BIGHORN RIVER AQUATIC MACROINVERTEBRATE MONITORING: SAMPLING AND ANALYSIS PLAN-2019

RI

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PREPARED FOR:

BIG HORN RIVER ALLIANCE

THE RESEARCH INITIATIVE

PREPARED BY:

David Stagliano
Montana Biological Survey
dstagliano88@gmail.com

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1.0 INTRODUCTION

1.1 Project Area Overview

The Bighorn River (HUC 10080015 Lower Bighorn) is the largest tributary to the Yellowstone River at approximately 481 miles (770 km) long with a watershed of ~22,000 square miles; it flows through the states of Wyoming and Montana and represents about 32 percent of the Yellowstone River basin (Petersen et al. 2001). Three reservoirs with storage capacities greater than 600,000 acre-feet (Bighorn Lake, Buffalo Bill Reservoir and Boysen Reservoir) are located on the Bighorn River or its tributaries. The river was named in 1805 by fur trader Francois Larocque for the bighorn sheep he saw along its banks as he explored the Yellowstone River upstream from its confluence with the Missouri.

Regulation and hypolimnetic release of the Bighorn River from the Yellowtail Dam has transformed the lower river from a large prairie river into one of Montana's premier trout rivers since being built in 1967. Trout fishermen are most familiar with the 43 mile section below Yellowtail Dam which forms Bighorn Lake (Reservoir) downstream to Hardin, MT. It is one of the most popular and heavily fished trout fisheries in Montana and is consistently ranked in the top three of the most heavily fished rivers in the state (MFWP 2015).

The BHRA proposes to quantitatively sample the macroinvertebrate communities of the main-stem Lower Bighorn River from downstream of the outflow of Yellowtail Dam to its confluence with the Yellowstone River) , a reach of ~84 miles.. The main tributaries that flow into this section of the river are Soap Creek, Rotten Grass Creek, Tullock Creek, Beavauis Creek and the Little Bighorn River.

The 40.2 mile reach of the Bighorn River from the Crow Indian Reservation Boundary to the mouth at the Yellowstone River (MDEQ assessment unit ID MT43R001_010) is listed as “impaired” for Drinking Water use due to Lead and Mercury; but, it has not been fully assessed (NA) for Aquatic Life Use (MDEQ 2016). This NA determination is unclear because numerous years (2001-2005) of macroinvertebrate samples have been taken at 2 sites in the assessment unit, as well as numerous fishery investigations. These impairments can be viewed via Montana DEQ’s Clean Water Act Information Center at www.cwaic.mt.gov

1.2 Project Goals and Objectives

The Research Initiative of the Bighorn River Alliance (BHRA) has identified multiple areas of scientific importance to the health of the river. First and foremost among these is water chemistry and quality. As part of this effort, this report discusses a benthic macroinvertebrate sampling and analysis plan (SAP). The plan will outline how the benthic macroinvertebrate populations and community assemblage structures will be sampled and analyzed to determine how these biological indicators relate to spatial and temporal trends in aquatic habitat health, as influenced by aquatic macrophyte beds, algae, aquatic invasive species, sedimentation, water quality, dissolved gases, and regulated flows

The goal is to collect baseline data using standardized methods and to interpret this information annually to establish trends indicating overall health of the river. With the inclusion of the water quality data, we will be able to better understand responses of macroinvertebrate and aquatic plant communities from year to year to determine how to promote the long-term health of the river.

1.3 Project Budget

For the first sampling year, the proposed SAP consists of 8 sites sampled during two seasonal visits with 3 replicates per site (n=48) and 1 duplicate each season for QA/QC purposes for a total of 50 samples. Costs for macroinvertebrate sample processing, metric analysis and reporting vary among contract laboratories ($11,500-$16,660) and are detailed in Appendix A. Total costs for the first year of field sampling, transportation, laboratory analysis and reporting could be between $13,900 and 19,900 depending on contractor (Appendix A). This first year sampling can inform subsequent years' seasonal sampling depending on the results and comparability to previous studies.

2.0 Sampling Process

2.1 Study Design

During our literature review, we determined that benthic macroinvertebrate sampling and monitoring had occurred at eight sites on the Bighorn River within our study area between 1986 and 2018; we could not identify any older invertebrate sampling events in the published or grey literature (Stagliano 2019). Four of these sites (Brammer RM82, Brammer RM75, Mallards Landing FAS and Manuel Lisa, *Table 1*) had quantitative data collected, while the others reported only qualitative samples. In spring and fall of 2020, we plan to replicate previous quantitative efforts at these four sites to continue building a baseline dataset from sites sampled between 1986 and 2018. We have also chosen four new designated sites that are both accessible and spatially representative of river sections in the study reach (Table 1). Water quality samples (see WQ SAP) will be taken concurrently at most of the sites to compare water chemistry and macroinvertebrate data.

Sampling Locations

Table 1. BHRA Sampling locations. Agency that was the original sampler. D/S=downstream. WQS=water quality samples.

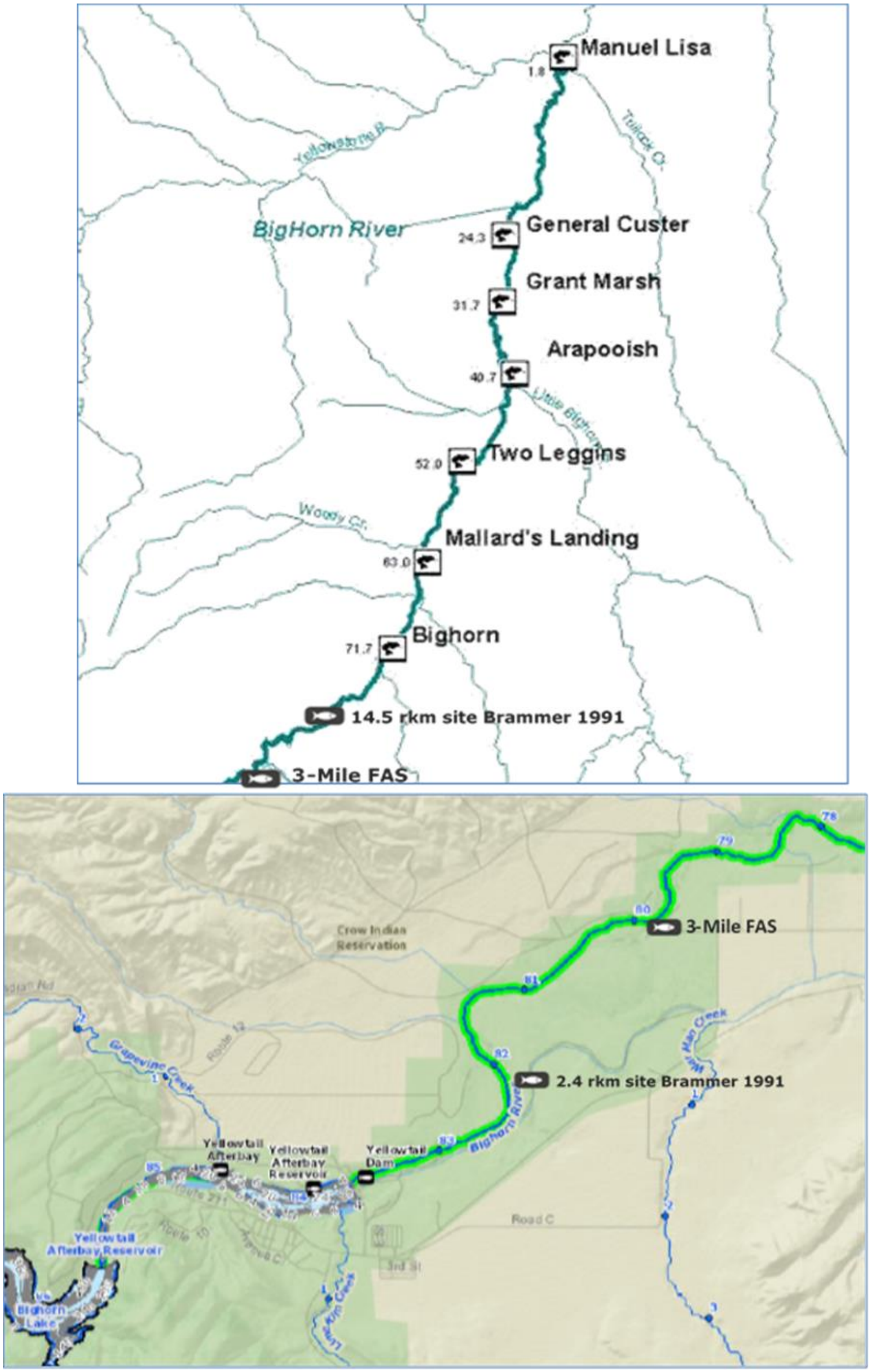
Station ID	Agency	Site Name	Latitude	Longitude	Parameter
BHRA_RM82	MSU	Bighorn River @ RM82 Upper Brammer Site	45.32863	-107.8985	Macroinverts, WQS
BHRA_RM75	MSU	Bighorn River @ RM75 Lower Brammer Site	45.38232	-107.8125	Macroinverts, WQS
BHRA_RM72	New BHRA	Big Horn River @ Bighorn FAS	45.41634	-107.7898	Macroinverts, WQS
BHRA_RM63	MDEQ	Big Horn River @ Mallards FAS	45.52166	-107.7258	Macroinverts, WQS
BHRA_RM52	New BHRA	Big Horn River @ Two Leggins FAS	45.64449	-107.6599	Macroinverts, WQS
BHRA_RM40	New BHRA	Big Horn River @ Arapooish FAS d/s Little Bighorn River	45.75664	-107.5653	Macroinverts, WQS
BHRA_RM24	New BHRA	Big Horn River @ General Custer FAS	45.92737	-107.5744	Macroinverts, WQS
BHRA_RM2	MDEQ	Bighorn River at Manuel Lisa FAS (river left)	46.14486	-107.4644	Macroinverts, WQS

**These are proposed sampling locations; locations may change due to unforeseen access or other sampling issues.*

Photo Link to Bighorn River Site near Brammer's 1986 & 1987 Upper Site (2.4 RKM, RM 82)
https://goo.gl/maps/Lu3rDfexDeq

Sampling Map

Figure 1 - Map of Sampling Locations



Sampling Timing

The index period is the period of time that samples should be collected to minimize seasonal variation. The index period for Montana's mountain streams is generally in the summer (June 21 to October 1), following runoff (Richards, D.C. 1996). Eastern Montana streams may be sampled from May 1 to October 1 (MDEQ 2012a).

Table 2 - Sample Collection Timeframe

Data Collection	Parameters	Reason for Date Selection
Week of April 15th	Macroinvertebrates, Water chemistry	Pre run-off, comparison to Brammer's study, outside of MDEQ Index Period
Last week of Sept	Macroinvertebrates, Water chemistry	Baseflow; post-summer growing season, within MDEQ Index Period

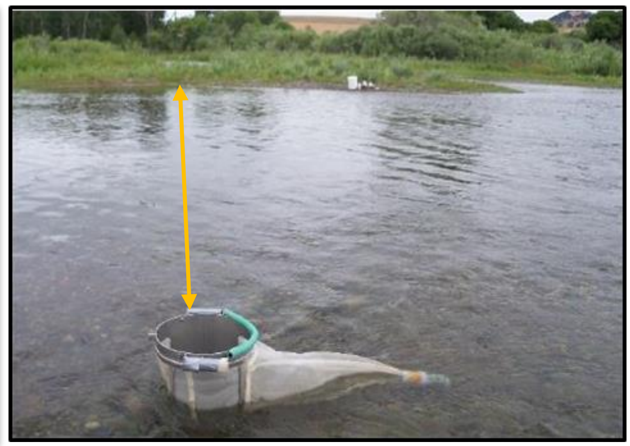
2.2 Field Sampling Methods

***In situ* Measurements using field meters:** During each sampling event at each monitoring site, an Oakton 10 (or similar model) water quality multi-meter will be used to collect *in situ* measurements of water temperature, specific conductance and pH. Air temperature will be recorded from a thermometer. These measurements will be collected prior to the collection of water samples or other disturbances to the water column or substrate during bug sampling.

Stream Physical Habitat Measures: A 30 m survey tape will be staked from the green-line on the stream bank to record sampling distances to where Hess samples are taken in the stream channel (Photo 1). Stream channel depths at each Hess sample point (n=3) will be recorded at the time of sampling. Substrate size-classes (based on Wolman 1954) and embeddedness of cobbles (>64mm) within the Hess sampler frame will be qualitatively estimated by relative percentage. This will give an estimation of sediment in the riffle being sampled. Photo points will be taken, incidental aquatic species and visual estimates of the adjacent streambank habitat will also be noted during the field visits.

Benthic Macroinvertebrate Collections: Three replicate Hess (33 cm diameter, 500 micron mesh) samples will be collected within a designated riffle at each site to quantitatively sample macroinvertebrates at measured distances from the bank (Photo 1 & 2). Three Hess samples typically capture 90% of the total taxa present in a riffle (Vinson and Hawkins 1996), and this sampling method has been used on the Bighorn River previously (Brammer 1990, MDEQ 2007). Each Hess sample constitutes a benthic area of 0.1 m^2, so a multiplier of 10 is applied to each sample to achieve a per meter squared density estimate. 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 sampler were scrubbed clean of organisms and removed; then the entire area within the sampler frame was raked for one minute until all organic matter and macroinvertebrates were washed into the collection net of the Hess sampler (Photo 1 & 2). Macroinvertebrates, organic and

Photo 1. *Hess sampling procedure in a Missouri River riffle near Little Prickly Pear Creek. Distance to the greenline was measured (orange arrow).*



inorganic matter were composited into a 40 liter bucket. By swirling the bucket with several water washes, organic material was elutriated from the inorganic (cobbles/gravels) portion onto a 500µm sieve, so that only macroinvertebrates and organic matter were transferred into 1 liter labeled sampling jars filled with 95% ethanol. The inorganic portion of the sample left in the bottom of the bucket was thoroughly examined for caddisfly cases before being discarded.

Flow (discharge) method: Streamflow data will be recorded from the USGS gage station on the Bighorn River nearest to the sampling location at the time of sampling. Three gages are present within the monitoring reach: USGS 06287800 at St. Xavier, MT, the USGS 06288400 at Two Leggins Bridge near Hardin and the USGS 06294500 above Tullock Creek downstream near Bighorn MT. Alternatively, flows in the lower portion of the river can be reliably estimated by adding the Little Bighorn River gage station and Two Leggins Bridge gage station flows.

Site photographs: Digital photographs will be taken at each site and during each sampling event, with at least one photo oriented upstream, one facing downstream and facing across the channel. Additional photos will be taken as deemed necessary by field crews to document changes in riparian vegetation condition, land uses, stream flora, flow conditions, water clarity, etc. Photos will be a combination of close-ups of water and substrate conditions as well as stream panoramas. The photo number and pertinent photo location, notes or other pertinent information will be recorded for each photo.

2.3 Laboratory/Analysis Methods

Samples will be transported to, processed and analyzed at the chosen contractor's laboratory either in Helena, Missoula, MT or Moscow, ID. Macroinvertebrates will be picked from the samples on a randomized grid pattern until 500-600 individuals are reached, placed in vials and then identified to the lowest taxonomic level possible (genus/species) with a dissecting microscope (10-40x) following MDEQ (2012a) protocols.

Raw macroinvertebrate taxa and sample count data will be entered into an Excel spreadsheet and imported into a Microsoft Access Database Platform (Ecological Data Applications System: EDAS) (Jessup 2006). Macroinvertebrate metrics known to be influenced by stream habitat and water quality will then be calculated from the macroinvertebrate data using EDAS, including EPT taxa {mayfly (Ephemeroptera), stonefly (Plecoptera) and caddisfly (Trichoptera)}, % EPT, % Non-insect, % Chironomidae and the Hilsenhoff Biotic Index (HBI).

MDEQ multi-metric indices (MMIs) designed for low valley (LVAL) and plains (PLNS) ecoregions will also be calculated. Both indices will be calculated for the Bighorn River because of the cool-cold water taxa in the upper 40 miles and warm-water characteristic taxa in the lower 40 miles. The MMIs use different suites of metrics: LVAL (6 metrics) and PLNS (5 metrics) to give a composite score that impairment can be determined; if scores are below the threshold of 48 for LVAL, and below 37 for the PLNS, then the community is considered impaired; MDEQ no longer uses the MMI to make site impairments for their 303(d) listings (MDEQ 2012a).

The combined mayfly, caddisfly and stonefly species (EPT taxa) and the percentage of these in the sample (% EPT) are always informative metrics, as EPT taxa contain some of the more intolerant aquatic insects. Generally, 20 or more EPT taxa collected at a site in the mountain streams of Montana is considered an unimpaired and healthy community (Bukantis 1996). EPT richness metrics typically decrease with increasing sediment (Barbour et al. 1999); although, Tricos (Tricorythodes and Caenis) and burrowing mayflies (Ephemera simulans) are more silt tolerant and can increase in numbers with increasing siltation.

One informative stand-alone metric is the Hilsenhoff Biotic Index (HBI) which measures the tolerance of a macroinvertebrate community to organic enrichment (Hilsenhoff 1987), but has also been used as a surrogate for sediment tolerance (MTDEQ 2012b). Tolerance values are based on a 0-10 scale, where zero-ranked taxa are most sensitive and 10-ranked taxa are most tolerant to pollutants. Values of 0.0-3.0 indicate no apparent organic pollution (excellent), 3.0-4.0 possible slight organic pollution (very good), 4.0-5.0 moderate pollution (good), 5.0-6.0 fairly significant (fair), 6.0-7.0 significant pollution (fairly poor), 7.0-8.0 very significant organic pollution 8.0-10 severe organic pollution. HBI scores are evaluated using a threshold value of 4.0 as a core indicator of organic or sediment impairment (MDEQ 2011).

Macroinvertebrate optimal and maximum thermal tolerances (Brandt 2001 and Ott and Maret 2003), categorical classifications (Apfelbeck 2007), and best professional judgment were used to categorize 225 taxa in the Madison and Missouri River systems (McGuire 2016). Many of these taxa are ubiquitous across watersheds and occur in the Bighorn River macroinvertebrate community. Community temperature metrics were calculated using pooled data (all replicates combined) where optimal and max. temperature values were applied to the abundance of each taxa (that values are available) for each site.

3.0 Quality Assurance/Quality Control

3.1 Quality Assurance and Quality Control Overview

To inform biological integrity studies, data needs to accurately represent conditions in the watershed. Most projects require some degree of proper sample handling, processing, and data quality assessment, particularly when scientific or resource management questions are being investigated.

Quality Assurance (**QA**) is the overall management of a sampling program. It ensures the monitoring process, from the methods used to how data will be managed and analyzed, is adequate for the project to meet its objectives with a stated level of confidence. QA activities include developing a sampling and analysis plan, making sure that contractors or staff are properly trained, and following standard operating procedures.

Quality control (**QC**) includes technical actions taken to detect and control errors. QC consists of developing measures and protocols to ensure sample collection and analyses are consistent and correct. If there is a problem, good QC will help to identify the problem. It also helps determine whether contractor work is being performed correctly. QC activities may include collecting replicate samples for comparison analyses or laboratory splits.

3.2 Data Quality Indicators

This section describes for each data quality indicator (representativeness, comparability, completeness, sensitivity, precision and accuracy) how the sampling and analysis plan and study design aims to achieve data quality. Data quality indicator criteria are specified, where appropriate.

Representativeness

Representativeness refers to the extent to which biological measurements represent an environmental condition in time and space. This BHRA project follows a “professional-judgment” sampling design in which the experience of the researchers has considered spatial and temporal factors to help ensure representativeness.

Spatial representation

Monitoring sites chosen by BHRA represent the entire reach of the Lower Bighorn River from below the Yellowtail Afterbay Dam to the confluence with the Yellowstone River. These sites were chosen to represent the upstream and downstream extents of the entire reach. Sample sites were also chosen above and below two major tributary streams (Little Bighorn River and Soap Creek) in order to examine how these tributaries influence water quality, aquatic plant growth, and macroinvertebrate assemblages.

Temporal representation

While most of the historical macroinvertebrate sites have only been sampled during the summer time period, spring and fall macroinvertebrate samples have been collected at 2 sites (Brammer 1991). Macroinvertebrate sampling dates were typically chosen to correspond to MDEQ’s post run-off index period (MDEQ 2012). Sampling dates are expected to be similar from year to year. Samples across the sites will be collected within the smallest possible time window (i.e., within a day or two). Seasonal sampling dates were chosen to represent the pre-runoff period (mid to the end of April), and the base-flow post growing period in autumn (late September). This timing best represents the impacts of spring high water, summer low water, and impacts on vegetative growth.

Comparability

BHRA will follow standard operating procedures for macroinvertebrate collection (MDEQ 2007, MDEQ 2012a & b), collecting data as consistently as was collected during the previous years’ monitoring efforts, calculating the same metrics from the data used by DEQ to assess biological integrity based on macroinvertebrates (MDEQ 2012a).

3.3 Data Management, Record Keeping & Reporting

The project manager will be responsible for data management and record keeping prepared by the Contract Sample Team.

- The project manager will store and backup all data generated during this project, including field forms, laboratory reports obtained from the laboratories, electronic copies of field photographs, and written field notes.
- The project manager will maintain records of hours worked by contractors or volunteers for purposes of budget tracking

The Contract Sample Team will manage data as it is collected, including the following activities that occur during or after the sampling is completed:

- A brief synopsis of any SAP methodology derivations that occurred.
- Review field forms for completeness and accuracy, especially Site Visit and Chain of Custody forms, if the collector and contract laboratory are different.
- Enter all laboratory data into an Excel spreadsheet compatible with the EDAS database and MT e-WQX database (Appendix C).

3.4 Data Routing

Benthic macroinvertebrate sample data analyzed by the contract laboratory will be initially entered into an Excel spreadsheet to be uploaded into EDAS (Jessup 2006) (see Appendix C); BHRA will receive a copy of this dataset within the Appendices of the report. This data could then be routed; stored and managed (e.g. data will be uploaded into the Montana DEQ Montana EqUIS database (http://deq.mt.go/Water/wquinfo/datamgmt/MTEWQX) for eventual upload into EPA's STORET database (http://www.epa.gov/storet/).

In situ measurements, site photos and field forms will be routed, stored and managed by BHRA project manager.

4.0 ASSESSMENT RESULTS

4.1 Data Analysis

Benthic macroinvertebrates and substrate characteristics will be compared to historical data, and will provide a current baseline against which future conditions can be compared. The metrics calculated from each years' data will be properly interpreted (Jessup et al. 2005, MDEQ 2012b) and compared to those values from previously collected samples (1986-2005) and against reported values at the same site over time, and will also be compared against numeric biological standards for wadeable streams in the Northwestern Glaciated Plains and Foothill & Valley ecoregions (MDEQ 2012b).

Water chemistry data will be collected concurrently to determine overall health of the river and will be compared with data collected from macroinvertebrate and aquatic plant studies to help determine associated factors that affect aquatic bug and plant life in the river.

4.2 Data Communication

BHRA will share data through its website and in summary reports to landowners, guides and project partners. BHRA will share properly-formatted data and final reports with DEQ and other agency personnel who may be interested in this data for further analysis.

5.0 References

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Appendix A – Contractor Labs Project Budget Cost Comparison—Annual Monitoring Spring and Fall

Rhithron Associates, Inc., Missoula, MT:

50 macroinvertebrate samples * $290 per sample processing/reporting= $14,500. They do not generally perform field work. If Montana Biological Survey collected samples, and sent to Missoula for processing. Field Trip (RT): Drive time from Helena- 5 hrs. 20 minutes (x2) + 10 hour sample time * field aquatic ecologist time ($50 per hour) = $1,000, 285 miles * $0.33 per mile X 2 = $188.10 + $1000= $1,188.10 total each trip

2 field trips and sample processing= $14,500 + $2,376.20= $16,876.20

EcoAnalysts, Inc., Moscow, ID

50 macroinvertebrate samples* $340 per sample processing/reporting=$16,660, will perform sampling. Field Trip (RT): Drive time from Moscow. ID- 11 hrs. 10 minutes (x2) + 10 hour sampling time * field aquatic ecologist time ($50 per hour) = $1,000, 680 miles * $0.53 per mile X2 = $720.80 + $900= $1,720.80 total each trip

2 field trips and sample processing= $16,660 + $3,441.60= $19,901.60

Montana Biological Survey, Inc., Helena, MT:

50 macroinvertebrate samples* $230 per sample processing/reporting = $11,500. Montana Biological Survey collects samples, and will be brought to Helena for processing. Field Trip (RT): Drive time from Helena- 5 hrs. 20 minutes (x2) + 10 hour sampling time * field aquatic ecologist ($50 per hour) = $1000, 285 miles * $0.33 per mile X2 = $188.10 + $1000= $1,188.10 total each trip

2 trips and sample processing= $11,500 + $2,376.20= $13,876.20

Appendix B – QA/QC Terms and Definitions

Duplicate sample. Used for quality control purposes, duplicate samples are an additional sample taken at the same time from, and representative of, the same site that are carried through all assessment and analytical procedures in an identical manner. Duplicate samples are used to measure natural variability as well as the precision of a method, monitor, and/or analyst. More than two duplicate samples are referred to as replicate samples.

Precision. A data quality indicator, precision measures the level of agreement or variability among a set of repeated measurements, obtained under similar conditions. Relative percent difference (RPD) is an example of a way to calculate precision by looking at the difference between results for two duplicate samples.

Protocols. Protocols are detailed, written, standardized procedures for field and/or laboratory operations.

Quality assurance (QA). QA is the process of ensuring quality in data collection including: developing a plan, using established procedures, documenting field activities, implementing planned activities, assessing and improving the data collection process and assessing data quality by evaluating field and lab quality control (QC) samples.

Quality control (QC). QC samples are the blank, duplicate and spike samples that are collected in the field and/or created in the lab for analysis to ensure the integrity of samples and the quality of the data produced by the lab.

Relative percent difference (RPD). RPD is an alternative to standard deviation, expressed as a percentage and used to determine precision when only two measurement values are available. Calculated with the following formula: RPD as % = ((D1 – D2)/((D1 + D2)/2)) x 100 Where: D1 is first replicate result D2 is second replicate result

Representativeness. A data quality indicator, representativeness is the degree to which data accurately and precisely portray the actual or true environmental condition measured.

Sampling and Analysis Plan (SAP). A SAP is a document outlining objectives, data collection schedule, methods and data quality assurance measures for a project.

Sensitivity. Related to detection limits, sensitivity refers to the capability of a method or instrument to discriminate between measurement responses representing different levels of a variable of interest. The more sensitive a method is, the better able it is to detect lower concentrations of a variable.

Standard operating procedures (SOPs). An SOP is a written document detailing the prescribed and established methods used for performing project operations, analyses, or actions.

APPENDIX C – EDAS COMBATIBLE SPREADSHEET EXAMPLE OF RAW DATA