APPENDIX D
STREAMBANK EROSION SOURCE ASSESSMENT

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D1.0 INTRODUCTION

This report presents an assessment of sediment loading due to streambank erosion along several stream segments in the West Fork Gallatin River watershed of the Upper Gallatin Total Maximum Daily Load (TMDL) Planning Area (TPA) located in Gallatin and Madison Counties, Montana. Sediment loads due to streambank erosion were estimated based on field data collected at 30 monitoring sites covering 5.2 miles of stream between July and October of 2008. Streambank erosion data collected at field monitoring sites was extrapolated to the stream reach and stream segment scales based on reach type characteristics identified in the Aerial Assessment Database, which was compiled in a geographic information system (GIS) prior to field data collection. Streambank erosion data collected in the field were also used to estimate sediment loading at the watershed scale and to assess the potential to decrease sediment inputs due to anthropogenically accelerated streambank erosion.

D2.0 METHODS

The streambank erosion assessment involved stratifying streams into reaches in GIS, collecting streambank erosion data in the field, estimating sediment loads from streambank erosion, extrapolating streambank erosion sediment loads to the entire stream, and estimating the potential for reducing anthropogenically accelerated streambank erosion.

D2.1 Aerial Assessment Reach Stratification

Prior to field data collection, an aerial assessment of streams in the West Fork Gallatin River watershed was conducted using National Agricultural Imagery Program (NAIP) color imagery from 2005 in GIS along with other relevant data layers, including the National Hydrography Dataset (NHD) 1:100,000 stream layer and United States Geological Survey 1:24,000 Topographic Quadrangle Digital Raster Graphics. GIS data layers were used to stratify streams into distinct reaches based on landscape and land-use factors following techniques described in *Watershed Stratification Methodology for TMDL Sediment and Habitat Investigations* (MT DEQ 2008a) and *White Paper: A Watershed Stratification Approach for TMDL Sediment and Habitat Impairment Verification* (MT DEQ 2008b).

The Aerial Assessment reach stratification process was completed for the following sediment listed stream segments in the West Fork Gallatin River watershed: Middle Fork West Fork Gallatin River, South Fork West Fork Gallatin River, and West Fork Gallatin River. In addition to the sediment listed stream segments, several other streams in the West Fork Gallatin River watershed were assessed to provide supporting information, including: Muddy Creek, First Yellow Mule Creek, Second Yellow Mule Creek, Third Yellow Mule Creek, North Fork West Fork Gallatin River, Beehive Creek, "Stony" Creek (including the mainstem, "North Fork" and "South Fork"), and "Moose Tracks" Creek (including the mainstem, "North Fork" and "South Fork"). *Note that " " indicates stream names assigned to un-named streams for the purposes of this assessment.*

D2.1.1 Reach Types

The Aerial Assessment reach stratification process involved dividing each stream into distinct reaches based on four landscape factors: Ecoregion, valley gradient, Strahler stream order, and valley confinement. Each individual combination of the four landscape factors is referred to as a "**reach type**" in this report based on the following definition:

Reach Type - Unique combination of Ecoregion, gradient, Strahler stream order and confinement

Reach types were described using the following naming convention based on the reach type identifiers presented in **Table D-1**:

Level III Ecoregion – Valley Gradient – Strahler Stream Order – Confinement

Table D-1. Reach Type Identifiers.

Landscape Factor	Stratification Category	Reach Type Identifier
Level III Ecoregion	Middle Rockies	MR
Valley Gradient	0-<2%	0
	2-<4%	2
	4-<10%	4
	>10%	10
Strahler Stream Order	first order	1
	second order	2
	third order	3
	fourth order	4
Confinement	unconfined	U
	confined	C

Thus, a stream reach identified as MR-0-3-U is a low gradient (0-<2%), 3rd order, unconfined stream in the Middle Rockies Level III Ecoregion.

D2.2 Field Data Collection

Field data collection utilized the approach described the in *Longitudinal Field Methods for the Assessment of TMDL Sediment and Habitat Impairments* (MT DEQ 2008). Field assessment reaches were typically selected in relatively low-gradient portions of the study streams where sediment deposition is likely to occur. Other considerations in selecting field assessment reaches included representativeness of the reach to other reaches of the same slope, order, confinement and Ecoregion, as well of ease of access, as outlined in *Upper Gallatin River TMDL Planning Area Sediment Monitoring Sampling and Analysis Plan* (PBS&J 2008a). Within each field assessment reach, streambank erosion was evaluated at monitoring sites, which were typically 500, 1000, or 2000 feet long and varied based on bankfull width of the stream (MT DEQ 2008).

At each monitoring site, all streambanks were assessed for erosion severity and categorized as either "actively/visually eroding" or "slowly eroding/vegetated/undercut". At each eroding bank, **Bank Erosion Hazard Index (BEHI)** measurements were performed and the **Near Bank Stress (NBS)** was evaluated (Rosgen 1996, 2004). Bank erosion severity was rated from "very low" to "extreme" based on the BEHI score, which was determined based on the following six parameters: bank height, bankfull height, root depth, root density, bank angle, and surface protection. Near Bank Stress was also rated from "very low" to "extreme" depending on the shape of the channel at the toe of the bank and the force of the water (i.e. "stream power") along the bank. In addition, the source or underlying cause of streambank erosion was evaluated based on observed anthropogenic disturbances within the riparian corridor, as well as current or historic land-use practices within the surrounding landscape. The source of streambank instability was identified based on the following near-stream source categories: transportation, riparian grazing, cropland, mining, silviculture, irrigation, natural, and "other". Naturally eroding streambanks were considered the result of "natural sources" while the "other" category was chosen when

streambank erosion resulted from a source not described in the list. If multiple sources were observed, then a percent was noted for each source.

D2.3 Streambank Erosion Sediment Load Calculations

For each eroding streambank, the average annual sediment load was estimated based on the bank's length, mean height, and estimated annual retreat rate. The length and mean height were measured in the field, while the annual retreat rate was determined based on the relationship between the BEHI and NBS ratings. Annual retreat rates were estimated based on retreat rates from the Lamar River in Yellowstone National Park (Rosgen 1996) (**Table D-2**). The annual sediment load in cubic feet was then calculated from the field data (annual retreat rate x mean bank height x bank length), converted into cubic yards, and finally converted into tons per year based on the bulk density of streambank material. The bulk density of streambank material was assumed to average 1.3 tons/yard^3 as identified in *Watershed Assessment of River Stability and Sediment Supply* (WARSSS) (EPA 2006, Rosgen 2006). This process resulted in a sediment load for each eroding bank expressed in tons per year.

Table D-2. Annual Streambank Retreat Rates (Feet/Year), Lamar River, Yellowstone National Park (adapted from Rosgen 1996).

BEHI	Near Bank Stress					
	very low	low	moderate	high	very high	extreme
very Low	0.002	0.004	0.009	0.021	0.050	0.12
low	0.02	0.04	0.10	0.24	0.57	1.37
moderate	0.10	0.17	0.28	0.47	0.79	1.33
high - very high	0.37	0.53	0.76	1.09	1.57	2.26
extreme	0.98	1.21	1.49	1.83	2.25	2.76

D2.4 Streambank Erosion Sediment Load Extrapolation

Streambank erosion data collected at **monitoring sites** were extrapolated to the **stream reach** and **stream segment** scales based on similar reach type characteristics as identified in the Aerial Assessment Database. Sediment load calculations were performed for monitoring sites, stream reaches and stream segments, which are defined as follows:

Monitoring Site - *A 500, 1000, or 2000 foot section of a stream reach where field monitoring was conducted*

Stream Reach - *Subdivision of the stream segment based on Ecoregion, stream order, gradient and confinement as evaluated in GIS*

Stream Segment - *303(d) listed segment* (Note: several additional non-listed streams were included within this assessment)

D2.4.1 Sediment Load Extrapolation Criteria

The extrapolation of average annual stream reach sediment loads due to streambank erosion was based on the following criteria:

1. Monitoring site sediment loads were extrapolated directly to the stream reach in which the monitoring site was located.
2. For reaches not assessed in the field, the average sediment load for all monitoring sites within a given reach type was applied. This "reach type" sediment load is the foundation of the streambank erosion extrapolation process.
3. For reaches assessed in the field, the field identified sources replaced the sources identified during the aerial assessment.

Exceptions to these criteria were made in several instances based on a detailed review of color aerial imagery in GIS and extensive on-the ground experience within the West Fork Gallatin River watershed, including:

1. In select situations, the sediment load derived for a specific reach was extrapolated directly to another reach, often when the two reaches were adjacent or within close proximity.
2. For reaches in which no historic or current land-use practices were observed (i.e. assigned a source of "100% natural"), the average of the "slowly eroding" banks was often applied (see **Section D3.4.1.2**).
3. For many of the headwater reaches, the sediment load from the only assessed site with a valley gradient of >10% was applied (see **Section D3.4.1.2**).
4. When anthropogenic disturbances were evident at the stream reach scale but not directly observed at the monitoring site, the sources identified in the Aerial Assessment Database were retained.

D2.5 Streambank Erosion Sediment Load Reductions

The potential to decrease sediment loads from anthropogenically induced streambank erosion through the implementation of Best Management Practices (BMPs) was evaluated for each monitoring site and then extrapolated to the stream reach and stream segment scales.

D2.5.1 Sediment Load Reduction Criteria

The potential for annual streambank erosion sediment load reductions were evaluated using the following criteria:

1. Only reaches with an identified anthropogenic source of sediment were considered for load reduction.
2. For reaches with anthropogenic sources of streambank erosion, the potential to decrease sediment loads was assessed by reducing the BEHI rating for all streambanks with a BEHI score greater than "moderate" (i.e. "high", "very high" or "extreme") down to "moderate".

Bank erosion reductions are based on the Beaverhead-Deerlodge National Forest (BDNF) reference dataset, which includes data from streams throughout southwest Montana (Bengeyfield n.d.). The BDNF reference dataset indicates that a "moderate" BEHI score (20-29.5) can be expected on reference streams with the following stream types: A, C, (C3, C4) and E (E3, E4, E5, Ea) (**Table D-3**). Streams classified as B stream types are on the border of the "moderate" and "high" (30.0-39.5) BEHI categories, with B3 streams falling in "moderate" category and B4

streams falling in the "high" category. Based on the BDNF reference dataset, it was determined that functioning streams in the Upper Gallatin TPA would tend to have a "moderate" BEHI score. In addition, the sediment load reduction criteria is based on the assumption that the application of all reasonable land, soil and water conservation practices will result in the growth and preservation of sufficient streambank vegetation to minimize streambank erosion.

Table D-3. Expected BEHI Values for Various Stream Types based on the BDNF Reference Dataset.

A	B3	B4	B	C3	C4	C	E3	E4	E5	Ea	E
24.2	27.1	31.7	29.7	26.9	26.5	26.5	26.3	24.2	22	22.7	23.6

D3.0 RESULTS

This section provides estimated average annual sediment loads due to streambank erosion at the monitoring site, stream segment and watershed scales based on similar reach type characteristics as determined through the Aerial Assessment process. In addition, the potential to reduce streambank erosion was examined.

D3.1 Aerial Assessment Reach Stratification

During the Aerial Assessment, a total of 88.1 miles of stream were identified in the West Fork Gallatin River watershed and 60.7 miles of stream were included in the aerial assessment reach stratification process (PBS&J 2008b). The remaining 27.4 miles of stream not included in the aerial assessment are small 1st order headwater streams. A total of 157 reaches were delineated in GIS and reach specific data were compiled into an Aerial Assessment Database. A total of 14 reach types were identified in the West Fork Gallatin River watershed, 9 of which were assessed in the field. Possible reach type combinations based on the Level III Ecoregion identified in the West Fork Gallatin River watershed are presented in **Table D-4**, along with the number of reaches assessed in the field for each reach type. A complete discussion of this assessment can be found in *Aerial Assessment Reach Stratification Upper Gallatin TMDL Planning Area* (PBS&J 2008b).

Table D-4. Aerial Assessment Reach Stratification Spatial Representation.

Reach Type	Number of Reaches	Number of Reaches Assessed
MR-0-3-U	12	5
MR-0-4-U	4	1
MR-2-1-U	2	1
MR-2-2-U	6	5
MR-2-3-C	2	0
MR-2-3-U	10	7
MR-4-1-C	10	2
MR-4-1-U	39	5
MR-4-2-C	2	0
MR-4-2-U	18	4
MR-4-3-C	2	0
MR-10-1-C	12	0
MR-10-1-U	36	1
MR-10-2-U	2	0

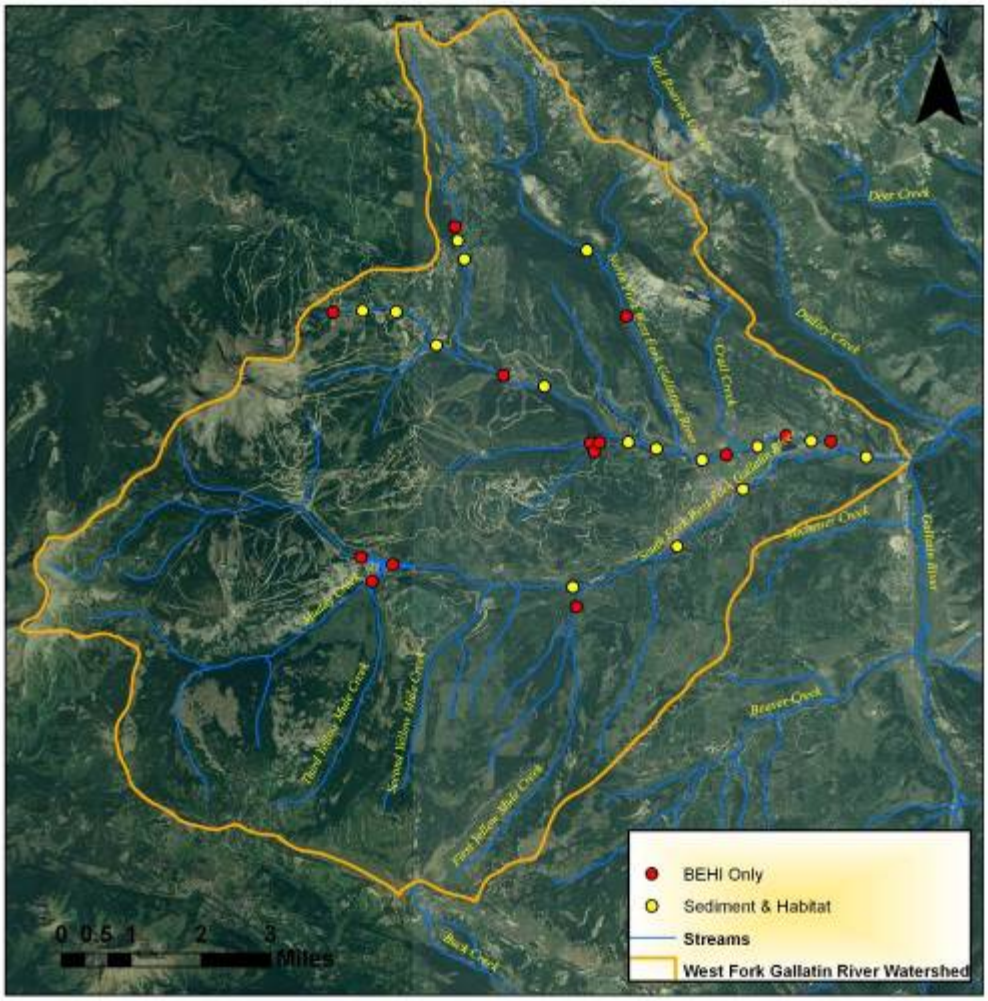
D3.2 Field Data Collection

A total of 30 sediment monitoring sites spatially distributed throughout the study tributaries in the West Fork Gallatin River watershed were assessed between July and October of 2008. Monitoring sites were identified through an assessment of aerial images and on-the-ground reconnaissance to capture the variability in land-use and watershed characteristics potentially contributing to sediment impairment issues in streams. At 16 of the monitoring sites, the

complete sediment and habitat assessment methodology was performed (MT DEQ 2008), while the remaining 14 monitoring sites were assessed only for streambank erosion. A total of 204 individual streambanks were assessed. The following streams were assessed in the West Fork Gallatin River watershed in 2008 (**Figure D3-1**) (specific reaches identified in parenthesis):

- Middle Fork West Fork Gallatin River (1-01, 2-01, 4-01, 7-02, 8-01, 9-01, 9-02)
- North Fork West Fork Gallatin River (10-01, 11-01)
- South Fork West Fork Gallatin River (17-02, 18-01, 22-01, 28-01, 29-02)
- West Fork Gallatin River (1-02, 1-03, 1-04, 1-05, 2-01, 2-02, 3-03)
- Beehive Creek (11-01, 12-01, 13-01)
- Muddy Creek (8-01, 8-02)
- First Yellow Mule Creek (16-01)
- Stony Creek (1-01)
- North Fork Stony Creek (7-01)
- South Fork Stony Creek (4-01)

Figure D3-1. West Fork Gallatin River Watershed Sediment Monitoring Sites.



D3.3 Streambank Erosion Sediment Load Calculations

Sediment loads for each eroding streambank assessed in the field were summed to provide a sediment load for each monitoring site.

D3.3.1 Monitoring Site Sediment Loads

An average annual sediment load of 397 tons/year was attributed to the 204 assessed eroding streambanks within the 30 monitoring sites (**Table D-5**). Approximately 30% of the streambank erosion sediment load at the monitoring sites was attributed to accelerated streambank erosion caused by historic or current human activities, while approximately 70% was attributed to natural erosional processes and sources. Monitoring site assessments indicate that transportation (8%), silviculture (10%), and "other" (12%) are the main types of anthropogenic activities in the West Fork Gallatin River watershed of the Upper Gallatin TPA. The "other" category primarily describes impacts due to resort area development, including downhill ski runs and golf courses, along with residential and commercial structures. Riparian grazing, cropland, mining and irrigation were not observed within the West Fork Gallatin River watershed.

Table D-5. Summary of Monitoring Site Sediment Loads.

Source	Sediment Load (Tons/Year)	Sediment Load (Percent)
Transportation	30	8
Riparian Grazing	0	0
Cropland	0	0
Mining	0	0
Silviculture	41	10
Irrigation	0	0
Natural Sources	278	70
Other	48	12
Total	**397**	**100**
Anthropogenic	**119**	**30**
Natural	**278**	**70**

Average annual sediment loads for each monitoring site were normalized to a length of 1,000 feet for the purpose of comparison and extrapolation. Sediment loads due to streambank erosion for each monitoring site are presented in **Table D-6** by stream segment, while sediment loads for each monitoring site are presented by source in **Table D-7**. Length of eroding bank, percent of eroding bank, and the estimated potential Rosgen stream type are also presented for each monitoring site in **Table D-6**.

Table D-6. Monitoring Site Estimated Average Annual Sediment Loads due to Streambank Erosion.

Stream Segment	ReachID	Reach Type	Estimated Potential Rosgen Stream Type	Length of Eroding Bank (feet)	Monitoring Site Length (feet)	Percent of Monitoring Site with Eroding Bank	Sediment Loading from Monitoring Site (Tons/Year)	Sediment Loading per 1000' of Stream (Tons/Year)
Middle Fork West Fork Gallatin River	MFWF01-01	MR-10-1-U	E4b	14	250	3	0.1	0.3
	MFWF02-01-1	MR-4-1-U	E4b	26	400	3	0.2	0.4
	MFWF02-01-2	MR-4-1-U	E4a	75	500	8	0.5	1.0
	MFWF04-01	MR-4-1-C	B4	41	600	3	0.8	1.3
	MFWF07-02	MR-4-2-U	B3/4	212	500	21	2.2	4.4
	MFWF08-01	MR-2-2-U	B3	97	1000	5	1.9	1.9
	MFWF09-01	MR-2-3-U	C3b	526	1000	26	26.2	26.2
	MFWF09-02	MR-2-3-U	C4	473	1000	24	24.5	24.5
North Fork West Fork Gallatin River	NFWF10-01	MR-2-2-U	C4b	191	1000	10	3.8	3.8
	NFWF12-01	MR-4-2-U	B3	310	500	31	1.0	2.1
Muddy Creek	MUDD08-01/02	MR-2-2-U	B4	1086	2050	26	30.9	15.1
South Fork West Fork Gallatin River	SFWF17-02	MR-2-2-U	B4	145	800	9	1.1	1.4
	SFWF18-01	MR-0-3-U	C4	222	900	12	5.8	6.4
	SFWF22-01	MR-0-3-U	C4	413	1000	21	24.5	24.5
	SFWF28-01	MR-2-3-U	B3	432	2000	11	12.0	6.0
	SFWF29-02	MR-0-3-U	C3	785	2000	20	57.3	28.6
West Fork Gallatin River	WFGR01-02	MR-2-3-U	C3b	436	1000	22	16.2	16.2
	WFGR01-03	MR-2-3-U	F3/4, B3/4	301	1000	15	7.0	7.0
	WFGR01-04	MR-2-3-U	C3	58	1000	3	2.9	2.9
	WFGR01-05	MR-2-3-U	C4	543	1000	27	29.2	29.2
	WFGR02-01	MR-0-3-U	C3	364	1000	18	25.1	25.1
	WFGR02-02	MR-0-3-U	B3/4	212	500	21	2.3	4.7
	WFGR03-03	MR-0-4-U	B3c	421	2000	11	2.7	1.3
Beehive Creek	BEEH11-01	MR-4-1-U	B4	275	500	28	4.4	8.8
	BEEH12-01	MR-2-1-U	E4	698	1000	35	84.5	84.5
	BEEH13-01	MR-4-1-U	B3a	404	1000	20	23.3	23.3
First Yellow Mule Creek	FYMC16-01	MR-4-2-U	B3/4	100	500	10	2.8	5.6
Stony Creek	STON01-01	MR-4-2-U	B3/4	108	500	11	2.1	4.1
North Fork Stony Creek	NFST07-01	MR-4-1-C	A3/4	88	500	9	0.9	1.9
South Fork Stony Creek	SFSC04-01	MR-4-1-U	A3/4	66	500	7	1.1	2.2

Table D-7. Monitoring Site Estimated Average Annual Sediment Loads from Individual Sources due to Streambank Erosion.

Stream Segment	ReachID	Monitoring Site Length (Feet)	Sediment Load	Transportation Load (Tons/Year)	Silviculture Load (Tons/Year)	Natural Load (Tons/Year)	"Other" Load (Tons/Year)	Sediment Loading from Monitoring Site (Tons/Year)
Middle Fork West Fork Gallatin River	MFWF01-01	250	**Total**	0.0	0.01	0.1	0.01	0.1
			Percent	0	10	80	10	
	MFWF02-01-1	400	**Total**	0.0	0.0	0.2	0.0	0.2
			Percent	0	0	100	0	
	MFWF02-01-2	500	**Total**	0.0	0.0	0.5	0.0	0.5
			Percent	0	0	100	0	
	MFWF04-01	600	**Total**	0.0	0.0	0.8	0.0	0.8
			Percent	0	0	100	0	
	MFWF07-02	500	**Total**	0.0	1.8	0.4	0.0	2.2
			Percent	0	83	17	0	
	MFWF08-01	1000	**Total**	0.0	1.2	0.7	0.0	1.9
			Percent	0	62	38	0	
	MFWF09-01	1000	**Total**	0.0	13.0	2.7	10.4	26.2
			Percent	0	50	10	40	
	MFWF09-02	1000	**Total**	0.0	0.0	24.5	0.0	24.5
			Percent	0	0	100	0	
North Fork West Fork Gallatin River	NFWF10-01	1000	**Total**	0.0	0.0	2.6	1.2	3.8
			Percent	0	0	68	32	
	NFWF12-01	500	**Total**	0.0	0.01	1.0	0.0	1.0
			Percent	0	1	99	0	
Muddy Creek	MUDD08-01/02	2050	**Total**	21.1	4.8	5.0	0.0	30.9
			Percent	68	15	16	0	
South Fork West Fork Gallatin River	SFWF17-02	800	**Total**	0.0	0.0	1.1	0.0	1.1
			Percent	0	0	100	0	
	SFWF18-01	900	**Total**	0.0	3.9	1.9	0.0	5.8
			Percent	0	67	33	0	
	SFWF22-01	1000	**Total**	0.0	13.3	11.2	0.0	24.5
			Percent	0	54	46	0	
	SFWF28-01	2000	**Total**	0.0	1.5	10.5	0.0	12.0
			Percent	0	13	87	0	
	SFWF29-02	2000	**Total**	0.0	0.0	57.3	0.0	57.3
			Percent	0	0	100	0	
West Fork Gallatin River	WFGR01-02	1000	**Total**	1.3	0.0	10.7	4.2	16.2
			Percent	8	0	66	26	
	WFGR01-03	1000	**Total**	0.6	0.0	2.7	3.7	7.0
			Percent	9	0	38	53	
	WFGR01-04	1000	**Total**	0.0	0.0	0.4	2.5	2.9
			Percent	0	0	14	86	
	WFGR01-05	1000	**Total**	5.9	0.0	2.2	21.1	29.2
			Percent	20	0	8	72	
	WFGR02-01	1000	**Total**	0.0	0.0	20.3	4.8	25.1
			Percent	0	0	81	19	
	WFGR02-02	500	**Total**	0.0	0.0	2.3	0.0	2.3
			Percent	0	0	100	0	
	WFGR03-03	2000	**Total**	0.3	0.0	2.4	0.0	2.7
			Percent	10	0	90	0	
Beehive Creek	BEEH11-01	500	**Total**	0.0	0.0	4.4	0.0	4.4
			Percent	0	0	100	0	
	BEEH12-01	1000	**Total**	0.0	0.0	84.5	0.0	84.5
			Percent	0	0	100	0	
	BEEH13-01	1000	**Total**	0.0	0.0	22.8	0.5	23.3
			Percent	0	0	98	2	
First Yellow Mule Creek	FYMC16-01	500	**Total**	0.0	0.8	2.0	0.0	2.8
			Percent	0	28	72	0	
Stony Creek	STON01-01	500	**Total**	0.4	0.4	1.3	0.0	2.1
			Percent	17	20	63	0	
North Fork Stony Creek	NFST07-01	500	**Total**	0.0	0.0	0.9	0.0	0.9
			Percent	0	0	100	0	
South Fork Stony Creek	SFSC04-01	500	**Total**	0.0	0.0	1.1	0.0	1.1
			Percent	0	0	100	0	

D3.4 Streambank Erosion Sediment Load Extrapolation

Sediment loads derived from the monitoring sites were extrapolated to the stream reach, stream segment and watershed scales based on the Aerial Assessment reach type analysis. The annual sediment load of all assessed monitoring sites of the same reach type was averaged to derive a reach type sediment load. The reach type sediment load was then extrapolated to all un-assessed reaches within the same reach type. This resulted in a sediment load for the entire stream segment, which, when combined with sediment loads from tributary streams, was used to derive a sediment load for each streams watershed.

D3.4.1 Reach Type Sediment Loads

Monitoring site sediment loads were averaged within a specific reach type to derive a reach type sediment load. The following sections present individual discussions for each reach type. Discussions are broken up between reach types with valley slopes <4%, which are generally the focus of this assessment methodology, and reach types with valley slopes >4%, which comprise the majority of the West Fork Gallatin River watershed. A summary of reach type sediment loads is presented in **Table D-8**.

Table D-8. Reach Type Sediment Loads.

Reach Type	Description	Average Streambank Erosion Sediment Load per 1000 Feet (Tons/Year)
MR-10-1-U	very steep 1st order streams	0.3
MR-4-1-C	steep 1st order streams, confined	1.6
MR-4-1-U	steep 1st order streams, unconfined	3.1
MR-4-2-U	steep 2nd order streams	4.1
MR-2-2-U	moderate gradient 2nd order streams	5.6
MR-2-3-U	moderate gradient 3rd order streams	16.0
MR-0-3-U	low gradient 3rd order streams	17.9
MR-0-4-U	low gradient 4th order streams	1.3

D3.4.1.1 Valley Gradient <4%

MR-0-3-U - Low gradient and unconfined 3rd order streams

A total of five reaches were assessed in this reach type out of a total of twelve reaches delineated in the Aerial Assessment. Three monitoring sites were on the South Fork West Fork Gallatin River (SFWF18-1, 22-1 and 29-2) and two monitoring sites were on the West Fork Gallatin River (WFGR02-01 and 02-02). Annual sediment loads ranged from 4.7 to 28.6 tons/1000 feet and averaged 17.9 tons/1000 feet. Out of the seven un-assessed reaches, six were on the South Fork West Fork Gallatin River and one was on the West Fork Gallatin River. The reach type average sediment load was applied to all un-assessed reaches on the South Fork West Fork Gallatin River within this reach type. For the West Fork Gallatin River, an annual sediment load of 4.7 tons/1000 feet measured in WFGR02-02 was applied directly to WFGR02-03 based on the similarity of their conditions as observed in the field.

MR-0-4-U - Low gradient and unconfined 4th order streams
The lowermost portion of the West Fork Gallatin River downstream of the confluence with the South Fork West Fork Gallatin River is the only stream that falls within this reach type category and included four reaches in the aerial assessment, one of which (WFGR03-03) was assessed in the field. Within this reach, an annual sediment load of 1.3 tons/1000 feet was identified. The low sediment load at the assessed monitoring site is primarily due to the large cobble substrate that dominates this portion of river and naturally armors the streambed and streambanks. This load was extrapolated directly to the other three reaches within this reach type.

MR-2-1-U – Moderate gradient and unconfined 1st order streams
There were only two reaches within this reach type and one was assessed in the field. At the BEEH12-01 monitoring site on Beehive Creek, extensive bank erosion was occurring in what appeared to have once been a beaver dominated meadow or former mountain lake. A perched culvert downstream of this reach appears to be at least partially responsible for the accelerated bank erosion. An annual sediment load of 84.5 tons/year was identified from this reach. This sediment load was not applied to the other reach (SFWF15-01) within this type. Instead, the sediment load for SFWF15-01 was based on the assessed value at SFWF17-02 (1.4 tons/1000 feet), which has similar reach type characteristics.

MR-2-2-U – Moderate gradient and unconfined 2nd order streams
A total of six reaches were identified within this reach type during the Aerial Assessment and five reaches were assessed in the field. However, only four reach specific sediment loads were derived for this reach type since reaches MUDD08-01 and MUDD08-02 were assessed in the field as one continuous monitoring site. Field monitoring sites were located on Muddy Creek, Middle Fork West Fork Gallatin River, North Fork West Fork Gallatin River and South Fork West Fork Gallatin River. Sediment loads ranged from 1.4 to 15.1 tons/1000 feet, with an average annual streambank sediment load of 5.6 tons/1000 feet. The mean sediment load was not extrapolated to the only un-assessed reach (SFWF17-01) within this reach type. Instead, the measured sediment load at SFWF17-02 (1.4 tons/1000 feet) was applied directly to SFWF17-01 based on the similarity in their conditions.

MR-2-3-C – Moderate gradient and confined 3rd order streams
There were only two reaches within this reach type and neither was assessed on the ground. Both reaches were located on the South Fork West Fork Gallatin River (SFWF20-01 and 27-01). The reach average annual streambank sediment load (16.0 tons/1000 feet) for the MR-2-3-U reach type was applied to these two reaches, with the only difference being the amount of confinement.

MR-2-3-U – Moderate gradient and unconfined 3rd order streams
A total of nine reaches were identified during the initial Aerial Assessment, but MFWF09 was split into two sub-reaches following site reconnaissance, so there are a total of ten reaches within this reach type. Stream reaches assessed in the field include sites on the Middle Fork West Fork Gallatin River, South Fork West Gallatin River and West Fork Gallatin River. A total of 7 reaches were assessed at field monitoring sites and the annual sediment load ranged from 2.9 to 26.2 tons/1000 feet, with a reach type average of 16.0 tons/1000 feet. The reach type annual average streambank sediment load was extrapolated directly to un-assessed reaches SFWF25-01

and WFGR01-01. For un-assessed reach SFWF28-02, the sediment load for SFWF28-01 (6.0 tons/year) was extrapolated directly based on the similarity in their conditions.

D3.4.1.2 Valley Gradient >4%

In the West Fork Gallatin River watershed, the vast majority of stream length is comprised of smaller and steeper streams. A total of 121 out of the 157 reaches included in the Aerial Assessment had a stream gradient of >4%, with seven distinct reach types. Out of these seven reach types, four reach types were assessed at twelve monitoring sites in the field. Sediment loads from streambank erosion within these reach types were relatively low. Since these reach types comprise the majority of the watershed and many of the reaches were not observed on the ground, streambank erosion rates were extrapolated to un-assessed reaches based on several factors, including:

1. Average reach type sediment load
2. On-the-ground knowledge
3. Observations from the 2005 color aerial imagery
4. Annual average streambank sediment loading on the same stream or in a similar landscape setting

In addition, the annual average streambank sediment load from "slowly eroding/vegetated/undercut" streambanks was evaluated for the entire dataset to estimate a background rate of erosion for streams in the West Fork Gallatin River watershed. In general, it is expected that the "slowly eroding" streambanks observed along a monitoring site are due to natural sources and are likely found along all streams, including ones in which no anthropogenic disturbance has occurred. The annual average sediment load from "slowly eroding" streambanks was reviewed for all monitoring sites and resulted in a sediment load of 1.1 tons/1000 feet of stream (5.6 tons/mile of stream). This was applied to several of the reaches with slopes >4% when other loads appeared to be either too high or too low.

MR-4-1-C – High gradient and confined 1st order streams

A total of ten reaches were delineated in the Aerial Assessment and two were assessed in the field. At MFWF04-01 on the Middle Fork West Fork Gallatin River, an average annual sediment load of 1.3 tons/1000 feet was estimated, while at NFST07-01 on "Stony" Creek, an average annual sediment load of 1.9 tons/1000 feet was estimated, for a reach type average of 1.6 tons/1000 feet. This value was applied to all un-assessed reaches within this reach type and included the following streams: "North Fork Stony" Creek and South Fork West Fork Gallatin River, along with First, Second and Third Yellow Mule creeks.

MR-4-1-U – High gradient and unconfined 1st order streams

Thirty-nine reaches were delineated in the Aerial Assessment and five were assessed in the field within this reach type, including monitoring sites on Middle Fork West Fork Gallatin River, Beehive Creek and "South Fork Stony" Creek. On the Middle Fork West Fork Gallatin River, two monitoring sites were assessed within reach MFWF02-01. For MFWF02-1, these two values were averaged to derive a reach load of 0.7 tons/1000 feet. At the five monitoring sites within this reach type, annual streambank sediment loads ranged from 0.4 to 23.3 tons/1000 feet. However, a sediment load of 23.3 tons/1000 feet, which was recorded at BEEH13-01 was

thought to be an outlier for this reach type and was removed from the dataset. Large eroding hillslopes along this reach on Beehive Creek are infrequent within the watershed. Thus, the data from four monitoring was used to develop a reach type average annual streambank sediment load of 3.1 tons/1000 feet, with a range of 0.4 to 8.8 tons/1000 feet. The reach type average was extrapolated to many of the un-assessed reaches, particularly to reaches lower in a particular stream's watershed. The "slowly eroding" streambank annual sediment load of 1.1 tons/1000 feet was applied to seven sites, generally in the upper watershed of a particular stream segment, while an annual sediment load of 0.3 tons/1000 feet, which was measured in a 1st order stream with a slope >10%, was applied to several of the most headwater reaches, particularly when a review of aerial imagery indicated a sub-alpine landscape and/or surrounding reaches had slopes >10%.

MR-4-2-C – High gradient and confined 2nd order streams
There were only two reaches within this reach type and no assessments were performed. The average sediment load for the MR-4-2-U reach type (4.1 tons/year) was extrapolated to MUDD06-01 and NFWF07-01.

MR-4-2-U – High gradient and unconfined 2nd order streams
Eighteen reaches were delineated in the Aerial Assessment for this reach type and four were assessed in the field, including monitoring sites on Middle Fork West Fork Gallatin River, North Fork West Fork Gallatin River, First Yellow Mule Creek and "Stony" Creek. Annual sediment loads ranged from 2.1 to 5.6 tons/1000 feet, with an average annual streambank sediment load of 4.1 tons/1000 feet, which is similar to their 1st order counterparts (3.1 tons/1000 feet). Un-assessed reaches were all applied this sediment load, except for MUDD07-01, which was applied the same sediment load as measured in MUDD08-01/02. In addition, five reaches on the North Fork West Fork Gallatin River were assigned the load measured at NFWF12-01, while MOOS01-01 was assigned a load of 0 tons/1000 feet since it appears to be in a culvert under Huntley Lodge.

MR-4-3-C – High gradient and confined 3rd order streams
There were two reaches within this reach type, neither of which was assessed in the field. An average annual streambank sediment load of 6.1 tons/1000 feet was applied to SFWF19-01 based on the estimated value at the SFWF18-01 monitoring site. An annual sediment load of 17.9 tons/1000 feet was applied to SFWF24-01 based on the reach type average for MR-0-3-U.

MR-10-1-C – Very high gradient and confined 1st order streams
There are twelve reaches within this reach type, none of which were assessed in the field. All but two reaches were assigned a value of 0.3 tons/1000 feet based on a measurement in MFWF01-01, which was unconfined. Reaches SFWF10-01 and TYMC08-01 were assigned a value of 3.1 tons/1000 feet based on the reach type average for MR-4-1-U.

MR-10-1-U – Very high gradient and unconfined 1st order streams
There are thirty six reaches within this reach type, one of which was assessed in the field with an annual streambank sediment load of 0.3 tons/1000 feet at MFWF01-01. This value was extrapolated to all reaches, except SFWF11-01, MUDD04-01, and BEEH10-01, 14-01, and 16-01, which were assigned the "slowly eroding" streambank sediment load (1.1 tons/1000 feet).

MR-10-2-U – Very high gradient and confined 2nd order streams
Two reaches were delineated within this reach type, neither of which was assessed in the field. The annual streambank sediment load for FYMC15-01 was based on the estimated results for FYMC16-01. The annual streambank sediment load for MFWF06-01 was based on the estimated results for MFWF07-02.

D3.4.2 Stream Segment Sediment Loads

Stream segment streambank sediment loads were estimated based on the cumulative sediment load of the stream reaches within each stream segment (**Attachment A**). These sediment loads were estimated for a total of 60.7 miles. An average annual sediment load of 1,778 tons/year was attributed to eroding streambanks at the stream segment scale (**Table D-9**). Approximately 33% of the sediment load due to streambank erosion at the stream segment scale was attributed to anthropogenic sources, while approximately 67% was attributed to natural sources. This assessment indicates that transportation (9%), silviculture (13%) and "other" (11%) are the greatest anthropogenic contributors of sediment loads due to streambank erosion in the Upper Gallatin TPA. The "other" category primarily describes impacts due to resort area development, including downhill ski runs and golf courses, along with residential and commercial structures. Sediment loads due to streambank erosion for each stream segment are provided for each source in **Table D-10**.

Table D-9. Summary of Stream Segment Sediment Loads.

Source	Sediment Load (Tons/Year)	Sediment Load (Percent)
Transportation	161	9
Silviculture	224	13
Natural Sources	1,190	67
Other	203	11
Total	**1,778**	**100**
Anthropogenic	**588**	**33**
Natural	**1,190**	**67**

Table D-10. Stream Segment Sediment Loads from Individual Sources due to Streambank Erosion.

Stream Segment	Stream Length (Miles)	Sediment Load	Transportation Load (Tons/Year)	Silviculture Load (Tons/Year)	Natural Load (Tons/Year)	"Other" Load (Tons/Year)	Total Load (Tons/Year)	Total Load per Mile (Tons/Year)	Total Load per 1000 Feet (Tons/Year)
Beehive Creek	4.78	**Tons/Year**	31.9	0.0	232.5	2.1	**266.5**	**55.8**	**10.6**
		Percent	12%	0%	87%	1%			
First Yellow Mule Creek	4.95	**Tons/Year**	2.2	4.2	49.1	0.0	**55.5**	**11.2**	**2.1**
		Percent	4%	8%	88%	0%			
Middle Fork West Fork Gallatin River	5.82	**Tons/Year**	3.8	58.4	92.5	34.9	**189.5**	**32.6**	**6.2**
		Percent	2%	31%	49%	18%			
Moose Tracks Creek	0.41	**Tons/Year**	2.3	0.0	0.6	2.9	**5.7**	**14.0**	**2.7**
		Percent	40%	0%	10%	50%			
Muddy Creek	5.22	**Tons/Year**	25.0	24.2	69.2	2.3	**120.7**	**23.1**	**4.4**
		Percent	21%	20%	57%	2%			
North Fork Moose Tracks Creek	1.62	**Tons/Year**	0.4	0.0	1.3	1.2	**2.8**	**1.7**	**0.3**
		Percent	14%	0%	45%	41%			
North Fork Stony Creek	2.38	**Tons/Year**	0.3	0.0	7.8	0.7	**8.8**	**3.7**	**0.7**
		Percent	3%	0%	89%	8%			
North Fork West Fork Gallatin River	7.37	**Tons/Year**	0.5	0.3	62.9	3.2	**66.9**	**9.1**	**1.7**
		Percent	1%	0%	94%	5%			
South Fork Moose Tracks Creek	1.14	**Tons/Year**	1.0	0.0	3.5	0.0	**4.5**	**3.9**	**0.7**
		Percent	22%	0%	78%	0%			
South Fork Stony Creek	1.70	**Tons/Year**	1.9	0.0	5.4	0.0	**7.3**	**4.3**	**0.8**
		Percent	26%	0%	74%	0%			
South Fork West Fork Gallatin River	13.78	**Tons/Year**	62.3	126.1	545.0	64.5	**798.0**	**57.9**	**11.0**
		Percent	8%	16%	68%	8%			
Stony Creek	0.20	**Tons/Year**	0.7	0.9	2.7	0.0	**4.3**	**21.7**	**4.1**
		Percent	17%	20%	63%	0%			
Second Yellow Mule Creek	3.82	**Tons/Year**	4.3	4.5	9.2	0.1	**18.1**	**4.7**	**0.9**
		Percent	24%	25%	51%	1%			
Third Yellow Mule Creek	3.88	**Tons/Year**	0.5	5.8	20.8	0.0	**27.1**	**7.0**	**1.3**
		Percent	2%	22%	77%	0%			
West Fork Gallatin River	3.61	**Tons/Year**	24.1	0.0	87.5	90.9	**202.5**	**56.1**	**10.6**
		Percent	12%	0%	43%	45%			

D3.4.3 Watershed Sediment Loads

Watershed average annual streambank sediment loads were estimated for the Upper Gallatin TPA based on the total length of stream within the watershed. These watershed sediment loads were estimated from the sum of the average annual streambank sediment loads at the stream segment scale combined with an estimate of streambank sediment loads from un-assessed streams. Assessed streams include 60.7 miles of stream segments described in the Aerial Assessment Database, while un-assessed streams include 27.4 miles of 1st order headwater tributaries. For the purposes of estimating an annual average watershed streambank sediment load, streambank erosion sediment inputs from un-assessed streams was assumed to be 0.3 tons/year for 1000 feet of stream (1.6 tons/year for a mile of stream) based on estimates from the headwater monitoring site in the West Fork Gallatin River watershed (MFWF01-01). Un-assessed streams were reviewed in GIS and assigned sources. This assessment results in an estimated average annual sediment load due to streambank erosion in the West Fork Gallatin River watershed of 1,821 tons/year (**Table D-11**). Note that actual stream length in the West Fork Gallatin River watershed likely exceeds the 88.1 miles measured from the 1:100,000 NHD stream layer.

Table D-11. Summary of Sediment Loads due to Streambank Erosion at the Watershed Scale.

Stream Length (Miles)	Length of Stream included in Aerial Assessment Database (Miles)	Length of Stream Un-assessed (Miles)	Estimated Sediment Load for Streams included in Aerial Assessment Database (Tons/Year)	Sediment Load applied to Un-assessed 1st Order Streams (1.6 Tons/Mile/Year)	Total Existing Sediment Load (Tons/Year)
88.1	60.7	27.4	1,778	43	1,821

Sediment loads due to streambank erosion for each stream segment are provided for each source in **Table D-12**.

Table D-12. Watershed Sediment Loads from Individual Sources due to Streambank Erosion.

Watershed	Stream Segment	Stream Length (Miles)	Sediment Load	Transportation Load (Tons/Year)	Silviculture Load (Tons/Year)	Natural Load (Tons/Year)	"Other" Load (Tons/Year)	Total Load (Tons/Year)
Middle Fork West Fork Gallatin River	Middle Fork West Fork Gallatin River	5.82	**Tons/Year**	3.8	58.4	92.5	34.9	**189.5**
			Percent	2%	31%	49%	18%	
	Moose Tracks Creek	0.41	**Tons/Year**	2.3	0.0	0.6	2.9	**5.7**
			Percent	40%	0%	10%	50%	
	North Fork Moose Tracks Creek	1.62	**Tons/Year**	0.4	0.0	1.3	1.2	**2.8**
			Percent	14%	0%	45%	41%	
	South Fork Moose Tracks Creek	1.14	**Tons/Year**	1.0	0.0	3.5	0.0	**4.5**
			Percent	22%	0%	78%	0%	
	Beehive Creek	4.78	**Tons/Year**	31.9	0.0	232.5	2.1	**266.5**
			Percent	12%	0%	87%	1%	
	Stony Creek	0.20	**Tons/Year**	0.7	0.9	2.7	0.0	**4.3**
			Percent	17%	20%	63%	0%	
	North Fork Stony Creek	2.38	**Tons/Year**	0.3	0.0	7.8	0.7	**8.8**
			Percent	3%	0%	89%	8%	
	South Fork Stony Creek	1.70	**Tons/Year**	1.9	0.0	5.4	0.0	**7.3**
			Percent	26%	0%	74%	0%	
	MF1	2.81	**Tons/Year**	0.9	0.9	2.7	0.0	**4.4**
			Percent	20%	20%	60%	0%	
North Fork West Fork Gallatin River	North Fork West Fork Gallatin River	7.37	**Tons/Year**	0.5	0.3	62.9	3.2	**66.9**
			Percent	1%	0%	94%	5%	
	NF1	1.27	**Tons/Year**	0.0	0.0	2.0	0.0	**2.0**
			Percent	0%	0%	100%	0%	
	NF2	1.66	**Tons/Year**	0.0	0.0	2.6	0.0	**2.6**
			Percent	0%	0%	100%	0%	
South Fork West Fork Gallatin River	South Fork West Fork Gallatin River	13.78	**Tons/Year**	62.3	126.1	545.0	64.5	**798.0**
			Percent	8%	16%	68%	8%	
	SF1	1.56	**Tons/Year**	0.0	0.0	2.5	0.0	**2.5**
			Percent	0%	0%	100%	0%	
	SF2	1.70	**Tons/Year**	0.3	0.0	2.4	0.0	**2.7**
			Percent	10%	0%	90%	0%	
	SF3	1.37	**Tons/Year**	0.4	0.0	1.3	0.4	**2.2**
			Percent	20%	0%	60%	20%	
	SF4	1.87	**Tons/Year**	0.3	2.1	0.6	0.0	**3.0**
			Percent	10%	70%	20%	0%	
	SF5	3.19	**Tons/Year**	0.5	3.5	1.0	0.0	**5.0**
			Percent	10%	70%	20%	0%	
	Muddy Creek	5.22	**Tons/Year**	25.0	24.2	69.2	2.3	**120.7**
			Percent	21%	20%	57%	2%	
	M1	2.31	**Tons/Year**	0.0	0.0	3.6	0.0	**3.6**
			Percent	0%	0%	100%	0%	
	M2	1.36	**Tons/Year**	0.0	0.0	2.1	0.0	**2.1**
			Percent	0%	0%	100%	0%	
	First Yellow Mule Creek	4.95	**Tons/Year**	2.2	4.2	49.1	0.0	**55.5**
			Percent	4%	8%	88%	0%	
	1YM1	2.46	**Tons/Year**	0.4	1.6	1.9	0.0	**3.9**
			Percent	10%	40%	50%	0%	
	1YM2	1.61	**Tons/Year**	0.3	1.0	1.3	0.0	**2.5**
			Percent	10%	40%	50%	0%	
	Second Yellow Mule Creek	3.82	**Tons/Year**	4.3	4.5	9.2	0.1	**18.1**
			Percent	24%	25%	51%	1%	
	2YM1	1.28	**Tons/Year**	0.2	1.4	0.4	0.0	**2.0**
			Percent	10%	70%	20%	0%	
	Third Yellow Mule Creek	3.88	**Tons/Year**	0.5	5.8	20.8	0.0	**27.1**
			Percent	2%	22%	77%	0%	
West Fork Gallatin River*	West Fork Gallatin River	3.61	**Tons/Year**	24.1	0.0	87.5	90.9	**202.5**
			Percent	12%	0%	43%	45%	
	Crail Creek	2.92	**Tons/Year**	0.5	0.0	3.2	0.9	**4.6**
			Percent	10%	0%	70%	20%	

*Remaining portion of watershed excluding South Fork West Fork, Middle Fork West Fork and North Fork West Fork.

D3.5 Streambank Erosion Sediment Load Reductions

The potential for streambank erosion sediment load reductions was evaluated in order to provide technical guidance in determining sediment allocations for human activities that cause accelerated streambank erosion. Determining a potential overall load reduction from streambank erosion will also help define how much sediment production from streambank erosion is likely derived from natural conditions. The results are only one of a number of components that will be considered during the TMDL sediment allocation process. The allocation process will also consider economic feasibility of restoration from each significant source and regional BMP effectiveness studies.

To estimate a potential decrease in sediment loading due to improved streambank stability, BEHI values in the existing dataset for each streambank within a monitoring site with an identified anthropogenic source that exceeded the "moderate" category were reduced to "moderate". The results of this model are presented in **Table D-13** for the individual monitoring sites and in **Table D-14** for each reach type. No potential reduction was identified for the reach types of 1st order streams, which is likely due to the small size of these streams and the generally large substrate. For 2nd order streams, moderate gradient reach types tended to have a greater potential for reduction than steeper reach types. For 3rd order streams, moderate gradient reach types tended to have a greater potential for streambank sediment load reductions than low gradient reach types. This appears to be due to the different levels of anthropogenic disturbance between the lesser developed South Fork West Fork Gallatin River, on which three out of the five monitoring sites in the MR-0-3-U reach type were located, and the West Fork Gallatin River, around which extensive development has occurred and along which four out of the seven monitoring sites in the MR-2-3-U reach type were located. The only 4th order stream assessed in the West Fork Gallatin River watershed was the West Fork Gallatin River downstream of the confluence with the South Fork West Fork Gallatin River. This section of stream had zero potential for streambank erosion load reductions since the banks are naturally armored with large cobbles.

Reductions calculated at the monitoring site scale were extrapolated to the stream segment scale and the watershed scale using the Aerial Assessment Database (**Attachment A**). This assessment indicates that anthropogenically induced streambank sediment loads at the stream segment scale could be reduced by 40% along the Middle Fork West Fork Gallatin River, 20% along the South Fork West Fork Gallatin River and 47% along the West Fork Gallatin River through the application of BMPs. Through BMPs, the actual length and height of eroding bank could also be reduced, which would lead to further reductions in sediment loading.

Table D-13. Monitoring Site Sediment Loads with BEHI Reduced to "Moderate".

Reach Type	Reach ID	Field Assessed Sediment Load per 1000 Feet (Tons/Year)	Number of Banks with "High" BEHI Rating	Anthropogenic Sources Identified Along Reach	Sediment Load per 1000 Feet with "High" BEHI Ratings Reduced to "Moderate" (Tons/Year)*
MR-0-3-U	SFWF 18-01	6.4	1	yes	2.6
MR-0-3-U	SFWF 22-01	24.5	1	yes	22.0
MR-0-3-U	SFWF 29-02	28.6	5	no	28.6
MR-0-3-U	WFGR 02-01	25.1	3	yes	12.1
MR-0-3-U	WFGR 02-02	4.7	0	no	4.7
MR-0-4-U	WFGR 03-03	1.3	0	yes	1.3
MR-2-1-U	BEEH 12-01	84.5	13	yes	29.4
MR-2-2-U	MFWF 08-01	1.9	0	yes	1.9
MR-2-2-U	MUDD 08-01/02	15.1	2	yes	9.0
MR-2-2-U	NFWF 10-01	3.8	0	yes	3.8
MR-2-2-U	SFWF 17-02	1.4	0	no	1.4
MR-2-3-U	MFWF 09-01	26.2	2	yes	12.1
MR-2-3-U	MFWF 09-02	24.5	1	no	24.5
MR-2-3-U	SFWF 28-01	6.0	1	yes	3.4
MR-2-3-U	WFGR 01-02	16.2	2	yes	6.3
MR-2-3-U	WFGR 01-03	7.0	1	yes	5.8
MR-2-3-U	WFGR 01-04	2.9	2	yes	1.1
MR-2-3-U	WFGR 01-05	29.2	2	yes	13.0
MR-4-1-C	MFWF 04-01	1.3	0	no	1.3
MR-4-1-C	NFST 07-01	1.9	0	no	1.9
MR-4-1-U	BEEH 11-01	8.8	4	no	8.8
MR-4-1-U	BEEH 13-01	23.3	4	yes	9.1
MR-4-1-U	MFWF 02-01	0.4	0	yes	0.4
MR-4-1-U	MFWF 02-01	1.0	0	yes	1.0
MR-4-1-U	SFSC 04-01	2.2	0	yes	2.2
MR-4-2-U	FYMC 16-01	5.6	2	yes	3.8
MR-4-2-U	MFWF 07-02	4.4	0	yes	4.4
MR-4-2-U	NFWF 12-01	2.1	0	yes	2.1
MR-4-2-U	STON 01-01	4.1	1	yes	2.9
MR-10-1-U	MFWF 01-01	0.3	0	yes	0.3

*If no "high" BEHI banks, then no reduction.

*If no anthopogenic sources within assessed reach, then no reduction.

Table D-14. Reach Type Sediment Load Reductions.

Reach Type	Description	Average Streambank Erosion Sediment Load per 1000 Feet (Tons/Year)	BEHI Reduced to Moderate (Tons/Year)	Potential Reduction (Tons/Year)	Percent Reduction	Sample Size
MR-10-1-U	very steep 1st order streams	0.3	0.3	0.0	0.0	1
MR-4-1-C	steep 1st order streams, confined	1.6	1.6	0.0	0.0	2
MR-4-1-U	steep 1st order streams, unconfined	3.1	3.1	0.0	0.0	5
MR-4-2-U	steep 2nd order streams	4.1	3.3	0.8	19.5	4
MR-2-2-U	moderate gradient 2nd order streams	5.6	4.0	1.6	28.6	4
MR-2-3-U	moderate gradient 3rd order streams	16.0	9.5	6.5	40.6	7
MR-0-3-U	low gradient 3rd order streams	17.9	14.0	3.9	21.8	5
MR-0-4-U	low gradient 4th order streams	1.3	1.3	0.0	0.0	1

Table D-15. Potential Reduction in Anthropogenic Sediment Load from Stream Segments with BEHI Reduced to "Moderate".

Stream Segment	Existing Sediment Load (Tons/Year)	Existing Load due to Anthropogenic Sources (Tons/Year)	Reduced Load with "Moderate" BEHI for Anthropogenically Induced Streambank Erosion (Tons/Year)	Reduced Load due to Anthropogenic Sources (Tons/Year)	Potential Reduction in Anthropogenic Sediment Load (Existing-Reduced) (Tons/Year)	Percent Reduction in Anthropogenic Sediment Load (Existing/Potential Reduction)
Beehive Creek	266.5	34.0	247.4	14.9	19.1	56%
First Yellow Mule Creek	55.5	6.4	54.2	5.1	1.3	20%
Middle Fork West Fork Gallatin River	189.5	97.0	150.8	58.3	38.7	40%
Moose Tracks Creek	5.7	5.2	4.6	4.2	1.0	19%
Muddy Creek	120.7	51.5	101.9	32.7	18.8	37%
North Fork Moose Tracks Creek	2.8	1.5	2.8	1.5	0.0	0%
North Fork Stony Creek	8.8	1.0	8.8	1.0	0.0	0%
North Fork West Fork Gallatin River	66.9	4.0	66.9	4.0	0.0	0%
South Fork Moose Tracks Creek	4.5	1.0	4.5	1.0	0.0	0%
South Fork Stony Creek	7.3	1.9	7.3	1.9	0.0	0%
South Fork West Fork Gallatin River	798.0	252.9	746.5	201.5	51.4	20%
Stony Creek	4.3	1.6	3.8	1.1	0.5	31%
Second Yellow Mule Creek	18.1	8.9	18.1	8.9	0.0	0%
Third Yellow Mule Creek	27.1	6.3	27.1	6.3	0.0	0%
West Fork Gallatin River	202.5	115.0	147.9	60.4	54.6	47%

Table D-16. Watershed Sediment Load Reductions from Individual Sources.

Watershed	Stream Segment	Stream Length (Miles)	Sediment Load	Transportation Load (Tons/Year)	Silviculture Load (Tons/Year)	Natural Load (Tons/Year)	"Other" Load (Tons/Year)	Total Load (Tons/Year)
Middle Fork West Fork Gallatin River	Middle Fork West Fork Gallatin River	5.82	**Tons/Year**	3.6	36.9	92.5	17.8	**150.8**
			Percent	2%	24%	61%	12%	
	Moose Tracks Creek	0.41	**Tons/Year**	1.8	0.0	0.6	2.3	**4.6**
			Percent	40%	0%	13%	50%	
	North Fork Moose Tracks Creek	1.62	**Tons/Year**	0.4	0.0	1.3	1.2	**2.8**
			Percent	14%	0%	45%	41%	
	South Fork Moose Tracks Creek	1.14	**Tons/Year**	1.0	0.0	3.5	0.0	**4.5**
			Percent	22%	0%	78%	0%	
	Beehive Creek	4.78	**Tons/Year**	14.0	0.0	232.5	0.9	**247.4**
			Percent	6%	0%	94%	0%	
	Stony Creek	0.20	**Tons/Year**	0.5	0.6	2.7	0.0	**3.8**
			Percent	14%	16%	70%	0%	
	North Fork Stony Creek	2.38	**Tons/Year**	0.3	0.0	7.8	0.7	**8.8**
			Percent	3%	0%	89%	8%	
	South Fork Stony Creek	1.70	**Tons/Year**	1.9	0.0	5.4	0.0	**7.3**
			Percent	26%	0%	74%	0%	
	MF1	2.81	**Tons/Year**	0.9	0.9	2.7	0.0	**4.4**
			Percent	20%	20%	60%	0%	
North Fork West Fork Gallatin River	North Fork West Fork Gallatin River	7.37	**Tons/Year**	0.5	0.3	62.9	3.2	**66.9**
			Percent	1%	0%	94%	5%	
	NF1	1.27	**Tons/Year**	0.0	0.0	2.0	0.0	**2.0**
			Percent	0%	0%	100%	0%	
	NF2	1.66	**Tons/Year**	0.0	0.0	2.6	0.0	**2.6**
			Percent	0%	0%	100%	0%	
South Fork West Fork Gallatin River	South Fork West Fork Gallatin River	13.78	**Tons/Year**	48.1	104.9	545.0	48.5	**746.5**
			Percent	6%	14%	73%	6%	
	SF1	1.56	**Tons/Year**	0.0	0.0	2.5	0.0	**2.5**
			Percent	0%	0%	100%	0%	
	SF2	1.70	**Tons/Year**	0.3	0.0	2.4	0.0	**2.7**
			Percent	10%	0%	90%	0%	
	SF3	1.37	**Tons/Year**	0.4	0.0	1.3	0.4	**2.2**
			Percent	20%	0%	60%	20%	
	SF4	1.87	**Tons/Year**	0.3	2.1	0.6	0.0	**3.0**
			Percent	10%	70%	20%	0%	
	SF5	3.19	**Tons/Year**	0.5	3.5	1.0	0.0	**5.0**
			Percent	10%	70%	20%	0%	
	Muddy Creek	5.22	**Tons/Year**	14.9	16.0	69.2	1.8	**101.9**
			Percent	15%	16%	68%	2%	
	M1	2.31	**Tons/Year**	0.0	0.0	3.6	0.0	**3.6**
			Percent	0%	0%	100%	0%	
	M2	1.36	**Tons/Year**	0.0	0.0	2.1	0.0	**2.1**
			Percent	0%	0%	100%	0%	
	First Yellow Mule Creek	4.95	**Tons/Year**	2.2	2.8	49.1	0.0	**54.2**
			Percent	4%	5%	91%	0%	
	1YM1	2.46	**Tons/Year**	0.4	1.6	1.9	0.0	**3.9**
			Percent	10%	40%	50%	0%	
	1YM2	1.61	**Tons/Year**	0.3	1.0	1.3	0.0	**2.5**
			Percent	10%	40%	50%	0%	
	Second Yellow Mule Creek	3.82	**Tons/Year**	4.3	4.5	9.2	0.1	**18.1**
			Percent	24%	25%	51%	1%	
	2YM1	1.28	**Tons/Year**	0.2	1.4	0.4	0.0	**2.0**
			Percent	10%	70%	20%	0%	
	Third Yellow Mule Creek	3.88	**Tons/Year**	0.5	5.8	20.8	0.0	**27.1**
			Percent	2%	22%	77%	0%	
West Fork Gallatin River*	West Fork Gallatin River	3.61	**Tons/Year**	13.5	0.0	87.5	46.9	**147.9**
			Percent	9%	0%	59%	32%	
	Crail Creek	2.92	**Tons/Year**	0.5	0.0	3.2	0.9	**4.6**
			Percent	10%	0%	70%	20%	

*Remaining portion of watershed excluding South Fork West Fork, Middle Fork West Fork and North Fork West Fork.

D4.0 DISCUSSION AND CONCLUSIONS

The results of this assessment indicate that historic timber harvest activities, the road network, and resort area development have increased streambank erosion sediment loads in the West Fork Gallatin River watershed. It is estimated that an annual average of 1,821 tons of streambank sediment are delivered to streams in the West Fork Gallatin River watershed and that 33% (604 tons) of this streambank sediment load is due to anthropogenic disturbances (**Table D-17**). Through the implementation of BMPs, it is estimated that the total sediment load from anthropogenically accelerated streambank erosion in the West Fork Gallatin River watershed can be reduced by 31% (186 tons/year), which is a 10% reduction in the overall sediment load associated with bank erosion.

Table D-17. Watershed Sediment Load Reduction Summary.

Watershed	Existing Sediment Load (Tons/Yr)	Existing Load due to Anthropogenic Sources (Tons/Yr)	Desired Reduced Load (Tons/Yr)	Potential Reduction in Anthropogenic Sediment Load (Existing-Reduced) (Tons/Yr)	Percent Reduction in Anthropogenic Sediment Load (Existing/Potential Reduction)	Percent Reduction Overall
Middle Fork	**494**	145	**435**	59	41%	**12%**
South Fork	**1049**	338	**977**	72	21%	**7%**
North Fork	**72**	4	**72**	0	0%	**0%**
West Fork	**207**	116	**153**	55	47%	**26%**
West Fork Total	**1821**	604	**1636**	186	31%	**10%**

D4.1 Streambank Erosion Results by Particle Size Class

During the Upper Gallatin sediment and habitat assessment in 2008, a total of 204 eroding streambanks were examined and streambank composition was recorded as a percentage for the following particle size classes: coarse gravel (>6mm), fine gravel (<6mm and >2mm) and sand/silt (<2mm). One streambank in BEEH12-01 lacked composition data and was excluded from the dataset, resulting in a total of 203 eroding streambanks in the West Fork Gallatin River watershed. Using this data, the average streambank composition within each particle size class was calculated based on the entire dataset for the West Fork Gallatin River watershed, while data from streams within the Middle Fork West Fork Gallatin River watershed and South Fork West Fork Gallatin River watershed were used to calculate the average streambank composition at the sub-watershed scale. Sediment loads due to streambank erosion were also calculated for each stream segment to facilitate the development of sediment TMDLs.

Based on the entire dataset, streambank composition averaged 33% coarse gravel, 12% fine gravel and 55% sand/silt in the West Fork Gallatin River watershed (**Table D-18**). The results for the Middle Fork West Fork Gallatin River watershed, which includes data from Middle Fork West Fork Gallatin River, Beehive Creek and Stony Creek (including tributaries), mirror the results for the entire West Fork Gallatin River watershed, with 32% coarse gravel, 11% fine gravel and 57% sand/silt. In the South Fork West Fork Gallatin River watershed, which includes data from South Fork West Fork Gallatin River, Muddy Creek and First Yellow Mule Creek,

streambank composition averaged 41% coarse gravel, 12% fine gravel and 47% sand/silt, indicating that streambanks in the South Fork West Fork Gallatin watershed contain a slightly greater component of coarse gravel and a slightly smaller component of sand/silt than is found in the rest of the West Fork Gallatin River watershed.

Table D-18. Mean Streambank Composition for Selected Watersheds.

Watershed	Sample Size	Coarse Gravel >6mm (Percent)	Fine Gravel <6mm & >2mm (Percent)	Sand/Silt <2mm (Percent)
Middle Fork West Fork Gallatin River	88	32	11	57
South Fork West Fork Gallatin River	46	41	12	47
West Fork Gallatin River	203	33	12	55

Streambank composition data for individual stream segments is presented in **Table D-19**. This data was used to amend **Table D-10** to include the sediment load for each particle size class, which is presented in **Table D-20**.

Table D-19. Mean Streambank Composition for Assessed Stream Segments.

Stream Segment	Sample Size	Coarse Gravel >6mm (Percent)	Fine Gravel <6mm & >2mm (Percent)	Sand/Silt <2mm (Percent)
Beehive Creek	27	18	11	71
First Yellow Mule Creek	5	32	10	58
Middle Fork West Fork Gallatin River	34	30	12	58
Muddy Creek	11	50	13	37
North Fork Stony Creek	11	45	10	45
North Fork West Fork Gallatin River	22	20	16	64
South Fork Stony Creek	7	46	10	44
South Fork West Fork Gallatin River	30	39	12	49
Stony Creek	9	57	12	31
West Fork Gallatin River	47	34	11	55

Table D-20. Stream Segment Sediment Loads due to Streambank Erosion.

Stream Segment	Stream Length (Miles)	Coarse Gravel >6mm Load (Tons/Year)	Fine Gravel <6mm & >2mm Load (Tons/Year)	Sand/Silt <2mm Load (Tons/Year)	Total Load (Tons/Year)
Beehive Creek	4.78	48.4	28.1	190.0	266.5
First Yellow Mule Creek	4.95	17.8	5.6	32.2	55.5
Middle Fork West Fork Gallatin River	5.82	56.9	22.3	110.4	189.5
Moose Tracks Creek*	0.41	1.9	0.7	3.2	5.7
Muddy Creek	5.22	60.3	15.4	45.0	120.7
North Fork Moose Tracks Creek*	1.62	0.9	0.3	1.5	2.8
North Fork Stony Creek	2.38	4.0	0.9	3.9	8.8

Table D-20. Stream Segment Sediment Loads due to Streambank Erosion.

Stream Segment	Stream Length (Miles)	Coarse Gravel >6mm Load (Tons/Year)	Fine Gravel <6mm & >2mm Load (Tons/Year)	Sand/Silt <2mm Load (Tons/Year)	Total Load (Tons/Year)
North Fork West Fork Gallatin River	7.37	13.4	10.6	42.9	66.9
South Fork Moose Tracks Creek*	1.14	1.5	0.5	2.5	4.5
South Fork Stony Creek	1.70	3.3	0.7	3.2	7.3
South Fork West Fork Gallatin River	13.78	313.9	95.8	388.3	798.0
Stony Creek	0.20	2.5	0.5	1.4	4.3
Second Yellow Mule Creek*	3.82	6.0	2.1	9.9	18.1
Third Yellow Mule Creek*	3.88	9.0	3.2	14.9	27.1
West Fork Gallatin River	3.61	68.1	23.3	111.2	202.5

*Streambank composition based on average for entire dataset.

D5.0 REFERENCES

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ATTACHMENT A
AERIAL ASSESSMENT DATABASE – STREAM REACH SEDIMENT LOADS, UPPER GALLATIN TMDL PLANNING AREA

STREAM NAME	REACH ID	REACH TYPE III	SUBREACH	REACH	ASSESSED Bank Erosion Sediment Load (Tons/1000 Feet)	BEHI Reduced to MODERATE for ASSESSED Sites (Tons/1000 feet)	EXTRAPOLATED Bank Erosion Sediment Load (Tons/1000 Feet)	EXTRAPOLATED BEHI Reduced to MODERATE (Tons/1000 feet)	TRANSPORTATION	GRAZING	CROPS	MINING	TIMBER	IRRIGATION	NATURAL	OTHER	LENGTH (ft)
Beehive Creek	BEEH 01-01	MR-10-1-U	1	1			0.3	0.3	0	0	0	0	0	0	100	0	2648
Beehive Creek	BEEH 02-01	MR-10-1-U	1	2			0.3	0.3	0	0	0	0	0	0	100	0	582
Beehive Creek	BEEH 03-01	MR-4-1-U	1	3			0.3	0.3	0	0	0	0	0	0	100	0	641
Beehive Creek	BEEH 04-01	MR-10-1-U	1	4			0.3	0.3	0	0	0	0	0	0	100	0	507
Beehive Creek	BEEH 05-01	MR-4-1-U	1	5			0.3	0.3	0	0	0	0	0	0	100	0	497
Beehive Creek	BEEH 06-01	MR-10-1-U	1	6			0.3	0.3	0	0	0	0	0	0	100	0	586
Beehive Creek	BEEH 07-01	MR-4-1-U	1	7			0.3	0.3	0	0	0	0	0	0	100	0	5251
Beehive Creek	BEEH 08-01	MR-10-1-U	1	8			0.3	0.3	0	0	0	0	0	0	100	0	1394
Beehive Creek	BEEH 09-01	MR-10-1-C	1	9			0.3	0.3	0	0	0	0	0	0	100	0	280
Beehive Creek	BEEH 10-01	MR-10-1-U	1	10			1.1	1.1	0	0	0	0	0	0	100	0	368
Beehive Creek	BEEH 11-01	MR-4-1-U	1	11	8.8	8.8	8.8	8.8	0	0	0	0	0	0	100	0	2896
Beehive Creek	BEEH 12-01	MR-2-1-U	1	12	84.5	29.4	84.5	29.4	20	0	0	0	0	0	80	0	1629
Beehive Creek	BEEH 13-01	MR-4-1-U	1	13	23.3	9.1	23.3	9.1	0	0	0	0	0	0	98	2	3899
Beehive Creek	BEEH 14-01	MR-10-1-U	1	14			1.1	1.1	35	0	0	0	0	0	45	20	760
Beehive Creek	BEEH 15-01	MR-4-1-U	1	15			3.1	3.1	55	0	0	0	0	0	45	0	2350
Beehive Creek	BEEH 16-01	MR-10-1-U	1	16			1.1	1.1	10	0	0	0	0	0	90	0	927
First Yellow Mule Creek	FYMC 01-01	MR-4-1-U	1	1			0.3	0.3	0	0	0	0	0	0	100	0	1657
First Yellow Mule Creek	FYMC 02-01	MR-10-1-U	1	2			0.3	0.3	0	0	0	0	0	0	100	0	1494
First Yellow Mule Creek	FYMC 03-01	MR-4-1-U	1	3			0.3	0.3	0	0	0	0	0	0	100	0	1052
First Yellow Mule Creek	FYMC 04-01	MR-10-1-U	1	4			0.3	0.3	0	0	0	0	0	0	100	0	837
First Yellow Mule Creek	FYMC 05-01	MR-4-1-U	1	5			0.3	0.3	0	0	0	0	0	0	100	0	1514
First Yellow Mule Creek	FYMC 06-01	MR-10-1-U	1	6			0.3	0.3	50	0	0	0	0	0	50	0	4147

STREAM NAME	REACH ID	REACH TYPE III	SUBREACH	REACH	ASSESSED Bank Erosion Sediment Load (Tons/1000 Feet)	BEHI Reduced to MODERATE for ASSESSED Sites (Tons/1000 feet)	EXTRAPOLATED Bank Erosion Sediment Load (Tons/1000 Feet)	EXTRAPOLATED BEHI Reduced to MODERATE (Tons/1000 feet)	TRANSPORTATION	GRAZING	CROPS	MINING	TIMBER	IRRIGATION	NATURAL	OTHER	LENGTH (ft)
First Yellow Mule Creek	FYMC 07-01	MR-4-1-U	1	7			3.1	3.1	0	0	0	0	0	0	100	0	3409
First Yellow Mule Creek	FYMC 08-01	MR-10-1-U	1	8			0.3	0.3	0	0	0	0	0	0	100	0	820
First Yellow Mule Creek	FYMC 09-01	MR-4-1-U	1	9			3.1	3.1	20	0	0	0	0	0	80	0	1606
First Yellow Mule Creek	FYMC 10-01	MR-4-1-C	1	10			1.6	1.6	0	0	0	0	0	0	100	0	437
First Yellow Mule Creek	FYMC 11-01	MR-4-1-U	1	11			3.1	3.1	0	0	0	0	0	0	100	0	482
First Yellow Mule Creek	FYMC 12-01	MR-10-1-U	1	12			0.3	0.3	0	0	0	0	0	0	100	0	527
First Yellow Mule Creek	FYMC 13-01	MR-10-1-C	1	13			0.3	0.3	0	0	0	0	0	0	100	0	295
First Yellow Mule Creek	FYMC 14-01	MR-4-1-U	1	14			3.1	3.1	5	0	0	0	0	0	95	0	3926
First Yellow Mule Creek	FYMC 15-01	MR-10-2-U	1	15			5.6	5.6	0	0	0	0	0	0	100	0	1280
First Yellow Mule Creek	FYMC 16-01	MR-4-2-U	1	16	5.6	3.8	5.6	3.8	0	0	0	0	28	0	72	0	2632
MFWF Gallatin River	MFWF 01-01	MR-10-1-U	1	1	0.3	0.3	0.3	0.3	0	0	0	0	10	0	80	10	1665
MFWF Gallatin River	MFWF 02-01	MR-4-1-U	1	2	0.4	0.4	0.7	0.7	30	0	0	0	0	0	15	55	7623
MFWF Gallatin River	MFWF 02-01	MR-4-1-U	2	2	1.0	1.0			30	0	0	0	0	0	15	55	
MFWF Gallatin River	MFWF 03-01	MR-4-1-U	1	3			1.1	1.1	50	0	0	0	0	0	25	25	399
MFWF Gallatin River	MFWF 04-01	MR-4-1-C	1	4	1.3	1.3	1.3	1.3	0	0	0	0	0	0	100	0	1221
MFWF Gallatin River	MFWF 05-01	MR-10-1-U	1	5			0.3	0.3	10	0	0	0	0	0	60	30	722
MFWF Gallatin River	MFWF 06-01	MR-10-2-U	1	6			4.4	4.4	15	0	0	0	0	0	85	0	1637
MFWF Gallatin River	MFWF 07-01	MR-4-2-U	1	7			4.1	3.3	10	0	0	0	0	0	90	0	2102
MFWF Gallatin River	MFWF 07-02	MR-4-2-U	2	7	4.4	4.4	4.4	4.4	0	0	0	0	83	0	17	0	2741
MFWF Gallatin River	MFWF 08-01	MR-2-2-U	1	8	1.9	1.9	1.9	1.9	0	0	0	0	62	0	38	0	7109
MFWF Gallatin River	MFWF 09-01	MR-2-3-U	1	9	26.2	12.1	26.2	12.1	0	0	0	0	50	0	10	40	3052
MFWF Gallatin River	MFWF09-02	MR-2-3-U	2	9	24.5	24.5	24.5	24.5	0	0	0	0	0	0	100	0	2453

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Moose Tracks	MOOS 01-01	MR-4-2-U	1	1			0.0	0.0	0	0	0	0	0	0	0	100	754
Moose Tracks	MOOS 01-02	MR-4-2-U	2	1			4.1	3.3	40	0	0	0	0	0	10	50	1401
Muddy Creek	MUDD 01-01	MR-10-1-U	1	1			0.3	0.3	0	0	0	0	0	0	100	0	3643
Muddy Creek	MUDD 02-01	MR-4-1-U	1	2			1.1	1.1	0	0	0	0	0	0	100	0	4134
Muddy Creek	MUDD 03-01	MR-4-1-U	1	3			1.1	1.1	0	0	0	0	0	0	100	0	1637
Muddy Creek	MUDD 04-01	MR-10-1-U	1	4			1.1	1.1	0	0	0	0	0	0	100	0	1757
Muddy Creek	MUDD 05-01	MR-4-2-U	1	5			4.1	4.1	0	0	0	0	0	0	100	0	7781
Muddy Creek	MUDD 05-02	MR-4-2-U	2	5			4.1	3.3	0	0	0	0	30	0	70	0	2944
Muddy Creek	MUDD 05-03	MR-4-2-U	3	5			4.1	3.3	0	0	0	0	40	0	10	50	1100
Muddy Creek	MUDD 06-01	MR-4-2-C	1	6			4.1	4.1	0	0	0	0	50	0	50	0	530
Muddy Creek	MUDD 07-01	MR-4-2-U	1	7			15.1	9.0	0	0	0	0	50	0	50	0	1591
Muddy Creek	MUDD 08-01	MR-2-2-U	1	8	15.1	9.0	15.1	9.0	68	0	0	0	15	0	16	0	1480
Muddy Creek	MUDD 08-02	MR-2-2-U	2	8			15.1	9.0	68	0	0	0	15	0	16	0	945
North Fork Moose Tracks	NFMT 01-01	MR-10-1-U	1	1			0.3	0.3	95	0	0	0	0	0	5	0	302
North Fork Moose Tracks	NFMT 02-01	MR-10-1-U	1	2			0.3	0.3	0	0	0	0	0	0	50	50	3890
North Fork Moose Tracks	NFMT 03-01	MR-4-1-U	1	3			1.1	1.1	0	0	0	0	0	0	50	50	523
North Fork Moose Tracks	NFMT 04-01	MR-10-1-U	1	4			0.3	0.3	10	0	0	0	0	0	50	40	1260
North Fork Moose Tracks	NFMT 05-01	MR-10-1-C	1	5			0.3	0.3	25	0	0	0	0	0	50	25	456
North Fork Moose Tracks	NFMT 06-01	MR-10-1-U	1	6			0.3	0.3	50	0	0	0	0	0	30	20	1578
North Fork Moose Tracks	NFMT 07-01	MR-4-1-U	1	7			0.0	0.0	10	0	0	0	0	0	5	85	527

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North Fork Stony Creek	NFST 01-01	MR-10-1-U	1	1			0.3	0.3	10	0	0	0	0	0	60	30	3872
North Fork Stony Creek	NFST 02-01	MR-4-1-U	1	2			1.1	1.1	10	0	0	0	0	0	65	25	1224
North Fork Stony Creek	NFST 03-01	MR-10-1-C	1	3			0.3	0.3	5	0	0	0	0	0	95	0	2960
North Fork Stony Creek	NFST 04-01	MR-4-1-C	1	4			1.6	1.6	0	0	0	0	0	0	100	0	1038
North Fork Stony Creek	NFST 05-01	MR-10-1-C	1	5			0.3	0.3	0	0	0	0	0	0	100	0	1296
North Fork Stony Creek	NFST 06-01	MR-10-1-U	1	6			0.3	0.3	0	0	0	0	0	0	100	0	495
North Fork Stony Creek	NFST 07-01	MR-4-1-C	1	7	1.9	1.9	1.9	1.9	0	0	0	0	0	0	100	0	1661
NFWF Gallatin River	NFWF 01-01	MR-10-1-U	1	1			0.3	0.3	0	0	0	0	0	0	100	0	1784
NFWF Gallatin River	NFWF 02-01	MR-4-1-U	1	2			0.3	0.3	0	0	0	0	0	0	100	0	3947
NFWF Gallatin River	NFWF 03-01	MR-10-1-U	1	3			0.3	0.3	0	0	0	0	0	0	100	0	5443
NFWF Gallatin River	NFWF 04-01	MR-4-1-U	1	4			1.1	1.1	0	0	0	0	0	0	100	0	1024
NFWF Gallatin River	NFWF 05-01	MR-4-2-U	1	5			2.1	2.1	0	0	0	0	0	0	100	0	1588
NFWF Gallatin River	NFWF 06-01	MR-4-2-U	1	6			2.1	2.1	0	0	0	0	0	0	100	0	1220
NFWF Gallatin River	NFWF 07-01	MR-4-2-C	1	7			4.1	4.1	0	0	0	0	0	0	100	0	965
NFWF Gallatin River	NFWF 08-01	MR-4-2-U	1	8			2.1	2.1	0	0	0	0	0	0	100	0	2192
NFWF Gallatin River	NFWF 09-01	MR-4-2-U	1	9			2.1	2.1	0	0	0	0	0	0	100	0	2054
NFWF Gallatin River	NFWF 10-01	MR-2-2-U	1	10	3.8	3.8	3.8	3.8	0	0	0	0	0	0	68	32	2576
NFWF Gallatin River	NFWF 11-01	MR-4-2-U	1	11			2.1	2.1	5	0	0	0	0	0	95	0	4758
NFWF Gallatin River	NFWF 12-01	MR-4-2-U	1	12	2.1	2.1	2.1	2.1	0	0	0	0	1	0	99	0	11365
South Fork Moose Tracks	SFMT 01-01	MR-10-1-U	1	1			0.3	0.3	10	0	0	0	0	0	90	0	2661
South Fork Moose Tracks	SFMT 02-01	MR-4-1-U	1	2			1.1	1.1	25	0	0	0	0	0	75	0	3363

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South Fork Stony Creek	SFSC 01-01	MR-10-1-U	1	1			0.3	0.3	40	0	0	0	0	0	60	0	3939
South Fork Stony Creek	SFSC 02-01	MR-4-1-U	1	2			1.1	1.1	10	0	0	0	0	0	90	0	3620
South Fork Stony Creek	SFSC 03-01	MR-10-1-U	1	3			0.3	0.3	0	0	0	0	0	0	100	0	487
South Fork Stony Creek	SFSC 04-01	MR-4-1-U	1	4	2.2	2.2	2.2	2.2	50	0	0	0	0	0	50	0	908
SFWF Gallatin River	SFWF 01-01	MR-10-1-U	1	1			0.3	0.3	0	0	0	0	0	0	100	0	2592
SFWF Gallatin River	SFWF 02-01	MR-4-1-U	1	2			0.3	0.3	0	0	0	0	0	0	100	0	2420
SFWF Gallatin River	SFWF 03-01	MR-10-1-C	1	3			0.3	0.3	0	0	0	0	0	0	100	0	480
SFWF Gallatin River	SFWF 04-01	MR-10-1-U	1	4			0.3	0.3	0	0	0	0	0	0	100	0	869
SFWF Gallatin River	SFWF 05-01	MR-10-1-U	1	5			0.3	0.3	0	0	0	0	0	0	100	0	1365
SFWF Gallatin River	SFWF 06-01	MR-10-1-C	1	6			0.3	0.3	0	0	0	0	0	0	100	0	417
SFWF Gallatin River	SFWF 07-01	MR-4-1-U	1	7			3.1	3.1	0	0	0	0	0	0	100	0	3279
SFWF Gallatin River	SFWF 08-01	MR-4-1-C	1	8			1.6	1.6	0	0	0	0	0	0	100	0	2212
SFWF Gallatin River	SFWF 09-01	MR-4-1-U	1	9			3.1	3.1	0	0	0	0	0	0	100	0	1426
SFWF Gallatin River	SFWF 10-01	MR-10-1-C	1	10			3.1	3.1	0	0	0	0	0	0	100	0	473
SFWF Gallatin River	SFWF 11-01	MR-10-1-U	1	11			1.1	1.1	0	0	0	0	0	0	100	0	404
SFWF Gallatin River	SFWF 12-01	MR-4-1-U	1	12			3.1	3.1	0	0	0	0	0	0	100	0	550
SFWF Gallatin River	SFWF 13-01	MR-4-1-C	1	13			1.6	1.6	0	0	0	0	0	0	100	0	1127
SFWF Gallatin River	SFWF 14-01	MR-4-1-U	1	14			3.1	3.1	0	0	0	0	0	0	100	0	776
SFWF Gallatin River	SFWF 15-01	MR-2-1-U	1	15			1.4	1.4	10	0	0	0	0	0	90	0	1948
SFWF Gallatin River	SFWF 16-01	MR-4-2-U	1	16			4.1	4.1	0	0	0	0	0	0	100	0	1869
SFWF Gallatin River	SFWF 16-02	MR-4-2-U	2	16			4.1	3.3	20	0	0	0	35	0	45	0	3619
SFWF Gallatin River	SFWF 17-01	MR-2-2-U	1	17			1.4	1.4	35	0	0	0	0	0	65	0	3294

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SFWF Gallatin River	SFWF 17-02	MR-2-2-U	2	17	1.4	1.4	1.4	1.4	0	0	0	0	0	0	100	0	2418
SFWF Gallatin River	SFWF 18-01	MR-0-3-U	1	18	6.4	2.6	6.4	2.6	0	0	0	0	67	0	33	0	2894
SFWF Gallatin River	SFWF 19-01	MR-4-3-C	1	19			6.4	6.4	0	0	0	0	0	0	100	0	1965
SFWF Gallatin River	SFWF 20-01	MR-2-3-C	1	20			16.0	16.0	0	0	0	0	0	0	100	0	1630
SFWF Gallatin River	SFWF 21-01	MR-0-3-U	1	21			17.9	14.0	0	0	0	0	30	0	70	0	2077
SFWF Gallatin River	SFWF 22-01	MR-0-3-U	1	22	24.5	22.0	24.5	22.0	0	0	0	0	54	0	46	0	7218
SFWF Gallatin River	SFWF 23-01	MR-0-3-U	1	23			17.9	14.0	35	0	0	0	0	0	65	0	1248
SFWF Gallatin River	SFWF 24-01	MR-4-3-C	1	24			17.9	14.0	25	0	0	0	0	0	60	15	2530
SFWF Gallatin River	SFWF 25-01	MR-2-3-U	1	25			16.0	9.5	0	0	0	0	0	0	75	25	1173
SFWF Gallatin River	SFWF 26-01	MR-0-3-U	1	26			17.9	14.0	10	0	0	0	0	0	90	0	2486
SFWF Gallatin River	SFWF 27-01	MR-2-3-C	1	27			16.0	9.5	25	0	0	0	0	0	50	25	1338
SFWF Gallatin River	SFWF 28-01	MR-2-3-U	1	28	6.0	3.4	6.0	3.4	0	0	0	0	13	0	87	0	1589
SFWF Gallatin River	SFWF 28-02	MR-2-3-U	2	28			6.0	3.4	10	0	0	0	0	0	80	10	834
SFWF Gallatin River	SFWF 29-01	MR-0-3-U	1	29			17.9	14.0	10	0	0	0	0	0	90	0	2459
SFWF Gallatin River	SFWF 29-02	MR-0-3-U	2	29	28.6	28.6	28.6	28.6	0	0	0	0	0	0	100	0	4080
SFWF Gallatin River	SFWF 29-03	MR-0-3-U	3	29			17.9	14.0	60	0	0	0	0	0	40	0	1097
SFWF Gallatin River	SFWF 29-04	MR-0-3-U	4	29			17.9	14.0	10	0	0	0	0	0	50	40	6591
Stony Creek	STON 01-01	MR-4-2-U	1	1	4.1	2.9	4.1	2.9	17	0	0	0	20	0	63	0	1060
Second Yellow Mule Creek	SYMC 01-01	MR-10-1-U	1	1			0.3	0.3	0	0	0	0	0	0	100	0	2553
Second Yellow Mule Creek	SYMC 02-01	MR-4-1-U	1	2			0.3	0.3	0	0	0	0	0	0	100	0	1966

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Second Yellow Mule Creek	SYMC 03-01	MR-10-1-C	1	3			0.3	0.3	0	0	0	0	0	0	100	0	868
Second Yellow Mule Creek	SYMC 04-01	MR-4-1-U	1	4			0.3	0.3	0	0	0	0	50	0	50	0	3151
Second Yellow Mule Creek	SYMC 05-01	MR-10-1-C	1	5			0.3	0.3	0	0	0	0	50	0	50	0	2333
Second Yellow Mule Creek	SYMC 06-01	MR-4-1-U	1	6			3.1	3.1	50	0	0	0	0	0	50	0	495
Second Yellow Mule Creek	SYMC 07-01	MR-10-1-C	1	7			0.3	0.3	0	0	0	0	35	0	50	15	2457
Second Yellow Mule Creek	SYMC 08-01	MR-4-1-C	1	8			1.6	1.6	5	0	0	0	45	0	50	0	2945
Second Yellow Mule Creek	SYMC 09-01	MR-4-1-U	1	9			3.1	3.1	0	0	0	0	0	0	100	0	550
Second Yellow Mule Creek	SYMC 10-01	MR-4-1-C	1	10			1.6	1.6	80	0	0	0	0	0	20	0	1839
Second Yellow Mule Creek	SYMC 11-01	MR-4-1-U	1	11			3.1	3.1	30	0	0	0	40	0	30	0	1018
Third Yellow Mule Creek	TYMC 01-01	MR-10-1-U	1	1			0.3	0.3	0	0	0	0	0	0	100	0	1615
Third Yellow Mule Creek	TYMC 02-01	MR-4-1-U	1	2			0.3	0.3	0	0	0	0	0	0	100	0	1687
Third Yellow Mule Creek	TYMC 03-01	MR-10-1-U	1	3			0.3	0.3	0	0	0	0	0	0	100	0	1608
Third Yellow Mule Creek	TYMC 04-01	MR-4-1-U	1	4			0.3	0.3	0	0	0	0	0	0	100	0	6323
Third Yellow Mule Creek	TYMC 05-01	MR-10-1-U	1	5			0.3	0.3	0	0	0	0	0	0	100	0	769
Third Yellow Mule Creek	TYMC 06-01	MR-4-1-U	1	6			3.1	3.1	0	0	0	0	30	0	70	0	4336

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Third Yellow Mule Creek	TYMC 07-01	MR-4-1-C	1	7			1.6	1.6	0	0	0	0	50	0	50	0	1058
Third Yellow Mule Creek	TYMC 08-01	MR-10-1-C	1	8			3.1	3.1	0	0	0	0	0	0	100	0	1631
Third Yellow Mule Creek	TYMC 09-01	MR-4-1-C	1	9			1.6	1.6	0	0	0	0	0	0	100	0	859
Third Yellow Mule Creek	TYMC 10-01	MR-4-1-U	1	10			3.1	3.1	25	0	0	0	50	0	25	0	623
WF Gallatin River	WFGR 01-01	MR-2-3-U	1	1			16.0	9.5	20	0	0	0	0	0	40	40	1407
WF Gallatin River	WFGR 01-02	MR-2-3-U	2	1	16.2	6.3	16.2	6.3	8	0	0	0	0	0	66	26	1426
WF Gallatin River	WFGR 01-03	MR-2-3-U	3	1	7.0	5.8	7.0	5.8	9	0	0	0	0	0	38	53	3043
WF Gallatin River	WFGR 01-04	MR-2-3-U	4	1	2.9	1.1	2.9	1.1	0	0	0	0	0	0	14	86	2342
WF Gallatin River	WFGR 01-05	MR-2-3-U	5	1	29.2	13.0	29.2	13.0	20	0	0	0	0	0	8	72	2227
WF Gallatin River	WFGR 02-01	MR-0-3-U	1	2	25.1	12.1	25.1	12.1	0	0	0	0	0	0	81	19	2042
WF Gallatin River	WFGR 02-02	MR-0-3-U	2	2	4.7	4.7	4.7	4.7	0	0	0	0	0	0	100	0	617
WF Gallatin River	WFGR 02-03	MR-0-3-U	3	2			4.7	4.7	40	0	0	0	0	0	40	20	558
WF Gallatin River	WFGR 03-01	MR-0-4-U	1	3			1.3	1.3	50	0	0	0	0	0	30	20	1150
WF Gallatin River	WFGR 03-02	MR-0-4-U	2	3			1.3	1.3	50	0	0	0	0	0	50	0	602
WF Gallatin River	WFGR 03-03	MR-0-4-U	3	3	1.3	1.3	1.3	1.3	10	0	0	0	0	0	90	0	2367
WF Gallatin River	WFGR 04-01	MR-0-4-U	1	4			1.3	1.3	10	0	0	0	0	0	20	70	1284