0.0	0.0	0	0.0%
Clinocera sp.	1	0	1	0.7	0.6	2	0.5%
EPHEMEROPTERA				25		74	20%
Baetis bicaudatus	6	6	4	5.3	1.2	16	4.4%
Baetis tricaudatus	0	0	0	0.0	0.0	0	0.0%
Caudatella hystrix	0	4	1	1.7	2.1	5	1.4%
Drunella grandis	0	1	0	0.3	0.6	1	0.3%
Ephemerella sp.	0	2	0	0.7	1.2	2	0.5%
Cinygmula spp.	2	0	1	1.0	1.0	3	0.8%
Epeorus longimanus	2	11	1	4.7	5.5	14	3.8%
Epeorus grandis	0	3	0	1.0	1.7	3	0.8%
Rhithrogena sp.	12	8	1	7.0	5.6	21	5.8%
Paraleptophlebia sp.	6	3	0	3.0	3.0	9	2.5%
PLECOPTERA				37		110	30%
Despaxia augusta	2	0	0	0.7	1.2	2	0.5%
Zapada cinctipes	0	2	4	2.0	2.0	6	1.6%
Chloroperlinae*	76	6	13	31.7	38.6	95	26.0%
Skwala sp.	0	0	0	0.0	0.0	0	0.0%
Doroneuria sp.	0	0	1	0.3	0.6	1	0.3%
Hesperoperla pacifica	2	3	1	2.0	1.0	6	1.6%
TRICHOPTERA				10		31	8%
Arctopsyche grandis	0	1	0	0.3	0.6	1	0.3%
Lepidostoma sp.	0	0	0	0.0	0.0	0	0.0%
Rhyacophila brunnea gp.	0	1	1	0.7	0.6	2	0.5%
Rhyacophila betteni gp.	0	0	2	0.7	1.2	2	0.5%
Rhyacophila coloradensis gp.	10	2	12	8.0	5.3	24	6.6%
Rhyacophila hyalinata gp.	0	0	0	0.0	0.0	0	0.0%
Rhyacophila sibirica gp.	2	0	0	0.7	1.2	2	0.5%

AQUATIC MACROINVERTEBRATE DATA
Northwestern Energy; Mystic Rosebud Creek, Stillwater County, MT
West Rosebud Creek: below Powerhouse
1-Oct-18 HESS SAMPLES 0.1 m^2

Hess sample (0.1m2):	1	2	3	MEAN	ST. DEV.	TOT #	%RA
ANNELIDA				1		3	1%
Enchytraeidae	2	0	1	1.0	1.0	3	0.8%
Nais sp.	1	0	1	0.7	0.6	2	0.5%
OTHER				9		27	7%
Polycelis sp.	10	7	7	8.0	1.7	24	6.6%
Pisidium sp.	2	0	1	1.0	1.0	3	0.8%
IDs by D. Stagliano							
TOTAL ORGANISMS	209	65	91	122	76.7	365	
TAXA RICHNESS	23	19	25	22.3	3.1	33	
EPT RICHNESS	10	14	12	12.0	2.0	19	
BIOTIC INDEX	2.57	1.60	3.38	2.52	0.89	2.60	
% DOMINANT TAXON	36%	17%	20%	24%	10%		
% COLLECTORS (g+f)	40%	28%	49%	39%	11%	40%	
% SCRAPER+SHREDDER	11%	42%	8%	20%	19%	16%	
%EPT	57%	82%	46%	62%	18%	59%	
SHANNON DIVERSITY	3.48	3.82	3.90	3.74	0.22	4.02	
EPT/(EPT + Chironomidae)	0.68	0.91	0.59	0.73	0.17	0.80	
% COLLECTOR-GATHERERS	39%	26%	48%	38%	11%	39%	
% SHREDDERS	1%	3%	4%	3%	2%	2%	
% SCRAPERS	11%	38%	3%	17%	19%	14%	
% FILTERERS	1%	2%	1%	1%	0%	1%	
% PREDATORS	48%	31%	43%	41%	9%	44%	
% CHIRONOMIDAE	27%	8%	32%	22%	13%	25%	
% TANYTARSINI	0%	0%	0%	0%	0%	0%	
Baetidae/EPHEMEROPTERA	21%	16%	50%	29%	18%	22%	
METALS TOLERANCE INDEX	3.39	1.74	4.00	3.04	1.17	3.25	

notes: Chloroperlinae mostly early instar- both Sweltsa and Suwallia present.
notes:Didymo visual estimate: scale: 0 not evident, 5 extensive clumps >50 coverage on cobbles

Didymo	**4**	**3**	**5**				

	<u>**Avg.**</u>
EPHEMEROPTERA	20.3%
PLECOPTERA	30.1%
TRICHOPTERA	8.5%
COLEOPTERA	3.3%
DIPTERA	29.0%
ANNELIDA	8.0%

AQUATIC MACROINVERTEBRATE DATA
Northwestern Enegy: Mystic **Stillwater County, MT**
West Rosebud Creek, **below West Rosebud Lake**
1-Oct-18 **HESS SAMPLES 0.1 m^2**

Hess sample (0.1m2):	1	2	3	MEAN	ST. DEV.	TOT #	%RA
Taxon							
COLEOPTERA				3		10	3%
Heterlimnius corpulentus	2	2	1	1.7	0.6	5	1.7%
Optioservus sp.	4	0	1	1.7	2.1	5	1.7%
Zaitzevia sp.	0	0	0	0.0	0.0	0	0.0%
DIPTERA				16		47	16%
Thienemannimyia gp.	1	0	0	0.3	0.6	1	0.3%
Pagastia sp.	5	9	2	5.3	3.5	16	5.6%
Potthastia sp.	0	2	0	0.7	1.2	2	0.7%
Eukiefferiella spp.	0	4	8	4.0	4.0	12	4.2%
Orthocladius sp.	1	6	0	2.3	3.2	7	2.4%
Nanocladius sp.	0	3	0	1.0	1.7	3	1.0%
Rheocricotopus sp.	0	0	1	0.3	0.6	1	0.3%
Micropsectra sp.	0	2	0	0.7	1.2	2	0.7%
Antocha sp.	0	0	0	0.0	0.0	0	0.0%
Hexatoma sp.	2	0	0	0.7	1.2	2	0.7%
Clinocera	0	0	1	0.3	0.6	1	0.3%
Simulium spp. (Eusimulium)	0	0	0	0.0	0.0	0	0.0%
EPHEMEROPTERA				20		60	21%
Baetis bicaudatus	0	0	0	0.0	0.0	0	0.0%
Baetis tricaudatus	0	4	11	5.0	5.6	15	5.2%
Caudatella hystrix	0	0	0	0.0	0.0	0	0.0%
Drunella doddsi	2	3	5	3.3	1.5	10	3.5%
Drunella grandis	1	0	0	0.3	0.6	1	0.3%
Ephemerella sp.	1	4	3	2.7	1.5	8	2.8%
Cinygmula spp.	1	7	5	4.3	3.1	13	4.5%
Epeorus grandis	0	0	0	0.0	0.0	0	0.0%
Epeorus longimanus	0	2	2	1.3	1.2	4	1.4%
Rhithrogena sp.	0	0	2	0.7	1.2	2	0.7%
Paraleptophlebia sp.	3	2	2	2.3	0.6	7	2.4%
Ameletus sp.	0	0	0	0.0	0.0	0	0.0%
PLECOPTERA				44		133	46%
Zapada cinctipes	19	41	39	33	12.2	99	34.4%
Chloroperlinae*	10	4	7	7.0	3.0	21	7.3%
Skwala sp.	0	2	1	1.0	1.0	3	1.0%
Hesperoperla pacifica	0	3	7	3.3	3.5	10	3.5%

AQUATIC MACROINVERTEBRATE DATA

Northwestern Enegy: Mystic **Stillwater County, MT**

West Rosebud Creek, **below West Rosebud Lake**

1-Oct-18 **HESS SAMPLES 0.1 m^2**

Hess sample (0.1m2):	1	2	3	MEAN	ST. DEV.	TOT #	%RA
TRICHOPTERA				5		16	6%
Arctopsyche sp.	0	0	0	0.0	0.0	0	0.0%
Hydropsyche (C) oslari	0	0	0	0.0	0.0	0	0.0%
Dolophilodes sp.	0	0	0	0.0	0.0	0	0.0%
Agraylea sp.	0	0	0	0.0	0.0	0	0.0%
Lepidostoma sp.	0	1	0	0.3	0.6	1	0.3%
Rhyacophila brunnea gp.	0	0	0	0.0	0.0	0	0.0%
Rhyacophila coloradensis gp.	0	14	1	5.0	7.8	15	5.2%
Rhyacophila sibirica gp.	0	0	0	0.0	0.0	0	0.0%
ANNELIDA				2		5	2%
Enchytraeidae	0	0	0	0.0	0.0	0	0.0%
Megadrilli	0	0	0	0.0	0.0	0	0.0%
Nais sp.	3	1	1	1.7	1.2	5	1.7%
OTHER				6		17	6%
Polycelis sp.	0	0	1	0.3	0.6	1	0.3%
Pisidium sp.	2	4	2	2.7	1.2	8	2.8%
Caecidotea sp.	0	0	0	0.0	0.0	0	0.0%
Nematoda	1	0	0	0.3	0.6	1	0.3%
Gyraulus sp	0	5	0	1.7	2.9	5	1.7%
Physella sp	2	0	0	0.7	1.2	2	0.7%

IDs by D. Stagliano

	1	2	3	MEAN	ST. DEV.	TOT #
TOTAL ORGANISMS	60	125	103	96	33.1	288
TAXA RICHNESS	17	22	21	20.0	2.6	32
EPT RICHNESS	7	12	12	10.3	2.9	14
BIOTIC INDEX	2.99	2.72	2.88	2.86	0.14	2.83
% DOMINANT TAXON	32%	33%	38%	34%	3%	
% COLLECTORS (g+f)	35%	33%	30%	33%	2%	32%
% SCRAPER+SHREDDER	45%	49%	53%	49%	4%	50%
%EPT	62%	70%	83%	71%	11%	73%
SHANNON DIVERSITY	3.36	3.65	3.33	3.45	0.18	3.83
EPT/(EPT + Chironomidae)	0.84	0.78	0.89	0.84	0.05	0.90
% COLLECTOR-GATHERERS	32%	30%	27%	29%	2%	29%
% SHREDDERS	32%	34%	38%	34%	3%	35%
% SCRAPERS	13%	15%	16%	15%	1%	15%
% FILTERERS	3%	3%	3%	3%	0%	3%
% PREDATORS	20%	18%	17%	18%	2%	18%
% CHIRONOMIDAE	12%	19%	11%	14%	5%	15%
% TANYTARSINI	0%	0%	0%	0%	0%	0%
Baetidae/EPHEMEROPTERA	0%	18%	37%	18%	18%	25%
METALS TOLERANCE INDEX	3.38	3.37	3.35	3.37	0.02	3.36

notes: Chloroperlinae mostly early instar- both Sweltsa and Suwallia present.

notes:Didymo visual estimate: scale: 0 not evident, 5 extensive clumps >50 coverage on cobbles

Didymo	**1**	**1**	**2**					

AQUATIC MACROINVERTEBRATE DATA

Northwestern Enegy: Mystic	**Stillwater County, MT**
West Rosebud Creek,	**below West Rosebud Lake**
1-Oct-18	**HESS SAMPLES 0.1 m^2**

Hess sample (0.1m2):	1	2	3	MEAN	ST. DEV.	TOT #	%RA

	Avg.
EPHEMEROPTERA	20.8%
PLECOPTERA	46.2%
TRICHOPTERA	5.6%
COLEOPTERA	3.5%
DIPTERA	16.3%
ANNELIDA	7.6%

AQUATIC MACROINVERTEBRATE DATA

Northwestern Enegy: Mystic | **Stillwater County, MT**

West Rosebud Creek, | **Pine Grove Campground**

2-Oct-18 | **HESS SAMPLES 0.1 m^2**

Hess sample (0.1m2):	1	2	3	MEAN	ST. DEV.	TOT #	%RA
Taxon							
COLEOPTERA				13		38	6%
Heterlimnius corpulentus	1	4	4	3.0	1.7	9	1.4%
Narpus concolor	0	0	0	0.0	0.0	0	0.0%
Optioservus sp.	12	4	13	9.7	4.9	29	4.7%
DIPTERA				39		116	19%
Thienemannimyia gp.	0	0	0	0.0	0.0	0	0.0%
Diamesa sp.	2	0	1	1.0	1.0	3	0.5%
Pagastia sp.	4	4	1	3.0	1.7	9	1.4%
Eukiefferiella spp.	10	1	1	4.0	5.2	12	1.9%
Orthocladius sp.	25	16	7	16.0	9.0	48	7.7%
Paraphaenocladius sp.	2	0	0	0.7	1.2	2	0.3%
Rheocricotopus sp.	0	0	1	0.3	0.6	1	0.2%
Micropsectra sp.	2	3	1	2.0	1.0	6	1.0%
Rheotanytarsus sp.	2	2	0	1.3	1.2	4	0.6%
Tvetenia sp.	0	0	0	0.0	0.0	0	0.0%
Antocha sp.	1	0	0	0.3	0.6	1	0.2%
Hexatoma sp.	2	6	17	8.3	7.8	25	4.0%
Chelifera	0	0	3	1.0	1.7	3	0.5%
Ceratopogoninae	0	0	1	0.3	0.6	1	0.2%
Simulium spp. (Eusimulium)	0	0	1	0.3	0.6	1	0.2%
EPHEMEROPTERA				76		229	37%
Baetis tricaudatus	1	1	4	2.0	1.7	6	1.0%
Caudatella hystrix	1	0	0	0.3	0.6	1	0.2%
Drunella doddsi	0	0	0	0.0	0.0	0	0.0%
Drunella grandis	0	1	1	0.7	0.6	2	0.3%
Ephemerella sp.	8	1	2	3.7	3.8	11	1.8%
Cinygmula spp.	35	37	89	53.7	30.6	161	25.9%
Epeorus longimanus	0	1	0	0.3	0.6	1	0.2%
Rhithrogena sp.	1	0	0	0.3	0.6	1	0.2%
Paraleptophlebia sp.	12	14	20	15.3	4.2	46	7.4%

AQUATIC MACROINVERTEBRATE DATA
Northwestern Enegy: Mystic **Stillwater County, MT**
West Rosebud Creek, **Pine Grove Campground**
2-Oct-18 **HESS SAMPLES 0.1 m^2**

Hess sample (0.1m2):	1	2	3	MEAN	ST. DEV.	TOT #	%RA
PLECOPTERA				39		116	19%
Leuctridae	0	0	0	0.0	0.0	0	0.0%
Zapada cinctipes	6	3	2	3.7	2.1	11	1.8%
Chloroperlinae*	14	27	53	31.3	19.9	94	15.1%
Skwala sp.	0	0	1	0.3	0.6	1	0.2%
Claassenia sabulosa	1	0	3	1.3	1.5	4	0.6%
Doroneuria sp.	0	0	0	0.0	0.0	0	0.0%
Hesperoperla pacifica	5	1	0	2.0	2.6	6	1.0%
TRICHOPTERA				36		109	18%
Arctopsyche sp.	2	14	5	7.0	6.2	21	3.4%
Hydropsyche (C) oslari	2	1	1	1.3	0.6	4	0.6%
Dolophilodes sp.	0	0	1	0.3	0.6	1	0.2%
Brachycentrus americanus	20	5	22	15.7	9.3	47	7.6%
Micrasema bactro	6	1	1	2.7	2.9	8	1.3%
Agraylea sp.	1	0	1	0.7	0.6	2	0.3%
Lepidostoma sp.	1	6	15	7.3	7.1	22	3.5%
Glossosoma sp.	0	0	1	0.3	0.6	1	0.2%
Rhyacophila narvae	0	0	1	0.3	0.6	1	0.2%
Rhyacophila coloradensis gp.	1	0	1	0.7	0.6	2	0.3%
ANNELIDA				4		13	2%
Enchytraeidae	1	5	7	4.3	3.1	13	2.1%
OTHER				0		0	0%
Polycelis sp.	0	0	0	0.0	0.0	0	0.0%
Pisidium sp.	0	0	0	0.0	0.0	0	0.0%

IDs by D. Stagliano

TOTAL ORGANISMS	181	158	282	207	66.0	621
TAXA RICHNESS	29	23	32	28.0	4.6	39
EPT RICHNESS	17	14	19	16.7	2.5	23
BIOTIC INDEX	2.48	1.85	1.40	1.91	0.54	1.83
% DOMINANT TAXON	19%	23%	32%	25%	6%	
% COLLECTORS (g+f)	56%	39%	26%	40%	15%	38%
% SCRAPER+SHREDDER	31%	39%	45%	38%	7%	39%
%EPT	65%	72%	79%	72%	7%	73%

AQUATIC MACROINVERTEBRATE DATA
Northwestern Enegy: Mystic **Stillwater County, MT**
West Rosebud Creek, **Pine Grove Campground**
2-Oct-18 **HESS SAMPLES 0.1 m^2**

Hess sample (0.1m2):	1	2	3		MEAN	ST. DEV.	TOT #	%RA
SHANNON DIVERSITY	3.95	3.62	3.45		3.67	0.25	3.86	
EPT/(EPT + Chironomidae)	0.71	0.81	0.95		0.83	0.12	0.89	
% COLLECTOR-GATHERERS	40%	26%	15%		27%	12%	25%	
% SHREDDERS	4%	6%	6%		5%	1%	6%	
% SCRAPERS	27%	33%	39%		33%	6%	34%	
% FILTERERS	17%	13%	11%		14%	3%	13%	
% PREDATORS	13%	22%	29%		21%	8%	22%	
% CHIRONOMIDAE	26%	16%	4%		16%	11%	14%	
% TANYTARSINI	0%	0%	0%		0%	0%	0%	
Baetidae/EPHEMEROPTERA	2%	2%	3%		2%	1%	3%	
METALS TOLERANCE INDEX	3.29	2.30	1.82		2.47	0.75	2.37	

notes: Chloroperlinae mostly early instar- both Sweltsa and Suwallia present.
notes:Didymo visual estimate: scale: 0 not evident, 5 extensive clumps >50 coverage on cobbles

Didymo	**3**	**2**	**1**					

	Avg.
EPHEMEROPTERA	36.9%
PLECOPTERA	18.7%
TRICHOPTERA	17.6%
COLEOPTERA	6.1%
DIPTERA	18.7%
ANNELIDA	2.1%

AQUATIC MACROINVERTEBRATE DATA
Northwestern Enegy: Mystic **Stillwater County, MT**
West Rosebud Creek, **U/S Allen Grade Bridge**
2-Oct-18 **HESS SAMPLES 0.1 m^2**

Hess sample (0.1m2):	1	2	3	MEAN	ST. DEV.	TOT #
Taxon						
COLEOPTERA				49		147
Narpus concolor	0	2	0	0.7	1.2	2
Cleptelmis	0	2	0	0.7	1.2	2
Helichus striatus	0	1	0	0.3	0.6	1
Optioservus sp.	52	44	46	47.3	4.2	142
DIPTERA				206		618
Pagastia sp.	10	8	2	6.7	4.2	20
Potthastia sp.	2	0	0	0.7	1.2	2
Eukiefferiella spp.	54	16	50	40.0	20.9	120
Orthocladius sp.	154	60	88	100.7	48.3	302
Paraphaenocladius sp.	2	0	6	2.7	3.1	8
Rheocricotopus sp.	0	2	0	0.7	1.2	2
Tvetenia sp.	0	4	0	1.3	2.3	4
Micropsectra spp.	40	6	4	16.7	20.2	50
Rheotanytarsus sp.	62	18	8	29.3	28.7	88
Antocha sp.	6	4	2	4.0	2.0	12
Hexatoma sp.	0	2	0	0.7	1.2	2
Chelifera	6	0	0	2.0	3.5	6
Simulium spp. (Eusimulium)	0	0	2	0.7	1.2	2
EPHEMEROPTERA				25		76
Acentrella insignificans	4	2	2	2.7	1.2	8
Baetis tricaudatus	0	2	0	0.7	1.2	2
Caudatella hystrix	6	0	2	2.7	3.1	8
Drunella doddsi	0	0	8	2.7	4.6	8
Drunella grandis	4	2	0	2.0	2.0	6
Ephemerella sp.	0	0	0	0.0	0.0	0
Cinygmula spp.	2	0	0	0.7	1.2	2
Rhithrogena sp.	2	12	28	14.0	13.1	42
Paraleptophlebia sp.	0	0	0	0.0	0.0	0

AQUATIC MACROINVERTEBRATE DATA

Northwestern Enegy: Mystic **Stillwater County, MT**

West Rosebud Creek, **U/S Allen Grade Bridge**

2-Oct-18 **HESS SAMPLES 0.1 m^2**

Hess sample (0.1m2):	1	2	3	MEAN	ST. DEV.	TOT #
PLECOPTERA				25		74
Zapada cinctipes	10	18	10	12.7	4.6	38
Zapada oregonensis gr.	2	0	0	0.7	1.2	2
Chloroperlinae*	2	0	6	2.7	3.1	8
Isoperla sp.	0	0	0	0.0	0.0	0
Claassenia sabulosa	2	2	6	3.3	2.3	10
Hesperoperla pacifica	10	4	2	5.3	4.2	16
TRICHOPTERA				101		302
Arctopsyche sp.	8	14	6	9.3	4.2	28
Hydropsyche (C) oslari	64	38	68	56.7	16.3	170
Hydropsyche cockerelli	0	0	0	0.0	0.0	0
Dolophilodes sp.	2	10	4	5.3	4.2	16
Brachycentrus americanus	10	8	4	7.3	3.1	22
Micrasema sp.	4	4	8	5.3	2.3	16
Lepidostoma sp.	2	0	2	1.3	1.2	4
Glossosoma sp.	2	4	18	8.0	8.7	24
Rhyacophila brunnea gp.	0	2	4	2.0	2.0	6
Rhyacophila coloradensis gp.	0	8	6	4.7	4.2	14
Rhyacophila betteni grp.	0	2	0	0.7	1.2	2
ANNELIDA				2		5
Megadrilli	6	0	0	2.0	3.5	6
Enchytraeidae	2	2	1	1.7	0.6	5
OTHER				1		2
Polycelis sp.	0	0	2	0.7	1.2	2
IDs by D. Stagliano						
TOTAL ORGANISMS	532	303	395	410	115.2	1230
TAXA RICHNESS	29	30	28	29.0	1.0	42
EPT RICHNESS	17	16	17	16.7	0.6	22
BIOTIC INDEX	4.55	3.69	3.97	4.07	0.44	4.15
% DOMINANT TAXON	29%	20%	22%	24%	5%	
% COLLECTORS (g+f)	91%	79%	75%	82%	8%	83%
% SCRAPER+SHREDDER	4%	14%	19%	12%	7%	11%
%EPT	26%	44%	47%	39%	11%	37%

AQUATIC MACROINVERTEBRATE DATA

Northwestern Enegy: Mystic **Stillwater County, MT**

West Rosebud Creek, **U/S Allen Grade Bridge**

2-Oct-18 **HESS SAMPLES 0.1 m^2**

Hess sample (0.1m2):	1	2	3		MEAN	ST. DEV.	TOT #
SHANNON DIVERSITY	3.50	3.99	3.67		3.72	0.25	3.88
EPT/(EPT + Chironomidae)	0.34	0.58	0.55		0.49	0.13	0.62
% COLLECTOR-GATHERERS	75%	56%	53%		62%	12%	63%
% SHREDDERS	3%	8%	5%		5%	3%	5%
% SCRAPERS	1%	5%	14%		7%	6%	6%
% FILTERERS	16%	23%	21%		20%	4%	19%
% PREDATORS	5%	7%	7%		6%	1%	6%
% CHIRONOMIDAE	49%	32%	38%		40%	9%	41%
% TANYTARSINI	8%	2%	1%		4%	4%	4%
Baetidae/EPHEMEROPTERA	22%	22%	5%		16%	10%	13%
METALS TOLERANCE INDEX	4.88	4.45	4.75		4.69	0.22	4.73

notes: Chloroperlinae mostly early instar- both Sweltsa and Suwallia present.

notes:Didymo visual estimate: scale: 0 not evident, 5 extensive clumps >50 coverage on cobbles

Didymo	**4**	**5**	**4**				

	Avg.
EPHEMEROPTERA	6.2%
PLECOPTERA	6.0%
TRICHOPTERA	24.6%
COLEOPTERA	12.0%
DIPTERA	50.2%
ANNELIDA	0.4%

Appendix B. A checklist of aquatic macroinvertebrates collected from West Rosebud Creek,Stillwater County, Montana during August, 2004 and 2005 and Oct. 2006, 2007, 2008, 2010, 2012, 2015 and 2018.

Order Family	Genus/species year:	**2004**	**2005**	**2006**	**2007**	**2008**	**2010**	**2012**	**2015**	**2018**
	# sites/samples	4/12	3/12	3/9	4/17	5/15	5/15	5/15	5/15	5/15
DIPTERA (two-winged flies)										
Athericidae	*Atherix sp.*	x								
Blephariceridae	*Agathon sp.*	x								
Ceratopgonidae	Ceratopogoninae	x	x		x		x	x	x	x
Chironomidae										
(Podonominae)	*Boreochlus sp.*	x								
(Tanypodinae)	*Thienemannimyia gp.*	x	x	x	x	x	x		x	x
(Diamesinae)	*Diamesa sp.*		x	x	x		x		x	x
	Pagastia sp.	x	x	x	x	x	x	x	x	x
	Potthastia sp.			x	x	x	x	x		x
	Pseudodiamesa sp.	x								
(Prodiamsinae)	*Prodiamesia sp.*	x								
(Orthocladinae)	*Brillia sp.*	x	x			x	x			
	Corynoneura sp.	x	x							
	Cricotopus spp.	x		x						
	Eukiefferiella spp.	x	x	x	x	x	x	x	x	x
	Heterotrissocladius sp.			x						
	Hydrobaenus sp.	x		x	x			x		
	Krenosmittia sp.	x			x					
	Lopescladius sp.			x						
	Orthocladius sp.	x	x	x	x	x	x	x	x	x
	Nanocladius sp.	x					x	x	x	x
	Parachaetocladius sp.				x					
	Parametriocnemus sp.	x	x	x	x	x				
	Paraphaenocladius sp.		x							x
	Rheocricotopus sp.	x	x	x	x	x	x	x	x	x
	Symposiocladius (Orthocladius)							x		
	Synorthocladius sp.	x		x	x	x	x	x	x	x
	Thienemanniella sp.				x					
	Tvetenia sp.	x	x	x	x	x	x	x	x	x
(Chironomini)	*Microtendipes sp.*	x								
	Paracladopelma sp.	x	x							
	Polypedilum sp.	x	x							
(Tanytasini)	*Cladotanytarsus sp.*	x	x		x					
	Rheotanytarsus sp.							x		x
	Sublettia sp.	x								
	Stempellinella sp.	x						x		
	Krenopsectra sp.	x	x	x	x					
	Micropsectra sp. (poss. early insta		x			x	x	x	x	x
	Tanytarsus sp.	x		x						
Deuterophlebiida	*Deuterophlebia sp.*	x	x							
Empididae	*Chelifera sp.*	x	x	x	x	x		x		x
	Clinocera sp.	x	x	x	x		x			x
Tipulidae	*Antocha sp.*	x	x	x	x		x	x	x	x
	Dicranota sp.	x		x	x	x	x			
	Hexatoma sp.	x	x	x	x	x	x	x	x	x
	Hesperoconopa sp.	x	x							
	Limnophila sp.	x	x		x					
	Rhabdomastix sp.					x		x		
Simuliidae	*Simulium sp. (Eusimulium)*	x	x	x	x	x	x	x	x	x

Appendix B. A checklist of aquatic macroinvertebrates collected from West Rosebud Creek,Stillwater County, Montana during August, 2004 and 2005 and Oct. 2006, 2007, 2008, 2010, 2012, 2015 and 2018.

Order	Family	Genus/species	year:	**2004**	**2005**	**2006**	**2007**	**2008**	**2010**	**2012**	**2015**	**2018**
EPHEMEROPTERA												
	Ameletidae	*Ameletus sp.*		x	x	x	x	x	x	x	x	
	Baetidae	*Acentrella insignificans*		x	x			x		x	x	x
		Baetis bicaudatus					x	x	x	x	x	x
		Baetis tricaudatus		x	x	x	x	x	x	x	x	x
		Diphetor hageni		x	x							
	Ephemerellidae	*Caudatella hystrix*		x			x	x	x	x	x	x
		Drunella coloradensis		x								
		Drunella doddsi		x	x	x	x	x	x	x	x	x
		Drunella grandis		x	x	x	x	x	x	x	x	x
		Drunella spinifera				x						
		Ephemerella sp.		x	x	x	x	x	x	x	x	x
		Seratella tibialis		x	x	x		x				x
	Heptageniidae	*Cinygmula sp.*		x	x	x	x	x	x	x	x	x
		Epeorus grandis		x	x				x		x	x
		Epeorus longimanus		x	x	x	x	x	x	x	x	x
		Rhithrogena sp.		x	x	x	x	x	x	x	x	x
	Leptophlebiidae	*Paraleptophlebia sp.*		x	x	x	x	x	x	x	x	x
PLECOPTERA												
	Capniidae			x			x	x	x			
	Leuctridae	*Despaxia augusta*		x	x	x	x	x	x	x	x	x
	Nemouridae	*Malenka sp.*		x	x							
		Podmosta sp.		x								
		Visoka cataractae		x		x						x
		Zapada oregonensis gp.		x				x				x
		Zapada cinctipes		x	x	x	x	x	x	x	x	x
	Chloroperlidae	Chloroperlinae*		x	x	x	x	x	x	x	x	x
		*(Swelta spp and Suwallia sp.)										
		Kathroperla sp.		x	x	x	x	x	x	x		
	Perlodidae	*Skwala sp.*		x	x	x	x	x	x	x	x	x
		Cultus sp.			x		x					
		Isoperla sp.								x	x	
		Unident. early instar		x		x	x					
	Perlidae	*Claassenia sabulosa*		x	x		x	x	x	x	x	x
		Doroneuria theodora		x		x	x	x	x	x	x	x
		Hesperoperla pacifica		x	x	x	x	x	x	x	x	x
TRICHOPTERA												
	Hydropsychidae	*Arctopsyche sp.*		x	x	x	x	x	x	x	x	x
		Hydropsyche (C) oslari		x	x		x	x	x	x	x	x
		Hydropsyche cockerelli									x	
	Philopotamidae	*Dolophilodes sp.*		x	x	x	x		x	x	x	x
	Limnephilidae	*Apatania sp.*				x						
		Neothremma alicia		x		x			x			x
		Ecclisomyia sp.		x					x		x	x
		Psychoglypha sp.		x			x	x				
	Hydroptilidae	*Agraylea sp.*		x	x	x	x	x	x	x	x	x
	Brachycentridae	*Brachycentrus americanus*						x	x	x	x	x
		Brachycentrus occidentalis		x	x	x	x	x				
		Micrasema bactro		x	x	x	x	x	x	x	x	x
	Lepidostomatidae	*Lepidostoma sp.*		x	x	x	x	x	x	x	x	x
	Glossosomatidae	*Glossosoma sp.*		x					x	x	x	x
	Uenoidae	*Neophylax sp.*		x		x	x					
	Rhyacophilidae	*Rhyacophila betteni gp.*		x	x	x	x	x	x	x		x
		Rhyacophila brunnea gp.			x	x	x	x	x	x	x	x
		Rhyacophila hyalinata gp.			x	x	x	x		x	x	x
		Rhyacophila coloradensis gp		x		x	x	x	x	x	x	x
		Rhyacophila narvae										x
		Rhyacophila sibirica gp.		x					x	x	x	x

Appendix B. A checklist of aquatic macroinvertebrates collected from West Rosebud Creek,Stillwater County, Montana during August, 2004 and 2005 and Oct. 2006, 2007, 2008, 2010, 2012, 2015 and 2018.

Order	Family	Genus/species	year:	**2004**	**2005**	**2006**	**2007**	**2008**	**2010**	**2012**	**2015**	**2018**
COLEOPTERA (beetles)												
	Dytiscidae	*Stictotarsus sp.*		x	x	x	x	x				
	Dryopidae	*Helichus striatus*										x
	Elmidae	*Heterlimnius corpulentus*						x	x	x	x	x
		Cleptelmis addenda										x
		Lara avara						x				
		Microcylloepus sp.		x	x		x	x				
		Narpus concolor		x	x	x	x	x	x	x	x	x
		Optioservus sp.			x	x	x		x	x	x	x
		Zaitzevia parvula					x		x	x	x	x
	Haliplidae	*Brychius sp.*										
ANNELIDA												
	Enchytraeidae			x	x	x	x	x	x	x	x	x
	Megadrilli			x		x		x		x	x	x
	Naididae	*Nais sp.*		x	x		x		x		x	x
	Tubificidae	immature wo/capilliform chaeta		x	x							
	Glossophoniidae	*Helobdella stagnalis*					x					
CRUS	Isopoda	*Caecidotea sp.*		x		x	x	x			x	x
	Ostracoda			x		x	x		x			
MOLL	Physidae	*Physella sp.*					x	x			x	x
	Planorbidae	*Gyraulus sp.*				x						x
	Sphaeriidae	*Pisidium sp.*		x	x	x	x	x			x	x
TURBELLARIA		*Polycelis sp.*		x	x	x	x	x	x	x	x	x
HYDRA							x	x	x	x		
PORIFERA				x	x	x			x	x		

Appendix B – Zooplankton and Periphyton Technical Reports, 2010-2018

Analysis of biological samples:
Technical summary of methods and quality assurance procedures
Prepared for PPL Montana
Frank Pickett, Project Manager
June 30, 2011

by
W. Bollman, Chief Biologist
Rhithron Associates, Inc.
Missoula, Montana

METHODS

Sample processing

Three periphyton samples, one phytoplankton sample and two zooplankton samples collected from Mystic Lake were delivered to Rhithron's laboratory facility in Missoula, Montana on April 11, 2011. All samples arrived in good condition. An inventory document containing sample identification information was provided by the PPL Montana (PPL) Project Manager. Upon arrival, samples were unpacked and examined, and checked against the PPL inventory. No discrepancies were noted.

The phytoplankton sample was repackaged and shipped to Karl Bruun, Nostoca Algae Laboratory, for sample analysis. Zooplankton samples were repackaged and shipped to Alex Salki, Salki Consultants Inc., for sample analysis.

The periphyton samples, preserved with Lugol's solution, were topped-off upon arrival at the laboratory. The samples were thoroughly mixed by shaking. Permanent diatom slides were prepared: subsamples were taken and treated with concentrated H_2SO_4 and 30% H_2O_2. The samples were neutralized by rinses with distilled water, and subsample volumes were adjusted to obtain adequate densities. Small amounts of each sample were dried onto 22-mm square coverslips. Coverslips were mounted on slides using Naphrax diatom mount. To ensure a high quality mount for identification and to make replicates available for archives, 3 slide mounts were made from each sample. One of the replicates was selected from each sample batch for identification. A diamond scribe mark was made to define a transect line on the cover slip, and a minimum of 800 diatom valves were identified along the transect mark. A Leica DM 2500 compound microscope, Nomarski contrast, and 1000x magnification were used for identifications. Diatoms were identified to the lowest possible taxonomic level, generally species, following standard taxonomic references.

For the soft-bodied (non-diatom) algae samples, the raw periphyton sample was manually homogenized and emptied into a porcelain evaporating dish. A small, random subsample of algal material was pipetted onto a standard glass microscope slide using a disposable dropper or soda straw. Visible (macroscopic) algae were also sub-sampled, in proportion to their estimated importance relative to the total volume of algal material in the sample, and added to the liquid fraction on the slide. The wet mount was then covered with a 22X30 mm cover slip.

Soft-bodied (non-diatom) algae were identified to genus using an Olympus BHT compound microscope under 200X and 400X. The relative abundance of each algal genus (and of all diatom genera collectively) was estimated for comparative purposes, and abundances were expressed according to the following system:

- rare (r): represented by a single occurrence in the sub-sample
- occasional (o): multiple occurrences, but infrequently seen
- common (c): multiple occurrences, regularly seen
- frequent (f): present in nearly every field of view
- abundant (a): multiple occurrences in every field of view, but well within limits of enumeration
- dominant (d): multiple occurrences in every field of view, but generally beyond practical limits of enumeration

Soft-bodied genera (and the diatom component) were also ranked according to their estimated contribution to the total algal biovolume present in the sample.

The phytoplankton sample, preserved with Lugol's solution, was agitated prior to removal of a 50ml subsample. This subsample was allowed to settle for 48 hours, after which 45ml of the overlying supernatant was carefully siphoned. The remaining 5ml was the working sample, which was agitated again to equally distribute the sample. After equally distributing the sample, 1ml was removed and placed in a Sedgewick-Rafter chamber and allowed to settle for 15 minutes prior to analysis. Sample density determined the number of transects analyzed; phytoplankton identifications were made during these transects. Counts were performed at 200x magnification. After the necessary number of transects were analyzed the entire chamber was scanned to identify any organisms not observed in the transects. Cell measurements were performed during this subsequent scan of the entire chamber. Phase contrast is primarily used during sample analysis but DIC contrasting techniques may also be employed for further identifications. Algae were reported to the genus or species level where possible. Diatoms were grouped into centric or pennate categories.

The resulting concentration factor from the settling procedure was 1:10. The calculated cell density was divided by this concentration factor prior to reporting. Samples demonstrating high cell density, such as bloom events, may be diluted prior to settling. In this case the calculated cell density was multiplied by the dilution factor prior to reporting.

Zooplankton samples and associated label information provided were transferred from plastic sample collection jars into glass vials. Sample volumes were standardized to 40 mls. Glass vials were placed in wooden racks for safety and longer-term storage. For samples containing more than 200 zooplankton specimens, calibrated pipettes were used to transfer sufficient aliquots to 1 ml Sedgwick-Rafter counting chambers and count and identify a minimum of 200 specimens using a Zeiss compound microscope at 65X – 400X. For samples containing less than 200 specimens, all specimens in the sample were counted and identified. Identifications were performed on all viewed zooplankton specimens, including mature and immature instars, to the species level with the exception of calanoid or cyclopoid nauplii. Abundant copepod and cladoceran species were further categorized into adult female, gravid female, male and immature instars. Identifications and enumerations were performed on all rare taxa in a sufficiently large subsample or the entire sample using a Wild stereo microscope (25x – 160x).

Quality control procedures

Quality control procedures for periphyton taxonomy involved the re-identification of diatoms and non-diatom algae from a randomly selected sample by an independent taxonomist. Re-identifications of diatoms and non-diatom algae were made internally at Rhithron. Bray-Curtis similarity statistics were generated by comparing the original identifications with the re-identifications, and adjustments to taxonomy were made where appropriate. Discrepancies in identifications were discussed, and rectifications were made to the data.

Quality control procedures for zooplankton taxonomy were based on synoptic digital photographs of the fauna encountered. Photos were exchanged between the contractor and a second taxonomist. Any discrepancies in identifications were discussed, and rectifications were made to the data.

Data analysis

Taxa lists and counts for each diatom sample were constructed. Standard metric calculations for periphyton assemblages were made using Rhithron's customized database software. Non-diatom algae identifications, relative abundances and biovolume rankings were compiled in Microsoft Excel.

Phytoplankton cell density and cellular biovolume were calculated. Individual cell density was calculated using the "Individual cell density field counts using Sedgewick-Rafter or Nannoplankton viewing chambers" equation. NCU density was calculated using the above mentioned formula and substituting the number of NCUs counted in place of the number of organisms counted in this equation. Cellular and NCU biovolumes were calculated according to the geometric equations presented in "Biovolume Calculation for Pelagic and Benthic Microalgae" (Hillebrand et. al 1999). Selected Hillebrand biovolume equations requiring the measurement of three dimensions were replaced by US EPA equations requiring the measurement of two dimensions.

Zooplankton abundance and relative proportions were calculated. The abundance (individuals per liter) of each species category in each sample were calculated using counts, sample depth and sampling net mouth opening. The relative proportion of each species in each sample was also calculated.

Phytoplankton and zooplankton sample results were compiled in Microsoft Excel.

RESULTS

Quality Control Procedures

Results of quality control procedures for zooplankton taxonomy are provided in the digital photographs of specimens on the photograph CD.

Data analysis

Taxa lists and counts, and values and scores for various standard bioassessment metrics and indices calculated by Rhithron are given in the Appendix.

Diatom and non-diatom algae identifications, phytoplankton and zooplankton sample results were sent to the PPL Project Manager via email.

A set of identified diatom slides, a photograph CD and hard copies of deliverables were shipped to the PPL Project Manager via US Mail.

REFERENCES

Bray, J. R. and J. T. Curtis. 1957. An ordination of upland forest communities of southern Wisconsin. Ecological Monographs 27: 325-349.

Hillebrand, H., Duerselen, C., Kirschtel, D., Pollingher, U., Zohary, T. 1999. Biovolume calculation for pelagic and benthic microalgae. Journal of Phycology 35: 403-424.

APPENDIX
Diatom taxa lists and metric summaries
Non-diatom algae identifications
Phytoplankton results
Zooplankton results
PPL Montana
Mystic Lake
2010

Taxa Listing

Project ID: **PPL10FP**
RAI No.: **PPL10FP008**

RAI No.: PPL10FP008 **Sta. Name:** Mystic Lake APH 2010
Client ID: Mystic Lake APH 2010
Date Coll.: 10/5/2010 **No. Jars:** 2 **STORET ID:**

Taxonomic Name	Count	PRA	Abnorm.	Comment
Diatoms				
Bacillariophyta				
Achnanthidium deflexum sp.	33	4.13%	0.00	
Achnanthidium gracillimum	75	9.38%	0.00	
Achnanthidium minutissimum	476	59.50%	0.00	
Brachysira microcephala	5	0.63%	0.00	
Cocconeis placentula	1	0.13%	0.00	
Cyclotella sp.	1	0.13%	0.00	
Cyclotella ocellata	9	1.13%	0.00	
Cymbella neocistula	3	0.38%	0.00	
Didymosphenia geminata	3	0.38%	0.00	
Encyonema minutum	15	1.88%	0.00	
Encyonema silesiacum	41	5.13%	0.00	
Fragilaria capucina v. gracilis	1	0.13%	0.00	
Fragilaria crotonensis	8	1.00%	0.00	
Fragilaria vaucheriae	69	8.63%	0.00	
Gomphonema sp.	3	0.38%	0.00	
Gomphonema minutum	3	0.38%	0.00	
Gomphonema olivaceoides	3	0.38%	0.00	
Hannaea arcus	11	1.38%	0.00	
Nitzschia angustata	11	1.38%	0.00	
Nitzschia fonticola	8	1.00%	0.00	
Nitzschia frustulum	8	1.00%	0.00	
Staurosira construens v. venter	5	0.63%	0.00	
Synedra ulna	5	0.63%	0.00	
Tabellaria fenestrata	3	0.38%	0.00	

Sample Count **800**

Taxa Listing

Project ID: PPL10FP
RAI No.: PPL10FP009

RAI No.: PPL10FP009 **Sta. Name:** Mystic Lake BPH 2010
Client ID: Mystic Lake BPH 2010
Date Coll.: 10/5/2010 **No. Jars:** 1 **STORET ID:**

Taxonomic Name	Count	PRA	Abnorm.	Comment
Diatoms				
Bacillariophyta				
Achnanthidium deflexum sp.	7	0.88%	0.00	
Achnanthidium gracillimum	71	8.88%	0.00	
Achnanthidium minutissimum	634	79.25%	0.00	
Achnanthidium rivulare	3	0.38%	0.00	
Brachysira microcephala	3	0.38%	0.00	
Cocconeis placentula	3	0.38%	0.00	
Cyclotella ocellata	12	1.50%	0.00	
Encyonema minutum	11	1.38%	0.00	
Encyonema silesiacum	3	0.38%	0.00	
Encyonopsis cesatii	3	0.38%	0.00	
Encyonopsis subminuta	5	0.63%	0.00	
Eucocconeis laevis	3	0.38%	0.00	
Fragilaria capucina v. gracilis	3	0.38%	0.00	
Fragilaria vaucheriae	17	2.13%	0.00	
Gomphonema olivaceum	5	0.63%	0.00	
Hannaea arcus	3	0.38%	0.00	
Navicula cryptotenella	4	0.50%	0.00	
Nitzschia frustulum	5	0.63%	0.00	
Synedra ulna	5	0.63%	0.00	

Sample Count **800**

Taxa Listing

Project ID: PPL10FP
RAI No.: PPL10FP010

RAI No.: PPL10FP010 **Sta. Name:** Mystic Lake BWRLD 2010
Client ID: Mystic Lake BWRLD 2010
Date Coll.: 10/15/2010 **No. Jars:** 1 **STORET ID:**

Taxonomic Name	Count	PRA	Abnorm.	Comment
Diatoms				
Bacillariophyta				
Achnanthidium deflexum sp.	4	0.50%	0.00	
Achnanthidium gracillimum	98	12.25%	0.00	
Achnanthidium minutissimum	301	37.63%	0.00	
Amphora inariensis	2	0.25%	0.00	
Amphora pediculus	2	0.25%	0.00	
Brachysira microcephala	50	6.25%	0.00	
Cyclostephanos invisitatus	1	0.13%	0.00	
Cyclotella ocellata	20	2.50%	0.00	
Denticula subtilis	6	0.75%	0.00	
Didymosphenia geminata	5	0.63%	0.00	
Diploneis ovalis	1	0.13%	0.00	
Encyonema minutum	18	2.25%	0.00	
Encyonema reichardtii	1	0.13%	0.00	
Encyonema silesiacum	15	1.88%	0.00	
Encyonema ventricosum	4	0.50%	0.00	
Encyonopsis cesatii	2	0.25%	0.00	
Eucocconeis flexella	13	1.63%	0.00	
Eucocconeis laevis	5	0.63%	0.00	
Fragilaria capucina v. gracilis	4	0.50%	0.00	
Fragilaria capucina v. mesolepta	2	0.25%	0.00	
Fragilaria crotonensis	11	1.38%	0.00	
Fragilaria vaucheriae	103	12.88%	0.00	
Gomphonema sp.	8	1.00%	0.00	
Gomphonema minusculum	5	0.63%	0.00	
Gomphonema olivaceum	2	0.25%	0.00	
Gomphonema truncatum	2	0.25%	0.00	
Hannaea arcus	25	3.13%	0.00	
Navicula cryptotenella	12	1.50%	0.00	
Nitzschia dissipata	4	0.50%	0.00	
Nitzschia frustulum	16	2.00%	0.00	
Nitzschia inconspicua	4	0.50%	0.00	
Nitzschia palea	2	0.25%	0.00	
Nitzschia perminuta	2	0.25%	0.00	
Staurosira construens v. venter	4	0.50%	0.00	
Synedra ulna	41	5.13%	0.00	
Tabellaria fenestrata	5	0.63%	0.00	
Sample Count	**800**			

Metrics Report

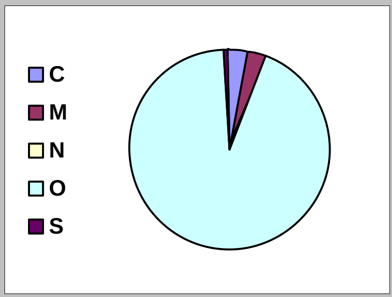
Project ID: PPL10FP
Sample ID: PPL10FP008
Station Name: Mystic Lake APH 2010
Client ID: Mystic Lake APH 2010
STORET ID:
Date Collected: 10/5/2010
Count Of Taxon: 24
Sum Of Count: 800

Table 1 Metrics

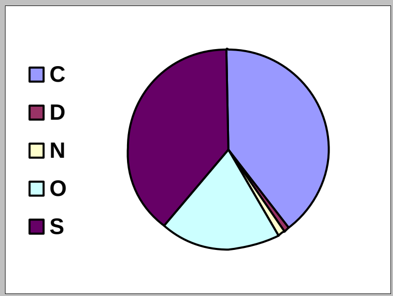
Metric	Value	MTM	MTP
Community Structure			
Shannon H (log2)	2.385	Good	Fair
Species Richness	24	Good	Fair
Native Taxa Percent	0.00%		
Cosmopolitan Taxa Percent	85.38%		
Mountains Rare Taxa Percent	0.00%		
Plains Rare Taxa Percent	4.13%		
Dominant Taxon Percent	59.50%	Fair	Fair
Sediment			
Siltation Taxa Percent	3.38%	Excellent	Excellent
Motile Taxa Percent	4.00%		
Mountains Brackish Taxa Percent	88.38%		
Plains Brackish Taxa Percent	1.88%		
Organic Nutrients			
Pollution Index	2.813	Excellent	Excellent
Nitrogen Heterotroph Taxa Percent	1.00%		
Polysaprobous Taxa Percent	16.25%		
Low DO Taxa Percent	0.00%		
Inorganic Nutrients			
Nitrogen Autotroph Taxa Percent	83.88%		
Eutraphentic Taxa Percent	10.13%		
Rhopalodiales Percent	0.00%		
Metals			
Disturbance Taxa Percent	59.50%	Fair	Fair
Acidophilous Taxa Percent	0.00%		
Metals Tolerant Taxa Percent	16.38%		
Abnormal Cells Percent	0.00%	Excellent	

Increaser/Decreaser Taxa

Metric	Value	Prob.
Mountains General Increasers Taxa Percent	3.63%	14.01%
Mountains Metals Increasers Taxa Percent	2.88%	4.55%
Mountains Nutrient Increasers Taxa Percent	0.13%	4.36%
Mountains Sediment Increasers Taxa Percent	0.63%	8.38%



Metric	Value	Prob.
Plains General Decreasers Taxa Percent	1.13%	87.90%
Plains General Increasers Taxa Percent	67.13%	99.22%



BioIndex	Description	Rating
MTM	Montana DEQ Mountains (Bahls 1992)	Fair
MTP	Montana DEQ Plains (Bahls 1992)	Fair

Metrics Report

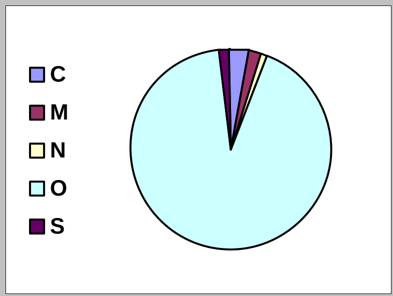
Project ID: PPL10FP
Sample ID: PPL10FP009
Station Name: Mystic Lake BPH 2010
Client ID: Mystic Lake BPH 2010
STORET ID:
Date Collected: 10/5/2010
Count Of Taxon: 19
Sum Of Count: 800

Table 1 Metrics

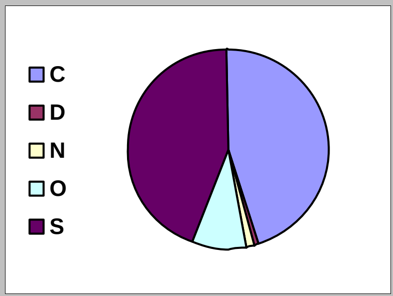
Metric	Value	MTM	MTP
Community Structure			
Shannon H (log2)	1.393	Fair	Poor
Species Richness	19	Fair	Poor
Native Taxa Percent	0.38%		
Cosmopolitan Taxa Percent	87.13%		
Mountains Rare Taxa Percent	0.38%		
Plains Rare Taxa Percent	0.88%		
Dominant Taxon Percent	79.25%	Poor	Poor
Sediment			
Siltation Taxa Percent	1.13%	Excellent	Excellent
Motile Taxa Percent	1.50%		
Mountains Brackish Taxa Percent	89.50%		
Plains Brackish Taxa Percent	2.25%		
Organic Nutrients			
Pollution Index	2.940	Excellent	Excellent
Nitrogen Heterotroph Taxa Percent	0.63%		
Polysaprobous Taxa Percent	4.50%		
Low DO Taxa Percent	0.00%		
Inorganic Nutrients			
Nitrogen Autotroph Taxa Percent	88.13%		
Eutraphentic Taxa Percent	3.75%		
Rhopalodiales Percent	0.00%		
Metals			
Disturbance Taxa Percent	79.25%	Poor	Poor
Acidophilous Taxa Percent	0.00%		
Metals Tolerant Taxa Percent	4.88%		
Abnormal Cells Percent	0.00%	Excellent	

Increaser/Decreaser Taxa

Metric	Value	Prob.
Mountains General Increasers Taxa Percent	3.63%	14.01%
Mountains Metals Increasers Taxa Percent	2.00%	4.01%
Mountains Nutrient Increasers Taxa Percent	1.00%	4.95%
Mountains Sediment Increasers Taxa Percent	1.88%	9.68%



Metric	Value	Prob.
Plains General Decreasers Taxa Percent	1.00%	88.10%
Plains General Increasers Taxa Percent	82.75%	99.38%



BioIndex	Description	Rating
MTM	Montana DEQ Mountains (Bahls 1992)	Poor
MTP	Montana DEQ Plains (Bahls 1992)	Poor

Metrics Report

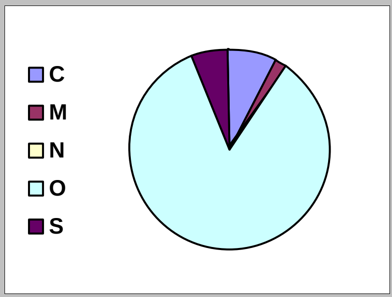
Project ID:	PPL10FP
Sample ID:	PPL10FP010
Station Name:	Mystic Lake BWRLD 20
Client ID:	Mystic Lake BWRLD 20
STORET ID:	
Date Collected:	10/15/2010
Count Of Taxon:	36
Sum Of Count:	800

Table 1 Metrics

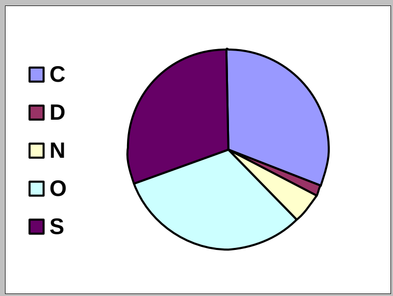
Metric	Value	MTM	MTP
Community Structure			
Shannon H (log2)	3.398	Excellent	Good
Species Richness	36	Excellent	Good
Native Taxa Percent	0.00%		
Cosmopolitan Taxa Percent	70.88%		
Mountains Rare Taxa Percent	0.00%		
Plains Rare Taxa Percent	0.50%		
Dominant Taxon Percent	37.63%	Good	Good
Sediment			
Siltation Taxa Percent	5.00%	Excellent	Excellent
Motile Taxa Percent	12.63%		
Mountains Brackish Taxa Percent	81.75%		
Plains Brackish Taxa Percent	5.63%		
Organic Nutrients			
Pollution Index	2.713	Excellent	Excellent
Nitrogen Heterotroph Taxa Percent	2.75%		
Polysaprobous Taxa Percent	23.38%		
Low DO Taxa Percent	0.25%		
Inorganic Nutrients			
Nitrogen Autotroph Taxa Percent	80.00%		
Eutraphentic Taxa Percent	16.13%		
Rhopalodiales Percent	0.00%		
Metals			
Disturbance Taxa Percent	37.63%	Good	Good
Acidophilous Taxa Percent	0.00%		
Metals Tolerant Taxa Percent	23.13%		
Abnormal Cells Percent	0.00%	Excellent	

Increaser/Decreaser Taxa

Metric	Value	Prob.
Mountains General Increasers Taxa Percent	8.63%	20.33%
Mountains Metals Increasers Taxa Percent	2.25%	4.18%
Mountains Sediment Increasers Taxa Percent	6.38%	16.11%



Metric	Value	Prob.
Plains General Decreasers Taxa Percent	2.25%	86.43%
Plains General Increasers Taxa Percent	49.13%	87.08%



BioIndex	Description	Rating
MTM	Montana DEQ Mountains (Bahls 1992)	Good
MTP	Montana DEQ Plains (Bahls 1992)	Good

PPL Montana : 2010 Non-Diatom Algae Determinations by Rhithron Associates, Inc.						
RAI Sample ID	**Client ID**	**Sample Date**	**Taxon**	**Division**	**Relative Abundance**	**Biovolume Rank**
PPL10FP008	Mystic Lake APH 2010	10/5/2010	*Spirogyra*	Chlorophyta	A	1
PPL10FP008	Mystic Lake APH 2010	10/5/2010	Diatoms	Bacillariophyta	A	2
PPL10FP008	Mystic Lake APH 2010	10/5/2010	*Zygnema*	Chlorophyta	F	3
PPL10FP008	Mystic Lake APH 2010	10/5/2010	*Klebsormidium*	Chlorophyta	C	4
PPL10FP008	Mystic Lake APH 2010	10/5/2010	*Ulothrix*	Chlorophyta	O	5
PPL10FP008	Mystic Lake APH 2010	10/5/2010	*Phormidium*	Cyanophyta	O	6
PPL10FP008	Mystic Lake APH 2010	10/5/2010	*Leptolyngbya* sp.2	Cyanophyta	F	7
PPL10FP008	Mystic Lake APH 2010	10/5/2010	*Tribonema*	Chrysophyta	O	8
PPL10FP008	Mystic Lake APH 2010	10/5/2010	*Heteroleibleinia*	Cyanophyta	F	9
PPL10FP008	Mystic Lake APH 2010	10/5/2010	*Homeothrix*	Cyanophyta	O	10
PPL10FP009	Mystic Lake BPH 2010	10/5/2010	Diatoms	Bacillariophyta	D	1
PPL10FP009	Mystic Lake BPH 2010	10/5/2010	*Zygnema*	Chlorophyta	A	2
PPL10FP009	Mystic Lake BPH 2010	10/5/2010	*Leptolyngbya* sp.2	Cyanophyta	F	3
PPL10FP009	Mystic Lake BPH 2010	10/5/2010	*Phormidium*	Cyanophyta	O	4
PPL10FP009	Mystic Lake BPH 2010	10/5/2010	*Cosmarium*	Chlorophyta	O	5
PPL10FP009	Mystic Lake BPH 2010	10/5/2010	*Homeothrix*	Cyanophyta	O	6
PPL10FP009	Mystic Lake BPH 2010	10/5/2010	*Leptolyngbya*	Cyanophyta	O	7
PPL10FP010	Mystic Lake BWRLD 2010	10/15/2010	Diatoms	Bacillariophyta	D	1
PPL10FP010	Mystic Lake BWRLD 2010	10/15/2010	*Phormidium*	Cyanophyta	A	2
PPL10FP010	Mystic Lake BWRLD 2010	10/15/2010	*Ulothrix*	Chlorophyta	C	3
PPL10FP010	Mystic Lake BWRLD 2010	10/15/2010	*Mougeotia*	Chlorophyta	O	4
PPL10FP010	Mystic Lake BWRLD 2010	10/15/2010	*Tolypothrix*	Cyanophyta	O	5
PPL10FP010	Mystic Lake BWRLD 2010	10/15/2010	*Leptolyngbya*	Cyanophyta	C	6
PPL10FP010	Mystic Lake BWRLD 2010	10/15/2010	*Schizothrix*	Cyanophyta	O	7
PPL10FP010	Mystic Lake BWRLD 2010	10/15/2010	*Klebsormidium*	Chlorophyta	O	8
PPL10FP010	Mystic Lake BWRLD 2010	10/15/2010	*Cosmarium*	Chlorophyta	O	9
PPL10FP010	Mystic Lake BWRLD 2010	10/15/2010	*Pediastrum*	Chlorophyta	R	10

Quantitative Phytoplankton Analysis
Rhithron Associates, Inc.
Mystic Lake 2010
8/3/2010

** designates scan results

Taxon Phyla	Genus Species	NCU Counted	Cells Counted	Calculated NCU NCU/ml	Calculated Cells Cells/ml	Ave. BV/Cell um^3/cell	Total BV/ml
Cyanophyta							
	Taxon Subtotal				**0**		**0**
Chlorophyta							
	Dictyosphaerium tetrachotomum	2	31	13	207	47	9,792
	Elekatothrix gelatinosa	2	4	13	27	23	602
	Taxon Subtotal				**233**		**10,394**
Chrysophyta							
	Dinobryon bavaricum	80	89	533	593	1,253	743,609
	Dinobryon sertularia	2	3	13	20	1,736	34,717
Bacillariophyceae							
	Asterionella formosa	9	63	60	420	669	280,980
	Cyclotella sp.	79	79	527	527	284	149,364
	Cyclotella sp.	110	110	733	733	926	679,262
	Cyclotella sp.	3	3	20	20	3,573	71,467
	Encyonema silesiacum**	1	1	<1	<1	320	32
	Fragilaria crotonensis**	2	35	<1	4	969	3,392
	Gomphonema sp.	1	1	7	7	1,316	8,777
	Navicula gregaria**	1	1	<1	<1	1,135	757
	Navicula sp.**	1	1	<1	<1	3,499	2,334
	Nitzschia sp.**	1	1	<1	<1	2,438	1,626
	Tabellaria fenestrata	10	1	67	7	2,343	15,631
	Tabellaria flocculosa**	1	1	<1	<1	2,769	1,938
	Taxon Subtotal				**2,330**		**1,993,886**
Cryptophyta							
	Cryptomonad	1	1	7	7	234	1,559
	Cryptomonas erosa	1	1	7	7	2,289	15,265
	Taxon Subtotal				**13**		**16,824**
Euglenophyta							
	Taxon Subtotal				**0**		**0**
Pyrrhophyta							
	Taxon Subtotal				**0**		**0**

Total BV um^3/ml	**2,021,104**
% Cyanophyta	0
% Chlorophyta	1
% Chrysophyta	99
% Cryptophyta	1
% Euglenophyta	0
% Pyrrhophyta	0

Total Cell Density cells/m	**2,577**
% Cyanophyta	0
% Chlorophyta	9
% Chrysophyta	90
% Cryptophyta	1
% Euglenophyta	0
% Pyrrhophyta	0

Zooplankton Analysis: PPL Montana Mystic Lake 2010	Rhithron Associates, Inc.	
Lake	MYSTIC	MYSTIC
Sample	**ML Zoo 1**	**ML Zoo 2**
Year	2010	2010
Month	AUGUST	AUGUST
Day	3	3
Time	13:00	13:00
Haul Depth m	33.3	33.3
Collector	RA	RA
Gear	NET	NET
S-Sample 1 Factor	41.67	62.5
S-Sample 2 Factor	19.2	19.2
S-Sample 3 Factor	1	1
Net Mouth Area cm2	615.8	615.8
Taxon	IND/LITER	IND/LITER
Diaptomus arapahoensis Dodds 1915		
Adult female	0.041	0.122
Gravid female	0.007	0.019
Adult male	0.009	0.009
Immature 1.0-1.5 mm	0.041	0.122
Immature 0.75-1.0 mm	0.264	1.372
Immature 0.50-0.75 mm	0.244	0.610
Immature <0.50 mm	0.081	0.213
Calanoid nauplii	1.179	1.493
Total Calanoida	**1.865**	**3.960**
Cyclops vernalis Fischer		
Adult male	0	0.009
Immature 0.50-0.75 mm	0.020	0.152
Immature <0.50 mm	0.183	0.274
Cyclopoid nauplii	0.284	0.518
Total Cyclopoida	**0.488**	**0.954**
Daphnia pulex Leydig		
Adult female 1.5 mm	0.019	0.091
Immature 1.0-1.5 mm	0.081	0.213
Immature 0.75-1.0 mm		0.061
Immature 0.50-0.75 mm	0.142	0.244
Total Cladocera	**0.242**	**0.610**
Total Crustaceans Ind/L	**2.595**	**5.524**
Digital Images		
DSC05272	D. arapahoensis imm. & D. pulex imm.	
DSC05273	D. arapahoensis females	
DSC05274	D. pulex female	
DSC05275	D. pules pecten on post abdominal claw	
DSC05276	Assorted	
DSC05277	D. pulex female	
DSC05278	D. arapahoensis male	
DSC05279	D. arapahoensis male 5th leg	
DSC05280	C. vernalis male	
DSC05281	C. vernalis male abdomen	

Analysis of biological samples:
Technical summary of methods and quality assurance procedures
Prepared for PPL Montana
Andy Welch, Project Manager
December 26, 2012

by
W. Bollman, Chief Biologist
Rhithron Associates, Inc.
Missoula, Montana

METHODS

Sample processing

Three periphyton samples, one phytoplankton sample and two zooplankton samples collected from Mystic Lake were delivered to Rhithron's laboratory facility in Missoula, Montana on October 11, 2012. All samples arrived in good condition. An inventory document containing sample identification information was provided by the PPL Montana (PPL) Project Manager. Upon arrival, samples were unpacked and examined, and checked against the PPL inventory. No discrepancies were noted.

The phytoplankton sample was repackaged and shipped to Karl Bruun, Nostoca Algae Laboratory, for sample analysis. Zooplankton samples were repackaged and shipped to Alex Salki, Salki Consultants Inc., for sample analysis.

The periphyton samples, preserved with Lugol's solution, were topped-off upon arrival at the laboratory. The samples were thoroughly mixed by shaking. Permanent diatom slides were prepared: subsamples were taken and treated with concentrated H_2SO_4 and 30% H_2O_2. The samples were neutralized by rinses with distilled water, and subsample volumes were adjusted to obtain adequate densities. Small amounts of each sample were dried onto 22-mm square coverslips. Coverslips were mounted on slides using Naphrax diatom mount. To ensure a high quality mount for identification and to make replicates available for archives, 3 slide mounts were made from each sample. One of the replicates was selected from each sample batch for identification. A diamond scribe mark was made to define a transect line on the cover slip, and a minimum of 800 diatom valves were identified along the transect mark. A Leica DM 2500 compound microscope, Nomarski contrast, and 1000x magnification were used for identifications. Diatoms were identified to the lowest possible taxonomic level, generally species, following standard taxonomic references.

For the soft-bodied (non-diatom) algae samples, the raw periphyton sample was manually homogenized and emptied into a porcelain evaporating dish. A small, random subsample of algal material was pipetted onto a standard glass microscope slide using a disposable dropper or soda straw. Visible (macroscopic) algae were also sub-sampled, in proportion to their estimated importance relative to the total volume of algal material in the sample, and added to the liquid fraction on the slide. The wet mount was then covered with a 22X30 mm cover slip.

Soft-bodied (non-diatom) algae were identified to genus using an Olympus BHT compound microscope under 200X and 400X. The relative abundance of each algal genus (and of all diatom genera collectively) was estimated for comparative purposes, and abundances were expressed according to the following system:

- rare (r): represented by a single occurrence in the sub-sample
- occasional (o): multiple occurrences, but infrequently seen
- common (c): multiple occurrences, regularly seen
- frequent (f): present in nearly every field of view
- abundant (a): multiple occurrences in every field of view, but well within limits of enumeration
- dominant (d): multiple occurrences in every field of view, but generally beyond practical limits of enumeration

Soft-bodied genera (and the diatom component) were also ranked according to their estimated contribution to the total algal biovolume present in the sample.

The phytoplankton sample, preserved with Lugol's solution, was agitated prior to removal of a 50ml subsample. This subsample was allowed to settle for 48 hours, after which 45ml of the overlying supernatant was carefully siphoned. The remaining 5ml was the working sample, which was agitated again to equally distribute the sample. After equally distributing the sample, 1ml was removed and placed in a Sedgewick-Rafter chamber and allowed to settle for 15 minutes prior to analysis. Sample density determined the number of transects analyzed; phytoplankton identifications were made during these transects. Counts were performed at 200x magnification. After the necessary number of transects were analyzed the entire chamber was scanned to identify any organisms not observed in the transects. Cell measurements were performed during this subsequent scan of the entire chamber. Phase contrast is primarily used during sample analysis but DIC contrasting techniques may also be employed for further identifications. Algae were reported to the genus or species level where possible. Diatoms were grouped into centric or pennate categories.

The resulting concentration factor from the settling procedure was 1:10. The calculated cell density was divided by this concentration factor prior to reporting. Samples demonstrating high cell density, such as bloom events, may be diluted prior to settling. In this case the calculated cell density was multiplied by the dilution factor prior to reporting.

Zooplankton samples and associated label information provided were transferred from plastic sample collection jars into glass vials. Sample volumes were standardized to 40 mls. Glass vials were placed in wooden racks for safety and longer-term storage. For samples containing more than 200 zooplankton specimens, calibrated pipettes were used to transfer sufficient aliquots to 1 ml Sedgwick-Rafter counting chambers and count and identify a minimum of 200 specimens using a Zeiss compound microscope at 65X – 400X. For samples containing less than 200 specimens, all specimens in the sample were counted and identified. Identifications were performed on all viewed zooplankton specimens, including mature and immature instars, to the species level with the exception of calanoid or cyclopoid nauplii. Abundant copepod and cladoceran species were further categorized into adult female, gravid female, male and immature instars. Identifications and enumerations were performed on all rare taxa in a sufficiently large subsample or the entire sample using a Wild stereo microscope (25x – 160x).

Quality control procedures

Quality control procedures for zooplankton taxonomy were based on synoptic digital photographs of the fauna encountered. Photos were exchanged between the contractor and a second taxonomist. Any discrepancies in identifications were discussed, and rectifications were made to the data.

Data analysis

Taxa lists and counts for each diatom sample were constructed. Standard metric calculations for periphyton assemblages were made using Rhithron's customized database software. Non-diatom algae identifications, relative abundances and biovolume rankings were compiled in Microsoft Excel.

Phytoplankton cell density and cellular biovolume were calculated. Individual cell density was calculated using the "Individual cell density field counts using Sedgewick-Rafter or Nannoplankton viewing chambers" equation. NCU density was calculated using the above mentioned formula and substituting the number of NCUs counted in place of the number of organisms counted in this equation. Cellular and NCU biovolumes were calculated according to the geometric equations presented in "Biovolume Calculation for Pelagic and Benthic Microalgae" (Hillebrand et. al 1999). Selected Hillebrand biovolume equations requiring the measurement of three dimensions were replaced by US EPA equations requiring the measurement of two dimensions.

Zooplankton abundance and relative proportions were calculated. The abundance (individuals per liter) of each species category in each sample were calculated using counts, sample depth and sampling net mouth opening. The relative proportion of each species in each sample was also calculated.

Phytoplankton and zooplankton sample results were compiled in Microsoft Excel.

RESULTS

Quality Control Procedures

Results of quality control procedures for zooplankton taxonomy are provided in the digital photographs of specimens on the photograph CD.

Data analysis

Taxa lists and counts, and values and scores for various standard bioassessment metrics and indices calculated by Rhithron are given in the Appendix.

Diatom and non-diatom algae identifications, phytoplankton and zooplankton sample results were sent to the PPL Project Manager via email.

A set of identified diatom slides and a photograph CD were shipped to the PPL Project Manager.

REFERENCES

Bray, J. R. and J. T. Curtis. 1957. An ordination of upland forest communities of southern Wisconsin. Ecological Monographs 27: 325-349.

Hillebrand, H., Duerselen, C., Kirschtel, D., Pollingher, U., Zohary, T. 1999. Biovolume calculation for pelagic and benthic microalgae. Journal of Phycology 35: 403-424.

APPENDIX
Diatom taxa lists and metric summaries
Non-diatom algae identifications
Phytoplankton results
Zooplankton results

PPL Montana
Mystic Lake
2012

Taxa Listing

Project ID: PPL12FP
RAI No.: PPL12FP008

RAI No.: PPL12FP008 **Sta. Name:** Mystic Lake APH 2012
Client ID: Mystic Lake APH
Date Coll.: 10/2/2012 **No Jars:** 1 **STORET ID:**
Sample Notes:

Taxonomic Name	Count	PRA	Abnorm.	Comment
Diatoms				
Bacillariophyta				
Achnanthidium gracillimum	137	17.13%	0	
Achnanthidium minutissimum	518	64.75%	0	
Achnanthidium pyrenaicum	2	0.25%	0	
Cocconeis placentula	3	0.38%	0	
Cocconeis pseudolineata	2	0.25%	0	
Cyclotella ocellata	5	0.63%	0	
Cymbella delicatula	8	1.00%	0	
Cymbella excisa	2	0.25%	0	
Cymbella excisiformis	1	0.13%	0	
Cymbella neocistula	4	0.50%	0	
Diatoma mesodon	2	0.25%	0	
Didymosphenia geminata	3	0.38%	0	
Encyonema minutum	6	0.75%	0	
Encyonema silesiacum	35	4.38%	0	
Eucocconeis flexella	2	0.25%	0	
Fragilaria capucina v. gracilis	2	0.25%	0	
Fragilaria vaucheriae	9	1.13%	0	
Gomphonema sp.	7	0.88%	0	
Gomphonema minutum	1	0.13%	0	
Hannaea arcus	24	3.00%	0	
Navicula cryptotenella	2	0.25%	0	
Nitzschia sp.	8	1.00%	0	
Nitzschia fonticola	2	0.25%	0	
Nitzschia inconspicua	6	0.75%	0	
Planothidium frequentissimum	2	0.25%	0	
Reimeria sinuata	1	0.13%	0	
Staurosira construens v. venter	4	0.50%	0	
Stephanocyclus meneghiniana	2	0.25%	0	

Sample Count **800**

Taxa Listing

Project ID: PPL12FP
RAI No.: PPL12FP009

RAI No.: PPL12FP009 **Sta. Name:** Mystic Lake BPH 2012
Client ID: Mystic Lake BPH
Date Coll.: 10/2/2012 **No Jars:** 1 **STORET ID:**
Sample Notes:

Taxonomic Name	Count	PRA	Abnorm.	Comment
Diatoms				
Bacillariophyta				
Achnanthidium gracillimum	97	12.13%	0	
Achnanthidium minutissimum	565	70.63%	0	
Achnanthidium pyrenaicum	2	0.25%	0	
Asterionella formosa	6	0.75%	0	
Brachysira microcephala	5	0.63%	0	
Cyclotella ocellata	2	0.25%	0	
Cymbella delicatula	1	0.13%	0	
Cymbella excisa	2	0.25%	0	
Cymbella excisiformis	2	0.25%	0	
Didymosphenia geminata	1	0.13%	0	
Encyonema minutum	3	0.38%	0	
Encyonema silesiacum	6	0.75%	0	
Eucocconeis flexella	4	0.50%	0	
Eucocconeis laevis	1	0.13%	0	
Eunotia sp.	3	0.38%	0	
Fragilaria capucina v. gracilis	2	0.25%	0	
Fragilaria crotonensis	9	1.13%	0	
Fragilaria vaucheriae	47	5.88%	0	
Gomphonema sp.	10	1.25%	0	
Gomphonema olivaceoides	1	0.13%	0	
Hannaea arcus	5	0.63%	0	
Navicula cryptotenella	3	0.38%	0	
Nitzschia sp.	4	0.50%	0	
Nitzschia dissipata	2	0.25%	0	
Nitzschia fonticola	5	0.63%	0	
Synedra ulna	2	0.25%	0	
Tabellaria flocculosa	10	1.25%	0	

Sample Count 800

Taxa Listing

Project ID: PPL12FP
RAI No.: PPL12FP010

RAI No.: PPL12FP010 **Sta. Name:** Mystic Lake BWRL 2012
Client ID: Mystic Lake BWRL
Date Coll.: 10/3/2012 **No Jars:** 1 **STORET ID:**
Sample Notes:

Taxonomic Name	Count	PRA	Abnorm.	Comment
Diatoms				
Bacillariophyta				
Achnanthidium gracillimum	93	11.63%	0	
Achnanthidium minutissimum	562	70.25%	0	
Brachysira microcephala	33	4.13%	0	
Cyclotella ocellata	3	0.38%	0	
Cymbella delicatula	2	0.25%	0	
Cymbella hustedtii	2	0.25%	0	
Discostella glomerata	2	0.25%	0	
Encyonema minutum	14	1.75%	0	
Encyonema silesiacum	7	0.88%	0	
Encyonopsis subminuta	2	0.25%	0	
Eucocconeis flexella	4	0.50%	0	
Eucocconeis laevis	2	0.25%	0	
Eunotia sp.	5	0.63%	0	
Fragilaria capucina v. gracilis	4	0.50%	0	
Fragilaria crotonensis	4	0.50%	0	
Fragilaria vaucheriae	24	3.00%	0	
Geissleria paludosa	2	0.25%	0	
Gomphonema sp.	4	0.50%	0	
Gomphonema parvulum	1	0.13%	0	
Hannaea arcus	2	0.25%	0	
Navicula cryptotenella	3	0.38%	0	
Navicula pseudolanceolata	3	0.38%	0	
Nitzschia sp.	6	0.75%	0	
Nitzschia fonticola	2	0.25%	0	
Nitzschia pura	2	0.25%	0	
Planothidium frequentissimum	1	0.13%	0	
Psammothidium daonense	3	0.38%	0	
Rossithidium pusillum	2	0.25%	0	
Staurosira construens v. venter	1	0.13%	0	
Staurosirella pinnata	1	0.13%	0	
Synedra ulna	2	0.25%	0	
Tabellaria flocculosa	2	0.25%	0	

Sample Count 800

Metrics Report

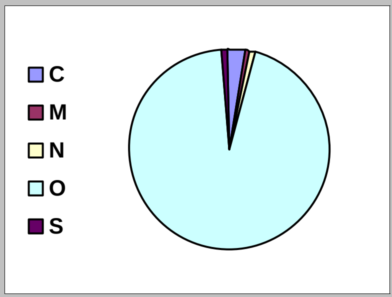
Project ID: PPL12FP
Sample ID: PPL12FP008
Station Name: Mystic Lake APH 2012
Client ID: Mystic Lake APH
STORET ID:
Date Collected: 10/2/2012
Count Of Taxon: 28
Sum Of Count: 800

Table 1 Metrics

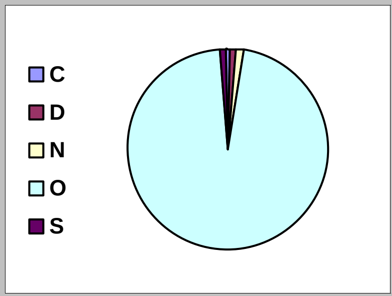
Metric	Value	MTM	MTP
Community Structure			
Shannon H (log2)	1.998	Fair	Poor
Species Richness	28	Good	Fair
Native Taxa Percent	0.25%		
Cosmopolitan Taxa Percent	77.13%		
Mountains Rare Taxa Percent	0.00%		
Plains Rare Taxa Percent	0.00%		
Dominant Taxon Percent	64.75%	Fair	Fair
Sediment			
Siltation Taxa Percent	2.25%	Excellent	Excellent
Motile Taxa Percent	2.38%		
Mountains Brackish Taxa Percent	79.00%		
Plains Brackish Taxa Percent	2.13%		
Organic Nutrients			
Pollution Index	2.910	Excellent	Excellent
Nitrogen Heterotroph Taxa Percent	1.00%		
Polysaprobous Taxa Percent	7.50%		
Low DO Taxa Percent	0.25%		
Inorganic Nutrients			
Nitrogen Autotroph Taxa Percent	78.38%		
Eutraphentic Taxa Percent	3.13%		
Rhopalodiales Percent	0.00%		
Metals			
Disturbance Taxa Percent	17.38%	Excellent	Excellent
Acidophilous Taxa Percent	0.00%		
Metals Tolerant Taxa Percent	6.75%		
Abnormal Cells Percent	0.00%	Excellent	

Increaser/Decreaser Taxa

Metric	Value	Prob.
Mountains General Increasers Taxa Percent	2.75%	12.92%
Mountains Metals Increasers Taxa Percent	1.25%	3.59%
Mountains Nutrient Increasers Taxa Percent	0.50%	4.55%
Mountains Sediment Increasers Taxa Percent	1.00%	8.69%



Metric	Value	Prob.
Plains General Decreasers Taxa Percent	0.63%	88.49%
Plains General Increasers Taxa Percent	1.25%	1.07%



BioIndex	Description	Rating
MTM	Montana DEQ Mountains (Bahls 1992)	Fair
MTP	Montana DEQ Plains (Bahls 1992)	Poor

Metrics Report

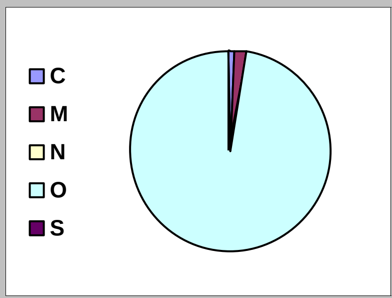
Project ID: PPL12FP
Sample ID: PPL12FP009
Station Name: Mystic Lake BPH 2012
Client ID: Mystic Lake BPH
STORET ID:
Date Collected: 10/2/2012
Count Of Taxon: 27
Sum Of Count: 800

Table 1 Metrics

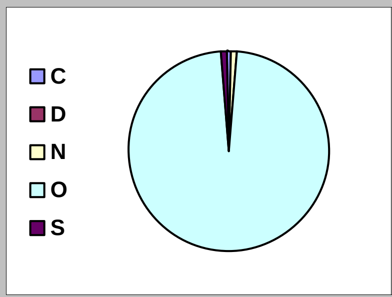
Metric	Value	MTM	MTP
Community Structure			
Shannon H (log2)	1.804	Fair	Poor
Species Richness	27	Good	Fair
Native Taxa Percent	0.25%		
Cosmopolitan Taxa Percent	83.13%		
Mountains Rare Taxa Percent	0.00%		
Plains Rare Taxa Percent	0.00%		
Dominant Taxon Percent	70.63%	Fair	Fair
Sediment			
Siltation Taxa Percent	1.75%	Excellent	Excellent
Motile Taxa Percent	2.38%		
Mountains Brackish Taxa Percent	85.38%		
Plains Brackish Taxa Percent	2.38%		
Organic Nutrients			
Pollution Index	2.916	Excellent	Excellent
Nitrogen Heterotroph Taxa Percent	0.00%		
Polysaprobous Taxa Percent	7.25%		
Low DO Taxa Percent	0.00%		
Inorganic Nutrients			
Nitrogen Autotroph Taxa Percent	84.75%		
Eutraphentic Taxa Percent	6.13%		
Rhopalodiales Percent	0.00%		
Metals			
Disturbance Taxa Percent	12.38%	Excellent	Excellent
Acidophilous Taxa Percent	1.25%		
Metals Tolerant Taxa Percent	7.25%		
Abnormal Cells Percent	0.00%	Excellent	

Increaser/Decreaser Taxa

Metric	Value	Prob.
Mountains General Increasers Taxa Percent	1.50%	11.70%
Mountains Metals Increasers Taxa Percent	1.25%	3.59%
Mountains Nutrient Increasers Taxa Percent	0.25%	4.46%



Metric	Value	Prob.
Plains General Increasers Taxa Percent	1.25%	1.07%



BioIndex	Description	Rating
MTM	Montana DEQ Mountains (Bahls 1992)	Fair
MTP	Montana DEQ Plains (Bahls 1992)	Poor

Metrics Report

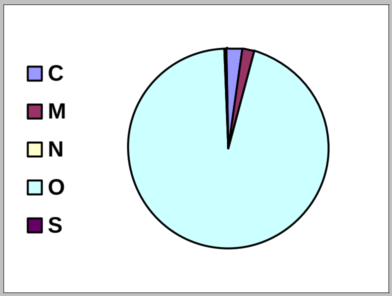
Project ID: PPL12FP
Sample ID: PPL12FP010
Station Name: Mystic Lake BWRL 201
Client ID: Mystic Lake BWRL
STORET ID:
Date Collected: 10/3/2012
Count Of Taxon: 32
Sum Of Count: 800

Table 1 Metrics

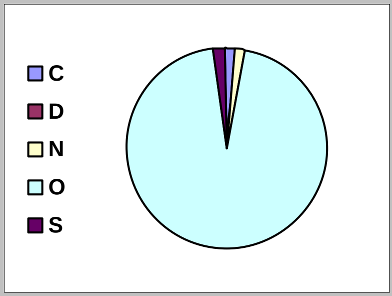
Metric	Value	MTM	MTP
Community Structure			
Shannon H (log2)	1.902	Fair	Poor
Species Richness	32	Excellent	Good
Native Taxa Percent	0.00%		
Cosmopolitan Taxa Percent	78.25%		
Mountains Rare Taxa Percent	0.00%		
Plains Rare Taxa Percent	0.00%		
Dominant Taxon Percent	70.25%	Fair	Fair
Sediment			
Siltation Taxa Percent	2.25%	Excellent	Excellent
Motile Taxa Percent	6.38%		
Mountains Brackish Taxa Percent	86.00%		
Plains Brackish Taxa Percent	1.88%		
Organic Nutrients			
Pollution Index	2.914	Excellent	Excellent
Nitrogen Heterotroph Taxa Percent	0.13%		
Polysaprobous Taxa Percent	6.13%		
Low DO Taxa Percent	0.13%		
Inorganic Nutrients			
Nitrogen Autotroph Taxa Percent	85.25%		
Eutraphentic Taxa Percent	3.13%		
Rhopalodiales Percent	0.00%		
Metals			
Disturbance Taxa Percent	11.63%	Excellent	Excellent
Acidophilous Taxa Percent	0.25%		
Metals Tolerant Taxa Percent	6.38%		
Abnormal Cells Percent	0.00%	Excellent	

Increaser/Decreaser Taxa

Metric	Value	Prob.
Mountains General Increasers Taxa Percent	2.50%	12.71%
Mountains Metals Increasers Taxa Percent	2.38%	4.27%
Mountains Nutrient Increasers Taxa Percent	0.38%	4.55%
Mountains Sediment Increasers Taxa Percent	0.25%	7.93%



Metric	Value	Prob.
Plains General Increasers Taxa Percent	2.13%	1.26%



BioIndex	Description	Rating
MTM	Montana DEQ Mountains (Bahls 1992)	Fair
MTP	Montana DEQ Plains (Bahls 1992)	Poor

Tuesday, December 18, 2012

PPL Montana : 2012 Non-Diatom Algae Determinations by Rhithron Associates, Inc.						
RAI Sample ID	**Client ID**	**Sample Date**	**Taxon**	**Division**	**Relative Abundance**	**Biovolume Rank**
PPL12FP008	Mystic Lake APH	10/2/2012	Diatoms	Bacillariophyta	D	1
PPL12FP008	Mystic Lake APH	10/2/2012	*Ulothrix*	Chlorophyta	F	2
PPL12FP008	Mystic Lake APH	10/2/2012	*Phormidium*	Cyanophyta	C	3
PPL12FP008	Mystic Lake APH	10/2/2012	*Homeothrix*	Cyanophyta	O	4
PPL12FP008	Mystic Lake APH	10/2/2012	*Stigeoclonium*	Chlorophyta	O	5
PPL12FP008	Mystic Lake APH	10/2/2012	*Heteroleibleinia*	Cyanophyta	O	6
PPL12FP008	Mystic Lake APH	10/2/2012	*Cladophora*	Chlorophyta	R	7
PPL12FP008	Mystic Lake APH	10/2/2012	*Scenedesmus*	Chlorophyta	R	8
PPL12FP009	Mystic Lake BPH	10/2/2012	Diatoms	Bacillariophyta	D	1
PPL12FP009	Mystic Lake BPH	10/2/2012	*Ulothrix*	Chlorophyta	O	2
PPL12FP009	Mystic Lake BPH	10/2/2012	*Homeothrix*	Cyanophyta	O	3
PPL12FP009	Mystic Lake BPH	10/2/2012	*Phormidium*	Cyanophyta	O	4
PPL12FP009	Mystic Lake BPH	10/2/2012	*Chroococcus*	Cyanophyta	O	5
PPL12FP009	Mystic Lake BPH	10/2/2012	*Stigeoclonium*	Chlorophyta	R	6
PPL12FP009	Mystic Lake BPH	10/2/2012	*Pseudanabaena*	Cyanophyta	R	7
PPL12FP009	Mystic Lake BPH	10/2/2012	*Cosmarium*	Chlorophyta	R	8
PPL12FP009	Mystic Lake BPH	10/2/2012	*Merismopedia*	Cyanophyta	R	9
PPL12FP010	Mystic Lake BWRL	10/3/2012	Diatoms	Bacillariophyta	D	1
PPL12FP010	Mystic Lake BWRL	10/3/2012	*Spirogyra*	Chlorophyta	O	2
PPL12FP010	Mystic Lake BWRL	10/3/2012	*Phormidium*	Cyanophyta	O	3
PPL12FP010	Mystic Lake BWRL	10/3/2012	*Merismopedia*	Cyanophyta	R	4
PPL12FP010	Mystic Lake BWRL	10/3/2012	*Cosmarium*	Chlorophyta	R	5
PPL12FP010	Mystic Lake BWRL	10/3/2012	*Tribonema*	Chrysophyta	R	6
PPL12FP010	Mystic Lake BWRL	10/3/2012	*Gloeocapsa*	Cyanophyta	R	7
PPL12FP010	Mystic Lake BWRL	10/3/2012	*Staurastrum*	Chlorophyta	R	8
PPL12FP010	Mystic Lake BWRL	10/3/2012	*Scenedesmus*	Chlorophyta	R	9

Quantitative Phytoplankton Analysis
Rhithron Associates, Inc.
Mystic Lake 2012
8/7/2012

Analysis Date
November 17, 2012
** designates scan results

Taxon Phyla	Genus Species	NCU Counted	Cells Counted	Calculated NCU NCU/ml	Calculated Cells Cells/ml	Ave. BV/Cell um^3/cell	Total BV/ml
Cyanophyta							
	Aphanothece**	1	42	1	42	47	1,970
	Microcystis cf. wesenbergii**	2	51	2	51	113	5,768
	Taxon Subtotal				**93**		**7,738**
Chlorophyta							
	Cosmarium depressum**	1	1	1	1	3,434	3,434
	Dictyosphaerium tetrachotomum**	4	49	4	49	39	1,929
	Elakatothrix	1	1	13	13	18	243
	Planktosphaeria gelatinosa**	5	5	5	5	212	1,061
	Raphidocelis subcapitata	168	168	2,220	2,220	6	14,073
	Sphaerocystis schroeteri	1	70	13	925	180	166,103
	Taxon Subtotal				**3,213**		**186,843**
Chrysophyta							
	Dinobryon bavaricum	17	17	225	225	1,762	395,792
	Dinobryon sertularia	2	2	26	26	2,321	61,356
Bacillariophyceae							
	Achnanthes	1	1	13	13	164	2,167
	Achnanthidium minutissima**	1	1	1	1	103	103
	Asterionella formosa	7	35	92	462	368	169,950
	Cyclotella	2	2	26	26	142	3,761
	Cyclotella	17	17	225	225	464	104,145
	Cyclotella	6	6	79	79	828	65,641
	Encyonema**	2	2	2	2	218	437
	Encyonema**	1	1	1	1	1,185	1,185
	Gomphonema**	1	1	1	1	3,297	3,297
	Navicula capitatoradiata**	1	1	1	1	510	510
	Navicula cf. cryptocephala	1	1	13	13	878	11,602
	Rhopalodia gibba**	1	1	1	1	1,620	1,620
	Synedra cf. ulna	2	2	26	26	1,495	39,518
	Synedra**	1	1	1	1	350	350
	Tabellaria fenestrata**	7	39	7	39	2,924	114,031
	Taxon Subtotal				**1,144**		**975,465**
Cryptophyta							
	Cryptomonas erosa**	1	1	1	1	2,452	2,452
	Rhodomonas minuta	3	3	40	40	473	18,762
	Taxon Subtotal				**41**		**21,214**
Euglenophyta							
	Taxon Subtotal				**0**		**0**
Pyrrhophyta							
	Taxon Subtotal				**0**		**0**
Undetermined							
	Unknown Cyanobacteria Filament**	1	1	1	1	17	17
	Taxon Subtotal				**1**		**17**
Xanthophyta							
	Taxon Subtotal				**0**		**0**

Total BV um^3/ml	**1,191,277**
% Cyanophyta	1
% Chlorophyta	16
% Chrysophyta	82
% Cryptophyta	2
% Euglenophyta	0
% Pyrrhophyta	0
% Undetermined	0
% Xanthophyta	0

Total Cell Density cells/ml	**4,491**
% Cyanophyta	2
% Chlorophyta	72
% Chrysophyta	25
% Cryptophyta	1
% Euglenophyta	0
% Pyrrhophyta	0
% Undetermined	0
% Xanthophyta	0

Zooplankton Analysis: PPL Montana Mystic Lake 2012	Rhithron Associates, Inc.	
Lake	MYSTIC	MYSTIC
Station	**1**	**2**
Year	2012	2012
Month	JULY	JULY
Day	8	8
Depth	10	10
Collector	PPL	PPL
Gear	WJ	WJ
Subsample Fraction 1	80	80
Subsample Fraction 2	10.5	10.5
Subsample Fraction 3	1	1
Net Mouth Opening cm2	102.6	102.6
INSTAR IDENTIFICATION & SIZE CLASSES	IND/LITER	IND/LITER
Diaptomus pribilofensis Juday and Muttkowski		
D. pribilofensis female	0.102	0.102
D. pribilofenis gravid female	0.010	0.102
D. pribilofensis male	0.000	0.000
D. pribilofensis immature 1.2mm	1.559	0.780
D. pribilofensis immature 1.0mm	5.458	13.255
D. pribilofensis immature 0.75mm	1.559	2.339
D. pribilofensis immature 0.5mm	0.780	1.559
Total D. pribilofensis	**9.469**	**9.469**
Calanoid nauplii	**10.916**	**10.916**
Acanthocyclops vernalis immature?	**4.678**	**1.559**
Cyclopoid nauplii	**6.238**	**3.119**
Daphnia pulex-schoedleri		
D. pulex-schoedleri 2.0mm	0.000	0.307
D. pulex-schoederi 1.5mm	0.716	0.512
D. pulex-schoedleri 1.0mm	0.614	0.205
D. pulex-schoedleri 0.5mm	0.780	2.339
Total D. pulex-schoedleri	**2.110**	**3.363**
Filinia sps	**60.039**	**78.752**
Keratella sps	**0.780**	**0.000**
Polyarthra sps	**0.780**	**0.780**
Conochilus sps	**451.462**	**629.240**
Gastropus sps	**17.934**	**28.070**
Kellicotia sps	**2.339**	**9.357**
Total Individuals per Liter	**566.745**	**783.294**
Total individuals ennumerated/identified	741	1015
Digital Images		
DSC 334	D. pribilofensis immature	
DSC 335	Conochilus sps	
DSC 336	Conochilus sps	
DSC 337	Calanoid nauplii	

Digital Images		
DSC 338	Conochilus colony	
DSC 339	Gastropus sps	
DSC 340	A. vernalis immature	
DSC 342	D. pulex-shoedleri	
DSC 343	D. pribilofensis female	
DSC 344	Mixture under Stereo	
DSC 345	D. pribilofensis gravid female	

Analysis of biological samples:
Technical summary of methods and quality assurance procedures
Prepared for NorthWestern Energy
Andy Welch, Project Manager
December 24, 2015

by
W. Bollman, Chief Biologist
Rhithron Associates, Inc.
Missoula, Montana

METHODS

Sample processing

Three periphyton samples, one phytoplankton sample and two zooplankton samples collected from Mystic Lake were delivered to Rhithron's laboratory facility in Missoula, Montana. The phytoplankton and zooplankton samples were delivered on September 25, 2015; the periphyton samples were delivered on October 16, 2015. All samples arrived in good condition. An inventory document containing sample identification information was provided by the NorthWestern Energy (NWE) Project Manager. Upon arrival, samples were unpacked and examined, and checked against the NWE inventory. No discrepancies were noted.

The periphyton samples, preserved with Lugol's solution, were topped-off upon arrival at the laboratory. Samples were thoroughly mixed by shaking. Permanent diatom slides were prepared: subsamples were taken and treated with 70% Nitric acid (HNO_3) and digested using a closed-vessel microwave digestion system (Milestone Ethos EZ), following the method developed by the Academy of Natural Sciences of Drexel University for the USGS NAWQA program (Charles et al. 2002). Samples were neutralized by rinses with distilled water, and subsample volumes were adjusted to obtain adequate densities. Small amounts of each sample were dried onto 22-mm square coverslips. Coverslips were mounted on slides using Naphrax diatom mount. To ensure a high quality mount for identification and to make replicates available for archives, 3 slide mounts were made from each sample. One of the replicates was selected from each sample batch for identification. A diamond scribe mark was made to define a transect line on the cover slip, and a minimum of 800 diatom valves were identified along the transect mark. A Leica DM 2500 compound microscope, Nomarski contrast, and 1000x magnification were used for identifications. Diatoms were identified to the lowest possible taxonomic level, generally species, following standard taxonomic references.

For the soft-bodied (non-diatom) algae samples, the raw periphyton sample was manually homogenized and emptied into a porcelain evaporating dish. A small, random subsample of algal material was pipetted onto a standard glass microscope slide using a disposable pasture pipette. Visible (macroscopic) algae were also sub-sampled, in proportion to their estimated importance relative to the total volume of algal material in the sample, and added to the liquid fraction on the slide. The wet mount was then covered with a 22X30 mm cover slip.

Soft-bodied (non-diatom) algae were identified to genus using a Leica DM 2500 compound microscope under 200X and 400X. The relative abundance of each algal genus (and of all diatom genera collectively) was estimated for comparative purposes, according to the following system (consistent with updated Montana DEQ data requirements):

- rare (R): fewer than 1 cell per field of view at 200X, on the average;
- common (C): at least 1 but fewer than 5 cells per field of view;
- very common (VC): between 5 and 25 cells per field of view;
- abundant (A): more than 25 cells per field of view, but countable;
- very abundant (VA): number of cells per field of view too numerous to count.

Soft-bodied genera (and the diatom component) were also ranked according to their estimated contribution to the total algal biovolume present in the sample. The genus with the most biomass ranked number 1; the genus with the next most biomass ranked number 2, and so on. Rare (R) taxa were recorded with a biomass rank of 0.

The phytoplankton sample was concentrated (2.5:45) to achieve ample cell density. Calibrated pipettes were used to transfer sufficient aliquots to Palmer-Maloney counting cells. Phytoplankton identifications were made during systematic microscopic examination of whole transects across the counting cells. A minimum of 300 natural counting units (NCUs) were identified. Cell morphometry was measured during counts and identifications, which were performed at 400x or greater magnification.

Zooplankton samples were concentrated by centrifuging a 50mL subsample. Supernatant (47.5mL) was decanted. Calibrated pipettes were used to transfer sufficient aliquots to Palmer-Maloney counting cells. A minimum of 1000 specimens were counted and identified, using a Leica DM2500 compound microscope at varying magnifications.

Data analysis

Taxa lists and counts for each diatom sample were constructed. Standard metric calculations for periphyton assemblages were made using Rhithron's customized database software. Non-diatom algae identifications, relative abundances and biovolume rankings were compiled in Microsoft Excel.

Phytoplankton cell density and cellular biovolume were calculated using equations published in Charles et al. (2002). NCU density was calculated similarly, substituting the number of NCUs counted in place of the number of organisms counted in this equation. Cellular biovolumes were calculated using published morphometric equations (Hillebrand et. al 1999).

Zooplankton abundance and relative proportions were calculated. Phytoplankton and zooplankton sample results were compiled in Microsoft Excel.

RESULTS

Data analysis

Taxa lists and counts, and values and scores for various standard bioassessment metrics and indices calculated by Rhithron are given in the Appendix.

Diatom and non-diatom algae identifications, phytoplankton and zooplankton sample results were sent to the NWE Project Manager via email.

A set of identified diatom slides were shipped to the NWE Project Manager.

REFERENCES

Charles, D., C. Knowles, and R.S. Davis. 2002. Protocols for the analysis of algal samples collected as part of the U.S. Geological Survey National Water-Quality Assessment Program. The Academy of Natural Sciences Patrick Center for Environmental Research: Report No. 02-06. May 2002.

Hillebrand, H., C. Duerselen, D. Kirschtel, U. Pollingher and T. Zohary. 1999. Biovolume calculation for pelagic and benthic microalgae. Journal of Phycology 35: 403-424.

APPENDIX
Diatom taxa lists and metric summaries
Non-diatom algae identifications
Phytoplankton results
Zooplankton results

NorthWestern Energy
Mystic Lake
2015

Taxa Listing

Project ID: PPL15FP2
RAI No.: PPL15FP2001

RAI No.: PPL15FP2001 **Sta. Name:** Mystic Lake APH 2015
Client ID: Mystic Lake APH
Date Coll.: 10/6/2015 **No Jars:** 1 **STORET ID:**
Sample Notes: 3:30:00 PM

Taxonomic Name	Count	PRA	Abnorm.	Comment
Diatoms				
Bacillariophyta				
Achnanthidium deflexum	2	0.25%	0	
Achnanthidium gracillimum	79	9.86%	1	
Achnanthidium minutissimum	504	62.92%	0	
Achnanthidium pyrenaicum	7	0.87%	0	
Achnanthidium thienemannii	21	2.62%	0	
Asterionella formosa	1	0.12%	0	
Cocconeis placentula	2	0.25%	0	
Cyclotella ocellata	1	0.12%	0	
Cymbella subturgidula	2	0.25%	0	
Delicata delicatula	37	4.62%	0	
Didymosphenia geminata	2	0.25%	0	
Encyonema minutum	17	2.12%	0	
Encyonema silesiacum	28	3.50%	0	
Encyonema ventricosum	6	0.75%	0	
Eucocconeis flexella	3	0.37%	0	
Fragilaria capucina	1	0.12%	0	
Fragilaria capucina v. gracilis	1	0.12%	0	
Fragilaria vaucheriae	25	3.12%	0	
Gomphonema sp.	2	0.25%	0	
Hannaea arcus	4	0.50%	0	
Navicula sp.	2	0.25%	0	
Nitzschia sp.	2	0.25%	0	
Nitzschia angustata	5	0.62%	0	
Nitzschia bryophila	12	1.50%	0	
Nitzschia fonticola	10	1.25%	0	
Nitzschia frustulum	6	0.75%	0	
Nitzschia inconspicua	9	1.12%	0	
Nitzschia microcephala	2	0.25%	0	
Nitzschia palea	1	0.12%	0	
Nitzschia sublinearis	1	0.12%	0	
Psammothidium daonense	1	0.12%	0	
Reimeria sinuata	4	0.50%	0	
Staurosirella pinnata	1	0.12%	0	
Sample Count	**801**			

Taxa Listing

Project ID: PPL15FP2
RAI No.: PPL15FP2002

RAI No.: PPL15FP2002 **Sta. Name:** Mystic Lake BPH 2015
Client ID: Mystic Lake BPH
Date Coll.: 10/7/2015 **No Jars:** 1 **STORET ID:**
Sample Notes: 9:00:00 AM

Taxonomic Name	Count	PRA	Abnorm.	Comment
Diatoms				
Bacillariophyta				
Achnanthidium gracillimum	103	12.84%	0	
Achnanthidium minutissimum	401	50.00%	2	
Achnanthidium pyrenaicum	5	0.62%	0	
Asterionella formosa	3	0.37%	0	
Brachysira microcephala	12	1.50%	0	
Cyclotella atomus	2	0.25%	0	
Cyclotella ocellata	4	0.50%	0	
Cymbella sp.	4	0.50%	0	
Delicata delicatula	2	0.25%	0	
Didymosphenia geminata	1	0.12%	0	
Encyonema minutum	20	2.49%	0	
Encyonema silesiacum	16	2.00%	0	
Encyonopsis montana	9	1.12%	0	
Encyonopsis subminuta	6	0.75%	0	
Eucocconeis flexella	1	0.12%	0	
Eucocconeis laevis	3	0.37%	0	
Fragilaria sp.	1	0.12%	0	
Fragilaria capucina	9	1.12%	0	
Fragilaria capucina v. gracilis	6	0.75%	0	
Fragilaria crotonensis	35	4.36%	0	
Fragilaria vaucheriae	90	11.22%	0	
Gomphoneis sp.	2	0.25%	0	
Gomphonema sp.	2	0.25%	0	
Gomphonema parvulum	1	0.12%	0	
Hannaea arcus	22	2.74%	0	
Navicula cryptotenella	1	0.12%	0	
Nitzschia bryophila	4	0.50%	0	
Nitzschia fonticola	11	1.37%	0	
Nitzschia frustulum	2	0.25%	0	
Nitzschia inconspicua	4	0.50%	0	
Nitzschia palea	2	0.25%	0	
Nitzschia perminuta	2	0.25%	0	
Nupela lapidosa	1	0.12%	0	
Platessa conspicua	2	0.25%	0	
Psammothidium subatomoides	1	0.12%	0	
Reimeria sinuata	3	0.37%	0	
Tabellaria fenestrata	2	0.25%	0	
Tabellaria flocculosa	2	0.25%	0	
Ulnaria ulna	5	0.62%	0	
Sample Count	**802**			

Taxa Listing

Project ID: PPL15FP2
RAI No.: PPL15FP2003

RAI No.: PPL15FP2003 **Sta. Name:** Mystic Lake BWRL 2015
Client ID: Mystic Lake BWRL
Date Coll.: 10/6/2015 **No Jars:** 1 **STORET ID:**
Sample Notes: 12:45:00 PM

Taxonomic Name	Count	PRA	Abnorm.	Comment
Diatoms				
Bacillariophyta				
Achnanthidium gracillimum	133	16.63%	0	
Achnanthidium minutissimum	371	46.38%	0	
Achnanthidium pyrenaicum	3	0.38%	0	
Achnanthidium rivulare	15	1.88%	0	
Amphora acutiuscula	1	0.13%	0	new name is Halamphora latecostata, DOTUS
Amphora inariensis	1	0.13%	0	
Amphora pediculus	2	0.25%	0	
Asterionella formosa	1	0.13%	0	
Brachysira microcephala	13	1.63%	0	
Cyclotella ocellata	6	0.75%	0	
Delicata delicatula	2	0.25%	0	
Denticula tenuis	3	0.38%	0	
Discostella pseudostelligera	2	0.25%	0	
Encyonema minutum	15	1.88%	0	
Encyonema silesiacum	3	0.38%	0	
Encyonopsis subminuta	2	0.25%	0	
Eucocconeis flexella	2	0.25%	0	
Eucocconeis laevis	4	0.50%	0	
Fragilaria sp.	6	0.75%	0	
Fragilaria capucina	15	1.88%	0	
Fragilaria capucina v. gracilis	3	0.38%	0	
Fragilaria crotonensis	23	2.88%	0	
Fragilaria famelica	3	0.38%	0	
Fragilaria vaucheriae	28	3.50%	0	
Fragilariforma sp.	16	2.00%	0	
Geissleria sp.	1	0.13%	0	
Geissleria acceptata	1	0.13%	0	
Gomphonema subclavatum	2	0.25%	0	
Halamphora tumida	1	0.13%	0	
Hannaea arcus	6	0.75%	0	
Navicula cryptotenella	11	1.38%	0	
Navicula densilineolata	2	0.25%	0	
Nitzschia acicularis	3	0.38%	0	
Nitzschia angustata	2	0.25%	0	
Nitzschia bryophila	3	0.38%	0	
Nitzschia fonticola	3	0.38%	0	
Nitzschia inconspicua	9	1.13%	0	
Nitzschia microcephala	5	0.63%	0	
Nitzschia perminuta	2	0.25%	0	
Nitzschia pura	8	1.00%	0	
Nitzschia sublinearis	2	0.25%	0	

Taxa Listing

Project ID: PPL15FP2
RAI No.: PPL15FP2003

RAI No.: PPL15FP2003 **Sta. Name:** Mystic Lake BWRL 2015
Client ID: Mystic Lake BWRL
Date Coll.: 10/6/2015 **No Jars:** 1 **STORET ID:**
Sample Notes: 12:45:00 PM

Taxonomic Name	Count	PRA	Abnorm.	Comment
Opephora olsenii	1	0.13%	0	
Planothidium frequentissimum	2	0.25%	0	
Planothidium lanceolatum	1	0.13%	0	
Platessa conspicua	1	0.13%	0	
Pseudostaurosira brevistriata	21	2.63%	0	
Pseudostaurosira robusta	1	0.13%	0	
Staurosira construens v. venter	19	2.38%	0	
Staurosirella pinnata	11	1.38%	0	
Tabellaria fenestrata	2	0.25%	0	
Ulnaria ulna	7	0.88%	0	

Sample Count **800**

Metrics Report

Project ID:	PPL15FP2
Sample ID:	PPL15FP2001
Station Name:	Mystic Lake APH 2015
Client ID:	Mystic Lake APH
STORET ID:	
Date Collected:	10/6/2015
Count Of Taxon:	33
Sum Of Count:	801

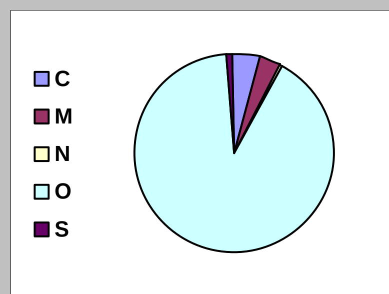
Metrics (Bahls 1993)

Metric	Value	MTM	MTP
Community Structure			
Shannon H (log2)	2.365	Good	Fair
Species Richness	33	Excellent	Good
Native Taxa Percent	1.12%		
Cosmopolitan Taxa Percent	77.03%		
Mountains Rare Taxa Percent	0.25%		
Plains Rare Taxa Percent	0.25%		
Dominant Taxon Percent	62.92%	Fair	Fair
Sediment			
Siltation Taxa Percent	6.24%	Excellent	Excellent
Motile Taxa Percent	6.74%		
Mountains Brackish Taxa Percent	79.28%		
Plains Brackish Taxa Percent	2.00%		
Organic Nutrients			
Pollution Index	2.792	Excellent	Excellent
Nitrogen Heterotroph Taxa Percent	2.25%		
Polysaprobous Taxa Percent	10.99%		
Low DO Taxa Percent	0.12%		
Inorganic Nutrients			
Nitrogen Autotroph Taxa Percent	78.03%		
Eutraphentic Taxa Percent	5.62%		
Rhopalodiales Percent	0.00%		
Metals			
Disturbance Taxa Percent	62.92%	Fair	Fair
Acidophilous Taxa Percent	0.00%		
Metals Tolerant Taxa Percent	9.11%		
Abnormal Cells Percent	0.12%	Good	

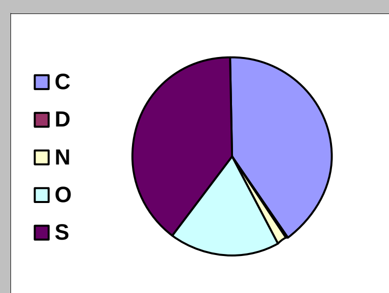
BioIndex	Description	Rating
MTM	Montana DEQ Mountains (Bahls 1992)	Fair
MTP	Montana DEQ Plains (Bahls 1992)	Fair

Increaser/Decreaser Taxa (Teply and Bahls 2005)

Metric	Value	Prob.
Mountains General Increasers Taxa Percent	4.99%	15.63%
Mountains Metals Increasers Taxa Percent	3.50%	4.95%
Mountains Nutrient Increasers Taxa Percent	0.25%	4.46%
Mountains Sediment Increasers Taxa Percent	1.25%	9.01%



Metric	Value	Prob.
Plains General Decreasers Taxa Percent	1.25%	87.70%
Plains General Increasers Taxa Percent	68.54%	99.38%



Dominant Taxa

Category	A	PRA
Achnanthidium minutissimum	504	62.92%
Achnanthidium gracillimum	79	9.86%
Delicata delicatula	37	4.62%
Encyonema silesiacum	28	3.50%
Fragilaria vaucheriae	25	3.12%
Achnanthidium thienemannii	21	2.62%
Encyonema minutum	17	2.12%
Nitzschia bryophila	12	1.50%
Nitzschia fonticola	10	1.25%
Nitzschia inconspicua	9	1.12%

Wednesday, December 23, 2015

Metrics Report

Project ID: PPL15FP2
Sample ID: PPL15FP2002
Station Name: Mystic Lake BPH 2015
Client ID: Mystic Lake BPH
STORET ID:
Date Collected: 10/7/2015
Count Of Taxon: 39
Sum Of Count: 802

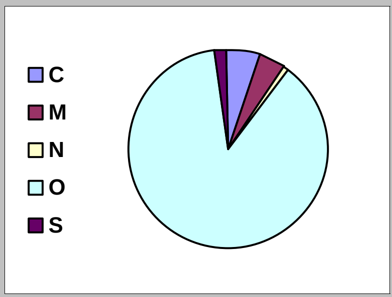
Metrics (Bahls 1993)

Metric	Value	MTM	MTP
Community Structure			
Shannon H (log2)	2.880	Good	Fair
Species Richness	39	Excellent	Good
Native Taxa Percent	0.87%		
Cosmopolitan Taxa Percent	78.43%		
Mountains Rare Taxa Percent	0.00%		
Plains Rare Taxa Percent	0.00%		
Dominant Taxon Percent	50.00%	Fair	Fair
Sediment			
Siltation Taxa Percent	3.24%	Excellent	Excellent
Motile Taxa Percent	5.11%		
Mountains Brackish Taxa Percent	82.29%		
Plains Brackish Taxa Percent	2.12%		
Organic Nutrients			
Pollution Index	2.792	Excellent	Excellent
Nitrogen Heterotroph Taxa Percent	1.12%		
Polysaprobous Taxa Percent	17.46%		
Low DO Taxa Percent	0.37%		
Inorganic Nutrients			
Nitrogen Autotroph Taxa Percent	80.55%		
Eutraphentic Taxa Percent	12.59%		
Rhopalodiales Percent	0.00%		
Metals			
Disturbance Taxa Percent	50.00%	Fair	Fair
Acidophilous Taxa Percent	0.50%		
Metals Tolerant Taxa Percent	17.96%		
Abnormal Cells Percent	0.25%	Good	

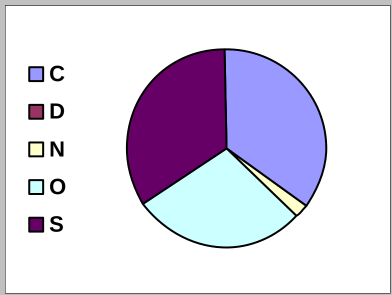
BioIndex	Description	Rating
MTM	Montana DEQ Mountains (Bahls 1992)	Fair
MTP	Montana DEQ Plains (Bahls 1992)	Fair

Increaser/Decreaser Taxa (Teply and Bahls 2005)

Metric	Value	Prob.
Mountains General Increasers Taxa Percent	6.11%	16.85%
Mountains Metals Increasers Taxa Percent	4.61%	5.82%
Mountains Nutrient Increasers Taxa Percent	0.87%	4.85%
Mountains Sediment Increasers Taxa Percent	2.12%	10.03%



Metric	Value	Prob.
Plains General Decreasers Taxa Percent	0.50%	88.69%
Plains General Increasers Taxa Percent	55.24%	94.18%



Dominant Taxa

Category	A	PRA
Achnanthidium minutissimum	401	50.00%
Achnanthidium gracillimum	103	12.84%
Fragilaria vaucheriae	90	11.22%
Fragilaria crotonensis	35	4.36%
Hannaea arcus	22	2.74%
Encyonema minutum	20	2.49%
Encyonema silesiacum	16	2.00%
Brachysira microcephala	12	1.50%
Nitzschia fonticola	11	1.37%
Encyonopsis montana	9	1.12%

Metrics Report

Project ID: PPL15FP2
Sample ID: PPL15FP2003
Station Name: Mystic Lake BWRL 2015
Client ID: Mystic Lake BWRL
STORET ID:
Date Collected: 10/6/2015
Count Of Taxon: 51
Sum Of Count: 800

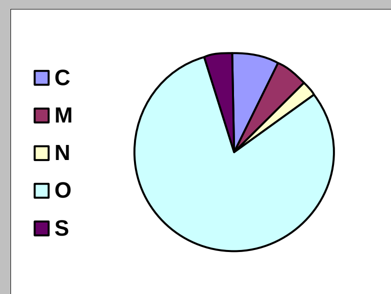
Metrics (Bahls 1993)

Metric	Value	MTM	MTP
Community Structure			
Shannon H (log2)	3.293	Excellent	Good
Species Richness	51	Excellent	Excellent
Native Taxa Percent	2.25%		
Cosmopolitan Taxa Percent	69.25%		
Mountains Rare Taxa Percent	1.88%		
Plains Rare Taxa Percent	0.00%		
Dominant Taxon Percent	46.38%	Good	Good
Sediment			
Siltation Taxa Percent	6.50%	Excellent	Excellent
Motile Taxa Percent	9.13%		
Mountains Brackish Taxa Percent	74.88%		
Plains Brackish Taxa Percent	2.88%		
Organic Nutrients			
Pollution Index	2.831	Excellent	Excellent
Nitrogen Heterotroph Taxa Percent	2.13%		
Polysaprobous Taxa Percent	9.13%		
Low DO Taxa Percent	0.38%		
Inorganic Nutrients			
Nitrogen Autotroph Taxa Percent	69.75%		
Eutraphentic Taxa Percent	6.00%		
Rhopalodiales Percent	0.00%		
Metals			
Disturbance Taxa Percent	46.38%	Good	Good
Acidophilous Taxa Percent	0.00%		
Metals Tolerant Taxa Percent	8.13%		
Abnormal Cells Percent	0.00%	Excellent	

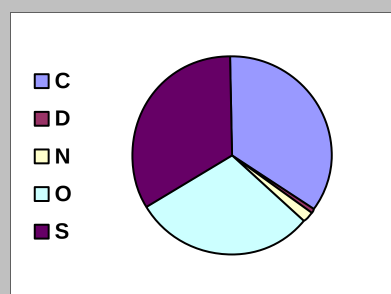
BioIndex	Description	Rating
MTM	Montana DEQ Mountains (Bahls 1992)	Good
MTP	Montana DEQ Plains (Bahls 1992)	Good

Increaser/Decreaser Taxa (Teply and Bahls 2005)

Metric	Value	Prob.
Mountains General Increasers Taxa Percent	8.75%	20.61%
Mountains Metals Increasers Taxa Percent	6.50%	7.35%
Mountains Nutrient Increasers Taxa Percent	2.88%	6.30%
Mountains Sediment Increasers Taxa Percent	5.13%	14.23%



Metric	Value	Prob.
Plains General Decreasers Taxa Percent	0.88%	88.10%
Plains General Increasers Taxa Percent	53.88%	92.92%



Dominant Taxa

Category	A	PRA
Achnanthidium minutissimum	371	46.38%
Achnanthidium gracillimum	133	16.63%
Fragilaria vaucheriae	28	3.50%
Fragilaria crotonensis	23	2.88%
Pseudostaurosira brevistriata	21	2.63%
Staurosira construens v. venter	19	2.38%
Fragilariforma	16	2.00%
Fragilaria capucina	15	1.88%
Encyonema minutum	15	1.88%
Achnanthidium rivulare	15	1.88%

NorthWestern Energy : 2015 Mystic Lake Non-Diatom Algae
Determinations by Rhithron Associates, Inc.

RAI Sample ID	Client ID	Sample Date	Taxon	Division	Relative Abundance	Biovolume Rank
PPL15FP2001	Mystic Lake APH	10/6/2015	*Spirogyra*	Chlorophyta	A	1
PPL15FP2001	Mystic Lake APH	10/6/2015	*Oedogonium*	Chlorophyta	VC	2
PPL15FP2001	Mystic Lake APH	10/6/2015	Diatoms	Bacillariophyta	A	3
PPL15FP2001	Mystic Lake APH	10/6/2015	*Klebsormidium*	Chlorophyta	C	4
PPL15FP2001	Mystic Lake APH	10/6/2015	*Homoeothrix*	Cyanophyta	C	5
PPL15FP2001	Mystic Lake APH	10/6/2015	*Chamaesiphon*	Cyanophyta	VC	6
PPL15FP2001	Mystic Lake APH	10/6/2015	*Chroococcus*	Cyanophyta	C	7
PPL15FP2001	Mystic Lake APH	10/6/2015	*Leptolyngbya*	Cyanophyta	C	8
PPL15FP2001	Mystic Lake APH	10/6/2015	*Heteroleibleinia*	Cyanophyta	VC	9
PPL15FP2001	Mystic Lake APH	10/6/2015	*Ulothrix*	Chlorophyta	R	0
PPL15FP2001	Mystic Lake APH	10/6/2015	*Calothrix*	Cyanophyta	R	0
PPL15FP2001	Mystic Lake APH	10/6/2015	*Zygnema*	Chlorophyta	R	0
PPL15FP2001	Mystic Lake APH	10/6/2015	*Phormidium*	Cyanophyta	R	0
PPL15FP2001	Mystic Lake APH	10/6/2015	*Chantransia*	Rhodophyta	R	0
PPL15FP2001	Mystic Lake APH	10/6/2015	*Cosmarium*	Chlorophyta	R	0
PPL15FP2002	Mystic Lake BPH	10/7/2015	*Phormidium*	Cyanophyta	VA	1
PPL15FP2002	Mystic Lake BPH	10/7/2015	*Ulothrix*	Chlorophyta	VC	2
PPL15FP2002	Mystic Lake BPH	10/7/2015	Diatoms	Bacillariophyta	VA	3
PPL15FP2002	Mystic Lake BPH	10/7/2015	*Cosmarium*	Chlorophyta	VC	4
PPL15FP2002	Mystic Lake BPH	10/7/2015	*Calothrix*	Cyanophyta	C	5
PPL15FP2002	Mystic Lake BPH	10/7/2015	*Sphaerocystis*	Chlorophyta	C	6
PPL15FP2002	Mystic Lake BPH	10/7/2015	*Planktosphaeria*	Chlorophyta	C	7
PPL15FP2002	Mystic Lake BPH	10/7/2015	*Oedogonium*	Chlorophyta	R	0
PPL15FP2002	Mystic Lake BPH	10/7/2015	*Tribonema*	Chrysophyta	R	0
PPL15FP2002	Mystic Lake BPH	10/7/2015	*Spirogyra*	Chlorophyta	R	0
PPL15FP2002	Mystic Lake BPH	10/7/2015	*Scenedesmus*	Chlorophyta	R	0
PPL15FP2002	Mystic Lake BPH	10/7/2015	*Stigeoclonium*	Chlorophyta	R	0
PPL15FP2002	Mystic Lake BPH	10/7/2015	*Microcystis*	Cyanophyta	R	0
PPL15FP2002	Mystic Lake BPH	10/7/2015	*Hydrococcus*	Cyanophyta	R	0
PPL15FP2002	Mystic Lake BPH	10/7/2015	*Heteroleibleinia*	Cyanophyta	R	0
PPL15FP2002	Mystic Lake BPH	10/7/2015	*Aphanocapsa*	Cyanophyta	R	0
PPL15FP2002	Mystic Lake BPH	10/7/2015	*Symploca*	Cyanophyta	R	0
PPL15FP2002	Mystic Lake BPH	10/7/2015	*Chroococcus*	Cyanophyta	R	0
PPL15FP2002	Mystic Lake BPH	10/7/2015	*Spondylosium*	Chlorophyta	R	0
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Spirogyra*	Chlorophyta	A	1
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Ulothrix*	Chlorophyta	C	2
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Oedogonium*	Chlorophyta	C	3
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Phormidium*	Cyanophyta	VC	4
PPL15FP2003	Mystic Lake BWRL	10/6/2015	Diatoms	Bacillariophyta	VA	5
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Cosmarium*	Chlorophyta	C	6
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Crucigeniella*	Chlorophyta	C	7
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Planktosphaeria*	Chlorophyta	C	8
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Leptolyngbya*	Cyanophyta	R	0
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Symploca*	Cyanophyta	R	0
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Stigeoclonium*	Chlorophyta	R	0
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Staurastrum*	Chlorophyta	R	0
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Spondylosium*	Chlorophyta	R	0
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Scenedesmus*	Chlorophyta	R	0
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Pseudanabaena*	Cyanophyta	R	0
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Pleurotaenium*	Chlorophyta	R	0
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Klebsormidium*	Chlorophyta	R	0
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Merismopedia*	Cyanophyta	R	0
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Ankistrodesmus*	Chlorophyta	R	0
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Homoeothrix*	Cyanophyta	R	0
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Desmidium*	Chlorophyta	R	0
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Chantransia*	Rhodophyta	R	0
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Monoraphidium*	Chlorophyta	R	0
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Heteroleibleinia*	Cyanophyta	R	0

NorthWestern Energy : 2015 Mystic Lake Non-Diatom Algae Determinations by Rhithron Associates, Inc.						
RAI Sample ID	**Client ID**	**Sample Date**	**Taxon**	**Division**	**Relative Abundance**	**Biovolume Rank**
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Chamaesiphon*	Cyanophyta	R	0
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Woronichinia*	Cyanophyta	R	0
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Aphanocapsa*	Cyanophyta	R	0
PPL15FP2003	Mystic Lake BWRL	10/6/2015	*Dinobryon*	Chrysophyta	R	0

NorthWestern Energy Mystic Lake 2015 Phytoplankton Determinations by Rhithron Associates, Inc.		PPL15FPH001 Mid Lake 2015 8/4/2015				
Taxon		**NCUCounted**	**CellsCounted**	**NCUCounted_mL**	**CellsCounted_mL**	**Biovolume_um3/mL**
Bacillariophyta	*Achnanthidium*	1	1	0.0005	0.0005	0.1475
	Asterionella formosa	4	12	0.0021	0.0063	3.3467
	Cyclotella	18	18	0.0094	0.0094	5.6915
	Epithemia sorex	1	1	0.0005	0.0005	0.6079
	Fragilaria crotonensis	15	31	0.0079	0.0162	18.8154
	Melosira varians	1	2	0.0005	0.0010	6.9317
	Navicula	2	2	0.0010	0.0010	2.9289
	Tabellaria flocculosa	6	8	0.0031	0.0042	4.7172
Chlorophyta	*Cosmarium*	1	1	0.0005	0.0005	9.9560
	Elakatothrix gelatinosa	30	40	0.0157	0.0209	1.3274
	Monoraphidium	1	1	0.0005	0.0005	0.0047
	Planktosphaeria gelatinosa	4	4	0.0021	0.0021	0.0558
Chrysophyta	*Dinobryon sertularia*	65	74	0.0340	0.0387	13.0358
Cryptophyta	*Cryptomonas erosa*	15	15	0.0079	0.0079	36.5667
	Rhodomonas minuta	74	74	0.0387	0.0387	7.5000
Pyrrophyta	*Gymnodinium*	112	112	0.0586	0.0586	3475.5237
	TOTALS	**350**	**396**	**0.1830**	**0.2070**	**3587.1569**

NorthWestern Energy Mystic Lake 2015 Zooplankton Determinations by Rhithron Associates, Inc.		PPL15FPZ001 Mid Lake 2015 8/4/2015		PPL15FPZ002 Mid Lake 2015 8/4/2015	
Taxon		**Count**	**Count_mL**	**Count**	**Count_mL**
Cladocera	Bosminidae	25	0.0022	12	0.0008
	Daphnia	47	0.0042	54	0.0036
Copepoda	Calanoida	1	0.0001		
	Copepoda: nauplius	35	0.0031	52	0.0034
	Cyclopidae	10	0.0009	17	0.0011
Rotifera	*Asplanchna*	18	0.0016	35	0.0023
	Conochilus	408	0.0361	380	0.0250
	Filinia longiseta	3	0.0003	15	0.0010
	Kellicottia bostoniensis	93	0.0082	126	0.0083
	Keratella	102	0.0090	100	0.0066
	Synchaeta	278	0.0246	222	0.0146
	TOTALS	**1020**	**0.0903**	**1013**	**0.0667**

Analysis of biological samples:
Technical summary of methods
Prepared for NorthWestern Energy
Jordan Tollefson, Project Manager
December 20, 2018

by
W. Bollman, Chief Biologist
Rhithron Associates, Inc.
Missoula, Montana

METHODS

Sample processing

Three periphyton samples, 1 phytoplankton sample and 2 zooplankton samples collected for the Mystic Lake project were delivered to Rhithron's laboratory facility in Missoula, Montana. Samples arrived in 2 separate deliveries: the first delivery included the phytoplankton sample and the zooplankton samples and arrived on August 23, 2018; the second delivery included the periphyton samples and arrived on October 24, 2018. An inventory document containing sample identification information was provided by the NorthWestern Energy (NWE) Project Manager. Upon arrival, samples were unpacked and examined, and checked against the NWE inventory. Sample metadata was uploaded to the Rhithron database.

The periphyton samples were preserved with Lugol's solution, and initial sample volumes were measured and recorded. The samples were thoroughly mixed by shaking, and split into 2 aliquots for diatom and soft-bodied algae analyses.

Permanent diatom slides were prepared: subsamples were taken and treated with 70% Nitric acid (HNO_3) and digested using a closed-vessel microwave digestion system (Milestone Ethos EZ), following the method developed by the Academy of Natural Sciences, Philadelphia (ANSP 2002). The samples were neutralized by rinses with distilled water, and subsample volumes were adjusted to obtain adequate densities for slide mounts. Dilution and concentration factors, as appropriate, were recorded for each sample. Subsamples were dried onto 22-mm square coverslips. Coverslips were mounted on slides using Naphrax diatom mount. To ensure a high quality mount for identification and to make replicates available for archives, 3 slide mounts were made from each sample. One of the replicates was selected from each sample batch for identification. A diamond scribe mark was made to define a transect line on the cover slip, and a minimum of 800 diatom valves were identified along the transect mark. A Leica DM 2500 compound microscope, Nomarski contrast, and 1000x magnification were used for identifications. Diatoms were identified to the lowest possible taxonomic level, generally species, following standard taxonomic references.

For the soft-bodied (non-diatom) algae samples, the raw periphyton sample was manually homogenized and emptied into a porcelain evaporating dish. A small, random subsample of algal material was pipetted into a standard Palmer-Maloney counting chamber using a disposable Pasteur pipette. Visible (macroscopic) algae were also sub-sampled, in proportion to their estimated importance relative to the total volume of algal material in the sample, and added to the liquid fraction on the slide. The Palmer-Maloney cell was then covered with a 22 x 30 mm coverslip.

Soft-bodied (non-diatom) algae were identified to genus using a Leica DM 2500 compound microscope under 200X and 400X magnification. The relative abundance of each algal genus (and of all diatom genera collectively) was estimated for comparative purposes, according to the following system (consistent with updated Montana DEQ data requirements):

- rare (R): fewer than 1 cell per field of view at 200X, on the average;
- common (C): at least 1 but fewer than 5 cells per field of view;
- very common (VC): between 5 and 25 cells per field of view;
- abundant (A): more than 25 cells per field of view, but countable;

- very abundant (VA): number of cells per field of view too numerous to count.

Soft-bodied genera (and the diatom component) were also ranked according to their estimated contribution to the total algal biovolume present in the sample. The genus with the most biomass ranked number 1; the genus with the next most biomass ranked number 2, and so on. Rare (R) taxa were recorded with a biomass rank of 0.

The phytoplankton sample was concentrated (2:100) to achieve ample cell density. Calibrated pipettes were used to transfer sufficient aliquots to Palmer-Maloney counting cells. Phytoplankton identifications were made during systematic microscopic examination of whole transects across the counting cells. A minimum of 300 natural counting units (NCUs) were identified. Cell morphometry was measured during counts and identifications, which were performed at 400x or greater magnification.

Zooplankton samples were concentrated by centrifuging a 35mL subsample. Calibrated pipettes were used to transfer sufficient aliquots to Sedgwick-Rafter counting cells. A minimum of 1000 specimens were counted and identified, using a Leica DM2500 compound microscope at varying magnifications.

Data analysis

Taxa and counts for each sample were entered into Rhithron's customized laboratory information management system (LIMS). Diatom metrics were formatted consistent with updated Montana DEQ requirements (Teply 2010). Non-diatom algae identifications, relative abundances and biovolume rankings were compiled in Microsoft Excel.

Phytoplankton cell density and cellular biovolume were calculated using equations published in Charles et al. (2002). NCU density was calculated similarly, substituting the number of NCUs counted in place of the number of organisms counted in this equation. Cellular biovolumes were calculated using published morphometric equations (Hillebrand et. al 1999).

Zooplankton abundance and relative proportions were calculated. Phytoplankton and zooplankton sample results were compiled in Microsoft Excel.

RESULTS

Data analysis

Taxa lists and counts, and values and scores for various standard bioassessment metrics and indices calculated by Rhithron are given in the Appendix. Diatom and non-diatom algae identifications, phytoplankton and zooplankton sample results were sent to the NWE Project Manager via email.

A set of identified diatom slides were shipped to the NWE Project Manager.

REFERENCES

ANSP. 2002. Protocols for the analysis of algal samples collected as part of the U.S. Geological Survey National Water-Quality Assessment Program. The Academy of Natural Sciences Patrick Center for Environmental Research: Report No. 02-06. May 2002.

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APPENDIX
Diatom taxa lists and metric summaries
Non-diatom algae identifications
Phytoplankton results
Zooplankton results

NorthWestern Energy
Mystic Lake
2018

Taxa Listing

Project ID: PPL18FP2
RAI No.: PPL18FP2001

RAI No.: PPL18FP2001 — Sta. Name: Mystic Lake APH 2018
Client ID: Mystic Lake APH
Date Coll.: 10/1/2018 — No Jars: 1 — STORET ID: West Rosebud Creek
Sample Notes:

Taxonomic Name	Count	PRA	Cell Count	Comment
Diatoms				
Bacillariophyta				
Achnanthidium gracillimum	50	6.02%		
Achnanthidium minutissimum	692	83.37%		
Brachysira microcephala	2	0.24%		
Cymbella cistula	2	0.24%		
Delicata montana	21	2.53%		
Encyonema caespitosum	2	0.24%		
Encyonema minutum	4	0.48%		
Encyonema silesiacum	15	1.81%		
Fragilaria sp.	2	0.24%		GV
Fragilaria microvaucheriae	2	0.24%		
Fragilaria vaucheriae	7	0.84%		
Gomphonema sp.	2	0.24%		GV
Gomphonema minutum	2	0.24%		
Hannaea arcus	2	0.24%		
Lindavia ocellata	1	0.12%		
Navicula sp.	8	0.96%		
Navicula antonii	3	0.36%		
Navicula cryptotenella	3	0.36%		
Nitzschia dissipata	2	0.24%		
Nitzschia fonticola	8	0.96%		se

Sample Count 830

Taxa Listing

Project ID: PPL18FP2
RAI No.: PPL18FP2002

RAI No.: PPL18FP2002 | Sta. Name: Mystic Lake BPH 2018
Client ID: Mystic Lake BPH
Date Coll.: 10/1/2018 | No Jars: 1 | STORET ID: West Rosebud Creek
Sample Notes:

Taxonomic Name	Count	PRA	Cell Count	Comment
Diatoms				
Bacillariophyta				
Achnanthidium gracillimum	35	4.33%		
Achnanthidium minutissimum	624	77.13%		
Delicata montana	19	2.35%		
Didymosphenia geminata	2	0.25%		
Discostella pseudostelligera	6	0.74%		
Encyonema minuta v. pseudogracilis	2	0.25%		
Encyonema minutum	6	0.74%		
Encyonema silesiacum	8	0.99%		
Encyonema ventricosum	1	0.12%		
Fragilaria sp.	6	0.74%		GV
Fragilaria capucina	1	0.12%		
Fragilaria microvaucheriae	13	1.61%		
Fragilaria vaucheriae	24	2.97%		
Gomphoneis olivaceum	3	0.37%		
Gomphonema sp.	18	2.22%		GV
Gomphonema cymbelliclinum	1	0.12%		
Hannaea arcus	2	0.25%		
Lindavia ocellata	8	0.99%		
Navicula sp.	6	0.74%		GV
Navicula cryptotenella	7	0.87%		
Navicula leptostriata	2	0.25%		
Nitzschia fonticola	9	1.11%		
Nitzschia radicula	2	0.25%		
Staurosira construens v. venter	2	0.25%		
Staurosirella pinnata	1	0.12%		
Ulnaria acus	1	0.12%		

Sample Count 809

Taxa Listing

Project ID: PPL18FP2
RAI No.: PPL18FP2003

RAI No.: PPL18FP2003 | Sta. Name: Mystic Lake BWRL 2018
Client ID: Mystic Lake BWRL
Date Coll.: 10/1/2018 | No Jars: 1 | STORET ID: West Rosebud Creek
Sample Notes:

Taxonomic Name	Count	PRA	Cell Count	Comment
Diatoms				
Bacillariophyta				
Achnanthidium crassum	1	0.12%		
Achnanthidium gracillimum	94	11.19%		
Achnanthidium minutissimum	668	79.52%		
Achnanthidium rivulare	1	0.12%		
Brachysira microcephala	2	0.24%		
Brachysira vitrea	1	0.12%		
Cymbella cistula	1	0.12%		
Discostella pseudostelligera	3	0.36%		
Encyonema minutum	1	0.12%		
Encyonema ventricosum	7	0.83%		
Encyonopsis stafsholtii	1	0.12%		
Eucocconeis flexella	4	0.48%		
Fragilaria sp.	8	0.95%		GV
Fragilaria capucina	3	0.36%		
Fragilaria microvaucheriae	8	0.95%		
Fragilaria pectinalis	8	0.95%		
Fragilaria vaucheriae	4	0.48%		
Gomphonema sp.	8	0.95%		GV
Hannaea arcus	2	0.24%		
Lindavia ocellata	6	0.71%		
Nitzschia fonticola	3	0.36%		
Planothidium sp.	4	0.48%		GV
Planothidium delicatulum	1	0.12%		
Ulnaria acus	1	0.12%		

Sample Count 840

Metrics Report

Project ID:	PPL18FP2
Sample ID:	PPL18FP2001
Station Name:	Mystic Lake APH 2018
Client ID:	Mystic Lake APH
STORET ID:	West Rosebud Creek
Date Collected:	10/1/2018
Count Of Taxon:	20
Sum Of Count:	830

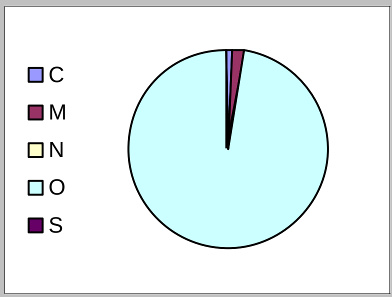
Metrics (Bahls 1993)

Metric	Value	MTM	MTP
Community Structure			
Shannon H (log2)	1.185	Fair	Poor
Species Richness	20	Good	Fair
Native Taxa Percent	0.00%		
Cosmopolitan Taxa Percent	89.16%		
Mountains Rare Taxa Percent	0.00%		
Plains Rare Taxa Percent	0.00%		
Dominant Taxon Percent	83.37%	Poor	Poor
Sediment			
Siltation Taxa Percent	2.89%	Excellent	Excellent
Motile Taxa Percent	3.13%		
Mountains Brackish Taxa Percent	89.76%		
Plains Brackish Taxa Percent	0.12%		
Organic Nutrients			
Pollution Index	2.948	Excellent	Excellent
Nitrogen Heterotroph Taxa Percent	0.00%		
Polysaprobous Taxa Percent	3.37%		
Low DO Taxa Percent	0.00%		
Inorganic Nutrients			
Nitrogen Autotroph Taxa Percent	88.55%		
Eutraphentic Taxa Percent	1.69%		
Rhopalodiales Percent	0.00%		
Metals			
Disturbance Taxa Percent	83.37%	Poor	Poor
Acidophilous Taxa Percent	0.00%		
Metals Tolerant Taxa Percent	3.13%		
Abnormal Cells Percent	0.00%	Excellent	

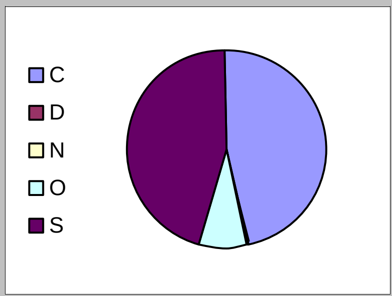
BioIndex	Description	Rating
MTM	Montana DEQ Mountains (Bahls 1992)	Poor
MTP	Montana DEQ Plains (Bahls 1992)	Poor

Increaser/Decreaser Taxa (Teply and Bahls 2005)

Metric	Value	Prob.
Mountains General Increasers Taxa Percent	1.45%	11.51%
Mountains Metals Increasers Taxa Percent	1.45%	3.75%



Metric	Value	Prob.
Plains General Increasers Taxa Percent	86.27%	99.38%



Dominant Taxa

Category	A	PRA
Achnanthidium minutissimum	692	83.37%
Achnanthidium gracillimum	50	6.02%
Delicata montana	21	2.53%
Encyonema silesiacum	15	1.81%
Navicula	8	0.96%
Nitzschia fonticola	8	0.96%
Fragilaria vaucheriae	7	0.84%
Encyonema minutum	4	0.48%
Navicula cryptotenella	3	0.36%
Navicula antonii	3	0.36%

Wednesday, December 19, 2018

Metrics Report

Project ID:	PPL18FP2
Sample ID:	PPL18FP2002
Station Name:	Mystic Lake BPH 2018
Client ID:	Mystic Lake BPH
STORET ID:	West Rosebud Creek
Date Collected:	10/1/2018
Count Of Taxon:	26
Sum Of Count:	809

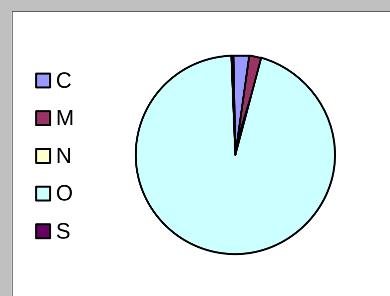
Metrics (Bahls 1993)

Metric	Value	MTM	MTP
Community Structure			
Shannon H (log2)	1.672	Fair	Poor
Species Richness	26	Good	Fair
Native Taxa Percent	0.00%		
Cosmopolitan Taxa Percent	84.92%		
Mountains Rare Taxa Percent	0.00%		
Plains Rare Taxa Percent	0.00%		
Dominant Taxon Percent	77.13%	Poor	Poor
Sediment			
Siltation Taxa Percent	3.21%	Excellent	Excellent
Motile Taxa Percent	3.21%		
Mountains Brackish Taxa Percent	86.40%		
Plains Brackish Taxa Percent	1.24%		
Organic Nutrients			
Pollution Index	2.914	Excellent	Excellent
Nitrogen Heterotroph Taxa Percent	0.00%		
Polysaprobous Taxa Percent	4.94%		
Low DO Taxa Percent	0.00%		
Inorganic Nutrients			
Nitrogen Autotroph Taxa Percent	85.41%		
Eutraphentic Taxa Percent	3.46%		
Rhopalodiales Percent	0.00%		
Metals			
Disturbance Taxa Percent	77.13%	Poor	Poor
Acidophilous Taxa Percent	0.25%		
Metals Tolerant Taxa Percent	4.82%		
Abnormal Cells Percent	0.00%	Excellent	

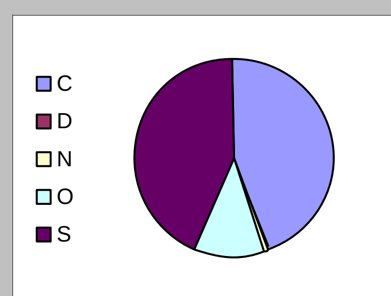
BioIndex	Description	Rating
MTM	Montana DEQ Mountains (Bahls 1992)	Poor
MTP	Montana DEQ Plains (Bahls 1992)	Poor

Increaser/Decreaser Taxa (Teply and Bahls 2005)

Metric	Value	Prob.
Mountains General Increasers Taxa Percent	2.47%	12.71%
Mountains Metals Increasers Taxa Percent	2.10%	4.09%
Mountains Sediment Increasers Taxa Percent	0.37%	8.08%



Metric	Value	Prob.
Plains General Increasers Taxa Percent	80.10%	99.38%



Dominant Taxa

Category	A	PRA
Achnanthidium minutissimum	624	77.13%
Achnanthidium gracillimum	35	4.33%
Fragilaria vaucheriae	24	2.97%
Delicata montana	19	2.35%
Gomphonema	18	2.22%
Fragilaria microvaucheriae	13	1.61%
Nitzschia fonticola	9	1.11%
Lindavia ocellata	8	0.99%
Encyonema silesiacum	8	0.99%
Navicula cryptotenella	7	0.87%

Metrics Report

Project ID:	PPL18FP2
Sample ID:	PPL18FP2003
Station Name:	Mystic Lake BWRL 2018
Client ID:	Mystic Lake BWRL
STORET ID:	West Rosebud Creek
Date Collected:	10/1/2018
Count Of Taxon:	24
Sum Of Count:	840

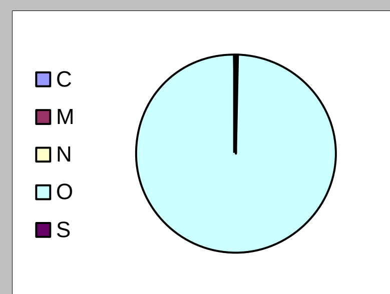
Metrics (Bahls 1993)

Metric	Value	MTM	MTP
Community Structure			
Shannon H (log2)	1.312	Fair	Poor
Species Richness	24	Good	Fair
Native Taxa Percent	0.12%		
Cosmopolitan Taxa Percent	81.07%		
Mountains Rare Taxa Percent	0.12%		
Plains Rare Taxa Percent	0.00%		
Dominant Taxon Percent	79.52%	Poor	Poor
Sediment			
Siltation Taxa Percent	0.36%	Excellent	Excellent
Motile Taxa Percent	0.71%		
Mountains Brackish Taxa Percent	83.69%		
Plains Brackish Taxa Percent	1.19%		
Organic Nutrients			
Pollution Index	2.971	Excellent	Excellent
Nitrogen Heterotroph Taxa Percent	0.00%		
Polysaprobous Taxa Percent	1.55%		
Low DO Taxa Percent	0.00%		
Inorganic Nutrients			
Nitrogen Autotroph Taxa Percent	83.33%		
Eutraphentic Taxa Percent	0.71%		
Rhopalodiales Percent	0.00%		
Metals			
Disturbance Taxa Percent	79.52%	Poor	Poor
Acidophilous Taxa Percent	0.00%		
Metals Tolerant Taxa Percent	0.95%		
Abnormal Cells Percent	0.00%	Excellent	

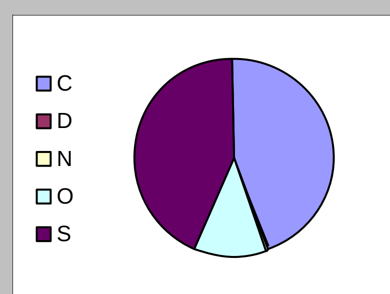
BioIndex	Description	Rating
MTM	Montana DEQ Mountains (Bahls 1992)	Poor
MTP	Montana DEQ Plains (Bahls 1992)	Poor

Increaser/Decreaser Taxa (Teply and Bahls 2005)

Metric	Value	Prob.
Mountains General Increasers Taxa Percent	0.60%	10.75%
Mountains Metals Increasers Taxa Percent	0.60%	3.29%



Metric	Value	Prob.
Plains General Increasers Taxa Percent	79.64%	99.38%



Dominant Taxa

Category	A	PRA
Achnanthidium minutissimum	668	79.52%
Achnanthidium gracillimum	94	11.19%
Fragilaria	8	0.95%
Gomphonema	8	0.95%
Fragilaria microvaucheriae	8	0.95%
Fragilaria pectinalis	8	0.95%
Encyonema ventricosum	7	0.83%
Lindavia ocellata	6	0.71%
Eucocconeis flexella	4	0.48%
Fragilaria vaucheriae	4	0.48%

NorthWestern Energy : 2018 Non-Diatom Algae Determinations by Rhithron Associates, Inc.						
RAI Sample ID	**Client ID**	**Sample Date**	**Taxon**	**Division**	**Relative Abundance**	**Biovolume Rank**
PPL18FP2001	Mystic Lake APH	10/1/2018	Diatoms	Bacillariophyta	VA	1
PPL18FP2001	Mystic Lake APH	10/1/2018	*Cladophora*	Chlorophyta	R	0
PPL18FP2001	Mystic Lake APH	10/1/2018	*Phormidium*	Cyanophyta	R	0
PPL18FP2002	Mystic Lake BPH	10/1/2018	Diatoms	Bacillariophyta	VA	1
PPL18FP2002	Mystic Lake BPH	10/1/2018	*Pleurocapsa*	Cyanophyta	C	2
PPL18FP2002	Mystic Lake BPH	10/1/2018	*Scenedesmus*	Chlorophyta	C	3
PPL18FP2002	Mystic Lake BPH	10/1/2018	*Phormidium*	Cyanophyta	R	0
PPL18FP2003	Mystic Lake BWRL	10/1/2018	Diatoms	Bacillariophyta	VA	1
PPL18FP2003	Mystic Lake BWRL	10/1/2018	*Klebsormidium*	Chlorophyta	C	2
PPL18FP2003	Mystic Lake BWRL	10/1/2018	*Scenedesmus*	Chlorophyta	C	3
PPL18FP2003	Mystic Lake BWRL	10/1/2018	*Mougeotia*	Chlorophyta	R	0
PPL18FP2003	Mystic Lake BWRL	10/1/2018	*Phormidium*	Cyanophyta	R	0
PPL18FP2003	Mystic Lake BWRL	10/1/2018	*Vaucheria*	Chrysophyta	R	0

NorthWestern Energy Mystic Lake 2018 Phytoplankton Determinations by Rhithron Associates, Inc.		PPL18FPH001 Mid Lake 2018 8/7/2018				
Taxon		**NCUCounted**	**CellsCounted**	**NCUCounted_mL**	**CellsCounted_mL**	**Biovolume_um3/mL**
Bacillariophyta	*Cyclotella*	154	154	11.7110	11.7110	92161.9349
	Encyonema	2	2	0.1521	0.1521	28.5188
	Hannaea	1	1	0.0760	0.0760	69.7680
Chlorophyta	*Sphaerocystis planctonica*	6	36	0.4563	2.7376	1019.1502
	Staurastrum	1	1	0.0760	0.0760	4515.2697
	Teilingia granulata	3	6	0.2281	0.4563	2567.1752
Chrysophyta	*Dinobryon*	4	4	0.3042	0.3042	1490.8491
	Cryptomonas	1	1	0.0760	0.0760	45.1258
Pyrrhophyta	*Undetermined Dinoflagellate*	4	4	0.3042	0.3042	43480.3903
	TOTALS	**176**	**209**	**13.3839**	**15.8934**	**145378.1821**

NorthWestern Energy Mystic Lake 2018 Zooplankton Determinations by Rhithron Associates, Inc.		PPL18FPZ001		PPL18FPZ002	
		Mid Lake 2018		Mid Lake 2018	
		8/7/2018		8/7/2018	
Taxon		Count	Count_mL	Count	Count_mL
Cladocera	*Bosmina*			3	0.0002
	Daphnia	6	0.0006	4	0.0002
Copepoda	Calanoida	77	0.0076	63	0.0032
	Copepoda: nauplius	31	0.0030	43	0.0022
Rotifera	*Asplanchna*	6	0.0006	4	0.0002
	Conochilus	801	0.0786	715	0.0362
	Filinia longiseta	1	0.0001	5	0.0003
	Filinia terminalis			6	0.0003
	Gastropus hyptopus	9	0.0009	18	0.0009
	Kellicottia longispina	17	0.0017	29	0.0015
	Keratella cochlearis	31	0.0030	70	0.0035
	Keratella hiemalis	19	0.0019	28	0.0014
	Polyarthra			1	0.0001
	Rotifera	2	0.0002	10	0.0005
	Synchaeta	5	0.0005	2	0.0001
	TOTALS	**1005**	**0.0987**	**1001**	**0.0508**

Appendix C – West Rosebud Creek Water Chemistry Data, 2010-2015

Table C-1: Water chemistry results for West Rosebud Creek taken from Above the Powerhouse, Below the Powerhouse, and Below West Rosebud Lake on April 6, July 7, and October 5, 2010. BD indicates below detection limit.

Parameters	Units	Detection Limit	Above Powerhouse			Below Powerhouse			Below West Rosebud Lake		
			6-Apr	7-Jul	5-Oct	6-Apr	7-Jul	5-Oct	6-Apr	7-Jul	5-Oct
Total Alkalinity	mg/L	4	21	13	16	16	9	12	16	9	18
Arsenic	mg/L	0.001	BD	BD	BD	BD	BD	BD	BD	BD	BD
Bicarbonate	mg/L	4	25	16	19	19	11	14	19	11	22
Cadmium	mg/L	0.00008	BD	BD	BD	BD	BD	BD	BD	BD	BD
Calcium	mg/L	1	6	4	6	5	4	4	5	4	4
Chloride	mg/L	1	BD	BD	BD	BD	BD	BD	BD	BD	BD
Copper	mg/L	0.001	BD	BD	BD	BD	BD	BD	BD	BD	BD
Iron	mg/L	0.05	0.09	0.08	BD	0.08	0.09	BD	0.11	0.09	BD
Lead	mg/L	0.0005	BD	BD	BD	BD	BD	BD	BD	BD	BD
Magnesium	mg/L	1	2	BD	1	1	BD	1	1	BD	1
Manganese	mg/L	0.005	BD	BD	BD	BD	BD	BD	BD	BD	BD
Nitrogen, Nitrate + Nitrite	mg/L	0.05	0.17	0.14	0.14	0.15	0.15	0.1	0.12	0.15	0.09
Nitrogen, Total (persulfate)	mg/L	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2
Orthophosphate	mg/L	0.01	BD	BD	BD	BD	BD	BD	BD	BD	BD
Total Phosphorus	mg/L	0.01	BD	BD	BD	BD	BD	BD	BD	BD	BD
Potassium	mg/L	1	1	BD	BD	1	BD	BD	1	1	BD
Sodium	mg/L	1	1	BD	1	BD	BD	BD	BD	BD	BD
TDS	mg/L	1	46	22	31	26	18	20	25	18	24
TSS	mg/L	10	BD	BD	BD	BD	BD	BD	BD	BD	BD
Sulfate	mg/L	1	4	2	5	3	2	3	3	2	3
Zinc	mg/L	0.01	BD	BD	BD	BD	BD	BD	BD	BD	BD

Table C-2: Water chemistry results for West Rosebud Creek taken from Above the Powerhouse, Below the Powerhouse, and Below West Rosebud Lake on April 3, July 3, and October 3, 2012. BD indicates below detection limit

Parameters	Units	Detection Limit	Above Powerhouse			Below Powerhouse			Below West Rosebud Lake		
			3-Apr	3-Jul	3-Oct	3-Apr	3-Jul	3-Oct	3-Apr	3-Jul	3-Oct
Total Alkalinity	mg/L	4	17	11	19	15	11	17	15	12	17
Arsenic	mg/L	0.001	0.002	BD	BD	0.002	BD	BD	0.002	BD	BD
Bicarbonate	mg/L	4	20	14	23	18	14	20	18	14	21
Cadmium	mg/L	0.00008	BD	BD	BD	BD	BD	BD	BD	BD	BD
Calcium	mg/L	1	6	4	5	5	4	4	5	4	4
Chloride	mg/L	1	BD	BD	BD	BD	BD	BD	BD	BD	BD
Copper	mg/L	0.001	BD	BD	BD	BD	BD	BD	BD	BD	BD
Iron	mg/L	0.05	BD	BD	BD	BD	BD	BD	BD	BD	0.04
Lead	mg/L	0.0005	BD	BD	BD	BD	BD	BD	BD	BD	BD
Magnesium	mg/L	1	1	BD	1	1	BD	1	1	BD	1
Manganese	mg/L	0.005	BD	BD	BD	0.002	BD	BD	0.002	BD	0.002
Nitrogen, Nitrate + Nitrite	mg/L	0.05	0.11	0.12	0.08	0.13	0.12	0.08	0.1	0.12	0.05
Nitrogen, Total (persulfate)	mg/L	0.1	BD	0.17	0.11	0.14	0.16	0.17	0.17	0.18	0.14
Orthophosphate	mg/L	0.01	BD	0.008	BD	BD	0.008	BD	BD	BD	BD
Total Phosphorus	mg/L	0.01	BD	0.006	BD	0.005	BD	BD	0.005	0.006	BD
Potassium	mg/L	1	BD	BD	BD	BD	BD	BD	BD	BD	BD
Sodium	mg/L	1	1	BD	BD	BD	BD	BD	BD	BD	BD
TDS	mg/L	1	27	32	33	26	12	70	24	BD	30
TSS	mg/L	10	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sulfate	mg/L	1	6	4	5	4	3	3	4	3	3
Zinc	mg/L	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table C-3: Water chemistry results for West Rosebud Creek taken from Above the Powerhouse, Below the Powerhouse, and Below West Rosebud Lake on April 1, July 7, and October 6, 2015. BD indicates below detection limit.

Parameters	Units	Detection Limit	Above Powerhouse			Below Powerhouse			Below West Rosebud Lake		
			1-Apr	7-Jul	6-Oct	1-Apr	7-Jul	6-Oct	1-Apr	7-Jul	6-Oct
Total Alkalinity	mg/L	4	20	12	18	18	13	16	18	14	16
Arsenic	mg/L	0.001	BD	BD	BD	BD	BD	BD	BD	BD	BD
Bicarbonate	mg/L	4	24	15	21	21	16	19	22	16	19
Cadmium	mg/L	0.0001	BD	BD	0.0002	BD	BD	0.0001	BD	BD	BD
Calcium	mg/L	1	6	4	6	5	4	5	5	4	5
Chloride	mg/L	1	BD	BD	BD	BD	BD	BD	BD	BD	BD
Copper	mg/L	0.001	BD	BD	BD	BD	BD	0.001	BD	BD	BD
Iron	mg/L	0.03	BD	0.02	BD	BD	BD	BD	BD	0.03	0.04
Lead	mg/L	0.001	BD	BD	BD	BD	BD	BD	BD	BD	BD
Magnesium	mg/L	1	1	1	2	1	1	1	1	1	1
Manganese	mg/L	0.001	BD	0.001	BD	0.011	0.001	0.002	0.003	0.003	0.003
Nitrogen, Nitrate + Nitrite	mg/L	0.01	0.14	0.07	0.12	0.15	0.08	0.05	0.08	0.09	0.07
Nitrogen, Total (persulfate)	mg/L	0.1	0.1	0.26	0.11	0.10	0.31	0.17	BD	0.29	0.11
Orthophosphate	mg/L	0.005	BD	BD	BD	BD	BD	BD	BD	BD	BD
Total Phosphorus	mg/L	0.005	BD	BD	BD	0.013	0.006	BD	BD	BD	BD
Potassium	mg/L	1	BD	BD	BD	BD	BD	BD	BD	BD	BD
Sodium	mg/L	1	1	BD	1	BD	BD	BD	BD	BD	BD
TDS	mg/L	10	29	30	44	21	29	38	16	28	44
TSS	mg/L	10	BD	BD	BD	BD	BD	BD	BD	BD	BD
Sulfate	mg/L	1	4	3	6	3	2	5	3	2	5
Zinc	mg/L	0.01	BD	BD	BD	BD	BD	BD	BD	BD	BD

Appendix D – Standard Operating Procedures

STANDARD OPERATING PROCEDURES

Mystic Lake Water Quality Monitoring Program

2020-2040

NorthWestern Energy

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Delivering a Bright Future

TABLE OF CONTENTS

1. Lake Depth Profile Sampling and Secchi Disk Depth Measurement

Purpose: Provide guidelines for the use of the Hydrolab HL7 Datasonde for creating a lake depth profile

Procedures:

1. Select the Hydrolab HL7 Datasonde with the 100m depth sensor. Decontaminate and calibrate instrument before each sampling event in accordance with procedures outlined in the Surface Water Sampling Equipment Decontamination SOP, and consistent with calibration procedures outlined in the user's manual.

2. At the sampling location, using the Hydrolab Operating Software, collect an instrument reading at every 1 meter interval from the water surface to 25 meters depth, and every 5 meters from 25-50 meters depth. The following parameters will be collected:

    - Temperature
    - Depth
    - DO in mg/l
    - DO%
    - Specific Conductivity
    - pH
    - Turbidity

3. Store and save each of these measurements in a data file on the field computer, and record notes in the field notebook such as the sample site, date, time, thermocline, maximum depth, and other relevant observations.

4. To collect Secchi disk depth, lower the Secchi disk into the water column until it reaches a point where you can no longer see the disk. Record this depth in the field notebook. Then slowly raise the disk until it reaches a point where you can see the disk again and record this depth in the field notebook. The Secchi disk depth for that location will be the average of these two measurements.

Associated SOP's:

- Surface Water Sampling Equipment Decontamination
- Project Field Logbook
- Field Measurements Using the Hydrolab HL7 Datasonde

References:

Hydrolab HL Series Sonde User Manual. Available 2019: https://www.ott.com/en-us/products/download/hl-series-sonde-bedienungsanleitung-user-manual-manuel-dutilisation-manual-de-usuario/

Initials: JT Revision: 2019

2. Lake Depth Integrated Water Sampling

Purpose: Provide guidelines for collection of representative depth integrated composite water samples

Procedures:

1. Decontaminate equipment before each sampling event in accordance with procedures outlined in the Surface Water Sampling Equipment Decontamination SOP.

2. At each sampling location one individual is designated as 'clean hands'. This person is responsible for all operations involving contact with the sampler bottle itself and all actual sample processing. Other operations including preparation of the sampler (except the sample bottle itself), and collection of the sample itself will be handled by other personnel. Clean hands personnel will wear protective gloves (polyethylene or latex or similar material) to minimize exposure to potential chemical hazards and reduce the potential for sample contamination. The person operating the sampling device will also wear polyethylene or latex gloves.

3. The water sample is collected from a composite of several point sub-samples from the zone of three times the Secchi depth or the top of the thermocline (determined using the Lake Depth Profile Sampling and Secchi Disk Depth Measurement SOP), whichever is shallower.

4. After determining your sampling zone, collect twelve water samples at equal intervals from and including the water surface through the sampling zone as described above. Collect samples using a Van Dorn sampler that has been rinsed with the site water.

5. Samples will be transferred to a decontaminated Teflon churn splitter and stored until processing. Processing of sample aliquots into sample bottles will occur at the end of each day in a clean indoor location. Filtration with a 0.45µm filter for dissolved parameters will be done as a batch process within 8 hours of sampling. All sample bottles will be virgin polyethylene plastic bottles. For chlorophyll-a samples, a total sample volume of approximately 2,000 milliliters (mL) is taken from the churn for the chlorophyll analysis and filtered on site through a 0.7-µm glass fiber filter (GF/F). The filter is then folded in half, wrapped in foil, and placed in a plastic zip lock bag with the site and sample information labeled on it.

6. Sampling time, depths collected, and relevant observations will be noted in the field logbook. Samples will be labeled, stored, and shipped with a completed chain of custody.

Associated SOP's:

- Surface Water Sampling Equipment Decontamination
- Project Field Logbook
- Surface Water Sample Packaging and Shipping
- Sample Blanks and Duplicates
- Sample Custody

References:

Green, W.R., Robertson, D.M., and Wilde, F.D., 2015, Lakes and reservoirs—Guidelines for study design and sampling: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A10, 65 p., http://dx.doi.org/10.3133/tm9a10

Initials: JT Revision: 2019

3. Lake Zooplankton Sampling

Purpose: Provide guidelines for collection of zooplankton samples

Procedures:
1. Decontaminate equipment before each sampling event in accordance with procedures outlined in the Surface Water Sampling Equipment Decontamination SOP.

2. At each sampling location one individual is designated as 'clean hands'. This person is responsible for all operations involving contact with the sampler bottle itself and all actual sample processing. Other operations including preparation of the sampler (except the sample bottle itself), and collection of the sample itself will be handled by other personnel. Clean hands personnel will wear protective gloves (polyethylene or latex or similar material) to minimize exposure to potential chemical hazards and reduce the potential for sample contamination. The person operating the sampling device will also wear polyethylene or latex gloves.

3. Sampling should be conducted between at a time of day 10:00 and 15:00 when the sun is high in the sky and zooplankton move up in the water column. The zooplankton sample is collected from a vertical tow using an 80 micrometer (μm) mesh net. The sample consists of one vertical tow from the 100’ depth to the surface.

4. After the tow is completed, rinse the net with ETOH into the collection container and place the sample in an ETOH preserved virgin polyethylene plastic sample bottle.

5. Collect a duplicate sample from the opposite side of the boat. Each sample will be processed separately.

6. Sampling time, depths collected, and relevant observations will be noted in the field logbook. Samples will be labeled, stored, and shipped with a completed chain of custody.

Associated SOP's:
- Surface Water Sampling Equipment Decontamination
- Project Field Logbook
- Surface Water Sample Packaging and Shipping
- Sample Blanks and Duplicates
- Sample Custody

References:
Green, W.R., Robertson, D.M., and Wilde, F.D., 2015, Lakes and reservoirs—Guidelines for study design and sampling: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A10, 65 p., http://dx.doi.org/10.3133/tm9a10

Initials: JT Revision: 2019

4. Field Measurements Using the Hydrolab HL7 Datasonde

Purpose: Provide guidelines for the use of the Hydrolab HL7 Datasonde multiprobe meter for measuring the following parameters in surface water samples:

- Temperature
- Dissolved oxygen (DO)
- Specific conductance
- pH
- Total dissolved gases (TDG)
- Turbidity

Procedures:
These procedures present guidelines for field measurement of water quality parameters using the Hydrolab HL7 Datasonde multiprobe. Field personnel should be familiar with procedures outlined in the probes user's manual referenced below.

1. Decontaminate instrument before each sampling event in accordance with Surface Water Sampling Equipment Decontamination SOP, and consistent with handling procedures outlined in the user's manual.
2. Prepare and assemble the probe in accordance with procedures in the user's manual.
3. Calibrate the probe following instructions in the user's manual. Calibration should be completed at the start of each second sampling day, and more frequently if calibration drift or problems with the sonde are suspected. The multiprobe has built in checks for calibration acceptance. If the "calibration failed" message appears, consult the user's manual for trouble shooting guidance. General instructions noted in the user's manual are as follows:
4. Calibration for specific conductance and salinity, pH, and redox is achieved by pouring a calibration standard into the DS calibration cup or immersing the entire multiprobe in a bucket of standard solution. Select the sensor to be calibrated, allow time for the solution to stabilize, and enter the value of the standard.
5. Dissolved oxygen (DO) and %DO saturation (%sat) are calibrated in the DS calibration cup using the saturated air method.
6. Temperature calibration is factory set and does not require any recalibration.
7. Note date, time and relevant information regarding calibration in the field notebook.
8. Immerse the DS into the river or body of water using appropriate weight and follow instructions in the user's manual for the various parameters.
9. Perform repeat measurements as necessary. This entails a minimum of 1 minute of stabilization, and 5 measures spaced at ten second intervals. The mean of the last 5 observations is computed and entered as the field value.
10. Sampling time, measurement data, and relevant observations will be noted in the field logbook (Project Field Logbook SOP).

Associated SOP's:

- Surface Water Sampling Equipment Decontamination
- Project Field Logbook

References:

Hydrolab HL Series Sonde User Manual. Available 2019: https://www.ott.com/en-us/products/download/hl-series-sonde-bedienungsanleitung-user-manual-manuel-dutilisation-manual-de-usuario/

Initials: JT Revision: 2019

5. Depth Integrated Point Surface Water Sampling

Purpose: Provide guidelines for collection of representative depth integrated point surface water samples.

Surface water sampling for the Mystic project will use the DH-81A sampler where depth integrated point samples are to be collected by wading from the bank.

This SOP describes the procedures used to collect point samples.

Procedures

1. Decontaminate instrument before each sampling event in accordance with Surface Water Sampling Equipment Decontamination SOP.
2. At each sampling location one individual is designated as 'clean hands'. This person is responsible for all operations involving contact with the sampler bottle itself and all actual sample processing. Other operations including preparation of the sampler (except the sample bottle itself), and collection of the sample itself will be handled by other personnel. Clean hands personnel will wear protective gloves (polyethylene or latex or similar material) to minimize exposure to potential chemical hazards and reduce the potential for sample contamination. The person operating the sampling device will also wear polyethylene or latex gloves.
3. The sampler rod and bottle will be positioned upstream to avoid collecting disturbed water samples. The sampler will be lowered into the water at an even rate with the intake facing upstream to a point just above the bottom, then removed upward at a constant rate.
4. Samples will be transferred to a decontaminated teflon churn splitter and stored until processing. Processing of sample aliquots into sample bottles will occur at the end of each day in a clean indoor location. Filtration with a 0.45um filter for dissolved parameters will be done as a batch process within 8 hours of sampling. All sample bottles will be virgin polyethylene plastic bottles supplied by Energy Laboratories.
5. Sampling time and relevant observations will be noted in the field logbook (Project Field Logbook SOP). Sample chain of custody will be completed in accordance with Sample Custody SOP. Samples will be labeled, stored and shipped in accordance with Surface Water Sample Packaging and Shipping SOP.

Associated SOP's:

- Surface Water Sampling Equipment Decontamination
- Project Field Logbook
- Surface Water Sample Packaging and Shipping
- Sample Blanks and Duplicates
- Sample Custody

Initials: JT Revision: 2019

6. Field Filter Techniques

Purpose: Provide guidelines for the field filtering of surface water and groundwater samples to be analyzed for the presence of various water quality indicators.

Necessary Equipment/Supplies:
Transfer Vessel, Tubing, Hand Pump, Disposable Inline or standalone Filters. Appropriate Sample Containers, Sample Container Labels, Chain of Custody, Custody Seal, Waterproof Pen.

Procedures: Sampling

Device:

1. Collect a sample following the appropriate SOP according to the water source being sampled, placing the sample into a decontaminated transfer vessel.

Filtering Technique:

1. Disposable polyethylene or latex gloves must be worn when drawing the sample, and during the filtering process.
2. Mount filter in apparatus (ring stand/clamp) and attach decontaminated Tygon tubing.
3. Verify filter flow direction is correct.
4. Attach pumping device (Peristaltic pump, hand pump, or syringe)
5. Run a small amount of sample water through the filter and discard before drawing filtered sample. 100mL for $30cm^2$ filter and 500mL for $770cm^2$ filter.
6. Care must be taken to prevent unfiltered water and rain water from entering the sample container during filling.
7. Fill the sample container to the top of the container so that a meniscus is formed.
8. Allow any air bubbles to rise to the surface; tap the container to dislodge any trapped air.
9. Carefully and quickly screw the cap onto the container and finger tighten.
10. The label must be completed including the following information: sample ID, date and time of collection, sampling personnel, well number, preservation, analysis requested, and job site description.
11. The sampling point and technique must be documented in the field notebook.
12. Place all samples in an ice chest containing ice or frozen blue ice. Complete the Chain of Custody.
13. Discard filter, do not reuse.

Initials: FJP Revision: 2010

7. Periphyton Species Composition and Chlorophyll a Sampling

Purpose: Provide guidelines for the collection of periphyton samples.

Procedures:

Periphyton species composition samples measure the relative abundances of species that are adhered to the substrate of a stream.

Periphyton chlorophyll *a* sampling methodology consists of collecting four replicate samples that represent the range of variability present at each site. A comparative study of two sampling methods on the Missouri and Madison rivers recommended the use of the "Stones" or whole rock sample method. It is especially useful where low biomass growth precludes the meaningful application of scraping methods.

1. Decontaminate sampling equipment before each sampling event (Surface Water Sampling Equipment Decontamination SOP) unless samplers are certain it was decontaminated following the previous sampling event.
2. Whole rock - four to five rocks will be placed into a suitable container (2 L poly wide-mouth bottle or plastic bag) and frozen. Repeat until a total of 4 sets (4 containers) of rocks are collected. Chlorophyll areal coverage is corrected for half of the rock surface area or the proportion of exposed rock surface area.
3. Sample field observations recorded along with sample should include water depth, median substrate size, and hydraulic feature (riffle, point bar, glide, run, etc).
4. For species composition samples, a single composite from a variety of microhabitats will be collected using the scrape method (MDEQ, 2012), and preserved with Lugol's (IKI) solution, "M3" fixative, buffered 4% formalin, 2% glutaraldehyde or other MDEQ approved method or immediately frozen.

Sampling time and relevant field observations will be noted in the field logbook (SOP for Project Field Logbook). Sample chain of custody will be completed in accordance with Sample Custody SOP. Samples will be labeled, stored and shipped in accordance with Surface Water Sample Packaging and Shipping SOP.

Associated SOP's:

- Surface Water Sampling Equipment Decontamination
- Project Field Logbook
- Surface Water Sample Packaging and Shipping
- Sample Custody

References:

Barbour, M.T., Gerritsen, J., Snyder, B.D., and J.B. Stribling, 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. US EPA Office of Water.

EPA, 1998. Lake and Reservoir Bioassessment and Biocriteria, Technical Guidance Document. U.S. EPA Office of Water. EPA 841-B-98-007. August 1998.

MDHES, 1993. Biological Monitoring Component, Long-Term Water Quality Monitoring Program, MPC Missouri/Madison Hydroelectric Project, FERC License No. 2188. Montana Department of Health and Environmental Sciences, Water Quality Division, Helena.

MDEQ, 1999. Water Quality Monitoring Standard Operating Procedures (SOP). 12.1.2 Periphyton. Obtained from web site: www.deq.state.mt.us.

MDEQ, 2012. Water Quality Planning Bureau Field Procedures Manual for Water Quality Assessment Monitoring. February 2012, Version 3.2 Available April 15, 2019: http://deq.mt.gov/Portals/112/Water/WQPB/QAProgram/Documents/PDF/SOPs/WQPB WQM-020.pdf

Initials: JT Revision: 2019

8. Macroinvertebrate Sampling

Purpose: Provide guidelines for the collection of macroinvertebrate samples.

Procedures:

This SOP obtains three replicate samples because West Rosebud Creek is small and to avoid repeated sampling from the same area.

1. Decontaminate sampling equipment before each sampling event (Surface Water Sampling Equipment Decontamination SOP).
2. Identify three representative sampling areas which include variations in depth, substrate sizes, channel position, and current velocity.
3. Use Hess sampler (0.1 m^2, 390 micron mesh) for macroinvertebrate samples. Take three replicate samples from each site in riffle habitats <30 cm in depth.
4. At each sampling point, push the Hess sampler into the stream bottom to form an effective seal and all cobbles (>64 mm) scrub clean and rake the entire area within the Hess sampling frame until all organic matter and macroinvertebrates are washed into the collection net of the Hess sampler.
5. Collect all macroinvertebrates, organic and inorganic matter from Hess sample into a 40 L bucket and transferred to 1 L Nalgene bottles with 95% ETOH for transport to the laboratory for identification.

Sampling time and relevant observations will be noted in the field logbook (Project Field Logbook SOP). Sample chain of custody will be completed in accordance with Sample Custody SOP. Samples will be labeled, stored and shipped in accordance with Surface Water Sample Packaging and Shipping SOP.

Associated SOP's:

- Surface Water Sampling Equipment Decontamination
- Project Field Logbook
- Surface Water Sample Packaging and Shipping
- Sample Custody

References:

Barbour, M.T., Gerritsen, J., Snyder, B.D., and J.B. Stribling, 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. US EPA Office of Water.

Bukantis, 1996. Rapid Bioassessment Macroinvertebrate Protocols: sample and analysis SOP’s. Draft. Montana Dept. of Environ. Quality.

EPA, 1998. Lake and Reservoir Bioassessment and Biocriteria, Technical Guidance Document. U.S. EPA Office of Water. EPA 841-B-98-007. August 1998.

Plafkin, J.L., Barbour, M.T., Porter, K.D., Gross, S.K., and R.M. Hughes, 1989. Rapid Bioassessment Protocols for Use in Streams and Reservoirs, Benthic Macroinvertebrates and Fish. USEPA Office of Water. EPA/440/4-89/001. May 1989.

Initials: JT Revision: 2019

9. Surface Water Sampling Equipment Decontamination

Purpose: Provide guidelines for decontamination of surface water sampling equipment.

Procedures:

1. All surface water sampling equipment and anything that comes into contact with the equipment should be decontaminated prior to use at each location. Sampling bottles typically do not need to be decontaminated if received from a certified laboratory and kept in a clean environment.
2. If the sampling equipment is visibly dirty an initial cleaning with soap such as
3. Alconox will be performed using a brush if necessary.
4. After visible foreign material has been removed, the equipment will undergo a triple rinse with distilled or deionized water, followed by a single 5% HCL acid wash, and a triple rinse with distilled or deionized water.
5. The source of deionized water should be noted in the field book and remain consistent throughout the sampling program.
6. All handling of the sampling equipment during the decontamination procedure will be conducted by personnel wearing protective gloves (latex or similar material).
7. Decontaminated equipment must be stored in a clean environment, wrapped securely in plastic bags.

Sampling decontamination and any relevant observations will be noted in the field logbook (Project Field Logbook SOP).

Initials: BKA Revision: 2001

10. Project Field Logbook

Purpose: Provide guidelines for documenting field activities in a logbook.

Procedures:

A field logbook(s) will be kept to document field activities for the 2188 study to provide a permanent accountable record of field activities. The logbook will be bound and should have consecutively numbered pages. Each logbook will be labeled with the logbook number, company and project name, and date. The field logbook should contain a complete record of activities including any sampling events, field measurements, personnel, photographs, and ancillary data including relevant observations of unusual conditions. The field logbook provides a record of sample identity from sample collection, Chain of Custody, to laboratory, database storage, and final reporting. Entries will be made in indelible ink and corrections must be line-out deletions which are initialized and dated by the person making the entry. Entries must not be erased or otherwise deleted.

All sampling event records will include the following entries in the logbook:

1. Date/Time
2. Personnel
3. Sample dates
4. Equipment decontamination/calibration notes
5. Field measurements
6. Sample labeling information, using a labeling scheme with station location (01) followed by date (i.e. 032101). Thus, a sample bottle label will read 01-032101 for a sample at station 1 taken on March 12, 2001
7. Contact with regulatory personnel
8. Field observations including, but not limited to weather, concurrent site activities, changes in sampling equipment or instruments from previous sampling event(s), instrument malfunction, sampling station condition, sampling delays, destruction or loss of documents/samples, and any other information deemed relevant.
9. Any deviation from or modification to the sampling and analysis plan or SOPs.

Field logbooks will be reviewed by the project manager to verify adherence to Standard Operating Procedures and the Monitoring and Quality Assurance Plans. Field logbooks will be stored in a designated secure area.

Initials: GEA Revision: 2001

11. Surface Water Sample Packaging and Shipping

Purpose: Provide guidelines for packaging and shipping of surface water samples.

Procedures:

The following steps will be followed when packaging and shipping environmental samples:

1. Verify proper sample identification and complete labels on all bottles.
2. Wipe exterior of sample bottle with distilled or deionized.
3. Place sample bottle(s) into cooler with frozen blue ice or dry ice as required.
4. Fill excess space in cooler with clean packing material.
5. Seal cooler and complete Chain of Custody following SOP
6. Complete appropriate UPS shipping form for Certified Return Shipping for water quality samples.
7. Verify that shipper will meet delivery schedule to lab for holding time limitation.
8. Notify laboratory that samples are being shipped and provide approximate time of delivery.
9. Note shipping number in field logbook.
10. Sample shipping procedures must comply with UPS shipping regulations.

Initials: BKA Revision: 2001

12. Sample Blanks and Duplicates

Purpose: Provide guidelines for sample blank and duplicate procedures.

Procedures:
The quality of analytical data collected in the field is evaluated by a combination of the following sampling techniques as required by the monitoring and quality assurance plans. Field personnel should consult with the project manager and quality assurance officer prior to field mobilization to determine if QA samples in addition to those specified in the monitoring and quality assurance plans are required.

FIELD REPLICATE SAMPLES

A field replicate sample is collected by repeating the sampling process to collect a second sample following the original sample. Replicate samples assess the combined field method and laboratory precision, and include any temporal variability associated with the delay between consecutive sampling events. Replicate samples will be collected for every group of 10 or fewer samples taken during a sampling event, or on a daily basis.

TRIP BLANK

Trip blanks are prepared at the laboratory by filling the sample bottle with deionized water and including this sample blank in the sampling kit. The trip blank remains in the shipping container (cooler) throughout the sampling event at the site and is returned to the laboratory for analysis along with the field collected samples. One trip blank is included for each container of samples submitted for analysis. Trip blanks containing target constituents above detection limits indicate problems during shipping and storage and may also suggest laboratory cross contamination.

Additional quality assurance samples may be specified by the quality assurance officer during the monitoring program. These additional samples may arise as a result of response actions dictated by problems identified with the data, and can include the following:

LABORATORY SPLIT

A laboratory split consists of one well-mixed and homogenized sample which is split into two samples in the field. One of the split samples is sent to the primary laboratory and the other sent to a referee laboratory, each with a unique sample ID number. Both split samples are analyzed for identical parameters, and results compared to determine inter-laboratory precision. Laboratory splits will be collected if problems with the laboratory are suspected and is directed by the quality assurance officer as a response action.

EQUIPMENT BLANK

Equipment blanks are samples of distilled/deionized water which are run through the sampling apparatus, filter (as appropriate), and other sampling processes once equipment decontamination has been completed in the field. The sample is transmitted to the laboratory "blind" in the appropriate sample container with required preservatives. Equipment blanks should contain no parameter of interest greater than two times the method detection limit. An equipment blank exceeding this limit will trigger an investigation of contaminant sources and corrective action. Equipment blanks are generally required where non-dedicated sampling equipment is in use to insure against cross contamination. Equipment blanks may be specified by the quality assurance officer as a response action if problems with decontamination procedures are suspected.

FIELD BLANKS

Field blanks for an analyte of interest are established by filling the sample bottle with deionized water at the laboratory. The field blank bottle is left open during sample collection for the period of time required to collect the sample. Field blanks reflect contamination due to atmospheric fallout or windy conditions. Field blanks may be specified by the quality assurance officer as a response action if external environmental contamination is suspected.

References:

U.S. EPA. 1987. A compendium of Superfund field operations methods. Report No. EPA/540/P-87/001.

Initials: BKA Revision: 2001