UPPER GALLATIN TMDL PLANNING AREA PATHOGEN MONITORING

Sampling and Analysis Plan

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June 2006

Project No. B15532.13

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1.0 Introduction

The Montana Department of Environmental Quality (MDEQ) is required to develop a Total Maximum Daily Load (TMDL) water quality restoration plan for the Upper Gallatin TMDL Planning Area (TPA) in order to satisfy state law as well as federal court requirements. This Sampling and Analysis Plan addresses pathogen monitoring planned for the Middle Fork West Fork Gallatin River, which is listed as impaired due to pathogens on the 2004 303(d) List. This plan also describes pathogen monitoring sites on the North Fork West Fork Gallatin River, South Fork West Fork Gallatin River, and West Fork Gallatin River. This monitoring network will provide the data necessary to assess compliance with Montana water quality standards for E. coli and will identify potential pathogen loading sources in the West Fork Gallatin watershed.

1.1 Water Quality Restoration Planning Process

In the State of Montana, the growth and propagation of fish and associated aquatic life, drinking water, agriculture, industrial supply, recreation, and wildlife are considered beneficial uses of water bodies. Beneficial use support is determined based on compliance with Montana's water quality standards. Water bodies failing to support one or more beneficial uses are described as impaired on the *303(d) List of Impaired and Threatened Waterbodies in Need of Water Quality Restoration* and the development of a water quality restoration plan is required. In 2004, the *303(d) List of Impaired and Threatened Waterbodies in Need of Water Quality Restoration* was combined with the 305(b) Report into the *2004 Montana Water Quality Integrated Report*. The 2004 Integrated Report incorporates new guidance from the EPA which requires TMDLs be developed for waters impaired by "pollutants," such as nutrients, sediment, metals, or pathogens. TMDLs are not required for waters impaired solely by "pollution," such as flow alterations or habitat degradation (MDEQ 2004).

1.2 Montana Standards

The State of Montana's standards for pathogen pollutants vary based on the classification of the water body. The Gallatin River and its tributary streams outside of Yellowstone National Park are **classified B-1 water bodies** by the State of Montana.

> *Waters classified B-1 are to be maintained suitable for drinking, culinary and food processing purposes, after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply [MCA 17.30.623(1)].*

The 2004 303(d) List indicates pathogen pollutants in the Middle Fork West Fork Gallatin River are impairing primary contact (recreation) beneficial use.

Prior to 2006, the State of Montana assessed pathogen impairments based on fecal coliform bacteria. The 2004 303(d) pathogen listing for the Middle Fork West Fork Gallatin River was based on water column measurements that detected fecal coliform concentrations which exceeded the Montana standard for B-1 waters. For B-1 water bodies, the fecal coliform

standards were temperature dependent and required that the geometric mean number of organisms in the fecal coliform group must not exceed 200 colony forming units (cfu) per 100 milliliters when the stream temperature exceeded 60ºF (**Table 1-1**). These standards also specified that no more than 10% of all the samples collected during any 30 day period exceeded 400 cfu/100mL. These standards are no longer applicable, though existing fecal coliform data from the West Fork Gallatin River watershed will be discussed within the context of these standards.

In 2006, the State of Montana adopted *Escherichia coli* (*E. coli*) as the indicator organism for pathogen pollutants [ARM 17.30.623 (2)(a)]. The newly adopted Montana standard for pathogen pollutants for B-1 water bodies specifies:

> *The geometric mean number of E. coli may not exceed 126 cfu/100mL and 10% of the total samples may not exceed 252 cfu/100mL during any 30-day period between April 1 through October 31 [ARM 17.30.623 (2)(i)] (**Table 1-1**). From November 1 through March 31, the geometric mean number of E. coli may not exceed 630 cfu/100mL and 10% of the samples may not exceed 1,260 cfu/100mL during any 30-day period [ARM 17.30.623 (2)(ii)]. The E. coli bacteria standard is based on a minimum of five samples obtained during separate 24-hour periods during any consecutive 30-day period that are analyzed by the most probable number (MPN) or equivalent membrane filter method [ARM 17.30.620(2)]. The geometric mean is the value obtained by taking the Nth root of the product of the measured values where values below the detection limit are taken to be the detection limit [ARM 17.30.602(13)].*

Table 1-1. Montana Standards for Pathogen Pollutants for B-1 Water Bodies.

	Applicable Period	Standard	Geometric mean of 5 samples collected over a 30-day time period	No more than 10% of the samples shall exceed:
Former Montana Standard (pre-2006)	Daily maximum water temperature is >60ºF	The geometric mean number of organisms in the **fecal coliform** group must not exceed 200 per 100 milliliters (ml) and no more than 10% of the total samples during any 30-day period shall exceed 400 fecal coliforms per 100 milliliters (ARM 17.30.623 (2)(a)).	<200 cfu/100mL	400 cfu/100mL
New Montana Standard (2006 -)	April 1 - October 31	The geometric mean number of ***E-coli*** may not exceed 126 colony forming units per 100 milliliters and 10% of the total samples may not exceed 252 colony forming units per 100 milliliters during any 30-day period (ARM 17.30.623 (2)(i)).	<126 cfu/100mL	252 cfu/100mL
	November 1 - March 31	The geometric mean number of ***E-coli*** may not exceed 630 colony forming units per 100 milliliters and 10% of the samples may not exceed 1,260 colony forming units per 100 milliliters during any 30-day period (ARM 17.30.623 (2)(ii)).	<630 cfu/100mL	1,260 cfu/100mL

2.0 Objectives and Design

The objectives of this assessment are to:

- Quantify pathogen (*E. coli*) levels within the Middle Fork West Fork Gallatin River.
- Identify potential sources of pathogens to the Middle Fork West Fork Gallatin River.

The Middle Fork West Fork Gallatin River was originally listed as impaired based on fecal coliform data. Data collected under this assessment will assist in evaluating the present impairment status of the Middle Fork West Fork Gallatin River using the new *E. coli* standard promulgated in 2006. This assessment will also identify potential sources of pathogen pollutants to the Middle Fork West Fork Gallatin River. This monitoring plan was developed through the review of existing fecal coliform and *E. coli* data. In addition, land-use practices and the on-going development in the Big Sky area were examined through GIS and aerial photography to identify potential sources of pathogens. A review of the existing data followed by an examination of potential sources is provided below. This section concludes with a description of the selected monitoring locations and a rational for these site selections.

2.1 Existing Data Review

To address water quality impairments in the Upper Gallatin TPA, the USEPA and MDEQ have begun inventorying the available data on stream segments that are listed as impaired on the 2004 303(d) List. In April of 2005, the *Upper Gallatin Total Maximum Daily Load Planning Area Phase I TMDL Status Report* was completed (CDM 2005). Data sources in the CDM report included:

- Baldwin fecal coliform data, 1994-1996

Baldwin (1996) presented fecal coliform data collected between 1994 and 1996 by the Big Sky Water and Sewer District (BSWSD). This monitoring covered several sites throughout the watershed and was geared towards identifying changes in stream chemistry within areas that were already developed (**Figure 2-1**).

Additional data utilized in the development of this Sampling and Analysis Plan included:

- Montana State University fecal coliform data , 2002-2004
- Blue Water Task Force *E. coli* data, 2000-2004

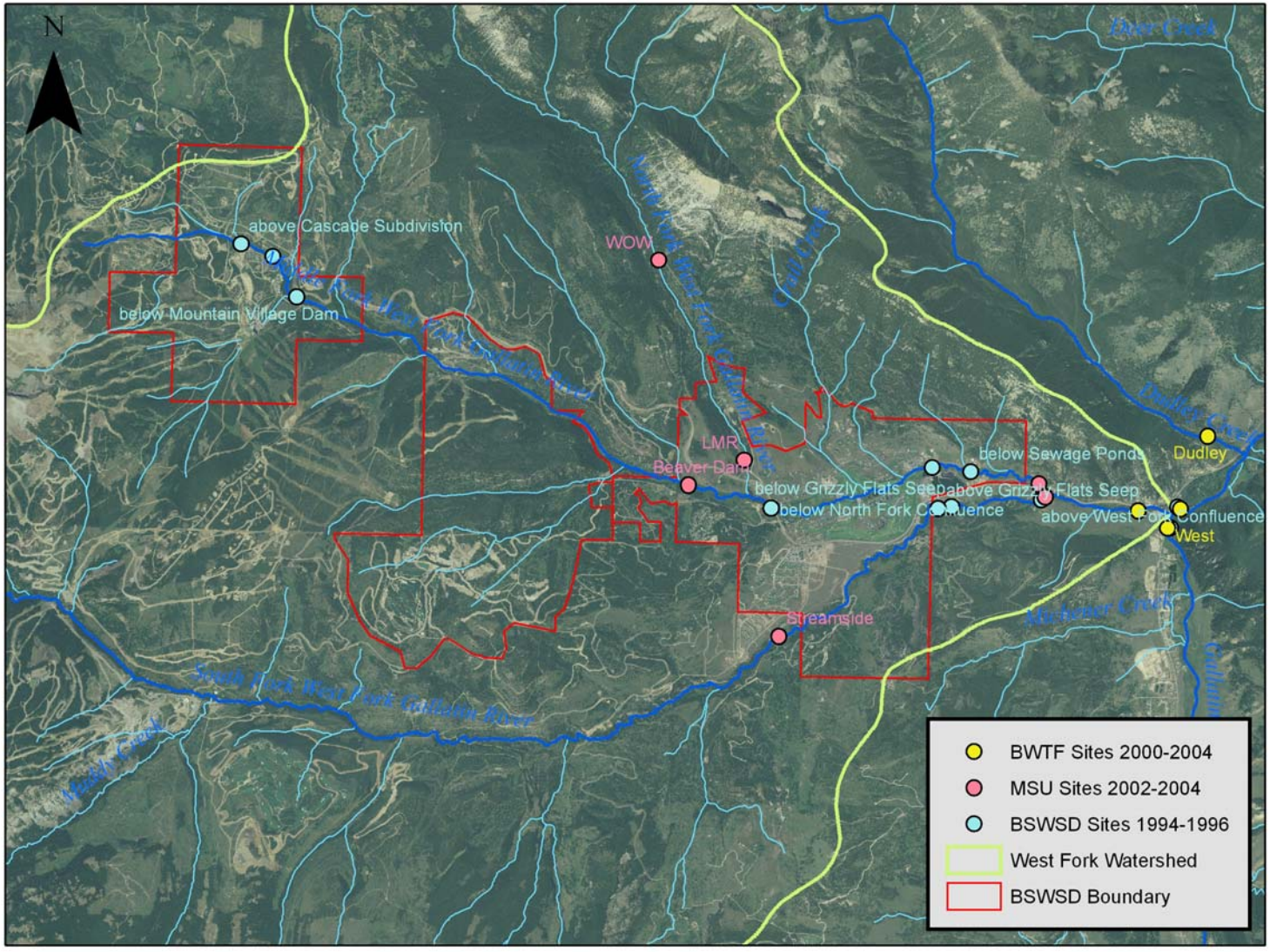
Fecal coliform data were collected by researchers at Montana State University (MSU) between 2002 and 2004 and *E. coli* data were collected by the Blue Water Task Force (BWTF) between 2000 and 2004. Monitoring sites from these two studies are presented in **Table 2-1** and **Figure 2-1.**

Table 2-1. MSU Fecal Coliform and BWTF *E. coli* Assessment Sites.

Stream	Sample Site	Sample Type	Collected By:	Timeframe
Gallatin River	Park	*E. coli*	BWTF	2000-2004
Gallatin River	Taylor	*E. coli*	BWTF	2000-2004
Gallatin River	Upstream	*E. coli*	BWTF	2000-2004
West Fork Gallatin River	West	*E. coli*	BWTF	2000-2004
Gallatin River	Downstream I	*E. coli*	BWTF	2000-2004
Dudley Creek	Dudley	*E. coli*	BWTF	2000-2004
Gallatin River	Downstream II	*E. coli*	BWTF	2000-2004
North Fork West Fork Gallatin River	WOW	fecal coliform	MSU	2002-2004
North Fork West Fork Gallatin River	LMR	fecal coliform	MSU	2002-2004
Middle Fork West Fork Gallatin River	Beaver Dam	fecal coliform	MSU	2002-2004
South Fork West Fork Gallatin River	Streamside	fecal coliform	MSU	2002-2004
South Fork West Fork Gallatin River	Elkhorn	fecal coliform	MSU	2002-2004
West Fork Gallatin River	J Walker	fecal coliform	MSU	2002-2004

Limitations in spatial and temporal coverage do not allow evaluation of this data under the new *E. coli* standards. However, these data are valuable for defining temporal and spatial trends in pathogen concentrations in the West Fork Gallatin River watershed and have been used to guide development of this Sampling and Analysis Plan.

Figure 2-1. Existing Monitoring Sites in the West Fork Gallatin River Watershed.



2.1.1 Middle Fork West Fork Gallatin River

Fecal coliform data were collected on a monthly basis by the Big Sky Water and Sewer District (BSWSD) from May 1995 through June of 1996 at three sites on the Middle Fork West Fork Gallatin River: above the Cascade subdivision, below the Cascade subdivision and below Mountain Village Dam (Lake Levinsky). The BSWSD sites were positioned to monitor changes in stream chemistry within areas that were already developed, except for the upper and lower Cascade sites on the Middle Fork West Fork Gallatin River, where no homes were present in 1996 (Baldwin 1996). A maximum concentration of 300 cfu/100mL was reported above the Cascade subdivision in June of 1995, while a maximum concentration of 320 cfu/100mL was reported below the Cascade subdivision in August of 1995 (**Table 2-2**). Downstream of the Big Sky Mountain Village and Lake Levinsky, a maximum fecal coliform concentration of 36 cfu/100mL was reported in May of 1995.

Total coliform and fecal coliform samples were collected on a semi-monthly basis at the Beaver Dam site on the Middle Fork West Fork Gallatin River upstream of the confluence with the North Fork West Fork Gallatin River during 17 site visits between July 26, 2002 and May 16, 2004. Two samples were collected during each visit, for a total of 34 samples. A review of the data indicates that there were greater than 200 cfu/100mL in five samples from four different days. These samples occurred on July 26 and August 11 in 2002 and July 15 and August 25 in 2003. A fecal coliform concentration of 500 cfu/100mL was reported in samples collected in July of both 2002 and 2003 (**Table 2-1**). While flow data were not recorded during these sampling events, sampled fecal coliform concentrations were highest during low flow conditions in the middle of the summer in 2002 and 2003 on the Middle Fork West Fork Gallatin River.

Table 2-2. Fecal Coliform Data for the Middle Fork West Fork Gallatin River (cfu/100mL).

Sample Site	Sample Timeframe	Sample Size	# of Detects	Mean*	Median*	Minimum*	Maximum	Date of Maximum Concentration
above Cascade subdivision	1995-1996	14	13	63	15	4	300	June 1995
below Cascade subdivision	1995-1996	14	14	43	15	2	320	August 1995
below Mountain Village Dam	1995-1996	14	12	9	7	1	36	May 1995
Beaver Dam	2002-2004	34	27	109	50	2	500	July 2002 & 2003

* Calculated for values above the detection limit.

2.1.2 North Fork West Fork Gallatin River

Fecal coliform monitoring was conducted at two sites on the North Fork West Fork Gallatin River on a semi-monthly basis between 2002 and 2004: WOW and LMR. Site WOW was upstream of the Lone Mountain Ranch, while site LMR was downstream of the Lone Mountain Ranch. The WOW site was sampled between July 26, 2002 and May 16, 2004. Thirty-four samples were collected over 17 site visits. A maximum fecal coliform concentration of 30 cfu/100mL was recorded on December 19, 2003 (**Table 2-3**). The LMR site was also sampled between July 26, 2002 and May 16, 2004, with 34 samples collected over 17 site visits. Similar to the upstream site, a maximum fecal coliform concentration of 30 cfu/100mL was recorded on December 19, 2003 at the LMR site.

Table 2-3. Fecal Coliform Data for the North Fork West Fork Gallatin River (cfu/100mL).

Sample Site	Sample Timeframe	Sample Size	# of Detects	Mean*	Median*	Minimum*	Maximum	Date of Maximum Concentration
WOW	2002-2004	34	22	8	4	2	30	December 2003
LMR	2002-2004	34	19	8	4	2	30	December 2003

* Calculated for values above the detection limit.

2.1.3 West Fork Gallatin River

Fecal coliform data were collected on a monthly basis by the Big Sky Water and Sewer District (BSWSD) from January 1994 through June of 1996 at three sites on the West Fork Gallatin River: West Fork below North Fork confluence, West Fork below Meadow Village Bridge, and West Fork below Sewage Ponds. These sites were positioned to monitor changes in stream chemistry within areas that were already developed (Baldwin 1996). A maximum concentration of 672 cfu/100mL was reported below the North Fork confluence in August of 1994, while a maximum concentration of 482 cfu/100mL was reported below Meadow Village Bridge in August of 1994 and a maximum concentration of 78 cfu/100mL was reported below the Sewage Ponds in August of 1994.

The J Walker sample site on the West Fork Gallatin River was sampled between July 26, 2002 and May 16, 2004. Thirty-four samples were collected over 17 site visits. A maximum concentration of 500 cfu/100mL was recorded on July 26, 2002, while all other measurements remained below 130 cfu/100mL (**Table 2-4**). A value of 500 cfu/100mL was also recorded at the Beaver Dam site on the Middle Fork West Fork Gallatin River on July 26, 2002.

Table 2-4. Fecal Coliform Data for the West Fork Gallatin River (cfu/100mL).

Sample Site	Sample Timeframe	Sample Size	# of Detects	Mean*	Median*	Minimum*	Maximum	Date of Maximum Concentration
below North Fork Confluence	1994-1996	30	26	42	9	1	672	August 1994
below Meadow Village Bridge	1994-1996	30	27	29	7	1	482	August 1994
below Sewage Ponds	1994-1996	30	27	12	8	1	78	August 1994
J Walker	2002-2004	34	29	46	17	2	500	July 2002

* Calculated for values above the detection limit.

E. coli data were collected at the West sample site on the West Fork Gallatin River between May 28, 2000 and January 19, 2004 during semi-monthly monitoring conducted by the Blue Water Task Force. A total of 67 samples were collected over 35 monitoring events, with two samples collected during each monitoring event in general. A maximum *E. coli* concentration of 220 cfu/100mL was reported on April 28, 2001 (**Table 2-5**). The second highest *E. coli* concentration at the West site was 140 cfu/100mL and was recorded on October 22, 2000. *E. coli* concentrations of 130 cfu/100mL were recorded on both September 9 and October 22, 2000.

Table 2-5. *E. coli* Data for the West Fork Gallatin River (cfu/100mL).

Sample Site	Sample Timeframe	Sample Size	# of Detects	Mean*	Median*	Minimum*	Maximum	Date of Maximum Concentration
West	2000-2004	67	63	28	13	2	220	April 2001

* Calculated for values above the detection limit.

2.1.4 South Fork West Fork Gallatin River

Fecal coliform data were collected on a monthly basis by the Big Sky Water and Sewer District (BSWSD) from January 1994 through June of 1996 on the South Fork above the West Fork Confluence, while data was collected above and below Grizzly Flats Seep between January 1995 and June 1996. Over a total of 30 sampling events at the site above the West Fork confluence, a maximum concentration of 66 cfu/100mL was reported in December of 1994 (**Table 2-6**). Above the Grizzly Flats Seep, a maximum concentration of 70 cfu/100mL was reported in May of 1995, while a maximum concentration of 30 cfu/100mL was reported below Grizzly Flats Seep in May of 1995 over a total of 18 monitoring events.

Fecal coliform concentrations were monitored at two sites on the South Fork West Fork Gallatin River on a semi-monthly basis between 2002 and 2004: Streamside and Elkhorn. Monitoring was conducted at the Streamside site during 17 sampling events between July 26, 2002 and May 16, 2004. Two samples were collected during each visit, for a total of 34 samples. The maximum concentration of fecal coliforms was 80 cfu/100mL on July 15, 2003 (**Table 2-6**). Monitoring was conducted at the Elkhorn site just upstream of the confluence with the West Fork during 16 sampling events between August 11, 2002 and May 16, 2004, with a total of 32 samples. A maximum value of 80 cfu/100mL was recorded on August 11, 2002 and August 25, 2003.

Table 2-6. Fecal Coliform Data for the South Fork West Fork Gallatin River (cfu/100mL).

Sample Site	Sample Timeframe	Sample Size	# of Detects	Mean*	Median*	Minimum*	Maximum	Date of Maximum Concentration
above Grizzly Flats Seep	1995-1996	18	12	11	3	1	70	May 1995
below Grizzly Flats Seep	1995-1996	18	13	11	4	2	30	May 1995
above West Fork Confluence	1994-1996	30	21	13	6	1	66	December 1994
Streamside	2002-2004	34	21	13	4	2	80	July 2003
Elkhorn	2002-2004	32	24	17	7	2	80	August 2002 & 2003

* Calculated for values above the detection limit.

2.2 Potential Sources of Pathogens

A review of potential pathogen sources based on land-use within the West Fork Gallatin River watershed was conducted in GIS using National Agriculture Imagery Program (NAIP) color aerial imagery from 2005, U.S. Geological Survey (USGS) National Hydrography Dataset (NHD) stream lines, National Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO) soils data, septic density information from the 2000 Census, and BSWSD

boundaries and sewer lines from 2002. USGS digital orthophotos from 1995 were also utilized to identify where recent development has taken place.

A study by Young and Thackston (1999) comparing sewered and unsewered watersheds indicated that fecal bacteria densities were directly related to the density of housing, population, development, percent impervious area, and domestic animal density. For purposes of the current study, aerial imagery was primarily utilized to evaluate housing density and to identify rapidly developing areas. A more detailed assessment of stream channel morphology, riparian vegetation characteristics, and potential pollution sources in the West Fork Gallatin River watershed is planned using up-to-date Ikonos satellite imagery. However, this imagery was not available during the development of this Sampling and Analysis Plan.

Sources of pathogens identified within the West Fork Gallatin River watershed include both point and nonpoint sources. The only point source is treated effluent discharged from the municipal wastewater treatment plant. However, no direct discharge to surface waters is currently occurring, since the wastewater is used to irrigate the golf courses and the sewage sludge is converted into compost. The wastewater is stored in a series of holding ponds prior to land application through sprinkler irrigation.

Potential nonpoint sources of pathogens to surface waters within the watershed include:

- Septic systems and wastewater
  - individual septic systems
  - failing wastewater treatment ponds and sewer lines
  - land application of sewage effluent

- Animal sources
  - wildlife/stormwater runoff
  - animal feeding operations
  - domestic pets/stormwater runoff

2.2.1 Septic Systems and Wastewater

Much of the development within the Big Sky area has occurred within the BSWSD boundary (**Figures 2-1** and **2-2**). The vast majority of the buildings within the BSWSD boundary are reportedly connected to the central sewer system (R. Edwards, personal communication, 5/26/06). The BSWSD reports that 100 percent of the sewage effluent collected by the BSWSD is applied through sprinkler irrigation to the golf courses in the Meadow Village and at the Yellowstone Mountain Club, while sewage sludge is composted and distributed throughout the Big Sky area and the Gallatin Valley.

Areas where development is occurring within the Middle Fork West Fork Gallatin River watershed that are outside of the BSWSD boundary include the headwaters of the Middle Fork on the eastern flank on Lone Mountain and the Beehive Creek watershed. An unnamed tributary in the drainage to the west of the North Fork West Fork Gallatin River also flows through an area

with recent development that is outside of the BSWSD boundary. The recent development surrounding Moonlight Basin resort in the headwaters of the Middle Fork West Fork Gallatin River relies on a privately maintained sewer system in which wastewater is transported to a treatment facility in the Jack Creek watershed. However, the Diamond Hitch subdivision is not included within this sewer network and residential development utilizes individual septic systems (K. Germain, personal communication, 6/2/06). Septic systems outside of the sewer network may potentially contribute pathogen loads to receiving water bodies due to system failure and surface or subsurface malfunctions.

2.2.1.1 Soils

The NRCS soils database indicates that soils in the West Fork Gallatin River watershed generally have a very limited capacity for septic tank absorption fields. Within the headwaters of the Middle Fork on the eastern flank of Lone Mountain, extensive development has occurred within the Shadow very channery loam soil unit. The NRCS soils database indicates that the Shadow soil unit has very limited potential for septic tank absorption fields due to slope and seepage (NRCS 2006). Seepage through this soil unit results in too much water movement and can lead to wastewater reaching the surface without adequate filtering through the soil. Overall, as slope increases, the capacity decreases for septic tank absorption fields and the likelihood of wastewater exiting out the side of the slope without adequate filtration increases. Progressing downstream, the Middle Fork passes through the MacFarlane stony sandy loam, the Yellowmule-Ouselfal complex, and the Beehive-Mooseflat complex, which are all considered very limited in their capacity for septic tank absorption fields. Some of these soil units are limited due to the depth to bedrock, where the bedrock is near the surface, again reducing the filtering of the wastewater. On soil units in valley bottoms near stream channels, there is a limited capacity for septic tank absorption fields since the water table is near the surface.

Different soils have different capacities for disposal of wastewater by irrigation. A review of NRCS soils database for soil units which comprise the Meadow Village golf course suggests that these soils may be poorly suited for the land application of wastewater. The Meadow Village golf course where wastewater effluent is applied through sprinkler irrigation between the West Fork Gallatin River and South Fork West Fork Gallatin River is situated on the Libeg cobbly loam soil unit. This soil unit is considered somewhat limited for disposal of wastewater by irrigation due to due to droughty nature of the soil, indicating that water rapidly flows through the soil (NRCS 2006). The Meadow Village golf course also extends onto the Beehive-Mooseflat complex soil unit along the West Fork Gallatin River. The Beehive and Mooseflat soil units are considered very limited for disposal of wastewater by irrigation since there is a relatively high water table and very little additional water can be absorbed.

2.2.2 Animal Sources

Runoff of animal waste from wildlife, livestock and domestic pets is a potential source of pathogen contamination to surface waters. Extensive wildlife populations within the West Fork Gallatin River watershed have the potential to lead to increased pathogen loads, especially in surface runoff during storm events. Since Big Sky is primarily a recreation community, runoff from agricultural livestock operations is not generally an issue within the watershed. However,

outfitters keep livestock used for trail rides and pack trips in localized areas. Runoff from these animal feeding operations during wet weather may deliver pathogens to the stream channel. Improperly managed waste from domestic pets is an additional source of pathogens that can also cause pollutants to enter surface waters.

2.3 Pathogen Monitoring Sites

A total of **15 pathogen monitoring sites** are described within this Sampling and Analysis Plan. This includes:

- five sites on the **Middle Fork West Fork Gallatin Ri**ver,
- four sites on **tributaries of the Middle Fork** West Fork Gallatin River,
- two sites on the **North Fork** West Fork Gallatin River,
- three sites on the **West Fork** Gallatin River, and
- one site on the **South Fork** West Fork Gallatin River.

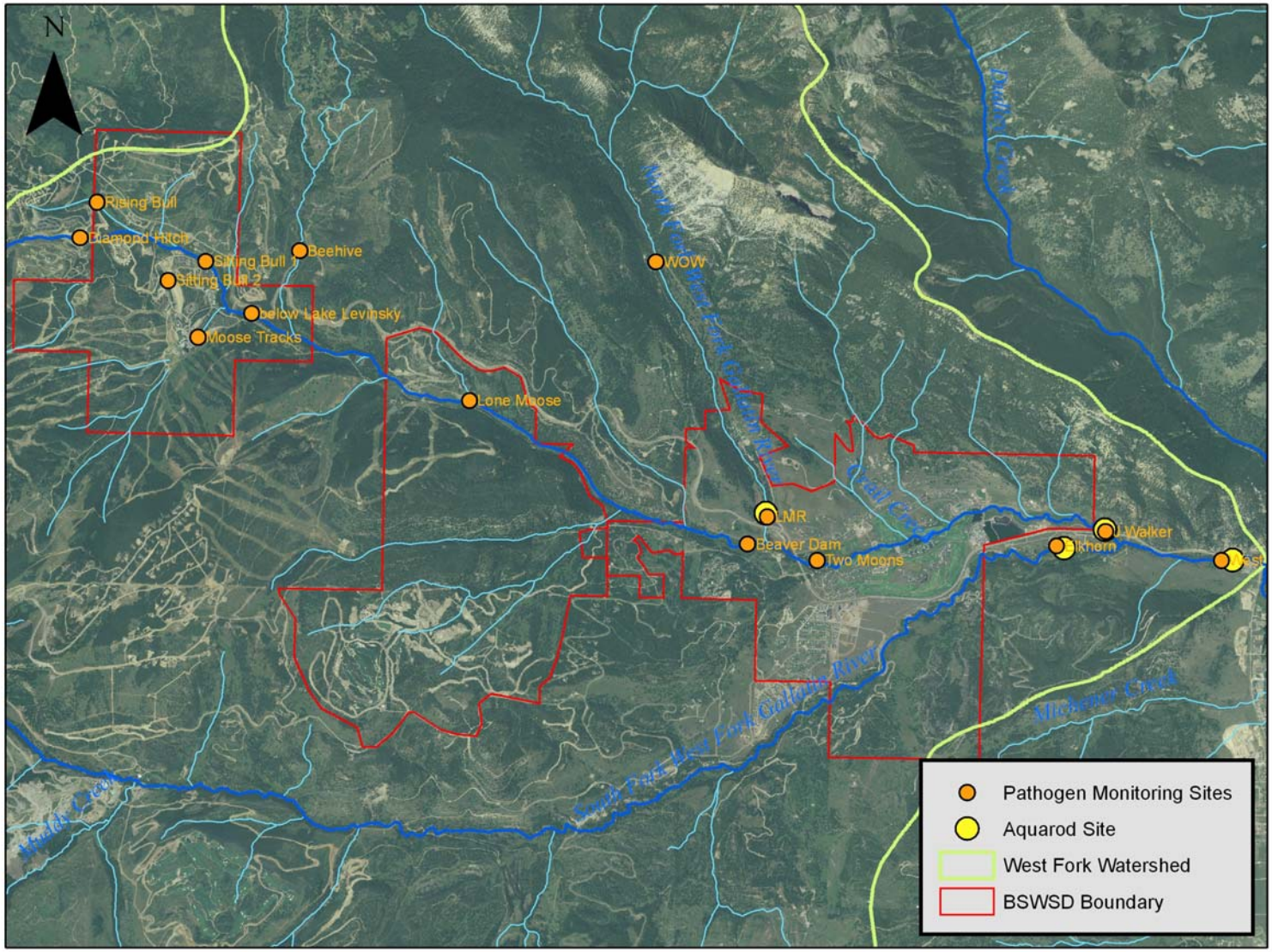
Pathogen monitoring sites are presented in **Table 2-7** and **Figure 2-2**.

Table 2-7. Pathogen Monitoring Sites in the West Fork Gallatin River Watershed.

Stream Segment	Sample Site Description	Sample Site Name	STORET ID*	5 samples collected over 30-day timeframe each season	1 sample collected each season	Stream flow measurement technique	Parameters to be collected
Middle Fork West Fork Gallatin River	Middle Fk West Fk Gallatin R at Diamond Hitch Rd	Diamond Hitch	UG05MFWF03	X		Flow meter	*E. coli* / Nitrate+nitrite
	Middle Fk West Fk Gallatin R at Sitting Bull Rd	Sitting Bull 1	UG05MFWF04	X		Flow meter	*E. coli* / Nitrate+nitrite
	Middle Fk West Fk Gallatin R upstrm of Beehive Ck	below Lake Levinsky	UG05MFWF01	X		Flow meter	*E. coli* / Nitrate+nitrite
	Middle Fk West Fk Gallatin R below Lone Moose	Lone Moose	UG05MFWF05	X		Flow meter	*E. coli* / Nitrate+nitrite
	Middle Fk West Fk Gallatin R upstrm of North Fk	Beaver Dam	UG05MFWF02	X		Flow meter	*E. coli* / Nitrate+nitrite
	Tributary to Middle Fk West Fk Gallatin R at Rising Bull Rd	Rising Bull	UG05MFTR01		X	Flow meter	*E. coli* / Nitrate+nitrite
	Tributary to Middle Fk West Fk Gallatin R above Lake Levinsky	Sitting Bull 2	UG05MFTR02		X	Flow meter	*E. coli* / Nitrate+nitrite
	Tributary to Middle Fk West Fk Gallatin R into Lake Levinsky	Moose Tracks	UG05MFTR03		X	Flow meter	*E. coli* / Nitrate+nitrite
	Beehive Creek, tributary to Middle Fk West Fk Gallatin R	Beehive	UG05BEHV01		X	Flow meter	*E. coli* / Nitrate+nitrite
North Fork West Fork Gallatin River	North Fk West Fk Gallatin R upstrm Lone Mt Ranch	WOW	UG05NFWF01		X	Flow meter	*E. coli* / Nitrate+nitrite
	North Fk West Fk Gallatin R dwnstrm Lone Mt Ranch	LMR	UG05NFWF02		X	Aquarod	*E. coli* / Nitrate+nitrite
West Fork Gallatin River	West Fk Gallatin R dwnstrm Middle Fk and North Fork	Two Moons	UG05WFGR01		X	Flow meter	*E. coli* / Nitrate+nitrite
	West Fk Gallatin R upstrm South Fk West Fk Gallatin R	J Walker	UG05WFGR02		X	Aquarod	*E. coli* / Nitrate+nitrite
	West Fk Gallatin R at mouth	West	UG05WFGR03		X	Aquarod	*E. coli* / Nitrate+nitrite
South Fork West Fork Gallatin River	South Fk West Fk Gallatin R upstrm of West Fk	Elkhorn	UG05SFWF03		X	Aquarod	*E. coli* / Nitrate+nitrite

*STORET IDs in blue indicate newely established sites for pathogen monitoring. Remaining STORET site IDs were established during biological monitoring in September 2005.

Figure 2-2. Pathogen Monitoring Sites in the West Fork Gallatin River Watershed.



2.3.1 Middle Fork West Fork Gallatin River

Fecal coliform data was collected on the Middle Fork West Fork Gallatin River at three sites between 1995 and 1996 and at one site between 2002 and 2004. Based on this data and a review of recent development in relation to the BSWSD boundary, pathogen monitoring is planned at a total of five sites on the Middle Fork West Fork Gallatin River. Monitoring at these sites will be conducted 5 times during each season. This monitoring network is designed to assess pathogen concentrations in the Middle Fork West Fork Gallatin River and to evaluate compliance with Montana's water quality standards.

- **Diamond Hitch (UG05MFWF03)**
  The uppermost site on the Middle Fork West Fork Gallatin River is at the Diamond Hitch Road crossing and is upstream of the BSWSD boundary. Upstream of this site, the Middle Fork flows under the Iron Horse and Pony Express chair lifts. Recent development outside of the BSWSD boundary has occurred upstream of this site and some of the development is on individual septic systems.

- **Sitting Bull (UG05MFWF04)**
  Progressing downstream, the next site on the Middle Fork West Fork Gallatin River is at the Sitting Bull Road crossing and is within the BSWSD boundary. The majority of the development between the uppermost site and this site is within the BSWSD boundary.

- **Below Lake Levinsky (UG05MFWF01)**
  The third site on the Middle Fork West Fork Gallatin River progressing in the downstream direction is below Lake Levinsky and upstream of the confluence with Beehive Creek. This site is established to document any changes in pathogen loads above and below the reservoir. This site was included in the biological monitoring event in September of 2005 (MFWF01).

- **Lone Moose (UG05MFWF05)**
  Progressing downstream from Lake Levinsky, the fourth site on the Middle Fork West Fork Gallatin River is planned in an area with a suspected sewer line break. This site is located downstream of the Lone Moose Road crossing. This sample site is downstream of an area where severe disturbance has occurred along the sewer line.

- **Beaver Dam (UG05MFWF02)**
  The fifth site on the Middle Fork West Fork Gallatin River at which pathogen monitoring is planned is the Beaver Dam site, where fecal coliform data were collected between 2002 and 2004. This site also corresponds with site MFWF02 on the Middle Fork upstream of the confluence with the North Fork at which biological monitoring was conducted in September of 2005.

In addition to the five monitoring sites on the Middle Fork West Fork Gallatin River, four tributaries of the Middle Fork will also be sampled on a seasonal basis. Three of these sites were selected to evaluate pathogen loading to the Middle Fork West Fork Gallatin River, while the site on Beehive Creek was selected to identify natural background conditions.

- **Rising Bull (UG05MFTR01)**
  This sample site is at the Rising Bull road crossing and is on an unnamed headwater tributary to the Middle Fork West Fork that enters from the north. This tributary flows through an area upstream of the BSWSD boundary within which recent development has taken place. This sample site is located just within the BSWSD boundary.

- **Sitting Bull 2 (UG05MFTR02)**
  This sample site is on an unnamed tributary to the Middle Fork West Fork that enters from the south just before the Middle Fork flows into Lake Levinsky. This tributary drains the Big Sky Ski Area, with headwaters under the Lone Peak Tram. This sample site is located within the BSWSD boundary. Recent development has occurred upstream of this site.

- **Moose Tracks (UG05MFTR03)**
  This sample site is on an unnamed tributary to the Middle Fork West Fork that flows into Lake Levinsky from the south. This tributary flows through the Big Sky Ski Area and the sample site is located within the BSWSD boundary.

- **Beehive (UG05BEHV01)**
  Monitoring will be conducted at a sample site on Beehive Creek, which is a tributary of the Middle Fork West Fork Gallatin River that enters from the north downstream of Lake Levinsky. This site is upstream of the majority of anthropogenic disturbance and is established to document natural background conditions within the West Fork Gallatin River watershed.

2.3.2 North Fork West Fork Gallatin River

Pathogen monitoring is planned at the two established sites on the North Fork West Fork Gallatin River.

- **WOW (UG05NFWF01)**
  The upper site on the North Fork West Fork Gallatin River is upstream of the majority of anthropogenic disturbance and is established to document natural background conditions within the West Fork Gallatin River watershed. This site corresponds to the WOW site that was sampled in 2002 through 2004, and the NFWF01 site, at which biological monitoring was conducted in September of 2005.

- **LMR (UG05NFWF02)**
  The lower site on the North Fork West Fork Gallatin River is established near the mouth to document potential pathogen loads to the West Fork Gallatin River when the North Fork and Middle Fork confluence. Development has occurred outside of the BSWSD

boundary between the upper and lower sample sites. This site corresponds to the LMR site that was sampled in 2002 through 2004, and the NFWF02 site, at which biological monitoring was conducted in September of 2005.

2.3.3 West Fork Gallatin River

Pathogen monitoring is planned at three sites on the West Fork Gallatin River.

- **Two Moons (UG05WFGR01)**
  The uppermost site on the West Fork Gallatin River will be located downstream of the confluences with the Middle Fork and North Forks. This site is established to document pathogen loading from the Middle Fork West Fork Gallatin River into the West Fork Gallatin River. This site is at the Two Moons Road crossing and was included in the biological monitoring event in September of 2005 (WFGR01). This site is within the BSWSD boundary and upstream of the Meadow Village area. This site is also upstream of the Meadow Village golf course where treated wastewater effluent is applied through sprinkler irrigation.

- **J Walker (UG05WFGR02)**
  The second sample site on the West Fork Gallatin River is at the downstream end of the highly developed Meadow Village area, which includes the Meadow Village golf course and the wastewater treatment plant. This site is at the eastern extent of the BSWSD boundary and corresponds with site WFGR02 at the Big Sky Spur road crossing where biological monitoring was conducted in September of 2005 and is just upstream of the confluence with the South Fork.

- **West (UG05WFGR03)**
  The third and lowermost site on the West Fork Gallatin River is near the mouth. This site is outside of the BSWSD boundary. This site corresponds with site WFGR03 at which biological monitoring was conducted in September 2005.

2.3.4 South Fork West Fork Gallatin River

Pathogen monitoring is planned at one site on the South Fork upstream of the confluence with the West Fork Gallatin River.

- **Elkhorn (UG05SFWF03)**
  Pathogen data will be collected on the South Fork at the Elkhorn sample site, which corresponds with site SFWF03 where biological data was collected in September 2005. The majority of the South Fork West Fork watershed is outside of the BSWSD boundary. The exception is the lower reaches of the stream in the Meadow Village area, which is within the BSWSD boundary.

3.0 Monitoring Parameters and Methodology

Pathogen monitoring will include the collection of *E. coli* and nitrate+nitrite nitrogen from the water column. Additional field parameters to be assessed at each site include temperature and conductivity. Stream flow will be measured using a Marsh-McBirney Model 200 Portable Flowmeter at sites where there are no aquarods. Aquarods are currently placed at the mouths of the West Fork Gallatin River, South Fork West Fork Gallatin River, North Fork West Fork Gallatin River and the Middle Fork West Fork Gallatin River (**Table 2-7**).

3.1 *Escherichia coli* (*E. coli*)

E. coli was recently adopted as the indictor organism for pathogen pollutants in Montana water bodies. *E. coli* is a nonpathogenic bacteria that is usually associated with pathogens transmitted by fecal contamination. While the presence of *E. coli* does not always prove or disprove the presence of human pathogen bacteria, viruses, or protozoans, *E. coli* is assumed to indicate the presence of human pathogens (USEPA 2001). Monitoring of the indicator organism is done since it is more easily sampled and measured. Thus, *E. coli* concentrations will be measured to assess existing pathogen loads and identify and quantify potential pathogen sources.

Field sampling methods for water column measurements of *E. coli* and nitrate+nitrite nitrogen will follow established DEQ protocols outlined in the Montana Department of Environmental Quality Standard Operation Procedure (SOP) manual, which is available on the internet at http://www.deq.state.mt.us/wqinfo/monitoring/SOP/sop.asp. A replicate sample will be collected at one site during each monitoring event.

3.2 Nitrate+Nitrite Nitrogen

Elevated nitrate concentrations are often found in areas with a high density of septic systems, since conventional septic systems are ineffective at removing nitrogen. Once the septic effluent enters the soil below the drainfield, almost all the nitrogen is converted to nitrate through the process of nitrification (Tri-State Water Quality Council 2005). Nitrate can then be transported relatively easily through the ground water, possibly reaching surface waters of nearby streams. Thus, nitrate+nitrite nitrogen concentrations will be measured during this study as supporting information help evaluate specific sources of pathogen loading. It should be noted that animal wastes, lawn fertilizers, and agricultural nonpoint source runoff in general are also potential sources of ntriate+nitrite nitrogen. A more detailed nitrate monitoring program being conducted by researchers at MSU will also be useful in identifying potential anthropogenic sources of nitrogen in the West Fork Gallatin River watershed.

Field sampling methods for water column measurements of nitrate+nitrite nitrogen will follow established DEQ protocols outlined in the Montana Department of Environmental Quality Standard Operation Procedure (SOP) manual, which is available on the internet at http://www.deq.state.mt.us/wqinfo/monitoring/SOP/sop.asp. A field blank will be performed during each sampling event.

3.3 Monitoring Schedule

Monitoring will occur on a seasonal basis, **with five samples collected over a 30-day time period within each of the seasons on the Middle Fork West Fork Gallatin River** (**Table 2-7**). The months of **February, May, August, and November** will be targeted to represent the winter, spring, summer, and fall seasons respectively. During the monitoring timeframe, an attempt will be made to capture at least one wet weather event. Samples collected during wet weather events will be noted as such, since samples collected during storm events will more likely capture nonpoint sources of pathogen due to inputs from surface runoff.

Monitoring on tributaries of the Middle Fork West Fork Gallatin River, North Fork West Fork Gallatin River, South Fork Gallatin River and West Fork Gallatin River will occur once during each season (**Table 2-7**). Data assessment and reporting will be completed once all the laboratory analysis has been received.

It should be noted that winter conditions may limit monitoring sites and parameters. While it is anticipated that water column measurements can be performed during the winter months, heavy snows and/or ice may prevent stream flow measurements from occurring at some sites. If this is the case, then stream flows will be estimated based on measurements performed during other sampling events.

4.0 Laboratory Analytical Methods

All water column data will be analyzed by Montana DEQ certified vendors following appropriate analytical protocols. *E. coli* and nitrate+nitrite nitrogen samples will be processed by the Montana Department of Health and Human Service Environmental Laboratory (DPHHS) in Helena. The DPHHS lab utilizes the Colilert 18 method for assessing *E. coli* bacteria (**Table 4-1**). Results are reported as colony forming units per 100 milliliters (cfu/100mL). Results will be reported at a detection limit of 1 cfu/100mL. All samples will be processes within six hours of collection.

Table 4-1. Requirements for Sample Collection and Analysis.

Analyte	Sample Volume	Container	Preservation	Holding Time	Analysis Method	Detection Limit
E. Coli	100 ml	Sterile polypropylene with sodium thiosulfate	cool to <10°C	6 hrs	Colilert 18	1 cfu/100 ml
Nitrate + Nitrite Nitrogen	250 ml	acid-washed polyethylene	Add H2SO4 to pH<2.0, cool to 4°C	28 days	EPA 353.2	0.01 mg/l

5.0 Quality Assurance and Quality Control Requirements

All quality assurance and quality control (QA/QC) requirements followed by Montana DEQ will be instituted for this project. The QA/QC requirements are described in *Quality Assurance Project Plan (QAPP) Sampling and Water Quality Assessment of Streams and Rivers in*

Montana, 2005, which is available on the internet at http://www.deq.state.mt.us/wqinfo/QAProgram/WQPBQAP-02.pdf.

6.0 Data Analysis, Record Keeping, and Reporting Requirements

Data generated during the Upper Gallatin TPA Pathogen Monitoring project will be stored in field notes, on field forms, and in spreadsheets obtained from the laboratories. Written field notes and measurements will be entered into a spreadsheet by PBS&J staff following QA/QC procedures to screen for data entry errors. PBS&J project staff will submit all pathogen monitoring data to the Blue Water Task Force and the Montana Department of Environmental Quality (DEQ) in a SIM-compatible format in an Excel spreadsheet that will provide for minimum data and metadata requirements for import into the EPA STORET database. All data generated during this project will be stored at PBS&J's Helena office, and will be made available to the public.

7.0 Schedule for Completion

Pathogen monitoring described within this Sampling and Analysis Plan is scheduled to be performed in 2006 and 2007. Additional monitoring may be undertaken once the initial data has been reviewed and an evaluation of pathogen concentrations has been performed.

8.0 Project Team and Responsibilities

This project is a partnership between the Blue Water Task Force, Montana Department of Environmental Quality and PBS&J. Personnel involved in this project are presented in **Table 9-1**.

Table 8-1. Project Personnel Roles.

Name	Organization	Project Responsibilities
Katie Alvin	Blue Water Task Force	Executive Director
Pete Schade	MT Dept. of Environmental Quality	Senior TMDL Planner
Gary Ingman	PBS&J	Project Manager
Jeff Dunn	PBS&J	Watershed Specialist
Mark Bostrom	MT Dept. of Environmental Quality	DEQ QA Officer

Katie Alvin is the Executive Director for the Blue Water Task Force. Katie is responsible for contract oversight and review of project deliverables.

The TMDL Planner for the Upper Gallatin TPA at the Montana Department of Environmental Quality is Pete Schade. Pete is responsible for contract oversight and review of all project deliverables.

The Upper Gallatin TPA Biological Monitoring project manager is Gary Ingman, senior biologist with PBS&J. The project manager will provide general oversight and coordination to the monitoring project and monitoring activities. He will also be responsible for reviewing the

monitoring procedures and results to ensure that measurement quality objectives and quality control requirements are met.

Jeff Dunn is a Watershed Specialist with PBS&J. Jeff's responsibilities include Sampling and Analysis Plan compilation, data collection, and data assessment and reporting.

Mark Bostrom of the Montana Department of Environmental Quality Water Quality Planning Bureau is the state water quality monitoring quality assurance officer.

9.0 References

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