APPENDIX D - ROAD SEDIMENT ASSESSMENT

LIST OF TABLES

LIST OF FIGURES

ATTACHMENTS

Acronym	Definition
BMP	Best Management Practices
CMP	Corrugated Metal Pipe
CY	Cubic Yard
EPA	Environmental Protection Agency (U.S.)
GIS	Geographic Information System
NHD	National Hydrography Dataset
QAPP	Quality Assurance Project Plan
TMDL	Total Maximum Daily Load
TPA	TMDL Planning Area
USFS	United States Forest Service
USGS	United States Geological Survey
WEPP	Water Erosion Prediction Project

D1.0 INTRODUCTION

An assessment of the road network within the Kootenai-Fisher Total Maximum Daily Load (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 Geographic Information System (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.

D1.1 SEDIMENT IMPAIRMENTS

The Kootenai-Fisher Project Area encompasses an area of approximately 2,511 square miles in Lincoln and Flathead counties in northwestern Montana. The Kootenai-Fisher Project Area includes both the Kootenai TMDL Planning Area (TPA) (1,667 square miles) and the Fisher TPA (844 square miles). The Kootenai TPA encompasses the majority of the Upper Kootenai River HUC8 (17010104), while the Fisher TPA aligns with the Fisher River HUC8 (17010101). Within the Kootenai-Fisher Project Area, there are six water body segments listed on the 2012 303(d) List for sediment-related impairments (**Table D1-1**). Bristow Creek, Libby Creek, Lake Creek and Quartz Creek are listed as impaired due to sediment in the Kootenai TPA, while Wolf Creek and Raven Creek are listed as impaired due to sediment in the Fisher TPA.

Table D1-1. Waterbody Segments Addressed during the Road Assessment

TPA	Segment ID	Waterbody Description
Fisher	MT76C001_020	WOLF CREEK, headwaters to mouth (Fisher River)
Fisher	MT76C001_030	RAVEN CREEK, headwaters to mouth (Pleasant Valley Fisher River)
Kootenai	MT76D002_110	BRISTOW CREEK, the headwaters to mouth at Lake Koocanusa
Kootenai	MT76D002_062	LIBBY CREEK, from the highway 2 bridge to mouth (Kootenai River)
Kootenai	MT76D002_070	LAKE CREEK, Bull Lake outlet to mouth (Kootenai River)
Kootenai	MT76D002_090	QUARTZ CREEK, headwaters to confluence with the Kootenai River

D2.0 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)* (U.S. Environmental Protection Agency, 2011) and *Road Sediment Assessment and Modeling: Kootenai-Fisher TMDL Planning Area Road GIS Layers and Summary Statistics* (Atkins Water Resources Group, 2011) and summarized below.

D2.1 SEDIMENT INPUTS FROM UNPAVED ROADS

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

D2.1.1 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 Kootenai-Fisher Project Area (Atkins Water Resources Group, 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 based on the Montana Public Lands layer: U.S. Forest Service (USFS), Montana State Trust Lands, Montana Fish, Wildlife and Parks, Private, and Unknown. The roads layer was primarily derived from the Travel Routes for Region 1 geodatabase developed by the USFS 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 USFS 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 United States Geological Survey (USGS) 6th Hydrologic Unit Code (HUC12) layer and modified where necessary to delineate the subwatersheds of interest (**Figure D2-1**). Landscapes were delineated according to the Environmental Protection Agency (EPA) 2002 level IV ecoregions (Woods et al., 2002) (**Figure D2-2**). 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.

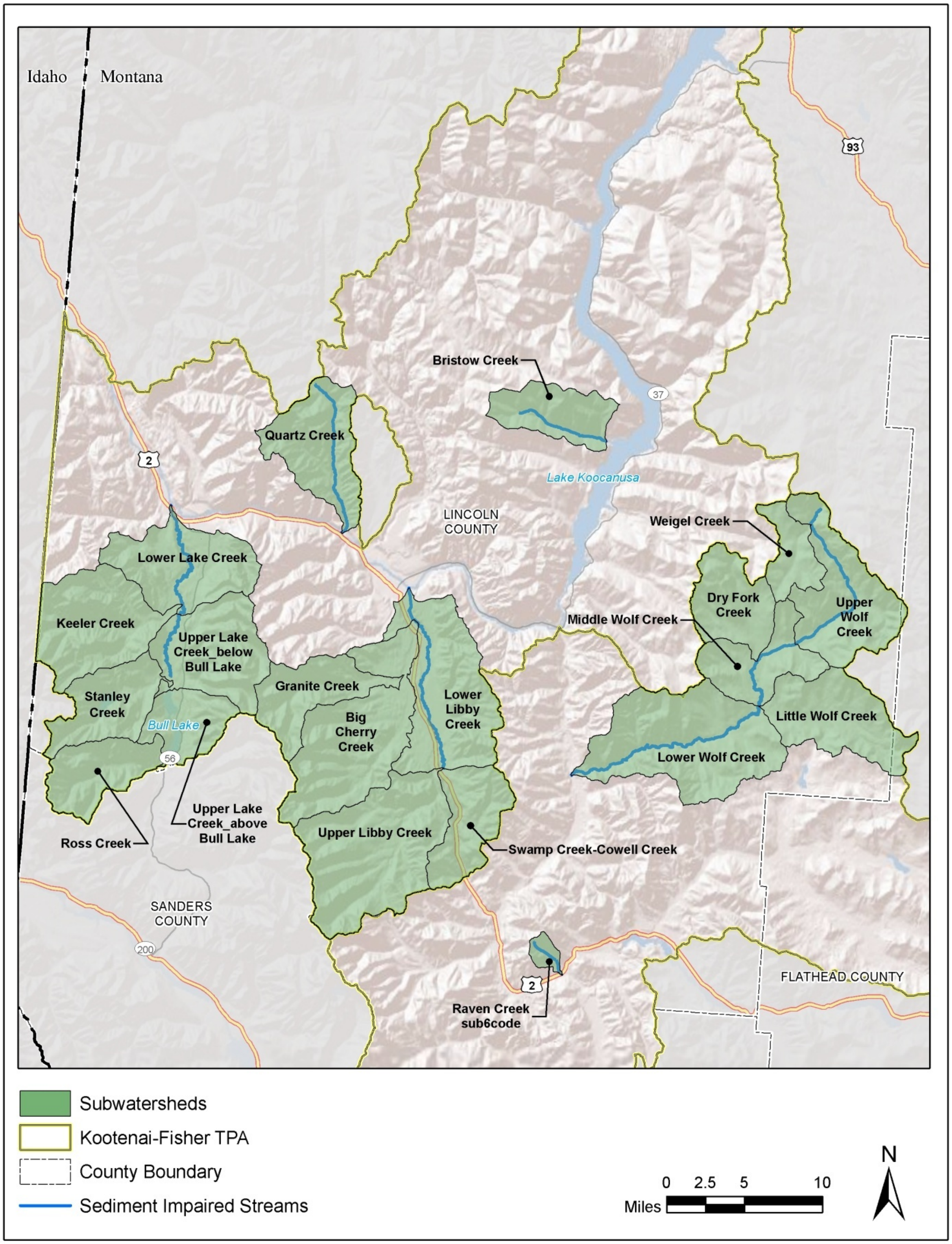

Figure D2-1. HUC12 Subwatersheds in the Kootenai-Fisher Project Area

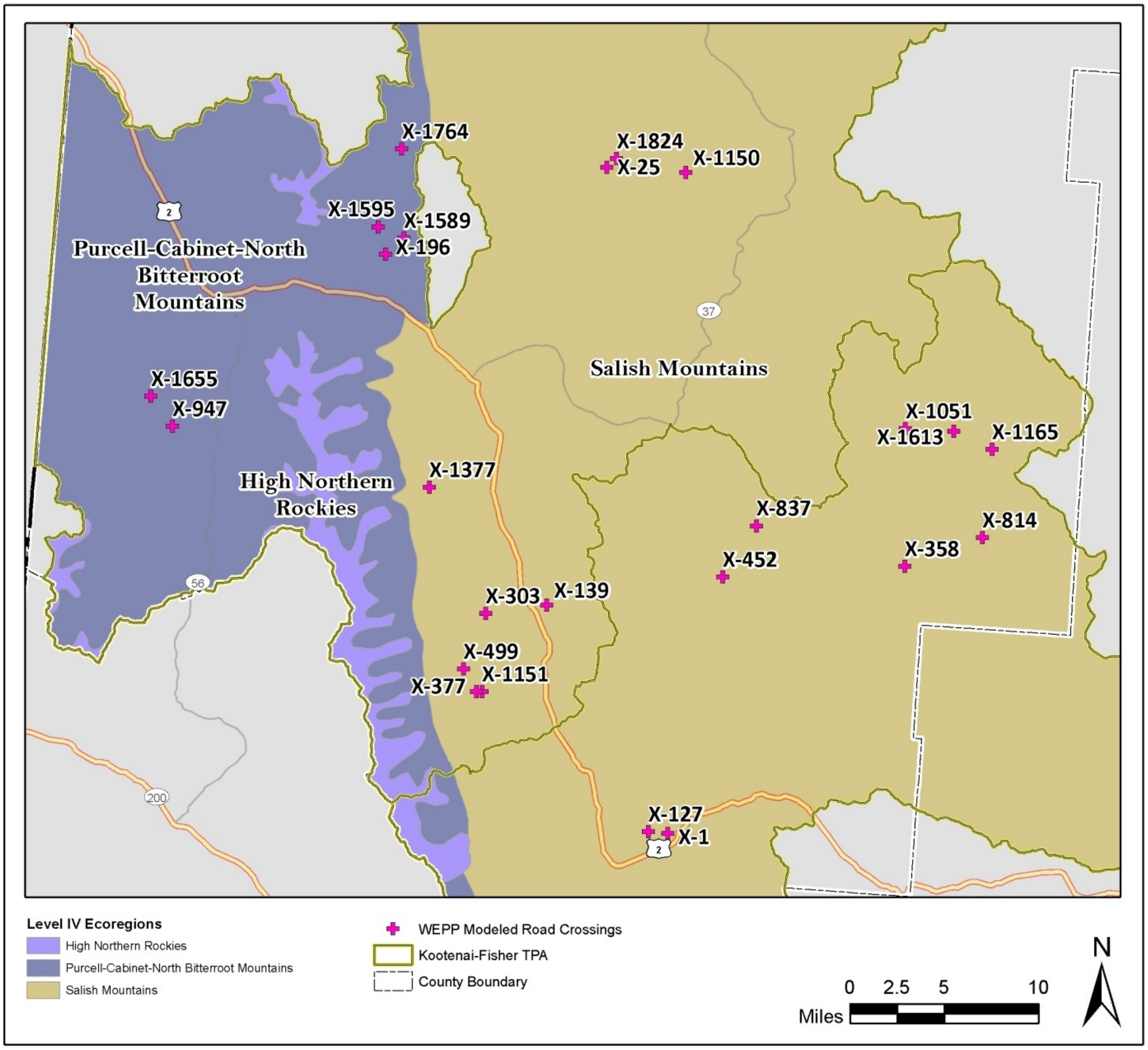

Figure D2-2. Level IV Ecoregions in the Kootenai-Fisher Project Area

Overall, GIS analysis identified 2,235 miles of road within the Kootenai-Fisher Project Area, with all but 195 miles (8.7%) being unpaved. Of the 1,989 road crossings identified within the Kootenai-Fisher Project Area, 1,703 were unpaved (gravel or native material) based on attribute information contained in the GIS roads database (**Figure D2-3**). An additional 102 crossings were identified with an 'unknown' surface type, but based on attributes of proximal road segments they are also likely to be unpaved. Therefore, there are an estimated total of 1,805 unpaved road crossings in the Kootenai-Fisher Project Area (**Table D2-1**). Over half of the crossings are on roads administered by the USFS, with the remainder being a mix of private, state, and county (**Table D2-2**).

Based on the analysis of near-stream parallel road segments, 77 miles (3.4%) are within 150 feet of a stream channel, and 55 of those miles are unpaved road segments. An additional 7.8 miles were classified as 'unknown' based on attribute information in the roads database, the majority of which are likely unpaved.

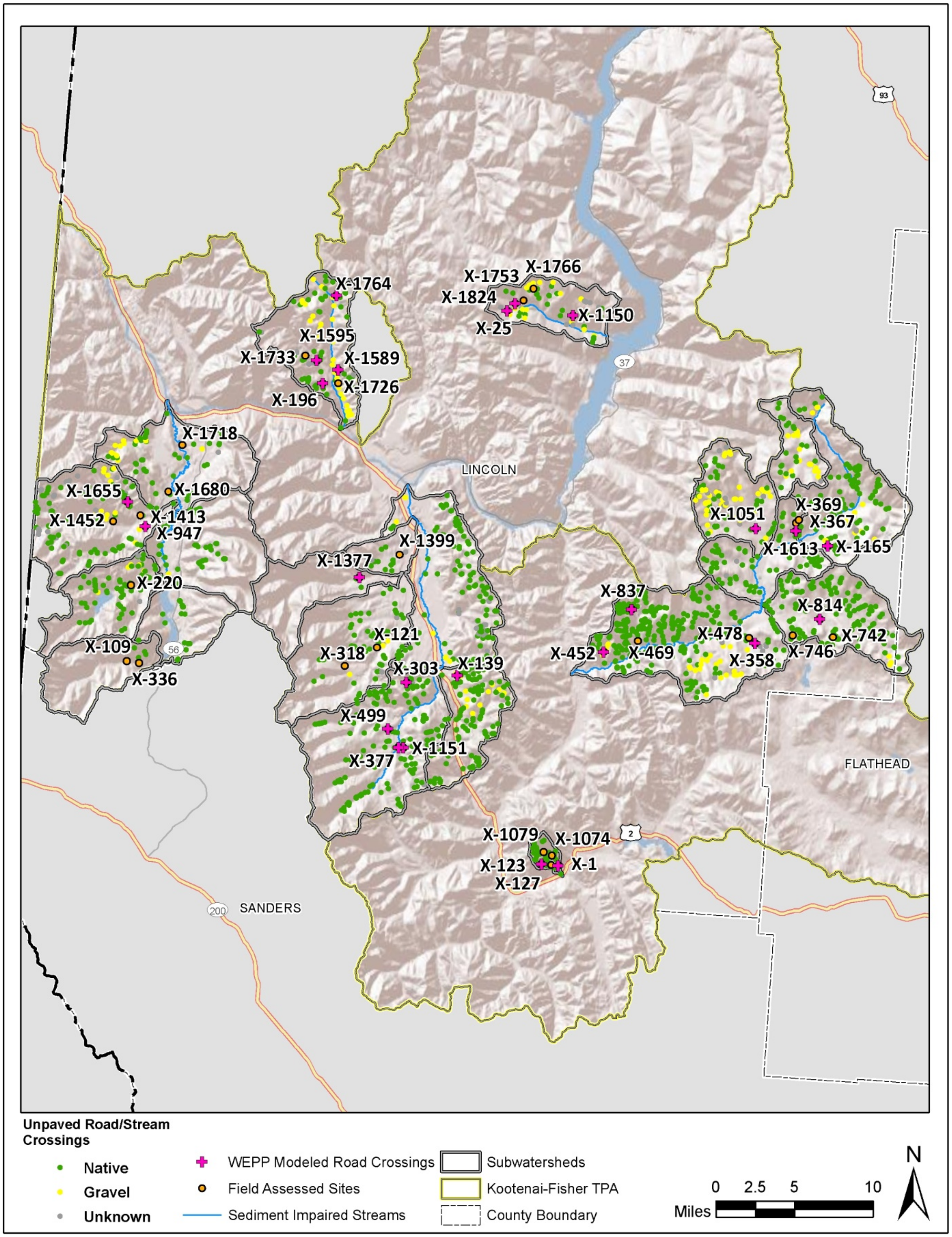

Figure D2-3. Unpaved Road Crossings and Road Surface Type in the Kootenai-Fisher Project Area

Table D2-1. Road Surface Types in the Kootenai-Fisher 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	184		184
Gravel	213	4	217
Native	1,490	98	1,588
Unknown	102		
Total Crossings	**1,989**	**102**	**1,989**
Total Unpaved Crossings	**1,703**	**102**	**1,805**

Table D2-2. Jurisdiction for Unpaved Road Crossings

Jurisdiction	Number of Crossings
County	25
Federal	1,083
Private	657
State	40
Total	**1,805**

D2.1.2 Field Data Collection

A field assessment of unpaved roads was conducted by performing an inspection of road crossings and parallel road segments throughout the Kootenai-Fisher Project Area in July 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).

D2.1.2.1 Crossing Assessment Sites

Forty sites were randomly selected for field data collection, with a goal of obtaining measurements from at least 24 sites. 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 crossings over 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 Quality Assurance Project Plan (QAPP) (U.S. Environmental Protection Agency, 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 factored into the extrapolation process. For each site that was excluded from field assessment because of not having a defined channel, an alternate site was chosen in the field by driving to a nearby crossing. Alternate sites were also chosen if a road was inaccessible due to a gate, the road was paved, or the crossing approach was paved.

Out of the 40 pre-selected sites, 35 were visited in the field in July 2011 and field forms were completed at 15 sites where unpaved road crossings of streams were observed. Of the 35 sites visited, 20 lacked defined stream crossings, 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. Measurements were taken and field forms completed at nine alternate sites. Three additional alternate sites were visited and no data were collected because they lacked defined channels or occurred on roads that were closed, re-vegetated or had a paved approach. Therefore, out of the 47 field assessed sites (i.e., 35 + 12 alternates), field forms were completed at a total of 24 unpaved road crossing sites, and those data were used in the Water Erosion Prediction Project (WEPP) soil erosion model (**Figures D2-2** and **D2-3**). Of the remaining 23 sites, 10 had no defined stream channel and the other 13 were either inaccessible due to closure or on paved roads or paved approaches (**Attachment A**).

D2.1.2.2 Parallel Road Segment Assessment Sites

While driving to the road crossing assessment sites, the field crew visually assessed the potential for sediment loading from parallel road segments identified during the GIS analysis. No evidence of sediment loading from these segments was observed, and based on the condition and composition of the vegetative buffer throughout the Project Area, unpaved parallel road segments were determined to be an insignificant sediment source (**Figure D2-4**). Thus, no field data was collected along parallel road segments in the Kootenai-Fisher Project Area.

Figure D2-4. Vegetative Buffer along Parallel Road Segment, Kootenai-Fisher Project Area

D2.1.3 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 USFS 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.

D2.1.3.1 Model Input Parameters

Road condition data collected throughout the Kootenai-Fisher Project Area in July 2011 was 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, two were selected in northwest Montana to represent the range of precipitation conditions at field assessed sites in the Kootenai-Fisher Project Area: LIBBY 1 NE RS MT and TROUT CREEK RS MT. Precipitation in the Kootenai-Fisher Project Area ranges from 16” to 100” 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 D2-5**). Road crossing assessments were conducted at field sites located in precipitation zones ranging from 18” to 42”, which covers over 80% of the unpaved road crossings identified in GIS. Because precipitation is a significant factor in erosion, modeled loads for stream crossings were grouped into three precipitation zones for the purposes of sediment load modeling and extrapolation in WEPP: Road: <20”, 20-26”, and >26”. To help increase the sample size for each zone, the load for each assessed crossing was modeled for each precipitation zone in WEPP: Road. The mean precipitation value of 17.18” at the LIBBY NE RS MT climate station was utilized for the <20” precipitation zone, while the mean precipitation value of 28.58” at the TROUT CREEK RS MT climate station was utilized for the >26” precipitation zone (**Table 2-3** and **Figure D2-5**). For the 20-26” precipitation zone, the mean precipitation value of 28.58” at the TROUT CREEK RS MT climate station was reduced by 20% to a value of 22.87”.

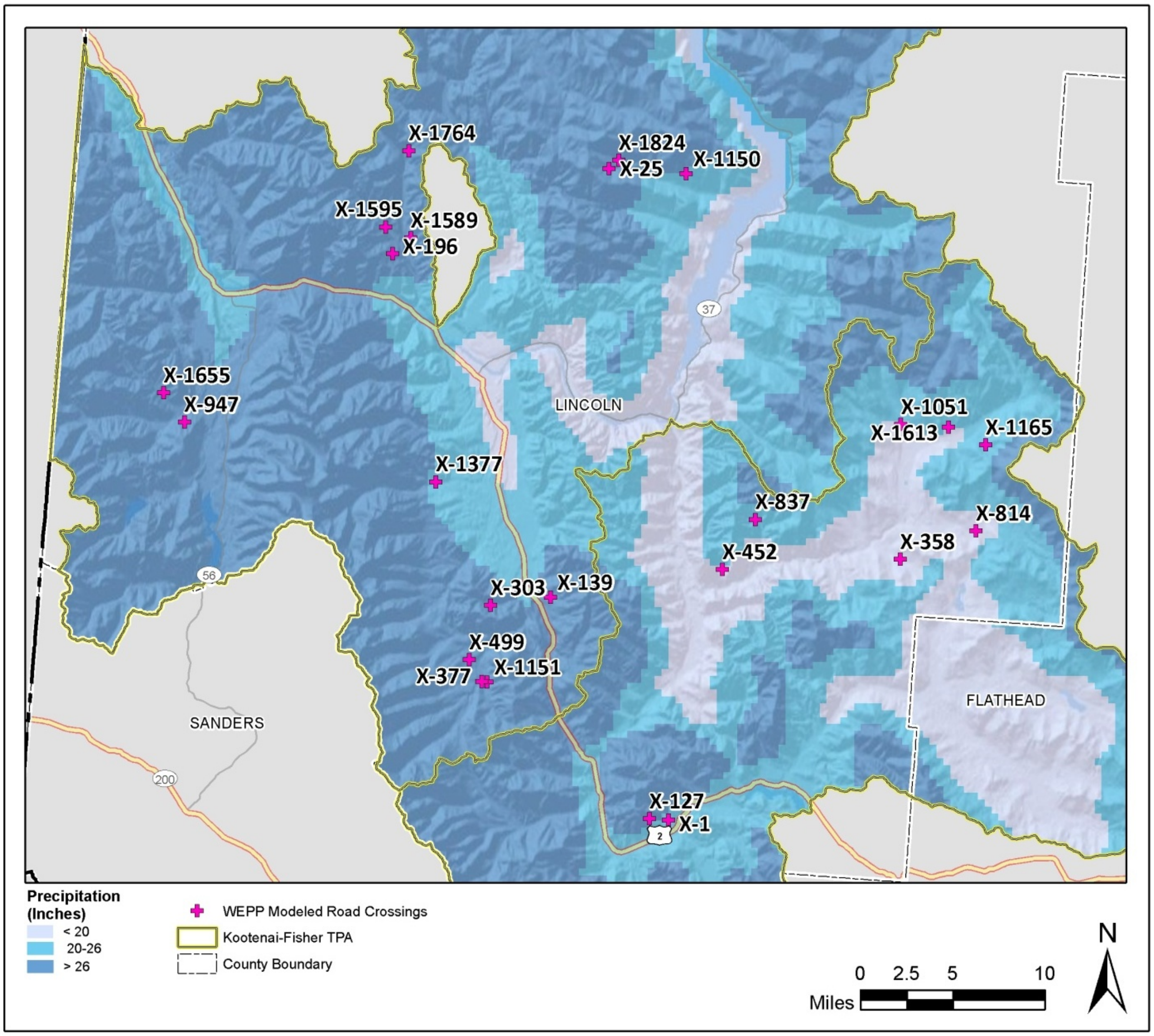

Figure D2-5. Precipitation Patterns in the Kootenai-Fisher Project Area

Table D2-3. Precipitation Data Applied in the WEPP: Road Model

Climate Station	Mean Precipitation (Inches)	Percent Adjustment	Adjusted Mean Precipitation (Inches)	PRISM Precipitation Zone (Inches)
LIBBY 1 NE RS MT	17.18	0	No adjustment	<20
TROUT CREEK RS MT	28.58	-20	22.87	20-26
TROUT CREEK RS MT	28.58	0	No adjustment	>26

D2.1.4 Potential Culvert Failures

A coarse assessment for each culvert was preformed 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, 2004). 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)*.

D2.2 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* (U.S. Department of Agriculture, Forest Service, Alaska Region, 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.

D3.0 Results

D3.1 Sediment Inputs from Unpaved Roads

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

D3.1.1 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. During the field assessment, sufficient BMPs were observed at 14 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 51 feet. In general, private/county roads had a higher proportion of crossings with adequate BMPs than federal roads (i.e., 5/7 vs. 4/17, respectively). This trend is also apparent in the contributing lengths when broken down by jurisdiction: the average contributing length at all private/county crossings was 60 feet and the average contributing length at all federal crossings was 167 feet.

During the field assessment, 15 crossings had insufficient BMPs. Note: the total number of crossings with sufficient and insufficient BMPs (i.e., 29 crossings) is greater than the 24 assessed crossings because both sides of each crossing were evaluated separately and some crossings receive sediment from both sides. At each of the 15 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 227 feet (**Table 3-1**), and based on field measurements, BMPs could reduce the average contributing length to 91 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. Additionally, the location of additional BMPs noted in the field was based on best professional judgment and are intended to be installed in the best practicable location, which may not coincide with the distances identified in **Table 3-1**. Just as additional BMPs used are up to the landowner, the placement of additional BMPs is also up to the landowner.

Table D3-1. 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-947 (F)	Left	142	75	47%
X-1589 (F)	Left	417	127	70%
X-1589 (F)	Right	285	194	32%
X-1764 (F)	Left	210	75	64%
X-1151 (F)	Left	158	92	42%
X-1151 (F)	Right	271	135	50%
X-499 (F)	Left	409	155	62%
X-837 (P)	Left	180	72	60%
X-358 (F)	Left	296	93	69%
X-1655 (F)	Right	254	56	78%
X-1595 (F)	Right	94	28	70%
X-196 (F)	Right	294	101	66%
X-303 (F)	Right	272	128	53%
X-1824 (F)	Right	149	67	55%
X-25 (F)	Right	275	80	71%
X-452 (F)	Right	70	38	46%
X-127 (P)	Right	80	28	65%
Average		**227**	**91**	**60%**

F = Federal, P = Private

D3.1.2 WEPP Modeled Sediment Loads at Unpaved Road Crossings

The average load per crossing was used during the extrapolation process to estimate loading associated with road crossings at a watershed scale. 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, fewer precipitation zones, the same number of precipitation zones, and jurisdiction. The approach selected was to use the three 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. WEPP: Road model results for these two categories are presented by precipitation zone in **Attachment C** and summarized in **Table D3-2** and **Figure D3-1**. As expected, loads for both jurisdictional categories increase with precipitation zone.

Table D3-2. Unpaved Road Crossing Mean Annual Sediment Loads

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)
Federal	<20	17	0.0118	0.0026	0.0005	0.0410	0.0054	0.0011	0.0004	0.0141
Federal	20-26	17	0.0156	0.0033	0.0011	0.0491	0.0073	0.0014	0.0007	0.0186
Federal	>26	17	0.0234	0.0049	0.0009	0.0740	0.0112	0.0024	0.0009	0.0321
Private	<20	7	0.0037	0.0017	0.0002	0.0121	0.0025	0.0011	0.0002	0.0077
Private	20-26	7	0.0039	0.0015	0.0002	0.0113	0.0028	0.0010	0.0002	0.0074
Private	>26	7	0.0054	0.0022	0.0007	0.0162	0.0039	0.0015	0.0007	0.0109
Entire Dataset	<20	24	0.0094	0.0020	0.0002	0.0410	0.0046	0.0009	0.0002	0.0141
Entire Dataset	20-26	24	0.0122	0.0026	0.0002	0.0491	0.0060	0.0011	0.0002	0.0186
Entire Dataset	>26	24	0.0182	0.0039	0.0007	0.0740	0.0090	0.0018	0.0007	0.0321

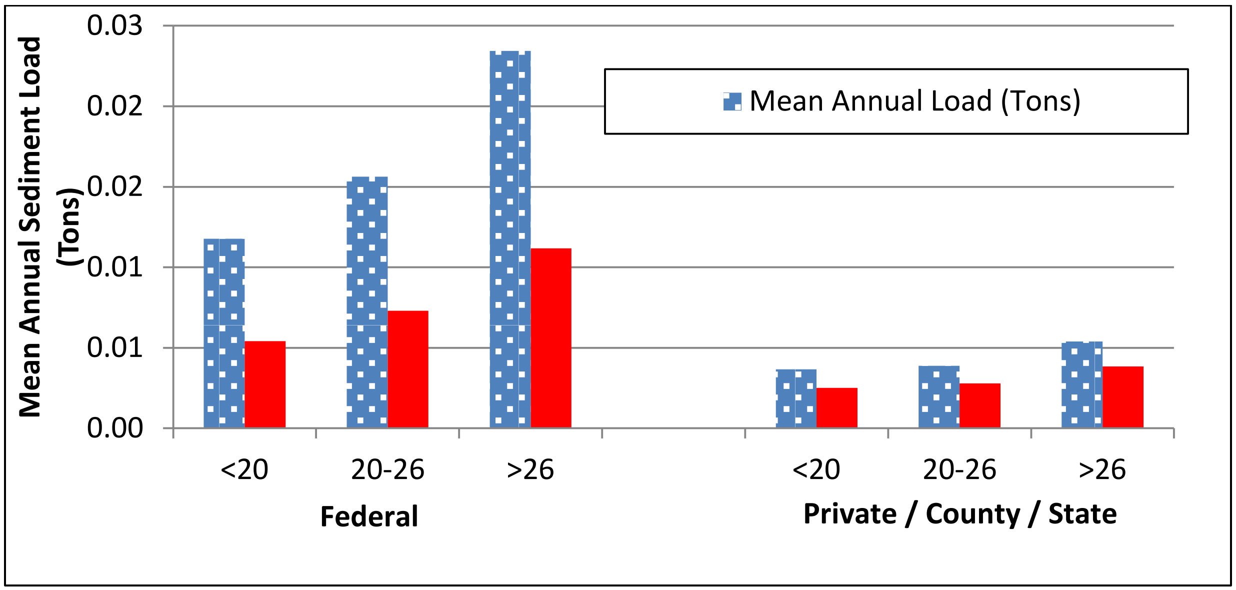

Figure D3-1. Unpaved Road Crossing Mean Annual Sediment Loads

D3.1.3 Unpaved Road Crossing Sediment Load Extrapolation

The 24 unpaved road crossings modeled in WEPP: Road were grouped based on jurisdiction and precipitation zone as presented in **Table D3-3** 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 1,805 unpaved road crossings were identified in the GIS analysis, while 10 out of 47 (21%) 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 over undefined channels that are not contributing road-related sediment to streams. Since 21% of the crossings were excluded for this reason, the total number on unpaved road crossings identified in GIS in each subwatershed was reduced by 21%, for an estimate of 1,426 unpaved road crossings.

Although some additional crossings were not assessed because the approach was paved or the crossing was inaccessible, those exclusions were not factored in because the reduction for undefined channels was performed as a result of the level of detail of the hydrology layer used to identify crossings in GIS, and the source assessment process aims to err on the conservative side as a part of the implicit margin of safety. However, it is noted that the Kootenai National Forest has been paving approaches in recent years as a BMP, particularly in watersheds inhabited by sensitive species, such as bull trout, westslope cutthroat trout, and redband rainbow trout (**Figure D3-2**). Based on data provided by the USFS (Hooper, P., personal communication 1/2/2013), approximately 19 approaches have been paved in the Kootenai Ranger District, with eight of those occurring on sediment listed streams in the project area (i.e., Libby and Wolf).

Figure D3-2. Paved Approach on Road Crossing of Leigh Creek, Tributary to Libby Creek, Kootenai National Forest

D3.1.4 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 D3-3** 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. For unpaved road crossings within the Kootenai-Fisher Project Area, the estimated mean annual sediment load ranges from 0.17 tons in the Raven Creek watershed to 6.86 tons in the Libby Creek watershed. Reductions are slightly greater for federally administered roads than private/county/state roads, but because of the greater average load per crossing at federal crossings, reductions at the subwatershed scale were similar. Sediment loading from unpaved roads could be reduced between 32% and 51% with additional BMPs, which averages to a 50% reduction across the project area. 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. Most loading is coming from a limited number of crossings with inadequate or improperly maintained BMPs. A complete evaluation of sediment loads at the HUC12 subwatershed scale by precipitation zone and ownership is presented in **Attachment D**.

Table D3-3. 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
Libby Creek Federal	380	300	6.44	3.06	53%
Libby Creek Private/County/State	107	85	0.42	0.30	29%
Libby Creek Total	**487**	**385**	**6.86**	**3.36**	**51%**
Lake Creek Federal	237	187	4.37	2.08	52%
Lake Creek Private/County/State	103	81	0.44	0.31	29%
Lake Creek Total	**340**	**269**	**4.81**	**2.40**	**50%**
Wolf Creek Federal	317	250	4.20	1.97	53%
Wolf Creek Private/County/State	474	374	1.46	1.03	29%
Wolf Creek Total	**791**	**625**	**5.67**	**3.01**	**47%**
Bristow Creek Federal	58	46	0.98	0.46	53%
Bristow Creek Total	**58**	**46**	**0.98**	**0.46**	**53%**
Quartz Creek Federal	89	70	1.62	0.77	52%
Quartz Creek Private/County/State	3	2	0.01	0.01	29%
Quartz Creek Total	**92**	**73**	**1.63**	**0.78**	**52%**
Raven Creek Federal	2	2	0.02	0.01	53%
Raven Creek Private/County/State	35	28	0.15	0.10	29%
Raven Creek Total	**37**	**29**	**0.17**	**0.12**	**32%**
Kootenai-Fisher Project Area Total	**1,805**	**1,426**	**20.11**	**10.12**	**50%**

D3.1.5 Potential Culvert Failures

Out of the 24 field assessed crossings in the Kootenai-Fisher Project Area, 22 crossings had culverts, while two were comprised of log crib structures overarching a natural streambed and no assessment was performed on the culvert at crossing X-947 since it was on a very small headwater channel located under extensive rock fill. While 18 of the culverts had flowing water at the time that field data was collected, all 21 culverts assessed in the field were evaluated for culvert failure to provide a conservative estimate of sediment loading. Of the 21 culverts assessed in the field, 100% are capable of passing the two-year flood event, while 15 of these culverts (71%) pass a 100-year flood event (**Tables D3-4** and **D3-5**, **Attachment E**). 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 D3-5** 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 D3-4. 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-1655	13	25	35	50	63	76	56	72
X-1589	10	19	27	38	48	59	126	138
X-1764	39	69	92	126	156	185	171	332
X-1595	4	9	13	19	24	30	81	55
X-196	4	9	13	19	24	30	67	172
X-1377	7	14	19	28	36	43	119	28
X-303	1	2	4	6	8	9	30	20
X-1151	2	5	8	12	15	19	100	65
X-499	1	2	4	6	8	9	14	20
X-377	60	104	138	184	227	268	1038	365
X-139	7	14	19	28	36	43	62	46
X-1B	60	104	138	184	227	268	61	162
X-1150	10	19	27	38	48	59	71	66
X-25	10	19	27	38	48	59	164	90
X-837	4	9	13	19	24	30	26	30
X-358	7	14	19	28	36	43	87	93
X-814	32	59	79	108	135	160	426	201
X-1051	86	147	191	252	309	363	351	305
X-1089	13	25	35	50	63	76	132	105
X-127	1	2	4	6	8	9	20	24
X-1	4	9	13	19	24	30	11	18

grey cells indicate culvert fails to pass a given discharge

Table D3-5. Culvert Failure Summary

Flood Frequency	Number of Culverts Passing	Number of Culverts Failing	Percent Passing	Percent Failing
Q2	21	0	100%	0%
Q5	20	1	95%	5%
Q10	19	2	90%	10%
Q25	19	2	90%	10%
Q50	18	3	86%	14%
Q100	15	6	71%	29%

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.

D3.2 Fish Passage Analysis

In the Kootenai-Fisher Project Area, none of the 18 culverts assessed at crossings with flowing water had a high probability of allowing fish passage (**Table D3-6**), while 17 culverts (96%) were classified as fish passage barriers (**Attachment F**). 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 culvert's ability to pass fish (**Figure D3-3**). 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, five additional culverts may pass some fish. This analysis was conducted to sample a representative subset of the population, and indicates fish passage may be a problem throughout the project area. However, this is a very coarse assessment with a high level of uncertainty, and additional evaluations should be conducted in consultation with a fish biologist at any culvert that may be replaced to facilitate fish passage. Under some circumstances, such as when a genetically pure native population is isolated from non-native species, it is desirable to maintain a fish passage barrier.

Table D3-6. Fish Passage Evaluation

Fish Passage Evaluation Categories	Fish Passage Evaluation Criteria	Number of Culverts	Percentage of Total Culverts Assessed
Green[1]	conditions that have a high certainty of meeting juvenile fish passage at all desired stream flows	0	0%
Red[2]	conditions that have a high certainty of not providing juvenile fish passage at all desired stream flows	17	94%
Grey[3]	conditions are such that additional and more detailed analysis is required to determine their juvenile fish passage ability	1	6%

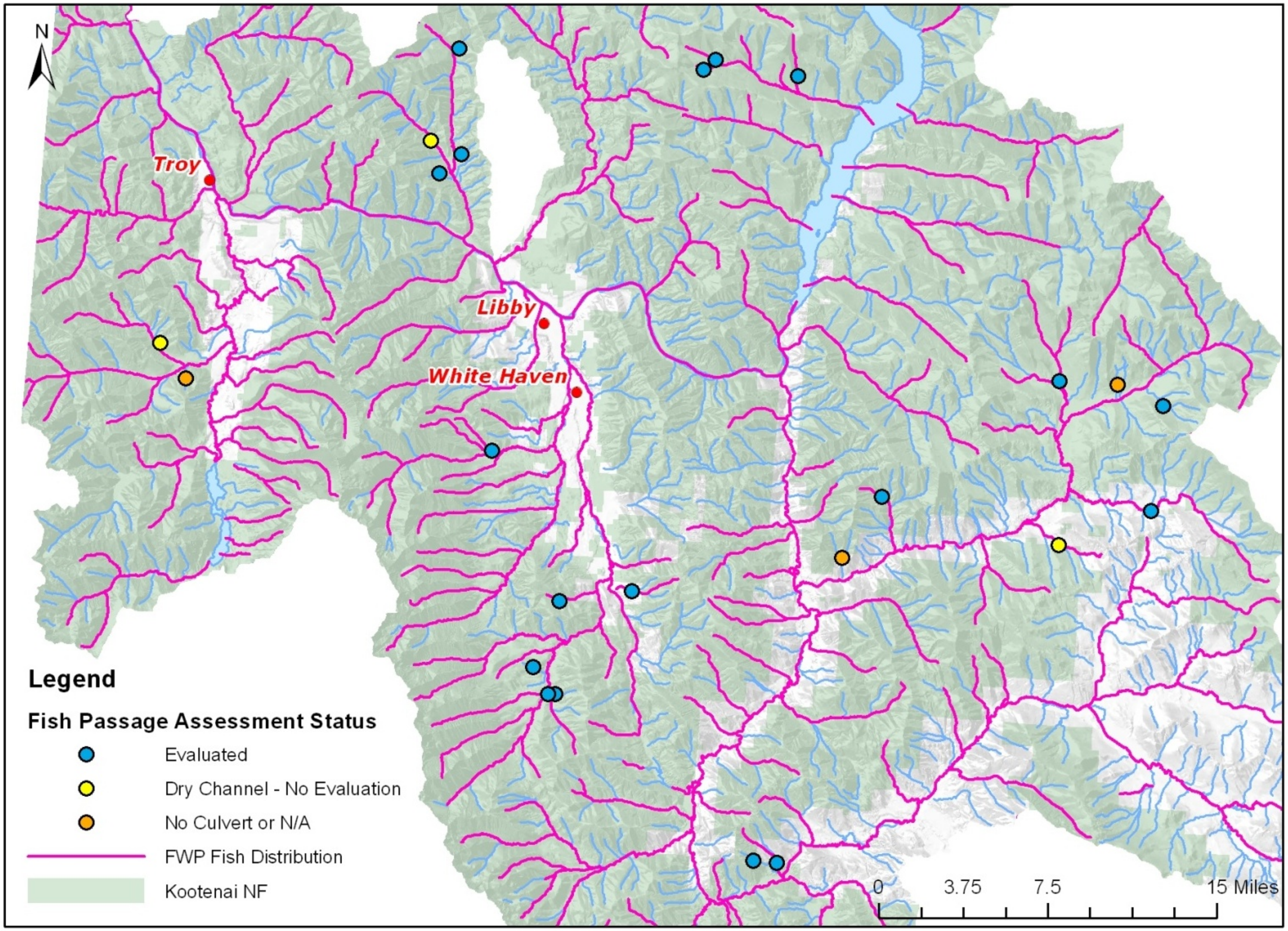

Figure D3-3. Montana Fish, Wildlife and Parks Fish Distribution in the Kootenai-Fisher Project Area

D4.0 Assumptions and Uncertainty

The 47 crossings that were assessed in the field represents approximately 3.3% of all crossings (based on crossings identified using GIS). Ideally, 5% of the roads would have been sampled, which is still a small portion of the unpaved crossings, but the sample size was limited by project resources. However, 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 Kootenai-Fisher 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 D3-3**) 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.

D5.0 DISCUSSION

Within the Kootenai-Fisher Project Area, there are six water body segments listed on the 2012 303(d) List for sediment-related impairments, including Lake Creek, Libby Creek, Wolf Creek, Bristow Creek, Quartz Creek, and Raven Creek. Mean annual sediment contributions from unpaved roads average 20.11 tons per year (**Table D4-1**). Through the application of BMPs, it is estimated that this sediment load can be reduced to 10.12 tons per year, which is a 50% reduction in sediment loads. This reduction is achieved by reducing contributing road lengths at unpaved road crossings through the application of BMPs.

Table D4-1. 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
Libby Creek	6.86	3.36	51%
Lake Creek	4.81	2.40	50%
Wolf Creek	5.67	3.01	47%
Bristow Creek	0.98	0.46	53%
Quartz Creek	1.63	0.78	52%
Raven Creek	0.17	0.12	32%
Kootenai-Fisher Project Area	**20.11**	**10.12**	**50%**

D6.0 REFERENCES

Atkins Water Resources Group. 2011. Road Sediment Assessment and Modeling: Kootenai-Fisher TMDL Planning Area Road GIS Layers and Summary Statistics. Helena, MT.

Burford, Drake D., T. E. McMahon, J. E. Cahoon, and M. Blank. 2009. Assessment of Trout Passage Through Culverts in a Large Montana Drainage During Summer Low Flow. *North American Journal of Fisheries Management.* 29: 739-752.

Hooper, P. 2013. Personal Communication. Forest Service, Kootenai Ranger District. Accessed 1/2/2013.

Parrett, Charles and Dave R. Johnson. 2004. Methods for Estimating Flood Frequency in Montana Based on Data Through Water Year 1998. Reston, VA: U.S. Geological Survey. Water Resource Investigations Report 03-4308.

Peterson, Phil N., R. K. Simmons, T. Cardoso, and J. T. Light. 2013. A Probabilistic Model for Assessing Passage Performance of Coastal Cutthroat Trout Through Corrugated Metal Culverts. *North American Journal of Fisheries Management.* 33: 192-199.

Sowers, George F. 1979. Introductory Soil Mechanics and Foundations: Geotechnical Engineering, 4th ed., New York: Prentice Hall.

U.S. Department of Agriculture, Forest Service, Alaska Region. 2002. A Summary of Technical Considerations to Minimize the Blockage of Fish at Culverts on the National Forests of Alaska. http://www.fs.fed.us/r10/ro/policy-reports/wfew/fish_blockage_at_culverts.pdf.

U.S. Environmental Protection Agency. 2011. Quality Assurance Project Plan and Sampling and Analysis Plan: Assessment of Unpaved Roads for TMDL Development. Task Ofer 18: Task 2b.

Woods, Alan J., James M. Omernik, John A. Nesser, Jennifer Shelden, Jeffrey A. Comstock, and Sandra J. Azevedo. 2002. Ecoregions of Montana, 2nd ed., Reston, VA: United States Geographical Survey.

ATTACHMENT DA - FIELD ASSESSED SITES

#	Field Site ID	GIS Site ID	Stream Segment Subwatershed	Pre-selected / Alternate	Field Form Completed	Road Closed / Re-vegetated / Obliterated	No Defined Channel	Comment
1	X-1718	X-1718	Lake Creek	pre-selected	no			paved
2	X-1680	X-1680	Lake Creek	pre-selected	no			paved
3	X-1655	X-1655	Lake Creek	pre-selected	yes			
4	X-1413	X-1413	Lake Creek	alternate	no			paved approach at Keeler Rattle 473 crossing of National Forest Keeler Creek
5	X-1452	X-1452	Lake Creek	pre-selected	no	Road Closed - Administrative Use By Permit		
6	X-1A	X-947	Lake Creek	alternate	yes			
7	X-220	X-220	Lake Creek	pre-selected	no	Road Closed - Re-vegetated	X	no channel at GIS identified crossing, but stream audible from site
8	X-336	X-336	Lake Creek	alternate	no	Road Closed - Administrative Use By Permit	X	no channel
9	X-109	X-109	Lake Creek	pre-selected	no			paved, only site noted as AS-ASPHALT out of 40 pre-selected sites
10	X-1736	X-1726	Quartz Creek	pre-selected	no		X	no channel, recorded in the field as X-1736, but at site X-1726
11	X-1589	X-1589	Quartz Creek	pre-selected	yes			
12	X-1764	X-1764	Quartz Creek	pre-selected	yes			
13	X-1595	X-1595	Quartz Creek	pre-selected	yes			
14	X-1733	X-1733	Quartz Creek	pre-selected	no	Road Closed - Re-vegetated		Forest Road 4691 closed
15	X-196	X-196	Quartz Creek	alternate	yes			
16	X-1377	X-1377	Libby Creek	pre-selected	yes			
17	X-1399	X-1399	Libby Creek	pre-selected	no			paved, Bituminous Surface Treatment in GIS database
18	X-121	X-121	Libby Creek	pre-selected	no			paved approach
19	X-318	X-318	Libby Creek	pre-selected	no			paved approach
20	X-303	X-303	Libby Creek	pre-selected	yes			
21	X-1151	X-1151	Libby Creek	pre-selected	yes			
22	X-499	X-499	Libby Creek	pre-selected	yes			
23	X-377	X-377	Libby Creek	alternate	yes			
24	X-139	X-139	Libby Creek	pre-selected	yes			
25	X-1B	X-1824	Bristow Creek	pre-selected	yes			Forest Road 6245 crossing on National Forest Bristow Creek assessed during recon
26	X-1150	X-1150	Bristow Creek	pre-selected	yes			
27	X-1753	X-1753	Bristow Creek	pre-selected	no		X	no channel, recorded as "ditch relief" on field checklist
28	X-1766	X-1766	Bristow Creek	pre-selected	no	Road Closed - Administrative Use By Permit		
29	X-25	X-25	Bristow Creek	alternate	yes			
30	X-452	X-452	Wolf Creek	alternate	yes			
31	X-469	X-469	Wolf Creek	pre-selected	no		X	no channel, recorded as "ditch relief" on field checklist
32	X-837	X-837	Wolf Creek	pre-selected	yes			
33	X-478	X-478	Wolf Creek	pre-selected	no		X	no channel, ponded water
34	X-358	X-358	Wolf Creek	alternate	yes			
35	X-746	X-746	Wolf Creek	pre-selected	no	Road Closed - Re-vegetated	X	no channel, Plum Creek managed road
36	X-742	X-742	Wolf Creek	pre-selected	no	Road Closed - Re-vegetated		
37	X-814	X-814	Wolf Creek	alternate	yes			
38	X-1051	X-1051	Wolf Creek	pre-selected	yes			
39	X-1089	X-1165	Wolf Creek	pre-selected	yes	Road Closed - Re-vegetated		
40	X-369	X-369	Wolf Creek	pre-selected	no	Road Closed - Re-vegetated	X	no channel, dry swale
41	X-367	X-367	Wolf Creek	alternate	no	Road Closed - Re-vegetated		
42	X-1613	X-1613	Wolf Creek	alternate	yes			
43	X-123	X-123	Raven Creek	pre-selected	no		X	no channel
44	X-127	X-127	Raven Creek	pre-selected	yes			
45	X-1074	X-1074	Raven Creek	pre-selected	no		X	no channel, road covered in knapweed
46	X-1	X-1	Raven Creek	alternate	yes			
47	X-1079	X-1079	Raven Creek	pre-selected	no	Road Closed - Re-vegetated		examined during recon

ATTACHMENT DB - UNPAVED ROAD CROSSING FIELD DATA

Waterbody	Stream Segment	Location ID	GIS ID	Date	Latitude	Longitude	Jurisdiction / Ownership	Estimated Mean Annual Precipitation (inches)	Soil Type	% Rock	Insloped/ Outsloped	Road Surface	Traffic Level	Years Modeled	Gradient CRL1 (%)	Length CRL1 (Ft)	Width CRL1 (Ft)	Gradient Fill (%)	Length Fill (Ft)	Gradient Buffer (%)	Length Buffer (Ft)	WEPP LOAD (lbs)	Gradient CRL1 (%)	Length CRL1 (Ft)	Width CRL1 (Ft)	Gradient Fill (%)	Length Fill (Ft)	Gradient Buffer (%)	Length Buffer (Ft)	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		
unknown	Lake Creek	X-1655	X-1655	07/26/11	48.35566	-115.92236	Federal	>26	Sand L	20	Insloped Veg/rock ditch	Part. Grav.	Low	30	-	-	-	-	-	-	-	0.00	3	254	22	119	5	0.3	1	52.75	52.75	12.81
unknown	Lake Creek	X-1A	X-947	07/26/11	48.33426	-115.89508	Federal	>26	Sand L	20	Outsloped Unrutted	Native	Low	30	8	142	12	101	30	0.3	1	56.80	-	-	-	-	-	-	-	0.00	56.80	30.00
unnamed	Quartz Creek	X-1589	X-1589	07/26/11	48.49219	-115.64647	Federal	>26	Sand L	10	Outsloped Unrutted	Native	Low	30	3	417	11	84	18	0.3	1	71.73	3	285	11	84	18	0.3	1	49.03	120.76	55.15
Hennessy Creek	Quartz Creek	X-1764	X-1764	07/26/11	48.56023	-115.65687	Federal	>26	Sand L	10	Outsloped Unrutted	Native	Low	30	7	210	10	119	26	0.3	1	64.76	3	54	10	119	26	0.3	1	15.24	80.00	38.37
West Fork Quartz Trib	Quartz Creek	X-1595	X-1595	07/26/11	48.49929	-115.67690	Federal	>26	Sand L	20	Outsloped Unrutted	Native	Low	30	-	-	-	-	-	-	-	0.00	3	94	11	100	12	0.3	1	13.49	13.49	4.02
unnamed	Quartz Creek	X-196	X-196	07/26/11	48.47878	-115.66622	Federal	>26	Sand L	20	Outsloped Unrutted	Native	Low	30	-	-	-	-	-	-	-	0.00	5	294	14	100	35	0.3	1	148.09	148.09	50.87
Shawnesy Creek	Libby Creek	X-1377	X-1377	07/27/11	48.30317	-115.59466	County	20-26	Sand L	30	Outsloped Unrutted	Part. Grav.	Low	30	1	6	16	58	8	0.3	1	0.40	1	6	16	58	8	0.3	1	0.40	0.80	0.80
unnamed	Libby Creek	X-303	X-303	07/27/11	48.21003	-115.51891	Federal	>26	Sand L	20	Outsloped Unrutted	Native	Low	30	-	-	-	-	-	-	-	0.00	3	272	11	70	7	0.3	1	21.35	21.35	10.04
unnamed	Libby Creek	X-1151	X-1151	07/27/11	48.15004	-115.51627	Federal	>26	Sand L	10	Outsloped Unrutted	Native	Low	30	2	158	10	47	15	0.3	1	11.78	3	271	10	47	15	0.3	1	21.56	33.34	17.60
unnamed	Libby Creek	X-499	X-499	07/27/11	48.16629	-115.53921	Federal	>26	Sand L	10	Outsloped Unrutted	Native	Low	30	4	409	13	58	6	0.3	1	38.87	-	-	-	-	-	-	-	0.00	38.87	14.73
Midas Creek	Libby Creek	X-377	X-377	07/27/11	48.14984	-115.52254	Federal	>26	Sand L	20	Outsloped Unrutted	Gravel	High	30	2	97	18	47	22	0.3	1	31.72	1	100	18	47	22	0.3	1	32.40	64.12	64.12
unnamed	Libby Creek	X-139	X-139	07/27/11	48.21997	-115.44976	Private	>26	Loa m	5	Outsloped Unrutted	Native	Low	30	-	-	-	-	-	-	-	0.00	5	69	15	100	12	0.3	1	21.75	21.75	21.75
North Fork Bristow Creek	Bristow Creek	X-1B	X-1824	07/12/11	48.56548	-115.40845	Federal	>26	Clay L	20	Outsloped Unrutted	Native	Low	30	7	48	14	58	19	0.3	1	12.56	5	149	14	84	15	0.3	1	38.09	50.65	29.69
unnamed	Bristow Creek	X-1150	X-1150	07/27/11	48.55885	-115.32752	Federal	20-26	Sand L	20	Outsloped Unrutted	Gravel	Low	30	3	79	16	58	10	0.3	1	6.80	-	-	-	-	-	-	-	0.00	6.80	6.80
unnamed	Bristow Creek	X-25	X-25	07/27/11	48.55840	-115.41904	Federal	>26	Sand L	10	Outsloped Unrutted	Native	Low	30	-	-	-	-	-	-	-	0.00	7	275	15	70	10	0.3	1	53.63	53.63	15.60
Ariana	Wolf Creek	X-452	X-452	07/28/11	48.25176	-115.25048	Federal	<20	Silt L	10	Outsloped Unrutted	Native	Low	50	1	20	7	58	8	0.3	1	0.18	1	70	7	100	8	0.3	1	1.19	1.37	0.82
unnamed	Wolf Creek	X-837	X-837	07/28/11	48.29262	-115.21642	Private	20-26	Silt L	20	Outsloped Unrutted	Native	Low	30	6	180	7	70	7	0.3	1	5.57	-	-	-	-	-	-	-	0.00	5.57	2.23
Kavala	Wolf Creek	X-358	X-358	07/28/11	48.26981	-115.04304	Federal	<20	Silt L	10	Outsloped Unrutted	Native	Low	50	4	296	14	58	17	0.3	1	22.22	2	60	14	58	17	0.3	1	3.50	25.72	10.48
Sinclair	Wolf Creek	X-814	X-814	07/28/11	48.29605	-114.95640	Private	<20	Sand L	30	Outsloped Unrutted	Native	Low	50	1	15	12	84	14	0.3	1	0.81	1	35	12	84	14	0.3	1	1.89	2.70	2.70
Dry Creek	Wolf Creek	X-1051	X-1051	07/28/11	48.37520	-115.05347	Federal	<20	Silt L	40	Outsloped Unrutted	Gravel	Low	50	1	20	20	47	18	0.3	1	0.57	1	16	20	36	18	0.3	1	0.33	0.90	0.90

Waterbody	Stream Segment	Location ID	GIS ID	Date	Latitude	Longitude	Jurisdiction / Ownership	Estimated Mean Annual Precipitation (inches)	Soil Type	% Rock	Insloped/ Outsloped	Road Surface	Traffic Level	Years Modeled	Gradient CRL1 (%)	Length CRL1 (Ft)	Width CRL1 (Ft)	Gradient Fill (%)	Length Fill (Ft)	Gradient Buffer (%)	Length Buffer (Ft)	WEPP LOAD (lbs)	Gradient CRL1 (%)	Length CRL1 (Ft)	Width CRL1 (Ft)	Gradient Fill (%)	Length Fill (Ft)	Gradient Buffer (%)	Length Buffer (Ft)	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	Wolf Creek	X-1089	X-1165	07/28/11	48.36396	-114.95220	Private	20-26	Silt L	5	Outsloped Unrutted	Native	Low	30	4	78	2	47	17	0.3	1	0.15	3	125	2	47	17	0.3	1	0.27	0.42	0.42
unnamed	Wolf Creek	X-1613	X-1613	07/28/11	48.37565	-114.99744	Private	20-26	Silt L	5	Outsloped Unrutted	Native	Low	30	1	10	10	47	10	0.3	1	0.29	5	60	10	47	10	0.3	1	3.35	3.64	3.64
Raven trib	Raven Creek	X-127	X-127	07/28/11	48.05256	-115.31427	Private	>26	Silt L	10	Outsloped Unrutted	Native	Low	30	2	50	15	84	8	0.3	1	5.95	11	80	15	84	8	0.3	1	26.52	32.47	15.23
Raven Creek	Raven Creek	X-1	X-1	07/28/11	48.05253	-115.29184	Federal	20-26	Sand L	40	Outsloped Unrutted	Native	Low	30	3	80	4	47	6	9	6	3.12	-	-	-	-	-	-	-	0.00	3.12	3.12

Waterbody	Location ID	GIS ID	Segment 1 Potential BMPs		Road Crossing and BMP Notes/Comments
			L	R	
unknown	X-1655	X-1655	n/a	water bar at 56', ditch relief culvert	reduce River Right contributing length to 56', road sloped to the left
unknown	X-1A	X-947	water bar @ 75'	n/a	142' up River Left to pipe, reduce to 75' from River Left, water partly flows past crossing to flat area
unnamed	X-1589	X-1589	water bar/dip @127'	water bar/drain dip @ 194'	reduce River Right to 127', started at culvert from River Left, reduce River Right to 194'
Hennessy Creek	X-1764	X-1764	water bar @ 75'	none	drain dip at top of River Left, add rubber water bar to make length 75'
West Fork Quartz Trib	X-1595	X-1595	-	water bar @ 28'	short length could be slightly reduced from River Right to 28'
unnamed	X-196	X-196	-	upgrade water bar @ 101'	101 at failed water bar on River Right, slopes past River Left
Shawnesy Creek	X-1377	X-1377	none	none	-
unnamed	X-303	X-303	-	water bar/rolling dip @ 128'	-
unnamed	X-1151	X-1151	water bar @ 92'	water bar @ 135'	reduce River Right to 135' feet, reduce River Left to 92' with water bar
unnamed	X-499	X-499	water bar at 155'	-	only from River Left, reduce River Left to 155'
Midas Creek	X-377	X-377	fix water bar	none	-
unnamed	X-139	X-139	-	no more needed	only from River Right, no BMP length reduction
North Fork Bristow Creek	X-1B	X-1824	none	water bar at 67'	grass buffer, rolling dip at ~150' on River Right, culvert drain on ditch on River Right
unnamed	X-1150	X-1150	none required	-	newly bladed
unnamed	X-25	X-25	-	water bar @ 80'	-
Ariana	X-452	X-452	-	water bar/dip @ 38'	reduce River Right to 38' with water bar; 3' vegetated tread reduce width to 7'
unnamed	X-837	X-837	water bar at 72'	-	-
Kavala	X-358	X-358	water bar @ 93'	none	-
Sinclair	X-814	X-814	slash filter	slash filter	-
Dry Creek	X-1051	X-1051	slash filter	slash filter	-
unnamed	X-1089	X-1165	-	-	vegetated road modeled for two 1-foot wide wheel tracks
unnamed	X-1613	X-1613	-	-	lightly used road w/knapweed in centerline
Raven trib	X-127	X-127	none	water bar at 28'	-
Raven Creek	X-1	X-1	none	-	slightly rutted w/veg in center and rocky, buffer then fill

ATTACHMENT DC - UNPAVED ROAD CROSSING WEPP MODELED SEDIMENT LOADS BY PRECIPITATION ZONE

Waterbody	Stream Segment	Location ID	GIS ID	Jurisdiction / Ownership	<20		20-26		>26	
					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)
unknown	Lake Creek	X-1655	X-1655	Federal	25.56	6.61	31.05	7.04	52.75	12.81
unknown	Lake Creek	X-1A	X-947	Federal	35.25	18.62	39.00	20.60	56.80	30.00
unnamed	Quartz Creek	X-1589	X-1589	Federal	52.07	23.81	81.51	37.28	120.76	55.15
Hennessy Creek	Quartz Creek	X-1764	X-1764	Federal	41.05	19.51	54.29	25.98	80.00	38.37
West Fork Quartz Trib	Quartz Creek	X-1595	X-1595	Federal	6.47	1.93	9.04	2.69	13.49	4.02
unnamed	Quartz Creek	X-196	X-196	Federal	81.94	28.15	98.11	33.70	148.09	50.87
Shawnesy Creek	Libby Creek	X-1377	X-1377	County	0.50	0.50	0.80	0.80	1.34	1.34
unnamed	Libby Creek	X-303	X-303	Federal	8.63	4.06	13.45	6.33	21.35	10.04
unnamed	Libby Creek	X-1151	X-1151	Federal	12.76	6.74	19.19	10.07	33.34	17.60
unnamed	Libby Creek	X-499	X-499	Federal	17.49	6.63	23.32	8.84	38.87	14.73
Midas Creek	Libby Creek	X-377	X-377	Federal	20.10	20.10	30.16	30.16	64.12	64.12
unnamed	Libby Creek	X-139	X-139	Private	15.35	15.35	14.77	14.77	21.75	21.75
North Fork Bristow Creek	Bristow Creek	X-1B	X-1824	Federal	36.24	21.33	36.10	21.26	50.65	29.69
unnamed	Bristow Creek	X-1150	X-1150	Federal	4.80	4.80	6.80	6.80	11.47	11.47
unnamed	Bristow Creek	X-25	X-25	Federal	28.33	8.24	32.82	9.55	53.63	15.60
Ariana	Wolf Creek	X-452	X-452	Federal	1.37	0.82	2.27	1.37	3.48	2.10
unnamed	Wolf Creek	X-837	X-837	Private	5.57	2.23	5.57	2.23	7.51	3.01
Kavala	Wolf Creek	X-358	X-358	Federal	25.72	10.48	47.57	19.89	42.85	17.87
Sinclair	Wolf Creek	X-814	X-814	Private	2.70	2.70	6.74	6.74	6.29	6.29
Dry Creek	Wolf Creek	X-1051	X-1051	Federal	0.90	0.90	3.84	3.84	3.64	3.64
unnamed	Wolf Creek	X-1089	X-1165	Private	0.35	0.35	0.42	0.42	2.57	2.57
unnamed	Wolf Creek	X-1613	X-1613	Private	2.66	2.66	3.64	3.64	3.70	3.70
Raven trib	Raven Creek	X-127	X-127	Private	24.16	11.32	22.53	10.54	32.47	15.23
Raven Creek	Raven Creek	X-1	X-1	Federal	1.62	1.62	3.12	3.12	1.89	1.89

ATTACHMENT DD - 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 (Tons)	MEAN ANNUAL LOAD (Tons)	MEAN ANNUAL LOAD with BMPs (Tons)	Percent Reduction
Big Cherry Creek	Federal	20-26	15	12	0.0156	0.0073	0.1853	0.0866	53%
Big Cherry Creek	Federal	>26	38	30	0.0234	0.0112	0.7038	0.3355	52%
			53	42			0.8891	0.4221	53%
Big Cherry Creek	Private	20-26	8	6	0.0039	0.0028	0.0246	0.0177	28%
Big Cherry Creek	Private	>26	5	4	0.0054	0.0039	0.0213	0.0152	29%
			13	10			0.0459	0.0329	28%
Big Cherry Creek	County	<20	1	1	0.0037	0.0025	0.0029	0.0020	32%
Big Cherry Creek	County	20-26	4	3	0.0039	0.0028	0.0123	0.0088	28%
Big Cherry Creek	County	>26	2	2	0.0054	0.0039	0.0085	0.0061	29%
			7	6			0.0237	0.0169	29%
Big Cherry Creek	State	>26	1	1	0.0054	0.0039	0.0043	0.0030	29%
			1	1			0.0043	0.0030	29%
Big Cherry Creek Total			**74**	**58**			**0.9630**	**0.4749**	**51%**
Granite Creek	Federal	20-26	1	1	0.0156	0.0073	0.0124	0.0058	53%
			1	1			0.0124	0.0058	53%
Granite Creek	County	20-26	2	2	0.0039	0.0028	0.0061	0.0044	28%
			2	2			0.0061	0.0044	28%
Granite Creek Total			**3**	**2**			**0.0185**	**0.0102**	**45%**
Swamp Creek-Cowell Creek	Federal	>26	81	64	0.0234	0.0112	1.5002	0.7151	52%
			81	64			1.5002	0.7151	52%
Swamp Creek-Cowell Creek	Private	>26	44	35	0.0054	0.0039	0.1877	0.1338	29%
			44	35			0.1877	0.1338	29%
Swamp Creek-Crowell Creek Total			**125**	**99**			**1.6879**	**0.8489**	**50%**
Lower Libby Creek	Federal	<20	1	1	0.0118	0.0054	0.0093	0.0043	54%
Lower Libby Creek	Federal	20-26	80	63	0.0156	0.0073	0.9881	0.4620	53%
Lower Libby Creek	Federal	>26	23	18	0.0234	0.0112	0.4260	0.2030	52%
			104	82			1.4234	0.6693	53%
Lower Libby Creek	Private	<20	3	2	0.0037	0.0025	0.0087	0.0059	32%
Lower Libby Creek	Private	20-26	9	7	0.0039	0.0028	0.0277	0.0199	28%
Lower Libby Creek	Private	>26	7	6	0.0054	0.0039	0.0299	0.0213	29%
			19	15			0.0662	0.0471	29%
Lower Libby Creek	County	20-26	2	2	0.0039	0.0028	0.0061	0.0044	28%
			2	2			0.0061	0.0044	28%
Lower Libby Creek	State	20-26	2	2	0.0039	0.0028	0.0061	0.0044	28%
			2	2			0.0061	0.0044	28%
Lower Libby Creek Total			**127**	**100**			**1.5019**	**0.7253**	**52%**
Upper Libby Creek	Federal	>26	141	111	0.0234	0.0112	2.6115	1.2448	52%
			141	111			2.6115	1.2448	52%
Upper Libby Creek	Private	>26	12	9	0.0054	0.0039	0.0512	0.0365	29%
			12	9			0.0512	0.0365	29%
Upper Libby Creek	County	>26	5	4	0.0054	0.0039	0.0213	0.0152	29%
			5	4			0.0213	0.0152	29%
Upper Libby Creek Total			**158**	**125**			**2.6841**	**1.2965**	**52%**
Libby Creek Total			**487**	**385**			**6.8554**	**3.3558**	**51%**
Keeler Creek	Federal	>26	126	100	0.0234	0.0112	2.3337	1.1124	52%
			126	100			2.3337	1.1124	52%
Keeler Creek	Private	>26	12	9	0.0054	0.0039	0.0512	0.0365	29%
			12	9			0.0512	0.0365	29%
Keeler Creek	State	>26	1	1	0.0054	0.0039	0.0043	0.0030	29%
			1	1			0.0043	0.0030	29%
Keeler Creek Total			**139**	**110**			**2.3892**	**1.1519**	**52%**
Ross Creek	Federal	>26	4	3	0.0234	0.0112	0.0741	0.0353	52%
			4	3			0.0741	0.0353	52%
Ross Creek	Private	>26	1	1	0.0054	0.0039	0.0043	0.0030	29%
			1	1			0.0043	0.0030	29%
Ross Creek Total			**5**	**4**			**0.0784**	**0.0384**	**51%**
Stanley Creek	Federal	>26	51	40	0.0234	0.0112	0.9446	0.4502	52%
			51	40			0.9446	0.4502	52%
Stanley Creek	Private	>26	18	14	0.0054	0.0039	0.0768	0.0547	29%
			18	14			0.0768	0.0547	29%
Stanley Creek Total			**69**	**55**			**1.0214**	**0.5050**	**51%**
Lower Lake Creek	Federal	20-26	3	2	0.0156	0.0073	0.0371	0.0173	53%
Lower Lake Creek	Federal	>26	24	19	0.0234	0.0112	0.4445	0.2119	52%
			27	21			0.4816	0.2292	52%
Lower Lake Creek	Private	>26	33	26	0.0054	0.0039	0.1408	0.1004	29%
			33	26			0.1408	0.1004	29%
Lower Lake Creek	State	>26	2	2	0.0054	0.0039	0.0085	0.0061	29%
			2	2			0.0085	0.0061	29%
Lower Lake Creek Total			**62**	**49**			**0.6309**	**0.3357**	**47%**
Upper Lake Creek - above Bull Lake	Federal	>26	3	2	0.0234	0.0112	0.0556	0.0265	52%

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
			3	2			0.0556	0.0265	52%
Upper Lake Creek - above Bull Lake	Private	>26	17	13	0.0054	0.0039	0.0725	0.0517	29%
			17	13			0.0725	0.0517	29%
Upper Lake Creek - above Bull Lake Total			**20**	**16**			**0.1281**	**0.0782**	**39%**
Upper Lake Creek - below Bull Lake	Federal	>26	26	21	0.0234	0.0112	0.4816	0.2295	52%
			26	21			0.4816	0.2295	52%
Upper Lake Creek - below Bull Lake	Private	>26	19	15	0.0054	0.0039	0.0811	0.0578	29%
			19	15			0.0811	0.0578	29%
Upper Lake Creek - below Bull Lake Total			**45**	**36**			**0.5626**	**0.2873**	**49%**
Lake Creek Total			**340**	**269**			**4.8105**	**2.3964**	**50%**
Lower Wolf Creek	Federal	<20	40	32	0.0118	0.0054	0.3721	0.1713	54%
Lower Wolf Creek	Federal	20-26	44	35	0.0156	0.0073	0.5435	0.2541	53%
			84	66			0.9156	0.4254	54%
Lower Wolf Creek	Private	<20	109	86	0.0037	0.0025	0.3156	0.2161	32%
Lower Wolf Creek	Private	20-26	111	88	0.0039	0.0028	0.3411	0.2451	28%
Lower Wolf Creek	Private	>26	4	3	0.0054	0.0039	0.0171	0.0122	29%
			224	177			0.6738	0.4734	30%
Lower Wolf Creek	County	<20	5	4	0.0037	0.0025	0.0145	0.0099	32%
			5	4			0.0145	0.0099	32%
Lower Wolf Creek	State	<20	17	13	0.0037	0.0025	0.0492	0.0337	32%
Lower Wolf Creek	State	20-26	11	9	0.0039	0.0028	0.0338	0.0243	28%
			28	22			0.0830	0.0580	30%
Lower Wolf Creek Total			**341**	**269**			**1.6868**	**0.9667**	**43%**
Middle Wolf Creek	Federal	<20	12	9	0.0118	0.0054	0.1116	0.0514	54%
Middle Wolf Creek	Federal	20-26	28	22	0.0156	0.0073	0.3458	0.1617	53%
			40	32			0.4575	0.2131	53%
Middle Wolf Creek	Private	<20	7	6	0.0037	0.0025	0.0203	0.0139	32%
Middle Wolf Creek	Private	20-26	18	14	0.0039	0.0028	0.0553	0.0397	28%
			25	20			0.0756	0.0536	29%
Middle Wolf Creek	State	<20	2	2	0.0037	0.0025	0.0058	0.0040	32%
			2	2			0.0058	0.0040	32%
Middle Wolf Creek Total			**67**	**53**			**0.5388**	**0.2707**	**50%**
Little Wolf Creek	Federal	20-26	18	14	0.0156	0.0073	0.2223	0.1039	53%
Little Wolf Creek	Federal	>26	10	8	0.0234	0.0112	0.1852	0.0883	52%
			28	22			0.4075	0.1922	53%
Little Wolf Creek	Private	<20	31	24	0.0037	0.0025	0.0898	0.0615	32%
Little Wolf Creek	Private	20-26	64	51	0.0039	0.0028	0.1967	0.1413	28%
Little Wolf Creek	Private	>26	7	6	0.0054	0.0039	0.0299	0.0213	29%
			102	81			0.3163	0.2241	29%
Little Wolf Creek	County	>26	4	3	0.0054	0.0039	0.0171	0.0122	29%
			4	3			0.0171	0.0122	29%
Little Wolf Creek	State	>26	3	2	0.0054	0.0039	0.0128	0.0091	29%
			3	2			0.0128	0.0091	29%
Little Wolf Creek Total			**137**	**108**			**0.7537**	**0.4376**	**42%**
Dry Fork Creek	Federal	<20	3	2	0.0118	0.0054	0.0279	0.0128	54%
Dry Fork Creek	Federal	20-26	31	24	0.0156	0.0073	0.3829	0.1790	53%
Dry Fork Creek	Federal	>26	32	25	0.0234	0.0112	0.5927	0.2825	52%
			66	52			1.0035	0.4744	53%
Dry Fork Creek	Private	<20	4	3	0.0037	0.0025	0.0116	0.0079	32%
Dry Fork Creek	Private	20-26	18	14	0.0039	0.0028	0.0553	0.0397	28%
			22	17			0.0669	0.0477	29%
Dry Fork Creek Total			**88**	**70**			**1.0704**	**0.5220**	**51%**
Upper Wolf Creek	Federal	20-26	58	46	0.0156	0.0073	0.7164	0.3349	53%
Upper Wolf Creek	Federal	>26	5	4	0.0234	0.0112	0.0926	0.0441	52%
			63	50			0.8090	0.3791	53%
Upper Wolf Creek	Private	<20	2	2	0.0037	0.0025	0.0058	0.0040	32%
Upper Wolf Creek	Private	20-26	44	35	0.0039	0.0028	0.1352	0.0972	28%
Upper Wolf Creek	Private	>26	13	10	0.0054	0.0039	0.0555	0.0395	29%
			59	47			0.1965	0.1407	28%
Upper Wolf Creek Total			**122**	**96**			**1.0055**	**0.5197**	**48%**
Weigel Creek	Federal	20-26	9	7	0.0156	0.0073	0.1112	0.0520	53%
Weigel Creek	Federal	>26	27	21	0.0234	0.0112	0.5001	0.2384	52%
			36	28			0.6112	0.2903	53%
Weigel Creek Total			**36**	**28**			**0.6112**	**0.2903**	**53%**
Wolf Creek Total			**791**	**625**			**5.6665**	**3.0071**	**47%**
Bristow Creek	Federal	<20	1	1	0.0118	0.0054	0.0093	0.0043	54%
Bristow Creek	Federal	20-26	14	11	0.0156	0.0073	0.1729	0.0808	53%
Bristow Creek	Federal	>26	43	34	0.0234	0.0112	0.7964	0.3796	52%
			58	46			0.9787	0.4647	53%

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
Bristow Creek Total			**58**	**46**			**0.9787**	**0.4647**	**53%**
Quartz Creek	Federal	20-26	5	4	0.0156	0.0073	0.0618	0.0289	53%
Quartz Creek	Federal	>26	84	66	0.0234	0.0112	1.5558	0.7416	52%
			89	70			1.6176	0.7704	52%
Quartz Creek	Private	>26	2	2	0.0054	0.0039	0.0085	0.0061	29%
			2	2			0.0085	0.0061	29%
Quartz Creek	State	20-26	1	1	0.0039	0.0028	0.0031	0.0022	28%
			1	1			0.0031	0.0022	28%
Quartz Creek Total			**92**	**73**			**1.6292**	**0.7787**	**52%**
Raven Creek	Federal	20-26	2	2	0.0156	0.0073	0.0247	0.0115	53%
			2	2			0.0247	0.0115	53%
Raven Creek	Private	20-26	2	2	0.0039	0.0028	0.0061	0.0044	28%
Raven Creek	Private	>26	33	26	0.0054	0.0039	0.1408	0.1004	29%
			35	28			0.1469	0.1048	29%
Raven Creek Total			**37**	**29**			**0.1716**	**0.1163**	**32%**
Kootenai-Fisher Project Area Total			**1,805**	**1,426**			**20.11**	**10.12**	**50%**

ATTACHMENT DE - 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)	(ft^3)	(CY)	(tons)
X-1655	CMP	2	5	7	13	25	35	50	63	76	56	4.5	15	7	37	1166	43	72
X-1589	CMP	3	8	6	10	19	27	38	48	59	126	15	45	6	25	2250	83	138
X-1764	CMP	4	8	12	39	69	92	126	156	185	171	10	50	12	45	5400	200	332
X-1595	CMP	2	12	4	4	9	13	19	24	30	81	8	23	4	28	896	33	55
X-196	CMP	2	16	4	4	9	13	19	24	30	67	20	25	4	35	2800	104	172
X-1377	Squash CMP	5 span 3.5 rise	3	5	7	14	19	28	36	43	119	4.5	24	5	20	450	17	28
X-303	CMP	2	7	2	1	2	4	6	8	9	30	5	60	2	32	320	12	20
X-1151	CMP	3	8	3	2	5	8	12	15	19	100	10	48	3	35	1050	39	65
X-499	CMP	1.5	3	2	1	2	4	6	8	9	14	4	60	2	40	320	12	20
X-377	Squash CMP	12.5 span 7 rise	3.5	15	60	104	138	184	227	268	1038	11	90	15	36	5940	220	365
X-139	CMP	3	5	5	7	14	19	28	36	43	62	5	35	5	30	750	28	46
X-1B	Squash CMP	3.6 span 2.25 rise	1.5	15	60	104	138	184	227	268	61	4	NA	15	44	2640	98	162
X-1150	CMP	3	5	6	10	19	27	38	48	59	71	6	4	6	30	1080	40	66
X-25	Squash CMP	4.5 span 3.5 rise	5	6	10	19	27	38	48	59	164	7	15	6	35	1470	54	90
X-837	CMP	2	8	4	4	9	13	19	24	30	26	4	20	4	30	480	18	30
X-358	CMP	3	9	5	7	14	19	28	36	43	87	8	40	5	38	1520	56	93
X-814	Squash CMP	7.5 span 5.5 rise	1.5	11	32	59	79	108	135	160	426	9	60	11	33	3267	121	201
X-1051	Squash CMP	9 span 8 rise	3	18	86	147	191	252	309	363	351	6	38	18	46	4968	184	305
X-1089	CMP	4	5	7	13	25	35	50	63	76	132	7	30	7	35	1715	64	105
X-127	CMP	1.5	10	2	1	2	4	6	8	9	20	6	30	2	33	396	15	24
X-1	CMP	1.5	3	4	4	9	13	19	24	30	11	2.5	12	4	30	300	11	18

*assuming a fill width equal to the bankfull width

culvert fails to pass a given discharge

CMP = Corrugated Metal Pipe, CY=cubic yard

ATTACHMENT DF - 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-1655	Corrugated metal pipe	3	2	2	5[2]	7	0.29[1]	9[2]	2[2]
X-1589	Corrugated metal pipe	3	3	3	8[2]	6	0.50[3]	26[2]	2[2]
X-1764	Corrugated metal pipe	3	4	4	8[2]	12	0.33[1]	24[2]	2[2]
X-1595	Corrugated metal pipe	3	2	2	12[2]	4	0.50[3]	24[2]	2[2]
X-196	Corrugated metal pipe	3	2	2	16[2]	4	0.50[3]	60[2]	2[2]
X-1377	Squash Corrugated metal pipe	3	3.5	5	3[2]	5	1.00[3]	18[2]	2[2]
X-303	Corrugated metal pipe	3	2	2	7[2]	2	1.00[3]	0[1]	1[2]
X-1151	Corrugated metal pipe	3	3	3	8[2]	3	1.00[3]	36[2]	2[2]
X-499	Corrugated metal pipe	3	1.5	1.5	3[2]	2	0.75[3]	0[1]	1[2]
X-377	Squash Corrugated metal pipe	4	7	12.5	3.5[2]	15	0.83[3]	0[1]	1[2]
X-139	Corrugated metal pipe	3	3	3	5[2]	5	0.60[3]	8[2]	2[2]
X-1B	Squash Corrugated metal pipe	3	3.6	2.25	1.5[2]	15	0.15[1]	0[1]	1[2]
X-1150	Corrugated metal pipe	3	3	3	5[2]	6	0.50[3]	7[2]	2[2]
X-25	Squash Corrugated metal pipe	3	3.5	4.5	5[2]	6	0.75[3]	9[2]	2[2]
X-837	Corrugated metal pipe	3	2	2	8[2]	4	0.50[3]	24[2]	2[2]
X-358	Corrugated metal pipe	3	3	3	9[2]	5	0.60[3]	12[2]	2[2]
X-814	Squash Corrugated metal pipe	4	5.5	7.5	1.5[3]	11	0.68[3]	0[1]	0[3]
X-1051	Squash Corrugated metal pipe	4	8	9	3[2]	18	0.50[3]	0[1]	1[2]
X-1089	Corrugated metal pipe	3	4	4	5[2]	7	0.57[3]	9[2]	2[2]
X-127	Corrugated metal pipe	3	1.5	1.5	10[2]	2	0.75[3]	24[2]	2[2]
X-1	Corrugated metal pipe	3	1.5	1.5	3[2]	4	0.38[1]	24[2]	2[2]

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*

1 conditions that have a high certainty of meeting juvenile fish passage at all desired streamflows

2 conditions that have a high certainty of not providing juvenile fish passage at all desired streamflows

3 conditions are such that additional and more detailed analysis is required to determine their juvenile fish passage ability