APPENDIX E - UNPAVED ROADS ASSESSMENT: SEDIMENT LOAD ESTIMATIONS AND POTENTIAL REDUCTIONS

E1.0 INTRODUCTION

In the summer of 2010, DEQ conducted a study of road systems in the Flint Creek TMDL planning area (TPA) to estimate sediment contributions and potential load reductions from unpaved roads. Data was collected from randomly selected road crossings and parallel segments and entered into a soil erosion model to quantify the amount of sediment produced at each location. The model was used to quantify loads from both existing conditions and potential BMP conditions. Results from assessed road features were then extrapolated to non-assessed features based on ownership, road-type, and landscape characteristics.

This report describes the analysis and results of the Flint Creek TPA road study. The information from this study will be used in conjunction with other sediment source assessment analyses for inclusion in TMDL development for Flint Creek TPA streams.

E2.0 MODEL

The Water Erosion Prediction Project (WEPP):Roads soil erosion model was used to model the amount of sediment transported from the road to the stream in the Flint Creek TPA. It was developed by an interagency group of scientists including the U.S. Department of Agriculture's Agricultural Research Service (ARS), Forest Service, and Natural Resources Conservation Service; and the U.S. Department of Interior's Bureau of Land Management and Geological Survey (Rocky Mountain Research Station and San Dimas technology and Development Center, 1999). The WEPP:Roads model has been used extensively by the USDA Forest Service for modeling sediment load from national forest roads, and by the Montana DEQ in developing TMDL sediment loads from roads in many TMDL projects.

The Water Erosion Prediction Project (WEPP) model is a soil erosion model based on rill and interrill erosion processes (Lal and Elliot, 1994). Interill erosion is overland flow of detached particles whereas rill erosion is transport of particles by concentrated flow. WEPP provides estimates of soil erosion and sediment yield by considering the specific soil, climate, ground cover, and topographic conditions.

WEPP:Roads is designed to predict runoff and sediment yield from:

- roads
- compacted landings
- compacted skid trails
- compacted foot, cattle, or off-road vehicle trails

WEPP:Road allows the user to specify the characteristics of the road in terms of

- climate
- soil and gravel addition
- local topography

- drain spacing
- road design and surface condition
- ditch condition

WEPP simulates the conditions that impact erosion, which includes the amount of vegetation canopy, the surface residue, and the daily soil water content in a multiple-year run. For each day that has a precipitation event, WEPP determines the type of event (rain or snow), and calculates the infiltration and runoff. If there is runoff, WEPP routes the runoff over the surface, calculating erosion or deposition rates for at least 100 points on the hillslope. It then calculates the average sediment yield from the hillslope (Elliot, et al., 2000). Measured road data from the Flint Creek TPA was entered into the application, and the annual amount of sediment (in pounds) leaving the road buffer was calculated for existing and potential BMP conditions.

There are two distinct landscape types within the Flint Creek watershed, each with different levels of precipitation (broad intermountain valley floor and steep mountainous terrain). Since the amount of sediment loading is directly related to the runoff associated with precipitation, DEQ used two weather stations for running the model on the measured road crossings and parallel road segments. The Drummond Aviation MT weather station, which is located on the valley floor at the lower end of the watershed, was used for all road crossings less than or equal to 16 inches of precipitation. For those crossings in the mountains (precipitation zones greater than 16 inches), DEQ generated a weather station model from a NRCS SNOTEL site (Combination 410). The Combination SNOTEL 410 weather station was added to the WEPP:Road interface with the assistance of David Hall (USDA Forest Service Rocky Mountain Research Station).

E3.0 GIS Analysis and SAP Development

DEQ conducted a GIS exercise to identify potential contributing road crossings and parallel segments. Details of the GIS layers used for analysis can be found in the summary report *Road Sediment Assessment & Modeling: Flint Creek TMDL Planning Area 303(D) Listed Tributary Streams – Road GIS Layers & Summary Statistics* (Montana Department of Environmental Quality, 2010).

All road crossings were identified as the intersection of road and stream layers within GIS. Parallel road segments were identified as those road segments adjacent to the stream within 150 feet from the center of the stream.

The identified road crossings (**Figure 2-1**) and parallel road segments (**Figure 2-2**) were then stratified by ecoregion, land ownership and road type. (**Figures 2-1**, **2-2** are located at the end of the report.)The Flint Creek TPA contains the following four ecoregions: 17ak (Deer Lodge-Philipsburg-Avon grassy intermontane hills and valleys; 17am (Flint Creek-Anaconda mountains); 17x (Rattlesnake-Blackfoot-South Swan-Northern Garnet-Sapphire mountains; and 17h (alpine zone). Landownership included BLM, Forest Service, private, Montana state government, and unidentified. Road type included paved, gravel, and native road surfaces.

Due to the large number of identified road features and limited available resources, a random subset of road crossings was selected for field sampling to represent the variety of road crossing conditions in the watershed. Parallel segments were not pre-selected, but chosen in the field en route between sampled road crossing locations.

E4.0 Field Assessment

The following section provides brief information that describes the goals of the field assessment, what data was collected, and success in meeting the goals of the field effort.

E4.1 Methods

Field assessment occurred during August of 2010. Data was collected from the pre-identified, randomly selected road crossings and along sections of the road that paralleled the stream as chosen in the field. At each site, the data parameters required for WEPP road modeling were recorded. This information includes road design (inslope bare, inslope vegetated, outslope rutted, outslope unrutted); road surface (native, gravel, paved); traffic level (high, low, none); road gradient (percent); road length (feet); road width (feet); fill gradient (percent); fill length (feet); buffer gradient (percent); buffer length (feet); rock fragments (percent); and soil texture (clay loam, silt loam, sandy loam, and loam). In addition, photos were taken along with notes and measurements to be used for the evaluation of potential BMP implementation.

E4.2 Results

Once in the field, DEQ found that some of the GIS identified road crossings occurred at ephemeral streams, topographical depressions, or drainages without perennial streams. In many cases, these sites were found not to contribute a sediment load to the stream of interest and were considered “false stream crossings”. Photos were taken at these sites to document their condition and the rationale for exclusion from the study and then an alternate road crossing was selected based on the nearest non pre-selected site of the same ecoregion, road type and land ownership. In all, 55 road crossings were visited during the field assessment; of these 38 crossings were measured and 17 (31%) were found to be “false crossings”. Similarly, some of the GIS identified parallel road segments were found to be greater than 150 feet from the stream and not contributing a sediment load. Information regarding these locations was noted and alternative sites were chosen.

Additionally, DEQ found in the GIS determined road type did not always equate to field observations. This occurred at several sites where the GIS attribute indicated the road was gravel, but the road type was native. For those locations where discrepancies were found, the road type identified in the field was considered the correct attribute, and the site information was adjusted accordingly.

Two weeks of fieldwork were allocated for collecting road crossing measurements. The goal for the study was to collect information to represent 50 road crossings and 10 parallel road segments (**Table E-1**). Over the course of the fieldwork, false stream crossings, remote locations, and poor road conditions prohibited the full achievement of all 50 sites within the two weeks. 38 road crossings (76% of desired) and 8 parallel road segments (80% of desired) were measured. However, although the goal was not met at the end of the two weeks, DEQ determined that the data collected was acceptable for representing the sediment load for the purposes of this assessment. This decision was based on available resources, with consideration that comparable sampling numbers were used in other TMDL road assessments of similar size.

Table E-1. Flint Creek TPA Roads Fieldwork Completion

	Total in Flint TPA	# Selected for Field Sampling	# Measured	Percent Measured of Selected Sites
Crossings	711	50	38	76
Parallel Segments	510	10	8	80

E5.0 WEPP Modeling Results

This section describes the results of the WEPP:Roads analysis for the measured road crossings and parallel road segments in the Flint Creek watershed. The sediment loads are calculated for each measured site, and then extrapolated to the rest of the road crossings or parallel road segments in the watershed. The extrapolated results are grouped by landownership and subwatershed.

E5.1 Road Crossings

Measurements gathered in the field were entered into the model to calculate the existing sediment load from each road crossing. For each site, WEPP:Roads calculates two loads: 1) average annual sediment load coming from the road; and 2) average annual sediment load coming from the buffer. The load coming from the buffer represents the capture of some sediment before it reaches the stream. Buffering capacity is a function of buffer length, slope and vegetation. For the purposes of this analysis, the load from the buffer is the load of concern.

Each site was individually modeled and the results were organized based on the ecoregion, land ownership, road type and associated climate station. The combination of these characteristics is defined as a road category. Loads for the measured sites were then averaged by road category (**Table E-2**).

Table E-2. Modeling Results for Measured Road Crossings

Site #	Land Ownership	Road Type	Load (lbs)	Category Average (lbs)
Drummond Weather Station				
17ak Ecoregion				
37a	BLM	Native	11	11
54a	Private	Native	695	
19a	Private	Native	9	
39	Private	Native	136	
45	Private	Native	40	220
49	Private	Gravel	120	
7a	Private	Gravel	0	
48a	Private	Gravel	185	
47a	Private	Gravel	107	
43a	Private	Gravel	96	
39	Private	Gravel	134	107
17am Ecoregion				
35a	USFS	Native	8	
1a	USFS	Native	1145	577
17x Ecoregion				
41a	Private	Native	344	344
Native Load Average			299	
Gravel Load Average			107	

Table E-2. Modeling Results for Measured Road Crossings

Site #	Land Ownership	Road Type	Load (lbs)	Category Average (lbs)
Combination Weather Station				
17ak Ecoregion				
9	MT State	Native	118	118
5	Private	Native	118	118
6a	Private	Gravel	50	50
17am Ecoregion				
36	Private	Native	138	
8	Private	Native	283	211
16a	BLM	Gravel	721	721
11	Private	Gravel	55	
25	Private	Gravel	161	
14	Private	Gravel	73	96
34	USFS	Gravel	255	
28a	USFS	Gravel	25	
51a	USFS	Gravel	132	
24	USFS	Gravel	441	213
21a	USFS	Native	512	
32a	USFS	Native	16	
52a	USFS	Native	2	
2a	USFS	Native	792	
26	USFS	Native	213	
18a	USFS	Native	9	257
17x Ecoregion				
40a	Private	Native	146	
53a	Private	Native	59	
13a	Private	Native	156	
44a	Private	Native	12	93
22a	USFS	Gravel	65	65
Native Load Average			184	
Gravel Load Average			198	

Total sediment load for the Flint Creek TPA road crossings were then extrapolated by multiplying the average sediment load for each road category by the total number of road crossings within that category (**Table E-3**). In those instances where no representative sites were sampled within a particular road category, the average load for **all** sites of a given road surface and climate station was applied. A total of 711 road crossings were identified in the Flint Creek TPA. Of these, 44 crossings were paved and therefore determined to not contribute road related sediment.

Table E-3. Extrapolation of Modeled Data to All Road Crossings

Drummond Weather Station						
	Gravel			**Native**		
Ownership	**Number**	**Load (lb)**	**Total (lb)**	**Number**	**Load (lb)**	**Total (lb)**
17ak Ecoregion						
BLM	1	[1]107	107	2	11	22
Private	103	107	11,021	64	220	14,080
State				3	[2]299	897
Unidentified	1	[1]107	107	1	[2]299	299

Table E-3. Extrapolation of Modeled Data to All Road Crossings

Drummond Weather Station						
	Gravel			**Native**		
Ownership	**Number**	**Load (lb)**	**Total (lb)**	**Number**	**Load (lb)**	**Total (lb)**
17am Ecoregion						
BLM				2	[2]299	598
USFS	5	[1]107	535	13	577	7501
Private	1	[1]107	107	6	[2]299	1794
17x Ecoregion						
Private	1	[1]107	107	2	344	688
Combination Weather Station						
17ak Ecoregion						
USFS	1	[3]198	198			
Private	30	50	1,500	19	118	2,242
State				2	118	236
Unidentified	1	[3]198	198			
17am Ecoregion						
BLM	7	721	5,047	3	[4]184	552
USFS	66	213	14,058	126	257	32,382
Private	50	96	4800	38	211	8,018
MT				7	[4]184	1,288
Unidentified	3	[3]198	594	1	[4]184	184
17x Ecoregion						
USFS	7	65	455	49	[4]184	9,016
Private	9	[3]198	1,782	43	93	3,999

[1]Average load for gravel (Drummond weather station)
[2]Average load for native (Drummond weather station)
[3]Average load for gravel (Combination weather station)
[4]Average load for native (Combination weather station)

As described in **Section 3.0**, a number of the randomly selected road crossings were determined to be "false stream crossings". It can be assumed therefore, that not all of the road crossings identified through the GIS analysis contribute sediment. In order to account for this, and thereby provide a more accurate representation of the sediment loads after extrapolation, a reduction factor was calculated using the difference between "true crossings" to "false crossings" as observed in the field. As described in Section 3.0, 31% of the sites encountered in the field were determined to be false crossings. That percentage was then considered the reduction factor. The reduction factor was applied to the total calculated loads for each watershed. Sediment loads per watershed are presented in **Table E-4**.

Table E-4. Estimated Sediment Load for all Road Crossings by Subwatershed

Watershed	**Number Crossings**	**Estimated Total Load (lb/year)**	**Estimated Total Load (tons/year)**	**Total Load 31% RF (tons/year)**
Barnes Creek	29	5,202	2.60	1.79
Boulder Creek	74	17,474	8.74	6.03
Douglas Creek (North)	34	7,145	3.57	2.46
Douglas Creek (South)	21	3,184	1.59	1.10
Fred Burr Creek	9	1,468	0.73	0.50
Lower Flint Creek	79	13,151	6.58	4.54
Middle Flint Creek	112	22,086	11.04	7.62
Upper Flint Creek	86	16,699	8.35	5.76

Table E-4. Estimated Sediment Load for all Road Crossings by Subwatershed

Watershed	Number Crossings	Estimated Total Load (lb/year)	Estimated Total Load (tons/year)	Total Load 31% RF (tons/year)
Smart Creek	72	16,793	8.40	5.80
Trout Creek	41	4,411	2.21	1.52
Lower Willow Creek	20	2,931	1.47	1.01
North Fork Willow Creek	38	5,892	2.95	2.04
South Fork Willow Creek	52	7,976	3.99	2.75
Total	**667**	**124,412**	**62.22**	**42.92**

E5.2 Parallel Road Segments

Without proper best management practices, uninterrupted parallel road segments can be thousands of feet in length. Particularly in mountainous reaches, the only place for a road is often along the narrow floodplains adjacent to the stream. Close proximity between streams and parallel roads can serve as a conduit for sediment loads to enter the stream, in addition to road/stream intersections.

In the Flint Creek TPA, parallel road segments were also investigated to calculate sediment contribution from roads. Parallel road segments were modeled with WEPP:Roads to calculate the amount of sediment from roads that are within a distance of 150 feet of the stream. Eight parallel segments were measured in the field. For modeling purposes, contributing road lengths were given a maximum contributing length of 1000'. The calculated load for each parallel segment was converted to an annual load per mile of road length. In this case, since the number of sampled parallel road segments was small, and did not allow to discern differences between road type, climate station, or ownership; a general average sediment load for parallel road segments was determined (**Table E-5**).

Table E-5. Modeling Results for Measured Parallel Road Segments

Site Number	Land Ownership	Road Type	Road Length (ft)	Measured Load (lbs/year)	Measured Load (tons/mile)
292-293	Private	Native	1000	883	2.3311
307	Private	Native	574	5	0.0230
327	USFS	Native	279	0	0
3	Private	Gravel	1000	748	1.9747
283	Private	Gravel	1000	253	0.6679
313	USFS	Gravel	492	231	1.2395
315	USFS	Gravel	361	131	0.9585
395	USFS	Gravel	377	65	0.4549
				Average	**0.9562**

The average value was then multiplied by the total miles of parallel road segments in each watershed. As with road crossings, a 31% reduction factor was applied to account for errors in GIS analysis, and an estimate of sediment load from parallel segments was determined for each watershed (**Table E-6**). The same reduction factor that was used with road crossings was used for parallel segments based on the assumption that the geographic occurrence of drainage features (ephemeral streams, swales, depressions) and road networks that do not ultimately connect to the perennial streams of interest corresponds with the findings of the road crossing assessments.

Table E-6. Estimated Sediment Loads for Parallel Segments for Flint Creek TPA Watersheds

Watershed	Number Miles	Number Miles	Total Miles	Estimated Total Load (tons/year)	Total Load 31% RF (tons/year)
	Gravel	Native			
Barnes Creek	0.88	0.74	1.62	1.55	1.07
Boulder Creek	3.86	3.10	6.96	6.66	4.60
Douglas Creek (North)	5.57	1.56	7.13	6.82	4.71
Douglas Creek (South)	1.32	1.02	2.34	2.24	1.56
Fred Burr Creek	0.16	0.75	0.91	0.87	0.60
Lower Flint Creek	3.03	7.37	10.40	9.94	6.86
Middle Flint Creek	5.70	5.07	10.77	10.30	7.11
Upper Flint Creek	3.18	8.94	12.12	11.59	8.00
Smart Creek	4.55	5.93	10.48	10.02	6.91
Trout Creek	1.64	1.85	3.49	3.34	2.30
Lower Willow Creek	0.66	0.30	0.96	0.92	0.63
North Fork Willow Creek	1.72	3.82	5.54	5.30	3.66
South Fork Willow Creek	1.00	3.30	4.30	4.11	2.84
Total	**33.27**	**43.76**	**77.02**	**73.65**	**50.85**

E6.0 BMP RESULTS

This section presents the results of WEPP:Roads analysis with modeled BMP data, and the extrapolation of the BMP sediment loads throughout the watershed. During data collection, photographs and notes were taken at each road crossing and parallel segment to document potential best management practices that could be implemented. Based on these observations, DEQ reran WEPP:Roads for each measured road crossing with modifications to represent the site specific application of BMPs.

E6.1 BMP RESULTS FOR ROAD CROSSINGS

For each sampled road crossing, potential BMPs were documented and the implementation of those BMPs were simulated using WEPP:Roads. As before, calculated loads were then averaged by road category (landownership, road type, and weather station) to provide a value to extrapolate to non-measured crossings (**Table E-7**).

Table E-7. Modeling Results for BMP Scenario of Measured Roads Crossings

Site	Ownership	Road Type	Load (lbs)	Category Average (lbs)
Drummond Weather Station				
17ak Ecoregion				
37a	BLM	Native	4	4
54a	Private	Native	41	
19a	Private	Native	3	
39	Private	Native	99	
45	Private	Native	21	41
49	Private	Gravel	43	
7a	Private	Gravel	0	
48a	Private	Gravel	76	
47a	Private	Gravel	37	
43a	Private	Gravel	13	
39	Private	Gravel	52	36

Table E-7. Modeling Results for BMP Scenario of Measured Roads Crossings

Site	Ownership	Road Type	Load (lbs)	Category Average (lbs)
17am Ecoregion				
35a	USFS	Native	88	
1a	USFS	Native	1	45
17x Ecoregion				
41a	Private	Native	17	17
Native Load Average			34	
Gravel Load Average			36	
Combination Weather Station				
17ak Ecoregion				
9	MT State	Native	13	13
5	Private	Native	81	81
6a	Private	Gravel	44	44
17am Ecoregion				
36	Private	Native	25	
8	Private	Native	125	75
16a	BLM	Gravel	47	47
11	Private	Gravel	8	
24	Private	Gravel	36	
14	Private	Gravel	59	34
34	USFS	Gravel	81	
28a	USFS	Gravel	5	
51a	USFS	Gravel	21	
24	USFS	Gravel	61	42
21a	USFS	Native	4	
32a	USFS	Native	4	
52a	USFS	Native	1	
2a	USFS	Native	11	
26	USFS	Native	57	
18a	USFS	Native	9	14
17x Ecoregion				
40a	Private	Native	16	
53a	Private	Native	13	
13a	Private	Native	4	
44a	Private	Native	7	10
22a	USFS	Gravel	15	15
Native Load Average			26	
Gravel Load Average			36	

For each road category, the corresponding average sediment loads from the BMP scenario results were applied. For those categories where no measured data existed, the average load from ALL crossings of a given road type and climate station was used (**Table E-8**).

Table E-8. Extrapolation of BMP Scenario to All Roads Crossings

Drummond Weather Station						
	Gravel			Native		
Ownership	**Number**	**Load (lb)**	**Total (lb)**	**Number**	**Load (lb)**	**Total (lb)**
17ak Ecoregion						
BLM	1	[1]36	36	2	4	8
Private	103	36	3,708	64	41	2,624
MT	0			3	[2]34	102
Unidentified	1	[1]36	36	1	[2]34	34
17am Ecoregion						
BLM	0			2	[2]34	68
USFS	5	[1]36	108	13	45	585
Private	1	[1]36	36	6	[2]34	204
17x Ecoregion						
Private	1	[1]36	36	2	17	34
Combination Weather Station						
17ak Ecoregion						
USFS	1	[3]36	36	0		
Private	30	44	1,320	19	81	1,539
MT	0			2	13	26
Unidentified	1	[3]36	36	0		
17am Ecoregion						
BLM	7	47	329	3	[4]26	78
USFS	66	42	2,772	126	14	1,764
Private	50	34	1,700	38	75	2,850
MT				7	[4]26	182
Unidentified	3	[3]36	108	1	[4]26	26
17x Ecoregion						
USFS	7	15	105	49	[4]26	1274
Private	9	[3]36	324	43	10	430

[1]Average load for gravel (Drummond weather station)
[2]Average load for native (Drummond weather station)
[3]Average load for gravel (Combination weather station)
[4]Average load for native (Combination weather station)

An estimated total load representing BMP implementation was then derived for each watershed in the Flint Creek TPA. A 31% reduction factor was again applied to account for "false" crossings identified in the GIS analysis (**Table E-9**).

Table E-9. BMP Sediment Load for Road Crossings

Watershed	Number Crossings	BMP Total Load (lb)	BMP Total Load (tons)	Total Load 31% RF (tons)
Barnes Creek	29	1,114	0.56	0.39
Boulder Creek	74	2,017	1.01	0.70
Douglas Creek (North)	34	803	0.40	0.28
Douglas Creek (South)	21	898	0.45	0.31
Fred Burr Creek	9	445	0.22	0.15
Lower Flint Creek	79	2,810	1.41	0.97
Middle Flint Creek	112	3,821	1.91	1.32

Table E-9. BMP Sediment Load for Road Crossings

Watershed	Number Crossings	BMP Total Load (lb)	BMP Total Load (tons)	Total Load 31% RF (tons)
Upper Flint Creek	86	3,150	1.58	1.09
Smart Creek	72	2,549	1.27	0.88
Trout Creek	41	1,866	0.93	0.64
Lower Willow Creek	20	755	0.38	0.26
North Fork Willow Creek	38	1,099	0.55	0.38
South Fork Willow Creek	52	1,263	0.63	0.43
Total	667	22,590	11.3	7.8

E6.2 Parallel Road Segments BMP

Sediment loads were modeled for each measured parallel road segment, with all sites reduced to a maximum contributing length of 200 feet. As before, the calculated load for each parallel segment was converted to an annual load per mile of road length, and a general average sediment load for parallel road segments was determined (**Table E-10**).

Table E-10. Modeling Results for BMP Parallel Road Segments

Site Number	Land Ownership	Road Type	Road Length (ft)	Measured Load (lbs/year)	Measured Load (tons/mile)
292-293	Private	Native	200	88	0.2024
307	Private	Native	200	2	0.0092
327	USFS	Native	200	0	0
3	Private	Gravel	200	92	0.1438
283	Private	Gravel	200	51	0.0547
313	USFS	Gravel	200	91	0.4883
315	USFS	Gravel	200	73	0.5341
395	USFS	Gravel	200	31	0.2170
				Average	**0.2062**

The average sediment loading rate from BMP implementation on parallel roads was then applied to the total number of parallel segment miles in each watershed. As before, the 30% reduction factor was incorporated to account for discrepancies between GIS analysis and field observations. (**Table E-11**).

Table E-11. Extrapolation of Modeled BMP Data to Parallel Road Segments by Watershed

Watershed	Miles of Road	Miles of Road	Total Miles	Estimated Total Load (tons/year)	Total Load 31% RF (tons/year)
	Gravel	Native		All	
Barnes Creek	0.88	0.74	1.62	0.33	0.23
Boulder Creek	3.86	3.10	6.96	1.44	0.99
Douglas Creek (North)	5.57	1.56	7.13	1.47	1.01
Douglas Creek (South)	1.32	1.02	2.34	0.48	0.33
Fred Burr Creek	0.16	0.75	0.91	0.19	0.13
Lower Flint Creek	3.03	7.37	10.40	2.14	1.48
Middle Flint Creek	5.70	5.07	10.77	2.22	1.53
Upper Flint Creek	3.18	8.94	12.12	2.50	1.72
Smart Creek	4.55	5.93	10.48	2.16	1.49
Trout Creek	1.64	1.85	3.49	0.72	0.50
Lower Willow Creek	0.66	0.30	0.96	0.20	0.14

Table E-11. Extrapolation of Modeled BMP Data to Parallel Road Segments by Watershed

Watershed	Miles of Road	Miles of Road	Total Miles	Estimated Total Load (tons/year)	Total Load 31% RF (tons/year)
North Fork Willow Creek	1.72	3.82	5.54	1.14	0.79
South Fork Willow Creek	1.00	3.30	4.30	0.89	0.61
Total	**33.27**	**43.76**	**77.02**	**15.88**	**10.95**

E7.0 Load Reductions and Summary

The analysis of roads in the Flint Creek TPA is an estimate based on data representative of on-the-ground conditions. The results of the GIS analysis and modeling effort provide a reasonable characterization of the sediment loads from roads throughout the Flint Creek watershed. In order to understand the relative impact of these loads, the existing loads have been normalized to provide a watershed by watershed comparison, independent of the watershed area (**Table E-12**). Based on this analysis, Smart Creek, Douglas Creek (North) , and Douglas Creek (South) provide the three largest sediment loads from roads in the Flint Creek TPA.

Table E-12. Existing Load Comparison Among Watersheds

EXISTING LOADS					
Watershed	**Acres**	**Crossings Load**	**Parallel Load**	**Total Load**	**Load/1000 acres**
Barnes Creek	13,649	1.79	1.07	2.86	0.21
Boulder Creek	45,207	6.03	4.60	10.63	0.24
Douglas Creek (North)	9393	2.46	4.71	7.17	0.76
Douglas Creek (South)	4118	1.10	1.56	2.66	0.65
Fred Burr Creek	10,082	0.50	0.60	1.10	0.11
Lower Flint Creek	49,485	4.54	6.86	11.40	0.23
Middle Flint Creek	48,657	7.62	7.11	14.73	0.30
Upper Flint Creek	44,707	5.76	8.00	13.76	0.31
Smart Creek	15,626	5.80	6.91	12.71	0.81
Trout Creek	22,565	1.52	2.30	3.82	0.17
Lower Willow Creek	9032	1.01	0.63	1.64	0.18
N. F. Willow Creek	19,453	2.04	3.66	5.70	0.29
S. F. Willow Creek	25,731	2.75	2.84	5.59	0.22

Sampled locations were modeled first for the existing load, and then again to incorporate changes that could occur given the implementation of potential BMPs. Reductions in sediment loads from road crossings are based on site specific information from each assessed crossing. Parallel road segments were re-modeled to simulate road sections with a maximum contributing distance of 200 feet. At the time of data collection, the field personnel recorded potential improvements in road design or maintenance, which were then later input into the model to simulate the sediment loads if all BMPs were installed. The BMP scenarios allow for the development of an estimate of the potential for improvement and load reduction throughout the watershed. Based on this analysis, on average, a 78% reduction in sediment loading from roads could be achieved throughout the watershed with the application of all appropriate Best Management Practices (**Table E-13**).

Table E-13. Sediment Loads from Roads with Application of All BMPs

BMP LOADS						
Watershed	**Acres**	**Crossings Load**	**Parallel Load**	**Total Load**	**Percent Reduction**	**Load/1000 acres**
Barnes Creek	13,649	0.39	0.23	0.62	78%	0.05
Boulder Creek	45,207	0.70	0.99	1.69	84%	0.04
Douglas Creek (North)	9393	0.28	1.01	1.29	82%	0.14
Douglas Creek (South)	4118	0.31	0.33	0.64	76%	0.16
Fred Burr Creek	10,082	0.15	0.13	0.28	75%	0.03
Lower Flint Creek	49,485	0.97	1.48	2.45	79%	0.05
Middle Flint Creek	48,657	1.32	1.53	2.85	81%	0.06
Upper Flint Creek	44,707	1.09	1.72	2.81	80%	0.06
Smart Creek	15,626	0.88	1.49	2.37	81%	0.15
Trout Creek	22,565	0.64	0.50	1.14	70%	0.05
Lower Willow Creek	9032	0.26	0.14	0.40	76%	0.04
N. F. Willow Creek	19,453	0.38	0.79	1.17	79%	0.06
S. F. Willow Creek	25,731	0.43	0.61	1.04	81%	0.04

In general, a few basic observations regarding the road systems can be made, independent of the model outputs. Roads in the mountains are often responsible for higher sediment loads due to steeper terrain, differences in geology, and higher precipitation. High traffic roads at lower elevations are often maintained year round, whereas less frequented roads (often at higher elevations) receive seasonal or little to no regular maintenance. In addition, the majority of the sediment load often comes from a relatively small percent of all road crossings, as illustrated in **Figure E-1**. With these things in mind, strategies can start to be developed on how to approach reducing sediment load from roads.

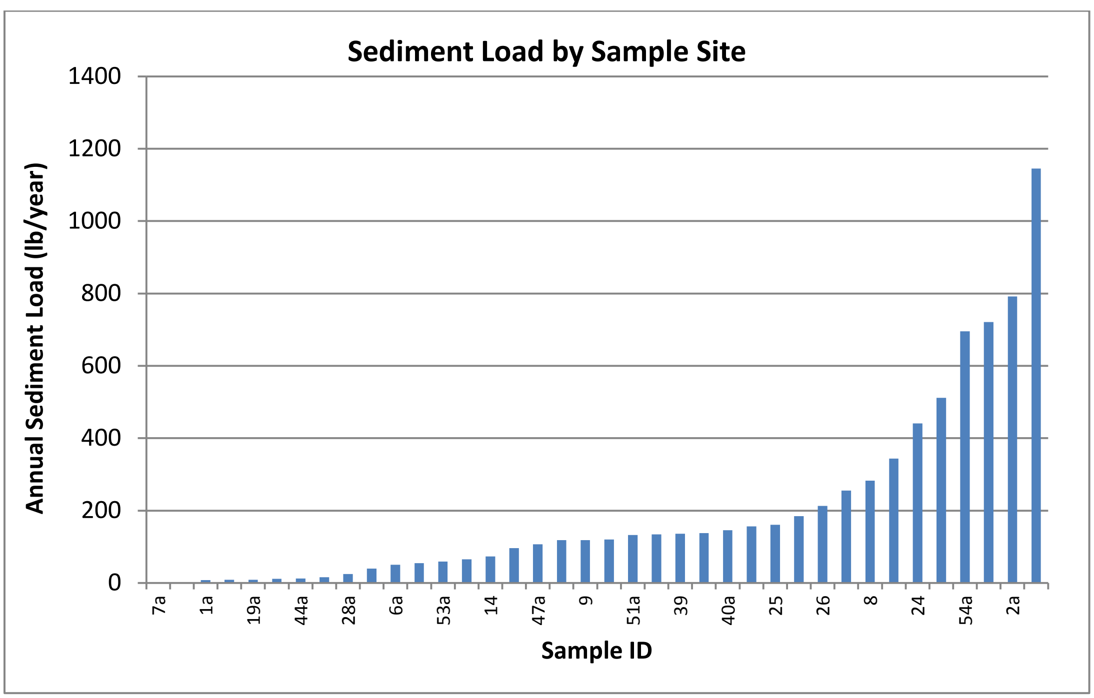

Figure E-1: Sediment Load by Sample Site

Although only a small percentage of sites were assessed, the random sampling design of the project assumes that those sites are representative of the watershed as a whole, and allows for a reasonable representation of what is occurring in the field. As shown in the results, 74% of the road crossings assessed contributed less than 200lbs/year, and only 10% of the road crossings contribute greater than 600 lbs/year. Therefore, it can be assumed that the greatest contribution of sediment loading comes from approximately 25% of the roads, with roughly 10% of the crossings in need of immediate concern. To eventually reduce the sediment load from road systems in the Flint Creek TPA, the best course of action is to identify those individual road crossings and parallel road segments with the largest contribution. The responsibility for determining which road crossings or segments deserve the most immediate attention lies with the owners of the roads in the respective watersheds. Ownership of crossings per watershed is presented in **Table E-14**.

Table E-14. Attributed Ownership of Road Crossings by Watershed

Road Crossings*					
	Attributed Ownership based on available GIS information				
Watershed	**BLM**	**USFS**	**State of Montana**	**Private**	**Unattributed**
Barnes Creek	-	2	-	26	1
Boulder Creek	1	69	-	4	-
Douglas Creek (North)	-	22	-	12	-
Douglas Creek (South)	1	-	-	19	1
Fred Burr Creek	-	-	-	9	-
Lower Flint Creek	-	14	3	62	-
Middle Flint Creek	10	31	-	70	1
Upper Flint Creek	-	47	-	35	4
Smart Creek	3	42	-	27	-
Trout Creek	-	-	9	32	-
Lower Willow Creek	-	-	-	20	-
North Fork Willow Creek	-	11	-	27	-
South Fork Willow Creek	-	29	-	23	-

* Road crossings as identified through initial GIS analysis and does not account for 30% reduction due to "false-crossings". Crossings were identified based on land ownership; it is acknowledged that road ownership may not always equate to adjacent land ownership and therefore the ownership attribution may not be entirely accurate.

The USFS, BLM, and other agencies and organizations have developed extensive documentation and guidelines for managing roads on public lands. BMPs such as dips, crossdrains, graded berms, proper culvert design, road relocation, alteration to road material, and revegetation are options for reducing sediment loads. The main BMPs that were observed in the field included cross drains and dips, and effective road grading. Of the assessed crossings, BMPs were observed on 27 percent of the USFS roads and 24 percent of the private roads, and one of two BLM roads. For the parallel road segments, 75 percent of the segments had some BMPs present. While road BMPs do exist in some in the Flint Creek TPA, the results from this study show there is still significant opportunity for improvement and reduction of sediment loads from roads.

E8.0 References

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