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**Upper Gallatin River Nutrient Assessment  
Sample and Analysis Plan (SAP)**

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**TABLE OF CONTENTS**

**1.0 Introduction and Background .....4**

**2.0 Overview of Sampling Strategy .....7**

**3.0 Field Sampling Methods.....10**

**4.0 Sample handling Procedures .....10**

**5.0 Laboratory Analytical Methods .....11**

**6.0 Quality Assurance and Quality Control Requirements .....11**

**7.0 Data Analysis, Record Keeping and Reporting Requirements and Schedule for  
Completion.....13**

**8.0 Project Team and Responsibilities .....13**

**9.0 References.....14**

**Appendix A .....16**

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## **Sampling and Analysis Plan Upper Gallatin Watershed TMDL**

This document constitutes the Sampling and Analysis Plan (SAP) for the completion of a nutrient source assessment and loading estimates and the establishment of reference conditions for the Upper Gallatin Watershed TMDL planning area (TPA).

### **1.0 Introduction and Background**

The Upper Gallatin TPA encompasses an area of approximately 756 square miles in Gallatin and Madison Counties in southwestern Montana. The Upper Gallatin TPA includes the area of the Gallatin River Watershed extending from the Montana/Wyoming border downstream approximately 52 river miles to the confluence with Spanish Creek.

Under Montana law, an impaired water body is defined as a water body for which sufficient and credible data indicates non-compliance with applicable water quality standards (MCA 75-5-103). Section 303 of the Federal Clean Water Act requires states to submit a list of impaired water bodies or stream segments to the U.S. Environmental Protection Agency (EPA) every two years. Prior to 2004, this list was referred to as the “303(d) list”, but is now named the “Integrated Report”. The Montana Water Quality Act further directs states to develop TMDLs for all water bodies appearing on the 303(d) list as impaired or threatened by “pollutants” (MCA 75-5-703).

A total of six stream segments in the Upper Gallatin TPA appeared on either Montana’s 1996 or 2004 Clean Water Act Section 303(d) list. These include Squaw Creek, Taylor Creek, Cache Creek, Middle Fork of the West Fork of the Gallatin River, South Fork of the West Fork of the Gallatin River, and the West Fork of the Gallatin River (Figure 1). Of those six, four were listed for nutrients including: Squaw Creek, Middle Fork of the West Fork of the Gallatin River, South Fork of the West Fork of the Gallatin River, and the West Fork of the Gallatin River (Table 1, 2).

The Phase 1 aerial photo and assessment suggests that channelization, streambank modification /destabilization, highway/road/bridge runoff, on-site treatment systems, residential districts, site clearance, industrial/commercial site stormwater discharge, drainage/filling/loss of wetlands, loss of riparian habitat and other recreational pollution sources may be negatively affecting the Gallatin River. Potential causes of pollution include impacts associated with land development and rural residential districts, along with impacts due to Highway 191. Sources of impairment identified within the Taylor Fork, Cache Creek and Squaw Creek watersheds may also be negatively impacting the mainstem of the Gallatin River (PBS&J, 2005).

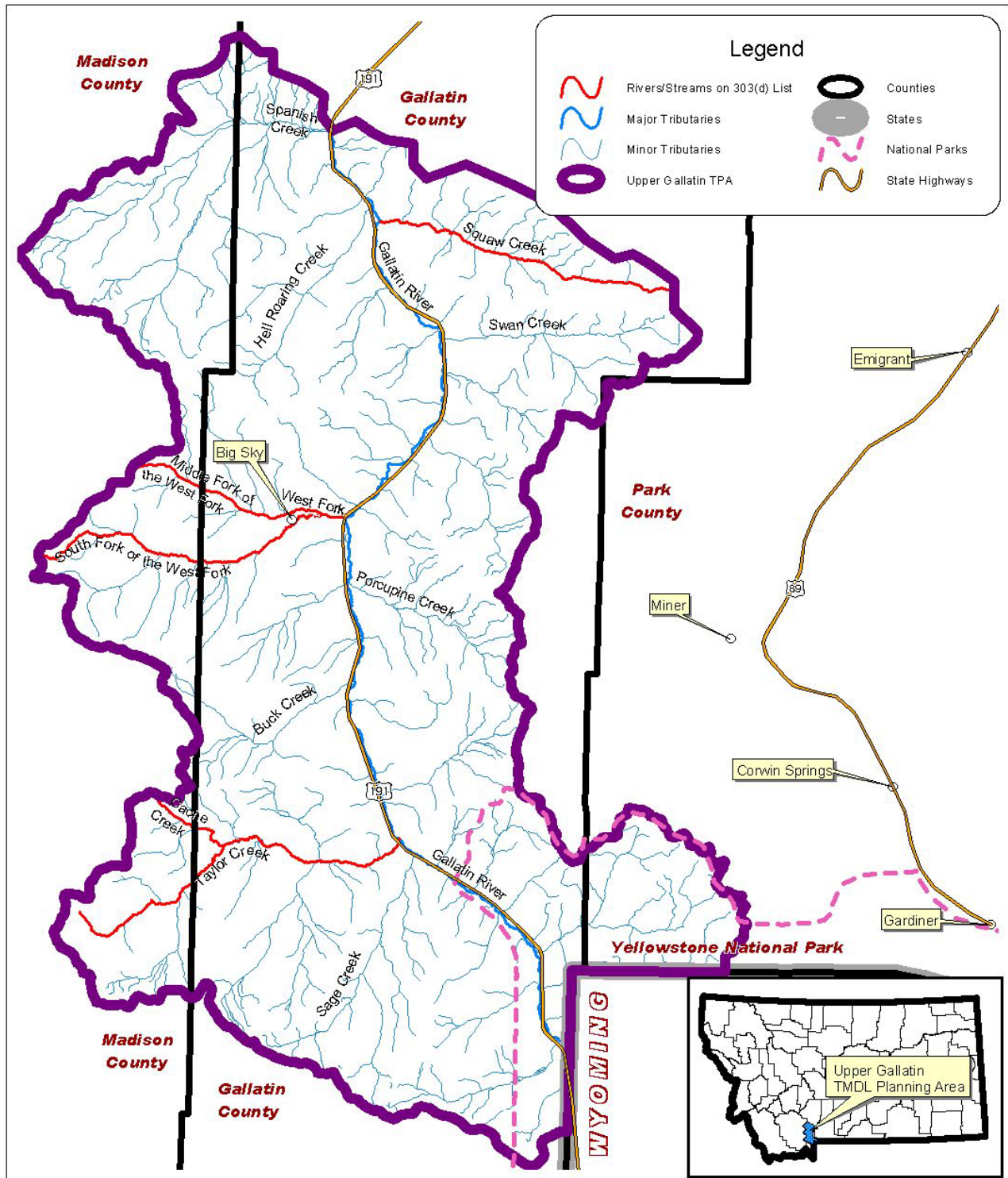


Figure 1: Upper Gallatin TMDL Planning Area and 303(d) listed streams (CDM, 2005)

**Table 1:** Water Bodies on Montana's 303(d) List of Impaired Waters and their Associated Level of Beneficial Use Support

Upper Gallatin									
Waterbody & Stream Description	Waterbody #	Use Class	Year	Aquatic Life	Coldwater Fishery	Drinking Water	Swimmable (Recreation)	Agriculture	Industry
SQUAW CREEK from headwaters to the mouth (Gallatin R)	MT41H005-1	B-1	1996		T				
			2004	P	P	X	F	F	F
TAYLOR CREEK, Lee Metcalf Wilderness boundary to the mouth (Gallatin R)	MT41H005-2	B-1	1996	NOT LISTED					
			2004	P	P	X	F	X	P
CACHE CREEK from headwaters to the mouth (Taylor Fork)	MT41H005-3	B-1	1996	P	P				
			2004	P	P	X	F	F	F
MIDDLE FK OF WEST FK GALLATIN RIVER, Headwaters to mouth (West Fk Gallatin R)	MT41H005-5	B-1	1996	P	P				
			2004	P	P	F	P	F	F
SOUTH FK OF WEST FK GALLATIN RIVER, Headwaters to mouth (West Fk Gallatin R)	MT41H005-6	B-1	1996	P	P				
			2004	P	P	F	P	F	F
WEST FK GALLATIN RIVER, Confluence Middle & North Fks of the West Gallatin to the mouth (Gallatin R)	MT41H005-4	B-1	1996	P	P				
			2004	P	P	F	N	F	F

F = Full Support; P = Partial Support; N = Not Supported; T = Threatened; X = Not Assessed (Insufficient Credible Data)

**Table 2:** Water Bodies on Montana's 303(d) List of Impaired Waters and their Associated Causes of Impairment

<b>Waterbody</b>	<b>1996 Causes</b>	<b>2004 Causes</b>
SQUAW CREEK from headwaters to the mouth (Gallatin R)	<i>Flow Alteration</i> <i>Other Habitat Alterations</i> Siltation	<i>Bank Erosion</i> <i>Fish Habitat Degradation</i> <i>Other Habitat Alterations</i> <b>Nutrients</b> <b>Phosphorus</b>
TAYLOR CREEK, Lee Metcalf Wilderness boundary to the mouth (Gallatin R)	Not Listed	Siltation <i>Fish Habitat Degradation</i> Suspended Solids <i>Other Habitat Alterations</i>
CACHE CREEK from headwaters to the mouth (Taylor Fork)	Siltation	Siltation <i>Other Habitat Alterations</i> Suspended Solids
MIDDLE FK OF WEST FK GALLATIN RIVER, Headwaters to mouth (West Fk Gallatin R)	Siltation Suspended Solids	<b>Nutrients</b> <i>Bank Erosion</i> Pathogens Suspended Solids <i>Other Habitat Alterations</i>
SOUTH FK OF WEST FK GALLATIN RIVER, Headwaters to mouth (West Fk Gallatin R)	Siltation Suspended Solids	<b>Nutrients</b> Siltation <i>Bank Erosion</i> <i>Fish Habitat Degradation</i> Algal Growth/Chlorophyll a <i>Other Habitat Alterations</i>
WEST FK GALLATIN RIVER, Confluence Middle & North Fks of the West Gallatin to the mouth (Gallatin R)	Siltation Suspended Solids	<b>Nutrients</b> Siltation <b>Algal Growth/Chlorophyll a</b>

## 2.0 Overview of Sampling Strategy

The objective of this sampling plan is to collect nutrient chemistry data that will be used for a variety of objectives:

- Verification of nutrient impairment conditions on 303(d) listed tributaries in the Upper Gallatin TMDL Planning Area
- Development of reference conditions for nutrients in the Upper Gallatin TMDL Planning Area
- Quantification of nutrient loads associated with specific land use categories in the Upper Gallatin TMDL Planning Area to assist in TMDL nutrient load allocations

### Sampling Activity

In order to meet the above objectives, nutrient conditions will be determined by extensive water quality sampling in the Upper Gallatin watershed. Three distinct but overlapping sampling projects will be covered in this Sampling and Analysis Plan.

### 1. **SYNOPTIC soluble nutrient surveys (3x/year)**

Synoptic surveys for nitrogen compounds ( $\text{NO}_3^-$ ,  $\text{NO}_2^-$ ,  $\text{NH}_4^+$ , and DON) in the water column will be performed at each of the 60 selected sample sites identified in figure, Appendix A. In addition to soluble nitrogen compounds, Soluble Reactive Phosphorous (SRP) will also be analyzed. Synoptic sampling events will occur 3 times a year throughout 2005-2007 in order to capture the spatial variation of nutrient water chemistry and flow. The three synoptic samplings will occur at:

- Baseline flow during the growing season (late August/early September)
- Baseline flow during dormant season (January/February)
- Peak flow (June)

Results will be used develop the nutrient export model (see below) and to characterize impairment conditions. Table A1 provides a summary of sites, locations, and water quality analyses that are performed on seasonal synoptic samples.

### 2. **WEEKLY soluble nutrient sampling (52x/year)**

Weekly sampling for nitrogen compounds ( $\text{NO}_3^-$ ,  $\text{NO}_2^-$ ,  $\text{NH}_4^+$ , and DON) at nine (Appendix A, figure A3) of the aforementioned 60 sites has been conducted since 2004 by Montana State University researchers. Weekly sampling of these nine sites will continue as a part of the Upper Gallatin River Nutrient Assessment. Weekly monitoring will capture the seasonal pattern in both streamwater nutrient concentrations and nutrient speciation. Results will be used develop the nutrient export model and to characterize impairment conditions. Table A2 provides a summary of sites, locations, and water quality analyses that are performed on weekly samples.

### 3. **TOTAL NUTRIENT sampling (2x/summer 2007)**

Sampling and analyses for total phosphorus (TP), total nitrogen (TN) and Total Suspended Solids (TSS) will be performed twice during the summer of 2007 at 13 sites (figure A4).

*Note that five of these sites are also included among the aforementioned nine weekly sampling sites.* Results will be used develop the nutrient export model and to characterize impairment conditions. Table A3 provides a summary of sites, locations, and water quality analyses that are performed on these samples.

### **Nutrient Export Model**

Nutrient sources associated with specific land uses in the Upper Gallatin Watershed will be identified through a nutrient export model. The land use/land cover and watershed characteristics (watershed residence times and riparian area) of the contributing area to each sampling point discussed above will be determined and implemented into a nitrogen export coefficient model to determine their relationships with the water quality data. The nitrogen export coefficient model is adapted from a mechanistic and spatial modeling approaches used by Worrall and Burt (2001) and Endreny and Wood (2003). In our model, the N export (NE) to sample point  $m$  (lower end of stream reach) is a function of (eqn. 1):

$$NE_m = \left( \sum_{i=1}^n LULC_i * E_i + (S_i * s) + (W_i * w) * TWF * RBI \right) + \left( (NE_{m-1}) \exp^{\frac{K_L X}{Q^{0.5}}} \right) \quad (1)$$

where  $LULC$  is the land use/land cover in grid cell  $i$ ,  $E$  is the export coefficient of  $LULC_i$ ,  $S_i$  is the number of septic systems in the pixel,  $s$  is the septic  $NO_3^-$  load,  $W_i$  is a wastewater coefficient (1 if wastewater is distributed on the cell, 0 if not),  $w$  is the wastewater  $NO_3^-$  load,  $TWF$  is a topographical weighting factor of grid cell  $i$ , and is a scaled combination of the TT index ( $TT$ ), and the topographic index ( $TI$ ),  $RBI$  is a riparian buffer index ratio *only activated if land upslope contributing area is not pristine*, and  $N_{m-1}$  is  $NO_3^-$  load from the upstream sampling point.  $N_{m-1}$  will decay exponentially as a function of stream uptake rate ( $K_L$ ), distance ( $X$ ), and is a function of stream size (specifically stream discharge  $Q^{0.5}$ ) (Wollheim et al., 2001). In the first model approximation,  $K_L$  and  $Q^{0.5}$  will be based on literature values to be tested and updated with field results from instream tracer additions.

This model calculates  $NE$  (N export) (eqn. 1) to location  $m$  (the end of each stream reach) by incorporating two major elements: Lateral loading of N to each stream reach (eqn. 2) and upstream loading (eqn. 3) of N to each stream reach ( $m-1$ ). In our first model approximation, only the load entering the reach from upstream is subject to uptake in each reach ( $NE_{m-1}$ ). Lateral inflows are subject to instream uptake in the next downstream reach. The model will be run for each stream reach and synoptic sampling point. The total watershed export for the West Fork watershed is then the  $NE_m$  for the last stream reach in the watershed and represents the integrated watershed response. The validated model will: 1) identify relationships between distribution of LULC, watershed characteristics, water quality, 2) identify nutrient sources to assist in TMDL nutrient load allocations, and 3) quantify map nutrient export risk according to spatial location and distribution of LULC and watershed characteristics.

Further details of the nutrient export model (calibration/validation techniques, analytical procedures etc.) will be discussed in the Quality Assurance Plan (QUAP).

## 2.1 Sampling locations

In all, there are 60 sampling sites spatially distributed throughout the Upper Gallatin Watershed (Figures A1 and A2). Sampling sites were chosen to represent the range of landscape characteristics and land use/land cover influences existing in the watershed, as well as at before and after confluences of major tributaries. Sampling sites were identified by both assessment of aerial images and field surveying to capture the variability in land use and watershed characteristics potentially contributing to nutrient concentrations in streams including: land use/land cover (number of septic tanks, forest, grass, riparian area, geology, soils, golf courses, ski slopes), watershed residence times, and stream order).

## 2.2 Chemical data

**Synoptic samples** and **weekly samples** (Tables A1 & A2) will be analyzed for soluble nitrogen species ( $\text{NO}_3^-$ ,  $\text{NO}_2$ ,  $\text{NH}_4^+$ , DON) soluble reactive phosphorous (SRP), and anions ( $\text{SO}_4^{2-}$ ) and cations ( $\text{Na}^+$ ,  $\text{Ca}^{+2}$ ,  $\text{Mg}^{+2}$ , and  $\text{K}^+$ ) at the Montana State University Geomicrobiology and Geochemistry Lab in Bozeman, MT. In addition, field parameters (conductivity, pH, temperature and flow) will be collected weekly at the nine selected long-term monitoring stations (Figure A3). See Tables A1 and A2 for a full summary of sites, parameters and sampling frequency.

**Total nutrient samples** (Table A3) will be analyzed for nitrogen species ( $\text{NO}_3+\text{NO}_2$ , TKN, SRP, TP) and total suspended solids (TSS) by the Montana State Lab in Helena, MT.

### 3.0 Field Sampling Methods

Each person involved in field sampling for activities will be trained in grab-sample collection methods by the PI. These methods include:

- Marking each bottle with sample site, date and time
- Sampling above any disturbance including his/herself
- Sampling in flowing water in main channel
- Rinsing bottle and cap three times with streamwater before drawing a sample
- Keeping hands out of bottle and cap
- Recording site, date, time, weather and any other observations on the “site characteristics sheet
- Placing sample in cooler immediately after collection

Stream discharge data will be collected by the PI at water quality monitoring sites using a *Marsh McBirney Flo-Mate 2000™* current velocity meter and standard USGS area-velocity method. The flow meter is calibrated on a monthly basis or in times of question by following the calibrations methods described in Marsh McBirney owners manual. Water quality parameters measured on site with a YSI 63 meter include: pH, conductivity, and temperature. The YSI will be calibrated monthly or in times of question by following calibration methods described in the YSI 63 owners manual.

**Total nutrient** samples will be acidified to a pH of less than 2 by adding concentrated sulfuric acid ( $\text{H}_2\text{SO}_4$ ). Water for soluble phosphorous (SRP) will be filtered in the field through a 0.45  $\mu\text{m}$  filter into acid-washed polyethylene bottles. A small volume of filtrate (30-50 ml) will be discarded before the sample is collected. Soluble Reactive Phosphorus (SRP) samples are not preserved with acid. SRP samples shall be cooled to 4°C or less, or frozen.

### 4.0 Sample Handling Procedures

Due to different analytical methods and laboratories used, sampling handling procedures will vary depending on the required analysis.

#### **For synoptic and weekly samples analyzed by Montana State University Geomicrobiology and Geochemistry Lab:**

Immediately following grab-sample collection, samples will be put on ice by the sample collector. At the end of a sampling event, all samples and site characteristics sheets will be

collected by the project PI. The chain of custody of each sample will be recorded in the “site characteristics” sheet recorded at each sampling location by the sample collector. Information in this sheet will include: sampler name, time, date, weather, and any observations/oddities that may have occurred. The Project PI will deliver all samples to the laboratory. Once at the laboratory, each sample is filtered with a 4 micron filter into a sterile bottle (3 X 20mL, 1 X 125 mL and 1 X 60mL) and immediately frozen until analysis. All lab assistants involved in the filtering of samples will be trained by a project PI in the appropriate methods of filtering samples including: wearing gloves, changing the filter after each sample, filtering into sterile bottles, and note-taking of any potential mishaps that may occur.

**For Total Nutrient Samples and all other samples sent to the Montana State Lab in Helena for analysis**, sampling handling procedures will follow DEQ standard operating procedures as defined in DEQ guidance, *Sampling and Water Quality Assessment of Streams and Rivers in Montana, 2005: Quality Assurance Project Plan (DEQ, 2005)*.

A summary of collection and handling parameters is provided in **Tables A4-A6**.

## 5.0 Laboratory Analytical Methods

### Montana State University Geomicrobiology and Geochemistry Laboratory (Bozeman, MT)

Soluble nitrogen species, anions, cations, nitrogen and phosphorous species will be analyzed at the Montana State University Geomicrobiology and Geochemistry laboratory. Anions (nitrate, nitrite, ortho-phosphate, chloride and sulfate) and cations (ammonium, sodium, magnesium, calcium, and potassium) will be analyzed by ion chromatography (U.S. EPA, 1993) with a Metrohm-Peak compact ion chromatograph. Dissolved Organic Nitrogen (DON) will be analyzed with a Shimadzu Total Nitrogen Analyzer by gas phase chemiluminescence (modified U.S. EPA, 1975).

### Montana State Lab (Helena, MT)

Details regarding analytical methods used are not included in this QAPP document but are described in *Standard Methods for the Examination of Water and Wastewater, 20<sup>th</sup> Ed* (APHA, 1999). Nutrient analyses (EPA 353.2, 365.1, 350.1, and 351.1) are outlined in EPA 600/4-79-020. Further information regarding analytical methods may be found in the state laboratory’s quality assurance plan (DEQ, 2005).

A summary of analytical methods is provided in **Tables A4-A6**.

## 6.0 Quality Assurance and Quality Control Requirements

Data quality objectives (DQOs) are the quantitative and qualitative criteria established for data in order to meet the project’s objectives. There are several categories of DQO including precision, accuracy, representativeness, completeness, comparability, and measurement range. This section describes the approach to ensure data collected for this effort meet a high standard for data quality.

### 6.1 Precision

Precision refers to the degree of agreement among repeated measurements of the same characteristic. The strategy to ensure a high level of precision involves several components. These include selection of relatively precise measures based on published or unpublished reports. Selection of field meters with demonstrably high precision as reported in the manufacturer's specifications for ranges likely to be encountered in the field is another approach to promote precision. With other parameters, training and adherence to SOPs provides a means to encourage a high degree of precision.

We will follow DEQ SOPs which require collection of duplicates and blanks for 10% of samples collected in the field. Similarly, laboratory methods will follow established QA/QC protocols that evaluate precision in accordance with commonly accepted analytical protocols. These include employing blanks and known NIST standards at the beginning and end of each time period and after every 10 samples analyzed. Statistics will be calculated after a run to assure that the ion chromatograph is measuring consistently throughout a sample run.

## 6.2 Accuracy and Bias

Accuracy is a measure of confidence that describes how close a measurement is to its "true value". While the true value may not be known, several steps will increase the accuracy of field measures and laboratory analyses. Strict adherence to SOPs, training, oversight by the PI, and implementation of QA/QC protocols are the primary means of promoting accuracy for physical and chemical assessments.

In order to check the accuracy of analyses conducted by the Montana State University, 'quality assurance' field split samples will be collected four (4) times per year during weekly sampling events. Field splits will be analyzed by the Montana State Lab in Helena, MT. Analysis will consist of: total dissolved nitrogen, NO<sub>3</sub>, NO<sub>2</sub>, NH<sub>4</sub>. Analytical methods for these field splits is given below in Table 3.

**Table 3: Field Split Samples: Sample Volumes, Preservation and Analytical Methods**

Analyte	Sample Volume	Preservation	Analytical Method
Total Dissolved Nitrogen	250 ml	Add H <sub>2</sub> SO <sub>4</sub> to pH<2, cool to 4°C	<i>Get from SL</i>
Nitrite Nitrogen (NO <sub>2</sub> )	250 ml	Add H <sub>2</sub> SO <sub>4</sub> to pH<2, cool to 4°C	EPA 354.1
Nitrate Nitrogen (NO <sub>3</sub> )	250 ml	Add H <sub>2</sub> SO <sub>4</sub> to pH<2, cool to 4°C	EPA 353.2
Ammonium (NH <sub>4</sub> )	250 ml	Add H <sub>2</sub> SO <sub>4</sub> to pH<2, cool to 4°C	EPA 350.2
Soluble Reactive Phosphorus (SRP)	250 ml	Filter, cool to 4°C or freeze	EPA 365.1

Bias is a systematic error introduced by selecting items from a wrong population or favoring some of the elements of a population. Random sampling described in Section 6.3 and sampling in flowing water will address methods to avoid this type of bias.

## 6.3 Representativeness

Representativeness refers to the extent to which measurements actually represent the true environmental condition. For example, sampling site selection should reflect the relative proportion of geology, watershed characteristics, and land use. Approaches to promote representativeness include a combination of random sampling, best professional judgment, and adherence to sampling methods described in section 3.0 and 4.0.

#### ***6.4 Completeness***

Completeness is a measure of the amount of data prescribed for assessment activities and the usable data actually collected, expressed as a percentage. QA/QC activities will promote a high degree of completeness for assessments in the Upper Gallatin drainage. A PI will be responsible for ensuring collection of all data for each site. Prior to leaving a sampling site each field person will be required to fill out a data sheet, which will be reviewed and initialed by the project manager. These checks will reduce the occurrence of empty data fields.

#### ***6.5 Measurement Range***

Detection limits for all anions and cations will be determined by the Method of Detection Limit described in the ARM referenced method at 40CFR Part 136, Appendix B Rev 1.11.

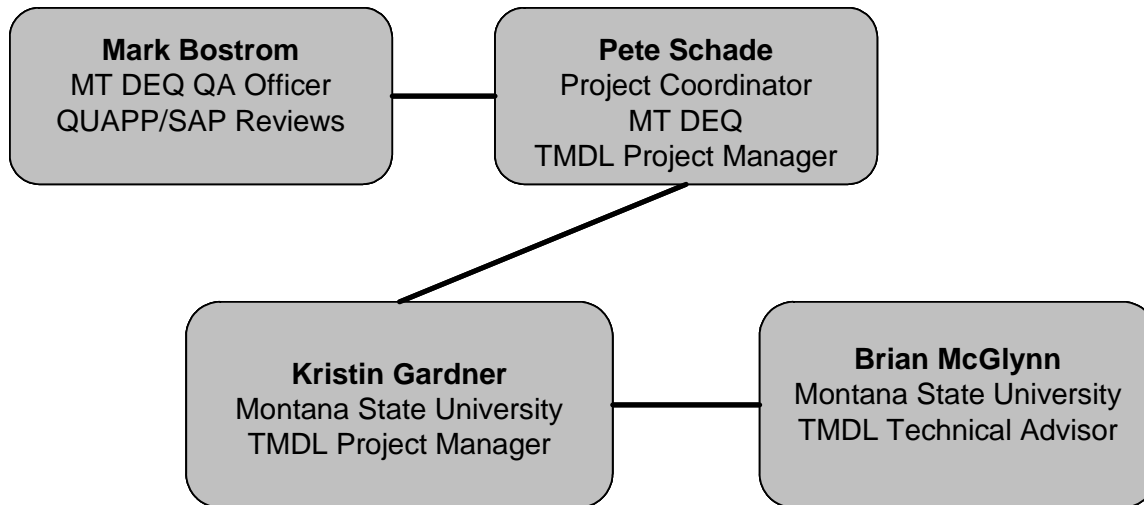
For each sample run a full suite of known NIST standards and DI will be run at the beginning and the end to make sure that the machine is not drifting throughout the sample run. In between every ten samples in a sample run will be one DI and one standard most representative of the samples being run. The detection limit of the ion chromatography will be tested by running 10 duplicates of known NIST standards. After each sample run, statistics will be calculated to ensure that the ion chromatograph is measuring the known NIST standards at the beginning, end and throughout the sample run consistently. All personnel involved in running the ion chromatography will be trained by a project PI.

### **7.0 Data Analysis, Record Keeping and Reporting Requirements and Schedule for Completion**

All field notes including the site characteristics sheets are kept by the PI. All flow, EC, and temperature data is in the PI's field notebook and input into a spreadsheet. All flow, EC, temperature, and results of the ion chromatograph are kept in excel spreadsheets and an access database that is backed up on a weekly basis.

All field work will be completed by the summer of 2007. Data from all sampling events and weekly monitoring events will be provided to DEQ in a STORET compatible electronic data deliverable, or entered into STORET. Instructions on how to import data to STORET can be found at DEQ's website at [http://www.deq.state.mt.us/wqinfo/datamgmt/STORET\\_SIM\\_Support.asp](http://www.deq.state.mt.us/wqinfo/datamgmt/STORET_SIM_Support.asp).

### **8.0 Project Team and Responsibilities**



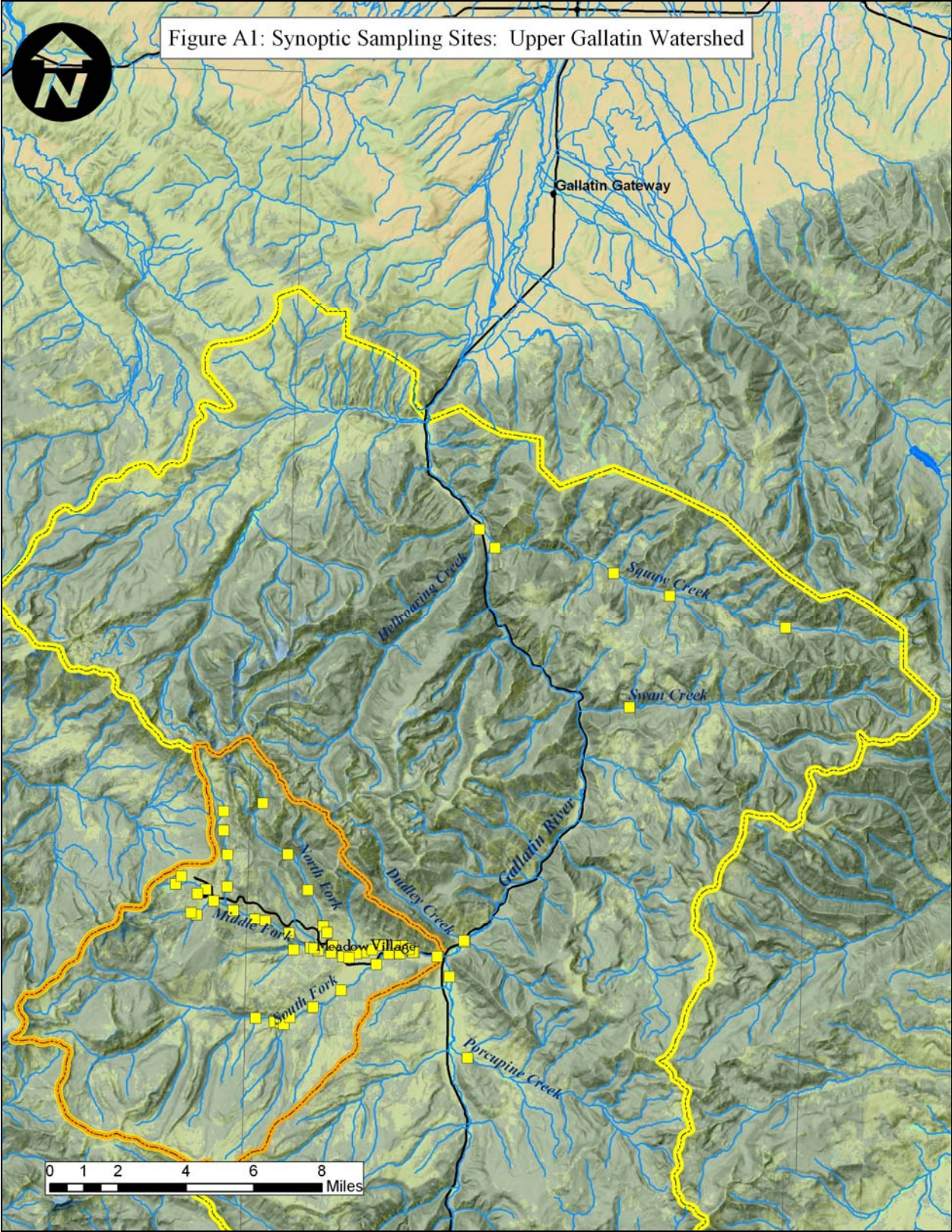
## 9.0 References

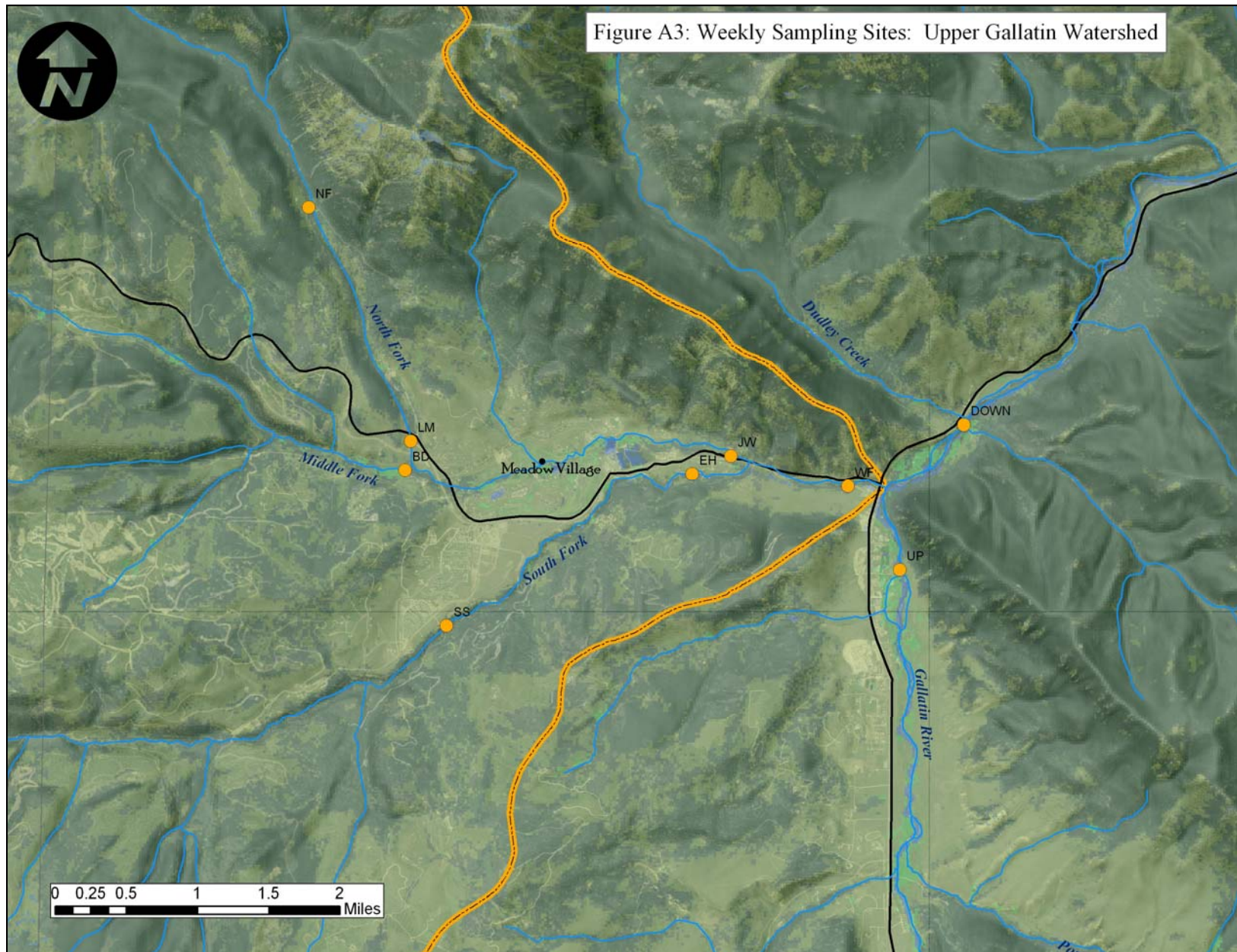
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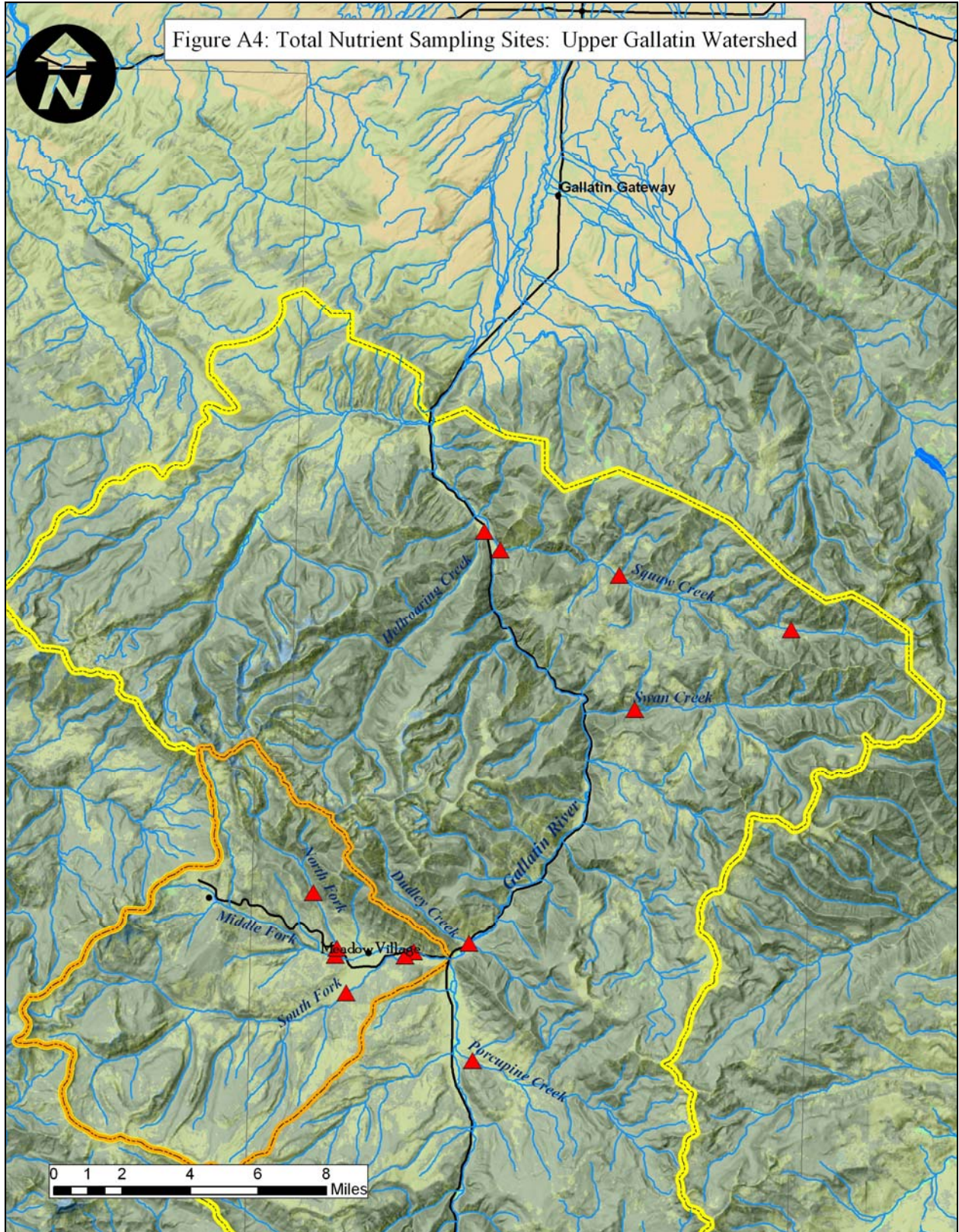
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**Table A1: Synoptic soluble nutrient survey summary**

Stream_Segment	Lat_dd	Long_dd	Site	Samples/Yr	Soluble_N	SRP	Cations	Anions
Beehive Creek	45.2934	-111.3853	SV	3	X	X	X	X
Beehive Creek	45.3071	-111.3855	BH	3	X	X	X	X
Beehive Creek	45.3256	-111.3885	BH_HW	3	X	X	X	X
Dudley Creek	45.2725	-111.2417	DUD	3	X	X	X	X
Gallatin River	45.2721	-111.2412	DOWN	3	X	X	X	X
Gallatin River	45.2572	-111.2500	UP	3	X	X	X	X
groundwater	45.2663	-111.2869	SEEP	3	X	X	X	X
Hell Roaring Creek	45.4486	-111.2380	HELLROARING	3	X	X	X	X
Middle Fork West Fork Gallatin River	45.2698	-111.2788	MF_ESTBSWS	3	X	X	X	X
Middle Fork West Fork Gallatin River	45.2799	-111.3681	LMM	3	X	X	X	X
Middle Fork West Fork Gallatin River	45.2696	-111.2830	MF_BSWS	3	X	X	X	X
Middle Fork West Fork Gallatin River	45.2671	-111.3295	MF_AANT	3	X	X	X	X
Middle Fork West Fork Gallatin River	45.2873	-111.3931	MF_ALL	3	X	X	X	X
Middle Fork West Fork Gallatin River	45.2700	-111.2906	MF_APND	3	X	X	X	X
Middle Fork West Fork Gallatin River	45.2682	-111.3340	MF_B4ANT	3	X	X	X	X
Middle Fork West Fork Gallatin River	45.2741	-111.3473	ORANGE	3	X	X	X	X
Middle Fork West Fork Gallatin River	45.2921	-111.3980	MF_B4LL	3	X	X	X	X
Middle Fork West Fork Gallatin River	45.2675	-111.2726	MF_B4SF	3	X	X	X	X
Middle Fork West Fork Gallatin River	45.2666	-111.3021	GOLF1	3	X	X	X	X
Middle Fork West Fork Gallatin River	45.2834	-111.3813	LOW	3	X	X	X	X
Middle Fork West Fork Gallatin River	45.2793	-111.3618	STINK	3	X	X	X	X
Middle Fork West Fork Gallatin River	45.2697	-111.2931	GOLF5	3	X	X	X	X
Middle Fork West Fork Gallatin River	45.2662	-111.3216	BD	3	X	X	X	X
Middle Fork West Fork Gallatin River	45.2647	-111.3144	MF_B4G	3	X	X	X	X
Middle Fork West Fork Gallatin River	45.2679	-111.2970	GOLF4	3	X	X	X	X
Middle Fork West Fork Gallatin River	45.2661	-111.3063	GOLF2	3	X	X	X	X
Middle Fork West Fork Gallatin River	45.2642	-111.3108	GOLF3	3	X	X	X	X
North Fork West Fork Gallatin River	45.3079	-111.3492	NF_BDGE	3	X	X	X	X
North Fork West Fork Gallatin River	45.2776	-111.3267	LM3	3	X	X	X	X
North Fork West Fork Gallatin River	45.2747	-111.3243	LM2	3	X	X	X	X
North Fork West Fork Gallatin River	45.2692	-111.3209	LM	3	X	X	X	X
North Fork West Fork Gallatin River	45.2928	-111.3364	NF	3	X	X	X	X
North Fork West Fork Gallatin River	45.3293	-111.3650	NF_HW	3	X	X	X	X
Porcupine Creek	45.2230	-111.2380	PORC	3	X	X	X	X
South Fork West Fork Gallatin River	45.2672	-111.2723	SF_B4WF	3	X	X	X	X
South Fork West Fork Gallatin River	45.2377	-111.3662	SF_BEZ	3	X	X	X	X
South Fork West Fork Gallatin River	45.2665	-111.2802	EH	3	X	X	X	X
South Fork West Fork Gallatin River	45.2504	-111.3151	SS	3	X	X	X	X
South Fork West Fork Gallatin River	45.2429	-111.3318	OUSEL	3	X	X	X	X
South Fork West Fork Gallatin River	45.2384	-111.3455	OUSEL_BDGE	3	X	X	X	X
South Fork West Fork Gallatin River	45.2617	-111.2943	SKY	3	X	X	X	X
Squaw Creek	45.4092	-111.0515	SQ4	3	X	X	X	X
Squaw Creek	45.4311	-111.1561	SQ2	3	X	X	X	X
Squaw Creek	45.4219	-111.1220	SQ3	3	X	X	X	X
Squaw Creek	45.4409	-111.2280	SQ1	3	X	X	X	X
Stony Creek	45.2672	-111.3442	STONY	3	X	X	X	X
Swan Creek	45.3740	-111.1450	SWAN	3	X	X	X	X
Tributary of Beehive Creek	45.3173	-111.3881	BH_LILTR	3	X	X	X	X
Tributary of Middle Fork	45.2903	-111.4031	B4_MOOS_r	3	X	X	X	X
Tributary of Middle Fork	45.2812	-111.4031	MC	3	X	X	X	X
Tributary of Middle Fork	45.2679	-111.3320	ANTLER	3	X	X	X	X
Tributary of Middle Fork	45.2819	-111.4067	WEST_MC	3	X	X	X	X
Tributary of the Middle Fork	45.2941	-111.4163	HW_MF1	3	X	X	X	X
Tributary of the Middle Fork	45.2975	-111.4131	HW_MF2	3	X	X	X	X
Tributary of the South Fork	45.2364	-111.3549	SF_LILTR2	3	X	X	X	X
Tributary of the South Fork	45.2361	-111.3510	SF_LILTR1	3	X	X	X	X
West Fork Gallatin River	45.2672	-111.2716	DB	3	X	X	X	X
West Fork Gallatin River	45.2656	-111.2577	WF	3	X	X	X	X
West Fork Gallatin River	45.2684	-111.2747	JW	3	X	X	X	X
Yellow Mule Creek	45.2354	-111.3491	YM	3	X	X	X	X

**Table A2: Weekly soluble nutrient sampling summary**

Stream_Segment	Lat_dd	Long_dd	Site	Samples/Yr	Soluble_N	SRP	Cations_Anions	Field_Parameters	Flow
Gallatin River	45.2721	-111.2412	DOWN	52	X	X	X	X	X
Gallatin River	45.2572	-111.2500	UP	52	X	X	X	X	X
Middle Fork West Fork Gallatin River	45.2662	-111.3216	BD	52	X	X	X	X	X
North Fork West Fork Gallatin River	45.2692	-111.3209	LM	52	X	X	X	X	X
North Fork West Fork Gallatin River	45.2928	-111.3364	NF	52	X	X	X	X	X
South Fork West Fork Gallatin River	45.2665	-111.2802	EH	52	X	X	X	X	X
South Fork West Fork Gallatin River	45.2504	-111.3151	SS	52	X	X	X	X	X
West Fork Gallatin River	45.2684	-111.2747	JW	52	X	X	X	X	X
West Fork Gallatin River	45.2656	-111.2577	WF	52	X	X	X	X	X

**Table A3 Total nutrient sampling summary**

StreamSegment	Lat_dd	Long_dd	Site	Samples/Yr	Nutrient_Suite	TSS
Middle Fork West Fork Gallatin River	45.2662	-111.3220	BD	2	X	X
North Fork West Fork Gallatin River	45.2928	-111.3360	NF	2	X	X
North Fork West Fork Gallatin River	45.2692	-111.3210	LM	2	X	X
West Fork Gallatin River	45.2684	-111.2750	JW	2	X	X
South Fork West Fork Gallatin River	45.2665	-111.2800	EH	2	X	X
South Fork West Fork Gallatin River	45.2504	-111.3150	SS	2	X	X
Squaw Creek	45.4409	-111.2280	SQ1	2	X	X
Squaw Creek	45.4312	-111.1560	SQ2	2	X	X
Squaw Creek	45.4092	-111.0515	SQ4	2	X	X
Porcupine Creek	45.2230	-111.2380	PORC	2	X	X
Dudley Creek	45.2725	-111.2417	DUD	2	X	X
Swan Creek	45.3740	-111.1450	SWAN	2	X	X
Hell Roaring Creek	45.4486	-111.2380	HELLROARING	2	X	X

<b>Analyte</b>	<b>Sample Volume</b>	<b>Container</b>	<b>Preservation</b>	<b>Analytical Method</b>
NO <sub>3</sub> , NO <sub>2</sub> , SRP, NH <sub>4</sub> <sup>+</sup>	250 ml	Acid-washed polyethylene	cool to <10C, filter. Freeze.	EPA 300.0
DON	250 ml	Acid-washed polyethylene	cool to <10C, filter. Freeze.	EPA (1975)
Cations/Anions	250 ml	Acid-washed polyethylene	cool to <10C, filter. Freeze.	EPA 300.0

<b>Analyte</b>	<b>Sample Volume</b>	<b>Container</b>	<b>Preservation</b>	<b>Analytical Method</b>
NO <sub>3</sub> , NO <sub>2</sub> , SRP, NH <sub>4</sub> <sup>+</sup>	250 ml	Acid-washed polyethylene	cool to <10C, filter. Freeze.	EPA 300.0
DON	250 ml	Acid-washed polyethylene	cool to <10C, filter. Freeze.	EPA (1975)
Cations/Anions	250 ml	Acid-washed polyethylene	cool to <10C, filter. Freeze.	EPA 300.0

<b>Analyte</b>	<b>Sample Volume</b>	<b>Container</b>	<b>Preservation</b>	<b>Analytical Method</b>
Total Phosphorus (TP)	250 ml	Acid-washed polyethylene	Add H <sub>2</sub> SO <sub>4</sub> to pH<2, cool to 4°C	EPA 365.1
Total Kjeldahl Nitrogen (TKN)	250 ml	Acid-washed polyethylene	Add H <sub>2</sub> SO <sub>4</sub> to pH<2, cool to 4°C	EPA 351.1
Nitrate + Nitrite-Nitrogen (NO <sub>3</sub> +NO <sub>2</sub> -N)	250 ml	Acid-washed polyethylene	Add H <sub>2</sub> SO <sub>4</sub> to pH<2, cool to 4°C	EPA 353.2
Total Ammonia-Nitrogen (NH <sub>3</sub> +NH <sub>4</sub> -N)	250 ml	Acid-washed polyethylene	Add H <sub>2</sub> SO <sub>4</sub> to pH<2, cool to 4°C	EPA 350.1
Soluble Reactive Phosphorus (SRP)	250 ml	Acid-washed polyethylene	Filter, cool to 4°C or freeze	EPA 365.1
Total Suspended Solids (TSS)	1000 ml	Acid-washed polyethylene	cool to 4°C	EPA 160.2