
2005 BIOLOGICAL MONITORING CHLOROPHYLL A DATA SUMMARY

Upper Gallatin River Water Quality Restoration Planning Areas



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October 2006

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1.0 INTRODUCTION

The Montana Department of Environmental Quality (DEQ) is required to develop a Total Maximum Daily Load (TMDL) water quality restoration plan for streams listed as impaired on the 2004 303(d) List within the Upper Gallatin TMDL Planning Area (TPA) in order to satisfy state law as well as federal court requirements. In September of 2005, biological monitoring was conducted on several streams in the Upper Gallatin TPA. Biological monitoring included the collection of macroinvertebrate, periphyton and chlorophyll *a* data. Monitoring sites and parameters of interest were outlined in the *Upper Gallatin TMDL Planning Area Biological Monitoring Plan* (PBS&J 2005). Monitoring was conducted to fill data gaps identified in the *Upper Gallatin Total Maximum Daily Load Planning Area Phase I TMDL Status Report* (CDM 2005). Data generated during this assessment will provide information useful in evaluating both sediment and nutrient related impairments in the Upper Gallatin TPA.

This report summarizes the chlorophyll *a* data collected during biological monitoring conducted in the Upper Gallatin TPA in September of 2005. Macroinvertebrate and periphyton data that was collected during biological monitoring can be found in accompanying reports prepared by the laboratories, with macroinvertebrate data summarized in *A Biological Assessment of Sites in the Gallatin River Watershed: Gallatin and Madison Counties, Montana* (Bollman 2006) and periphyton data summarized in *Biological Integrity of Selected Major Tributaries to the Gallatin River in Southwestern Montana, Based on the Structure and Composition of the Benthic Algae Community* (Weber 2006).

During biological monitoring in September of 2005, samples were collected at seventeen sites on eight streams, including eleven sites on streams that are listed as impaired on the 2004 303(d) List and six potential reference sites (**Table 1-1, Figures 1-1 and 1-2**). Geographic coordinates for sample sites are presented in **Appendix A**.

Streams within the Upper Gallatin TPA listed as impaired on the 2004 303(d) List where biological monitoring was conducted include:

- Middle Fork West Fork Gallatin River
- South Fork West Fork Gallatin River
- West Fork Gallatin River
- Squaw Creek

Several additional streams were also assessed in an attempt to identify potential reference conditions within the Upper Gallatin TPA. Potential reference streams included:

- Dudley Creek
- Hell Roaring Creek
- Swan Creek
- North Fork West Fork Gallatin River

Table 1-1. Biological Monitoring Sites, September 2005.

Stream Segment	STORET ID	Sample Site	Established Site	Macroinvertebrates	Periphyton	Chlorophyll a
South Fork West Fork Gallatin River	UG05SFWF01	South Fk West Fk Gallatin R upstrm of Ousel Falls	H, E	x	x	x
	UG05SFWF03	South Fk West Fk Gallatin R at Stream Side road	M05GALWFSS			x
	UG05SFWF03	South Fk West Fk Gallatin R upstrm of West Fk	M05GALWFEH			x
Middle Fork West Fork Gallatin River	UG05MFWF01	Middle Fk West Fk Gallatin R upstrm of Beehive Ck	A, F, J	x	x	x
	UG05MFWF02	Middle Fk West Fk Gallatin R upstrm of North Fk	M05GALWFBD			x
North Fork West Fork Gallatin River	UG05NFWF01	North Fk West Fk Gallatin R upstrm Lone Mt Ranch	M05GALWFWW			x
	UG05NFWF02	North Fk West Fk Gallatin dwnstrm Lone Mt Ranch	M05GALWFLM			x
West Fork Gallatin River	UG05WFGR01	West Fk Gallatin R dwnstrm North Fk and Middle Fk	MWG-1	x	x	x
	UG05WFGR02	West Fk Gallatin R upstrm of South Fk Gallatin R	M05GALWFJW			x
	UG05WFGR03	West Fk Gallatin R at mouth	West Fork	x	x	x
Squaw Creek	UG05SQAW01	Squaw Creek upper	Reach 3	x	x	x
	UG05SQAW02	Squaw Creek at Rat Lake bridge	at mouth	x	x	x
	UG05SQAW03	Squaw Creek at mouth	at Rat Lake Bridge	x	x	x
Dudley Creek	UG05DDLY01	Dudley Creek	Dudley Creek	x	x	x
Swan Creek	UG05SWAN01	Swan Creek above trailhead, lower		x	x	x
Swan Creek	UG05SWAN02	Swan Creek above trailhead, upper		x	x	x
Hell Roaring Creek	UG05HLRG01	Hell Roaring Creek		x	x	x

Figure 1-1. Biological Monitoring Sites in West Fork Gallatin River Watershed and Dudley Creek.

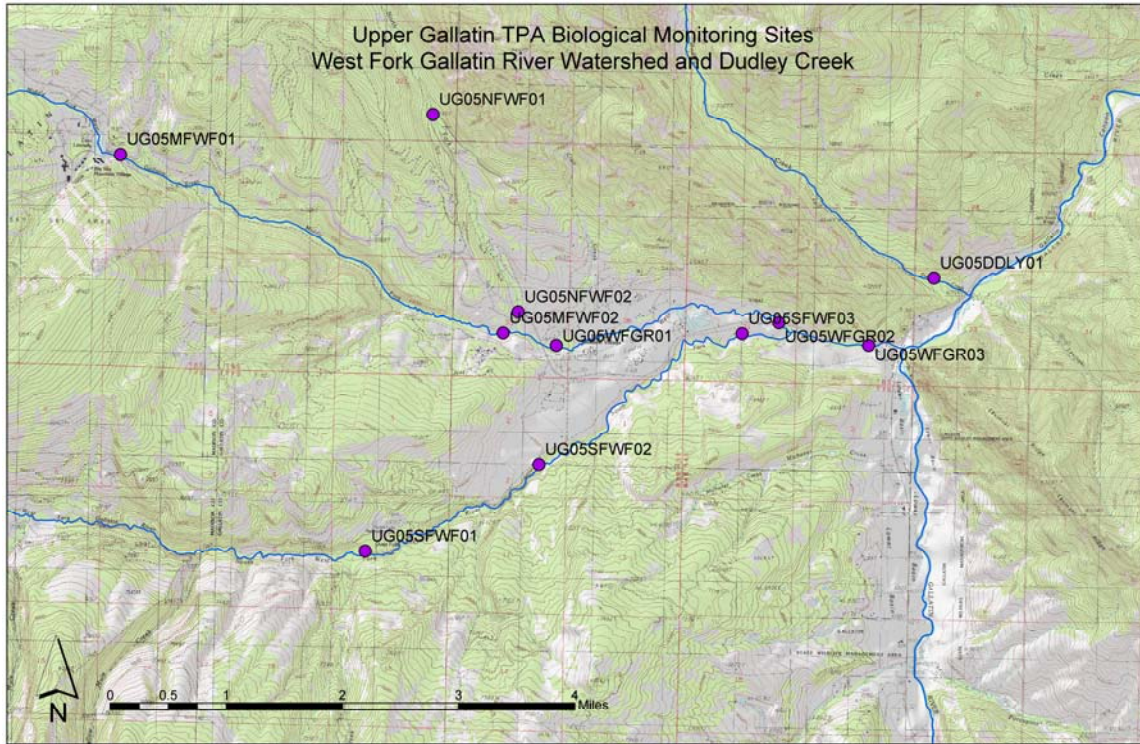
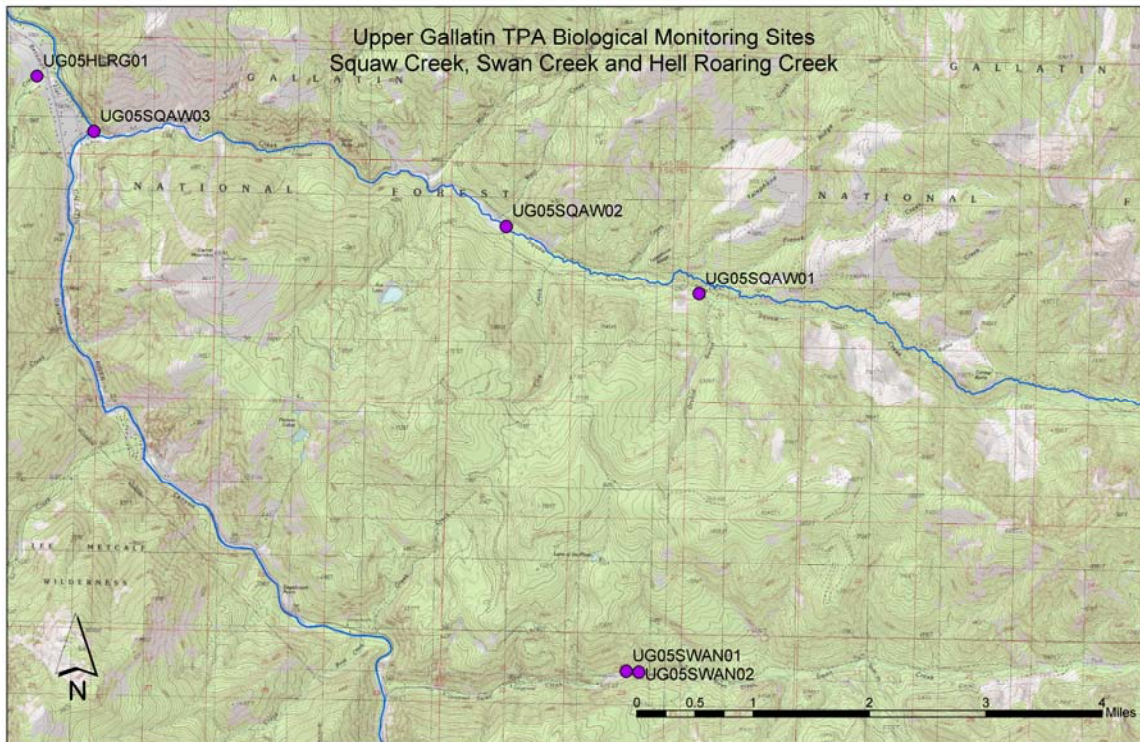


Figure 1-2. Biological Monitoring Sites on Squaw, Swan and Hell Roaring Creeks.



2.0 BIOLOGICAL MONITORING PARAMETERS

Biological monitoring in September of 2005 included the collection of macroinvertebrates (aquatic insects), periphyton (algae) and chlorophyll *a* (pigment in algae). Macroinvertebrate and periphyton communities were sampled since shifts in community structure are often related to specific pollutants, such as metals, nutrients or sediment. Chlorophyll *a*, which is a pigment found in algae growing on the streambed, was sampled in an attempt to relate nutrient levels to algae growth since chlorophyll *a* concentrations often increase when nutrient loads increase. Chlorophyll *a* data was collected at all seventeen sites included in the biological monitoring program, while macroinvertebrate and periphyton data were only collected at sites for which there was not any recently collected data. In addition, the streambed median particle size (D50) and the percent of fine sediment <6mm and <2mm in riffles were evaluated using a Wolman pebble count.

2.1 Chlorophyll *a*

Information regarding algal densities is valuable when developing nutrient TMDLs, since most waters in Montana are protected from excessive nutrient concentrations by narrative standards, which stipulate:

“State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will create conditions which produce undesirable aquatic life” [ARM 17.30.637 (1)(e)].

Chlorophyll *a* data facilitates the development of nutrient TMDLs since excessive algae growth is considered “undesirable aquatic life”. While the State standard for nutrients is narrative, numeric nutrient standards utilizing chlorophyll *a* concentrations have been developed for individual waterbodies, often in conjunction with the TMDL process. The numeric standards developed for the Clark Fork River are often used as a preliminary water quality target when developing nutrient TMDLs. For the Clark Fork River, a chlorophyll *a* standard of 100 mg/m² as a summer mean concentration and 150 mg/m² as a maximum value has been established.

2.1.1 Nutrient Impairments in the Upper Gallatin TPA

In the Upper Gallatin TPA, the South Fork West Fork Gallatin River and the West Fork Gallatin River are listed as impaired due to nutrients and algal growth/chlorophyll *a*, while the Middle Fork West Fork Gallatin River is listed as impaired due to nutrients on the 2004 303(d) List. Squaw Creek is listed as impaired due to nutrients and phosphorus.

3.0 CHLOROPHYLL A DATA

A brief summary of chlorophyll *a* data collected during biological monitoring in 2005 is presented by water body in this section. During biological monitoring in September of 2005, a total of five replicate chlorophyll *a* samples were collected at each site. Five replicates were performed since algal coverage and chlorophyll *a* concentrations can vary significantly within a short section of stream. Chlorophyll *a* concentrations for each replicate sample are presented for each sample site, along with the mean and median concentrations. Laboratory analytical results are presented in **Appendix B**.

3.1 Squaw Creek

3.1.1 SQA01

The uppermost site on Squaw Creek (SQA01) was just downstream of a bridge and below a gate that restricted access higher in the watershed. Chlorophyll *a* concentrations were low at this site, suggesting that either nitrogen or phosphorus may be limiting algae production. Extensive streamside shading and active streambed scour during runoff are other factors that may limit algae production at this site. The median chlorophyll *a* concentration was 2.8 mg/m², while the mean chlorophyll *a* concentration was 4.0 mg/m². Chlorophyll *a* concentrations ranged from 0.8 to 11.8 mg/m² (**Table 3-1**).

Table 3-1. Chlorophyll *a* concentrations at SQA01.

Sample Site STORET ID	Sample Site Field ID	Sample Date	Chlorophyll <i>a</i> Concentration (mg/m ²)	Mean Chlorophyll <i>a</i> Concentration (mg/m ²)	Median Chlorophyll <i>a</i> Concentration (mg/m ²)
UG05SQA01	SQA01-09-1	09/13/05	11.8	4.0	2.8
	SQA01-09-2	09/13/05	2.8		
	SQA01-09-3	09/13/05	0.8		
	SQA01-09-4	09/13/05	3.4		
	SQA01-09-5	09/13/05	1.1		

3.1.2 SQA02

Site SQA02 was sampled upstream of the Rat Lake bridge. The median chlorophyll *a* concentration at site SQA02 was 3.1 mg/m², while the mean chlorophyll *a* concentration was 3.8 mg/m². Chlorophyll *a* concentrations ranged from 2.2 to 7.3 mg/m² (**Table 3-2**). These values are similar to the uppermost site (SQA01), suggesting there are no additional nutrient sources between the sites.

Table 3-2. Chlorophyll *a* concentrations at SQAW02.

Sample Site STORET ID	Sample Site Field ID	Sample Date	Chlorophyll <i>a</i> Concentration (mg/m ²)	Mean Chlorophyll <i>a</i> Concentration (mg/m ²)	Median Chlorophyll <i>a</i> Concentration (mg/m ²)
UG05SQAW02	SQAW02-09-1	09/13/05	7.3	3.8	3.1
	SQAW02-09-2	09/13/05	2.8		
	SQAW02-09-3	09/13/05	3.4		
	SQAW02-09-4	09/13/05	3.1		
	SQAW02-09-5	09/13/05	2.2		

3.1.3 SQAW03

Site SQAW03 was located at the mouth of Squaw Creek. The median chlorophyll *a* concentration at site SQAW03 was 11.5 mg/m², while the mean chlorophyll *a* concentration was 14.6 mg/m². Chlorophyll *a* concentrations ranged from 10.4 to 25.5 mg/m² (**Table 3-3**). These values are slightly higher than the upstream sites, though relatively low overall.

Table 3-3. Chlorophyll *a* concentrations at SQAW03.

Sample Site STORET ID	Sample Site Field ID	Sample Date	Chlorophyll <i>a</i> Concentration (mg/m ²)	Mean Chlorophyll <i>a</i> Concentration (mg/m ²)	Median Chlorophyll <i>a</i> Concentration (mg/m ²)
UG05SQAW03	SQAW03-09-1	09/13/05	11.5	14.6	11.5
	SQAW03-09-2	09/13/05	15.1		
	SQAW03-09-3	09/13/05	10.4		
	SQAW03-09-4	09/13/05	25.5		
	SQAW03-09-5	09/13/05	10.6		

3.2 West Fork Gallatin River

3.2.1 WFGR01

The upper site on the West Fork Gallatin River (WFGR01) was located downstream of the Middle Fork West Fork Gallatin River and North Fork West Fork Gallatin River confluence. The median chlorophyll *a* value at site WFGR01 was 23.8 mg/m², while the mean chlorophyll *a* concentration was 22.7 mg/m². Chlorophyll *a* concentrations ranged from 6.7 to 33.6 mg/m² (**Table 3-4**). A chlorophyll *a* concentration of 33 mg/m² from one of the replicates collected at this site is presented in **Figure 3-1**. The algae growth was observed to be less dense here than at the downstream sites (WFGR02 & WFGR03) on the West Fork Gallatin River.

Table 3-4. Chlorophyll *a* concentrations at WFGR01.

Sample Site STORET ID	Sample Site Field ID	Sample Date	Chlorophyll <i>a</i> Concentration (mg/m ²)	Mean Chlorophyll <i>a</i> Concentration (mg/m ²)	Median Chlorophyll <i>a</i> Concentration (mg/m ²)
UG05WFGR01	WFGR01-09-1	09/15/05	6.7	22.7	23.8
	WFGR01-09-2	09/15/05	23.8		
	WFGR01-09-3	09/15/05	33.0		
	WFGR01-09-4	09/15/05	16.5		
	WFGR01-09-5	09/15/05	33.6		

Figure 3-1. Chlorophyll *a* concentration of 33 mg/m² at WFGR01.



3.2.2 WFGR02

Site WFGR02 on the West Fork Gallatin River was located upstream of the confluence with the South Fork West Fork Gallatin River. The median chlorophyll *a* concentration at site WFGR02 was 312.6 mg/m², while the mean chlorophyll *a* concentration was 318.4 mg/m². Chlorophyll *a* concentrations ranged from 226.3 to 404.7 mg/m² (**Table 3-5**). A chlorophyll *a* concentration of 313 mg/m² from one of the replicates collected at this site is presented in **Figure 3-2**.

Chlorophyll *a* data collected at this site suggests there may be a significant amount of nutrient loading occurring between site WFGR01 and WFGR02, which is an approximately 2.3 mile long reach of stream. Streamside shading and streambed scour are other factors that may influence chlorophyll *a* concentrations within this reach. Potential nutrient sources within this reach include the golf course, wastewater treatment facility, commercial developments and residential developments.

Table 3-5. Chlorophyll *a* concentrations at WFGR02.

Sample Site STORET ID	Sample Site Field ID	Sample Date	Chlorophyll <i>a</i> Concentration (mg/m ²)	Mean Chlorophyll <i>a</i> Concentration (mg/m ²)	Median Chlorophyll <i>a</i> Concentration (mg/m ²)
UG05WFGR02	WFGR02-09-1	09/14/05	226.3	318.4	312.6
	WFGR02-09-2	09/14/05	312.6		
	WFGR02-09-3	09/14/05	352.9		
	WFGR02-09-4	09/14/05	404.7		
	WFGR02-09-5	09/14/05	295.5		

Figure 3-2. Chlorophyll *a* concentration of 313 mg/m² at WFGR02.



3.2.3 WFGR03

Site WFGR03 on the West Fork Gallatin River was located upstream of the Big Sky Spur road crossing a short distance upstream from the confluence with the mainstem of the Gallatin River. The median chlorophyll *a* concentration at site WFGR03 was 73.4 mg/m², while the mean chlorophyll *a* concentration was 442.8 mg/m² (**Table 3-6**). Chlorophyll *a* concentrations ranged from 12.0 to 1889.1 mg/m², which was the highest value recorded during the current monitoring event. The wide range of values may be related to the fact that two samples were collected from areas in the shade and three samples were collected in areas exposed to direct sunlight. Thus, dense coniferous canopy cover along the stream channel may be leading to lower algal densities locally. The second highest chlorophyll *a* value found during this sampling event was 1739.2 mg/m² at site SFWF03 on the South Fork West Fork Gallatin River just upstream of the confluence with the West Fork Gallatin River.

Table 3-6. Chlorophyll *a* concentrations at WFGR03.

Sample Site STORET ID	Sample Site Field ID	Sample Date	Chlorophyll <i>a</i> Concentration (mg/m ²)	Mean Chlorophyll <i>a</i> Concentration (mg/m ²)	Median Chlorophyll <i>a</i> Concentration (mg/m ²)
UG05WFGR03	WFGR03-09-1	09/14/05	12.0	442.8	73.4
	WFGR03-09-2	09/14/05	180.9		
	WFGR03-09-3	09/14/05	1889.1		
	WFGR03-09-4	09/14/05	58.5		
	WFGR03-09-5	09/14/05	73.4		

3.3 South Fork West Fork Gallatin River

3.3.1 SFWF01

The uppermost site sampled on the South Fork West Fork Gallatin River (SFWF01) was located upstream of Ousel Falls, which is slightly more than half-way down the creek. The median chlorophyll *a* concentration at site SFWF01 was 3.1 mg/m², while the mean chlorophyll *a* concentration was 15.1 mg/m². Chlorophyll *a* concentrations ranged from 2.8 to 63.3 mg/m² (Table 3-8).

Table 3-7. Chlorophyll *a* concentrations at SFWF01.

Sample Site STORET ID	Sample Site Field ID	Sample Date	Chlorophyll <i>a</i> Concentration (mg/m ²)	Mean Chlorophyll <i>a</i> Concentration (mg/m ²)	Median Chlorophyll <i>a</i> Concentration (mg/m ²)
UG05SFWF01	SFWF01-09-1	09/15/05	3.4	15.1	3.1
	SFWF01-09-2	09/15/05	3.1		
	SFWF01-09-3	09/15/05	2.8		
	SFWF01-09-4	09/15/05	63.3		
	SFWF01-09-5	09/15/05	3.1		

3.3.2 SFWF02

Site SFWF02 was located upstream of the Streamside Way road crossing. The median chlorophyll *a* concentration at site SFWF02 was 160.5 mg/m², while the mean chlorophyll *a* concentration was 136.3 mg/m², indicating a significant increase in algal growth between site SFWF01 and SFWF02, which covers a distance of approximately 2 miles. Chlorophyll *a* concentrations ranged from 3.9 to 277.8 mg/m² (Table 3-8). A chlorophyll *a* concentration of 42 mg/m² from one of the replicates collected at this site is presented in Figure 3-3, while a snapshot of the streambed at the sample site is presented in Figure 3-4. Residential and commercial developments are potential sources of nutrients within this reach.

Table 3-8. Chlorophyll *a* concentrations at SFWF02.

Sample Site STORET ID	Sample Site Field ID	Sample Date	Chlorophyll <i>a</i> Concentration (mg/m ²)	Mean Chlorophyll <i>a</i> Concentration (mg/m ²)	Median Chlorophyll <i>a</i> Concentration (mg/m ²)
UG05SFWF02	SFWF02-09-1	09/14/05	277.8	136.3	160.5
	SFWF02-09-2	09/14/05	160.5		
	SFWF02-09-3	09/14/05	42.3		
	SFWF02-09-4	09/14/05	3.9		
	SFWF02-09-5	09/14/05	197.2		

Figure 3-3. Chlorophyll *a* concentration of 42 mg/m² at SFWF02.



Figure 3-4. Streambed at SFWF02.



3.3.3 SFWF03

The lowermost site on the South Fork West Fork Gallatin River (SFWF03) was just upstream of the confluence with the West Fork Gallatin River. The median value chlorophyll *a* concentration at site SFWF03 was 164.7 mg/m², while the mean chlorophyll *a* concentration was 468.0 mg/m². Chlorophyll *a* concentrations ranged from 52.9 to 1739.2 mg/m² (**Table 3-9**). A chlorophyll *a* concentration of 155 mg/m² from one of the replicates collected at this site is presented in **Figure 3-5**, while a snapshot of the streambed at this sample site is presented in **Figure 3-6**. The second highest chlorophyll *a* concentration found during this sampling event (1739.2 mg/m²) was reported at this site. Field notes describe the algae at site SFWF02 as less dense than at site SFWF03. Thus, it appears that there may be additional sources of nutrient inputs over the approximately 2.6 miles of stream between sites SFWF02 and SFWF03. Alternatively, environmental conditions, such as the amount of sunlight, presence of appropriate substrate and/or the amount of scour are potentially more favorable for algal growth at site SFWF03. Site SFWF03 is downstream of the meadow village and the golf course, though the golf course is on the opposite side of the road as the stream. Residential and commercial developments are potential sources of increased nutrient loads.

Table 3-9. Chlorophyll *a* concentrations at SFWF03.

Sample Site STORET ID	Sample Site Field ID	Sample Date	Chlorophyll <i>a</i> Concentration (mg/m ²)	Mean Chlorophyll <i>a</i> Concentration (mg/m ²)	Median Chlorophyll <i>a</i> Concentration (mg/m ²)
UG05SFWF03	SFWF03-09-1	09/14/05	228.5	468.0	164.7
	SFWF03-09-2	09/14/05	1739.2		
	SFWF03-09-3	09/14/05	52.9		
	SFWF03-09-4	09/14/05	164.7		
	SFWF03-09-5	09/14/05	154.6		

Figure 3-5. Chlorophyll *a* concentration of 155 mg/m² at SFWF03.



Figure 3-6. Streambed at SFWF03.



3.4 Middle Fork West Fork Gallatin River

3.4.1 MFWF01

Site MFWF01 on the Middle Fork West Fork Gallatin River was located downstream of the earthen dam impounding Lake Levinsky. The median chlorophyll *a* concentration at site MFWF01 was 64.7 mg/m², while the mean chlorophyll *a* concentration was 81.1 mg/m². Chlorophyll *a* concentrations ranged from 18.5 to 163.0 mg/m² (**Table 3-10**). Algal densities were described as greater at site MFWF01 than at site MFWF02 in the field notes.

Table 3-10. Chlorophyll *a* concentrations at MFWF01.

Sample Site STORET ID	Sample Site Field ID	Sample Date	Chlorophyll <i>a</i> Concentration (mg/m ²)	Mean Chlorophyll <i>a</i> Concentration (mg/m ²)	Median Chlorophyll <i>a</i> Concentration (mg/m ²)
UG05MFWF01	MFWF01-09-1	09/15/05	123.8	81.8	64.7
	MFWF01-09-2	09/15/05	18.5		
	MFWF01-09-3	09/15/05	163.0		
	MFWF01-09-4	09/15/05	64.7		
	MFWF01-09-5	09/15/05	35.3		

3.4.2 MFWF02

Site MFWF02 was located upstream of the confluence with the North Fork West Fork Gallatin River. The median chlorophyll *a* concentration at site MFWF02 was 22.1 mg/m², while the

mean chlorophyll *a* concentration was 22.8 mg/m². Chlorophyll *a* concentrations ranged from 4.2 to 34.7 mg/m² (**Table 3-11**). A snapshot of the substrate at this sample site is presented in **Figure 3-7**. A decrease in chlorophyll *a* concentrations at the lower site on the Middle Fork West Fork Gallatin River may be related to dilution provided by Beehive Creek, which is reported to represent reference conditions.

Table 3-11. Chlorophyll *a* concentrations at MFWF02.

Sample Site STORET ID	Sample Site Field ID	Sample Date	Chlorophyll <i>a</i> Concentration (mg/m ²)	Mean Chlorophyll <i>a</i> Concentration (mg/m ²)	Median Chlorophyll <i>a</i> Concentration (mg/m ²)
UG05MFWF02	MFWF02-09-1	09/15/05	4.2	22.8	22.1
	MFWF02-09-2	09/15/05	32.8		
	MFWF02-09-3	09/15/05	20.2		
	MFWF02-09-4	09/15/05	22.1		
	MFWF02-09-5	09/15/05	34.7		

Figure 3-7. Streambed at MFWF02.



3.5 North Fork West Fork Gallatin River

3.5.1 NFWF01

The upper site on North Fork West Fork Gallatin River (NFWF01) was located upstream of the uppermost road crossing in the North Fork watershed. The median chlorophyll *a* concentration at site NFWF01 was 2.7 mg/m², while the mean chlorophyll *a* concentration was 3.6 mg/m². Chlorophyll *a* concentrations ranged from 0.8 to 8.4 mg/m² (**Table 3-12**). These values are

based on four replicate samples. A chlorophyll *a* concentration of 8 mg/m² from one of the replicates collected at this site is presented in **Figure 3-8**. A chlorophyll *a* concentration of 103.6 mg/m² from sample #5 was discarded since field notes indicated this sample included mossy growth found on rocks along the channel margin that was not sampled at any other sites. No filamentous algae were observed at the site.

Table 3-12. Chlorophyll *a* concentrations at NFWF01.

Sample Site STORET ID	Sample Site Field ID	Sample Date	Chlorophyll <i>a</i> Concentration (mg/m ²)	Mean Chlorophyll <i>a</i> Concentration (mg/m ²)	Median Chlorophyll <i>a</i> Concentration (mg/m ²)
UG05NFWF01	NFWF01-09-1	09/14/05	0.8	3.6	2.7
	NFWF01-09-2	09/14/05	4.5		
	NFWF01-09-3	09/14/05	8.4		
	NFWF01-09-4	09/14/05	0.8		
	NFWF01-09-5	09/14/05	103.6*		

*Discarded from mean and median calculations.

Figure 3-8. Chlorophyll *a* concentration of 8 mg/m² at NFWF01.



3.5.2 NFWF02

Site NFWF02 was located upstream of the confluence with the Middle Fork West Fork Gallatin River. The median chlorophyll *a* concentration at site NFWF02 was 52.4 mg/m², while the mean chlorophyll *a* concentration was 154.3 mg/m². Chlorophyll *a* concentrations ranged from 30.2 to 450.9 mg/m² (**Table 3-13**). A chlorophyll *a* concentration of 30 mg/m² from one of the replicates collected at this site is presented in **Figure 3-9**. Long strands of bright green

filamentous algae were observed in areas exposed to direct sunlight, from which two samples were collected. The other three samples were collected in shaded areas, which appeared to be the dominant condition along this reach due to extensive overstory coniferous canopy cover.

Table 3-13. Chlorophyll *a* concentrations at NFWF02.

Sample Site STORET ID	Sample Site Field ID	Sample Date	Chlorophyll <i>a</i> Concentration (mg/m ²)	Mean Chlorophyll <i>a</i> Concentration (mg/m ²)	Median Chlorophyll <i>a</i> Concentration (mg/m ²)
UG05NFWF02	NFWF02-09-1	09/15/05	450.9	154.3	52.4
	NFWF02-09-2	09/15/05	52.4		
	NFWF02-09-3	09/15/05	205.9		
	NFWF02-09-4	09/15/05	32.2		
	NFWF02-09-5	09/15/05	30.2		

Figure 3-9. Chlorophyll *a* concentration of 30 mg/m² at NFWF02.



3.6 Dudley Creek

3.6.1 DDLY01

Site DDLY01 was located where the valley opens up prior to the confluence with the Gallatin River. The median chlorophyll *a* concentration at site DDLY01 was 15.1 mg/m², while the mean chlorophyll *a* concentration was 18.9 mg/m². Chlorophyll *a* concentrations ranged from 0.8 to 46.5 mg/m² (Table 3-14).

Table 3-14. Chlorophyll *a* concentrations at DDLY01.

Sample Site STORET ID	Sample Site Field ID	Sample Date	Chlorophyll <i>a</i> Concentration (mg/m ²)	Mean Chlorophyll <i>a</i> Concentration (mg/m ²)	Median Chlorophyll <i>a</i> Concentration (mg/m ²)
UG05DDL01	DDL01-09-1	09/16/05	46.5	18.9	15.1
	DDL01-09-2	09/16/05	23.5		
	DDL01-09-3	09/16/05	0.8		
	DDL01-09-4	09/16/05	15.1		
	DDL01-09-5	09/16/05	8.4		

3.7 Swan Creek

3.7.1 SWAN01

The lower site on Swan Creek (SWAN01) was within an open meadow where the stream flowed through an old beaver complex. This site is located just downstream of SWAN02. The median chlorophyll *a* concentration at site SWAN01 was 2.5 mg/m², while the mean chlorophyll *a* concentration was 2.1 mg/m². Chlorophyll *a* concentrations ranged from 1.1 to 2.5 mg/m² (Table 3-15).

Table 3-15. Chlorophyll *a* concentrations at SWAN01.

Sample Site STORET ID	Sample Site Field ID	Sample Date	Chlorophyll <i>a</i> Concentration (mg/m ²)	Mean Chlorophyll <i>a</i> Concentration (mg/m ²)	Median Chlorophyll <i>a</i> Concentration (mg/m ²)
UG05SWAN01	SWAN01-09-1	09/13/05	2.5	2.1	2.5
	SWAN01-09-2	09/13/05	2.5		
	SWAN01-09-3	09/13/05	2.0		
	SWAN01-09-4	09/13/05	1.1		
	SWAN01-09-5	09/13/05	2.5		

3.7.2 SWAN02

Site SWAN02 was located just upstream of SWAN01, which varies from the standard downstream numbering convention. This site was located along a forested reach of stream. The median chlorophyll *a* concentration at site SWAN02 was 9.0 mg/m², while the mean chlorophyll *a* concentration was 24.2 mg/m². Chlorophyll *a* concentrations ranged from 0.8 to 89.1 mg/m² (Table 3-16).

Table 3-16. Chlorophyll *a* concentrations at SWAN02.

Sample Site STORET ID	Sample Site Field ID	Sample Date	Chlorophyll <i>a</i> Concentration (mg/m ²)	Mean Chlorophyll <i>a</i> Concentration (mg/m ²)	Median Chlorophyll <i>a</i> Concentration (mg/m ²)
UG05SWAN02	SWAN02-09-1	09/13/05	2.5	24.2	9.0
	SWAN02-09-2	09/13/05	89.1		
	SWAN02-09-3	09/13/05	9.0		
	SWAN02-09-4	09/13/05	0.8		
	SWAN02-09-5	09/13/05	19.6		

3.8 Hell Roaring Creek

3.8.1 HLRG01

Site HLRG01 was located upstream of the Highway 191 crossing and the confluence with the mainstem of the Gallatin River. The median chlorophyll *a* concentration at site HLRG01 was 10.9 mg/m², while the mean chlorophyll *a* concentration was 29.8 mg/m². Chlorophyll *a* concentrations ranged from 3.6 to 112.3 mg/m² (Table 3-17).

Table 3-17. Chlorophyll *a* concentrations at HLRG01.

Sample Site STORET ID	Sample Site Field ID	Sample Date	Chlorophyll <i>a</i> Concentration (mg/m ²)	Mean Chlorophyll <i>a</i> Concentration (mg/m ²)	Median Chlorophyll <i>a</i> Concentration (mg/m ²)
UG05HLRG01	HLRG01-09-1	09/16/05	3.6	29.8	10.9
	HLRG01-09-2	09/16/05	112.3		
	HLRG01-09-3	09/16/05	10.9		
	HLRG01-09-4	09/16/05	9.8		
	HLRG01-09-5	09/16/05	12.3		

4.0 SUMMARY

Chlorophyll *a* data collected at seventeen sites in the Upper Gallatin TPA suggests algal growth is elevated above natural background levels at a portion of the sample sites. Median chlorophyll *a* concentrations remained below 20 mg/m² at several of the identified reference sites, including the upper site on the North Fork West Fork Gallatin River (NFWF01), Dudley Creek (DDLY01), Hell Roaring Creek (HLRG01), and both sites on Swan Creek (SWAN01 & SWAN02). Median chlorophyll *a* concentrations remained below 20 mg/m² at all three sites Squaw Creek as well. Chlorophyll *a* concentrations at both sites on the Middle fork West Fork Gallatin River appeared somewhat elevated above natural background conditions, though median values remained below 100 mg/m². Along the West Fork Gallatin River, chlorophyll *a* concentrations increased in the downstream direction, from a median value of 23.8 mg/m² at the uppermost site (WFGR01) to a median value of 312.6 mg/m² upstream of the South Fork West Fork Gallatin River confluence (WFGR02). The median chlorophyll *a* concentration decreased downstream of the confluence with the South Fork West Fork to a value of 73.4 mg/m² at site WFGR03, though the highest single sample value (1889.1 mg/m²) was recorded at this site. Similar to the West Fork Gallatin River, chlorophyll *a* concentrations increased in the downstream direction along the South Fork West Fork Gallatin River, with median values of 160.5 mg/m² and 164.7 mg/m² at sites SFWF02 and SFWF03, respectively. Overall, chlorophyll *a* data collected in September 2005 suggests that algal growth is elevated above natural background levels in the lower reaches of the South Fork West Fork Gallatin River and in the West Fork Gallatin River above and below the confluence with the South Fork Gallatin River.

5.0 REFERENCES

Bollman, W. 2006. A Biological Assessment of Sites in the Gallatin River Watershed: Gallatin and Madison Counties, Montana. Prepared for PBS&J. Prepared by Rithron Associates, Inc, Missoula, Montana.

CDM. 2005. Upper Gallatin Total Maximum Daily Load Planning Area Phase I TMDL Status Report. Prepared for U.S. Environmental Protection Agency, Contract Number 68-C-02-109.

PBS&J. 2005. Upper Gallatin Watershed Aerial Photo Assessment and Reach Stratification (Draft). Prepared for Montana Department of Environmental Quality, Helena, Montana.

Weber, E.E. 2006. Biological Integrity of Selected Major Tributaries to the Gallatin River in Southwestern Montana Based on the Structure and Composition of the Benthic Algae Community. Prepared for PBS&J. Prepared by *PhycoLogic*, East Helena, Montana.

Appendix A

SAMPLE SITE GEOGRAPHIC COORDINATES

Upper Gallatin TMDL Planning Area

STORET ID	Stream	Latitude	Longitude
UG05MFWF01	Middle Fk West Fk Gallatin R	45.2872	-111.3916
UG05MFWF02	Middle Fk West Fk Gallatin R	45.2662	-111.3233
UG05NFWF01	North Fk West Fk Gallatin R	45.2931	-111.3367
UG05NFWF02	North Fk West Fk Gallatin R	45.2689	-111.3207
UG05WFGR01	West Fk Gallatin R	45.2648	-111.3138
UG05WFGR02	West Fk Gallatin R	45.2682	-111.2746
UG05WFGR03	West Fk Gallatin R	45.2657	-111.2587
UG05SFWF01	South Fk West Fk Gallatin R	45.2385	-111.3468
UG05SFWF02	South Fk West Fk Gallatin R	45.2500	-111.3167
UG05SFWF03	South Fk West Fk Gallatin R	45.2667	-111.2812
UG05SQAW01	Squaw Creek	45.4228	-111.1211
UG05SQAW02	Squaw Creek	45.4308	-111.1553
UG05SQAW03	Squaw Creek	45.4415	-111.2286
UG05DDL01	Dudley Creek	45.2743	-111.2475
UG05SWAN01	Swan Creek	45.3755	-111.1325
UG05SWAN02	Swan Creek	45.3753	-111.1303
UG05HLRG01	Hell Roaring Creek	45.4481	-111.2389

Note: "UG05" in the STORET ID refers to the STORET Project ID for TMDL monitoring in the upper Gallatin TPA.

Appendix B

LABORATORY ANALYTICAL RESULTS FOR CHLOROPHYLL A

Upper Gallatin TMDL Planning Area

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