ATTACHMENT C – UNPAVED ROADS ASSESSMENT

Thompson TMDL Project Area:
Road Sediment Assessment & Modeling

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1.0 INTRODUCTION

An assessment of the road network within the Thompson TMDL Project Area (Project Area) was performed as part of the development of sediment TMDLs for 303(d) listed stream segments with sediment as a documented impairment. This assessment employed GIS, field data collection, and sediment modeling to assess sediment inputs from the unpaved road network. In addition, because undersized and improperly installed and maintained culverts can be a substantial source of sediment to streams and a barrier to fish and other aquatic organisms, potential loading from undersized culverts was also evaluated, along with an evaluation of fish passage at assessed crossings.

1.1 SEDIMENT IMPAIRMENTS

The Thompson Project Area includes three TMDL Planning Areas (TPAs): the Thompson TPA, a portion of the Lower Flathead TPA, and a portion of the Middle Clark Fork Tributaries TPA. Within the Thompson Project Area, there are nine water body segments listed on the 2012 303(d) List for sediment-related impairments (**Table 1-1**). McGinnis Creek, Lazier Creek, Little Thompson River, and McGregor Creek are listed as impaired due to sediment in the Thompson TPA, while Henry Creek, Lynch Creek and Swamp Creek are listed as impaired due to sediment in the Middle Clark Fork Tributaries TPA. The Little Bitterroot River and Sullivan Creek are listed as impaired due to sediment in the Lower Flathead TPA.

Table 1-1. Waterbody Segments Addressed during the Road Assessment

TPA	List ID	Waterbody Description
Thompson	MT76N005_070	MCGINNIS CREEK, headwaters to mouth (Little Thompson River)
Thompson	MT76N005_060	LAZIER CREEK, headwaters to mouth (Thompson River)
Thompson	MT76N005_040	LITTLE THOMPSON RIVER, headwaters to mouth (Thompson River), T22N R25W S8
Thompson	MT76N005_030	McGREGOR CREEK, McGregor Lake to mouth (Thompson River)
Middle Clark Fork Tributaries	MT76N003_170	HENRY CREEK, headwaters to mouth (Clark Fork River), T19N R26W S1
Middle Clark Fork Tributaries	MT76N003_010	LYNCH CREEK, headwaters to mouth (Clark Fork River)
Middle Clark Fork Tributaries	MT76N003_160	SWAMP CREEK, West Fork Swamp Creek to mouth (Clark Fork River), T20N R27W S3
Lower Flathead	MT76L002_060	LITTLE BITTERROOT RIVER, Hubbart Reservoir to Flathead Reservation Boundary
Lower Flathead	MT76L002_070	SULLIVAN CREEK, headwaters to Flathead Indian Reservation

2.0 METHODS

Methods employed in this assessment are outlined in *Quality Assurance Project Plan and Sampling and Analysis Plan: Assessment of Unpaved Roads for TMDL Development (Task Order 18: Task 2b)* (EPA 2011) and *Road Sediment Assessment and Modeling: Thompson Area TMDL Planning Area Road GIS Layers and Summary Statistics* (Atkins 2011) and summarized below.

2.1 SEDIMENT INPUTS FROM UNPAVED ROADS

Sediment inputs from unpaved roads were evaluated through a combination of GIS analysis, field data collection and computer modeling.

2.1.1 GIS Analysis

Prior to field data collection, GIS data layers representing land ownership, road attributes, stream network, watersheds, and ecoregions were used to summarize the road network in the Thompson Project Area (Atkins 2011). Because unpaved road crossings and near-stream parallel segments are the most likely sources of sediment loading to streams from the road network, the GIS analysis focused on these areas. Land ownership was divided into five categories: U.S. Forest Service, U.S. Fish and Wildlife Service, Montana Fish, Wildlife and Parks, Montana State Trust Lands, and Private. The roads layer was primarily derived from the Travel Routes for Region 1 geodatabase developed by the U.S. Forest Service and available from the Northern Region Geospatial Library (http://www.fs.fed.us/r1/gis/), supplemented with the State of Montana Base Map Service Center Transportation Framework Theme data. Following the initial GIS analysis, Jurisdiction was assigned to each unpaved road crossing based on information in the U.S Forest Service Travel Routes for Region 1 layer and the Montana Public Lands layer. Stream layers were developed using the National Hydrography Dataset (NHD) 1:24,000 high-resolution flowline layer. The high-resolution NHD layer was used because it is the most conservative (i.e., inclusive) stream network layer. Flowlines were limited to streams/rivers and artificial paths; ditches and pipelines were not included. Watersheds were delineated on the basis of the USGS 6th Hydrologic Unit Code (HUC12) layer and modified where necessary to delineate the subwatersheds of interest (**Figure 2-1**). Landscapes were delineated according to the EPA 2002 level IV ecoregions (Woods, et al., 2002) (**Figure 2-2**). These GIS layers were utilized to develop a database of stream crossings and parallel road segments that includes land ownership, road surface type, subwatershed, and ecoregion attributes in one attribute table.

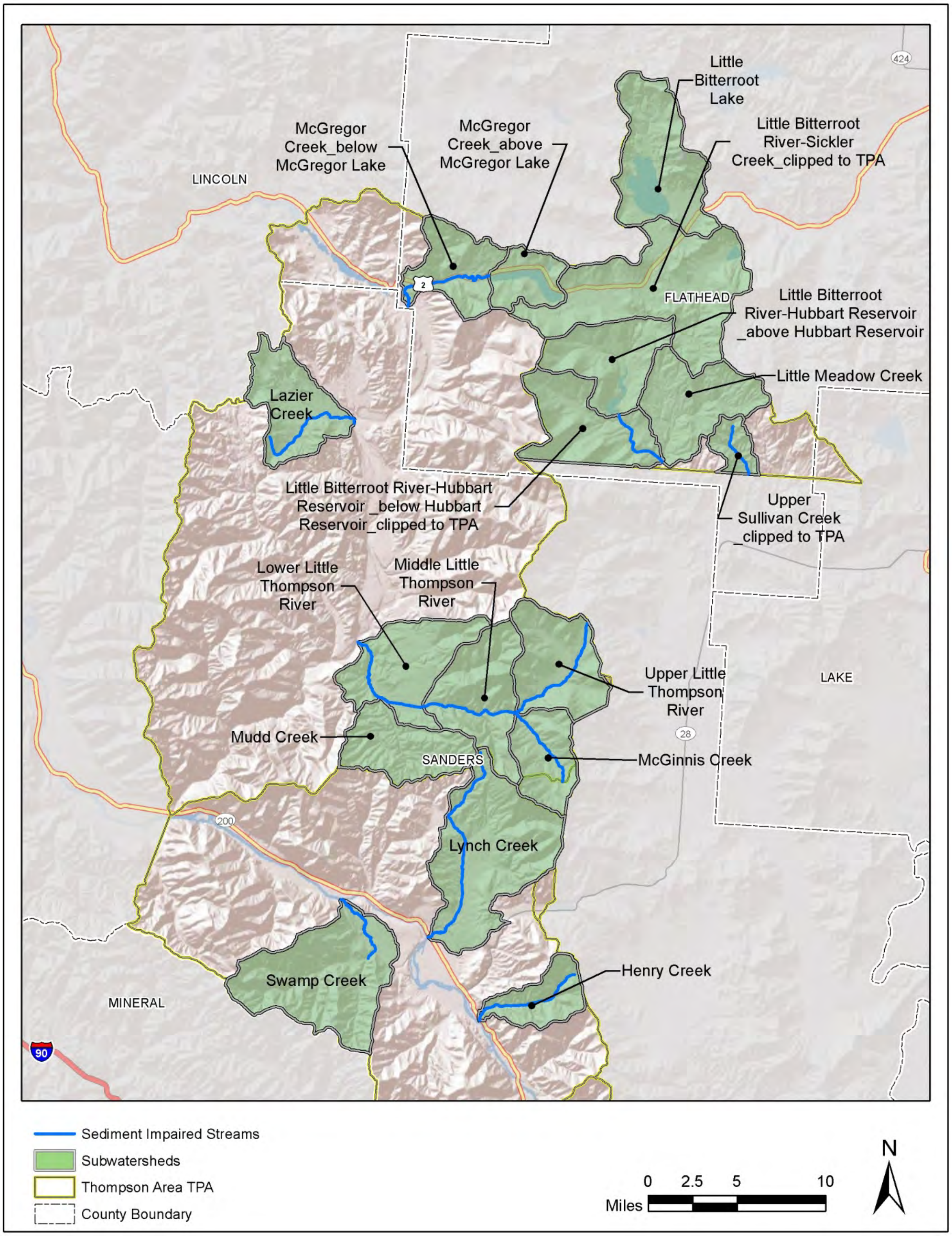

Figure 2-1. HUC12 Subwatersheds in the Thompson Project Area

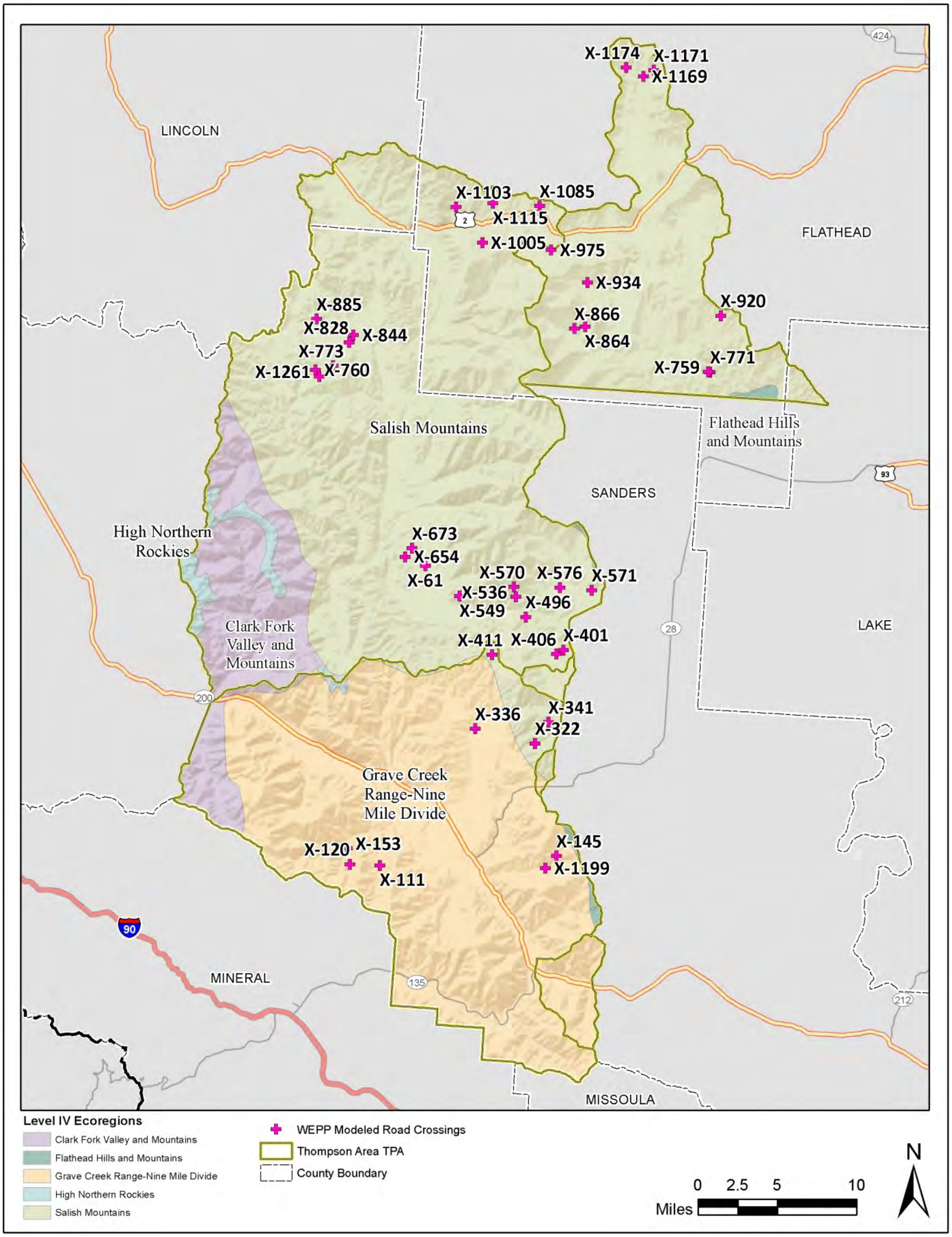

Figure 2-2. Level IV Ecoregions in the Thompson Project Area

Overall, GIS analysis identified 1,671 miles of road within the Thompson Area Project Area, with all but 37 miles (2.2%) being unpaved. Of the 1,494 road crossings identified within the Thompson Project Area, 1,211 were unpaved (gravel or native material) based on attribute information contained in the GIS roads database (**Figure 2-3**). An additional 253 crossings were identified with an 'unknown' surface type, but based attributes of proximal road segments they are also likely to be unpaved. Therefore, there are an estimated total of 1,464 unpaved road crossings in the Thompson Project Area (**Table 2-1**). Approximately 42% of the crossings are on roads administered by the USFS, with the remainder being a mix of private, state, and county (**Table 2-2**).

Based on the analysis of near-stream parallel road segments, 78 miles (4.7%) are within 150 feet of a stream channel, and 61 of those miles are unpaved road segments (**Figure 2-4**). An additional 16 miles were classified as 'unknown' based on attribute information in the GIS roads database, the majority of which are likely unpaved.

Table 2-1. Road Surface Types in the Thompson Project Area

Road Surface Type	Number of Crossings based on GIS Attribute Information	Number of Crossings Re-classified based on Attributes of Proximal Road Segments	Total Number of Crossings
Paved	30		30
Gravel	164	10	174
Native	1,047	243	1,290
Unknown	253		
Total Crossings	**1,494**	**253**	**1,494**
Total Unpaved Crossings	**1,211**	**253**	**1,464**

Table 2-2. Jurisdiction for Unpaved Road Crossings

Jurisdiction	Number of Crossings Identified in GIS
County	113
Federal	601
Private	694
State	56
Total	**1,464**

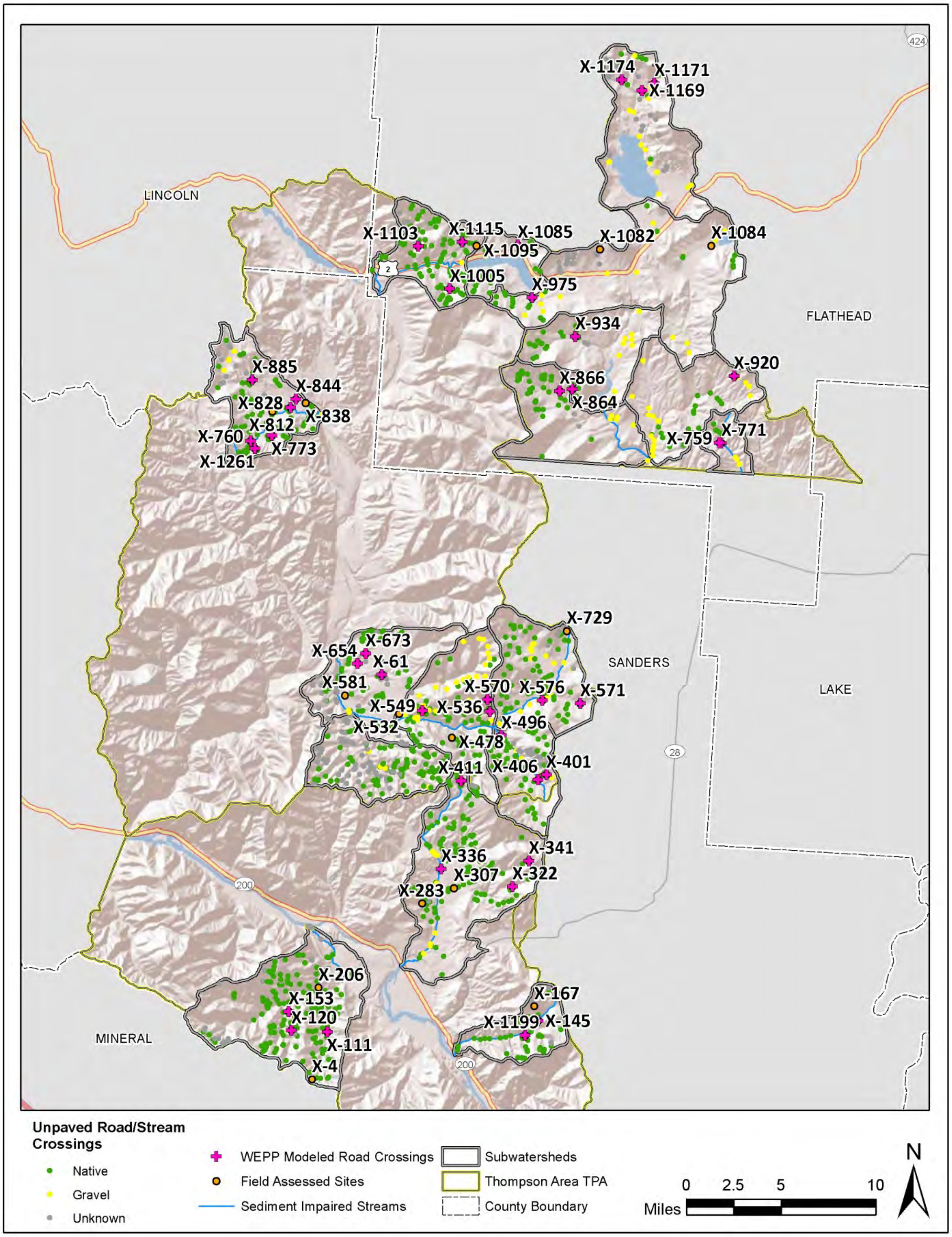

Figure 2-3. Unpaved Road Crossings and Road Surface Type in the Thompson Project Area

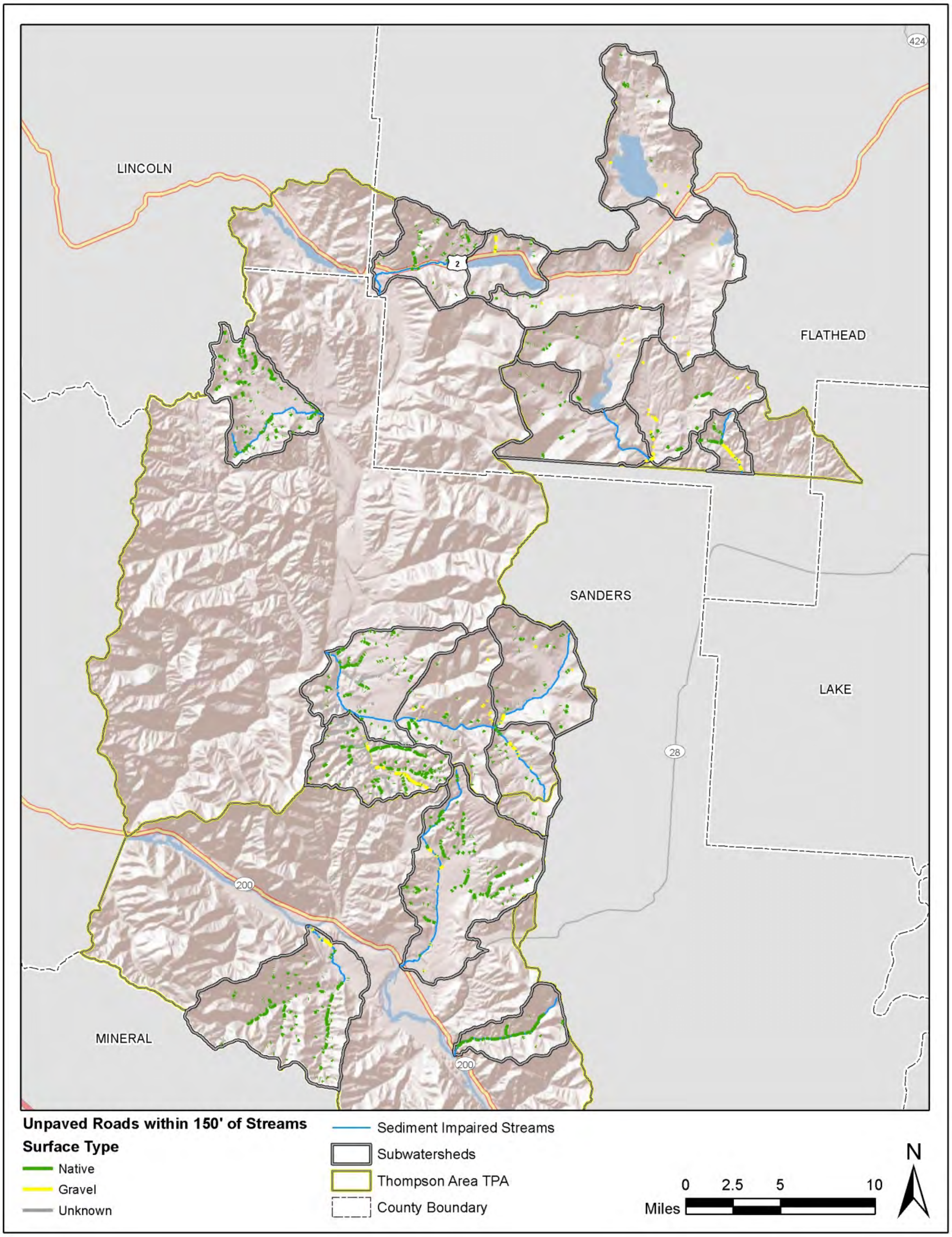

Figure 2-4. Unpaved Parallel Road Segments and Road Surface Type in the Thompson Project Area

2.1.2 Field Data Collection

A field assessment of unpaved roads was conducted by performing an inspection of road crossings and parallel road segments throughout the Thompson Project Area in September and October of 2011. For each unpaved crossing, a series of measurements were performed to characterize road design, maintenance level, condition, culvert size, and sediment loading potential. Measurements included the length, gradient, and width of road contributing sediment from each side of a stream crossing. Additional information was collected describing road design, road surface type, soil type, rock content, traffic level, and the presence of any Best Management Practices (BMPs).

2.1.2.1 Crossing Assessment Sites

Sixty crossing assessment sites were randomly selected for field data collection. Field measurements included the length, gradient, and width of road contributing sediment from each side of a stream crossing. Additional information was collected describing road design, road surface type, soil type, rock content, traffic level, and the presence of any BMPs, while notes were made regarding road condition at all sites visited. Since the high-resolution NHD layer used to identify road crossings includes intersections of roads with intermittent and ephemeral channels that may not be conduits for road-related sediment, many of the randomly selected sites lacked an actual crossing when visited in the field. As outlined in the project QAPP (EPA 2011), crossings randomly chosen for field assessment that did not have a defined channel (and were unlikely to be pathways for road-related sediment) were excluded from field measurements, and the percentage of randomly selected field sites that had an undefined channel relative to the total number of randomly selected field sites were later factored into the extrapolation process.

Out of the 60 pre-selected crossing assessment sites, 52 crossings were visited in the field in September and October 2011 and field forms were completed at 39 sites. Of the 52 sites visited, 13 crossings lacked defined stream channels, had become re-vegetated due to road closures, or were inaccessible due to road closures; no measurements were taken at these sites, but notes were made regarding road condition. In addition, measurements were taken and field forms completed at one alternate crossing site, while no data was collected at a second alternate site visited because it lacked a defined channel. Therefore, out of the 54 crossing assessment sites (i.e., 52 + 2 alternates), field forms were completed at a total of 40 unpaved road crossings, and those data were used in the Water Erosion Prediction Project (WEPP) soil erosion model (**Figures 2-2** and **2-3**). Of the remaining 14 sites, 12 had no defined stream channel, while two were at bridges that were not assessed (**Attachment A**).

2.1.2.2 Parallel Road Segment Assessment Sites

To account for the contribution of sediment from road segments parallel to the stream, field data collected at unpaved road crossings in which there was at least five feet of buffer on both the left and right sides of the crossings were used as a surrogate. A total of 14 of the unpaved road crossings out of the 40 crossings modeled in WEPP had at least five feet of buffer on both the left and right sides, with buffer distances ranging from five feet to 200 feet.

2.1.3 WEPP Modeling

Sediment loading from unpaved road crossings was estimated using the WEPP:Road soil erosion model version 2011.12.20 (http://forest.moscowfsl.wsu.edu/fswepp/). WEPP:Road is an interface to the Water Erosion Prediction Project (WEPP) model developed by the U.S. Forest Service and other agencies, and is used to predict runoff, erosion, and sediment delivery from forest roads. The WEPP:Road model predicts sediment yields based on specific soil, climate, ground cover, and topographic conditions. Field data collected from each field assessed site provided the following input data necessary to run the WEPP:Road model:

- Road design: insloped, bare ditch; insloped, vegetated or rocked ditch; outsloped, rutted; outsloped unrutted
- Road surface: native, graveled, paved
- Traffic level: high, low, none
- Soil texture: clay loam, silt loam, sandy loam, loam
- Rock content
- Gradient, length and width of the road, fill and buffer
- Climate data
- Years to simulate

The WEPP:Road model was used to evaluate existing conditions at each road crossing based on the field collected data. The WEPP:Road model was also used to estimate the potential to reduce sediment loads through the application of BMPs. During field data collection, the location of potential BMPs, such as water bars and rolling dips, were identified and the distance to the stream crossing was measured. During the BMP modeling scenario, the contributing road length was reduced from the existing length to the potential BMP length based on the field measured values.

2.1.3.1 Model Input Parameters

Road condition data collected throughout the Thompson Project Area in September and October of 2011 were input directly into the WEPP:Road model following guidance outlined in *WEPP Interface for Predicting Forest Road Runoff, Erosion and Sediment Delivery Technical Documentation*, which is available on the Internet at http://forest.moscowfsl.wsu.edu/fswepp/docs/wepproaddoc.html (**Attachment B**). In addition to field collected data, the WEPP:Road model requires the selection of a climate station to provide an estimate of mean annual precipitation. The WEPP:Road model contains 55 custom climate stations for Montana. Out of these 55 custom climate stations, three were selected in northwest Montana to represent the range of precipitation conditions at field assessed sites in the Thompson Project Area: KALISPELL WB AP MT, LIBBY 1 NE RS MT, and TROUT CREEK RS MT. Precipitation in the Thompson Project Area ranges from 14” to 55” annually based on data collected from 1971 to 2000 and compiled by the PRISM Group at Oregon State University (http://nris.mt.gov/nsdi/nris/precip71_00.html) (**Figure 2-5**). Road crossing assessments in the Thompson Project Area were conducted at sites located in precipitation zones ranging from 16” to 38”, which covers over 95% of the unpaved road crossings identified in GIS. Because precipitation is a significant factor in erosion, road assessment sites were grouped into two precipitation zones for streams in the Lower Flathead TPA (<20” and > 20”) and four precipitation zones for streams in the Thompson TPA and the Middle Clark Fork Tributaries TPA (<20”, 20-26”, 26-30”, and >30”). In order to improve the representation of conditions within each precipitation zone, all assessed road sites were modeled in WEPP:Road for each precipitation zone. It is assumed that the range of road conditions associated with all of the sites visited would be seen throughout the watershed, and is not dependent on the precipitation zone. Therefore, modeling the entire data set in each precipitation zone provides a better estimate for the range of sediment production that would be seen for that zone. In the Lower Flathead TPA, the KALISPELL WB AP MT climate station was used, while in the Thompson TPA and the Middle Clark Fork Tributaries TPA, both the LIBBY 1 NE RS MT and the TROUT CREEK RS MT climate stations were applied. The mean precipitation values at the selected climate stations were adjusted where necessary to approximate the mean values within each precipitation zone as presented in **Table 2-3** and **Figure 2-5**.

Table 2-3. Precipitation Data Applied in the WEPP:Road Model

Climate Station	Mean Precipitation (Inches)	Percent Adjustment	Adjusted Mean Precipitation (inches)	PRISM Precipitation Zone (Inches)
Lower Flathead TPA				
KALISPELL WB AP MT	15.43	0	n/a	<20
KALISPELL WB AP MT	15.43	50	23.15	>20
Thompson TPA / Middle Clark Fork Tributaries TPA				
LIBBY 1 NE RS MT	17.18	0	n/a	<20
TROUT CREEK RS MT	28.58	-20	22.87	20-26
TROUT CREEK RS MT	28.58	0	n/a	26-30
TROUT CREEK RS MT	28.58	20	34.30	>30

2.1.4 Potential Culvert Failures

A coarse assessment for each culvert was performed on-site to calculate its conveyance capacity and the amount of sediment at-risk for eroding into the stream channel during culvert failure. The assessment included measurements of structure type, structure diameter, and structure gradient, bankfull width upstream of the culvert, fill height, fill length, fill width, outlet invert, and the presence of streambed materials in the culvert. At each culvert assessed in the field, flood frequencies for the 2, 5, 10, 25, 50, and 100-year events were determined based on the bankfull width upstream of the culvert using U.S. Geological Survey Montana Region regression equations (Parrett and Johnson, 1998). The Urban Drainage and Flood Control District Sewer and Culvert Hydraulics Version 2.0 (http://www.udfcd.org/) spreadsheet model was then utilized to establish the flow capacity of each field assessed culvert. The amount of sediment contributed during a culvert failure was calculated conservatively, assuming that culvert failure would erode sediment to a width equal to the bankfull width of the stream channel upstream of the culvert. For this analysis, an estimated soil weight of 1.66 tons/yard^3 was utilized based on the maximum unit weight for dry well-graded subangular sand presented in Table 1:4 of *Introductory Soil Mechanics and Foundations: Geotechnical Engineering Forth Edition* (Sowers 1979).

2.2 Fish Passage Analysis

Measurements were collected at each of the field assessed road crossing sites, and these values were used to determine if culverts represented potential fish passage barriers at various flow conditions. The fish passage evaluation was completed using the criteria listed in Table 1 of the document *A Summary of Technical Considerations to Minimize the Blockage of Fish at Culverts on National Forests in Alaska* (USFS 2002). The analysis uses site-specific information to classify culverts as green (passing all lifestages of salmonids), red (partial or total barrier to salmonids), or grey (needs additional analysis). Indicators used in the classification are the ratio of the culvert width to bankfull width (constriction ratio), culvert slope, and outlet drop, with large diameter (>48 in) and small (<48 in) culvert groups evaluated differently. Failure of any one of the three indicators results in a red classification.

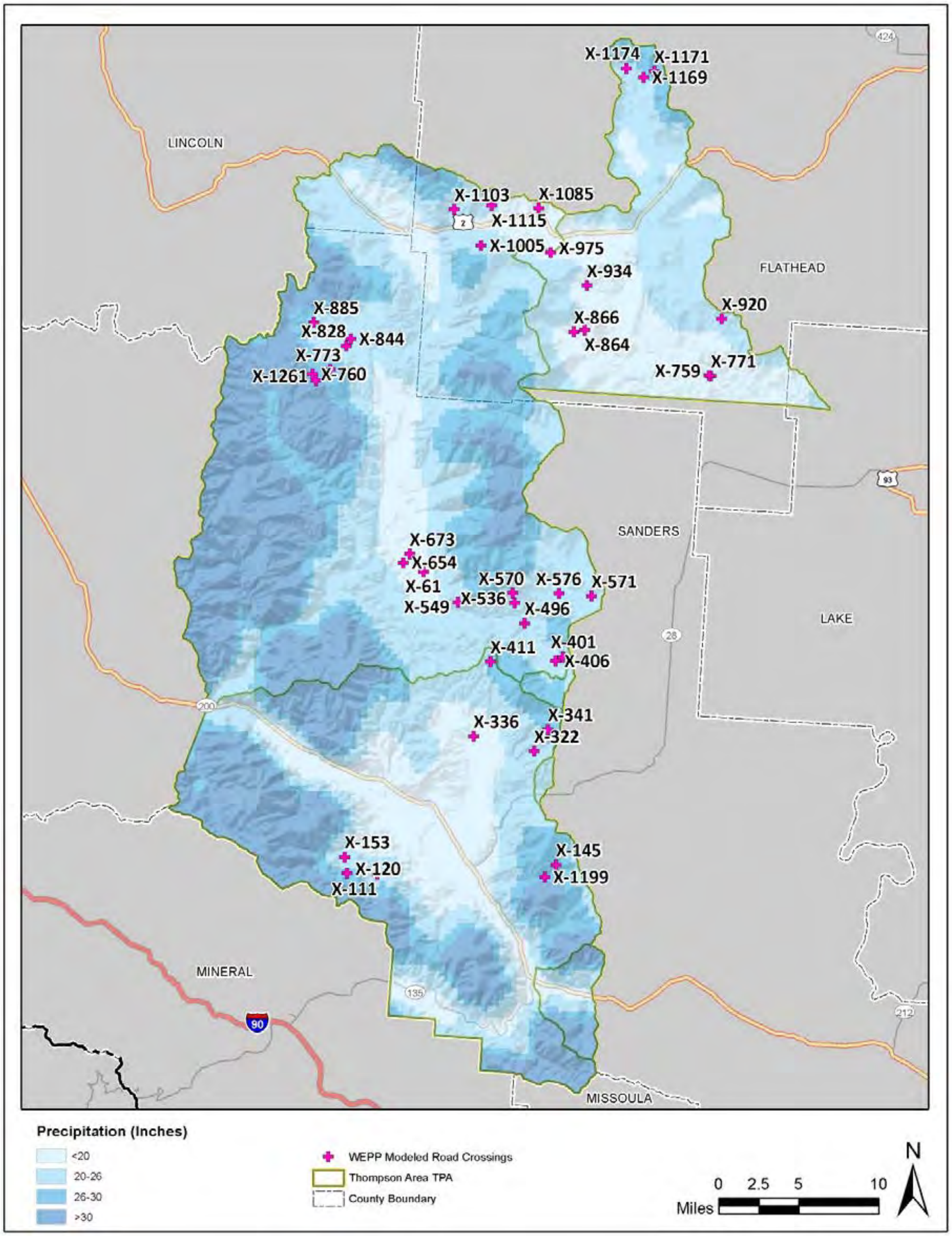

Figure 2-5. Precipitation Patterns in the Thompson Project Area

3.0 RESULTS

3.1 SEDIMENT INPUTS FROM UNPAVED ROADS

The results of the field and WEPP modeling assessment examining sediment loading from roads to streams within the Thompson Project Area are presented in the following sections.

3.1.1 Summary of BMPs and Contributing Length

Because allocations for sediment TMDLs are based on improving management practices, identifying the current practices and areas where improvements are needed is a significant component of the unpaved roads assessment. Out of the 40 unpaved crossings modeled using WEPP:Road, potential BMPs were identified at 20 crossings, while sufficient BMPs were observed at 20 crossings (**Attachment B**). The most common BMPs observed were rolling dips and water bars. Both of these BMPs interrupt the flow of water, reducing the amount of road surface that water can erode as it moves towards the stream channel (i.e., the contributing length). The contributing length was evaluated separately for each side of a crossing and the average contributing length at sites where all reasonable BMPs have been implemented was 70 feet. During the field assessment, 20 crossings had insufficient BMPs. At each of the 20 crossings with insufficient BMPs, the optimal location (i.e., distance from the stream) of BMP placement to reduce contributing length was identified. This technique incorporated conditions specific to this project area and allowed for loads at each site to be modeled under a BMP scenario to determine achievable reductions in sediment loading from unpaved roads. The average contributing length at the sites needing additional BMPs was 319 feet (**Table 3-1**), and based on field measurements, BMPs could reduce the average contributing length to 101 feet. Although a reduction in contributing length was used for the BMP scenario for the model, other BMPs for unpaved roads include design and siting considerations of topography, soils, and stream crossings; routine maintenance; seasonal usage modification; and filter strips.

Table 3-1. Contributing Road Lengths at Sites with the Potential for Additional BMPs

GIS Site ID	Segment of Road Contributing Sediment (Facing Downstream)	Existing Contributing Length (Feet)	BMP Contributing Length (Feet)	Percent Reduction in Contributing Length
X-401 (F)	Left	324	119	63%
X-496 (F)	Left	180	100	44%
X-496 (F)	Right	190	60	68%
X-571 (F)	Left	750	70	91%
X-571 (F)	Right	417	67	84%
X-576 (F)	Left	200	90	55%
X-576 (F)	Right	160	70	56%
X-336 (C)	Left	150	70	53%
X-336 (C)	Right	410	300	27%
X-341 (F)	Left	225	125	44%
X-341 (F)	Right	570	100	82%
X-773 Segment 2 (P)	Left	300	45	85%
X-654 (P)	Left	232	132	43%
X-111 (F)	Left	550	100	82%
X-1199 (F)	Left	235	105	55%
X-1085 (P)	Left	295	60	80%
X-975 (S)	Left	250	50	80%
X-975 (S)	Right	385	145	62%
X-759 (C)	Left	190	80	58%
X-1174 (F)	Left	158	86	46%
X-1174 (F)	Right	100	40	60%
X-570 (F)	Right	1,000	300	70%
X-411 (F)	Right	621	120	81%
X-549 (P)	Right	218	100	54%
X-1103 (F)	Right	250	50	80%
X-1171 (F)	Right	130	50	62%
X-866 (P)	Right	132	100	24%
Average		**319**	**101**	**68%**

F = Federal, P = Private, C = County, S = State

3.1.2 WEPP Modeled Sediment Loads at Unpaved Road Crossings

The average load per crossing was used during the extrapolation process to estimate sediment loading associated with road crossings at a watershed scale. Unpaved road sediment loads were initially grouped by precipitation zone for modeling, but then the output was evaluated to determine the most appropriate approach for extrapolation. Considerations included ecoregion, precipitation zone, and jurisdiction. The approach selected for the Thompson TPA and Middle Clark Fork TPA was to use the four precipitation zones but to group the crossings into two categories based on jurisdiction: Unpaved road crossings with federal jurisdiction were grouped into one category and those with private, county, or state jurisdiction were grouped into a second category. This distinction between jurisdictions was made based on a review of the WEPP outputs for road crossing sediment production; the data appeared to show consistently higher sediment loads from sites managed by federal land than from those not. The approach for the Lower Flathead TPA was to use two precipitation zones for the Flathead TPA and group all the crossings together. All crossings were combined in the Lower Flathead because no discernible difference in severity of sediment loading appeared to be distinguishable from the sites modeled in this part of the project area. WEPP:Road model results for the two jurisdiction categories are presented by precipitation zone in **Attachment C** and summarized in **Table 3-2** and **Figure 3-1**. As expected, loads for both jurisdictional categories increase with increasing precipitation zone.

Table 3-2. Unpaved Road Crossing Mean Annual Sediment Loads

TPA	Jurisdiction	PRISM Precipitation Zone (Inches)	Number of Sites Assessed	Mean Annual Load (Tons)	Standard Error (Tons)	Minimum (Tons)	Maximum (Tons)	Mean Annual Load with BMP's (Tons)	Standard Error (Tons)	Minimum (Tons)	Maximum (Tons)
Lower Flathead	All	<20	10	0.0028	0.0008	0.0000	0.0059	0.0021	0.0007	0.0000	0.0059
	All	>20	10	0.0027	0.0008	0.0000	0.0062	0.0022	0.0007	0.0000	0.0062
Thompson/ Middle Clark Fork Tributaries	Federal	<20	17	0.0703	0.0213	0.0010	0.2756	0.0186	0.0048	0.0010	0.0658
	Federal	20-26	17	0.0824	0.0257	0.0009	0.3057	0.0190	0.0053	0.0005	0.0777
	Federal	26-30	17	0.1069	0.0335	0.0025	0.4201	0.0230	0.0056	0.0023	0.0836
	Federal	>30	17	0.1223	0.0388	0.0028	0.5170	0.0259	0.0066	0.0021	0.0990
Thompson/ Middle Clark Fork Tributaries	Private	<20	13	0.0103	0.0043	0.0000	0.0428	0.0050	0.0023	0.0000	0.0271
	Private	20-26	13	0.0177	0.0089	0.0000	0.1178	0.0089	0.0056	0.0000	0.0764
	Private	26-30	13	0.0192	0.0089	0.0000	0.1131	0.0099	0.0056	0.0000	0.0759
	Private	>30	13	0.0252	0.0119	0.0002	0.1539	0.0122	0.0073	0.0002	0.1003
Entire Thompson / Middle Clark Fork Tributaries Dataset	All	<20	30	0.0432	0.0131	0.0000	0.2756	0.0125	0.0031	0.0000	0.0658
	All	20-26	30	0.0532	0.0158	0.0000	0.3057	0.0144	0.0039	0.0000	0.0777
	All	26-30	30	0.0671	0.0205	0.0000	0.4201	0.0171	0.0041	0.0000	0.0836
	All	>30	30	0.0785	0.0237	0.0002	0.5170	0.0197	0.0050	0.0002	0.1003

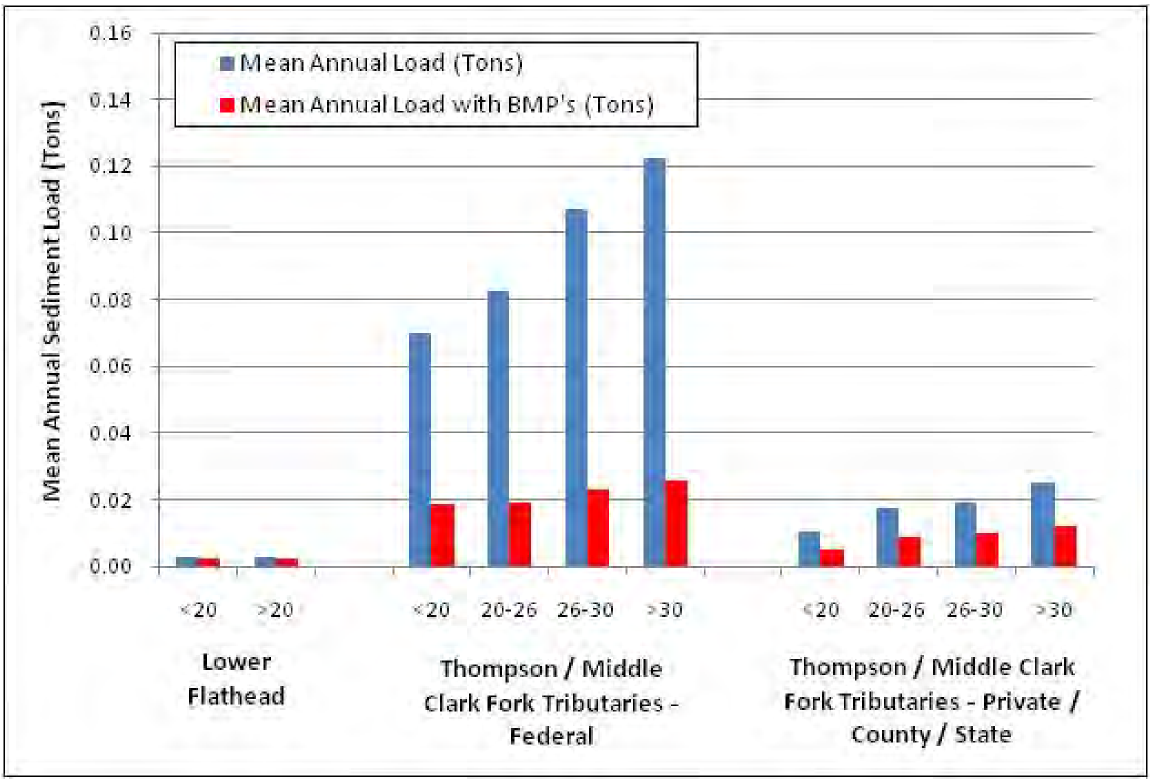

Figure 3-1. Unpaved Road Crossing Mean Annual Sediment Loads

3.1.3 Unpaved Road Crossing Sediment Load Extrapolation

The 40 unpaved road crossings modeled in WEPP:Road were grouped based on jurisdiction and precipitation zone as presented in **Table 3-2** for extrapolation to the subwatershed scale and the total number of crossings was adjusted to account for crossings over undefined channels (**Attachment D**). A total of 1,464 unpaved road crossings were identified during GIS analysis. Crossings upstream of Hubbart Reservoir on the Little Bitterroot River and McGregor Lake on McGregor Creek were then removed from the dataset under the assumption that sediment is trapped by these impoundments, resulting in a total of 1,299 unpaved road crossings. A total of 12 out of 54 (22%) of all the visited sites were at undefined channels. Thus, the number of unpaved road crossings identified in the GIS analysis was adjusted downward during the extrapolation process to account for crossings assumed to be over undefined channels that are not contributing road-related sediment to streams. Since 22% of the crossings were excluded for this reason, the total number of unpaved road crossings identified in GIS in each subwatershed was reduced by 22%, for an estimate of 1,013 unpaved road crossings.

3.1.4 Unpaved Road Parallel Segment Sediment Loads Extrapolation

A total of 76.3 miles of unpaved parallel road segments were identified during GIS analysis. Parallel road segments upstream of Hubbart Reservoir on the Little Bitterroot River and McGregor Lake on McGregor Creek were then removed from the dataset under the assumption that sediment is trapped by these impoundments, resulting in a total of 71.5 miles of unpaved parallel road segments. Since no field data was collected along parallel road segments in the Thompson Project Area, field data collected at 14 unpaved road crossings in which there was at least five feet of buffer on both the left and right sides of the crossing were used as a surrogate for parallel road segments. Parallel road segment sediment loads were developed in pounds/foot of contributing road length and grouped based on precipitation zone for extrapolation to the subwatershed scale (**Table 3-3** and **Attachment E**). Since a smaller dataset was used in this analysis, no differentiation was made between roads under federal jurisdiction and roads under private, state or county jurisdiction.

Table 3-3. Unpaved Parallel Segment Mean Annual Sediment Loads

TPA	Jurisdiction	PRISM Precipitation Zone (Inches)	Number of Sites Assessed	Mean Annual Load (Pounds/Foot)	Mean Annual Load with BMP's (Pounds/Foot)
Lower Flathead	All	<20	3	0.0030	0.0010
	All	>20	3	0.0029	0.0010
Thompson/ Middle Clark Fork Tributaries	All	<20	11	0.1027	0.0723
	All	20-26	11	0.1803	0.1193
	All	26-30	11	0.1931	0.1276
	All	>30	11	0.2600	0.1620

3.1.5 Unpaved Road Sediment Loads by Subwatershed

Both the GIS identified number of unpaved road crossings and the corrected number of unpaved road crossings are presented in **Table 3-4** by jurisdiction for each subwatershed, along with the mean annual sediment load for existing conditions and the mean annual sediment load achievable through the application of BMPs. Mean annual sediment contributions from unpaved road crossings total 48.27 tons per year. Through the application of BMPs, it is estimated that this sediment load can be reduced to 13.24 tons per year. From unpaved road crossings within the Thompson Project Area, the estimated mean annual subwatershed sediment load ranges from 0.04 tons in the Sullivan Creek watershed to 16.56 tons in the Little Thompson River watershed. Reduction potential appears to be slightly greater for federally administered roads than private/county/state roads. Sediment loading from unpaved road crossings could be reduced between 20% and 78% with additional BMPs, which averages to a 73% reduction across the project area. In addition to the sediment load from unpaved road crossings, the mean annual sediment contribution from unpaved parallel road segments is estimated to be 30.17 tons per year. Through the application of BMPs, it is estimated that the parallel segment sediment loads in the project area can be reduced to 19.97 tons per year, which is a 34% reduction (**Table 3-5**). Although the field assessment is a limited sampling of all road crossings, based on observations while completing the field work, the sampled population of road crossings is representative of conditions throughout the project area. Overall, conditions for unpaved roads within the project area are good. In general, it appears most road sediment comes from a limited number of crossings with inadequate or improperly maintained BMPs. A more detailed accounting of sediment loads at the HUC12 subwatershed scale by precipitation zone and ownership is presented in **Attachment D** for unpaved road crossings and **Attachment F** for unpaved parallel road segments.

Table 3-4. Unpaved Road Crossing Mean Annual Sediment Loads by Subwatershed

Subwatershed	Number of Crossings Identified in GIS	Corrected Number of Crossings based on Field Data	Mean Annual Load (Tons)	Mean Annual Load with BMPs (Tons)	Percent Reduction
Little Bitterroot below Hubbart Reservoir Federal	9	7	0.02	0.02	20%
Little Bitterroot below Hubbart Reservoir Private/County/State	78	61	0.17	0.13	23%
Little Bitterroot below Hubbart Reservoir Total	**87**	**68**	**0.19**	**0.14**	**23%**
McGregor Creek below McGregor Lake Federal	18	14	1.24	0.28	77%
McGregor Creek below McGregor Lake Private/County/State	87	68	1.16	0.58	50%
McGregor Creek below McGregor Lake Total	**105**	**82**	**2.39**	**0.87**	**64%**
McGinnis Creek Federal	86	67	6.16	1.38	78%
McGinnis Creek Total	**86**	**67**	**6.16**	**1.38**	**78%**
Little Thompson River Federal (excluding McGinnis Creek)	175	137	12.46	2.80	78%
Little Thompson River Private/County/State (excluding McGinnis Creek)	314	245	4.10	2.06	50%
Little Thompson River Total (excluding McGinnis Creek)	**489**	**381**	**16.56**	**4.86**	**71%**
Henry Creek Federal	50	39	4.21	0.91	78%
Henry Creek Private/County/State	4	3	0.05	0.03	49%
Henry Creek Total	**54**	**42**	**4.26**	**0.94**	**78%**
Lazier Creek Federal	30	23	2.58	0.56	78%
Lazier Creek Private/County/State	76	59	1.16	0.58	50%
Lazier Creek Total	**106**	**83**	**3.75**	**1.14**	**70%**
Lynch Creek Federal	20	16	1.51	0.34	78%
Lynch Creek Private/County/State	140	109	1.47	0.73	50%
Lynch Creek Total	**160**	**125**	**2.99**	**1.07**	**64%**
Swamp Creek Federal	144	112	11.36	2.53	78%
Swamp Creek Private/County/State	50	39	0.57	0.29	50%
Swamp Creek Total	**194**	**151**	**11.94**	**2.82**	**76%**
Sullivan Creek Private/County/State	18	14	0.04	0.03	24%
Sullivan Creek Total	**18**	**14**	**0.04**	**0.03**	**24%**
Thompson Project Area Total	**1,299**	**1,013**	**48.27**	**13.24**	**73%**

Table 3-5. Unpaved Parallel Road Segment Mean Annual Sediment Loads by Subwatershed

Subwatershed	Road Length (Miles)	Mean Annual Load (Tons)	Mean Annual Load with BMPs (Tons)	Percent Reduction
Little Bitterroot River below Hubbart Reservoir	3.3	0.026	0.009	67%
McGinnis Creek	1.5	0.72	0.48	34%
Little Thompson River (excluding McGinnis Creek)	32.5	14.62	9.72	34%
McGregor Creek below McGregor Lake	2.6	1.15	0.77	33%
Henry Creek	4.4	2.15	1.42	34%
Lazier Creek	8.3	4.70	3.03	36%
Lynch Creek	9.0	3.44	2.32	32%
Swamp Creek	7.6	3.34	2.22	34%
Sullivan Creek	2.2	0.02	0.01	67%
Thompson Project Area Total	**71.5**	**30.17**	**19.97**	**34%**

3.1.6 Potential Culvert Failures

Out of the 40 field assessed sites in the Thompson Project Area, 39 had culverts, while one site was at a bridge crossing. While only 20 of the culverts had flowing water at the time that field data was collected, all 39 culverts assessed in the field were evaluated for culvert failure to provide a conservative estimate of sediment loading. Out of the 39 culverts assessed in the field, 38 (97%) are capable of passing the two-year flood event, while only 19 of these culverts (49%) pass a 100-year flood event (**Tables 3-6** and **3-7**, **Attachment F**). Once a culvert's carrying capacity is exceeded, the potential for culvert failure increases, though the point at which a given culvert will fail remains uncertain. Hydraulic analysis of a culvert is extremely complex and potential sediment loads from the eroding fill as presented in **Table 3-6** are estimates assuming the entire height and length of road fill are eroded to a width equal to the bankfull width of the stream.

Table 3-6. Culvert Failure and Potential Sediment Load Evaluation

Location ID	Q2	Q5	Q10	Q25	Q50	Q100	Estimated Maximum Culvert Capacity (cfs)	Potential Sediment Load if Culvert Fails (Tons)
X-401	4	9	13	19	24	30	16	35
X-406	10	19	27	38	48	59	89	53
X-571	17	32	45	63	79	94	64	71
X-576	7	14	19	28	36	43	24	152
X-570	4	9	13	19	24	30	100	111
X-536	106	178	230	303	370	432	40	374
X-411	2	5	8	12	15	19	29	111
X-336	27	49	67	92	115	137	229	639
X-322	2	5	8	12	15	19	30	42
X-341	22	40	55	77	96	115	123	249
X-885	10	19	27	38	48	59	39	74
X-844	7	14	19	28	36	43	10	15
X-828	22	40	55	77	96	115	176	91
X-773	3	7	10	15	19	24	12	13
X-760	2	5	8	12	15	19	15	21
X-1261	6	11	16	23	30	36	37	48

Table 3-6. Culvert Failure and Potential Sediment Load Evaluation

Location ID	Q2	Q5	Q10	Q25	Q50	Q100	Estimated Maximum Culvert Capacity (cfs)	Potential Sediment Load if Culvert Fails (Tons)
X-673	17	32	45	63	79	94	37	70
X-654	60	104	138	184	227	268	160	235
X-61	22	40	55	77	96	115	26	71
X-549	7	14	19	28	36	43	30	295
X-153	10	19	27	38	48	59	26	47
X-120	2	5	8	12	15	19	40	59
X-111	3	7	10	15	19	24	23	20
X-145	10	19	27	38	48	59	87	59
X-1199	2	5	8	12	15	19	24	55
X-1103	1	2	4	6	8	9	30	21
X-1115	2	4	6	8	11	14	12	15
X-1005	4	9	13	19	24	30	62	33
X-1085	4	9	13	19	24	30	30	31
X-975	27	49	67	92	115	137	68	98
X-1171	7	14	19	28	36	43	64	105
X-771	45	80	107	144	179	211	62	128
X-759	7	14	19	28	36	43	15	39
X-920	1	2	4	6	8	9	14	11
X-1169	4	9	13	19	24	30	22	21
X-1174	15	29	40	56	70	85	110	131
X-934	27	49	67	92	115	137	363	197
X-866	4	9	13	19	24	30	19	21
X-864	7	14	19	28	36	43	13	57

Grey cells indicate culvert fails to pass a given discharge

Table 3-7. Culvert Failure Summary

Flood Frequency	Number of Culverts Passing	Number of Culverts Failing	Percent Passing	Percent Failing
Q2	38	1	97%	3%
Q5	35	4	90%	10%
Q10	31	8	79%	21%
Q25	27	12	69%	31%
Q50	22	17	56%	44%
Q100	19	20	49%	51%

If a culvert fails for a given event, the replacement culvert should address several issues. First, culverts typically cause changes in the upstream elevation and the new culvert should mitigate these effects to ensure that culvert placement does not negatively affect the surrounding habitat. Next, environmental considerations such as fish passage need to be accurately predicted. New three-sided culverts, where the bottom of the culvert is typically the natural channel bottom, allow better holding habitat and maintain a continuous stream channel bottom. The hydrology of the area should also be determined and directly related to the culvert design size for the given watershed. Following these principals will help improve the stream system, increase fish habitat, and reduce potential sediment loads from failed culverts.

3.2 Fish Passage Analysis

In the Thompson Project Area, none of the 20 culverts assessed at crossings with flowing water had a high probability of allowing fish passage (**Table 3-8**), while 18 (90%) were classified as fish passage barriers (**Attachment G**). The majority of these culverts were located on streams containing fish as evaluated by Montana Fish, Wildlife and Parks, though this was not considered when evaluating a culverts ability to pass fish (**Figure 3-2**). In general, too steep of slope led to most of these culverts being classified as fish passage barriers. Recent research suggests fish can pass steeper culverts than indicated by the Alaska criteria (Burford et al. 2009; Peterson et al. 2013), particularly if there is no outlet drop (Peterson et al. 2013). When gradients up to 8% are considered at culverts with no outlet perch, seven additional culverts may pass some fish. As this is a very coarse assessment, additional evaluations should be conducted at any culvert that may be replaced to facilitate fish passage.

Table 3-8. Fish Passage Evaluation

Fish Passage Evaluation Categories	Fish Passage Evaluation Criteria	Number of Culverts	Percentage of Total Culverts Assessed
green	conditions that have a high certainty of meeting juvenile fish passage at all desired stream flows	0	0%
red	conditions that have a high certainty of not providing juvenile fish passage at all desired stream flows	18	90%
grey	conditions are such that additional and more detailed analysis is required to determine their juvenile fish passage ability	2	10%

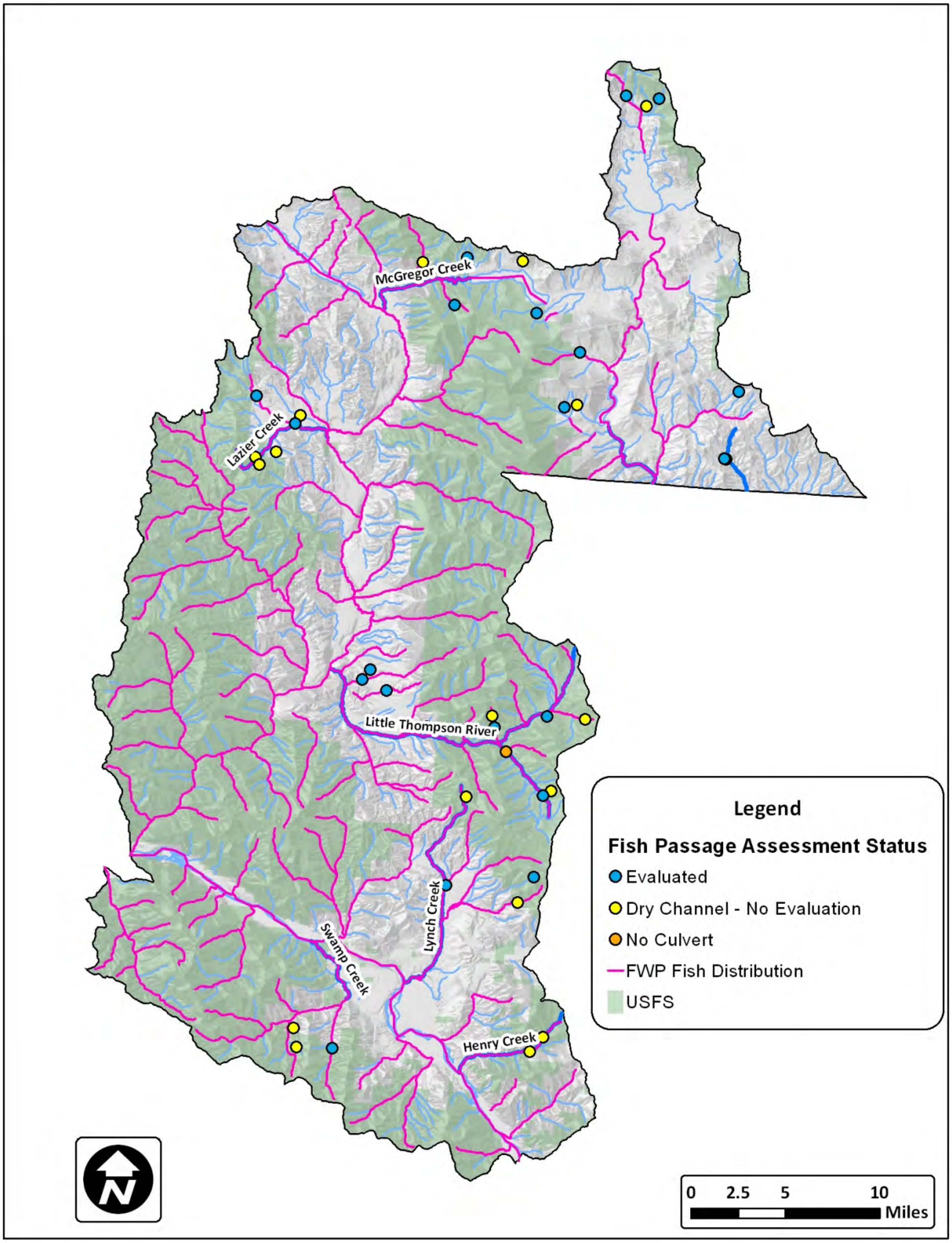

Figure 3-2. Montana Fish, Wildlife and Parks Fish Distribution in the Thompson Project Area

4.0 ASSUMPTIONS AND UNCERTAINTY

Additions were added to Section 4.0 by EPA, 2014

The 54 crossings that were assessed in the field represents approximately 5% of all crossings (based on crossings identified using GIS), which meets the project goal but is acknowledgedly a small portion of the unpaved crossings. Sites were randomly selected and extras were added in the field when necessary with the goal of selecting representative sites. It is assumed that the crossings assessed in the field are representative of crossings throughout the project area.

However, a degree of uncertainty is unavoidable when extrapolating data from assessed sites to un-assessed sites. The largest potential sources of inaccuracy within the project are the small sample size, which was selected based on available resources, and potential errors in the GIS data layers. These are minimized by performing a random selection of representative monitoring sites and by adjusting the results of the GIS data analysis to account for sites where no active stream crossing was observed during field data collection. Since sediment source modeling may under-estimate or over-estimate sediment inputs due to selection of sediment monitoring sites and the extrapolation methods used, model results should not be taken as an absolutely accurate account of sediment production within each sub-watershed. Instead, the unpaved road assessment model results should be considered an instrument for estimating existing sediment loads and making general comparisons of road sediment loads under different management scenarios.

The fish passage and culvert failure assessments are coarse evaluations with a high level of uncertainty; they were primarily performed to highlight the importance of considering aquatic life passage for prioritizing culvert replacement or when installing new culverts, as well as proper culvert design, installation, and maintenance to minimize the risk of substantial loading to streams from partial to complete culvert failure. Although sediment loading estimates from partial culvert failure are not being incorporated into the estimate of road-related sediment loading for the project area because of the uncertainty of the timing and magnitude of culvert failure in any given year, there is also uncertainty associated with predicting the capacity of each culvert. Peak flows that pass through each assessed culvert were generated using the USGS regression equations, which are subject to large standard errors that may substantially over or underestimate peak discharge. Uncertainty is also associated with the culvert slope values for both the culvert failure and fish passage assessment. Culvert slope was estimated using a handheld inclinometer. Different slope estimates may lead to variations in peak flow calculations and can alter the outcome of the fish passage analysis, which is sensitive to slope. Also, the culvert assessment was conducted on the same crossings that were assessed for road sediment loading, which is a small subset of all culverts in the project area. It is assumed that the culverts evaluated in the field are representative of culverts throughout the Thompson Project Area. Lastly, no formal evaluation was conducted to determine if streams where culverts were assessed are fish-bearing. Montana Fish, Wildlife and Parks distribution data in GIS was checked after field work was completed (**Figure 3-2**) and indicates that most assessed culverts are on fish bearing streams, but a fish biologist should be consulted before a culvert is installed or replaced. In some instances, it is desirable to maintain fish passage barriers to preserve vulnerable populations.

5.0 DISCUSSION

Within the Thompson Project Area, there are nine water body segments listed on the 2012 303(d) List for sediment related impairments including McGinnis Creek, Lazier Creek, Little Thompson River, and McGregor Creek within the Thompson TPA, while Henry Creek, Lynch Creek, and Swamp Creek are listed as impaired due to sediment in the Middle Clark Fork Tributaries TPA. The Little Bitterroot River and Sullivan Creek are listed as impaired due to sediment in the Lower Flathead TPA. Mean annual sediment contributions from unpaved road crossings average 48.27 tons per year (**Table 4-1**). Through the application of BMPs, it is estimated that this sediment load can be reduced to 13.24 tons per year, which is a 73% reduction in sediment load. The mean annual sediment contribution from unpaved parallel road segments is estimated to be 30.17 tons per year. Through the application of BMPs, it is estimated that the parallel segment sediment load can be reduced to 19.97 tons per year, which is a 34% reduction in sediment load. Overall, unpaved roads in the Thompson Project Area are estimated to contribute 78.44 tons/year. Through the application of BMPs, it is estimated that this sediment load can be reduced to 33.20 tons per year, which is a 58% reduction in the overall sediment load.

Table 4-1. Potential Reduction in Sediment Loads from Unpaved Roads through Application of BMPs

Subwatershed	Mean Annual Load (Tons)	Mean Annual Load with BMPs (Tons)	Percent Reduction
Little Bitterroot below Hubbart Reservoir	0.21	0.15	28%
McGregor Creek below McGregor Lake	3.54	1.63	54%
McGinnis Creek	6.88	1.85	73%
Little Thompson River (excluding McGinnis Creek)	31.18	14.58	53%
Henry Creek	6.41	2.36	63%
Lazier Creek	8.45	4.17	51%
Lynch Creek	6.43	3.39	47%
Swamp Creek	15.28	5.03	67%
Sullivan Creek	0.06	0.04	38%
Thompson Project Area	**78.44**	**33.20**	**58%**

6.0 REFERENCES

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U.S. Forest Service. 2002. A Summary of Technical Considerations to Minimize the Blockage of Fish at Culverts on National Forests in Alaska. US Forest Service, Alaska Region, September 27, 2002.

Attachment A

Field Assessed Sites

#	Field Site ID	Stream Name	Stream Segment Subwatershed	Pre-selected / Alternate	Field Form Completed	Road Closed / Re-vegetated / Obliterated	No Defined Channel	Comment
1	X-167	unnamed	Henry Creek	pre-selected	no		x	no crossing, no culvert
2	X-145	unnamed	Henry Creek	pre-selected	yes			
3	X-1199	unnamed	Henry Creek	pre-selected	yes			
4	X-885	Whitney Creek	Lazier Creek	pre-selected	yes			
5	X-844	unnamed	Lazier Creek	pre-selected	yes			
6	X-838	unnamed	Lazier Creek	pre-selected	no		x	no channel, no culvert
7	X-812	unnamed	Lazier Creek	pre-selected	no		x	no channel, no culvert
8	X-828	Lazier Creek	Lazier Creek	pre-selected	yes			
9	X-760	unnamed	Lazier Creek	pre-selected	yes			
10	X-773	unnamed	Lazier Creek	pre-selected	yes			
11	X-1261	unnamed	Lazier Creek	pre-selected	yes			
12	X-975	unnamed	Little Bitterroot	pre-selected	yes			
13	X-1082	unnamed	Little Bitterroot	pre-selected	no		x	no crossing, no channel, no culvert
14	X-1171	unnamed	Little Bitterroot	pre-selected	yes			
15	X-1084	unnamed	Little Bitterroot	pre-selected	no		x	no crossing, no channel, no culvert
16	X-920	unnamed	Little Bitterroot	pre-selected	yes			
17	X-864	unnamed	Little Bitterroot	alternate	yes			
18	X-866	unnamed	Little Bitterroot	pre-selected	yes			
19	X-934	Tamarack Creek	Little Bitterroot	pre-selected	yes			
20	X-1174	Herrig Creek	Little Bitterroot	pre-selected	yes			
21	X-1169	unnamed	Little Bitterroot	pre-selected	yes			no gps listed on field form
22	X-478	unnamed	Little Thompson River	pre-selected	no		x	no culvert, no channel
23	X-576	unnamed	Little Thompson River	pre-selected	yes			
24	X-571	Nancy Creek	Little Thompson River	pre-selected	yes			
25	X-729	unnamed	Little Thompson River	pre-selected	no		x	no channel, no crossing
26	X-570	Cabin Creek	Little Thompson River	pre-selected	yes			
27	X-536	Cabin Creek	Little Thompson River	pre-selected	yes			
28	X-411	unnamed	Little Thompson River	pre-selected	yes			
29	X-654	Little Rock Creek	Little Thompson River	pre-selected	yes			
30	X-673	unnamed	Little Thompson River	pre-selected	yes			
31	X-532	North Fork Little Thompson River	Little Thompson River	pre-selected	no			bridge crossing; road drains away in both directions
32	X-549	unnamed	Little Thompson River	pre-selected	yes			
33	X-581	unnamed	Little Thompson River	pre-selected	no		x	no channel, no crossing; no connectivity with d/s stream
34	X-61	unnamed	Little Thompson River	pre-selected	yes			
35	X-283	unnamed	Lynch Creek	alternate	no	revegetated	x	there is a culvert but no channel or any evidence of flowing water
36	X-322	unnamed	Lynch Creek	pre-selected	yes			
37	X-341	unnamed	Lynch Creek	pre-selected	yes			no gps listed on field form
38	X-336	Lynch Creek	Lynch Creek	pre-selected	yes			
39	X-307	Clark Creek	Lynch Creek	pre-selected	no			
40	X-401	unnamed	McGinnis Creek	pre-selected	yes			
41	X-406	McGinnis Creek	McGinnis Creek	pre-selected	yes			
42	X-496	McGinnis Creek	McGinnis Creek	pre-selected	yes			
43	X-1103	unnamed	McGregor Creek	pre-selected	yes			
44	X-1085	unnamed	McGregor Creek	pre-selected	yes			
45	X-1115	unnamed	McGregor Creek	pre-selected	yes			
46	X-1095	unnamed	McGregor Creek	pre-selected	no		x	no crossing, no channel, no culvert
47	X-1005	unnamed	McGregor Creek	pre-selected	yes			
48	X-771	Sullivan Creek	Sullivan Creek	pre-selected	yes			
49	X-759	unnamed	Sullivan Creek	pre-selected	yes			
50	X-111	unnamed	Swamp Creek	pre-selected	yes			
51	X-4	East Fork Swamp Creek	Swamp Creek	pre-selected	no		x	no channel, no crossing
52	X-120	unnamed	Swamp Creek	pre-selected	yes			
53	X-153	unnamed	Swamp Creek	pre-selected	yes			
54	X-206	unnamed	Swamp Creek	pre-selected	no		x	no channel, no crossing

Attachment B

Unpaved Road Crossing Field Data

Waterbody	Location ID	Date	Latitude	Longitude	Jurisdiction / Ownership	PRISM Precip 1971-2000 (range)	Soil Type	% Rock	Insloped/ Outsloped	Road Surface	Traffic Level	Years Modeled	Gradient CRL1 (%)	Length CRL1 (Feet)	Width CRL1 (Feet)	Gradient Fill (%)	Length Fill (Feet)	Gradient Buffer (%)	Length Buffer (Feet)	WEPP LOAD (lbs)	Gradient CRL1 (%)	Length CRL1 (Feet)	Width CRL1 (Feet)	Gradient Fill (%)	Length Fill (Feet)	Gradient Buffer (%)	Length Buffer (Feet)	WEPP LOAD (lbs)	MEAN ANNUAL LOAD (lbs)	MEAN ANNUAL LOAD with BMPs (lbs)
													L	L	L	L	L	L	L	L	R	R	R	R	R	R	R	R		
unnamed	X-401	09/28/11	47.64707	-114.76959	Federal	24-26	Silt L	10	Insloped Veg/rock ditch	Native	Low	30	10.5	324	16	47	7.5	0.3	1	160.99	-	-	-	-	-	-	-	0.00	160.99	26.25
McGinnis Creek	X-406	09/28/11	47.64291	-114.77860	Federal	24-26	Sand L	5	Outsloped Unrutted	Native	Low	30	2.5	162	18	70	7	0.5	75	0.00	3.5	80	18	47	10	0.3	1	6.67	6.67	6.67
McGinnis Creek	X-496	09/28/11	47.67488	-114.82345	Federal	22-24	Silt L	5	Outsloped Unrutted	Native	High	30	2.0	180	20	58	13	0.5	10	1.73	3.5	190	20	58	13	1.0	45	0.00	1.73	0.96
Nancy Creek	X-571	09/28/11	47.70340	-114.73669	Federal	22-24	Silt L	5	Outsloped Rutted	Native	Low	30	3.0	750	11	62	7	1.0	4	376.12	4.0	417	11	36	8	1.0	4	137.53	513.65	10.83
unnamed	X-576	09/28/11	47.70389	-114.78005	Federal	22-24	Sand L	10	Outsloped Unrutted	Native	Low	30	3.0	200	13	47	33	0.3	1	17.09	1.5	160	13	70	14	0.3	1	14.70	31.79	14.12
Cabin Creek	X-570	09/29/11	47.70147	-114.84204	Federal	24-26	Silt L	10	Insloped Veg/rock ditch	Native	Low	30	-	-	-	-	-	-	-	0.00	5.0	1000	12	58	24	0.3	1	611.43	611.43	113.96
Cabin Creek	X-536	09/29/11	47.69269	-114.83855	Federal	22-24	Silt L	15	Insloped Veg/rock ditch	Native	High	30	5.0	210	18	70	14	5.0	5	126.47	2.0	90	18	70	13	5.2	5	28.93	155.40	155.40
unnamed	X-411	09/29/11	47.63822	-114.86539	Federal	26-30	Silt L	30	Insloped Veg/rock ditch	Native	Low	30	-	-	-	-	-	-	-	0.00	4.5	621	22	70	20	0.3	1	695.22	695.22	67.29
Lynch Creek	X-336	09/29/11	47.56981	-114.88118	County	16-18	Silt L	90	Insloped Veg/rock ditch	Gravel	High	50	1.5	150	34	47	25	3.0	5	21.24	2.5	410	34	70	20	3.5	10	64.27	85.51	54.22
Clark Creek	X-322	09/29/11	47.56014	-114.79921	Private	22-24	Silt L	30	Outsloped Unrutted	Native	Low	30	1.5	62	18	47	10.5	3.0	10	0.82	1.5	50	18	53	10	3.5	15	0.00	0.82	0.82
unnamed	X-341	09/29/11	47.58045	-114.78289	Federal	26-30	Silt L	30	Insloped Veg/rock ditch	Native	Low	30	3.0	225	18	70	16	0.3	1	98.01	6.0	570	18	70	20	0.3	1	212.04	310.05	85.84
Whitney Creek	X-885	09/30/11	47.93300	-115.13424	Federal	24-26	Silt L	15	Outsloped Rutted	Native	Low	30	1.0	40	11	58	8	0.9	0.5	3.01	8.0	80	11	58	8	10.5	6	18.39	21.40	21.40
unnamed	X-844	09/30/11	47.92065	-115.08278	State	20-22	Silt L	50	Insloped Veg/rock ditch	Part. Grav.	Low	30	5.0	40	10	36	6	1.5	35	0.00	3.0	65	10	45	7	2.0	50	0.00	0.00	0.00
Lazier Creek	X-828	09/30/11	47.91385	-115.08806	Private	20-22	Sand L	50	Insloped Veg/rock ditch	Part. Grav.	Low	30	3.0	60	10	47	12	2.0	55	0.00	3.5	70	10	47	11	1.0	96	0.00	0.00	0.00
unnamed	X-773 Seg 1	09/30/11	47.89155	-115.10753	Private	26-30	Silt L	5	Outsloped Unrutted	Native	Low	30	2.0	45	11	36	6	2.0	47	0.11	1.5	63	11	47	6	0.3	1	2.26	2.37	2.37
unnamed	X-773 Seg 2	09/30/11	47.89155	-115.10753	Private	26-30	Silt L	5	Outsloped Rutted	Native	Low	30	12.5	300	11	36	6	2.0	47	87.49	-	-	-	-	-	-	-	0.00	87.49	0.34
unnamed	X-760	09/30/11	47.88639	-115.13081	Federal	26-30	Silt L	30	Outsloped Rutted	Native	Low	30	2.5	92	10	47	8	2.0	25	2.81	3.0	115	10	62	7	0.3	1	15.82	18.63	18.63
unnamed	X-1261	09/30/11	47.88073	-115.12538	Private	30-34	Sand L	15	Outsloped Unrutted	Native	Low	30	4.0	95	15	58	13	0.3	1	14.85	0.5	80	15	47	13	0.3	1	9.76	24.61	24.61
unnamed	X-673	09/30/11	47.73031	-114.98349	Private	18-20	Silt L	10	Insloped Veg/rock ditch	Native	Low	50	0.5	50	11	47	9	1.0	50	0.00	2.5	35	11	53	9	1.5	30	0.00	0.00	0.00
Little Rock Creek	X-654	09/30/11	47.72207	-114.99157	Private	18-20	Silt L	10	Insloped Veg/rock ditch	Native	Low	50	5.0	232	15	70	12	0.3	1	60.61	-	-	-	-	-	-	-	0.00	60.61	29.88
unnamed	X-61	09/30/11	47.71510	-114.96344	State	18-20	Silt L	5	Insloped Veg/rock ditch	Native	Low	50	1.0	37	15	47	7	0.5	100	0.00	2.0	22	15	47	7	1.0	18	0.00	0.00	0.00
unnamed	X-549	09/30/11	47.68976	-114.91464	Private	22-24	Silt L	30	Outsloped Unrutted	Native	Low	30	-	-	-	-	-	-	-	0.00	4.5	218	20	70	25	0.3	1	68.62	68.62	31.47
unnamed	X-153	10/01/11	47.45283	-115.04192	Federal	22-24	Sand L	30	Outsloped Rutted	Native	Low	30	-	-	-	-	-	-	-	0.00	6.5	120	18	58	9	0.3	1	23.83	23.83	23.83
unnamed	X-120	10/01/11	47.43843	-115.03712	Federal	26-30	Silt L	40	Outsloped Rutted	Native	Low	30	1.5	30	14	58	13	0.3	1	4.09	5.5	128	14	36	13	0.3	1	32.57	36.66	36.66
unamed	X-111	10/01/11	47.43936	-114.99683	Federal	22-24	Silt L	20	Insloped Veg/rock ditch	Native	Low	30	5.0	550	16	58	7	0.3	1	151.78	-	-	-	-	-	-	-	0.00	151.78	15.37
unnamed	X-145	10/01/11	47.45889	-114.76013	Federal	26-30	Silt L	55	Outsloped Rutted	Part. Grav.	Low	30	9.0	65	16	47	8	12.0	9	5.30	-	-	-	-	-	-	-	0.00	5.30	5.30
unnamed	X-1199	10/01/11	47.44718	-114.77385	Federal	26-30	Silt L	30	Insloped Bare	Native	Low	30	4.0	235	18	90	18	0.3	1	221.33	2.0	62	18	97	20	0.3	1	30.77	252.10	95.75
unnamed	X-1103	10/17/11	48.04390	-114.95607	Federal	22-24	Sand L	50	Outsloped Rutted	Part. Grav.	Low	30	1.0	35	20	50	9	0.3	1	2.41	4.5	250	20	50	9	1.5	200	0.00	2.41	2.41
unnamed	X-1115	10/17/11	48.04967	-114.90615	Private	20-22	Clay L	15	Outsloped Rutted	Native	Low	30	-	-	-	-	-	-	-	0.00	1.0	75	8	35	5	0.3	1	2.24	2.24	2.24
unnamed	X-1005	10/17/11	48.01309	-114.91686	Private	22-24	Silt L	10	Outsloped Unrutted	Native	Low	30	8.0	69	12	55	7	0.3	1	5.35	0.5	56	12	55	7	0.3	1	2.09	7.44	7.44
unnamed	X-1085	10/17/11	48.05014	-114.84275	Private	18-20	Silt L	50	Outsloped Unrutted	Part. Grav.	High	50	9.0	295	14	55	7	7.0	27	0.00	-	-	-	-	-	-	-	0.00	0.00	0.00
unnamed	X-975	10/17/11	48.01089	-114.82265	State	18-20	Silt L	10	Outsloped Unrutted	Native	Low	50	3.0	250	12	55	6	1.5	15	0.67	4.0	385	12	55	6	1.5	15	1.46	2.13	0.68
unnamed	X-1171	10/17/11	48.18079	-114.69946	Federal	26-30	Sand L	25	Outsloped Unrutted	Native	Low	30	3.0	80	10	50	14	0.3	1	3.31	2.0	130	10	50	14	0.3	1	4.84	8.15	5.17
Sullivan Creek	X-771	10/18/11	47.90917	-114.59613	County	16-18	Sand L	5	Insloped Veg/rock ditch	Native	High	50	3.0	50	10	50	10	0.3	1	5.46	3.0	50	10	50	10	0.3	1	5.46	10.92	10.92
unnamed	X-759	10/18/11	47.90937	-114.59843	County	16-18	Sand L	5	Outsloped Unrutted	Native	High	50	5.0	190	12	28	9	0.5	35	0.00	0.5	110	12	28	9	0.5	35	0.00	0.00	0.00
unnamed	X-920	10/18/11	47.96121	-114.58664	County	20-22	Sand L	30	Outsloped Rutted	Part. Grav.	Low	30	-	-	-	-	-	-	-	0.00	2.5	84	12	50	7	3.0	50	0.00	0.00	0.00
unnamed	X-1169	10/18/11	48.17460	-114.71321	Federal	24-26	Sand L	20	Outsloped Unrutted	Part. Grav.	Low	30	0.5	10	12	40	5	0.3	1	0.38	0.5	10	12	40.0	5	0.3	1	0.41	0.79	0.79
Herrig Creek	X-1174	10/18/11	48.18166	-114.73727	Federal	24-26	Sand L	15	Outsloped Unrutted	Native	Low	30	2.0	158	10	68	12	0.3	1	6.65	5.0	100	10	68	12	0.3	1	5.46	12.11	5.80
Tamarack Creek	X-934	10/18/11	47.98333	-114.77043	Private	18-20	Sand L	25	Outsloped Unrutted	Native	Low	30	1.0	50	12	47	16	0.3	1	1.99	-	-	-	-	-	-	-	0.00	1.99	1.99
unnamed	X-866	10/18/11	47.94078	-114.78382	Private	18-20	Sand L	5	Outsloped Rutted	Native	Low	30	3.0	45	8	48	14	0.3	1	1.73	2.5	132	8	48	14	0.3	1	8.81	10.54	6.38
unnamed	X-864	10/18/11	47.94300	-114.76968	Private	18-20	Sand L	5	Outsloped Rutted	Native	Low	30	0.5	60	12	55	9	0.3	1	3.15	3.0	125	12	55	9	0.3	1	8.65	11.80	11.80

Waterbody	Location ID	Segment 1 Installed BMPs		Segment 1 Potential BMPs		Road Crossing and BMP Notes/Comments
		L	R	L	R	
unnamed	X-401	none	n/a	119'	n/a	dry channel, no existing BMPs, water bar or other BMP could reduce contributing length to 119'
McGinnis Creek	X-406	none	none	n/a	n/a	Appears to be low sed contribution and low priority on left and right. Existing veg buffer appears to provide good sed filtration.
McGinnis Creek	X-496	driveable dip at 180'	dip at 190'	could reduce to 100'	could reduce to 60'	Little evidence of chronic crossing at this bridge. Could reduce contributing area w/ water bar but low priority.
Nancy Creek	X-571	none	none	water bar would reduce contribution area to 70'	water bar would reduce contribution area to 67'	Most water appears to pond on road surface near xing w/min delivery - see photo #29.
unnamed	X-576	none	none	could reduce C.A. to 90'	could reduce to 70'	
Cabin Creek	X-570	-	road, but	-	water bar & relief pipe would reduce C.A. to 300'	
Cabin Creek	X-536	relief pipe, driveable dip, straw wattles & slash	-	none-plenty of new BMPs already in place	-	No gps listed on field form; gravel berm, straw wattles & slash filter at/near xing. Not much room for improvement.
unnamed	X-411	-	none	-	could reduce C.A. to ~120' w/bar & relief pipe	
Lynch Creek	X-336	gravel/pavement mix	mix of old	could reduce C.A. to 70'	could reduce C.A. to 300'	Road surface is a mix of old pavement & gravel. Slash filter would be helpful.
Clark Creek	X-322	driveable dip	dip	none needed	none needed	Berms on both sides of road at xing = additional BMP
unnamed	X-341	none	-	could reduce C.A. to 125' w/BMP	could reduce C.A. to 100' w/BMP	(no gps listed on field form); road needs BMPs to reduce contribution area. Right side modeled as outsloped, unrutted.
Whitney Creek	X-885	driveable dip	dip	none needed	none needed	sediment to stream.
unnamed	X-844	none	none	none needed	none needed	delivery seemed possible. (Note: by mistake for X-838)
Lazier Creek	X-828	none	none	none needed	none needed	Road is highest at culvert & slopes away in both directions. We measured potentially contributing area on both sides.
unnamed	X-773 Seg 1	none	dip		none needed	
unnamed	X-773 Seg 2			difficult BMP situation. A sediment trap would reduce C.A. to 45'		
unnamed	X-760	driveable dip at 92'	dip	none needed	none needed	Sed delivery appears to be minimal, but there is standing water on road. The road could use additional drainage to protect road surface.
unnamed	X-1261	driveable dip	none	none needed	none needed	Road surface is partially revegetated; there is little evidence of chronic erosion.
unnamed	X-673	none	none	none needed	none needed	Road slopes away from culvert in both directions.
Little Rock Creek	X-654	dip at 232'	n/a	could reduce to 132' w/BMP - water bar, etc.	-	Contributing segment from RL to ~3' past xing on RR all treated as one segment.
unnamed	X-61	none	none	none needed	none needed	Road slopes away from xing in both directions. Road surface is covered by vegetation.
unnamed	X-549	n/a	none	-	could reduce to 100' w/BMP	
unnamed	X-153	-	also old	-	none needed	Contributes from RR only.
unnamed	X-120	none	dip at 128'	none needed	see notes	Despite short C.A. this site appears to produce & deliver significant sediment. A slash filter could help reduce the load.
unamed	X-111	cross drain at 550'	-	could reduce contributing road surface, ditch to 100' w/dip, x-drain	-	Additional BMPs needed to protect the road & reduce potential loading at d/s site but would not sig. reduce loading at site, which is
unnamed	X-145	d. dip at 65'	n/a	none needed	-	Short contributing area, but still some obvious delivery. Road very close to Henry Creek. Slash filter would be helpful.
unnamed	X-1199	driveable dip at 235'	none	could reduce C.A. to 105' w/water bar or dip	none needed	At xing, road slopes steeply toward d/s side of culvert & this probably delivers most of the sediment load to the stream.
unnamed	X-1103	dip at 35'	dip at 250'	n/a	reduce to 50' w/bar	Very little real sed delivery to stream. Not much of a defined channel. Good filter between par point & flow path. Slash filter in place.
unnamed	X-1115	-	slash filter	-	-	Low use, no sign of erosion/failure; very limited delivery.
unnamed	X-1005	dip at 69'	-	none	none	mostly vegetated road surface
unnamed	X-1085	dip at 295'	-	bar at 60'	-	Very obvious delivery from R/L - filter not effective at capturing delivery.
unnamed	X-975	none	-	bar at 50'	bar at 145'	Mostly vegetated road surface, not much sign of sed delivery - low gradient new xing.
unnamed	X-1171	dip at 80'	none	none	bar at 50'	Good condition and low use = low delivery.
Sullivan Creek	X-771	none	none	slash filter	slash filter	High point is at xing and road slopes away in both directions.
unnamed	X-759	none	none	bar at 80'	none	Xing has been moved and stream put into road side ditch for approx 150' from old xing location to new.
unnamed	X-920	none	none	none	slash filter	
unnamed	X-1169	none	none	none	none	no gps listed on field form; Road slopes away from xing, very short delivery area & low gradient - not a significant source.
Herrig Creek	X-1174	dip at	dip at 100'	bar at 86'	bar at 40'	Well maintained, no sign of significant sed delivery.
Tamarack Creek	X-934	dip at 50'	-	none	-	Well maintained road w/short contributing length - low priority.
unnamed	X-866	dip	dip	none	bar at 100'	Channel is incised ~ 2' below culvert.
unnamed	X-864	none	none	none	none	Road changes slope at end of contributing lengths. (Note: instead of X-881)

Attachment C

Unpaved Road Crossing WEPP Modeled Sediment Loads by Precipitation Zone

Waterbody	Location ID	Jurisdiction / Ownership	Lower Flathead <20		Lower Flathead >20		Thompson/MCFT <20		Thompson/MCFT 20-26		Thompson/MCFT 26-30		Thompson/MCFT >30	
			MEAN ANNUAL LOAD (lbs)	MEAN ANNUAL LOAD with BMPs (lbs)	MEAN ANNUAL LOAD (lbs)	MEAN ANNUAL LOAD with BMPs (lbs)	MEAN ANNUAL LOAD (lbs)	MEAN ANNUAL LOAD with BMPs (lbs)	MEAN ANNUAL LOAD (lbs)	MEAN ANNUAL LOAD with BMPs (lbs)	MEAN ANNUAL LOAD (lbs)	MEAN ANNUAL LOAD with BMPs (lbs)	MEAN ANNUAL LOAD (lbs)	MEAN ANNUAL LOAD with BMPs (lbs)
unnamed	X-401	Federal					125.94	28.40	160.99	26.25	207.63	33.87	252.35	38.26
McGinnis Creek	X-406	Federal					5.30	5.30	6.67	6.67	11.16	11.16	11.29	11.29
McGinnis Creek	X-496	Federal					3.57	1.98	1.73	0.96	9.32	5.02	16.74	8.42
Nancy Creek	X-571	Federal					373.39	11.50	513.65	10.83	725.03	14.17	847.50	14.49
unnamed	X-576	Federal					29.42	13.12	31.79	14.12	67.38	30.04	68.02	30.33
Cabin Creek	X-570	Federal					551.16	96.81	611.43	113.96	840.11	117.52	1034.08	144.22
Cabin Creek	X-536	Federal					131.62	131.62	155.40	155.40	167.19	167.19	198.00	198.00
unnamed	X-411	Federal					479.72	66.01	586.79	59.28	695.22	67.29	706.95	77.57
Lynch Creek	X-336	County					85.51	54.22	235.68	152.73	226.27	151.79	307.72	200.62
Clark Creek	X-322	Private					1.72	1.72	0.82	0.82	4.60	4.60	6.42	6.42
unnamed	X-341	Federal					246.73	77.47	261.95	67.90	310.05	85.84	320.93	88.98
Whitney Creek	X-885	Federal					17.43	17.43	21.40	21.40	27.53	27.53	29.18	29.18
unnamed	X-844	State					0.00	0.00	0.00	0.00	0.10	0.10	1.08	1.08
Lazier Creek	X-828	Private					0.00	0.00	0.00	0.00	0.00	0.00	0.52	0.52
unnamed	X-773 Seg 1	Private					1.51	1.51	1.94	1.94	2.37	2.37	2.54	2.54
unnamed	X-773 Seg 2	Private					48.33	0.01	66.00	0.00	87.49	0.34	123.28	0.85
unnamed	X-760	Federal					17.51	17.51	13.91	13.91	18.63	18.63	19.92	19.92
unnamed	X-1261	Private					11.17	11.17	15.20	15.20	24.02	24.02	24.61	24.61
unnamed	X-673	Private					0.00	0.00	0.08	0.08	0.06	0.06	0.62	0.62
Little Rock Creek	X-654	Private					60.01	29.88	79.72	34.08	74.35	33.33	103.90	41.69
unnamed	X-61	State					0.00	0.00	0.12	0.12	0.10	0.10	0.35	0.35
unnamed	X-549	Private					68.91	31.61	68.62	31.47	93.34	42.81	90.81	41.65
unnamed	X-153	Federal					22.27	22.27	23.83	23.83	39.24	39.24	42.10	42.10
unnamed	X-120	Federal					31.50	31.50	27.00	27.00	36.66	36.66	39.76	39.76
unamed	X-111	Federal					155.91	18.10	151.78	15.37	202.85	19.54	259.86	21.28
unnamed	X-145	Federal					3.57	3.57	5.30	5.30	9.33	9.33	9.83	9.83
unnamed	X-1199	Federal					191.71	87.06	226.81	80.77	252.10	95.75	297.11	102.94
unnamed	X-1103	Federal					2.00	2.00	2.41	2.41	4.91	4.64	5.63	4.12
unnamed	X-1115	Private					2.37	2.37	2.24	2.24	2.78	2.78	2.55	2.55
unnamed	X-1005	Private					8.09	8.09	7.44	7.44	11.14	11.14	10.80	10.80
unnamed	X-1085	Private					0.00	0.00	16.50	3.36	11.59	2.36	30.19	6.14
unnamed	X-975	State	2.13	0.68	0.00	0.00								
unnamed	X-1171	Federal	6.94	4.44	8.15	5.17								
Sullivan Creek	X-771	County	10.92	10.92	10.08	10.08								
unnamed	X-759	County	0.00	0.00	0.00	0.00								
unnamed	X-920	County	0.02	0.02	0.00	0.00								
unnamed	X-1169	Federal	0.66	0.66	0.79	0.79								
Herrig Creek	X-1174	Federal	10.61	5.06	12.11	5.80								
Tamarack Creek	X-934	Private	1.99	1.99	2.31	2.31								
unnamed	X-866	Private	10.54	6.38	8.11	6.80								
unnamed	X-864	Private	11.80	11.80	12.49	12.49								

Attachment D

Unpaved Road Crossing Subwatershed Sediment Loads

Subwatershed	Jurisdiction	PRISM Precipitation Zone (Inches)	Number of Crossings Identified in GIS	Corrected Number of Crossings based on Field Data	MEAN ANNUAL LOAD per CROSSING (Tons)	MEAN ANNUAL LOAD per CROSSING with BMPs	MEAN ANNUAL LOAD (Tons)	MEAN ANNUAL LOAD with BMPs (Tons)	Percent Reduction
Little Bitterroot River-Hubbart Reservoir_below Hubbart Reservoir	Federal	20-26	9	7	0.0027	0.0022	0.019	0.015	20%
			9	7			0.019	0.015	20%
Little Bitterroot River-Hubbart Reservoir_below Hubbart Reservoir	Private	<20	24	19	0.0028	0.0021	0.052	0.039	24%
Little Bitterroot River-Hubbart Reservoir_below Hubbart Reservoir	Private	20-26	13	10	0.0027	0.0022	0.027	0.022	20%
			37	29			0.079	0.061	23%
Little Bitterroot River-Hubbart Reservoir_below Hubbart Reservoir	County	<20	5	4	0.0028	0.0021	0.011	0.008	24%
			5	4			0.011	0.008	24%
Little Bitterroot River-Hubbart Reservoir_below Hubbart Reservoir			**51**	**40**			**0.109**	**0.085**	**22%**
Little Meadow Creek	Private	<20	5	4	0.0028	0.0021	0.011	0.008	24%
			5	4			0.011	0.008	24%
Little Meadow Creek	County	<20	26	20	0.0028	0.0021	0.056	0.043	24%
Little Meadow Creek	County	20-26	5	4	0.0027	0.0022	0.011	0.008	20%
			31	24			0.067	0.051	24%
Little Meadow Creek			**36**	**28**			**0.078**	**0.059**	**24%**
Little Bitterroot below Hubbart Reservoir Total			**87**	**68**			**0.187**	**0.144**	**23%**
McGregor Creek_below McGregor Lake	Federal	<20	1	1	0.0703	0.0186	0.055	0.014	74%
McGregor Creek_below McGregor Lake	Federal	20-26	13	10	0.0824	0.0190	0.836	0.192	77%
McGregor Creek_below McGregor Lake	Federal	26-30	3	2	0.1069	0.0230	0.250	0.054	78%
McGregor Creek_below McGregor Lake	Federal	>30	1	1	0.1223	0.0259	0.095	0.020	79%
			18	14			1.236	0.281	77%
McGregor Creek_below McGregor Lake	Private	<20	3	2	0.0103	0.0050	0.024	0.012	51%
McGregor Creek_below McGregor Lake	Private	20-26	65	51	0.0177	0.0089	0.895	0.452	50%
McGregor Creek_below McGregor Lake	Private	26-30	10	8	0.0192	0.0099	0.150	0.077	49%
			78	61			1.069	0.540	49%
McGregor Creek_below McGregor Lake	County	<20	1	1	0.0103	0.0050	0.008	0.004	51%
			1	1			0.008	0.004	51%
McGregor Creek_below McGregor Lake	State	<20	5	4	0.0103	0.0050	0.040	0.020	51%
McGregor Creek_below McGregor Lake	State	20-26	3	2	0.0177	0.0089	0.041	0.021	50%
			8	6			0.081	0.040	50%
McGregor Creek_below McGregor Lake			**105**	**82**			**2.395**	**0.866**	**64%**
McGregor Creek below McGregor Lake Total			**105**	**82**			**2.395**	**0.866**	**64%**
Upper Little Thompson River	Federal	20-26	63	49	0.0824	0.0190	4.051	0.933	77%
Upper Little Thompson River	Federal	26-30	12	9	0.1069	0.0230	1.000	0.216	78%
			75	59			5.051	1.148	77%
Upper Little Thompson River	Private	20-26	13	10	0.0177	0.0089	0.179	0.090	50%
			13	10			0.179	0.090	50%
Upper Little Thompson River			**88**	**69**			**5.230**	**1.239**	**76%**
McGinnis Creek	Federal	20-26	53	41	0.0824	0.0190	3.408	0.785	77%
McGinnis Creek	Federal	26-30	33	26	0.1069	0.0230	2.750	0.593	78%
			86	67			6.158	1.378	78%
McGinnis Creek Total			**86**	**67**			**6.158**	**1.378**	**78%**
Middle Little Thompson River	Federal	<20	1	1	0.0703	0.0186	0.055	0.014	74%
Middle Little Thompson River	Federal	20-26	37	29	0.0824	0.0190	2.379	0.548	77%
Middle Little Thompson River	Federal	26-30	32	25	0.1069	0.0230	2.667	0.575	78%
Middle Little Thompson River	Federal	>30	3	2	0.1223	0.0259	0.286	0.061	79%
			73	57			5.387	1.198	78%
Middle Little Thompson River	Private	20-26	29	23	0.0177	0.0089	0.399	0.202	50%
Middle Little Thompson River	Private	26-30	1	1	0.0192	0.0099	0.015	0.008	49%
			30	23			0.414	0.209	50%
Middle Little Thompson River	State	<20	1	1	0.0103	0.0050	0.008	0.004	51%
			1	1			0.008	0.004	51%
Middle Little Thompson River			**104**	**81**			**5.809**	**1.411**	**76%**
Mudd Creek	Federal	20-26	14	11	0.0824	0.0190	0.900	0.207	77%
Mudd Creek	Federal	26-30	1	1	0.1069	0.0230	0.083	0.018	78%
Mudd Creek	Federal	>30	9	7	0.1223	0.0259	0.859	0.182	79%
			24	19			1.842	0.407	78%
Mudd Creek	Private	20-26	140	109	0.0177	0.0089	1.928	0.973	50%
Mudd Creek	Private	26-30	14	11	0.0192	0.0099	0.210	0.108	49%
Mudd Creek	Private	>30	5	4	0.0252	0.0122	0.098	0.047	52%
			159	124			2.236	1.128	50%
Mudd Creek	County	20-26	5	4	0.0177	0.0089	0.069	0.035	50%
			5	4			0.069	0.035	50%
Mudd Creek			**188**	**147**			**4.147**	**1.570**	**62%**
Lower Little Thompson River	Federal	<20	1	1	0.0703	0.0186	0.055	0.014	74%
Lower Little Thompson River	Federal	20-26	2	2	0.0824	0.0190	0.129	0.030	77%
			3	2			0.183	0.044	76%
Lower Little Thompson River	Private	<20	34	27	0.0103	0.0050	0.272	0.133	51%
Lower Little Thompson River	Private	20-26	40	31	0.0177	0.0089	0.551	0.278	50%
			74	58			0.823	0.411	50%
Lower Little Thompson River	County	<20	1	1	0.0103	0.0050	0.008	0.004	51%
Lower Little Thompson River	County	20-26	3	2	0.0177	0.0089	0.041	0.021	50%
			4	3			0.049	0.025	50%
Lower Little Thompson River	State	<20	12	9	0.0103	0.0050	0.096	0.047	51%
Lower Little Thompson River	State	20-26	16	12	0.0177	0.0089	0.220	0.111	50%
			28	22			0.316	0.158	50%
Lower Little Thompson River Total			**109**	**85**			**1.372**	**0.638**	**53%**
Little Thompson River Total (excluding McGinnis Creek)			**489**	**381**			**16.559**	**4.858**	**71%**
Henry Creek	Federal	<20	1	1	0.0703	0.0186	0.055	0.014	74%
Henry Creek	Federal	20-26	4	3	0.0824	0.0190	0.257	0.059	77%
Henry Creek	Federal	26-30	33	26	0.1069	0.0230	2.750	0.593	78%
Henry Creek	Federal	>30	12	9	0.1223	0.0259	1.145	0.242	79%
			50	39			4.207	0.909	78%
Henry Creek	Private	<20	1	1	0.0103	0.0050	0.008	0.004	51%
			1	1			0.008	0.004	51%
Henry Creek	State	26-30	3	2	0.0192	0.0099	0.045	0.023	49%
			3	2			0.045	0.023	49%
Henry Creek Total			**54**	**42**			**4.260**	**0.936**	**78%**

Subwatershed	Jurisdiction	PRISM Precipitation Zone (Inches)	Number of Crossings Identified in GIS	Corrected Number of Crossings based on Field Data	MEAN ANNUAL LOAD per CROSSING (Tons)	MEAN ANNUAL LOAD per CROSSING with BMPs (Tons)	MEAN ANNUAL LOAD (Tons)	MEAN ANNUAL LOAD with BMPs (Tons)	Percent Reduction
Lazier Creek	Federal	20-26	7	5	0.0824	0.0190	0.450	0.104	77%
Lazier Creek	Federal	26-30	5	4	0.1069	0.0230	0.417	0.090	78%
Lazier Creek	Federal	>30	18	14	0.1223	0.0259	1.717	0.364	79%
			30	23			2.584	0.557	78%
Lazier Creek	Private	20-26	37	29	0.0177	0.0089	0.510	0.257	50%
Lazier Creek	Private	26-30	22	17	0.0192	0.0099	0.330	0.169	49%
Lazier Creek	Private	>30	15	12	0.0252	0.0122	0.295	0.142	52%
			74	58			1.134	0.568	50%
Lazier Creek	State	20-26	2	2	0.0177	0.0089	0.028	0.014	50%
			2	2			0.028	0.014	50%
Lazier Creek Total			**106**	**83**			**3.746**	**1.140**	**70%**
Lynch Creek	Federal	<20	2	2	0.0703	0.0186	0.110	0.029	74%
Lynch Creek	Federal	20-26	5	4	0.0824	0.0190	0.321	0.074	77%
Lynch Creek	Federal	26-30	13	10	0.1069	0.0230	1.083	0.234	78%
			20	16			1.515	0.337	78%
Lynch Creek	Private	<20	65	51	0.0103	0.0050	0.521	0.255	51%
Lynch Creek	Private	20-26	55	43	0.0177	0.0089	0.757	0.382	50%
Lynch Creek	Private	26-30	5	4	0.0192	0.0099	0.075	0.038	49%
			125	98			1.353	0.675	50%
Lynch Creek	County	<20	14	11	0.0103	0.0050	0.112	0.055	51%
			14	11			0.112	0.055	51%
Lynch Creek	State	<20	1	1	0.0103	0.0050	0.008	0.004	51%
			1	1			0.008	0.004	51%
Lynch Creek Total			**160**	**125**			**2.988**	**1.071**	**64%**
Swamp Creek	Federal	<20	27	21	0.0703	0.0186	1.480	0.391	74%
Swamp Creek	Federal	20-26	31	24	0.0824	0.0190	1.993	0.459	77%
Swamp Creek	Federal	26-30	26	20	0.1069	0.0230	2.167	0.467	78%
Swamp Creek	Federal	>30	60	47	0.1223	0.0259	5.725	1.212	79%
			144	112			11.364	2.530	78%
Swamp Creek	Private	<20	17	13	0.0103	0.0050	0.136	0.067	51%
Swamp Creek	Private	20-26	24	19	0.0177	0.0089	0.331	0.167	50%
Swamp Creek	Private	26-30	5	4	0.0192	0.0099	0.075	0.038	49%
			46	36			0.542	0.272	50%
Swamp Creek	County	<20	2	2	0.0103	0.0050	0.016	0.008	51%
			2	2			0.016	0.008	51%
Swamp Creek	State	<20	2	2	0.0103	0.0050	0.016	0.008	51%
			2	2			0.016	0.008	51%
Swamp Creek Total			**194**	**151**			**11.938**	**2.817**	**76%**
Upper Sullivan Creek	County	<20	18	14	0.0028	0.0021	0.039	0.029	24%
			18	14			0.039	0.029	24%
Sullivan Creek Total			**18**	**14**			**0.039**	**0.029**	**24%**
Thompson Project Area Total			**1299**	**1013**			**48.27**	**13.24**	**73%**

Attachment E

Unpaved Parallel Road Segment Subwatershed Sediment Loads

Subwatershed	PRISM Precipitation Zone (Inches)	Road Length (Feet)	Road Length (Miles)	Mean Annual Sediment Load (Pounds/ Foot)	Mean Annual Sediment Load with BMPs (Pounds/ Foot)	MEAN ANNUAL LOAD (Tons)	MEAN ANNUAL LOAD with BMPs (Tons)	Percent Reduction
Little Bitterroot River-Hubbart Reservoir_below Hubbart Reservoir	<20	4,519	0.9	0.0030	0.0010	0.0068	0.0023	67%
Little Bitterroot River-Hubbart Reservoir_below Hubbart Reservoir	20-26	766	0.1	0.0029	0.0010	0.0011	0.0004	65%
Little Bitterroot River-Hubbart Reservoir_below Hubbart Reservoir Total		**5,285**	**1.0**			**0.0079**	**0.0027**	**66%**
Little Meadow Creek	<20	11,863	2.2	0.0030	0.0010	0.0178	0.0059	67%
Little Meadow Creek	20-26	129	0.0	0.0029	0.0010	0.0002	0.0001	65%
Little Meadow Creek Total		**11,992**	2.3			**0.0180**	**0.0060**	**67%**
Little Bitterroot River-below Hubbart Reservoir Total		**17,277**	**3.3**			**0.0259**	**0.0087**	**67%**
McGinnis Creek	20-26	6,586	1.2	0.1803	0.1193	0.5937	0.3928	34%
McGinnis Creek	26-30	1,305	0.2	0.1931	0.1276	0.1260	0.0833	34%
McGinnis Creek Total		**7,891**	**1.5**			**0.7197**	**0.4761**	**34%**
Upper Little Thompson River	20-26	10,153	1.9	0.1803	0.1193	0.9153	0.6056	34%
Upper Little Thompson River	26-30	22	0.0	0.1931	0.1276	0.0021	0.0014	34%
Upper Little Thompson River Total		**10,175**	**1.9**			**0.9174**	**0.6070**	**34%**
Middle Little Thompson River	<20	10	0.0	0.1027	0.0723	0.0005	0.0004	30%
Middle Little Thompson River	20-26	9,088	1.7	0.1803	0.1193	0.8192	0.5421	34%
Middle Little Thompson River	26-30	892	0.2	0.1931	0.1276	0.0861	0.0569	34%
Middle Little Thompson River	>30	12	0.0	0.2600	0.1620	0.0015	0.0009	38%
Middle Little Thompson River Total		**10,001**	**1.9**			**0.9074**	**0.6003**	**34%**
Mudd Creek	20-26	94,885	18.0	0.1803	0.1193	8.5539	5.6599	34%
Mudd Creek	26-30	3,103	0.6	0.1931	0.1276	0.2995	0.1979	34%
Mudd Creek	>30	2,053	0.4	0.2600	0.1620	0.2669	0.1663	38%
Mudd Creek Total		**100,040**	**18.9**			**9.1203**	**6.0241**	**34%**
Lower Little Thompson River	<20	25,122	4.8	0.1027	0.0723	1.2900	0.9082	30%
Lower Little Thompson River	20-26	26,168	5.0	0.1803	0.1193	2.3590	1.5609	34%
Lower Little Thompson River	26-30	297	0.1	0.1931	0.1276	0.0287	0.0190	34%
Lower Little Thompson River Total		**51,587**	**9.8**			**3.6777**	**2.4880**	**32%**
Little Thompson River (excluding McGinnis Creek) Total		**171,803**	**32.5**			**14.6228**	**9.7194**	**34%**
McGregor Creek_below McGregor Lake	<20	2,698	0.5	0.1027	0.0723	0.1385	0.0975	30%
McGregor Creek_below McGregor Lake	20-26	11,108	2.1	0.1803	0.1193	1.0014	0.6626	34%
McGregor Creek_below McGregor Lake	26-30	107	0.0	0.1931	0.1276	0.0103	0.0068	34%
McGregor Creek below McGregor Lake Total		**13,913**	**2.6**			**1.1503**	**0.7670**	**33%**
Henry Creek	<20	2,078	0.4	0.1027	0.0723	0.1067	0.0751	30%
Henry Creek	20-26	4,808	0.9	0.1803	0.1193	0.4334	0.2868	34%
Henry Creek	26-30	16,290	3.1	0.1931	0.1276	1.5728	1.0393	34%
Henry Creek	>30	251	0.0	0.2600	0.1620	0.0326	0.0203	38%
Henry Creek Total		**23,427**	**4.4**			**2.1456**	**1.4215**	**34%**
Lazier Creek	20-26	14,284	2.7	0.1803	0.1193	1.2877	0.8520	34%
Lazier Creek	26-30	13,138	2.5	0.1931	0.1276	1.2684	0.8382	34%
Lazier Creek	>30	16,511	3.1	0.2600	0.1620	2.1465	1.3374	38%
Lazier Creek Total		**43,933**	**8.3**			**4.7026**	**3.0276**	**36%**
Lynch Creek	<20	21,482	4.1	0.1027	0.0723	1.1031	0.7766	30%
Lynch Creek	20-26	24,975	4.7	0.1803	0.1193	2.2515	1.4897	34%
Lynch Creek	26-30	897	0.2	0.1931	0.1276	0.0866	0.0572	34%
Lynch Creek Total		**47,354**	**9.0**			**3.4412**	**2.3236**	**32%**
Swamp Creek	<20	13,614	2.6	0.1027	0.0723	0.6991	0.4921	30%
Swamp Creek	20-26	14,743	2.8	0.1803	0.1193	1.3291	0.8794	34%
Swamp Creek	26-30	6,909	1.3	0.1931	0.1276	0.6670	0.4408	34%
Swamp Creek	>30	4,983	0.9	0.2600	0.1620	0.6478	0.4036	38%
Swamp Creek Total		**40,249**	**7.6**			**3.3430**	**2.2160**	**34%**
Upper Sullivan Creek_clipped to TPA	<20	11,733	2.2	0.0030	0.0010	0.0176	0.0059	67%
Upper Sullivan Creek Total		**11,733**	**2.2**			**0.0176**	**0.0059**	**67%**
Thompson Project Area Total		**377,579**	**71.5**			**30.17**	**19.97**	**34%**

Attachment F

Culvert Failure Analysis

Location ID	Structure Type	Culvert Dimensions	Culvert Slope	Bankfull Width	Q2	Q5	Q10	Q25	Q50	Q100	Estimated Maximum Capacity at Cross Section	Headwater Hieght (Fill Hieght)	Field Measured Fill Width	Modeled Fill Width*	Fill Length	Fill Volume*	Fill Volume*	Potential Sediment Load if Culvert Fails*
		(ft)	(%)	(ft)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft³)	(CY)	(tons)
X-401	CMP	1.5	9	4	4	9	13	19	24	30	16	4	25	4	36	576	21	35
X-406	Squash CMP	4.5 span 3 rise	0.5	6	10	19	27	38	48	59	89	4.5	25	6	32	864	32	53
X-571	Squash CMP	3.5 span 2.25 rise	3	8	17	32	45	63	79	94	64	4.5	32	8	32	1152	43	71
X-576	CMP	1.5	9	5	7	14	19	28	36	43	24	9	70	5	55	2475	92	152
X-570	CMP	3	11	4	4	9	13	19	24	30	100	10	40	4	45	1800	67	111
X-536	CMP	2	5	20	106	178	230	303	370	432	40	8	60	20	38	6080	225	374
X-411	CMP	1.5	18	3	2	5	8	12	15	19	29	12	25	3	50	1800	67	111
X-336**	CMP	4	12	10	27	49	67	92	115	137	229	16	85	10	65	10400	385	639
X-322	CMP	2	5	3	2	5	8	12	15	19	30	5	32	3	45	675	25	42
X-341	Squash CMP	3.5 span 2.5 rise	12	9	22	40	55	77	96	115	123	10	35	9	45	4050	150	249
X-885	CMP	2.5	1	6	10	19	27	38	48	59	39	5	30	6	40	1200	44	74
X-844	CMP	1.5	2	5	7	14	19	28	36	43	10	2.5	35	5	20	250	9	15
X-828	Squash CMP	5.5 span 4.5 rise	1	9	22	40	55	77	96	115	176	5.5	50	9	30	1485	55	91
X-773	CMP	1.5	3	3.5	3	7	10	15	19	24	12	3	30	3.5	20	210	8	13
X-760	CMP	1.5	2	3	2	5	8	12	15	19	15	4.5	50	3	25	337.5	13	21
X-1261	CMP	2	7	4.5	6	11	16	23	30	36	37	7	35	4.5	25	787.5	29	48
X-673**	Squash CMP	2.25 span 1.75 rise	3	8	17	32	45	63	79	94	37	5.5	60	8	26	1144	42	70
X-654**	CMP	3	2.5	15	60	104	138	184	227	268	160	7.5	50	15	34	3825	142	235
X-61	CMP	2	6	9	22	40	55	77	96	115	26	4	38	9	32	1152	43	71
X-549	CMP	1.5	0.1	5	7	14	19	28	36	43	30	16	50	5	60	4800	178	295
X-153	CMP	2	6	6	10	19	27	38	48	59	26	4	40	6	32	768	28	47
X-120	CMP	2	7.5	3	2	5	8	12	15	19	40	8	55	3	40	960	36	59
X-111	CMP	2	7	3.5	3	7	10	15	19	24	23	3.5	25	3.5	26	318.5	12	20
X-145	Squash CMP	4.25 span 3.25 rise	7	6	10	19	27	38	48	59	87	4	45	6	40	960	36	59
X-1199	CMP	1.5	24	3	2	5	8	12	15	19	24	8	25	3	37	888	33	55
X-1103	CMP	2	11	2	1	2	4	6	8	9	30	5	30	2	34	340	13	21
X-1115	CMP	1.5	1	2.5	2	4	6	8	11	14	12	3.5	25	2.5	27	236.25	9	15
X-1005	CMP	3	9	4	4	9	13	19	24	30	62	5	25	4	27	540	20	33
X-1085	CMP	2	8	4	4	9	13	19	24	30	30	5	14	4	25	500	19	31
X-975	Squash CMP	3.5 span 2.5 rise	1	10	27	49	67	92	115	137	68	5	30	10	32	1600	59	98
X-1171	CMP	2.5	11	5	7	14	19	28	36	43	64	8.5	20	5	40	1700	63	105
X-771	CMP	3	5	13	45	80	107	144	179	211	62	5	30	13	32	2080	77	128
X-759	CMP	1.5	7	5	7	14	19	28	36	43	15	4	20	5	32	640	24	39
X-920	CMP	1.5	5	2	1	2	4	6	8	9	14	3.5	20	2	26	182	7	11
X-1169	Squash CMP	2.5 span 1.5 rise	1	4	4	9	13	19	24	30	22	3	20	4	28	336	12	21
X-1174	CMP	3.5	4	7.5	15	29	40	56	70	85	110	7.5	20	7.5	38	2137.5	79	131
X-934	Squash CMP	6.25 span 4.75 rise	6	10	27	49	67	92	115	137	363	8	25	10	40	3200	119	197
X-866	CMP	1.5	5	4	4	9	13	19	24	30	19	6	30	4	14	336	12	21
X-864	CMP	1.25	7	5	7	14	19	28	36	43	13	5.5	15	5	34	935	35	57

*assuming a fill width equal to the bankfull width

**bankfull width estimated from field photos

culvert fails to pass a given discharge

Attachment G

Fish Passage Assessment

Location ID	Structure Type	Evaluation Method	Culvert Dimensions (ft)	Width (ft)	Culvert Slope (%)	Bankfull Width (ft)	Culvert/ Bankfull Ratio	Outlet Perch (inches)	Final Classification (# of failures)
X-406	Squash CMP	3	3	4.5	0.5	6	0.75	6	1
X-576	CMP	3	1.5	1.5	9	5	0.30	18	3
X-536	CMP	3	2	2	5	20	0.10	6	3
X-336	CMP	3	4	4	12	50	0.08	0	2
X-341	Squash CMP	3	2.5	3.5	12	9	0.39	6	3
X-885	CMP	3	2.5	2.5	1	6	0.42	12	2
X-828	Squash CMP	3	4.5	5.5	1	9	0.61	0	0
X-673	Squash CMP	3	1.75	2.25	3	50	0.05	9	3
X-654	CMP	3	3	3	2.5	30	0.10	36	3
X-61	CMP	3	2	2	6	9	0.22	0	2
X-111	CMP	3	2	2	7	3.5	0.57	0	1
X-1115	CMP	3	1.5	1.5	1	2.5	0.60	0	0
X-1005	CMP	3	3	3	9	4	0.75	4	2
X-975	Squash CMP	3	2.5	3.5	1	10	0.35	0	1
X-1171	CMP	3	2.5	2.5	11	5	0.50	12	2
X-759	CMP	3	1.5	1.5	7	5	0.30	0	2
X-920	CMP	3	1.5	1.5	5	2	0.75	0	1
X-1174	CMP	3	3.5	3.5	4	7.5	0.47	12	3
X-934	Squash CMP	4	4.75	6.25	6	10	0.63	6	2
X-866	CMP	3	1.5	1.5	5	4	0.38	18	3

Note: Evaluation Method based on Table:1 Fish Passage Evaluation Criteria located in *A Summary of Techincal Considerations to Minimize the Blockage of Fish at Culverts on the National Forests of Alaska*

(green)	conditions that have a high certainty of meeting juvenile fish passage at all desired stream flows
(gray)	conditions are such that additional and more detailed analysis is required to determine their juvenile fish passage ability
(red)	conditions that have a high certainty of <u>not</u> providing juvenile fish passage at all desired stream flows