APPENDIX E - 2007 STREAM BANK EROSION SOURCE ASSESSMENT – BITTERROOT TMDL PLANNING AREA

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E1.0 INTRODUCTION

This appendix includes a summary of the field protocols and results from sediment loading due to streambank erosion along several stream segments in the Bitterroot TMDL Planning Area (TPA). It is an excerpt from the Streambank Erosion Source Assessment (PBS&J 2008), which is on file at DEQ. Sediment loads due to streambank erosion were calculated based on field data collected in 2007. Streambank erosion assessments were conducted over two monitoring timeframes, with 32 monitoring sites assessed during June/August and 23 monitoring sites assessed during October/November. Streambank erosion data collected at field monitoring sites was extrapolated to the stream reach and stream segment scales based on information in the Aerial Assessment Database, which was compiled in GIS prior to field data collection. Streambank erosion data collected in the field was also used to estimate sediment loading at the watershed scale and to assess the potential to decrease sediment inputs due to streambank erosion.

Reach type as identified in this appendix and in the Streambank Erosion Source Assessment Report will differ from reach types in **Section 5 of the TMDL document**, as a result of ecoregion reassignment **(See Section 5.3.1.2 in the TMDL document)**; with streams originating within the Idaho Batholith ecoregion that were assessed in the 2007 DEQ field effort considered to be Idaho Batholith, and reaches located on streams that are split between Northern Rockies and Middle Rockies ecoregions assigned an ecoregion based on where the majority of the stream is located. Reach type was not modified in this appendix or the original report, and is provided without edits here to demonstrate the original sampling rationale.

E1.1 TERMINOLOGY

Streambank erosion data collected at monitoring sites was extrapolated to the stream reach and stream segment scales based on similar reach 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 reach where field monitoring was conducted*
Stream Reach -	*Subdivision of the stream segment based on Ecoregion, stream order, gradient and confinement*
Stream Segment -	*303(d) listed segment*

Prior to field data collection, each 303(d) listed ***stream segment*** was broken into several ***stream reaches*** based on Ecoregion, gradient, Strahler stream order and confinement through the use of GIS data layers and color aerial imagery. Stream reaches were delineated following the methodology outlined in *A Watershed Stratification Approach for TMDL Sediment and Habitat Impairment Verification* (MDEQ 2007a). Stream reach data was compiled into an Aerial Assessment Database, which included a total of 915 stream reaches on 23 stream segments in the Bitterroot TPA. A subset of the stream reaches identified in the Aerial Assessment Database were assessed in the field at ***monitoring sites***, which were selected to represent conditions at the stream reach scale. At each monitoring site, eroding streambanks were assessed following protocols established in *Longitudinal Field Methodology for the Assessment of Sediment and Habitat Impairments* (MDEQ 2007b).

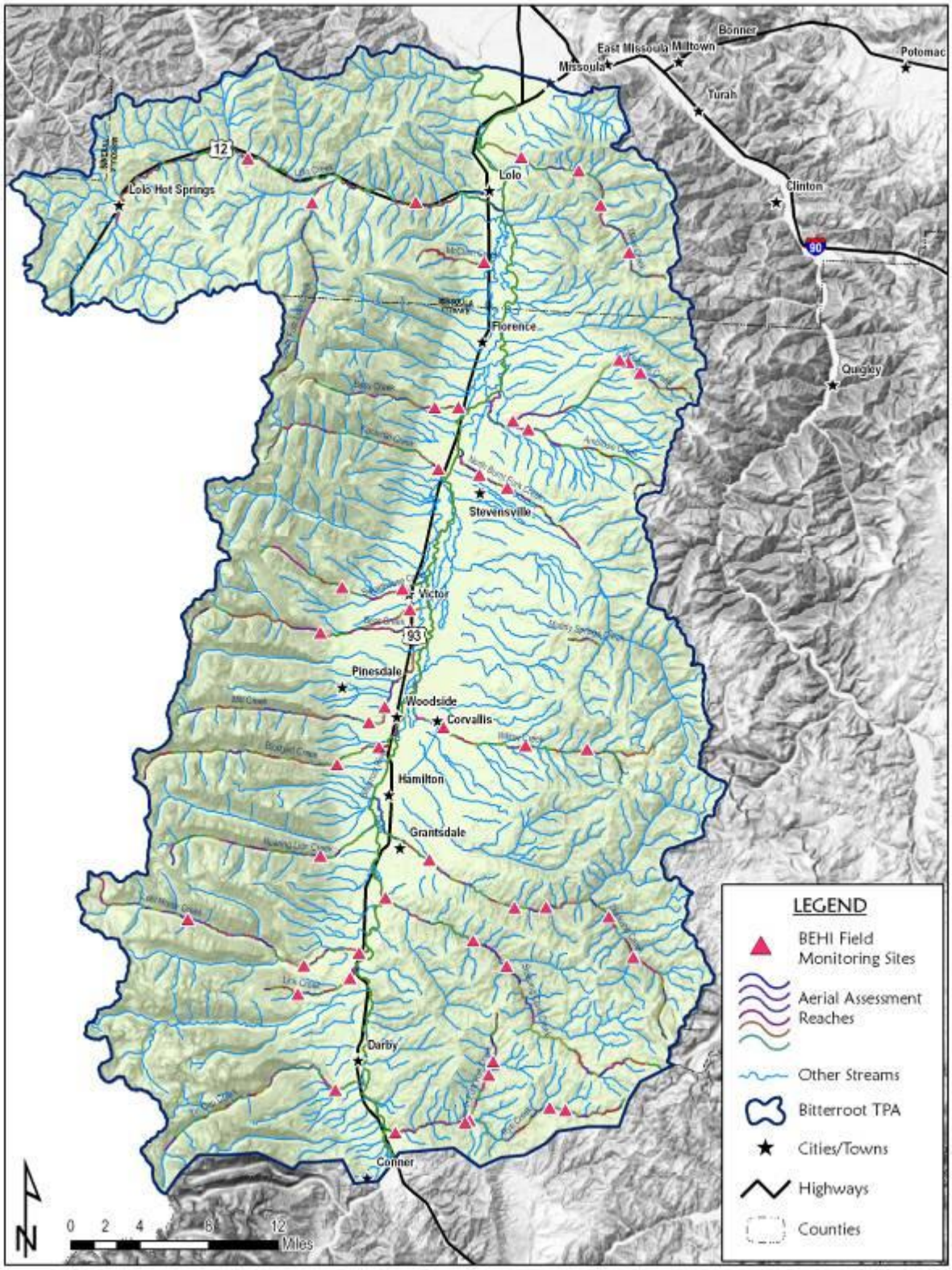
E1.2 SEDIMENT IMPAIRMENTS

In the Bitterroot TPA, twelve stream segments are listed on the 2010 303(d) List for sediment impairments including: Lick Creek, Lolo Creek (3 segments), McClain Creek, Miller Creek, Muddy Springs Creek, North Fork Burnt Creek, Rye Creek, Sleeping Child Creek, Threemile Creek, and Willow Creek.

E2.0 DATA COLLECTION AND EXTRAPOLATION METHODOLOGY

Streambank erosion assessments were performed on 191 streambanks at 55 monitoring sites in 2007. A total of 11.4 miles of stream were assessed along 23 stream segments, including: Ambrose Creek, Bass Creek, Bear Creek, North Bear Creek, Blodgett Creek, Kootenai Creek, Lick Creek, Lolo Creek, South Fork Lolo Creek, Lost Horse Creek, McClain Creek, Mill Creek, Miller Creek, North Burnt Fork Creek, Roaring Lion Creek, Rye Creek, North Fork Rye Creek, Skalkaho Creek, Sleeping Child Creek, Sweathouse Creek, Threemile Creek, Tin Cup Creek, and Willow Creek. One to five monitoring sites were assessed on each of these stream segments. Monitoring site lengths varied from 500 feet to 1,000 feet to 2,000 feet depending on the bankfull width of the stream. Monitoring site locations are presented in **Figure E-1**. Sites were chosen following the same process described in **Appendix D, Section D1.1**

Figure E-1. Monitoring sites.



E2.1 STREAMBANK EROSION RATES

At each monitoring site, streambank erosion rates were assessed by performing **Bank Erosion Hazard Index (BEHI)** measurements and evaluating the **Near Bank Stress (NBS)** (Rosgen 1996, 2004). At each eroding bank, the BEHI score was determined based on the following six parameters:

- Bank height
- Bankfull height
- Root depth
- Root density
- Bank angle
- Surface protection

Evaluation of these six parameters resulted in a BEHI score, which was then rated from "very low" to "extreme". In addition to the BEHI assessment, the Near Bank Stress was also determined at each eroding bank. Near Bank Stress was assessed by evaluating the shape of the channel at the toe of the bank and the force of the water (i.e. "stream power") along the bank. Near Bank Stress was also rated from "very low" to "extreme". The BEHI and NBS ratings were used to estimate the annual retreat rate of each streambank based on measured retreat rates from the Lamar River in Yellowstone National Park (Rosgen 1996) (**Table E-1**).

Table E-1. Annual Streambank Retreat Rates (Feet/Year) (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

E2.2 STREAMBANK SEDIMENT LOADS

For each eroding bank assessed in the Bitterroot TPA, the annual sediment load due to streambank erosion was determined based on the banks length, mean height, and 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 (**Table E-1**). The annual sediment load in cubic feet was calculated from the field data and then 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) (Rosgen 2006, EPA 2006). This process resulted in a sediment load for each eroding bank expressed in tons per year. The sediment loads for each eroding bank within a monitoring site were summed to provide an overall sediment load due to streambank erosion for each monitoring site in tons per year.

E2.3 AERIAL ASSESSMENT DATABASE

Streambank erosion measured at 52 of the monitoring sites assessed in the field was extrapolated to the stream reach and stream segment scales based on the Aerial Assessment Database. In the field, monitoring sites were selected in areas that were representative of the overall stream condition at the stream reach scale. Stream reaches were defined in the Aerial Assessment Database prior to field work

through the use of GIS data layers and color aerial imagery from 2005. Sediment loads derived from the monitoring sites were extrapolated to the stream reach scale. Sediment loads at the stream reach scale were then summed to achieve an estimate of sediment loads due to streambank erosion for each 303(d) listed stream segment.

E2.3.1 Reach Types

Prior to field data collection, stream segments in the Bitterroot TPA were broken into stream reaches based on Ecoregion, gradient, Strahler stream order and confinement. For streambank erosion sediment load extrapolation purposes, stream reaches were grouped based on three possible categories for Ecoregion, two possible categories for confinement, three possible categories for gradient, and four possible categories for Strahler stream order (**Table E-2)**. For each of the two confinement categories, there are 12 possible slope and stream order combinations, resulting in a total of 24 possible confinement, slope and stream order combinations. With three categories of Level III Ecoregions, the Bitterroot TPA has a total of 72 possible combinations of Ecoregion, gradient, Strahler stream order and confinement. These 72 possible combinations will be referred to as "**reach types**" in this report.

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

Out of the 72 possible reach types in the Bitterroot TPA, a total of 45 reach types were identified during the aerial assessment process. Monitoring site assessments were performed within 18 of the 45 identified reach types.

Table E-2. Possible Level III Ecoregion, Gradient, Strahler Stream Order, and Confinement Combinations

Ecoregion III	Gradient	Confinement	Strahler Stream Order
Idaho Batholith	> 4%	Unconfined/Moderately Confined	1
Middle Rockies	2 - < 4%	Confined	2
Northern Rockies	< 2%		3
			4

E2.3.2 Sediment Load Extrapolation

Sediment loads due to streambank erosion were extrapolated from monitoring sites to stream reaches based on reach types as delineated in the Aerial Assessment Database. The sediment load calculated within an individual monitoring site was extrapolated directly to the stream reach in which it was located. When several monitoring sites were located within a single reach type, the mean sediment load from the monitoring sites was calculated. This mean "reach type" sediment load was then assigned to each reach of that type under the assumption that reaches with the same reach type will have the same mean annual sediment load due to streambank erosion.

Since only 18 out of the 45 identified reach types were assessed in the field, it was necessary to extrapolate the data from the 18 assessed reach types to the 27 un-assessed reach types. Out of the 27 un-assessed reach types, 9 were 1st order streams that were assigned a sediment load of zero due to their relatively small size, steep gradient and coarse streambank material. For the 18 stream reach types (excluding 1st order streams) in which no monitoring site was located, sediment loads were extrapolated from reach types exhibiting the most similarity to the un-assessed reach types. Gradient was the primary factor considered when extrapolating sediment loading data from assessed reach types to us-assessed reach types, though a detailed review of the 2005 color aerial imagery was also conducted to assure that reaches were comparable.

The process of extrapolating sediment loading data collected at monitoring sites to the stream reach scale is presented in the following sections for each of the three Level III Ecoregions in the Bitterroot TPA.

E2.3.2.1 Idaho Batholith Reach Types

In the Idaho Batholith Level III Ecoregion, a total of 13 monitoring sites were assessed in the field. Monitoring sites were assessed in 7 out of the 17 reach types identified in the Idaho Batholith Level III Ecoregion. For reach types with field data, the mean sediment load due to streambank erosion was calculated. For reach types that were not assessed in the field, gradient was the primary factor considered when assigning sediment loads from reach types in which monitoring sites were located. Sediment loads from 1st order streams were assumed to be zero since their relatively small size; steep gradient and coarse streambank material generally tend to limit streambank erosion (**Table E-3)**.

Table E-3. Idaho Batholith Reach Types and Sediment Loads

Ecoregion III	Gradient	Strahler Stream Order	Confinement	Stream Reach Count	Monitoring Site Count	Field Monitoring Site	Mean Sediment Load per 1000' (Tons/Year)	Justification of Load	Notes
Idaho Batholith	> 4%	1	C	9			0	Strahler 1	
Idaho Batholith	> 4%	1	U/M	62			0	Strahler 1	
Idaho Batholith	> 4%	2	C	31	1	SWEA-18	0.10	Monitoring Site	
Idaho Batholith	> 4%	2	U/M	90	1	LICK-08	3.90	Monitoring Site	
Idaho Batholith	> 4%	3	C	3			0.10	SWEA-18	Based on confinement
Idaho Batholith	> 4%	3	U/M	13			3.90	LICK-08	Based on confinement
Idaho Batholith	2 to < 4%	1	U/M	5			0	Strahler 1	
Idaho Batholith	2 to < 4%	2	C	6			0.10	SWEA-18	Based on confinement
Idaho Batholith	2 to < 4%	2	U/M	71	3	BLOD-35, RYEC-14, ROLI-24	3.93	Monitoring Site	Average of monitoring sites
Idaho Batholith	2 to < 4%	3	C	7			0.10	SWEA-18	Based on confinement
Idaho Batholith	2 to < 4%	3	U/M	31	4	NFRC-12, RYEC-16, LOST-33, NFRC-22	5.15	Monitoring Site	Average of monitoring sites
Idaho Batholith	2 to < 4%	4	U/M	1			5.15	NFRC-12, RYEC-16, LOST-33, NFRC-22	Based on confinement
Idaho Batholith	< 2%	1	U/M	3			0	Strahler 1	

Table E-3. Idaho Batholith Reach Types and Sediment Loads

Ecoregion III	Gradient	Strahler Stream Order	Confinement	Stream Reach Count	Monitoring Site Count	Field Monitoring Site	Mean Sediment Load per 1000' (Tons/Year)	Justification of Load	Notes
Idaho Batholith	< 2%	2	U/M	38	1	NFRC-10	2.20	Monitoring Site	
Idaho Batholith	< 2%	3	C	2			0.10	SWEA-18	Based on confinement
Idaho Batholith	< 2%	3	U/M	20	2	BEAR-19, TINC-21	6.50	Monitoring Site	Average of monitoring sites
Idaho Batholith	< 2%	4	U/M	5	1	RYEC-28	66.00	Monitoring Site	If not adjacent to RYEC-28, use 6.5 from average of BEAR-19 & TINC-21

E2.3.2.2 Middle Rockies Reach Types

In the Middle Rockies Level III Ecoregion, a total 36 monitoring sites were assessed in the field. Monitoring sites were assessed in 9 out of the 20 reach types identified in the Middle Rockies Level III Ecoregion. For reach types with field data, the mean sediment load due to streambank erosion was calculated. For reach types that were not assessed in the field, gradient was the primary factor considered when assigning sediment loads from reach types in which monitoring sites were located. Sediment loads from 1st order streams were assumed to be zero since their relatively small size; steep gradient and coarse streambank material generally tend to limit streambank erosion (**Table E-4**).

Table E-4. Middle Rockies Reach Types and Sediment Loads

Ecoregion III	Gradient	Strahler Stream Order	Confinement	Stream Reach Count	Monitoring Site Count	Field Monitoring Site	Mean Sediment Load per 1000' (Tons/Year)	Justification of Load	Notes
Middle Rockies	> 4%	1	C	21			0	Strahler 1	
Middle Rockies	> 4%	1	U/M	34			0	Strahler 1	
Middle Rockies	> 4%	2	C	22	1	THRE-21	4.80	Monitoring Site	
Middle Rockies	> 4%	2	U/M	48	3	THRE-14, MCCL-15	8.80	Monitoring Site	Average of monitoring sites
Middle Rockies	> 4%	3	C	1			4.90	THRE-21	Based on confinement and gradient
Middle Rockies	> 4%	3	U/M	10			6.27	THRE-14, MCCL-15	Based on confinement and gradient
Middle Rockies	> 4%	4	C	2			4.90	THRE-21	Based on confinement and gradient

Table E-4. Middle Rockies Reach Types and Sediment Loads

Ecoregion III	Gradient	Strahler Stream Order	Confinement	Stream Reach Count	Monitoring Site Count	Field Monitoring Site	Mean Sediment Load per 1000' (Tons/Year)	Justification of Load	Notes
Middle Rockies	2 to < 4%	1	U/M	1		MILR-11	0	Monitoring Site	
Middle Rockies	2 to < 4%	2	C	4			3.75	THRE-21 & SLEE-30	Based on confinement
Middle Rockies	2 to < 4%	2	U/M	39	6	BLOD-49, THRE-16, BASS-24, BASS-27, LICK-19, MILL-43	4.28	Monitoring Site	Average of monitoring sites
Middle Rockies	2 to < 4%	3	C	1			3.75	THRE-21 & SLEE-30	Based on confinement
Middle Rockies	2 to < 4%	3	U/M	33	3	SKAL-13, WILL-28, SKAL-21	8.53	Monitoring Site	Average of field reaches
Middle Rockies	2 to < 4%	4	C	3			3.75	THRE-21 & SLEE-30	Based on confinement
Middle Rockies	2 to < 4%	4	U/M	6	2	SLEE-27, SKAL-36	7.15	Monitoring Site	Average of monitoring sites
Middle Rockies	< 2%	2	C	1			2.60	SLEE-30	Based on confinement and gradient
Middle Rockies	< 2%	2	U/M	35	3	KOOT-52, MILL-50, MILR-21	19.10	Monitoring Site	Average of KOOT-52 & MILR-21
Middle Rockies	< 2%	3	U/M	107	11	AMBR-30, BEAR-30, MILR-28, MILR-33, NBEAR-08, NBFC-11, NBFC-15, SWEA-29, TINC-31/32, LOST-43, WILL-38	16.69	Monitoring Site	Average of monitoring sites
Middle Rockies	<2%	4	C	3	1	SLEE-30	2.60	Monitoring Site	
Middle Rockies	< 2%	4	U/M	63	5	SKAL-48, THRE-35, RYEC-36, SKAL-33, SLEE-44	14.80	Monitoring Site	Average of monitoring sites

E2.3.2.3 Northern Rockies Reach Types

In the Northern Rockies Level III Ecoregion, a total of 4 monitoring sites were assessed in the field. Monitoring sites were assessed in 2 out of the 9 reach types identified in the Northern Rockies Level III Ecoregion. For reach types with field data, the mean sediment load due to streambank erosion was calculated. For reach types that were not assessed in the field, gradient was the primary factor considered when assigning sediment loads from reach types in which monitoring sites were located. Sediment loads from 1st order streams were assumed to be zero since their relatively small size, steep gradient and coarse streambank material generally tend to limit streambank erosion (**Table E-5**).

Table E-5. Northern Rockies Reach Types and Sediment Loads

Ecoregion III	Gradient	Strahler Stream Order	Confinement	Stream Reach Count	Monitoring Ste Count	Field Monitoring Site	Mean Sediment Load per 1000' (Tons/Year)	Justification of Load	Notes
Northern Rockies	> 4%	1	U/M	2			0	Strahler 1	
Northern Rockies	> 4%	1	C	1			0	Strahler 1	
Northern Rockies	> 4%	2	C	6			1.20	SFLO-43	Closest reach
Northern Rockies	> 4%	3	C	2			10.40	LOLO-26, LOLO-34, LOLO-56	Average of monitoring sites
Northern Rockies	2 to < 4%	3	C	1			1.20	SFLO-43	Closest reach
Northern Rockies	2 to < 4%	3	U/M	4	1	SFLO-43	1.20	Monitoring Site	
Northern Rockies	< 2%	3	C	1			1.20	SFLO-43	Closest reach
Northern Rockies	< 2%	3	U/M	5			10.40	LOLO-26, LOLO-34, LOLO-56	Average of monitoring sites
Northern Rockies	< 2%	4	U/M	62	3	LOLO-26, LOLO-34, LOLO-56	10.40	Monitoring Site	Average of monitoring sites

E2.4 SOURCES OF STREAMBANK EROSION

At each eroding bank, the source of streambank erosion was evaluated based on observed anthropogenic disturbances and the surrounding land-use practices. The source of streambank instability was identified based on the following near-stream source categories:

- Transportation
- Riparian grazing
- Cropland
- Mining
- Silviculture
- Irrigation-shifts in stream energy

- Natural sources
- Other

For example, an eroding streambank in a heavily grazed area in which all the willows had been removed was assigned a source of "100% riparian grazing", while an eroding streambank due to road encroachment upstream was assigned a source of "100% transportation". Naturally eroding streambanks were considered the result of "natural sources". 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.

Streambank erosion sources identified along a monitoring site were extrapolated directly to the stream reach in which the monitoring site was located. For stream reaches in which no monitoring site was located, streambank erosion sources were assigned based on a review of land-use practices as observed in color aerial imagery from 2005. Streambank erosion sources at the stream segment scale were derived from the sources identified along the individual stream reaches within the stream segment. Streambank erosion sources for the stream segment's watershed were assumed to be the same as those along the stream segment and were assigned equal percentages as identified for the stream segment. A more detailed review of streambank erosion sources is provided in **Section B3**.

E2.5 ACTIVELY AND SLOWLY ERODING STREAMBANKS

As discussed in the introduction, streambank erosion assessments were conducted over two monitoring timeframes: June/August and October/November. During the June/August monitoring timeframe, only "actively/visually" eroding streambanks were assessed in the field, while during the October/November monitoring timeframe, sites were assessed for both "actively/visually" eroding streambanks and for "slowly eroding/undercut/vegetated" streambanks. The bank erosion assessment methodology was refined between these two timeframes to provide for a better estimate of the "total" sediment load. However, this resulted in an underestimated sediment load for sites assessed during the June/August monitoring timeframe since "slowly eroding/undercut/vegetated" banks were not included. To "normalize" the June/August data, the average sediment load due to streambank erosion from "slowly eroding/undercut/vegetated" banks at sites from October/November was determined and added to the sites assessed during the June/August monitoring timeframe.

During the October/November monitoring timeframe, a total of 23 monitoring sites were assessed. "Slowly eroding/undercut/vegetated" banks were measured along 19 of the monitoring sites, while two sites had no bank erosion and two sites had only "actively/visually" eroding banks. Out of these 23 monitoring sites, a total of 107 "slowly eroding/undercut/vegetated" were assessed, with a mean height of 2.8 feet. Within these monitoring sites, "slowly eroding/undercut/vegetated" streambanks comprised an average of 22.7%, or 454 feet of bank per 1,000 feet of stream (2,000 feet of bank). Due to the stable nature of these streambanks, they were assigned a Bank Erosion Hazard Index (BEHI) score of low and a NBS score of very low, which results in a retreat rate of 0.02 feet per year (Rosgen 1996). Based on this retreat rate, an average sediment load of 1.2 tons/year was estimated to be derived from "slowly eroding/undercut/vegetated" per 1,000 feet of stream within the Bitterroot TPA. This value was added to monitoring sites assessed during the June/August monitoring timeframe and assigned as a natural source of sediment for extrapolation purposes.

E3.0 SEDIMENT LOADING DUE TO STREAMBANK EROSION

Sediment load calculations and estimates at the monitoring site, stream reach, stream segment and watershed scales are presented in the following sections.

E3.1 MONITORING SITE SEDIMENT LOADS

A total sediment load of 758 tons/year was attributed to eroding streambanks within the monitoring sites (**Table E-6**). Approximately 60% of the sediment load due to streambank erosion at the monitoring sites was due to anthropogenic sources, while approximately 40% was due to natural sources. Monitoring site assessments suggest that riparian grazing and cropland are the greatest anthropogenic contributors of sediment loads due to streambank erosion in the Bitterroot TPA, followed by the "other" category, which primarily describes impacts due to residential and commercial encroachment within the watershed, but also includes riprap, upstream channelization or land uses, recreation, and historical agriculture.

Table E-6. Summary of Monitoring Site Sediment Loads

Source	Sediment Load (Tons/Year)	Sediment Load (Percent)
Transportation	40	5.3
Riparian Grazing	170	22.4
Cropland	127	16.7
Mining	0	0
Silviculture	13	1.6
Irrigation	17	2.3
Natural Sources	306	40.4
Other	86	11.3
Total	**758**	**100**
Anthropogenic	**452**	**59.6**
Natural	**306**	**40.4**

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 E-7** in descending order, while sediment loads for each monitoring site are presented by source in **Table E-8**. Mean BEHI scores, length of eroding bank, percent of eroding bank, and the estimated potential Rosgen stream type are also presented for each monitoring site in **Table E-7**. This assessment indicates that a substantial portion of the sediment load due to streambank erosion is derived from relatively few monitoring sites, with 9 monitoring sites on 8 stream segments providing 65% (495 tons/year) of the total sediment load, including the following stream segments:

- Mill Creek (MILL-50)
- Rye Creek (RYEC-28)
- Miller Creek (MILL-28)
- Skalkaho Creek (SKAL-48)
- Sweathouse Creek (SWEA-29)
- North Burnt Fork Creek (NBFC-11, NBFC-15)
- Kootenai Creek (KOOT-52)

Table E-7. Monitoring Site Sediment Loads due to Streambank Erosion

Stream Segment	ReachID	Estimated Potential Rosgen Stream Type	Mean BEHI Score	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)
Mill	MILL-50	C4	34.0	456	1000	22.8	125.3	125.3
Rye	RYEC-28	B3/4c	39.4	298	1000	14.9	66.0	66.0
Miller	MILR-28	F4, B4c	29.0	950	1000	47.5	39.9	39.9
Skalkaho	SKAL-48	C3	26.5	672	2000	16.8	73.2	36.6
Sweathouse	SWEA-29	C4	36.1	390	1000	19.5	35.1	35.1
Threemile	THRE-35	C4	29.5	511	1000	25.6	33.8	33.8
North Burnt Fork	NBFC-11	C3	34.0	337	1000	16.9	31.9	31.9
Kootenai	KOOT-52	B3,B3c	30.6	681	2000	17.0	62.0	31.0
North Burnt Fork	NBFC-15	C3/4	35.9	416	1000	20.8	27.8	27.8
Bear	BEAR-30	C3	55.8	43	1000	2.2	18.0	18.0
Willow	WILL-28	B4	36.0	121	1000	6.1	15.0	15.0
Lolo	LOLO-56	C4	33.2	242	2000	6.1	29.0	14.5
Lolo	LOLO-26	B4c,C4	37.2	221	2000	5.5	27.0	13.5
Threemile	THRE-16	C4, B4c	28.7	409	500	40.9	6.7	13.3
Skalkaho	SKAL-36	C3/4, C3/4/b	30.4	1455	2000	36.4	26.6	13.3
McClain	MCCL-15	E4,E4b	34.9	254	500	25.4	6.5	12.9
North Fork Rye	NFRC-22	B4	41.7	74	1000	3.7	11.2	11.2
North Bear	NBEAR-08	C3	24.4	119	1000	6.0	11.0	11.0
Miller	MILR-33	C4,E4	40.5	104	1000	5.2	10.1	10.1
Rye	RYEC-14	B4, C4b	21.5	295	500	29.5	4.3	8.6
Blodgett	BLOD-49	B3c	30.7	63	1000	3.2	7.6	7.6
Miller	MILR-21	C4,E4	38.1	66	1000	3.3	7.2	7.2
Tin Cup	TINC-21	C4, B4c	18.3	2620	2000	65.5	14.2	7.1
Rye	RYEC-16	B4	26.7	330	1000	16.5	7.1	7.1
Skalkaho	SKAL-21	B3/4	17.2	1647	1000	82.4	6.1	6.1
Bear	BEAR-19	B3	14.3	1095	1000	54.8	5.9	5.9
Ambrose	AMBR-30	E4	37.9	52	500	5.2	2.6	5.2
Threemile	THRE-21	B4, B4c	29.4	135	500	13.5	2.5	4.9
Threemile	THRE-14	B4, B4c	27.8	217	500	21.7	2.4	4.7
Skalkaho	SKAL-13	B4, C4b	18.0	882	1000	44.1	4.5	4.5
Lick	LICK-08	B4	16.0	500	500	50.0	1.9	3.8
Lolo	LOLO-34	C3/4	33.9	45	2000	1.1	6.4	3.2
Sleeping Child	SLEE-30	B3/4	19.9	190	1000	9.5	2.6	2.6
Blodgett	BLOD-35	B3	12.4	670	1000	33.5	2.5	2.5
Tin Cup	TINC-31/32	B3,B3c	20.9	100	2000	2.5	4.4	2.2
North Fork Rye	NFRC-10	C4	19.6	195	500	19.5	1.1	2.2
North Fork Rye	NFRC-12	B3/4	17.7	245	1000	12.3	1.5	1.5
Bass	BASS-24	B3			1000		1.2	1.2
Bass	BASS-27	B3c			1000		1.2	1.2
Lick	LICK-19	E4b,B4			500		0.6	1.2
Lost Horse	LOST-43	C3,B3			2000		2.4	1.2
Mill	MILL-43	C3b,B3			1000		1.2	1.2
Miller	MILR-11	B4			500		0.6	1.2
Rye	RYEC-36	C4			1000		1.2	1.2
South Fork Lolo	SFLO-43	B3			1000		1.2	1.2
Skalkaho	SKAL-33	B3, B3c			2000		2.4	1.2
Sleeping Child	SLEE-44	C3,B3c			1000		1.2	1.2
Willow	WILL-38	C4			1000		1.2	1.2
Sleeping Child	SLEE-27	B3	13.0	225	1000	11.3	1.0	1.0
Lost Horse	LOST-33	B3	18.4	365	2000	9.1	1.6	0.8
Roaring Lion	ROLI-24	B3	15.7	110	1000	5.5	0.7	0.7
Sweathouse	SWEA-18	A2/3	12.6	55	1000	2.8	0.1	0.1
Blodgett	BLOD-42	A2, B2		0	1000		0.0	0.0
Lost Horse	LOST-15	B3			1000		0.0	0.0

Table E-8. Monitoring Site Sediment Loads from Individual Sources due to Streambank Erosion

Stream Segment	Reach ID	Monitoring Site Length		Transportation Load (Tons/Year)	Riparian Grazing Load (Tons/Year)	Cropland Load (Tons/Year)	Mining Load (Tons/Year)	Silviculture Load (Tons/Year)	Irrigation Load (Tons/Year)	Natural Load (Tons/Year)	"Other" Load (Tons/Year)	Total Load
Ambrose Creek	AMBR-30	500	Total	0.0	0.1	0.0	0.0	0.0	0.0	0.9	1.7	2.6
			Percent	0	3	0	0	0	0	33	64	
Bass Creek	BASS-24	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	1.2
			Percent	0	0	0	0	0	0	100	0	
Bass Creek	BASS-27	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	1.2
			Percent	0	0	0	0	0	0	100	0	
Bear Creek	BEAR-19	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	5.9	0.0	5.9
			Percent	0	0	0	0	0	0	100	0	
Bear Creek	BEAR-30	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	9.6	8.4	18.0
			Percent	0	0	0	0	0	0	53	47	
Blodgett Creek	BLOD-35	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	2.5
			Percent	0	0	0	0	0	0	100	0	
Blodgett Creek	BLOD-42	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			Percent	0	0	0	0	0	0	0	0	
Blodgett Creek	BLOD-49	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	2.5	5.1	7.6
			Percent	0	0	0	0	0	0	33	68	
Kootenai Creek	KOOT-52	2000	Total	0.0	0.0	0.0	0.0	0.0	0.0	61.9	0.0	62.0
			Percent	0	0	0	0	0	0	100	0	
Lick Creek	LICK-08	500	Total	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.0	1.9
			Percent	0	0	0	0	0	0	100	0	
Lick Creek	LICK-19	500	Total	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.6
			Percent	0	0	0	0	0	0	100	0	
Lolo Creek	LOLO-26	2000	Total	22.2	0.0	0.0	0.0	0.0	0.0	4.9	0.0	27.0
			Percent	82	0	0	0	0	0	18	0	
Lolo Creek	LOLO-34	2000	Total	0.4	0.0	0.0	0.0	2.8	0.0	3.2	0.0	6.4
			Percent	6	0	0	0	44	0	50	0	
Lolo Creek	LOLO-56	2000	Total	0.0	0.0	0.0	0.0	0.0	0.0	21.0	8.0	29.0
			Percent	0	0	0	0	0	0	72	28	
Lost Horse Creeek	LOST-15	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
			Percent	0	0	0	0	0	0	0	0	
Lost Horse Creeek	LOST-33	2000	Total	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	1.6
			Percent	0	0	0	0	0	0	100	0	
Lost Horse Creeek	LOST-43	2000	Total	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	2.4
			Percent	0	0	0	0	0	0	100	0	
McClain Creek	MCCL-15	500	Total	0.0	5.3	0.0	0.0	0.0	0.0	1.2	0.0	6.5
			Percent	0	82	0	0	0	0	18	0	
Mill Creek	MILL-43	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	1.2
			Percent	0	0	0	0	0	0	100	0	
Mill Creek	MILL-50	1000	Total	0.0	0.0	91.2	0.0	0.0	0.0	30.1	4.0	125.3
			Percent	0	0	73	0	0	0	24	3	
Miller Creek	MILR-11	500	Total	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.6
			Percent	0	0	0	0	0	0	100	0	
Miller Creek	MILR-21	1000	Total	0.6	3.0	0.0	0.0	0.6	0.0	3.0	0.0	7.2
			Percent	8	42	0	0	8	0	42	0	
Miller Creek	MILR-28	1000	Total	0.0	13.0	0.0	0.0	0.0	8.0	18.9	0.0	39.9
			Percent	0	33	0	0	0	20	47	0	
Miller Creek	MILR-33	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	1.2	8.9	10.1
			Percent	0	0	0	0	0	0	12	88	
North Bear Creek	NBEAR-08	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	7.1	3.9	11.0
			Percent	0	0	0	0	0	0	64	36	
North Bunt Fork Creek	NBFC-11	1000	Total	9.1	21.3	0.0	0.0	0.0	0.0	1.5	0.0	31.9
			Percent	29	67	0	0	0	0	5	0	
North Bunt Fork Creek	NBFC-15	1000	Total	0.0	24.1	0.0	0.0	0.0	2.5	1.2	0.0	27.8
			Percent	0	87	0	0	0	9	4	0	

Table E-8. Monitoring Site Sediment Loads from Individual Sources due to Streambank Erosion

Stream Segment	Reach ID	Monitoring Site Length		Transportation Load (Tons/Year)	Riparian Grazing Load (Tons/Year)	Cropland Load (Tons/Year)	Mining Load (Tons/Year)	Silviculture Load (Tons/Year)	Irrigation Load (Tons/Year)	Natural Load (Tons/Year)	"Other" Load (Tons/Year)	Total Load
North Fork Rye Creek	NFRC-10	500	Total	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	1.1
			Percent	0	0	0	0	0	0	100	0	
North Fork Rye Creek	NFRC-12	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0	1.5
			Percent	0	0	0	0	0	0	100	0	
North Fork Rye Creek	NFRC-22	1000	Total	0.0	1.4	8.3	0.0	0.0	0.0	1.5	0.0	11.2
			Percent	0	12	74	0	0	0	13	0	
Roaring Lion Creek	ROLI-24	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.7
			Percent	0	0	0	0	0	0	100	0	
Rye Creek	RYEC-14	500	Total	0.0	0.0	0.0	0.0	0.0	4.3	0.0	0.0	4.3
			Percent	0	0	0	0	0	101	0	0	
Rye Creek	RYEC-16	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	7.1	0.0	7.1
			Percent	0	0	0	0	0	0	100	0	
Rye Creek	RYEC-28	1000	Total	0.0	23.5	23.5	0.0	9.0	0.0	8.7	0.0	66.0
			Percent	0	36	36	0	15	0	14	0	
Rye Creek	RYEC-36	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	1.2
			Percent	0	0	0	0	0	0	100	0	
Skalkaho Creek	SKAL-13	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0	4.5
			Percent	0	0	0	0	0	0	100	0	
Skalkaho Creek	SKAL-21	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	6.1	0.0	6.1
			Percent	0	0	0	0	0	0	100	0	
Skalkaho Creek	SKAL-33	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	2.4
			Percent	0	0	0	0	0	0	100	0	
Skalkaho Creek	SKAL-36	2000	Total	0.0	19.8	0.0	0.0	0.0	0.0	6.7	0.0	26.6
			Percent	0	75	0	0	0	0	25	0	
Skalkaho Creek	SKAL-48	2000	Total	6.5	7.3	0.0	0.0	0.0	0.0	31.3	28.2	73.2
			Percent	9	10	0	0	0	0	43	39	
Sleeping Child Creek	SLEE-27	2000	Total	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
			Percent	0	0	0	0	0	0	100	0	
Sleeping Child Creek	SLEE-30	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	2.6
			Percent	0	0	0	0	0	0	100	0	
Sleeping Child Creek	SLEE-44	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	1.2
			Percent	0	0	0	0	0	0	100	0	
South Fork Lolo Creek	SFLO-43	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	1.2
			Percent	0	0	0	0	0	0	100	0	
Sweathouse Creek	SWEA-18	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
			Percent	0	0	0	0	0	0	100	0	
Sweathouse Creek	SWEA-29	1000	Total	0.0	28.3	0.0	0.0	0.0	2.5	1.2	3.1	35.1
			Percent	0	81	0	0	0	7	3	9	
Threemile Creek	THRE-14	500	Total	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	2.4
			Percent	0	0	0	0	0	0	100	0	
Threemile Creek	THRE-16	500	Total	1.2	4.8	0.0	0.0	0.0	0.0	0.7	0.0	6.6
			Percent	18	73	0	0	0	0	11	0	
Threemile Creek	THRE-21	500	Total	0.1	0.1	0.0	0.0	0.0	0.0	2.2	0.0	2.4
			Percent	4	4	0	0	0	0	92	0	
Threemile Creek	THRE-35	1000	Total	0.0	14.0	0.0	0.0	0.0	0.0	5.3	14.5	33.8
			Percent	0	41	0	0	0	0	16	43	
Tin Cup Creek	TINC-21	2000	Total	0.0	0.0	0.0	0.0	0.0	0.0	14.2	0.0	14.2
			Percent	0	0	0	0	0	0	100	0	
Tin Cup Creek	TINC-31/32	2000	Total	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	4.4
			Percent	0	0	0	0	0	0	100	0	
Willow Creek	WILL-28	1000	Total	0.0	3.5	3.5	0.0	0.0	0.0	8.1	0.0	15.0
			Percent	0	23	23	0	0	0	54	0	
Willow Creek	WILL-38	1000	Total	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	1.2
			Percent	0	0	0	0	0	0	100	0	

E3.2 STREAM REACH SEDIMENT LOADS

Sediment loads calculated at the monitoring site scale were extrapolated to the stream reach scale based on the Aerial Assessment Database. First, the monitoring site sediment load was extrapolated directly to the stream reach in which it was located. Second, the mean sediment load was calculated for each stream reach type in which one or more monitoring sites were located. This mean "reach type" sediment load was then assigned to each reach of that type. Finally, for stream reach types in which no monitoring site was located, sediment loads were extrapolated from reach types exhibiting the most similarity to the un-assessed reach types (see **Tables B-3, B-4** and **B-5).** This decision was based on several factors as described in **Section B2.4**, including the information in the Aerial Assessment Database, a review of 2005 color aerial imagery in GIS, and best professional judgment based on site-specific knowledge acquired during the monitoring site assessment process. This process was performed individually for each reach, with sediment loads assigned to each observed source based on the overall estimated reach load. Data extrapolated to the stream reach scale is presented in the Streambank Erosion Database in the Streambank Erosion Source Assessment (PBS&J 2008).

E3.3 STREAM SEGMENT SEDIMENT LOADS

Stream segment sediment loads were estimated based on the cumulative sediment load of the stream reaches within the stream segment. Sediment loads were estimated for a total of 360.9 miles along 23 stream segments. A total sediment load of 15,639 tons/year was attributed to eroding streambanks at the stream segment scale (**Table E-9**). Approximately 49% of the sediment load due to streambank erosion at the stream segment scale was due to anthropogenic sources, while approximately 51% was due to natural sources. Stream segment sediment loading estimates indicate that riparian grazing, cropland, transportation and "other" (residential and commercial encroachment) are the greatest anthropogenic contributors of sediment loads due to streambank erosion in the Bitterroot TPA. Sediment loads due to streambank erosion for each stream segment are provided for each source in **Table E-10**.

Table E-9. Summary of Stream Segment Sediment Loads

Source	Sediment Load (Tons/Year)	Sediment Load (Percent)
Transportation	1,268	8.1
Riparian Grazing	2,438	15.6
Cropland	1,913	12.2
Mining	36	0.2
Silviculture	78	0.5
Irrigation	299	1.9
Natural Sources	7,947	50.9
Other	1,661	10.6
Total	**15,639**	**100**
Anthropogenic	**7,692**	**49.1**
Natural	**7,947**	**50.9**

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

Stream Segment	Stream Segment Length (Miles)	Sediment Load	Sources								Total Load (Tons/Year)	Total Load per Mile (Tons/Year)	Total Load per 1000 Feet (Tons/Year)
			Transportation	Riparian Grazing	Cropland	Mining	Silviculture	Irrigation - shifts in stream energy	Natural Sources	Other			
Ambrose Creek	12.7	Tons/Year	40.5	107.4	173.4	0.0	0.0	0.0	120.5	44.6	486.4	38.3	7.3
		Percent	*8%*	*22%*	*36%*	*0%*	*0%*	*0%*	*25%*	*9%*			
Bass Creek	10.0	Tons/Year	2.7	9.8	0.0	0.0	0.0	0.9	107.7	5.2	126.3	12.7	2.4
		Percent	*2%*	*8%*	*0%*	*0%*	*0%*	*1%*	*85%*	*4%*			
Bear Creek	20.2	Tons/Year	27.8	64.1	0.0	0.0	0.0	9.2	563.5	189.8	854.3	42.2	8.0
		Percent	*3%*	*8%*	*0%*	*0%*	*0%*	*1%*	*66%*	*22%*			
Blodgett Creek	18.7	Tons/Year	14.5	59.3	32.1	33.7	0.0	13.8	251.5	52.7	457.6	24.5	4.6
		Percent	*3%*	*13%*	*7%*	*7%*	*0%*	*3%*	*55%*	*12%*			
Kootenai Creek	13.5	Tons/Year	4.9	25.6	0.8	0.0	0.0	16.1	277.0	59.2	383.5	28.4	5.4
		Percent	*1%*	*7%*	*0%*	*0%*	*0%*	*4%*	*72%*	*15%*			
Lick Creek	6.4	Tons/Year	10.0	30.8	0.0	0.0	0.0	0.0	73.8	2.2	116.9	18.3	3.5
		Percent	*9%*	*26%*	*0%*	*0%*	*0%*	*0%*	*63%*	*2%*			
Lolo Creek	31.5	Tons/Year	367.7	196.8	60.6	0.0	36.4	40.9	886.3	153.1	1741.7	55.3	10.5
		Percent	*21%*	*11%*	*3%*	*0%*	*2%*	*2%*	*51%*	*9%*			
Lost Horse Creek	19.6	Tons/Year	27.8	23.3	0.0	0.0	0.0	7.3	468.5	4.3	531.2	27.1	5.1
		Percent	*5%*	*4%*	*0%*	*0%*	*0%*	*1%*	*88%*	*1%*			
McClain Creek	5.4	Tons/Year	15.4	29.5	8.0	2.0	0.0	5.2	21.6	0.0	81.7	15.3	2.9
		Percent	*19%*	*36%*	*10%*	*2%*	*0%*	*6%*	*26%*	*0%*			
Mill Creek	19.1	Tons/Year	23.5	178.2	527.6	0.0	0.0	1.0	495.3	76.4	1302.1	68.1	12.9
		Percent	*2%*	*14%*	*41%*	*0%*	*0%*	*0%*	*38%*	*6%*			
Miller Creek	18.3	Tons/Year	82.9	201.5	362.4	0.0	0.7	30.1	429.5	249.8	1356.8	74.0	14.0
		Percent	*6%*	*15%*	*27%*	*0%*	*0%*	*2%*	*32%*	*18%*			
Muddy Springs Creek	2.0	Tons/Year	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
		Percent	*100%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*			
North Burnt Fork Creek	10.9	Tons/Year	68.7	402.1	132.2	0.0	0.0	24.3	227.2	84.5	939.0	85.8	16.3
		Percent	*7%*	*43%*	*14%*	*0%*	*0%*	*3%*	*24%*	*9%*			
North Fork Rye Creek	7.1	Tons/Year	11.0	2.7	12.1	0.0	1.8	0.0	63.4	5.0	95.9	13.5	2.6
		Percent	*11%*	*3%*	*13%*	*0%*	*2%*	*0%*	*66%*	*5%*			
Roaring Lion Creek	15.0	Tons/Year	2.4	4.4	0.0	0.0	0.0	0.0	277.0	1.3	285.1	19.0	3.6
		Percent	*1%*	*2%*	*0%*	*0%*	*0%*	*0%*	*97%*	*0%*			
Rye Creek	17.5	Tons/Year	38.9	84.2	53.5	0.0	13.4	21.5	450.0	3.1	664.6	38.0	7.2
		Percent	*6%*	*13%*	*8%*	*0%*	*2%*	*3%*	*68%*	*0%*			
Skalkaho Creek	27.7	Tons/Year	82.1	286.6	125.0	0.0	0.0	16.5	1069.9	148.7	1728.7	62.4	11.8
		Percent	*5%*	*17%*	*7%*	*0%*	*0%*	*1%*	*62%*	*9%*			
Sleeping Child Creek	24.9	Tons/Year	22.4	99.5	66.2	0.0	25.5	13.6	417.9	22.3	667.3	26.8	5.1
		Percent	*3%*	*15%*	*10%*	*0%*	*4%*	*2%*	*63%*	*3%*			
South Fork Lolo Creek	14.9	Tons/Year	2.2	10.2	0.0	0.0	0.0	0.0	236.0	0.0	248.4	16.7	3.2
		Percent	*1%*	*4%*	*0%*	*0%*	*0%*	*0%*	*95%*	*0%*			
Sweathouse Creek	11.2	Tons/Year	10.3	320.3	5.5	0.0	0.0	30.8	170.8	80.0	617.6	55.3	10.5
		Percent	*2%*	*52%*	*1%*	*0%*	*0%*	*5%*	*28%*	*13%*			
Threemile Creek	18.0	Tons/Year	357.4	84.2	214.8	0.0	0.0	21.1	471.4	312.5	1461.4	81.1	15.4
		Percent	*24%*	*6%*	*15%*	*0%*	*0%*	*1%*	*32%*	*21%*			
Tin Cup Creek	16.2	Tons/Year	16.1	23.9	6.9	0.0	0.0	11.9	436.4	58.2	553.3	34.2	6.5
		Percent	*3%*	*4%*	*1%*	*0%*	*0%*	*2%*	*79%*	*11%*			
Willow Creek	20.1	Tons/Year	38.8	193.6	132.1	0.0	0.0	34.6	432.0	108.4	939.4	46.6	8.8
		Percent	*4%*	*21%*	*14%*	*0%*	*0%*	*4%*	*46%*	*12%*			

E3.4 WATERSHED SEDIMENT LOADS

Watershed sediment loads were estimated for the Bitterroot TPA based on the total length of stream within the watershed. The Bitterroot TPA includes the entire Bitterroot River watershed from the confluence of the East Fork Bitterroot River and West Fork Bitterroot River downstream to the Confluence with the Clark Fork River. The Bitterroot TPA also includes the Lolo Creek watershed from the confluence of the East Fork Lolo Creek and West Fork Lolo Creek downstream to the confluence with the Bitterroot River. In addition, the Upper Lolo TPA, which extends from the headwaters downstream to the confluence of the East Fork Lolo Creek and West Fork Lolo Creek, was also included in this assessment.

Watershed sediment loads were estimated from the sum of the sediment loads at the stream segment scale combined with an estimate of sediment loads from un-assessed streams. Assessed streams include 360.9 miles of stream segments described in the Aerial Assessment Database, while un-assessed streams were identified using a modified version of the USGS National Hydrography Dataset (NHD) in which irrigation ditches were removed. The modified NHD layer indicates there are 2,397.2 miles of stream within the Bitterroot TPA. Thus, a total of 2,036.3 miles of stream were not included in the Aerial Assessment Database.

Sediment loading along the 2,036.3 miles of un-assessed streams was evaluated using the 25th percentile of sediment loading from the entire dataset. Based on the 25th percentile of the entire dataset at the stream segment scale, an annual sediment load of 18.6 tons/mile was estimated to be the average rate of streambank erosion within the Bitterroot TPA. This value is equivalent to 3.5 tons/year of sediment input from every 1,000 feet of stream. Based on the estimated sediment load of 18.6 tons per mile, eroding streambanks along the 2,036.3 un-assessed miles of stream in the Bitterroot TPA are estimated to contribute 37,875 tons of sediment per year (**Table E-11**). The total sediment load for the Bitterroot TPA is estimated at 53,514 tons/year. Sediment loads for individual watersheds are provided in **Table E-12**.

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

Stream Length (Miles)	Length of Stream Assessed using Aerial Imagery (Miles)	Length of Stream Un-assessed (Miles)	Estimated Sediment Load for Assessed Streams (Tons/Year)	Estimated Sediment Load for Un-assessed Streams based on Stream Segment Extrapolation (18.6 Tons/Mile/Year)	Total Sediment Load (Tons/Year)
2,397.2	360.9	2,036.3	15,639	37,875	53,514

In addition to the 53,514 tons/year estimated for the Bitterroot TPA, which includes the Lolo Creek watershed, a sediment load of 21,059 tons/year was estimated for the Bitterroot Headwaters TPA based on an estimated sediment load of 18.6 tons/mile/year and 1,132.23 miles of stream. Thus, a total sediment load of 74,574 tons/year is estimated for the entire Bitterroot River watershed.

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

Stream Segment	Stream Segment Length (Miles)	Sediment Load	Sources								Total Load (Tons/Year)	Total Load per Mile (Tons/Year)	Total Load per 1000 Feet (Tons/Year)
			Transportation	Riparian Grazing	Cropland	Mining	Silviculture	Irrigation - shifts in stream energy	Natural Sources	Other			
Ambrose Creek	38.1	Tons/Year	79.9	211.7	341.9	0.0	0.0	0.0	237.6	87.9	959.0	25.2	4.8
		Percent	*8%*	*22%*	*36%*	*0%*	*0%*	*0%*	*25%*	*9%*			
Bass Creek	16.1	Tons/Year	5.2	18.7	0.0	0.0	0.0	1.7	205.2	9.9	240.6	14.9	2.8
		Percent	*2%*	*8%*	*0%*	*0%*	*0%*	*1%*	*85%*	*4%*			
Bear Creek	36.1	Tons/Year	36.9	86.6	0.0	0.0	0.0	12.4	758.3	255.9	1150.0	31.9	6.0
		Percent	*3%*	*8%*	*0%*	*0%*	*0%*	*1%*	*66%*	*22%*			
Blodgett Creek	36.6	Tons/Year	24.1	102.8	53.4	55.9	0.0	22.9	435.1	94.9	791.1	21.6	4.1
		Percent	*3%*	*13%*	*7%*	*7%*	*0%*	*3%*	*55%*	*12%*			
Kootenai Creek	40.5	Tons/Year	11.4	59.1	1.7	0.0	0.0	37.3	639.8	136.6	885.9	21.9	4.1
		Percent	*1%*	*7%*	*0%*	*0%*	*0%*	*4%*	*72%*	*15%*			
Lick Creek	9.8	Tons/Year	15.5	47.5	0.0	0.0	0.0	0.0	113.9	3.4	180.3	18.4	3.5
		Percent	*9%*	*26%*	*0%*	*0%*	*0%*	*0%*	*63%*	*2%*			
Lolo Creek (including South Fork Lolo Creek)	332.2	Tons/Year	1548.3	828.6	255.2	0.0	153.3	172.2	3732.2	644.7	7334.5	22.1	4.2
		Percent	*21%*	*11%*	*3%*	*0%*	*2%*	*2%*	*51%*	*9%*			
Lost Horse Creek	40.7	Tons/Year	48.4	41.4	0.0	0.0	0.0	12.8	813.6	7.4	923.6	22.7	4.3
		Percent	*5%*	*4%*	*0%*	*0%*	*0%*	*1%*	*88%*	*1%*			
McClain Creek	7.0	Tons/Year	21.2	40.5	11.1	2.7	0.0	7.1	29.8	0.0	112.4	16.1	3.0
		Percent	*19%*	*36%*	*10%*	*2%*	*0%*	*6%*	*26%*	*0%*			
Mill Creek	71.0	Tons/Year	41.0	310.3	918.7	0.0	0.0	1.8	862.4	133.1	2267.2	31.9	6.0
		Percent	*2%*	*14%*	*41%*	*0%*	*0%*	*0%*	*38%*	*6%*			
Miller Creek	56.9	Tons/Year	126.7	308.0	554.0	0.0	1.1	46.0	656.5	381.8	2074.0	36.4	6.9
		Percent	*6%*	*15%*	*27%*	*0%*	*0%*	*2%*	*32%*	*18%*			
Muddy Springs Creek	2.0	Tons/Year	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
		Percent	*100%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*			
North Burnt Fork Creek	107.0	Tons/Year	199.4	1167.2	383.7	0.0	0.0	70.5	659.6	245.3	2725.7	25.5	4.8
		Percent	*7%*	*43%*	*14%*	*0%*	*0%*	*3%*	*24%*	*9%*			
North Fork Rye Creek	26.8	Tons/Year	52.8	13.1	58.5	0.0	8.7	0.0	305.6	24.0	462.7	17.3	3.3
		Percent	*11%*	*3%*	*13%*	*0%*	*2%*	*0%*	*66%*	*5%*			
Roaring Lion Creek	28.3	Tons/Year	4.6	8.1	0.0	0.0	0.0	0.0	516.6	2.4	531.7	18.8	3.6
		Percent	*1%*	*2%*	*0%*	*0%*	*0%*	*0%*	*97%*	*0%*			
Rye Creek (including North Fork Rye Creek)	85.8	Tons/Year	113.4	245.0	155.6	0.0	39.1	62.6	1310.4	9.1	1935.2	22.6	4.3
		Percent	*6%*	*13%*	*8%*	*0%*	*2%*	*3%*	*68%*	*0%*			
Skalkaho Creek	135.9	Tons/Year	177.7	620.2	270.4	0.0	0.0	35.6	2315.4	321.7	3741.1	27.5	5.2
		Percent	*5%*	*17%*	*7%*	*0%*	*0%*	*1%*	*62%*	*9%*			
Sleeping Child Creek	117.4	Tons/Year	80.1	355.9	236.9	0.0	91.2	48.5	1495.0	79.6	2387.2	20.3	3.9
		Percent	*3%*	*15%*	*10%*	*0%*	*4%*	*2%*	*63%*	*3%*			
South Fork Lolo Creek	60.1	Tons/Year	9.7	44.5	0.0	0.0	0.0	0.0	1035.7	0.0	1090.0	18.1	3.4
		Percent	*1%*	*4%*	*0%*	*0%*	*0%*	*0%*	*95%*	*0%*			
Sweathouse Creek	33.7	Tons/Year	17.2	537.7	9.3	0.1	0.0	51.6	286.7	134.3	1036.9	30.8	5.8
		Percent	*2%*	*52%*	*1%*	*0%*	*0%*	*5%*	*28%*	*13%*			
Threemile Creek (including Ambrose Creek)	120.6	Tons/Year	824.1	194.1	495.2	0.0	0.0	48.6	1087.0	720.6	3369.6	27.9	5.3
		Percent	*24%*	*6%*	*15%*	*0%*	*0%*	*1%*	*32%*	*21%*			
Tin Cup Creek	42.7	Tons/Year	32.5	48.4	13.9	0.0	0.0	24.0	811.7	115.6	1046.2	24.5	4.6
		Percent	*3%*	*5%*	*1%*	*0%*	*0%*	*2%*	*78%*	*11%*			
Willow Creek	61.3	Tons/Year	70.4	351.4	239.8	0.0	0.0	62.7	784.0	196.8	1705.0	27.8	5.3
		Percent	*4%*	*21%*	*14%*	*0%*	*0%*	*4%*	*46%*	*12%*			

E4.0 POTENTIAL SEDIMENT LOAD REDUCTIONS

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

E4.1 STREAMBANK EROSION REDUCTION

To estimate a potential decrease in sediment loading due to improved streambank stability, BEHI values in the existing dataset for each streambank that exceeded the “moderate” category were reduced to “moderate”. The results of this model are presented in **Table E-13** for the individual monitoring sites. Reductions calculated at the monitoring site scale were extrapolated to the stream segment scale using the Aerial Assessment Database (**Table E-14**). This reduction often resulted in a “moderate BEHI/low NBS” combination for an expected retreat rate of 0.17 feet/year. Through BMPs, the actual length and height of eroding bank could also be reduced, which would lead to further reductions in sediment loading.

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

Stream Segment	ReachID	Sediment Loading from Monitoring Sites (Tons/Year)	Sediment Loading from 1000' of Stream (Tons/Year)	Sediment Loading from Monitoring Sites with Moderate BEHI (Tons/Year)	Sediment Loading from 1000' of Stream with Moderate BEHI (Tons/Year)
Ambrose Creek	AMBR-30	2.6	5.2	1.3	2.5
Bass Creek	BASS-24	1.2	1.2	1.2	1.2
Bass Creek	BASS-27	1.2	1.2	1.2	1.2
Bear Creek	BEAR-19	5.9	5.9	5.9	5.9
Bear Creek	BEAR-30	18.0	18.0	7.1	7.1
Blodgett Creek	BLOD-35	2.5	2.5	2.5	2.5
Blodgett Creek	BLOD-42	0.0	0.0	0.0	0.0
Blodgett Creek	BLOD-49	7.6	7.6	3.3	3.3
Kootenai Creek	KOOT-52	62.0	31.0	47.1	23.5
Lick Creek	LICK-08	1.9	3.8	1.9	3.8
Lick Creek	LICK-19	0.6	1.2	0.6	1.2
Lolo Creek	LOLO-26	27.0	13.5	10.3	5.2
Lolo Creek	LOLO-34	6.4	3.2	4.5	2.3
Lolo Creek	LOLO-56	29.0	14.5	10.9	5.5
Lost Horse Creek	LOST-15	0.0	0.0	0.0	0.0
Lost Horse Creek	LOST-33	1.6	0.8	1.6	0.8
Lost Horse Creek	LOST-43	2.4	1.2	2.4	1.2
McClain Creek	MCCL-15	6.5	12.9	3.7	7.5
Mill Creek	MILL-43	1.2	1.2	1.2	1.2
Mill Creek	MILL-50	125.3	125.3	66.1	66.1
Miller Creek	MILR-11	0.6	1.2	0.6	1.2
Miller Creek	MILR-21	7.2	7.2	3.1	3.1
Miller Creek	MILR-28	39.9	39.9	21.2	21.2
Miller Creek	MILR-33	10.1	10.1	4.1	4.1
North Bear Creek	NBEAR-08	11.0	11.0	11.0	11.0
North Burnt Fork Creek	NBFC-11	31.9	31.9	12.3	12.3
North Burnt Fork Creek	NBFC-15	27.8	27.8	10.4	10.4
North Fork Rye Creek	NFRC-10	1.1	2.2	1.1	2.2
North Fork Rye Creek	NFRC-12	1.5	1.5	1.5	1.5
North Fork Rye Creek	NFRC-22	11.2	11.2	4.4	4.4
Roaring Lion Creek	ROLI-24	0.7	0.7	0.7	0.7
Rye Creek	RYEC-14	4.3	8.6	4.3	8.6
Rye Creek	RYEC-16	7.1	7.1	7.1	7.1
Rye Creek	RYEC-28	66.0	66.0	25.1	25.1
Rye Creek	RYEC-36	1.2	1.2	1.2	1.2
South Fork Lolo Creek	SFLO-43	1.2	1.2	1.2	1.2
Skalkaho Creek	SKAL-13	4.5	4.5	4.5	4.5
Skalkaho Creek	SKAL-21	6.1	6.1	6.1	6.1
Skalkaho Creek	SKAL-33	2.4	1.2	2.4	1.2
Skalkaho Creek	SKAL-36	26.6	13.3	22.4	11.2
Skalkaho Creek	SKAL-48	73.2	36.6	62.2	31.1
Sleeping Child Creek	SLEE-27	1.0	1.0	1.0	1.0
Sleeping Child Creek	SLEE-30	2.6	2.6	2.6	2.6
Sleeping Child Creek	SLEE-44	1.2	1.2	1.2	1.2
Sweathouse Creek	SWEA-18	0.1	0.1	0.1	0.1
Sweathouse Creek	SWEA-29	35.1	35.1	12.9	12.9
Threemile Creek	THRE-14	2.4	4.7	2.4	4.7
Threemile Creek	THRE-16	6.7	13.3	6.7	13.3
Threemile Creek	THRE-21	2.5	4.9	2.5	4.9
Threemile Creek	THRE-35	33.8	33.8	12.9	12.9
Tin Cup Creek	TINC-21	14.2	7.1	14.2	7.1
Tin Cup Creek	TINC-31/32	4.4	2.2	4.4	2.2
Willow Creek	WILL-28	15.0	15.0	5.6	5.6
Willow Creek	WILL-38	1.2	1.2	1.2	1.2

Table E-14. Potential Sediment Load Reduction from Stream Segments with BEHI Reduced to "Moderate"

Stream Segment	Total Load (Tons/Year)	Total Load with "Moderate" BEHI (Tons/Year)	Total Load due to Anthropogenic Sources (Tons/Year)	Total Load with "Moderate" BEHI due to Anthropogenic Sources (Tons/Year)	Potential Reduction in Anthropogenic Sediment Load with "Moderate" BEHI	Percent Reduction in Anthropogenic Sediment Load with "Moderate" BEHI
Ambrose Creek	486.4	315.8	365.9	215.9	150.0	41%
Bass Creek	126.3	115.0	18.6	15.5	3.1	17%
Bear Creek	854.3	531.0	290.8	158.1	132.7	46%
Blodgett Creek	457.6	345.9	206.1	124.1	82.0	40%
Kootenai Creek	383.5	302.8	106.6	71.0	35.5	33%
Lick Creek	116.9	92.3	43.1	30.6	12.5	29%
Lolo Creek	1741.7	723.6	855.4	355.8	499.7	58%
Lost Horse Creek	531.2	412.3	62.6	37.4	25.2	40%
McClain Creek	81.7	73.4	60.0	52.4	7.7	13%
Mill Creek	1302.1	817.2	806.8	460.9	345.9	43%
Miller Creek	1356.8	748.3	927.3	517.7	409.6	44%
Muddy Springs Creek	0.1	0.0	0.1	0.0	0.1	100%
North Burnt Fork Creek	939.0	442.1	711.7	327.7	384.0	54%
North Fork Rye Creek	95.9	72.2	32.6	19.7	12.9	40%
Roaring Lion Creek	285.1	260.2	8.1	6.8	1.3	16%
Rye Creek	664.6	513.1	214.6	130.5	84.1	39%
Skalkaho Creek	1728.7	1175.5	658.8	455.6	203.2	31%
Sleeping Child Creek	667.3	501.0	249.4	166.1	83.3	33%
South Fork Lolo Creek	248.4	191.3	12.4	5.8	6.6	54%
Sweathouse Creek	617.6	322.8	446.9	187.2	259.6	58%
Threemile Creek	1461.4	776.0	989.9	478.1	511.8	52%
Tin Cup Creek	553.3	374.9	116.9	61.0	55.9	48%
Willow Creek	939.4	533.7	507.5	252.5	255.0	50%

E5.0 REFERENCES

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