APPENDIX G - ROAD SEDIMENT ASSESSMENT, TOBACCO TMDL PLANNING AREA

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G1.0 INTRODUCTION

This appendix presents a sediment and culvert assessment of the road network within the Tobacco River TMDL Planning Area (TPA). The information is derived from a roads assessment report prepared by Water and Environmental Technologies for presentation to the Kootenai River Network and the Montana Department of Environmental Quality (DEQ) (Water and Environmental Technologies, PC, 2009). Roads located near stream channels can impact stream function through degradation of riparian vegetation, channel encroachment, and sediment loading. The degree of impact is determined by a number of factors, including road type, construction specifications, drainage, soil type, topography, precipitation, and the use of Best Management Practices (BMPs). Through a combination of GIS analysis, field assessment, and computer modeling, estimated sediment loads were developed for road crossing and parallel road segments. Existing road conditions were modeled and future road conditions were estimated after the application of sediment reducing Best Management Practices (BMPs). Existing culverts were also assessed for fish passage and failure from runoff events.

G2.0 DATA COLLECTION

The Tobacco Road Sediment assessment consisted of three primary tasks:
1.) GIS Layer development and summary statistics,
2.) field assessment (2008) and subsequent sediment modeling, and
3.) sediment load calculations and assessment of existing and potential load reduction capability via application of best management practices.

Additional information on assessment techniques is available in prior reporting for this project: Road GIS Layers and Summary Statistics (Water & Environmental Technologies, PC., 2007a), and Sampling and Analysis Plan (Water & Environmental Technologies, PC., 2007b).

G2.1 SPATIAL ANALYSIS

Using road layers provided by the Kootenai National Forest (KNF), road crossings and parallel segments in the road network were identified and classified relative to 6th code subwatershed, land ownership, and landscape type (**Table G2-1 and Figures G1, G2 and G3**). These classifications facilitated a statistically representative sample of roads within the entire watershed, based on a number of road conditions (subwatershed, road design, soil type, maintenance level, etc). Summary statistics show that there are a total of 1345 road crossings in the Tobacco River TPA, with 1231 unpaved crossings and 105 paved crossings. There are 854 Mountain crossings (838 unpaved), 438 Foothill crossings (377 unpaved), and 44 Valley crossings (16 unpaved). There are 822 road crossings on federal lands (797 unpaved), 455 crossings on private lands (378 unpaved), and 59 crossings (56 unpaved) crossings on state lands. A random subset of unpaved crossing sites was generated for field assessment based on the proportion of total crossings within each landscape type, with approximately 4% of the total unpaved crossings assessed (50 sites). Parallel road segments were identified as areas where roads encroach upon the stream channel, and total road lengths within 50-foot buffer zones were generated. There is a total of 19.2 miles of unpaved parallel road segments within 50 feet of stream channels. Statistics generated using GIS were updated in the field, as described in **Section G2.4**.

Table G2-1. Road Summary by Landscape Type, Land Ownership, and Soil Erosion Hazard Classification

Landscape Type	Area (Mi2)	Stream Miles (Mi)	Unpaved Crossings	Unpaved Crossing Density (Crossing / Mi2)	Paved Crossings	Total Crossings	Total Road Length (Mi)	Total Road Density (Mi/Mi2)	% of Total Roads which are unpaved	Total Unpaved Road Length w/in 50 ft Streams (Mi)	Total Unpaved Road Density w/in 50 ft of Streams (Mi/Mi2)
Foothill	121.15	242.47	377	3.11	61	438	533.66	4.41	86.9%	8.36	0.07
Mountain	216.27	455.91	838	3.87	16	854	712.86	3.30	98.1%	10.40	0.05
Valley	28.71	42.79	16	0.56	28	44	79.45	2.77	44.8%	0.43	0.02
Total	366.13	741.17	1231	3.36	105	1336	1325.97	3.62	90.4%	19.2	0.05
Land Ownership	**Area (Mi2)**	**Stream Miles (Mi)**	**Unpaved Crossings**	**Unpaved Crossing Density (Crossing / Mi2)**	**Paved Crossings**	**Total Crossings**	**Total Road Length (Mi)**	**Total Road Density (Mi/Mi2)**	**% of Total Roads which are unpaved**	**Total Unpaved Road Length w/in 50 ft Streams (Mi)**	**Total Unpaved Road Density w/in 50 ft of Streams (Mi/Mi2)**
Federal Land	228.88	454.70	797	3.48	25	822	762.47	3.33	96.6%	11.75	0.05
Private	123.22	251.83	378	3.07	77	455	523.87	4.25	81.2%	6.64	0.05
State Land	11.49	26.47	56	4.87	3	59	38.77	3.38	91.7%	0.80	0.07
Water	2.54	17.31									
Total	366.13	741.17	1231	3.36	105	1336	1325.12	3.62	90.4%	19.2	0.05
Soil Erosion Hazard Classification	**Area (Mi2)**	**Stream Miles (Mi)**	**Unpaved Crossings**	**Unpaved Crossing Density (Crossing / Mi2)**	**Paved Crossings**	**Total Crossings**	**Total Road Length (Mi)**	**Total Road Density (Mi/Mi2)**	**% of Total Roads which are unpaved**	**Total Unpaved Road Length w/in 50 ft Streams (Mi)**	**Total Unpaved Road Density w/in 50 ft of Streams (Mi/Mi2)**
Mod(60%), Slight(40%)	5.38	23.05	29	5.39	8	37	33.23	6.17	73.1%	0.28	0.05
Moderate	8.88	24.79	25	2.82	5	30	35.66	4.02	69.3%	0.24	0.03
Severe	328.37	594.56	1119	3.41	62	1181	1177.14	3.58	93.2%	17.54	0.05
Slight	19.42	81.46	57	2.94	30	87	79.46	4.09	65.3%	1.10	0.06
Water	3.57	17.31	1	0.28		1					
Total	365.62*	741.17	1231	3.37	105	1336	1325.49	3.62	90.4%	19.2	0.05

*The GIS boundary was slightly smaller for soil erosion hazard classification than for landscape type and land ownership models. Thus, total area is slightly less within the soil classification boundary.

G2.2 Field Data Collection

A total of 50 unpaved crossings and 10 parallel segments were evaluated in the field during 2008. Thirty-seven crossings were assessed on Federal lands, 12 crossings were assessed on Private lands, and one crossing was assessed on State lands. Twenty-nine crossings were assessed in the mountain landscape (25 Federal, 4 private); 17 crossings were assessed in the foothill landscape (12 Federal, 5 private); and 4 crossings (3 private; one State) were assessed in the valley landscape type. Forty-eight crossings were assessed on soil rated "severe" per the USDA-NRCS, Hazard of Erosion and Suitability for Roads on Forestland category (**Figure G4**). The remaining two crossings were LFTN-F-09 on "moderate" soil and INC-V-26 on "slight" soil. Crossing assessment sites were randomly selected with the goal of being representative of landscape type and ownership category.

In the field, parallel segments were selected based on best professional judgment while traveling roads on which specific crossings were selected for evaluation. When a parallel reach was encountered, the reach was divided into smaller segments and assessed at pre-selected intervals to eliminate sample bias. Generally, the majority of parallel road segments are located in narrow stream valleys or canyons in foothill and mountain landscapes, where roads are constructed near streams. Three (3) parallel segments were assessed in the mountain landscape type and seven (7) segments were assessed in the foothill landscape type. No parallel segments were encountered or assessed in the valley landscape type due to the small overall area of the valley landscape, and the observation that the majority of valley roads were paved and/or did not parallel a stream channel. All ten of the parallel sites were located on federal lands and on soil rated "severe" per the USDA-NRCS, Hazard of Erosion and Suitability for Roads on Forestland category.

G2.3 Sediment Assessment Methodology

The road sediment assessment was conducted using the WEPP:Road forest road erosion prediction model (http://forest.moscowfsl.wsu.edu/fswepp/). WEPP:Road is an interface to the Water Erosion Prediction Project (WEPP) model (Flanagan and Livingston, 1995), developed by the USDA Forest Service and other agencies, and is used to predict runoff, erosion, and sediment delivery from forest roads. The model predicts sediment yields based on specific soil, climate, ground cover, and topographic conditions. Specifically, the following model input data was collected in the field: soil type, percent rock, road surface, road design, traffic level, and specific road topographic values (road grade, road length, road width, fill grade, fill length, buffer grade, and buffer length). In addition, supplemental data was collected on vegetation condition of the buffer, evidence of erosion from the road system, and potential for fish passage and culvert failure.

Site-specific climate profiles were created using data from the Western Regional Climate Center (http://www.wrcc.dri.edu). Climate stations were selected from within the Tobacco TPA boundary that exhibited similar conditions for each specific landscape type. The Eureka Ranger station (242827: 2530 ft elevation, 14.34-inches annual precipitation), was selected for valley sites, the Fortine 1N station (243139: 3000-feet elevation, 16.79-inches annual precipitation) was selected to model the foothill sites, and the Olney station (246218: 3180-feet elevation, 22.06-inches annual precipitation) was used to model the mountain sites.

Generally, 30-year model simulations are adequate to obtain a reliable average erosion estimate. However, in drier climates (less than 500 mm/19.68 inches of precipitation), 50-year or longer simulations are necessary to obtain average erosion estimates. For the Tobacco TPA, 30-year simulations were run for mountain sites, and fifty-year simulations were run for valley and foothill sites.

Some road conditions encountered in the field are not accurately represented in the WEPP:Road design options; as a result, some adjustments were made to the model to more appropriately represent these types of roads. **Attachment B** contains a description of model or site condition adjustments, as recommended by the model author or by professional judgment.

G2.4 Field Adjustments

Field conditions required that a number of sites be moved to different locations due to lack of access (landowner permission or road condition), or inaccuracies in the road or stream GIS layers. It was noted during field activities that some roads were classified as unpaved on the GIS layer attributes, when in fact, they were found to be paved roads upon field inspection. Also, some road crossings or parallel segments were not present upon field inspection. GIS layers often contain additional crossings when road and stream layers parallel each other close together. Records were kept in the field and edits were made to the GIS layers. Revised unpaved road network statistics were generated, which resulted in unpaved road crossings decreasing from 1240 to 1231 crossings (**Table G2-2**).

The ability to generate completely accurate road and stream crossing layers is not feasible; however, this revised tally represents a more accurate representation of existing conditions.

Table G2-2. Total Number of Unpaved Crossings

Landscape Type	Unpaved Road Crossings using GIS Only	Revised Unpaved Crossings After Field and Map Adjustments
Mountain	839	838
Foothill	386	377
Valley	15	16
Total	1240	1231

Total unpaved road crossings and crossing densities were also classified by major land ownership within the TPA, with results shown in **Table G2-3**. **Table G2.3** also includes the sampling statistics by ownership.

Table G2-3. Unpaved Road Crossings Sorted by Major Land Ownership

Land Ownership / Management Unit	Number of Unpaved Crossings	Ownership Area (sq mi)	Ownership Area (%)	Crossing Density (crossings/sq mi)	Sites Sampled (& Percent of Total)
Federal	797	228.9	62.5%	3.48	37 (4.6%)
State of Montana	56	11.5	3.1%	4.87	1 (1.8%)
Private	378	123.2	33.7%	3.07	12 (3.2%)
Water	0	2.5	0.7%	0.0	NA
Total	1231	366.1	100%	3.37	50 (4.1%)

Federal land contains the most unpaved road crossings, and State lands have the highest density of road crossings when compared with ownership area.

G2.5 Sediment Loads from Field Assessed Sites – Stream Crossings

Field assessment data and WEPP:Road modeling results were used to develop sediment loads based on various watershed criteria. A standard statistical breakdown of loads from the unpaved road network within each sediment-listed watershed was generated using the applicable dataset of field assessed crossing and parallel sites. Mean load and contributing length, median load, maximum and minimum loads, and 25th and 75th percentile loads were calculated for unpaved road crossings within each landscape type that was the basis of the field assessment. Mean sediment loads from unpaved road crossings were modeled at 0.07 tons/year in mountain landscapes, 0.04 tons/year in the foothill landscapes, and 0.26 tons/year in the valley landscapes. A statistical summary of sediment loads for field assessed sites are included in **Table G2-4**. This information will be used for extrapolating total loads throughout the watershed (**Section G3**).

Table G2-4. Sediment Load Summary for Field Assessed Crossings by Landscape Type

Statistical Parameter	Mountain	Foothill	Valley	Total of Field Assessed Crossings
Number of Sites (n)	29	17	4	50
Mean Contributing Length (ft)	214	305	433	262
Mean Load (tons/year)	0.07	0.04	0.26	0.08
Median Load (tons/year)	0.01	0.01	0.06	0.01
Maximum Load (tons/year)	0.37	0.25	0.92	0.92
Minimum Load (tons/year)	0	0	0	0
25th Percentile (tons/year)	0.006	0.004	0.040	0.005
75th Percentile (tons/year)	0.09	0.07	0.28	0.08

The sediment load summary shows significant differences between minimum and maximum load values, as well as between mean and median values for valley landscape types. These data suggest that a small number of high sediment load crossing sites impact the average values.

When evaluated by ownership, the mean load for the 12 private crossings was 0.12 tons/year. The mean load for the 37 federal crossing plus the one state crossing was 0.06 tons/year, or about half of the mean load per private crossing. This information is useful to evaluate and track BMP implementation by major owner categories, but because ownership is typically not distributed equally among landscape types, it is not used as an extrapolation factor for estimating the total loads throughout the watershed.

G2.6 Sediment Loads from Field Assessed Sites – Unpaved Parallel Road Segments

Mean sediment loads were calculated for 10 assessed unpaved parallel road segments; 3 sites were within the mountain landscape type and 7 sites were within foothills landscape type. No valley parallel segments were assessed in the field due to the minimal presence of roads (within 50 feet) which paralleled streams in the valley landscape. The average load from the 7 parallel sites in the foothills landscape type was 0.03 tons/year, and the average load from the 3 parallel sites in the mountain landscape type was also 0.03 tons/year. The load per mile of contributing road length was also evaluated for the 10 sites with an average loading rate of about 0.47 tons/year/mile. A summary of modeling results from field assessed sites is located in **Attachment C**.

G2.7 Paved Roads

As shown by **Table G2.1** and **Figure G5**, many of the road crossings and parallel roads are paved. Traction sand is used in the winter on the paved roads and is divided between county and state responsibility. The Lincoln County Road Department, District 3 estimates an annual average application of 3,500 to 4,000 cubic yards of sand for a total of 180 miles (24 tons/mile). The Montana Department of

Transportation (MDT) estimates 1,500 cubic yards of sand each year for the past five years for 28 miles of road along the Tobacco River (67 tons/mile); however the state has discontinued the use of sand in 2008 in favor of using salt. Conversions were calculated with an assumed bulk density of 1.25 tons per cubic yard. Over 208 miles of road, the normalized annual application rate (prior to 2008) for paved roads would equate to about 30 tons/mile.

Below is a summary of traction sand application reported from other TMDL project areas. Note that application rates can vary considerably. The application rate in the Tobacco is closest to the amount of traction sand in the Prospect Creek TPA and the Blackfoot Headwaters TPA:

- Bitterroot Headwaters TPA: MDT estimated an application rate of 1 ton/mile/year on Highway 93
- Prospect Creek TPA: MDT: 1587.3 tons / 22 miles / year = 72 tons/mile/year
- Blackfoot Headwaters TPA: The amount of traction sand applied to the highways was provided by MDT personnel and was 73 tons/mile/year (Highway 200 from the junction of Highway 279 to Rogers Pass and Highway 279 from the junction with Highway 200 to Flesher Pass) and 36 tons/mile/year (Highway 200 from the junction of Highway 279 to all points west).
- Upper Lolo Creek TPA: Approximately 3,300 tons/ 6.4 miles on the West Fork of Upper Lolo Creek equates to 516 tons/mile/year.

No field assessments were completed for paved road crossings or paved parallel segments. Dave Rauser has been with MDT for 21 years and stated that many of the silt fences near the Tobacco River show minimal accumulation of traction sand, suggesting an overall low delivery rate for road sand.

The above information along with assessment approaches from other TMDL documents is used to estimate a road sand load in **Section G3** of this appendix.

G2.8 Road Statistics by Subwatershed

Total road crossings and parallel road distances were further defined by land ownership and subwatershed. USGS 6th code subwatersheds were used as a basis for road sediment categorization in order to provide means for identifying the most impacted areas, and opportunities for potential restoration planning. A summary of road conditions by 6th code/303(d) subwatershed is included as **Table G2-5**; road crossing and parallel road distance sorted by ownership and landscape type is included in **Table G2-6** and **Table G2-7**.

Table G2-5. Tobacco River TPA Road Summary by 6th Code HUC/303(d) Watershed

6th Code Subwatershed (USGS HUC 12)	Area (Mi2)	Stream Miles (Mi)	Unpaved Crossings	Unpaved Crossing Density (Crossing / Mi2)	Paved Crossings	Total Crossings	Total Road Length (Mi)	Total Road Density (Mi/Mi2)	% of Total Roads which are unpaved	Total Unpaved Road Length w/in 50 ft Streams (Mi & % of total)	Total Unpaved Road Density w/in 50 ft of Streams (Mi/Mi2)
Deep Creek	19.39	45.63	45	2.32	3	54	59.15	3.05	96.7%	0.71 (3.7)	0.04
Edna Creek	23.28	54.50	120	5.15	3	123	105.10	4.52	97.5%	1.97 (10.3)	0.08
Indian Creek	17.72	37.35	8	0.45	4	12	20.13	1.14	64.5%	0.26 (1.4)	0.01
Lower Fortine Creek	60.79	137.52	231	3.80	19	255	242.33	3.99	90.2%	4.85 (25.3)	0.08
Meadow Creek	27.32	62.74	171	6.26	7	179	133.07	4.87	95.8%	3.41 (17.8)	0.12
Middle Fortine Creek	36.86	87.03	202	5.48	8	206	171.15	4.64	95.3%	2.56 (13.3)	0.07
Sinclair Creek	12.63	23.55	9	0.71	7	16	11.74	0.93	47.3%	0.04 (0.2)	0.00
Swamp Creek-Lake Creek	45.25	75.04	127	2.81	0	128	152.73	3.38	99.8%	0.54 (2.8)	0.01
Therriault Creek	21.13	39.87	50	2.37	13	65	59.02	2.79	84.1%	0.82 (4.3)	0.04
Tobacco River	62.53	88.94	104	1.66	30	131	233.75	3.74	76.7%	2.91(15.2)	0.05
Upper Fortine Creek	39.24	88.99	164	4.18	11	176	137.79	3.51	94.2%	1.12 (5.8)	0.03
Total	366.13	741.17	1231	3.36	105	1345	1325.97	3.62	90.4%	19.19 (100)	0.05

Table G2-6. Unpaved Road Crossings by Ownership and Landscape Type

Ownership	2010	Federal			Private			State			
Watershed	303(d)	Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	Total
Deep Creek	Yes	0	25	9	0	11	0	0	0	0	59
Edna Creek	Yes	0	0	68	0	1	51	0	0	0	12
Indian Creek	No	0	0	0	4	0	0	3	0	1	10
Lower Fortine Creek	Yes	0	96	39	0	87	9	0	0	0	1
Meadow Creek	No	0	4	75	0	39	42	0	0	11	91
Middle Fortine Creek	Yes	0	1	117	0	7	39	0	0	38	21
Sinclair Creek	No	0	0	5	1	3	0	0	0	0	46
Swamp Creek-Lake Creek	Yes	0	0	118	0	0	9	0	0	0	120
Therriault Creek	Yes	0	7	14	0	26	3	0	0	0	147
Tobacco River	Yes	0	39	25	8	29	1	0	2	0	121
Upper Fortine Creek	Yes	0	0	155	0	0	8	0	0	1	73
Total		0	172	625	13	203	162	3	2	51	1231

Table G2-7. Detailed Length (miles) of Parallel Road Segments Within 50-Feet of Streams

Ownership	**2010**	**Federal**			**Private**			**State**			
SubWatershed	**303(d)**	**Valley**	**Foothill**	**Mountain**	**Valley**	**Foothill**	**Mountain**	**Valley**	**Foothill**	**Mountain**	**Total**
Deep Creek	Yes	0.0	0.5	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.7
Edna Creek	Yes	0.0	0.0	1.2	0.0	0.0	0.8	0.0	0.0	0.0	2.0
Indian Creek	No	0.0	0.0	0.0	0.2	0.0	0.0	0.1	0.0	0.0	0.3
Lower Fortine Creek	Yes	0.0	2.2	0.6	0.0	1.8	0.2	0.0	0.1	0.0	4.9
Meadow Creek	No	0.0	0.1	1.6	0.0	0.6	0.9	0.0	0.0	0.2	3.4
Middle Fortine Creek	Yes	0.0	0.0	1.7	0.0	0.0	0.4	0.0	0.0	0.4	2.6
Sinclair Creek	No	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Swamp Creek-Lake Creek	Yes	0.0	0.0	0.5	0.0	0.0	0.1	0.0	0.0	0.0	0.5
Therriault Creek	Yes	0.0	0.3	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.8
Tobacco River	Yes	0.1	1.4	0.6	0.1	0.7	0.0	0.0	0.0	0.0	2.9
Upper Fortine Creek	Yes	0.0	0.0	1.0	0.0	0.0	0.1	0.0	0.0	0.0	1.1
Total		0.1	4.4	7.3	0.3	3.8	2.5	0.1	0.1	0.6	19.2

G3.0 ROAD NETWORK LOAD ANALYSIS

This section uses the **Section G2.0** information to extrapolate road loads at a watershed scale.

G3.1 SEDIMENT LOAD FROM ROAD CROSSINGS

Mean unpaved road crossing sediment loads from field assessed sites were used to extrapolate existing loads throughout the entire watershed. Mean loads for unpaved crossings within mountain (0.07 tons/year), foothill (0.04 tons/year), and valley (0.26 tons/year) landscape types were applied to the total number of crossings within the TPA, and further classified by 6th code HUC and land ownership. The existing total Tobacco River watershed sediment load from unpaved road crossings was estimated at 77.9 tons/year (**Table G3-1**). Detailed sediment loads for road crossings classified by ownership and landscape type within each 6th code/303(d) subwatershed are included in **Table G3-2**.

Table G3-1. Sediment Load Summary from Unpaved Road Crossings – Existing Conditions

Road Feature	Landscape Type	Total Number of Crossings	Mean Sediment Load (Tons/year)	Total Sediment Load (Tons/year)
Crossing	Mountain	838	0.07	58.7
Crossing	Foothill	377	0.04	15.1
Crossing	Valley	16	0.26	4.2
Total:		1231		77.9

Using the above described landscape extrapolation approach, the total sediment load from unpaved crossings was 77.9 tons/year from a total of 1231 crossings, or an average of 0.075 tons/year/crossing across all land units. Per **Table G2-6** the majority of sediment load is generated from crossings on Federal land (50.63 tons/year), followed by private land (22.84 tons/year), and State land (4.43 tons/year). This equates to approximately 0.06 tons/year per crossing on federal land and also to approximately 0.06 tons/year per crossing on private lands. The value for state land is higher at 0.08 tons/year per crossing, but this value is based on only one sampled location.

Road crossing results showed that the Middle Fortine Creek (13.90 tons/year), Upper Fortine Creek (11.48 tons/year), and the Upper Fortine Creek / Meadow Creek (both segments 10.68 tons/year) contained the three highest sediment loads from unpaved road crossings (**Table G3-2**). Lime Creek, also a 303(d) impaired water, is located within the Middle Fortine Creek subwatershed. Lime Creek includes 50 unpaved road crossings, 49 of which are within the Mountain landscape and 1 which is in the Foothill landscape. This results in an extrapolated sediment load of 3.5 tons/year for Lime Creek. In other words, of the 13.9 tons/year extrapolated load for the Middle Fortine Creek subwatershed, 3.5 tons is from the Lime Creek portion of this subwatershed.

Note that the **Table G3-2** results are summarized by HUC and impaired subwatersheds. To obtain the load for the complete Fortine Creek and Tobacco River watersheds, some subwatershed areas must be summed. The annual summed sediment loads by impaired waters are:

- Deep Creek: 2.1 tons/year
- Edna Creek: 8.4 tons/year
- Sinclair Creek: 0.7 tons/year
- Swamp Creek: 8.9 tons/year
- Therriault Creek: 2.5 tons/year

- Fortine Creek: 65.5 tons (includes everything except Tobacco River, Therriault Creek Sinclair Creek, and Indian Creek).
- Tobacco River: 77.9 tons (includes all loads)

Table G3-2. Detailed Sediment Load From Unpaved Road Crossings by HUC /303(d) Subwatershed – Existing Conditions

Ownership	2010	Federal Land			Private			State			Total
SubWatershed	**303(d)**	**Valley**	**Foothill**	**Mountain**	**Valley**	**Foothill**	**Mountain**	**Valley**	**Foothill**	**Mountain**	**Load (t/y)**
Deep Creek	Yes	0	1	0.63	0	0.44	0	0	0	0	2.07
Edna Creek	Yes	0	0	4.76	0	0.04	3.57	0	0	0	8.37
Indian Creek	No	0	0	0	1.04	0	0	0.78	0	0.07	1.89
Lower Fortine Creek	Yes	0	3.84	2.73	0	3.48	0.63	0	0	0	10.68
Meadow Creek	No	0	0.16	5.25	0	1.56	2.94	0	0	0.77	10.68
Middle Fortine Creek	Yes	0	0.04	8.19	0	0.28	2.73	0	0	2.66	13.90
Sinclair Creek	No	0	0	0.35	0.26	0.12	0	0	0	0	0.73
Swamp Creek-Lake Creek	Yes	0	0	8.26	0	0	0.63	0	0	0	8.89
Therriault Creek	Yes	0	0.28	0.98	0	1.04	0.21	0	0	0	2.51
Tobacco River	Yes	0	1.56	1.75	2.08	1.16	0.07	0	0.08	0	6.70
Upper Fortine Creek	Yes	0	0	10.85	0	0	0.56	0	0	0.07	11.48
Total		0	6.88	43.75	3.38	8.12	11.34	0.78	0.08	3.57	77.9

G3.2 Sediment Load from Parallel Roads

As identified in **Table G2.1**, there are approximately 19.2 miles of parallel road segment within 50 feet of a stream in the watershed. A load is determined using the same extrapolation value for all landscape types because of the relatively small sample size, the similar loading results for the mountain and foothill landscape types where the majority of parallel sites are located, and the relatively low sediment contribution in comparison to the unpaved road crossings. The contributing length of the assessed parallel segments equates to approximately 0.6 mile, and the contributing load from these assessed segments equals 0.28 tons. If it assumed that the 0.6 miles assessed is a fractional representation of the total 19.2 miles of parallel road segments within 50 feet, then the total modeled load from parallel segments would equal 9.0 tons per year. Each watershed's existing unpaved parallel road load can be determined using the percentage of parallel road segment within each watershed (**Table G2.7**). Note that the **Table G2.8** results are summarized by subwatersheds. To obtain the load for the complete Fortine Creek watershed, some subwatershed areas must be summed. This results in the following contributions:

- Deep Creek: 0.33 tons/year
- Edna Creek: 0.93 tons/year
- Sinclair Creek: 0.02 tons/year
- Swamp Creek: 0.2 tons/year
- Therriault Creek: 0.4 tons/year
- Fortine Creek: 8.56 tons
- Tobacco River: 9.0 tons

Not included in **Table G2.7** is a parallel road length value for Lime Creek, where there are 50 unpaved road crossings. A contribution from Lime Creek can be calculated using the percentage of these crossings to all crossings (50/1231 or 4%), multiplied by the total 9.0 ton load to provide an estimate of parallel road segment sediment contribution. This results in an estimated load of 0.4 tons/year for Lime Creek parallel road segments, which would be a subset of the total Fortine Creek load.

G3.3 Grave Creek Road Sediment Load

The total Tobacco River TPA load of 77.9 tons/year does not include Grave Creek loading. The road load from Grave Creek should be added to this value to accurately account for all road sediment loading to the Tobacco River since Grave Creek is a major tributary to the Tobacco River.

Roads sediment loading for the Grave Creek TMDL (Montana Department of Environmental Quality, et al., 2005) source assessment was modeled using a different type of WEPP: Road application that resulted in 203 tons/year contribution from road crossings and parallel segments. This is from the Grave Creek watershed where there was a road density of about 2 to 2.5 miles per square mile and a total road length of about 170 miles. This is significantly lower road density and total road length than the remainder of the Tobacco watershed (i.e., the Tobacco TPA) where there is a road density of about 3.6 miles per square mile and a total road length of about 1,326 miles. The significantly higher modeled load in the Grave Creek watershed provides an example of how differing TMDL assessment approaches can result in very different total load values. Since no calibration has been performed for either assessment approach, the sediment loads within each evaluation can be considered as relative loads among the various roads within the specific modeled project area, but should not be considered actual load values.

In order to provide a Grave Creek road load to the Tobacco River that is consistent with the method described in this appendix, total road length is used as an indicator for sediment loading in both watersheds. The ratio of Grave Creek total road length to the Tobacco TPA road length is therefore used to extrapolate an equivalent Grave Creek road load for Tobacco TPA comparison purposes. The resulting road length ratio of 0.13 (170/1326) is multiplied by the total Tobacco road sediment load for road crossings, resulting in a total estimated Grave Creek road load of 10 tons per year ((0.13)(78)). This same approach for parallel segments results in a load estimate of about 1 ton per year.

G3.4 Sediment Load from Road Sand

An estimate of road sand loading from paved roads can be made for the 105 paved road crossings by using the unpaved road results summarized in this appendix along with road sand loading estimates from previous TMDL projects. The average contributing length of all unpaved crossings is 228 feet (**Attachment C**). If this value is assumed similar for the 105 paved crossings, then there would be a total of 4.5 miles of paved road length with about 136 tons of road sand applied within the contributing length of paved road crossings.

For the Blackfoot Headwaters TPA DEQ assumed a delivery rate of 5% for roads within 100 to 200 feet and 10% for roads within 100 feet of surfacewater. DEQ assumed similar delivery rates for contributing paved road lengths along the Swan TPA, with a 5% delivery for low potential sites and a 10% delivery rate for high potential sites. Using an average delivery rate value of 7.5% for all paved Tobacco road crossings would result in a total yearly road sand load of about 10 tons prior to 2008.

Per Table 2.6, about 10% of the parallel segments within 50 feet of a stream are paved; resulting in about 2 miles of paved roads within 50 feet of a stream. If a 10% delivery is assumed for these segments consistent with approaches used in the Blackfoot Headwaters and Swan TMDL documents, then the additional road sand load from parallel paved segments would equate to 6 tons per year (2 miles x 30 tons sand applied per mile x 10%).

Of the above computed total road sand load of 16 tons, 30% is linked to State road maintenance and would represent loading prior to 2008 only, reducing the existing (post 2008) load to about 11 tons/year from road sanding throughout the Tobacco TPA.

G4.0 Culvert Assessment

Culverts were analyzed for their ability to allow for fish passage, and for their ability to pass adequate flood flows. Of the 50 field assessed road crossing sites, field sites with bridges, along with any sites where any of the required screening data could not be accurately collected were removed from the dataset. After removing these sites from the dataset, eight (8) culverts were determined to be suitable for fish passage assessment and forty-seven (47) were suitable for culvert failure potential (**Figure G6**).

G4.1 Fish Passage

Measurements were collected at each field assessed crossing site, and these values were used to determine if culverts represented 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. 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 (>48-inches) and small (<48-inches) culvert groups evaluated differently. Failure of any one of the three indicators results in a red classification. Using the Alaska fish passage analysis, 4 of 8 culverts (50%) were classified as partial or total fish barriers, and 4 of 8 (50%) were classified as needing additional evaluation. None of the field assessed culverts were classified as capable of passing fish at all flows and life stages (**Table G4-1** and **Table G4-2**).

Table G4-1. Fish Passage Analysis for Selected Culverts

Culvert Classification or Indicator	Definition of Indicator	Number of Culverts	Percentage of Total Culverts Assessed (n = 8)
Green[1]	High certainty of meeting juvenile fish passage at all flows	0	0%
Grey[2]	Additional and more detailed analysis is required to determine juvenile fish passage ability	4	50%
Red[3]	High certainty of not providing juvenile fish passage at all desired streamflows	4	50%

Table G4-2. Fish Passage Analysis for Selected Road Crossings Using Alaska Region Criteria

Location ID	Structure Type	Structure Diameter or Dimensions	Culvert width (ft)	Structure Gradient (%)	Culvert slope	Bankfill (BF) in Riffle Above Culvert (ft)	Culvert /BF ratio	Fill Height (ft)	Fill Width (ft)	Fill Length (ft)	Fill Volume (Fill Height x width x Bf)	Outlet Invert (inches)	Final Classification
MFTN-M-5A	Wood Culvert	24"	2	1.0%	1[2]	2.5	0.80[1]	2.5	18	15	4.17	0[1]	GREY[2]
TOB-F-23	CMP	2'	2	4.0%	4[3]	3	0.67[2]	1	16	120	1.78	2[2]	RED[3]
MFTN-M-7A	CMP	24"	2	1.5%	1.5[3]	4	0.50[2]	5	22	15	16.30	1[2]	RED[3]
UFTN-M-32	CMP	2'	2	6.0%	6[3]	6	0.33[3]	6.5	30	27	43.33	7[3]	RED[3]
UFTN-M-30	CMP	3.5'	3.5	3.0%	3[3]	12	0.29[3]	3	37	22	49.33	0.5[2]	RED[3]
MC-F-35	CMP	5'	5	2.0%	2[2]	4	1.3[1]	0.5	28	25		0[1]	GREY[2]
UFTN-M-3A	Squash CMP	36"H x 54"W	4.5	1.0%	1[2]	4	1.1[1]	2	20	12	0.00	0[1]	GREY[2]
LFTN-F-10A	CMP (square)	72"H x 84"W	7	1.5%	1.5[2]	10	0.7[2]	1.5	18	12	10.00	0[1]	GREY[2]

Constriction ratios less than 1.0 not only indicate a potential fish passage problem, but also an increased potential for culvert failure. Five of the eight culverts assessed (63%) have a constriction ratio less than 1.0.

Many of the assessed culverts could not be assessed for fish passage because the bankfull width was not available (23 culverts) or the bankfull width was zero due to the lack of a defined stream channel as shown in **Photograph G1**. These culverts would not be viable for a year-round fish population. An example of a culvert assessed for fish passage is shown in **Photograph G2**; UFTN-M-3A was classified as Grey in the fish passage analysis.

Photograph G1. THR-F-19A

Photograph G2. UFTN-M-3A

G4.2 Culvert Failure Potential

Each culvert with available data was evaluated to determine peak flow using USGS regression equations developed by Omang (1992) for un-gaged sites, and flow estimates using Manning's equation. Using the regression equations, peak discharge flows were developed for the 2-, 5-, 10-, 25-, 50-, and 100-

recurring intervals for each selected culvert. Montana is divided into eight hydrologic regions, with a unique set of equations developed for each region. The Tobacco River TPA is located in the West Region for Omang equations; independent variables within these equations are drainage area (square miles) and precipitation (inches). Drainage area above each culvert was calculated using a digital elevation model (DEM) and the ArcSwat extension in GIS. The average mean annual precipitation was calculated within each drainage area from a mean precipitation layer available on NRIS (Prism Group, 2004).

Using site-specific culvert information collected in the field (including material, shape, dimensions, and slope) a peak flow was also calculated using Manning's equation. Variables in Manning's equation are culvert area, hydraulic radius, slope, and roughness coefficient (based on culvert material). The peak flow calculated using Manning's equation was compared with Omang values to estimate the maximum storm event that each culvert could convey without water backup. The number of culverts passing each specific storm event is shown in **Table G4-3**. Data for each culvert is shown in **Table G4-4**.

Table G4-3. Percent of Culverts Passing Design Storm Events

Design Storm Event	Number of Culverts Passing	Number of Culverts Failing Design Flow	Cumulative Percent Passing (All)	Cumulative Percent Passing (Federal)	Cumulative Percent Passing (Private)
Total Culverts	47		100%	100%	100%
Q2	42	5	89%	94%	73%
Q5	38	9	81%	89%	55%
Q10	36	11	77%	86%	46%
Q25	29	18	62%	69%	36%
Q50	29	18	62%	69%	36%
Q100	27	20	57%	66%	27%

Table G4-4. Culvert Failure Analysis

Site ID	Ownership	Peak Discharge Results Using Omang Equations Formula Variables											Peak Discharge Results Using Manning's Equation, pipes flowing full Formula Variables					
		Area - A (sqmi)	Avg Precip - p (in)	Structure	Volume of fill at risk (tons)	CMP Diameter or Height (ft)	Q2 (cfs)	Q5 (cfs)	Q10 (cfs)	Q25 (cfs)	Q50 (cfs)	Q100 (cfs)	Streambed Materials in Culvert	Roughness Coefficient[1]	Slope %	Velocity (ft/sec)	Peak Flow (cfs)	Max. Conveyance Manning's > Omang
DEP-F-11A	Private	0.17	20.8	CMP	0	1.5	0.7	1.5	2.1	3.0	3.7	4.4	N/A	0.035	1.0	2.21	3.90	Passes All
DEP-F-12A	Federal	0.55	25.5	CMP	0	1.5	3.0	5.7	7.9	10.6	13.1	15.3	N/A	0.035	5.0	4.94	8.72	<Q25
DEP-F-15A	Federal	0.24	33.9	CMP	1.8	2.5	2.1	3.9	5.3	7.2	8.9	10.4	N/A	0.035	1.5	3.80	18.66	Passes All
EN-M-03	Federal	0.07	30.4	CMP	9.4	1.5	0.5	1.1	1.5	2.1	2.7	3.2	No	0.035	6.0	5.41	9.56	Passes All
EN-M-04	Federal	0.22	26.4	CMP	9.0	1.5	1.3	2.6	3.7	5.0	6.2	7.4	Yes	0.035	4.0	4.42	7.80	Passes All
EN-M-06	Federal	0.64	25.1	CMP	16.4	2	3.3	6.3	8.8	11.8	14.6	17.0	No	0.035	8.0	7.57	23.77	Passes All
EN-M-07	Federal	10.91	29.6	CMP	66	10	61.9	101.9	136.3	171.0	204.2	231.0	Yes	0.035	2.0	11.06	868.66	Passes All
INC-V-26	Private	0.06	14.6	CMP	5.9	1.5	0.2	0.4	0.6	0.8	1.0	1.2	No	0.035	4.0	4.42	7.80	Passes All
INC-V-27	Private	4.26	37.0	CMP	172.3	2	35.6	58.4	77.9	98.2	117.9	134.0	No	0.035	4.0	5.35	16.81	<Q2
INC-V-28	State	0.02	20.0	CMP	N/A	1.5	0.1	0.2	0.3	0.4	0.5	0.6	No	0.035	2.0	3.12	5.52	Passes All
LFTN-F-10A	Federal	2.94	34.0	CMP (square)	6.5	7	22.1	37.5	50.4	64.3	77.6	88.7	No	0.035	1.5	7.55	317.15	Passes All
LFTN-M-08	Federal	0.04	19.5	CMP	1.0	1.5	0.2	0.4	0.6	0.8	1.0	1.3	No	0.035	2.0	3.12	5.52	Passes All
LFTN-F-09	Private	0.08	16.4	CMP	11.0	1.5	0.3	0.6	0.8	1.2	1.5	1.8	No	0.035	3.0	3.82	6.76	Passes All
LFTN-F-09A	Federal	0.46	17.7	CMP	5.4	2.5	1.5	3.0	4.2	5.9	7.3	8.6	N/A	0.035	1.5	3.80	18.66	Passes All
MC-F-19	Private	6.97	27.5	CMP	23.7	4	36.4	61.8	83.4	106.1	127.4	145.0	Yes	0.035	1.0	4.25	53.35	<Q5
MC-F-35	Private	19.54	24.5	CMP	1.8	5	80.6	134.1	180.3	226.2	269.6	304.4	No	0.035	2.0	6.97	136.81	<Q10
MC-M-16	Federal	0.08	28.3	CMP	13.8	2	0.6	1.2	1.6	2.3	2.9	3.4	No	0.035	3.0	4.63	14.55	Passes All
MC-M-17	Federal	0.88	26.0	CMP	91.5	1.5	4.8	8.9	12.3	16.3	20.1	23.3	No	0.035	5.0	4.94	8.72	<Q5
MC-M-18	Private	1.68	25.1	CMP	6.5	3	8.3	15.2	21.0	27.6	33.7	38.9	No	0.035	1.0	3.50	24.77	<Q25
MFTN-M-33	Federal	0.74	32.0	CMP	15.6	2	5.5	10.0	13.7	18.1	22.1	25.7	No	0.035	4.0	5.35	16.81	<Q25
MFTN-M-5A	Federal	1.49	27.0	Wood Culvert	3.4	2	8.3	15.0	20.6	27.1	33.0	38.2	Yes	0.035	1.0	2.67	8.40	<Q5
MFTN-M-6A	Federal	0.42	30.7	CMP	6.5	1.5	3.1	5.8	7.9	10.6	13.1	15.3	N/A	0.035	5.0	4.94	8.72	<Q25
MFTN-M-7A	Private	1.48	31.0	CMP	10.8	2	10.1	17.9	24.4	31.8	38.7	44.6	No	0.035	1.5	3.28	10.29	<Q5
MFTN-M-8A	Federal	0.11	34.6	CMP	1.6	1.5	1.0	2.0	2.8	3.8	4.7	5.6	N/A	0.035	1.5	2.70	4.78	<Q100
SWP-M-01	Federal	0.93	24.7	CMP	15.8	3	4.6	8.7	12.1	16.1	19.7	23.0	No	0.035	1.0	3.50	24.77	Passes All
SWP-M-10	Federal	0.52	30.7	CMP	4.2	2	3.7	6.8	9.4	12.5	15.4	18.0	No	0.035	9.0	8.02	25.21	Passes All
SWP-M-11	Federal	0.53	28.4	CMP	21.1	3	3.4	6.3	8.8	11.7	14.4	16.8	No	0.035	5.0	7.84	55.40	Passes All
SWP-M-12	Federal	0.39	24.9	CMP	11.8	3	2.1	4.0	5.6	7.6	9.4	11.0	No	0.035	12.0	12.14	85.82	Passes All
SWP-M-13	Federal	1.38	26.7	(2) CMP	31.8	3	7.6	13.8	19.0	25.0	30.5	35.3	No	0.035	2.0	4.96	70.07	Passes All
SWP-M-02	Federal	0.63	30.0	CMP	120.6	3	4.3	8.0	10.9	14.5	17.8	20.8	No	0.035	10.0	11.08	78.34	Passes All
THR-F-18A	Federal	1.51	16.3	CMP	2.2	1.5	4.0	7.8	11.1	15.0	18.5	21.6	N/A	0.035	1.0	2.21	3.90	<Q2
THR-F-19A	Federal	0.56	22.4	CMP	2.2	2	2.5	4.8	6.8	9.2	11.4	13.3	N/A	0.035	1.0	2.67	8.40	<Q25
THR-M-20A	Private	1.88	44.2	CMP	2.7	1.5	21.5	35.4	47.1	59.7	72.0	82.2	N/A	0.035	1.0	2.21	3.90	<Q2
TOB-F-20	Federal	0.20	20.4	CMP	6.5	1.5	0.8	1.7	2.4	3.4	4.3	5.0	No	0.035	10.0	6.98	12.34	Passes All
TOB-F-22	Federal	6.69	20.2	CMP	1.4	1.5	22.1	39.7	54.6	70.8	85.6	98.1	No	0.035	2.0	3.12	5.52	<Q2
TOB-F-23	Federal	0.08	19.2	CMP	12.9	2	0.3	0.7	1.0	1.4	1.8	2.2	No	0.035	4.0	5.35	16.81	Passes All
TOB-F-24	Federal	0.04	18.0	CMP	13.1	2	0.1	0.3	0.5	0.7	0.9	1.0	No	0.035	3.0	4.63	14.55	Passes All
TOB-F-25	Private	3.23	22.9	CMP	8.1	1.5	13.4	24.3	33.5	43.7	53.1	61.1	No	0.035	2.0	3.12	5.52	<Q2
TOB-F-36	Federal	0.61	22.9	CMP	12.1	1.5	2.8	5.4	7.6	10.2	12.6	14.8	Yes	0.035	3.0	3.82	6.76	<Q10
UFTN-M-14a	Private	0.12	24.9	CMP	1.1	1.5	0.7	1.4	2.0	2.8	3.6	4.2	No	0.035	1.0	2.21	3.90	<Q100
UFTN-M-15	Federal	1.71	26.1	Squash CMP	10.0	4	9.0	16.3	22.3	29.3	35.7	41.3	No	0.035	2.0	6.00	75.45	Passes All
UFTN-M-02A	Federal	0.20	25.0	CMP	4.3	1.5	1.1	2.2	3.1	4.2	5.3	6.3	No	0.035	5.0	4.94	8.72	Passes All
UFTN-M-30	Federal	2.03	31.8	CMP	28.4	3.5	14.2	24.6	33.4	43.1	52.3	60.1	No	0.035	3.0	6.73	64.73	Passes All
UFTN-M-31	Federal	0.08	29.0	CMP	9.7	1.5	0.6	1.2	1.7	2.4	3.0	3.6	No	0.035	7.0	5.84	10.32	Passes All

Table G4-4. Culvert Failure Analysis

Site ID	Ownership	Peak Discharge Results Using Omang Equations Formula Variables											Peak Discharge Results Using Manning's Equation, pipes flowing full Formula Variables					
		Area - A (sqmi)	Avg Precip - p (in)	Structure	Volume of fill at risk (tons)	CMP Diameter or Height (ft)	Q2 (cfs)	Q5 (cfs)	Q10 (cfs)	Q25 (cfs)	Q50 (cfs)	Q100 (cfs)	Streambed Materials in Culvert	Roughness Coefficient[1]	Slope %	Velocity (ft/sec)	Peak Flow (cfs)	Max. Conveyance Manning's > Omang
UFTN-M-32	Federal	1.04	28.1	CMP	37.8	2	6.3	11.5	15.8	20.8	25.4	29.5	No	0.035	6.0	6.55	20.58	<Q25
UFTN-M-03A	Federal	1.46	28.9	Squash CMP	3.4	3	9.0	16.1	22.1	28.8	35.2	40.6	Yes	0.035	1.0	3.50	24.77	<Q25
UFTN-M-04A	Federal	0.07	27.4	CMP	1.6	1.5	0.5	0.9	1.3	1.9	2.3	2.8	N/A	0.035	1.0	2.21	3.90	Passes All

[1] Derived from: Manning's Equation Roughness Coefficient References: Wanielista, M., Kersten, R., & Eaglin, R. (1997). Hydrology, Water Quantity and Control, 2nd Ed., New York: John Wiley & Sons, Inc.
Corrugated metal pipe, maximum roughness for 6 by 2 in. corrugations

As peak discharge increases, so does the percentage of culverts incapable of passing the greater flows. Based on the peak flow analysis, it appears that most culverts were designed to pass the Q100 flow, as the majority of culverts (57%) passed the Q100 (**Table G4-3**). However, there were 18 culverts (38%) that failed to pass the Q25 design flow. Note that the culvert flow capabilities for the federal crossings are significantly greater than for private crossings (**Table G4-3**). For example, 69% of the federal crossings passed the Q25, whereas only 36% of the private crossings passed this flow event. Many of the private crossings did not pass the 2, 5 or 10 year flow events, indicating a significant culvert failure risk for this category of culverts.

It is difficult to develop a specific road crossing load estimate for sediment delivered in the event of a culvert failure, as there are several factors that may impact the accuracy of the data. First, peak flows generated using the USGS regression equations are subject to large standard errors that may substantially over or underestimate peak discharge. In addition, peak flows generated using Manning's equation rely heavily on culvert slope. Slope values measured during field activities were estimated using a handheld inclinometer where accessible and visual estimates were recorded where access or use of an inclinometer was not possible. Different slope estimates may lead to variations in peak flow calculations. Second, the culvert assessment was conducted on a small subset of culverts, which may or may not be representative of the entire Tobacco TPA. Third, it is difficult if not impossible to estimate which culverts will fail in any given year, and what percentage of at-risk fill material will be delivered to the stream. Some culvert failure might be mitigated by the ability to store excess runoff at the road crossing where there is significant freeboard between the top of the culvert and the road crossing location where runoff would overtop the road. Due to these difficulties in sediment delivery estimation, specific sediment loads were not developed for each crossing.

G5.0 Application of Best Management Practices

Sediment impacts are widespread throughout the Tobacco River TMDL Planning Area, and sediment loading from the unpaved road network is one of several sources within the watershed. Application of Best Management Practices (BMPs) on the unpaved road network will result in a decrease in sediment loading to streams. BMP sediment reduction was evaluated based on a reduction in contributing road length.

Due to the extent of the unpaved road network and the resulting inability to assess it in its entirety, generalized assumptions are necessary for modeling the effects of BMPs. The selected scenario for estimating sediment load reductions was calculated by assuming a uniform reduction in contributing road length to 200-feet for each unpaved crossing. This 200-foot BMP scenario is a general approximation of achievable modeled load reductions to help develop road crossing sediment load allocations. Field surveillance of existing road BMPs in portions of the Tobacco watershed reveals that the application of BMPs has reduced or has the ability to reduce the contributing length to less 100 feet for many or most road crossings. Ultimately, restoration efforts would need to consider site-specific BMPs that, on average, would likely be represented by the modeling assumptions. Load reductions from potential culvert failures could be addressed on a case-by-case basis depending on a number of evaluation factors such as design flow conveyance, constriction ratio, or fill at risk of being delivered.

G5.1 Contributing Road Length Reduction Scenario

A contributing road length reduction scenario for unpaved road crossings was selected assuming a length reduction to 200 feet (100-feet on each side of a crossing or 200-feet on one side). On crossing locations in excess of this length reduction scenario, road lengths were reduced to the corresponding post-BMP scenario of 200-feet. No changes were made to crossing locations where the contributing road length was less than the 200-foot BMP reduction scenario. The 200-foot BMP scenario was evaluated using the WEPP:Road model, so potential sediment load reductions could be estimated. Reduced mean sediment loads were then extrapolated to the entire watershed in the same manner in which the existing sediment loads were calculated. For the 200-foot BMP scenario, mean sediment loads would be reduced from 0.07 tons/year to 0.03 tons/year for mountain crossings, from 0.04 tons/year to 0.02 tons/year for foothill crossings, and from 0.26 tons/year to 0.05 tons/year for valley crossings. Estimated summary load reductions by landscape type are show in **Table G5-1**.

Table G5-1. Estimated Sediment Load Summary – Reduce Crossing Length to 200-feet

Landscape Type	Total Number of Sites	Mean Sediment Load (Tons/year)	Total Sediment Load (Tons/year)	Load Reduction %
Mountain	838	0.03	25.14	57.0%
Foothill	377	0.02	7.54	50.0%
Valley	16	0.05	0.80	80.6%
Total:	1231		33.48	57.0%

Total sediment load from road crossings would be reduced from 77.9 tons/year to 33.5 tons/year (57.0% reduction), assuming all sites had a minimum 200-foot contributing length BMP applied.

The most significant reduction in total sediment load occurs in the mountain landscape type due to the overall percentage of mountain landscape (59.1%) and crossing density (3.88 crossing/sq.mile). Estimated total sediment load reductions for crossings with 200-foot contributing length BMP applications were also classified by 6th code HUC/303(d) watershed (**Table G5-2A and G5-2B**). When evaluated by ownership, the federal road crossing percent reduction calculates to a 56% reduction from 50.6 tons/year to 22.2 tons/year. The private road crossing percent reduction calculates to a 58% reduction from 22.8 to 9.6 tons/year.

Lime Creek is a sub-watershed of Middle Fortine Creek and therefore not included in the below table. Lime Creek has 50 unpaved road crossings, 49 of which are in the Mountain landscape type and 1 which is in the Foothills landscape type. This results in a total sediment load of 3.5 tons/year from unpaved road crossings. Application of the **Table G5-1** reductions to the Lime Creek watershed results in a sediment load of 1.5 tons/year.

Table G5-2A. Estimated Sediment Load from Unpaved Road Crossings – Reduce Length to 200-feet

Ownership	2010	Federal Land			Private			State			Total
Watershed	**303(d)**	**Valley**	**Foothill**	**Mountain**	**Valley**	**Foothill**	**Mountain**	**Valley**	**Foothill**	**Mountain**	**Load (t/y)**
Deep Creek	Yes	0.00	0.50	0.27	0.00	0.22	0.00	0.00	0.00	0.00	0.99
Edna Creek	Yes	0.00	0.00	2.04	0.00	0.02	1.53	0.00	0.00	0.00	3.59
Indian Creek	No	0.00	0.00	0.00	0.20	0.00	0.00	0.15	0.00	0.03	0.38
Lower Fortine Creek	Yes	0.00	1.92	1.17	0.00	1.74	0.27	0.00	0.00	0.00	5.10
Meadow Creek	No	0.00	0.08	2.25	0.00	0.78	1.26	0.00	0.00	0.33	4.70
Middle Fortine Creek	Yes	0.00	0.02	3.51	0.00	0.14	1.17	0.00	0.00	1.14	5.98
Sinclair Creek	No	0.00	0.00	0.15	0.05	0.06	0.00	0.00	0.00	0.00	0.26
Swamp Creek-Lake Creek	Yes	0.00	0.00	3.54	0.00	0.00	0.27	0.00	0.00	0.00	3.81
Therriault Creek	Yes	0.00	0.14	0.42	0.00	0.52	0.09	0.00	0.00	0.00	1.17
Tobacco River	Yes	0.00	0.78	0.75	0.40	0.58	0.03	0.00	0.04	0.00	2.58
Upper Fortine Creek	Yes	0.00	0.00	4.65	0.00	0.00	0.24	0.00	0.00	0.03	4.92
Total		0.00	3.44	18.75	0.65	4.06	4.86	0.15	0.04	1.53	33.48

Table G5-2B. Total Sediment Load Reductions from Unpaved Road Network: 200-feet Crossing BMP

Watershed	2010 303(d)	Total Sediment Load From Unpaved Roads Existing Conditions (tons/year)	Total Sediment Load After 200-ft Crossing Road Length BMPs (tons/year)	Percent Reduction in Load After 200-ft Crossing Road Length BMPs (tons/year)
Deep Creek	Yes	2.07	0.99	52.2%
Edna Creek	Yes	8.37	3.59	57.1%
Indian Creek	No	1.89	0.38	79.9%
Lower Fortine Creek	Yes	10.68	5.10	52.2%
Meadow Creek	No	10.68	4.70	56.0%
Middle Fortine Creek	Yes	13.90	5.98	57.0%
Sinclair Creek	No	0.73	0.26	64.4%
Swamp Creek-Lake Creek	Yes	8.89	3.81	57.1%
Therriault Creek	Yes	2.51	1.17	53.4%
Tobacco River	Yes	6.70	2.58	61.5%
Upper Fortine Creek	Yes	11.48	4.92	57.1%
Total		77.9	33.48	57.0%

G5.2 Assessment of Existing BMPs

The presence of BMPs was noted for each of the field-assessed stream crossing sites. Of the 50 sites, 35 had at least one of the following: graveled surface, water bar, culvert drain, drive through dip, or a road swale. Results are shown in **Figure G7**. Sample sizes for each category are included in the legend on the graph. Almost all noted BMPs were applied at the federal road crossing locations. Of the 37 federal crossings, 27 (73%) had at least one type of BMP, whereas only 2 of the 12 private crossings (17%) had at least one type of BMP. The lone state crossing evaluated had no apparent BMPs in place.

The sediment yield for each crossing was impacted by the road surface (gravel or native) and the traffic level (high, low or none) in the WEPP model. Conclusions from **Figure G7** are preliminary due to the small sample sizes; however it appears that the absence of traffic eliminates sediment yield regardless of the presence of BMPs. The presence of gravel minimally improves sediment yield as noted in the comparison of the following categories: 0&1, 2&4, 3&5. The water bar or equivalent BMP to reduce road contributing length appeared to be the most effective BMP whether alone or in combination with other BMPs (categories 2, 4, and 6 through 12) for the Tobacco River assessed crossings. WEPP software does not allow for specific modeling of BMPs and the results may not completely indicate effectiveness.

G5.3 Culvert Replacement Recommendations

USFS documentation (U.S. Department of Agriculture, Forest Service, 1995) recommends that as old culverts are replaced, new culverts should be designed to pass the 100-year flow event. It is recommended that all culvert crossings in the Tobacco TPA be upgraded to pass the Q100 flood event. It is also recommended that culvert replacements be completed in a manner that allows for full fish and Aquatic Organism Passage (AOP) on fish-bearing streams. Specifically, culverts would be sized with constriction ratios at 1.0 or greater, and with a goal of re-creating the stream channel through the crossing to match those channel conditions outside of the crossing influence.

The identification of priority culverts for replacement should be on the following factors:
1.) Inability to pass the Q25 design flow;
2.) Constriction ratio <0.75;
3.) Location on a perennial fish bearing stream; and
4.) Fill at risk of being delivered to stream exceeds the median value of 8.6 tons/crossing.

Achieving full culvert replacement could take many years to complete if only addressed during major road upgrades or after some form of failure. This would result in continued potentially significant loads from culvert failures in the foreseeable future. Nevertheless, even if done over time, the replacement of culverts failing the above criteria will significantly reduce sediment loading potential. Because this culvert assessment work was intended as a coarse screening tool, additional evaluation should be conducted to prioritize culvert replacement work and verify conditions for each potentially undersized culvert in the watershed.

G5.4 Additional BMPs

As an alternative to or in combination with reductions in contributing road length or crossing density, other potential BMPs are available that would reduce sediment loading from the unpaved road network. Road sediment reduction strategies such as the installation of full structural BMPs at existing road crossings (drive through dips, culvert drains, settling basins, silt fence, etc), road surface improvement, reduction in road traffic levels (seasonal or permanent road closures), and timely road maintenance to reduce surface rutting are all BMPs that would lead to reduced sediment loading from the road network.

G6.0 References

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FIGURES

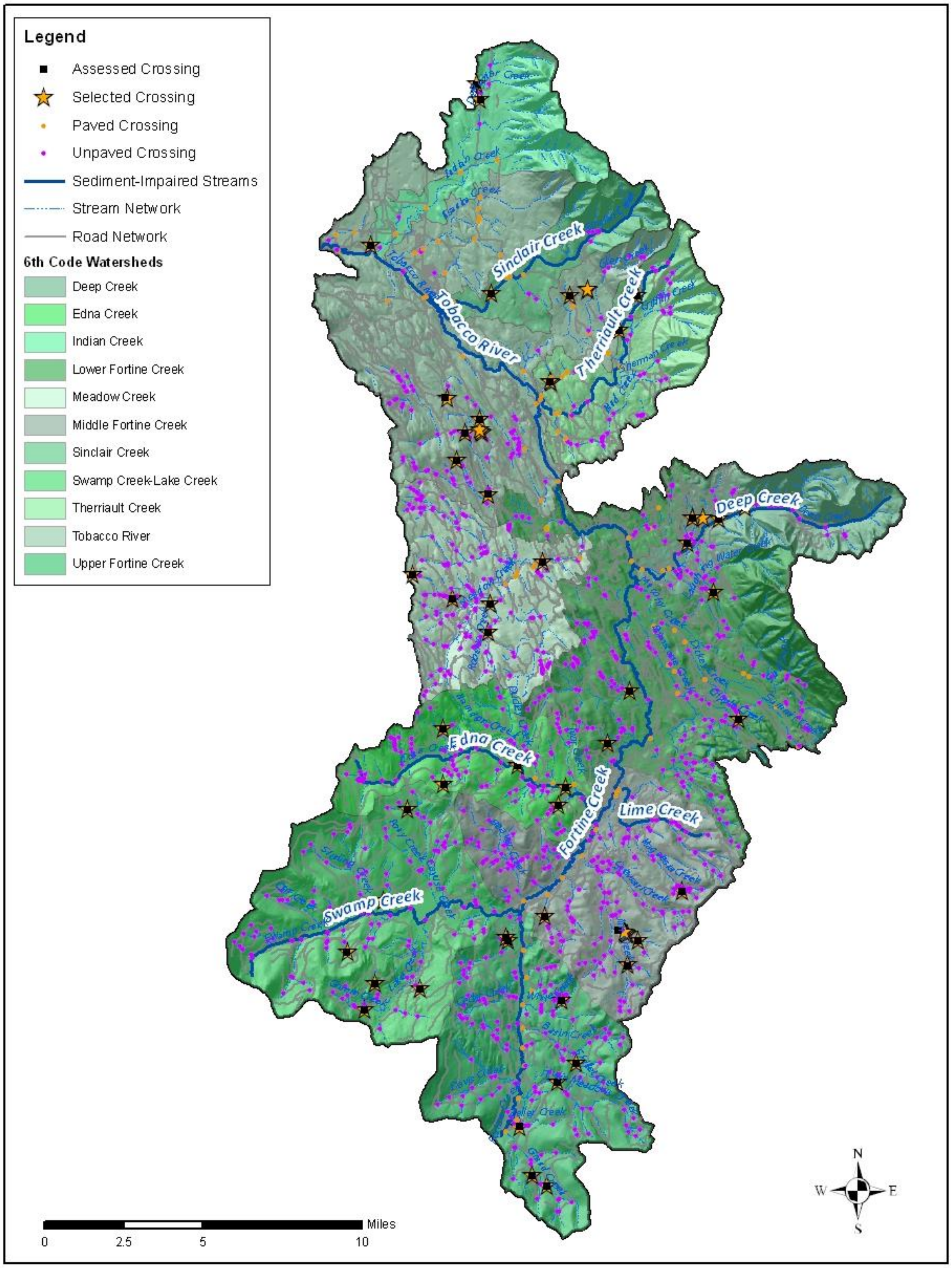

Figure G1. Road Crossings by 6th Code Subwatershed

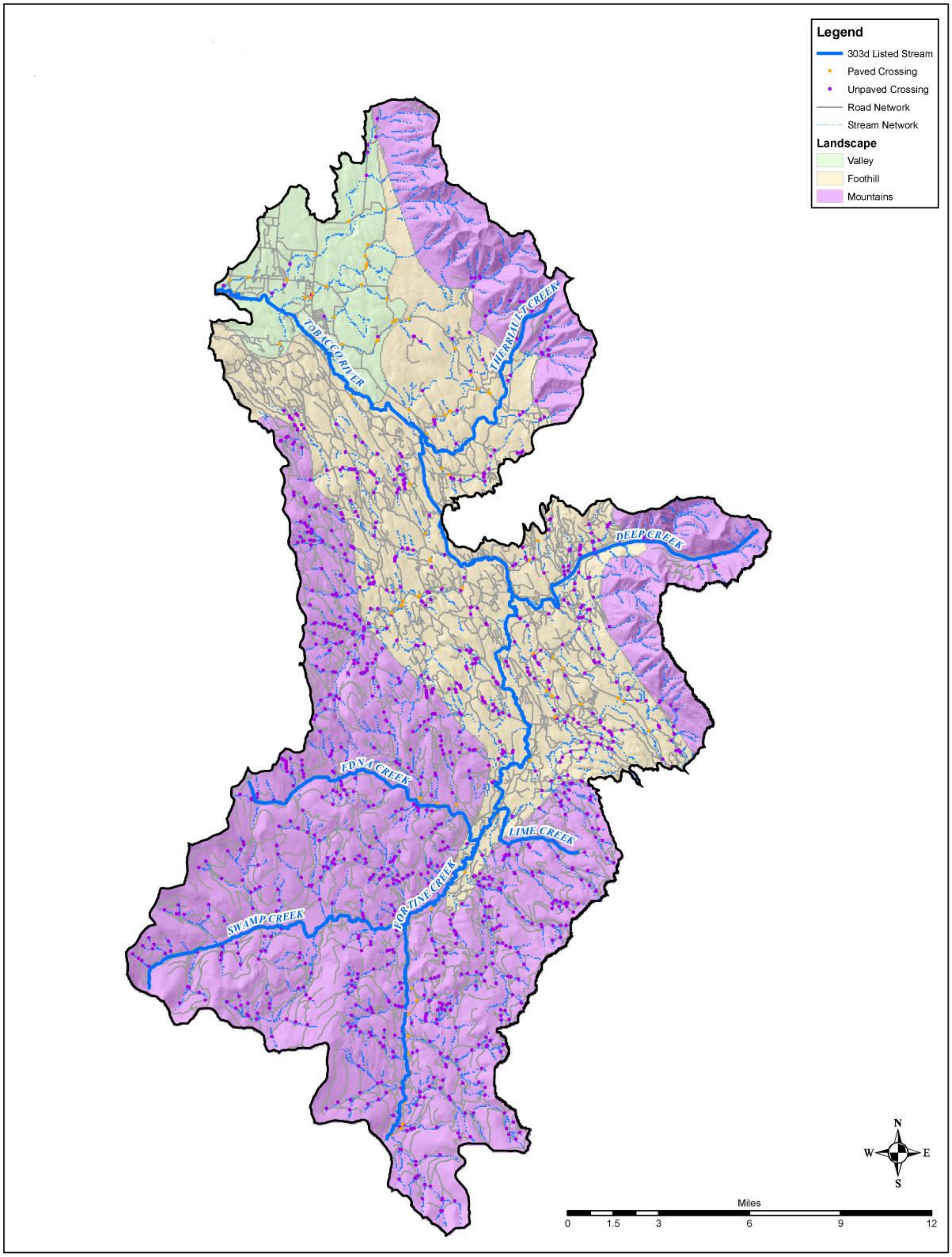

Figure G2. Road Crossings by Landscape Type

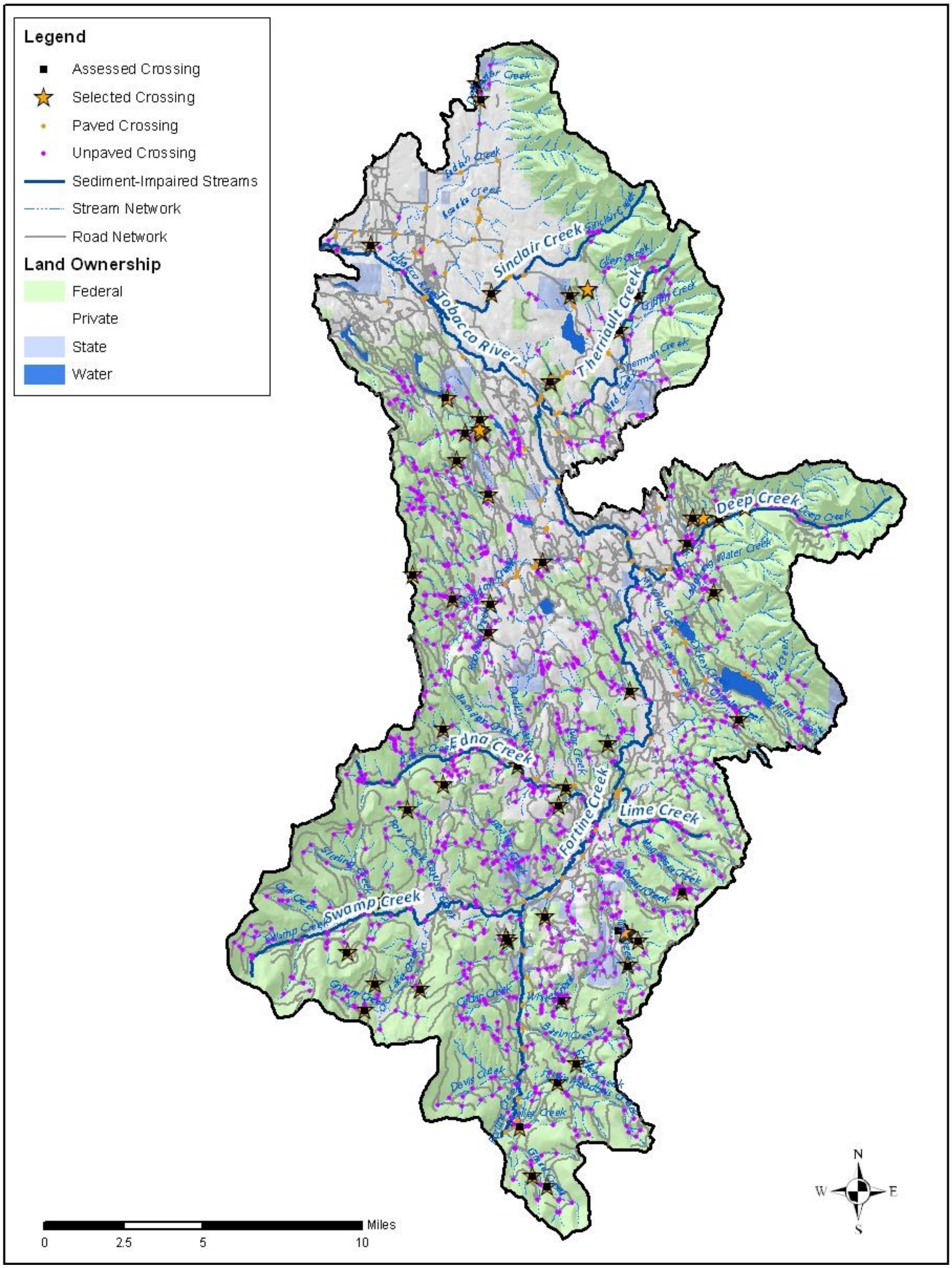

Figure G3. Road Crossings by Land Ownership

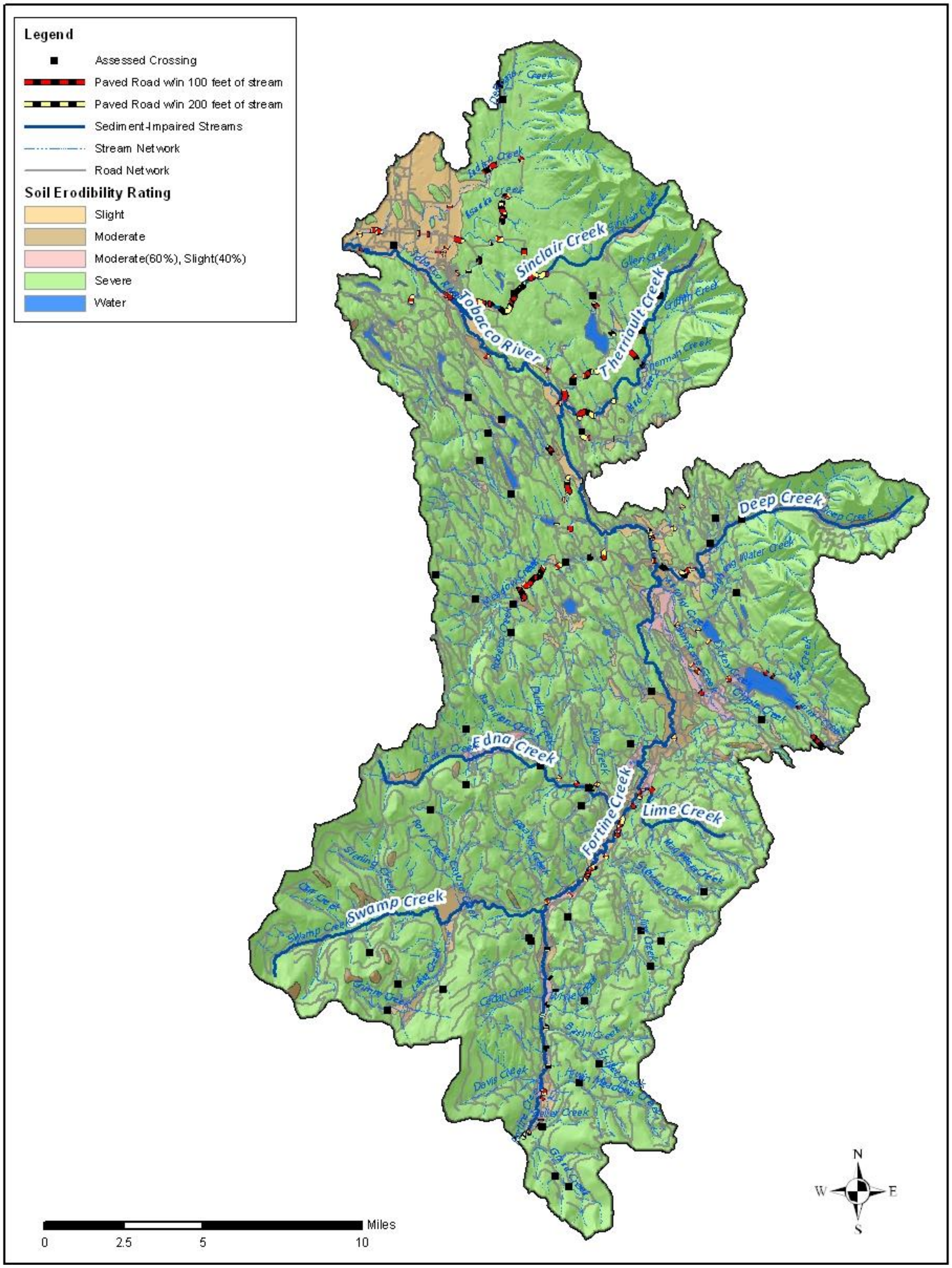

Figure G4. Road Crossings by Soil Erosion Hazard Classification

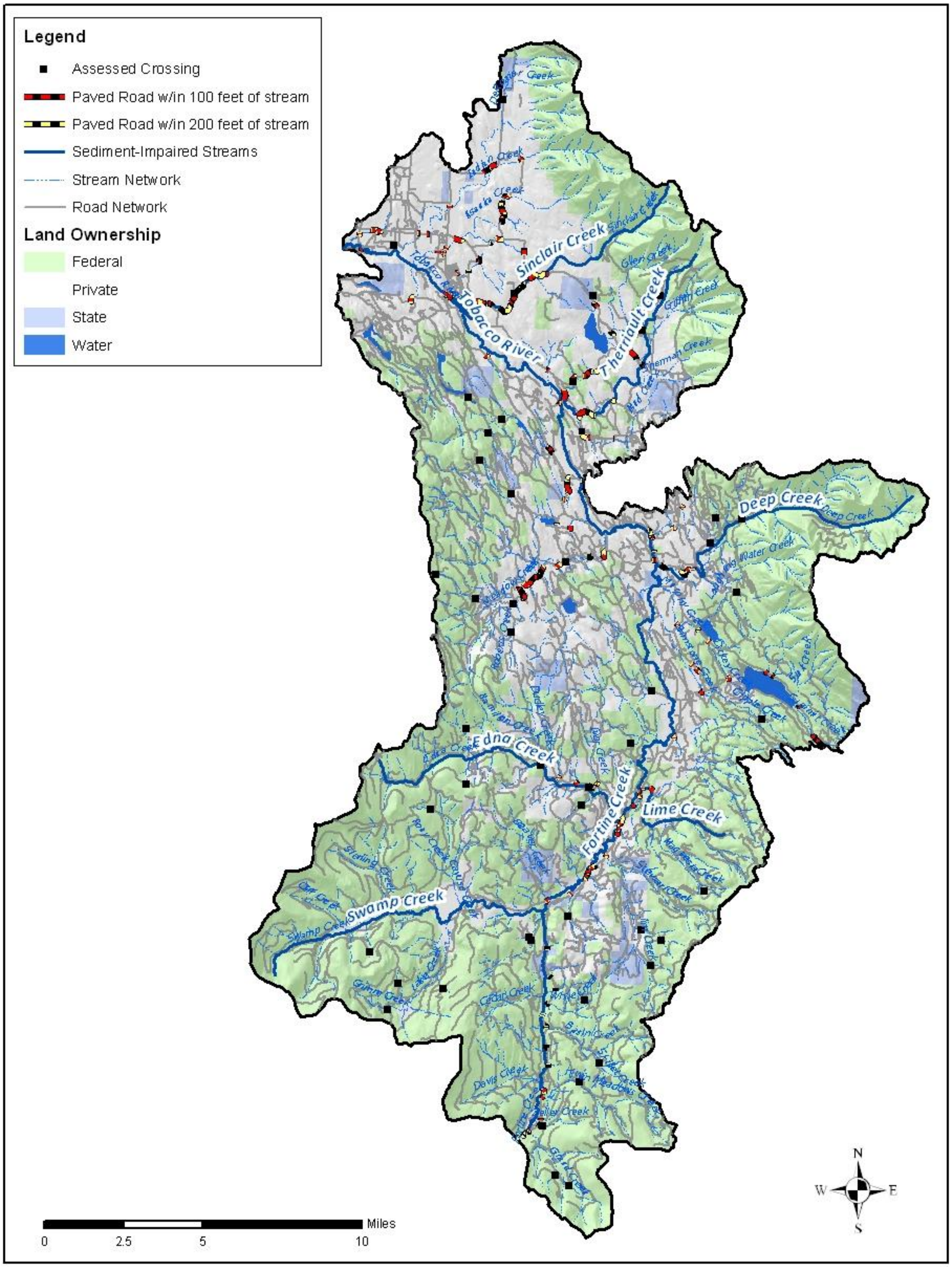

Figure G5. Paved Roads within 100 feet and within 200-Feet of Surface Water

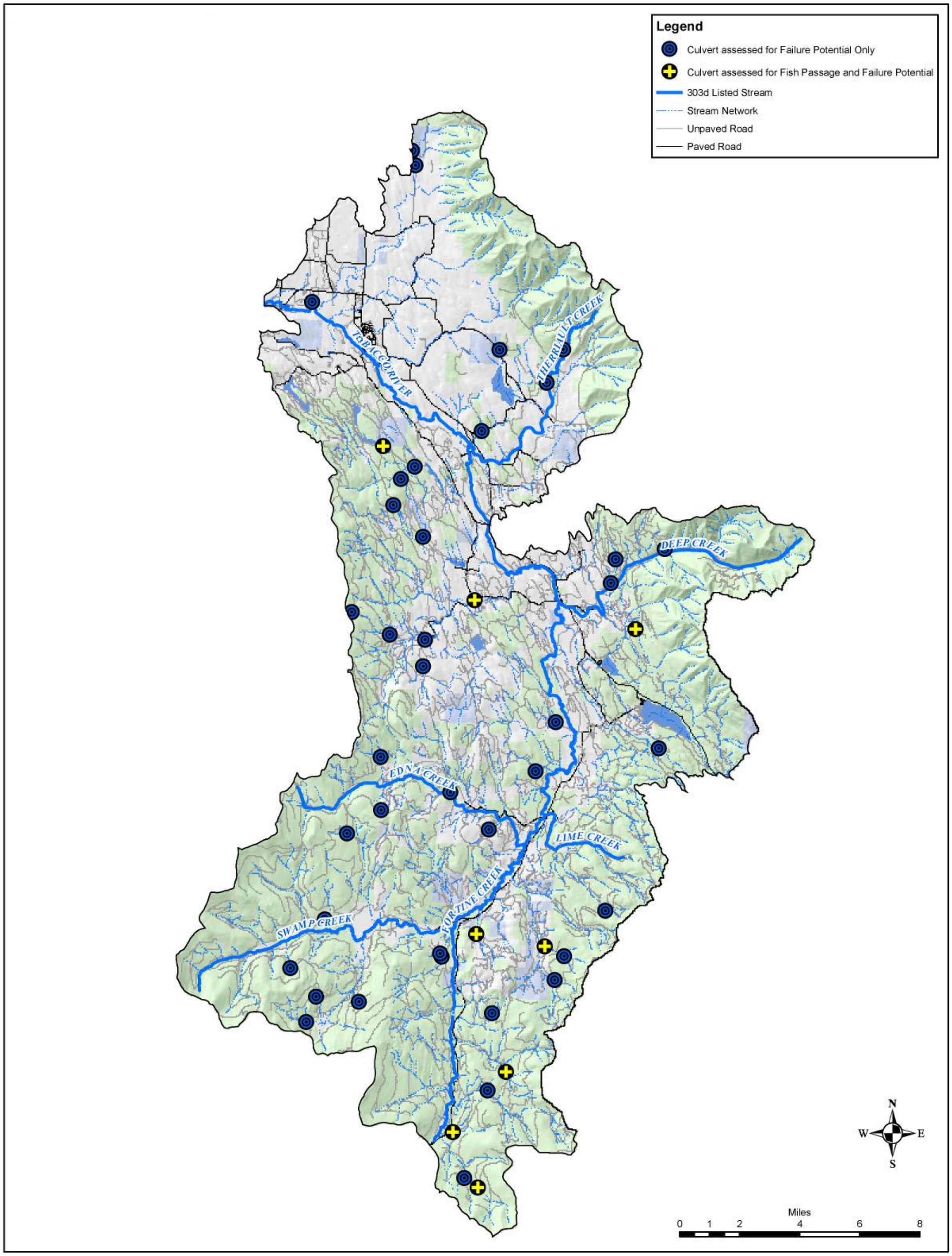

Figure G6. Culverts Assessed for Fish Passage and Failure Potential

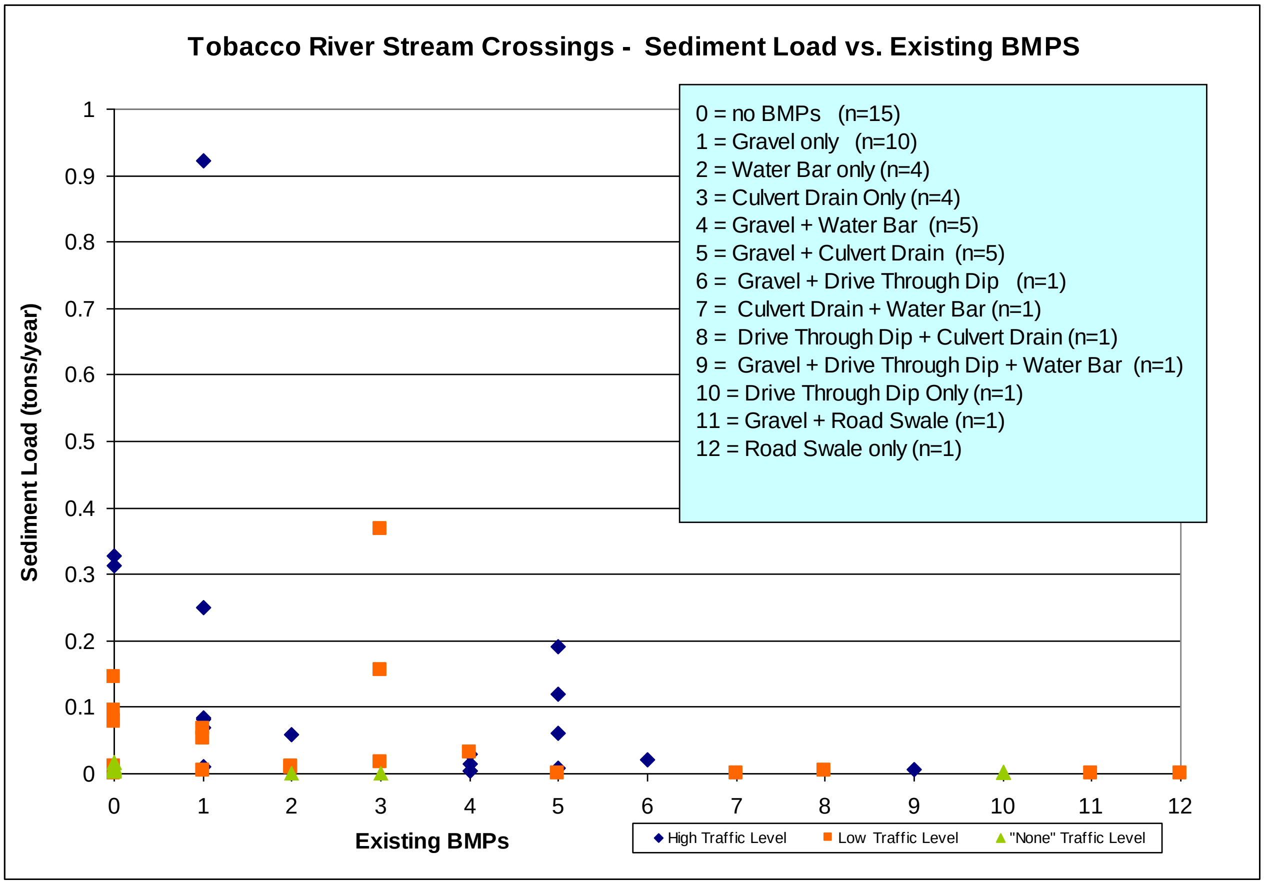

Figure G7. WEPP sediment results for each BMP category

ATTACHMENT A - FIELD ASSESSMENT SITE LOCATION DATA

Table A5. Field Assessment Site Location Information

SITE ID	X	Y	SITEID	X	Y
DEP-F-11A	-114.8617	48.7743	MFTN-M-8A	-114.8494	48.6165
DEP-F-12A	-114.8593	48.7859	SNC-V-29	-115.0084	48.8812
DEP-F-15A	-114.8241	48.7924	SWP-M-01	-115.0523	48.6029
DEP-F-16A	-114.8414	48.7864	SWP-M-02	-115.0405	48.6451
ENA-M-01A	-114.9336	48.6602	SWP-M-10	-115.0233	48.5644
ENA-M-03	-115.0171	48.6574	SWP-M-11	-115.0749	48.5784
ENA-M-04	-115.0201	48.6829	SWP-M-12	-115.0545	48.5654
ENA-M-06	-114.9378	48.6518	SWP-M-13	-115.0605	48.5529
ENA-M-07	-114.9676	48.6684	THR-F-18A	-114.9633	48.8431
INC-V-26	-115.0934	48.8994	THR-F-19A	-114.9184	48.8686
INC-V-27	-115.0251	48.9686	THR-M-20A	-114.9080	48.8850
INC-V-28	-115.0283	48.9755	TOB-F-20	-115.0196	48.8173
LFTN-F-09	-114.8946	48.7055	TOB-F-22	-115.0103	48.8238
LFTN-F-09A	-114.8184	48.6965	TOB-F-23	-115.0344	48.8326
LFTN-F-10A	-114.8413	48.7529	TOB-F-24	-115.0237	48.8046
LFTN-M-08	-114.9068	48.6812	TOB-F-25	-115.0006	48.7903
MC-F-19	-114.9938	48.7408	TOB-F-36	-114.9543	48.8828
MC-F-35	-114.9598	48.7615	UFTN-M-02A	-114.9256	48.5262
MC-M-16	-115.0485	48.7516	UFTN-M-03A	-114.9133	48.5357
MC-M-17	-115.0198	48.7421	UFTN-M-04A	-114.9262	48.5635
MC-M-18	-114.9938	48.7280	UFTN-M-14	-114.9669	48.5905
MFTN-M-33	-114.8769	48.5932	UFTN-M-15	-114.9657	48.5890
MFTN-M-5A	-114.9417	48.6011	UFTN-M-30	-114.9278	48.4791
MFTN-M-6A	-114.8827	48.5815	UFTN-M-31	-114.9380	48.4832
MFTN-M-7A	-114.8910	48.5973	UFTN-M-32	-114.9488	48.5050

ATTACHMENT B - WEPP: ROAD MODEL ADJUSTMENTS

WEPP: Road Model Adjustments
Heavily vegetated road conditions are not properly represented in the standard WEPP:Road assumption. As a result, William J. Elliott, author of the model, was consulted to determine how best to represent these roads within the confines of the model.

There are three traffic scenarios available in the model. For roads where vegetation has grown up on the edges, the no traffic scenario is most appropriate as this scenario grows a limited amount of vegetation on the road. It uses the same plant growth for the road that the high traffic used for the fillslope. The following table explains the model assumptions for the three traffic scenarios:

Traffic	High	Low	None
Erodibility	100%	25%	25%
Hydraulic Conductivity	100%	100%	100%
Vegetation on Road Surface	0	0	50%
Vegetation on fill	50%	50%	100% Forested
Buffer	Forested	Forested	Forested

Based on conversations with Dr. Elliott, it was not appropriate to use the forest buffer to describe the road as the hydraulic conductivity of the soil would be too high. However, the hydraulic conductivity of the fillslope would be reasonable to use to describe the road surface for a fully forested scenario. This means, for the fully vegetated/forested road surface scenario, minimize the road segment length, put the remainder of the road surface length and gradient into the fillslope box, and minimize the buffer length and gradient at stream crossings.

Parallel Road Adjustments
The WEPP:Road model has a maximum contributing road length of 1000-feet. According to Dr. Elliott, it is rare that the contributing road length ever exceeds this distance. As a result, any field assessed parallel road segment in excess of this distance was reduced to 1000-feet for modeling purposes.

Road Crossing Model Adjustments
Some road crossing locations had contributing road length on each side of the crossing, and road conditions were significantly different on each side. In these situations, each road segment was modeled separately and the two segments were then summed to get the total sediment load for the crossing. Also, some crossing locations were located at the convergence of two or more roads, with all roads contributing to sediment load at the crossing. In these cases, road segments were modeled separately and then summed to get the total sediment load for the crossing.

ATTACHMENT C - WEPP: ROAD MODELING RESULTS FOR FIELD ASSESSED SITES

Table C-1. WEPP: Road Modeling Results for Field Assessed Crossings

Comment	Climate	Soil	Years	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual rain runoff (in)	Average annual snow runoff (in)	Average annual sediment leaving road (lb/yr)	Average annual sediment leaving buffer (lb/yr)
Valley Crossings																	
INC-V-26	Eureka	Silty Loam	50	Insloped, bare ditch	graveled high	5	230	22	25	9	0.3	1	80	0.2	0	153	138
UNKN-V-27a	Eureka	Silty Loam	50	Insloped, bare ditch	graveled high	10	594	26	102	24	0.3	1	90	0.4	0	1953	1844
UNKN-V-27b	Eureka	Silty Loam	50	Insloped, bare ditch	graveled high	9	275	31	102	24	0.3	1	90				
UNKN-V-28	Eureka	Silty Loam	50	Outsloped, rutted	graveled low	6	530	14	87	9	0.3	1	75	0.2	0	111	105
SNC-V-29	Eureka	Silty Loam	50	Outsloped, rutted	graveled low	4	101	10	48	12	0.3	1	70	0.2	0	9	8
Valley Results							433									Mean (t/yr)	0.26
														25th	0.040	Median	0.06
														75th	0.28	Maximum	0.92
																Minimum	0.00
Mountain Crossings																	
UFTN-M-2A	Olney	Silty Loam	30	Outsloped, unrutted	graveled high	5	262	14	70	16	0.3	1	0	0.1	0	135	29
UFTN-M-3A	Olney	Silty Loam	30	Outsloped, rutted	native high	4	453	10	84	7	0.3	1	10	0.9	1.1	785	656
UFTN-M-4A	Olney	Silty Loam	30	Outsloped, unrutted	graveled high	1	100	14	70	9	0.3	1	0	0	0	42	7
MFTN-M-5A	Olney	Silty Loam	30	Insloped, bare ditch	native high	5	309	14	84	6	0.3	1	5	0.8	1	865	625
MFTN-M-6A	Olney	Silty Loam	30	Outsloped, unrutted	graveled high	6	250	15	70	10	0.3	1	0	0.1	0	154	42
MFTN-M-7A	Olney	Silty Loam	30	Outsloped, unrutted	graveled high	1	137	15	78	8	0.3	1	0	0.1	0	62	11
MFTN-M-8A	Olney	Silty Loam	30	Outsloped, unrutted	graveled high	5	388	16	70	8	0.3	1	0	0.1	0	232	60
THR-M-20A	Olney	Silty Loam	30	Insloped, vegetated or rocked ditch	graveled high	9	361	14	32	8	0.3	1	0	0.5	0.1	439	381
SWP-M-01	Olney	Silty Loam	30	Insloped, vegetated or rocked ditch	native low	3	49	14	82	12	0.3	1	30	0.2	0.1	18	8
SWP-M-02	Olney	Silty Loam	30	Outsloped, unrutted	native low	3	67	12	98	25	0.3	1	10	0	0	8	1
ENA-M-03	Olney	Silty Loam	30	Outsloped, unrutted	native low	9	168	15	85	9	0.3	1	4	0.2	0.1	50	16
ENA-M-04	Olney	Silty Loam	30	Outsloped, rutted	native none	4	78	14	83	15	0.3	1	10	0.2	0.2	15	5
ENA-M-06	Olney	Silty Loam	30	Outsloped, rutted	native high	5	95	20	102	13	0.3	1	40	0.6	0.4	164	117
ENA-M-07	Olney	Silty Loam	30	Insloped, vegetated or rocked ditch	graveled high	8	40	26	110	14	0.3	1	60	0.1	0	25	15
LFTN-M-08	Olney	Silty Loam	30	Outsloped, rutted	graveled high	5	406	15.5	80	3	0.3	1	70	0.2	0	182	167
SWP-M-10	Olney	Silty Loam	30	Insloped, vegetated or rocked ditch	native none	2	16	22	35	9	0.3	1	0	0.1	0	4	0
SWP-M-11 (extra)	Olney	Silty Loam	30	Outsloped, rutted	native low	3	90	22	81	18	0.3	1	25	0.3	0.2	46	33
SWP-M-12	Olney	Silty Loam	30	Outsloped, rutted	native low	9	132	21.5	94	33	0.3	1	65	0.8	0.4	428	313
SWP-M-13a	Olney	Silty Loam	30	Outsloped, rutted	native low	2	54	12	100	9	0.3	1	15	1	1.3	365	292
SWP-M-13b	Olney	Silty Loam	30	Outsloped, rutted	native low	5	395	12	100	9	0.3	1	15				
UFTN-M-14a	Olney	Silty Loam	30	Outsloped, rutted	native low	2	13	12	50	4	0.3	1	25	0.8	0.9	24	13
UFTN-M-14b	Olney	Silty Loam	30	Insloped, vegetated or rocked ditch	native low	2	164	18	5	4	0.3	1	25				
UFTN-M-15	Olney	Silty Loam	30	Outsloped, rutted	native low	6	512	15	62	19	0.3	1	20	0.8	0.9	893	735
MC-M-16	Olney	Silty Loam	30	Outsloped, rutted	graveled high	5	103	13	35	13	0.3	1	60	0.1	0	27	19
MC-M-17	Olney	Silty Loam	30	Insloped, vegetated or rocked ditch	graveled high	7	380	18	50	41	0.3	1	45	0.2	0	235	239
MC-M-18a	Olney	Silty Loam	30	Outsloped, rutted	native low	5	205	16	10	4	0.3	1	0	1.5	1.7	247	188
MC-M-18b	Olney	Silty Loam	30	Outsloped, rutted	native low	6	246	16	10	4	0.3	1	0				

Table C-1. WEPP: Road Modeling Results for Field Assessed Crossings

Comment	Climate	Soil	Years	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual rain runoff (in)	Average annual snow runoff (in)	Average annual sediment leaving road (lb/yr)	Average annual sediment leaving buffer (lb/yr)
FTN-M-30	Olney	Silty Loam	30	Insloped, vegetated or rocked ditch	graveled low	5	413	8	90	17	0.3	1	80	0.4	0	70	63
FTN-M-30	Olney	Silty Loam	30	Outsloped, rutted	graveled low	5	413	8	90	17	0.3	1	80				
FTN-M-31	Olney	Silty Loam	30	Outsloped, unrutted	native none	10	50	11	111	14	0.3	1	5	0.1	0	10	1
FTN-M-32	Olney	Silty Loam	30	Insloped, vegetated or rocked ditch	native low	8	53	9	133	15	0.3	1	45	0.5	0.2	46	22
MFTN-M-33	Olney	Silty Loam	30	Insloped, vegetated or rocked ditch	native none	4	161	22	70	16	0.3	1	15	0.4	0.5	41	19
ENA-M-1A	Olney	Sandy Loam	30	Outsloped, unrutted	graveled high	5	53	19	55	13	0.3	1	0	0.1	0	25	9
Mountain Results							214									Mean (t/yr)	0.07
														25th	0.006	Median	0.01
														75th	0.09	Maximum	0.37
																Minimum	0.00
Foothill Crossings																	
DEP-F-11A	Fortine	Loam	50	Outsloped, rutted	native none	3	178	9	18	1	0.3	1	0	1.4	0.8	21	13
LFTN-F-10A	Fortine	Sandy Loam	50	Outsloped, unrutted	native low	1	10	14	47	8	0.3	1	10	0	0	0	0
LFTN-F-9A	Fortine	Silty Loam	50	Outsloped, unrutted	graveled low	2	250	11	58	9	0.3	1	0	0	0	20	2
DEP-F-12A	Fortine	Silty Loam	50	Outsloped, unrutted	graveled low	2	478	11	0.3	10	0.3	1	0	0	0	38	0
DEP-F-15A	Fortine	Silty Loam	50	Insloped, vegetated or rocked ditch	graveled high	5	810	18	120	1	0.3	1	0	0.4	0	545	501
DEP-F-16A	Fortine	Silty Loam	50	Outsloped, rutted	native none	3	250	8	0.3	1	0.3	1	10	0.9	0.5	27	15
THR-F-18A	Fortine	Silty Loam	50	Outsloped, rutted	native none	6	165	14	63	10	0.3	1	15	0.5	0.2	58	32
THR-F-19A	Fortine	Silty Loam	50	Outsloped, unrutted	graveled high	3	126	20	100	5	0.3	1	0	0.1	0	73	20
LFTN-F-09	Fortine	Silty Loam	50	Outsloped, rutted	graveled high	8	218	13.5	62	8	0.3	1	80	0.2	0	190	163
LFTN-F-09	Fortine	Silty Loam	50	Insloped, bare ditch	graveled high	8	218	13.5	62	8	0.3	1	80				
MC-F-19	Fortine	Silty Loam	50	Outsloped, rutted	native low	4	29	13	40	5	0.3	1	45	0.4	0.1	4	1
TOB-F-20	Fortine	Silty Loam	50	Outsloped, rutted	native none	8	90	10	8	12	0.3	1	10	0.2	0.1	22	7
TOB-F-22	Fortine	Silty Loam	50	Outsloped, rutted	native low	8	102	9	150	3	0.3	1	10	0.6	0.2	32	20
TOB-F-23	Fortine	Silty Loam	50	Outsloped, rutted	native low	5	410	9	60	9	0.3	1	20	0.9	0.4	187	161
TOB-F-24a	Fortine	Silty Loam	50	Outsloped, rutted	native low	5	242	11	46	1	0.3	1	10	1.5	0.7	189	156
TOB-F-24b	Fortine	Silty Loam	50	Outsloped, rutted	native low	4	307	12	48	15	0.3	1	10				
TOB-F-25	Fortine	Silty Loam	50	Outsloped, rutted	native low	7	116	9.5	50	7	0.3	1	5	0.5	0.1	28	19
MC-F-35a	Fortine	Silty Loam	50	Outsloped, rutted	graveled low	9	810	8	90	9	0.3	1	75	0.2	0	146	136
MC-F-35b	Fortine	Silty Loam	50	Outsloped, rutted	graveled low	8	320	8	90	9	0.3	1	75				
TOB-F-36	Fortine	Silty Loam	50	Outsloped, rutted	graveled high	5	270	24	100	9	0.3	1	60	0.1	0	138	122
Foothill Results							305									Mean (t/yr)	0.04
														25th	0.004	Median	0.01
														75th	0.07	Maximum	0.25
																Minimum	0.00
Total Crossing Data							262									Mean (t/yr)	0.08
														25th	0.005	Median	0.01
														75th	0.080	Maximum	0.92
																Minimum	0.00

Table C-2. WEPP: Road Modeling Results for Field Assessed Parallel Segments

Comment	Climate	Soil	Years	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual rain runoff (in)	Average annual snow runoff (in)	Average annual sediment leaving road (lb/yr)	Average annual sediment leaving buffer (lb/yr)
Foothill Parallel																	
DEP-F-13A-P	Fortine	Loam	50	Outsloped, unrutted	native none	1	200	6	0.3	1	1	20	57	0	0	9	0
DEP-F-14A-P	Fortine	Loam	50	Outsloped, rutted	native none	5	1000	6	0.3	1	1	30	5	0.3	0.2	639	78
THR-F-17A-P	Fortine	Silty Loam	50	Insloped, vegetated or rocked ditch	graveled none	3	214	12	0.3	5	0.3	3	0	0.1	0	17	4
TOB-F3-21-Pa	Fortine	Silty Loam	50	Outsloped, rutted	native low	9	528	9	90	16	1	9	20	0.5	0.2	716	254
TOB-FP-21b	Fortine	Silty Loam	50	Outsloped, rutted	native low	6	264	9	40	12	1	11	15	0.2	0.1	113	27
TOB-FP-21b add	Fortine	Silty Loam	50	Outsloped, rutted	native low	8	36	9	0.3	1	0.3	1	15	0.3	0.1	5	1
TOB-F-37b-P	Fortine	Silty Loam	50	Outsloped, rutted	graveled low	5	150	21	74	9	1	97	30	0	0	46	0
Foothill Results																Mean (t/yr)	0.026
																Median	0.002
																Maximum	0.127
																Minimum	0
Mountain Parallel																	
MFTN-M-34a-P	Olney	Silty Loam	50	Outsloped, rutted	native low	9	200	9	45	70	0.3	1	20	0.2	0.1	117	78
MFTN-M-34b-P	Olney	Silty Loam	50	Outsloped, rutted	native low	9	300	11	35	110	2	8	20	0.1	0.1	348	96
MFTN-M-34c-P	Olney	Silty Loam	50	Outsloped, rutted	native low	9	250	11	35	130	2	20	20	0.1	0	247	28
Mountain Results																Mean (t/yr)	0.034
																Median	0.039
																Maximum	0.048
																Minimum	0.014

Shaded cells in the Road length column represent two upstream sections of the culvert. These cells were summed prior to calculating the average road length for each crossing within an ecoregion.
Shaded cells in the last four columns were summed either because the road was crowned and was modeled as two widths (inslope and outslope portion) or because of the multiple upstream road sections