**Group Name**

**Descriptive Project Title**

**Sampling and Analysis Plan**

Insert Photo

Date

**Prepared by:**

Name of Project Coordinator/Leader

Organization/Affiliation

Address

**Approved by:**

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Abbie Ebert (Montana DEQ VM Lab Analysis Program Manager) Date

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Katie Makarowski (Quality Assurance Officer) Date

# Table of Contents

[Table of Contents 1](#_Toc93061818)

[1.0 INTRODUCTION 1](#_Toc93061819)

[1.1 Project Overview 1](#_Toc93061820)

[1.2 Project Area Overview 1](#_Toc93061821)

[1.3 Project Team and Responsibilities 1](#_Toc93061822)

[2.0 Objectives and Sampling Design 2](#_Toc93061823)

[2.1 Project Goals and Objectives 2](#_Toc93061824)

[2.2 Monitoring Locations 3](#_Toc93061825)

[2.3 Monitoring Schedule 3](#_Toc93061826)

[2.4 Water Quality Parameters 4](#_Toc93061827)

[3.0 Field Procedures 4](#_Toc93061828)

[3.1 Order of Operations 4](#_Toc93061829)

[3.2 Field Forms 5](#_Toc93061830)

[3.3 Data Collection Standard Operating Procedures 5](#_Toc93061831)

[4.0 Laboratory Analytical Requirements 5](#_Toc93061832)

[5.0 Quality Assurance/Quality Control (QA/QC) 5](#_Toc93061833)

[5.1 Overview 6](#_Toc93061834)

[5.2 Training 6](#_Toc93061835)

[5.3 QC Samples: Field Duplicates 6](#_Toc93061836)

[5.4 QC Samples: Field Blanks 7](#_Toc93061837)

[5.5 Instrument Calibration and Maintenance 7](#_Toc93061838)

[5.6 Data Quality Indicators 8](#_Toc93061839)

[5.7 Field Health and Safety 9](#_Toc93061840)

[6.0 Data Management, Record Keeping & Reporting 10](#_Toc93061841)

[6.1 DEQ’s MT-eWQX database and Data Quality Review 10](#_Toc93061842)

[6.1.1 Project ID 11](#_Toc93061843)

[6.2 Other Data Management Approaches 11](#_Toc93061844)

[7.0 Data Analysis and Reporting 11](#_Toc93061845)

[7.1 Data Analysis 11](#_Toc93061846)

[7.2 Reporting 11](#_Toc93061847)

[8.0 References 11](#_Toc93061848)

[Appendix A - Project Budget 12](#_Toc93061849)

[Appendix B – Field Forms 13](#_Toc93061850)

[Appendix c – Equipment and supplies 14](#_Toc93061851)

[Appendix D – QA/QC Terms and Definitions 15](#_Toc93061852)

Note: to update this table of contents, right click on it and select “update field” then “update entire table”.

# 1.0 INTRODUCTION

## 1.1 Project Overview

Begin with a paragraph or two introducing your program and your monitoring project.

* Your organization’s name
* The reason you are conducting water quality monitoring
* How you expect your monitoring project will benefit your community
* How your monitoring project fits into local watershed planning efforts

A budget table for laboratory analytical costs is included in **Appendix A**.

## 1.2 Project Area Overview

The purpose of this section is to describe **WHERE** you will conduct water quality monitoring.

* Describe the waterbody and monitoring sites
* Describe the surrounding watershed and landscape (e.g., primary land uses, vegetation)
* List any water quality impairments (if any) that DEQ has identified for the waters you plan to monitor; search DEQ’s Clean Water Act Information Center at <https://deq.mt.gov/water/resources>
* Other relevant information (e.g., known or suspected pollution sources, recent related water quality monitoring efforts)
* Consider including a map of the project area

Include a map of your project area.

Insert project area map

## 1.3 Project Team and Responsibilities

The purpose of this section is to specify the project team members involved with this monitoring project and to clarify the roles and responsibilities of each member. Add additional tasks to the table as needed.

**Table 1. Project Team Roles and Responsibilities**

| **Role** | **Person(s)** | **Contact phone, email** |
| --- | --- | --- |
| Develop Sampling and Analysis Plan (SAP) |  |  |
| Oversee monitoring personnel |  |  |
| Training monitoring personnel |  |  |
| Review field forms |  |  |
| Lab coordination (e.g., bottle orders, shipping notifications, lab EDDs) |  |  |
| Ship or deliver samples to lab |  |  |
| Review data quality |  |  |
| Upload data into MT-eWQX database |  |  |
| Write final report |  |  |

# 2.0 Objectives and Sampling Design

## 2.1 Project Goals and Objectives

The purpose of this section is to articulate **WHY** you are monitoring. Clearly state your project goals and your specific and measurable monitoring objective or objectives that will allow you to achieve each goal. Also include a brief explanation of how you will analyze the data that is produced.

Include a table of your project goals, monitoring objectives, and data analyses (see examples below):

* List the **goals** that motivate your project. Goals are the big picture desired outcomes of your project; they can be broadly stated (e.g., evaluate current conditions, establish a baseline for future comparisons, identify sources of pollution, evaluate if projects effectively improved water quality, analyze trends over time, educate the community about water quality).
* List the monitoring **objectives** associate with each goal. Objectives should start with the word “to” and include four elements: 1) Parameter(s), 2) Location, 3) Timing, and 4) Context.
* Summarize how you plan to **analyze each type of data** you collect to answer each question.

**Table 2. Project Goals, Objectives and Analyses** [replace examples with your own]

|  |  |  |
| --- | --- | --- |
| **Goal** | **Objective** | **Data Analysis** |
| Evaluate current nutrient conditions in Anywhere Creek and establish a baseline for future comparisons. | To collect nutrient samples (TN, TP and NO2+3) at five sites along the entire length of Anywhere Creek during the summertime growing season from July 1 - September 30 when nutrient standards criteria apply. | Compare nutrient concentrations against to numeric nutrient standards in Montana Circular DEQ-12A. |
| Graph nutrient concentrations from upstream to downstream and observe spatial patterns among sites. |
| To take photos of the stream substrate at each location and during each site visit where nutrient samples are being collected to visually document benthic algae conditions. | Visually estimate algae biomass at each site using guide in Montana DEQ's Chlorophyll-a SOP. |
| Evaluate whether septic systems are a likely source of excess nutrients in Anywhere Creek. | To collect nitrate samples in Anywhere Creek at a site upstream and a site downstream from Any Town during baseflow conditions in November to determine whether septic systems appear to be a source of excess nutrients. | Compare nitrate concentrations between the site above town and the site below town to determine if there is a significant increase. |
| Evaluate whether an abandoned mine cleanup project near the headwaters of Mine Creek was successful in improving water quality. | To collect water samples at five sites along Mine Creek, one above the project area and the rest in depositional areas spaced throughout the reaches downstream from the project area, to evaluate metals concentrations. | Compare metals concentrations against metals standards in Montana Circular DEQ-7. |
| Graph metals concentrations collected three years ago alongside current metals concentrations to visualize how conditions have changed over space and time. |
| To collect fine sediment samples at five sites along Mine Creek, one above the project area and the rest in depositional areas spaced throughout the reaches downstream from the project area, to evaluate metals concentrations. | Compare sediment metals concentrations against NOAA's Screening Quick Reference Tables for Inorganics in Sediment. |

## 2.2 Monitoring Locations

In this section, include a table that shows all monitoring sites of sites, including the site name, description, latitude, longitude, which parameters will be collected at each site, and the rationale for why you selected the site.

* **Note**: Monitoring locations should be carefully selected to represent conditions of the waterbody or reach that you are monitoring. When selecting monitoring locations, consider aspects that may impact the parameters that you are sampling such as tributaries, springs, irrigation withdrawals or diversions, suspected pollution hotspots, roads/bridges, landowner access issues, changes in ecoregion, slope, or geology.
* **Note**:Guidance on Station ID naming conventions can be found in the *Overview of Project and Station Naming for DEQ’s EQuIS (MT-eWQX) Database* document located at <https://deq.mt.gov/water/Programs/sw>.

**Table 3. Monitoring Locations\***

| **Site Name** | **Site Description** | **Station ID** | **Latitude** | **Longitude** | **Parameters to Collect** | **Rationale for Site Selection** |
| --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |

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

Also include a map showing your monitoring sites within your project area.

Insert site map

## 2.3 Monitoring Schedule

Describe WHEN monitoring will occur.

* State the monitoring timeframe (e.g., Monitoring will occur between May 1 and September 30).
* State the frequency of sampling per parameter. For example, nutrients will be collected at least 14 days apart at a site, algae will be collected monthly, sediment parameters will be measured once per summer, etc.
* Describe any seasonal or flow conditions that the sampling timeframe is trying to capture such as baseflow, high flow, summertime growing season, before irrigation withdrawals, etc.

Include a table showing when each sampling event will occur; include specific dates if possible.

**Table 4. Monitoring Schedule**

|  |  |  |
| --- | --- | --- |
| **Date** | **Parameters** | **Rationale for Timing** |
| 1st week of May, 2019 | Metals, TSS, flow | High flow expected |
| Mid-July | Nutrients | Baseflow, summer growing season, before irrigation |
| Mid-August | Nutrients, Algae | Baseflow; summer growing season |
| Mid-September | Nutrients, Metals, Sediment metals | Baseflow; summer growing season, after irrigation |

## 2.4 Water Quality Parameters

List all the water quality parameters that you will incorporate into your project and include a brief introduction to how you will collect that data and why. See example below.

**Table 5. Water Quality Parameters**

| **Parameter or Data Type** | **Collection Approach** | **Justification for Collecting** |
| --- | --- | --- |
| Total Nitrogen (TN) | Parameters measured via water samples analyzed by an analytical lab | Existing nutrient impairments. |
| Total Phosphorus (TP) |
| Nitrite plus Nitrate (NO2+3) |
| Total suspended solids (TSS) | TSS can help evaluate nutrient patterns |
| pH | Parameters measured *in situ* with YSI field meter | Common descriptive water quality parameter |
| Water temperature |
| Specific conductance (SC) |
| Dissolved oxygen (DO) |
| Discharge (flow) | Measured with OTT flow meter. | Necessary to pair concentrations with flow data to calculate loads. |
| Photos | Taken with digital camera | Tracking riparian conditions, benthic algae conditions, and other site conditions; low-cost. |

# 3.0 Field Procedures

## 3.1 Order of Operations

Include an explanation of the order in which you will complete each task while packing, navigating to the site, performing data collections, and return from the field.

## 3.2 Field Forms

The purpose of this section is to list the field forms that volunteers will complete during sampling activities.

* Include a list of forms and include an electronic copy of each form in Appendix A.

Copies of field forms are included in **Appendix B**.

## 3.3 Data Collection Standard Operating Procedures

The purpose of this section is to specify **HOW** you are going to perform each monitoring task, including the specific monitoring protocols you will use.

**Note**: Many volunteer monitoring programs either write out each method’s step-by-step instructions here in their SAP to use as a guide in the field, or they develop a separate Standard Operating Procedure (SOP) document that is cited here.

Consider (if applicable):

* **Field meters:** type of meter, which parameters will be measured, necessary calibrations, etc.
* **Water Sampling Methods, Sediment Sampling Methods, Biological Sampling Methods**: type of samples (water, sediment, macroinvertebrates, algae), list of parameters that will be analyzed per sample, method of collection to be used (e.g., grab, filtered grab, Van Dorn), rinsing or other decontamination method, filtration method (if applicable), acid preservation type and method (if applicable), sample storage method (on ice, frozen, room temperature), chain of custody field form requirements.
* **Flow/discharge methods**: where and how to measure flow, which meter (if applicable) or alternate method will be used, where flow will be measured
* **Site photographs**: how many (minimum) photos will be taken per site, what crews should take pictures of, and how will photos be tracked or recorded.

## 4.0 Laboratory Analytical Requirements

Include a table which lists each parameter you will collect and, for each, the preferred and alternate laboratory analytical method, required reporting limit (and units), holding time, sample container and preservative.

* Copy the analytical information for relevant parameters from DEQ’s Volunteer Monitoring Suite Table to build your own analytical table below.

**Table 6. Monitoring Parameter Suite, Sample Handling, Analysis & Preservation**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameter** | **Preferred Method** | **Required Reporting Limit (µg/L)** | **Holding Time (days)** | **Sample Container (size and material)** | **Preservative** |
|  |  |  |  |  |  |

# 5.0 Quality Assurance/Quality Control (QA/QC)

The purpose of this section is to summarize all quality assurance and quality control requirements associated with your project.

* This will help to ensure that the data you are collecting will be of sufficiently high quality to suit the needs of your project, and to communicate the quality of your data for other potential users of your data.
* Where prompted, fill in your project-specific information. Information in black font is suggested language to keep.

## 5.1 Overview

Projects require adequate documentation, proper sample collection, handling, and analysis, and other measured to produce high quality, credible data that accurately represent conditions in the watershed and can be used to answer scientific questions or guide resource management decisions.

Quality Assurance (QA) is the overall system used to ensure a monitoring project produces data of the desired level of quality necessary to meet project goals and objectives. For example, QA activities include developing a sampling and analysis plan, properly training volunteers, communicating analytical requirements to the lab, and adhering to standard operating procedures.

Quality control (QC) are technical activities used to detect and control errors. For example, QC activities include collecting field duplicates, preparing field blanks, reviewing field forms for accuracy, and calibrating equipment. Good QC will help to identify problems with the data if they arise and help identify what the cause of the problem likely is.

A list of QA/QC terms and definitions is included in **Appendix C**.

## 5.2 Training

Specify your training approach.

* Do you have training events already planned? Do you have water quality professionals lined up to help you, or is the project administrator able to provide the training? Will someone accompany volunteers in the field?

For example:

All program participants will attend a monitoring training in which protocols are reviewed by the program leader and/or water quality professionals. Each participant will be provided with and asked to review this sampling and analysis plan, the SRWG Standard Operating procedure (cite), and field forms before sampling commences, and must have copies with them in the field during all sampling events for reference. A program leader or alternate experienced volunteer will accompany each volunteer during sampling events at least until they demonstrate proficiency.

## 5.3 QC Samples: Field Duplicates

Include or modify the following language if it is relevant to your project.

Field duplicates are two samples (i.e., a routine sample and a duplicate sample) of ambient water collected from a waterbody as close as possible to the same time and place by the same person and carried through identical sampling and analytical procedures. Field duplicate samples are labeled, collected, handled and stored in the same way as the routine samples and are sent to the laboratory at the same time.

Field duplicates are typically collected at a rate of approximately 10% of the total number of routine samples collected. Therefore, to achieve this, one set of field duplicates will be collected during each sampling event. Duplicates may be collected at any of the monitoring locations shown in **Section 2.2**. See **Section 3.4** for information about duplicate sample labelling, and **Section 4.0** for analytical requirements.

Field duplicates are used to determine field precision to ensure that proper procedures are followed consistently. For each field duplicate set collected, the relative percent difference will be calculated:

Relative Percent Different (RPD) = ((D1 – D2) / ((D1 + D2)/2)) x 100

where: D1 = routine sample result value

D2 = duplicate sample result value

Precision will be assessed by ensuring that relative percent difference (RPD) between duplicates is less than 25%. If the RPD of field duplicates is greater than 25% and the parent and duplicate result values are greater than five times the lower reporting limit, the result values will be flagged with a “J”.

## 5.4 QC Samples: Field Blanks

Include or modify the following language if it is relevant to your project.

Field blanks are samples of analyte-free, laboratory-grade deionized water poured into a sample container in the field using the same method, container, and preservation as routine samples, and shipped to the lab along with other field (i.e., routine and duplicate) samples. All labeling, rinsing, preservation, and storage requirements applied for routine and duplicate samples are applied to field blanks; the only difference is that the water is deionized water rather than ambient stream water. Field blanks must be prepared while in the field.

One set of field blanks is submitted to the laboratory with each batch of samples delivered to the laboratory. Therefore, one set of field blanks will be prepared at or near the end of each monthly sampling event and submitted to the laboratory alongside the other routine and duplicate samples from that trip. See **Section 3.4** for information about field blank sample labelling, and **Section 4.0** for analytical requirements.

Field blanks are used to determine the integrity of the field personnel’s handling of samples, the condition of the sample containers supplied by the laboratory, and the accuracy of the laboratory methods. Accuracy will be assessed by ensuring that field blanks return values less than the lower reporting limit (i.e., non-detects) (shown in **Section 4.0**). If an analyte is detected in a field blank, all result values for that analyte from that batch of samples associated with the field blank will be qualified with a “B” flag. The exception is that data with a value greater than 10 times the detected value in the blank does not need to be qualified.

## 5.5 Instrument Calibration and Maintenance

In this section, describe any calibration and maintenance tasks that you will perform for any of the instruments you plan to use.

## 5.6 Data Quality Indicators

Include or modify the following language if it is relevant to your project.

Data quality indicators (DQIs) are attributes of samples that allow data users to assess data quality. Because there are large sources of variability in streams and rivers, DQIs are used to evaluate the sources of variability and error and thereby increasing confidence in our data.

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

**Representativeness**

Representativeness refers to the extent to which measurements represent an environmental condition in time and space.

**Spatial representation**

Describe how your sampling design helps achieve spatial representativeness.

* For example, were sampling sites chosen to capture variability in land use, flow or other watershed characteristics that may be influencing water quality? Were monitoring site locations limited because of site accessibility and landowner permission? Were monitoring sites selected along the entire length of the stream from headwaters to mouth, or do they represent some more specific reach?

**Temporal representation**

Describe how your sampling design helps achieve temporal representativeness.

* For example, will samples collected from the same site on different days be collected at approximately the same time of day? Will sampling on the same waterbody on the same day be conducted from downstream to upstream to ensure that the same water is not being sampled twice and so field crews are not disturbing the sampling locations? Will sufficient time will be allowed to pass between sampling events at the same site (e.g., 14 days for nutrients; 7 days for metals)? Will flow monitoring occur in conjunction with chemistry sampling to help ensure comparable conditions?

**Comparability**

Comparability is the degree to which methods, data, or decisions are similar. Comparability expresses the confidence with which one data set can be compared to another. To achieve a comparable result, both the field collection method and the analytical method must be comparable.

Describe how your sampling design helps achieve comparability.

* For example, will you follow standard operating procedures? Will you collect the same data as was collected during previous years’ monitoring efforts? Will you use the same analytes, analytical methods, holding times, sample containers, and reporting limits as previous monitoring efforts? Will you use an accredited laboratory to perform analysis?

**Completeness**

Completeness is a measure, expressed as a percentage, of the amount of data that you *planned to collect* compared to the amount of data that you *actually collected*. The overall project goal is …

State your overall project completeness goal.

* For example, how many sampling events or samples do you plan to complete and what percentage of this total is your goal to actually complete. A reasonable completeness goal is generally 90% even if you strive for 100%.

Describe how your sampling design helps achieve completeness.

* For example, “Prior to leaving a sampling site, field forms will be reviewed by the field leader on site to reduce the occurrence of empty data fields. Sampling events that are cancelled due to unforeseen circumstances will be rescheduled. Samples that are damaged within a short amount of time after collection will be recollected. Lab reports will be reviewed upon receipt to ensure that results for each sample submitted are received.”

**Sensitivity**

Sensitivity refers to the limit of a measurement to reliably detect a characteristic of a sample. Related to detection limits, the more sensitive a method is, the better able it is to detect lower concentrations of a variable; for analytical methods, sensitivity is expressed as the method detection limit (MDL).

Detection and reporting limits are specified for this project which are adequately low enough to enable comparison to the thresholds of interest (e.g., numeric nutrient standards). The laboratory routinely checks sensitivity (e.g., method blanks, continuing calibration blanks, and laboratory reagent blanks) per their quality management plan.

**Precision, Bias, and Accuracy**

Bias is the degree of systematic error in an assessment or analysis process; when bias is present, the sampling result value will differ from the accepted, or true, value of the parameter. Adhering to standard operating procedures during sampling will reduce sampling bias.

Precision measures the level of agreement or variability among a set of repeated measurements obtained under similar conditions. Field duplicates (**Section 5.3**) will be collected during this project and used to determine field precision. If problems are linked to field crew sampling error, supplemental training will be provided prior to the next sampling event.

Accuracy is the extent of agreement between an observed value (sampling result) and the accepted, or true, value of the parameter being measured. Field blanks (**Section 5.4**) will be prepared during this project and used to evaluate accuracy for field activities. The laboratory uses EPA approved and validated methods and performs precision and accuracy performance evaluations per their quality management plan.

**Holding Time**

All samples will be checked to verify that they were processed within their specified holding times. Sample results whose holding time was exceeded prior to being processed will be qualified with an “H” flag.

## 5.7 Field Health and Safety

Include or modify the following language if it is relevant to your project.

Field personnel commonly encounter hazards while performing monitoring activities. All participants are advised to take adequate precautions to avoid injury or loss of life due to hazards including, but not limited to, driving, wading and other activities in and around water, weather conditions, wildlife interactions, people interactions, use of chemical preservatives, etc.

On every sampling trip, field personnel should carry with them a communication device (e.g., cell phone), first aid kit, bear spray, adequate drinking water, clothing appropriate for a range of weather conditions, personal protective equipment including waders, adequate footwear, and gloves to be worn while handling preservatives, and any other necessary safety-related items.

Each volunteer will be required to sign a waiver acknowledging risk and these waivers will be kept on file by the project coordinator. If, for any reason, field personnel feel unsafe while navigating to or from monitoring sites or while collecting data, they should err on the side of caution and not collect the data. Any delays or changes should be reported to the project coordinator as soon as possible so sampling can be rescheduled if possible.

# 6.0 Data Management, Record Keeping & Reporting

The person(s) responsible for data management, record keeping, data quality review and data upload will perform the following activities:

* Review field forms for completeness and accuracy, especially Site Visit and Chain of Custody forms.
* Draft a brief synopsis of any SAP derivations that occurred.
* 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.
* Review data quality and flag result values, as needed, prior to uploading into the database(s). Upload all laboratory data into MT e-WQX database (if DEQ funding or support is provided).
* Maintain records of volunteer hours, travel and other budget tracking, as needed.

## 6.1 DEQ’s MT-eWQX database and Data Quality Review

Analytical laboratories will prepare and analyze the samples in accordance with the chain-of-custody forms and analytical methods specified in **Table 6**. The lab will then supply the project coordinator with laboratory analytical reports and Electronic Data Deliverable (EDD) spreadsheets.

If DEQ funding is received in support of the monitoring project (e.g., through DEQ’s Volunteer Monitoring Lab Analysis Support Program or other funding mechanism), all data collected must be entered by the project coordinator into DEQ’s MT-eWQX database (also known as EQuIS). Instructions for preparing, validating and submitting the EDD to MT-eWQX must be followed (available at https://deq.mt.gov/water/Programs/sw). For example, steps include:

* Compiling data (including site information, field measurements and lab results),
* Transforming the data into the required format,
* Performing a thorough quality control check of the data to correct errors, qualify problematic sample result values with data flags, etc.,
* Validating the data, and
* Submitting EDDs to MT-eWQX.

## 6.1.1 Project ID

The purpose of this section is to state your Project ID, Name, and Description that will be used during EDD submission to the EQuIS (MT-eWQX) database. If you have submitted data to EQuIS in previous years for your project, state your established information.

* **\*Note:** Guidance on Project ID naming conventions can be found in the *Overview of Project and Station Naming for DEQ’s EQuIS (MT-eWQX) Database* document located at <https://deq.mt.gov/water/Programs/sw>.

## 6.2 Other Data Management Approaches

Specify any other data management approaches that will be used.

* For example, will you also upload other quantitative data that are not laboratory results (such as instantaneous measurements from field meters and flow measurements) into the database? Will you scan and archive electronic copies of all field forms, or hard copies? Will you use a naming convention or filing system to manage photos?

# 7.0 Data Analysis and Reporting

The purpose of this section is to map out your intended plan for analyzing the data that you collect. Refer back to **Table 2**.This will help ensure that you are collecting the correct type, amount, and quality of data to achieve your objectives. This section also outlines how you intend to make the data and analyses available to others so it can be used to inform research, educate the public, develop future monitoring plans, etc.

## 7.1 Data Analysis

* For each parameter covered under this SAP, describe how you plan to analyze the data and use it to achieve your goals and objectives stated in Section 1.
* Note whether sufficient data will be collected following completion of this SAP or if additional data collection is anticipated.

## 7.2 Reporting

Specify your intended mechanisms for data sharing and reporting

* For example, will you upload your data into DEQ’s publicly-available MT-eWQX database? Will you write a report summarizing your data collection and findings? Will you give a presentation in your community or share information via local media outlets?

# 8.0 References

List any citations that you reference throughout this document.

# Appendix A - Project Budget

**Projected Budget for Laboratory Analysis and Shipping**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Parameter** | **Price per Parameter** | **Number of Sites** | **Number of visits per site** | **Number of routine samples** (number of sites x number of visits per site) | **Number of field blanks** (often one per sampling event) | **Number of field duplicates** (often ~10% of the total number of routine samples) | **Total number of samples** (routine + duplicates + blanks) | **Total Cost** (Total number of samples x cost per parameter) |
|  |  |  |  |  |  |  |  |  |

\*include a line for shipping, if applicable

# Appendix B – Field Forms

# Appendix c – Equipment and supplies

The purpose of this appendix is to create a list of equipment and supplies needed to complete monitoring events.

# Appendix D – QA/QC Terms and Definitions

**Accuracy**. A data quality indicator, accuracy is the extent of agreement between an observed value (sampling result) and the accepted, or true, value of the parameter being measured. High accuracy can be defined as a combination of high precision and low bias.

**Analyte**. Within a medium, such as water, an analyte is a property or substance to be measured. Examples of analytes would include pH, dissolved oxygen, bacteria, and heavy metals.

**Bias**. Often used as a data quality indicator, bias is the degree of systematic error present in the assessment or analysis process. When bias is present, the sampling result value will differ from the accepted, or true, value of the parameter being assessed.

**Blind sample**. A type of sample used for quality control purposes, a blind sample is a sample submitted to an analyst without their knowledge of its identity or composition. Blind samples are used to test the analyst’s or laboratory’s expertise in performing the sample analysis.

**Comparability**. A data quality indicator, comparability is the degree to which different methods, data sets, and/or decisions agree or are similar.

**Completeness**. A data quality indicator that is generally expressed as a percentage, completeness is the amount of valid data obtained compared to the amount of data planned.

**Data users**. The group(s) that will be applying the data results for some purpose. Data users can include the monitors themselves as well as government agencies, schools, universities, businesses, watershed organizations, and community groups.

**Data quality indicators (DQIs)**. DQIs are attributes of samples that allow for assessment of data quality. These include precision, accuracy, bias, sensitivity, comparability, representativeness and completeness.

**Data quality objectives (DQOs)**. Data quality objectives are quantitative and qualitative statements describing the degree of the data’s acceptability or utility to the data user(s). They include data quality indicators (DQIs) such as accuracy, precision, representativeness, comparability, and completeness. DQOs specify the quality of the data needed in order to meet the monitoring project's goals. The planning process for ensuring environmental data are of the type, quality, and quantity needed for decision making is called the DQO process. Madison Stream Team Sampling and Analysis Plan Page 23

**Detection limit**. Applied to both methods and equipment, detection limits are the lowest concentration of a target analyte that a given method or piece of equipment can reliably ascertain and report as greater than zero.

**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.

**Environmental sample**. An environmental sample is a specimen of any material collected from an environmental source, such as water or macroinvertebrates collected from a stream, lake, or estuary.

**Field blank**. Used for quality control purposes, a field blank is a “clean” sample (e.g., distilled water) that is otherwise treated the same as other samples taken from the field. Field blanks are submitted to the analyst along with all other samples and are used to detect any contaminants that may be introduced during sample collection, storage, analysis, and transport.

**Instrument detection limit**. The instrument detection limit is the lowest concentration of a given substance or analyte that can be reliably detected by analytical equipment or instruments (see detection limit).

**Matrix**. A matrix is a specific type of medium, such as surface water or sediment, in which the analyte of interest may be contained.

**Measurement Range**. The measurement range is the extent of reliable readings of an instrument or measuring device, as specified by the manufacturer.

**Method detection limit (MDL)**. The MDL is the lowest concentration of a given substance or analyte that can be reliably detected by an analytical procedure (see detection limit).

**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 assurance project plan (QAPP)**. A QAPP is a formal written document describing the detailed quality control procedures that will be used to achieve a specific project’s data quality requirements. This is an overarching document that might cover a number of smaller projects a group is working on. A QAPP may have a number of sample analysis plans (SAPs) that operate underneath it.

**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

**Replicate samples**. See duplicate samples.

**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.

**Spiked samples**. Used for quality control purposes, a spiked sample is a sample to which a known concentration of the target analyte has been added. When analyzed, the difference between an environmental sample and the analyte’s concentration in a spiked sample should be equivalent to the amount added to the spiked sample.

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