APPENDIX F – UPLAND SEDIMENT SOURCE ASSESSMENT – BEAVERHEAD TPA

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

F1.0 INTRODUCTION

The Beaverhead TMDL Planning Area (TPA) is located in Beaverhead County, with a small portion in Madison County and includes the towns of Dillon and Twin Bridges. The Beaverhead TPA encompasses the entire Beaverhead River watershed, which begins at the outlet of the Clark Canyon Reservoir and flows northeast 79.5 miles before joining the Big Hole River to form the Jefferson River. The TPA coincides with the 10020002 fourth-code hydrologic unit code (HUC), and is bounded by the Pioneer Mountains on the west, the Ruby Range to the east, and the Snowcrest Range and Blacktail Mountains to the south. This report provides an upland source assessment that will be used for TMDL development.

Upland sediment loading due to hillslope erosion was modeled using the Universal Soil Loss Equation (USLE) and sediment delivery to the stream was predicted using a sediment delivery ratio. This model provided an assessment of existing sediment loading from upland sources and an assessment of potential sediment loading through the application of Best Management Practices (BMPs). The BMPs evaluated assumed modifications in upland management practices as well as improvements within the riparian buffer zone. When reviewing the results of the upland sediment load model, it is important to note that a significant portion of the sediment load is the “natural upland load” and not affected by the application of BMPs to the upland management practices.

The general form of the USLE has been widely used for erosion prediction in the U.S. and is presented in the National Engineering Handbook (1983) as:

(1) $A = RK(LS)CP$ (in tons per acre per year)

where soil loss (A) is a function of the rainfall erosivity index (R), soil erodibility factor (K), overland flow slope and length (LS), crop management factor (C), and conservation practice factor (P) (Wischmeier and Smith 1978, Renard et al. 1997). USLE was selected for the Beaverhead TPA due to its relative simplicity and ease in parameterization and the fact that it has been integrated into a number of other erosion prediction models. These include: (1) the Agricultural Nonpoint Source Model (AGNPS), (2) Areal Nonpoint Source Watershed Environment Response Simulation Model (ANSWERS), (3) Erosion Productivity Impact Calculator (EPIC), (4) Generalized Watershed Loading Functions (GWLF), and (5) the Soil Water Assessment Tool (SWAT) (Doe, 1999). A detailed description of the general USLE model parameters is presented below.

The **R-factor** is an index that characterizes the effect of raindrop impact and rate of runoff associated with a rainstorm. It is a summation of the individual storm products of the kinetic energy in rainfall (hundreds of ft-tons per acre per year) and the maximum 30-minute rainfall intensity (inches per hour). The total kinetic energy of a storm is obtained by multiplying the kinetic energy per inch of rainfall by the depth of rainfall during each intensity period.

The **K-factor** or soil erodibility factor indicates the susceptibility of soil to resist erosion. It is a measure of the average soil loss (tons per acre per hundreds of ft-tons per acre of rainfall intensity) from a particular soil in continuous fallow. The K-factor is based on experimental data from the standard SCS erosion plot that is 72.6 ft long with uniform slope of 9%.

The **LS-factor** is a function of the slope and overland flow length of the eroding slope or cell. For the purpose of computing the LS-factor, slope is defined as the average land surface gradient. The flow length refers to the distance between where overland flow originates and runoff reaches a defined channel or depositional zone. According to McCuen (1998), flow lengths are seldom greater than 400 ft or shorter than 20 ft.

The **C-factor** or crop management factor is the ratio of the soil eroded from a specific type of cover to that from a clean-tilled fallow under identical slope and rainfall. It integrates a number of factors that affect erosion including vegetative cover, plant litter, soil surface, and land management. The original C-factor of the USLE was experimentally determined for agricultural crops and has since been modified to include rangeland and forested cover. It is now referred to as the vegetation management factor (VM) for non-agricultural settings (Brooks, 1997).

Three different kinds of effects are considered in determination of the VM-factor. These include: (1) canopy cover effects, (2) effects of low-growing vegetal cover, mulch, and litter, and (3) rooting structure. A set of metrics has been published by the Soil Conservation Service (SCS) for estimation of the VM-factors for grazed and undisturbed woodlands, permanent pasture, rangeland, and idle land. Although these are quite helpful for the Beaverhead setting, Brooks (1997) cautions that more work has been carried out in determining the agriculturally based C-factors than rangeland/forest VM-factors. Because of this, the results of the interpretation should be used with discretion.

The **P-factor** or conservation practice factor is a function of the interaction of the supporting land management practice and slope. It incorporates the use of erosion control practices such as strip-cropping, terracing and contouring, and is applicable only to agricultural lands. Values of the P-factor compare straight-row (up-slope down-slope) farming practices with that of certain agriculturally based conservation practices.

F2.0 Modeling Approach

Sediment delivery from hillslope erosion was estimated using a Universal Soil Loss Equation (USLE) based model to predict soil loss along with a distance and riparian health based sediment delivery ratio (SDR) to predict sediment delivered to the stream. This USLE based model is implemented as a watershed scale, grid format, GIS model using ArcView v 9.2 GIS software.

Desired results from the modeling effort include the following: (1) annual sediment load from each of the water quality limited segments on the state's 303(d) list, (2) the mean annual source distribution from each land category type, (3) annual potential sediment load from each of the water quality limited segments on the state's 303(d) list after the application of riparian buffer zone management BMPs, (4) annual potential sediment load from each of the water quality limited segments on the state's 303(d) list after the application of upland management BMPs, and (5) annual potential sediment load from each of the water quality limited segments on the state's 303(d) list after the application of riparian buffer zone management BMPs and upland management BMPs. Based on these considerations, a GIS - modeling approach (USLE) was formulated to facilitate database development and manipulation, provide spatially explicit output, and supply output display for the modeling effort.

F3.0 Modeling Scenarios

Four management scenarios were evaluated for the Beaverhead TPA. They include: (1) an existing conditions scenario that considers the current land cover, management practices, and riparian health in the watershed; (2) an upland BMP conditions scenario that considers improved grazing and cover management; (3) a riparian health BMP conditions scenario that considers improved riparian buffer zones; and (4) a riparian health BMP and upland BMP conditions scenario that considers improved riparian buffer zones and grazing and cover management.

Erosion was differentiated into two source categories for each scenario: (1) natural erosion that occurs on the time scale of geologic processes and (2) anthropogenic erosion that is accelerated by human-caused activity. A similar classification is presented as part of the National Engineering Handbook Chapter 3 – Sedimentation (USDA, 1983). Differentiation is necessary for TMDL planning. Land cover categories considered to be affected by human-caused activity and therefore affected by BMPs within the Beaverhead TPA were developed (open space), developed (low intensity), developed (medium intensity), developed (high intensity), pasture/hay, grasslands/herbaceous, shrub/scrub, cultivated crops, and transitional (logging). All other land cover categories were considered to have "natural erosion."

Well vegetated riparian buffers have been shown to act as filters that help to remove sediment from overland flow. In general, the effectiveness of vegetated riparian buffers is proportional to their width and overall health. A riparian health assessment was completed by the Montana Department of Environmental Quality (DEQ) for the Beaverhead TPA. The DEQ riparian health assessment is used here to estimate further reduction in the quantity of eroded sediment that is ultimately delivered to the streams. These riparian areas are also considered to be affected by human-caused activity and are therefore subject to improved riparian health management.

F4.0 Data Sources

The USLE model was parameterized using a number of published data sources. These include information from: (1) U.S. Geological Survey (USGS), (2) Spatial Climate Analysis Service (SCAS), and (3) Soil Conservation Service (SCS). Additionally, local information regarding specific land cover was acquired from the U.S. Forest Service (USFS) and the Natural Resource Conservation Service (NRCS). Specific GIS data used in the modeling effort included the following:

Grid data of the **R-factor** was obtained from the NRCS, and is based on Parameter-elevation Regressions on Independent Slopes Model (PRISM) precipitation data. PRISM precipitation data is derived from weather station precipitation records, interpolated to a gridded landscape coverage by a method (developed by the Spatial Climate Analysis Service of Oregon State University) which accounts for the effects of elevation on precipitation patterns.

Polygon data of the **K-factor** were obtained from the NRCS General Soil Map (STATSGO) database and the NRCS Soil Survey Geographic (SSURGO) database. The USLE K factor is a standard component of the STATSGO soil survey, but has not been included for all polygons in the SSURGO soil survey. SSURGO data has higher resolution and is more current than the STATSGO dataset, however, the SSURGO data for the

Beaverhead TPA did not contain the required K-factor for the entire watershed. STATSGO data was used to fill in the blanks. Soils polygon data were summarized and interpolated to grid format.

The **LS-factor** was derived from 30m USGS digital elevation model (DEM) grid data, interpolated to a 10m pixel. This factor is calculated within the model.

The **C-factor** was estimated using the National Land Cover (NLCD) dataset and using C-factor interpretations provided by the NRCS with input from Montana Department of Environmental Quality (DEQ). C-factors are intended to be conservatively representative of conditions in the Beaverhead TPA.

The **P-factor** was set to one, as per previous communication with the NRCS State Agronomist who suggested that this value is the most appropriate representation of current management practices in the Beaverhead TPA.

The **sediment delivery ratio** was derived by the model for each grid cell based on the observed relationship between the distance from the delivery point to the stream and the percent of eroded sediment delivered to the stream. This relationship was established by Megehan and Ketcheson (1996).

The **riparian health factor** was derived from a riparian health assessment completed by DEQ. Riparian health ratings of good, moderately good, fair, moderately fair, and poor were assigned according to the professional judgment of the assessment team. The percent of each sub-basin's area falling in each category was reported.

F5.0 Modeling Methods

An appropriate grid for each data source was created, giving full and appropriate consideration to proper stream network delineation, grid cell resolution, etc. A computer model was built using ArcView Model Builder to derive the five factors from model inputs, multiply the five factors and arrive at a predicted sediment production for each grid cell. The model also derived a sediment delivery ratio for each cell, and reduced the predicted sediment production by that factor to estimate sediment delivered to the stream network.

Specific parameterization of the USLE factors were preformed as follows (**Section 1.5.1** through **Section 1.5.12**).

F5.1 Sub-basins

The Beaverhead TPA boundary and the sub-basin boundaries were defined using the USGS 6th code Hydrologic Unit Codes (HUC) (**Figure F1-1**). Farlin Creek, Steel Creek, Scudder Creek, West Fork Dyce Creek, Dyce Creek, Taylor Creek, Reservoir Creek, and French Creek are 303(d) listed streams that were not represented in the 6th code HUCs. These sub-basins were cut from the larger HUC sub-basins using USGS topography as a guide to drainage divides. Additionally, the Rattlesnake Creek, Stone Creek, and Beaverhead River sub-basins were divided into an upper and lower sub-basin also using USGS topography as a guide at locations defined by DEQ.

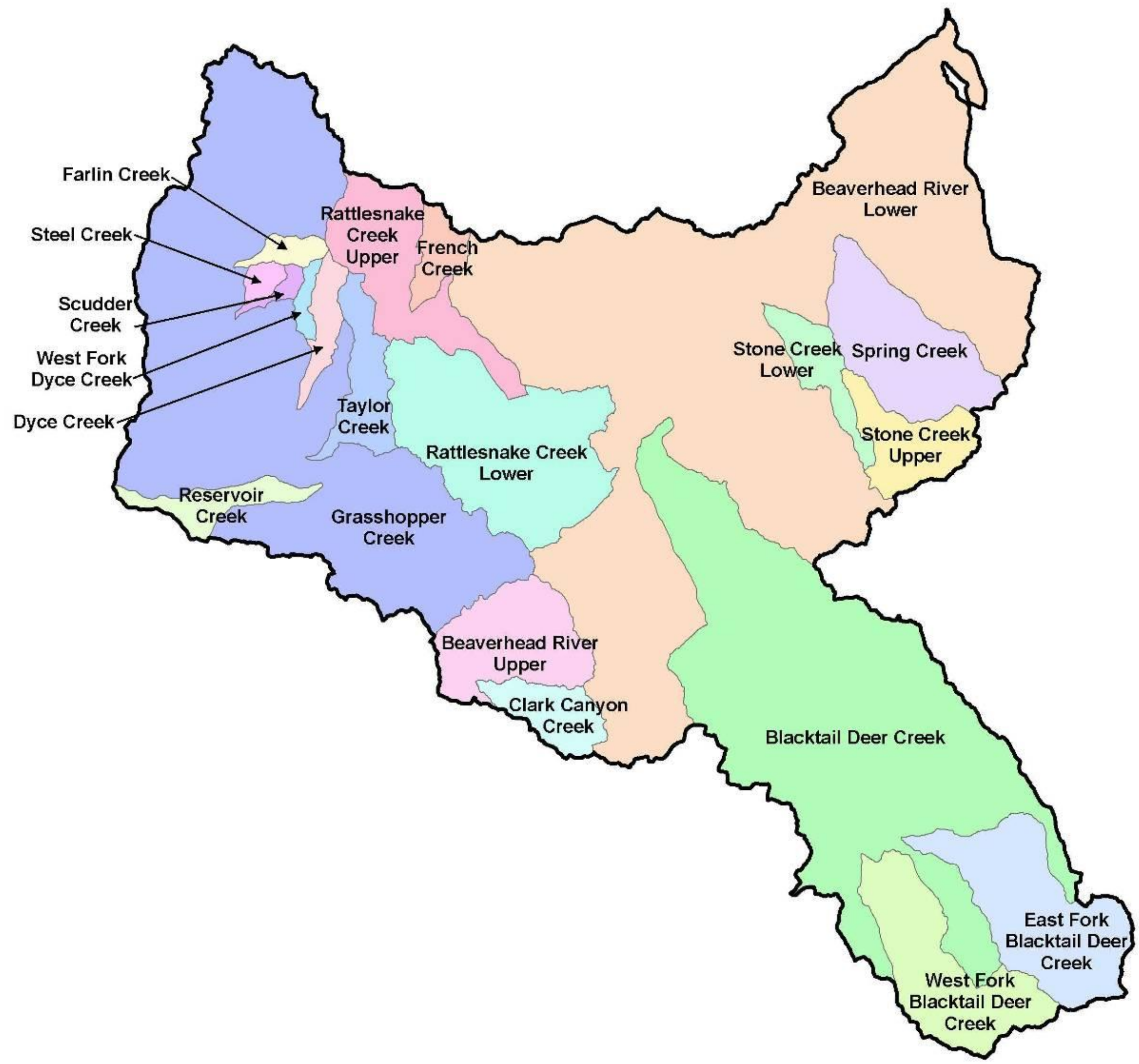

Figure F1-1. Sub-basin polygons for the Beaverhead TPA.

F5.2 Beaverhead TPA DEM

The digital elevation model (DEM) for the Beaverhead TPA is the foundation for developing the LS factor, for defining the extent of the bounds of the analysis area, and for delineating the area within the outer bounds of the analysis for which the USLE model is not valid (i.e. the concentrated flow channels of the stream network). The USGS 30m DEM (level 2) for the Beaverhead TPA was used for these analyses (**Figure F1-2**). The DEM was interpolated to a 10m analytic grid cell to render the delineated stream network more representative of the actual size of Beaverhead TPA streams and to minimize resolution dependent stream network anomalies. The resulting interpolated 10m DEM was then subjected to standard hydrologic preprocessing, including the filling of sinks to create a positive drainage condition for all areas of the watershed.

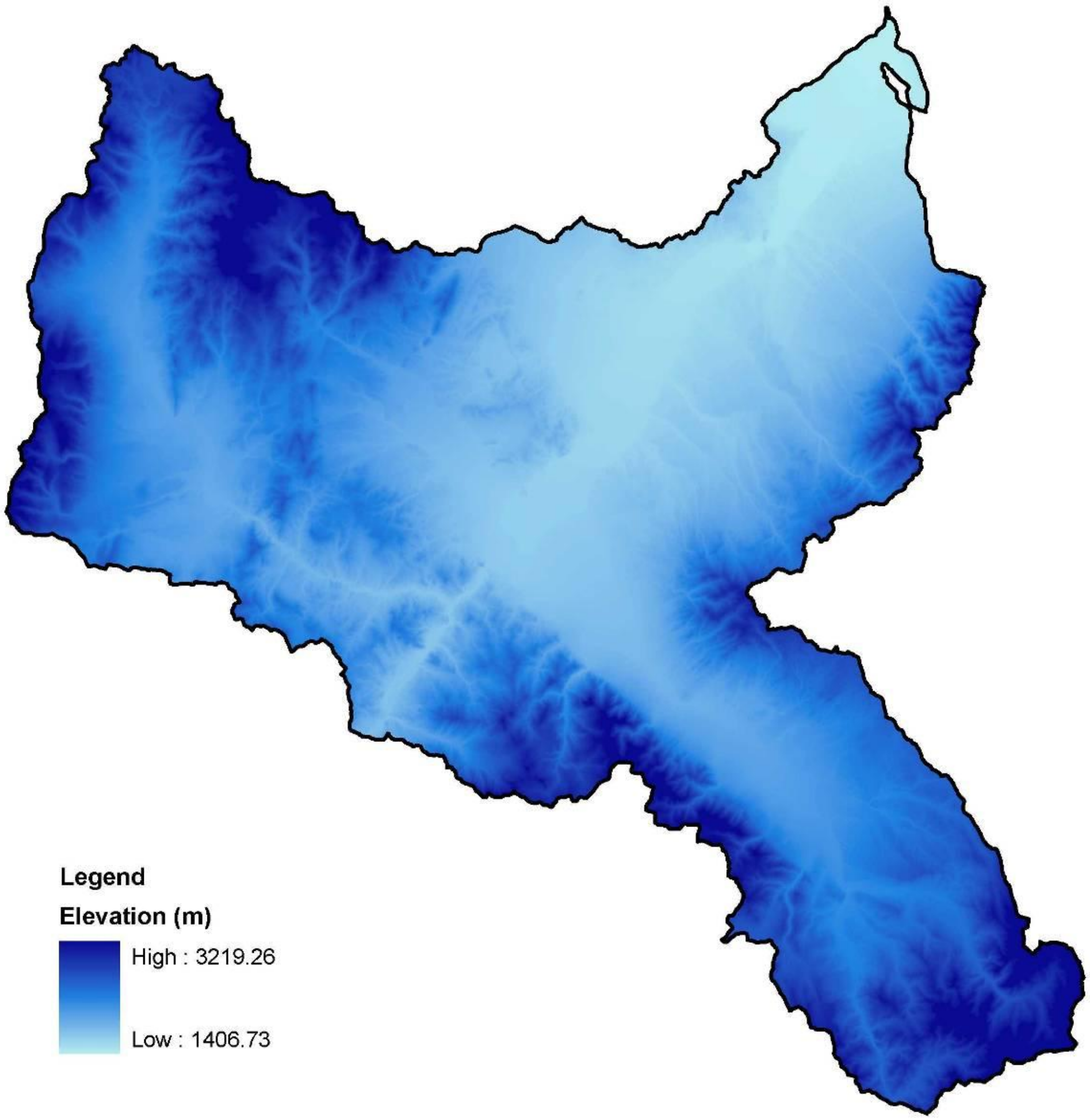

Figure F1-2. Digital Elevation Model (DEM) of the Beaverhead TPA Prepared for Hydrologic Analysis.

F5.3 Beaverhead TPA Flow Network

The stream network for the watershed was derived from the 10m DEM, using hydrologic analysis methods developed by the Utah State University Hydrology Research Group, and implemented in the TauDEM (Terrain Analysis Using Digital Elevation Models) software (**Figure F1-3**). These tools prepare a hydrologically correct surface from standard DEM data, filling errant sinks and ensuring positive drainage toward defined pour points. From this surface, a stream network is derived by calculating the watershed area for each pixel in the DEM, and assigning to the stream network those pixels that exceed a specified accumulation area threshold. The threshold is watershed specific, and is chosen in a manner whereby the resulting stream network satisfies the key elevation scaling laws (constant drop property and power law scaling of slope with area) that differentiate concentrated flow processes (channel erosion and transport) from the diffusive processes that characterize hillslope transport of sediment.

Figure F1-3. Flow network for the Beaverhead TPA.

F5.4 R-Factor

The rainfall and runoff factor grid was prepared by the Spatial Climate Analysis Service of Oregon State University, at 4 km grid cell resolution (**Figure F1-4**). For the purposes of this analysis, the SCAS R-factor grid was reprojected to Montana State Plane Coordinates (NAD83, meters), resampled to a 10m analytic cell size and clipped to the extent of the Beaverhead TPA, to match the project's standard grid definition.

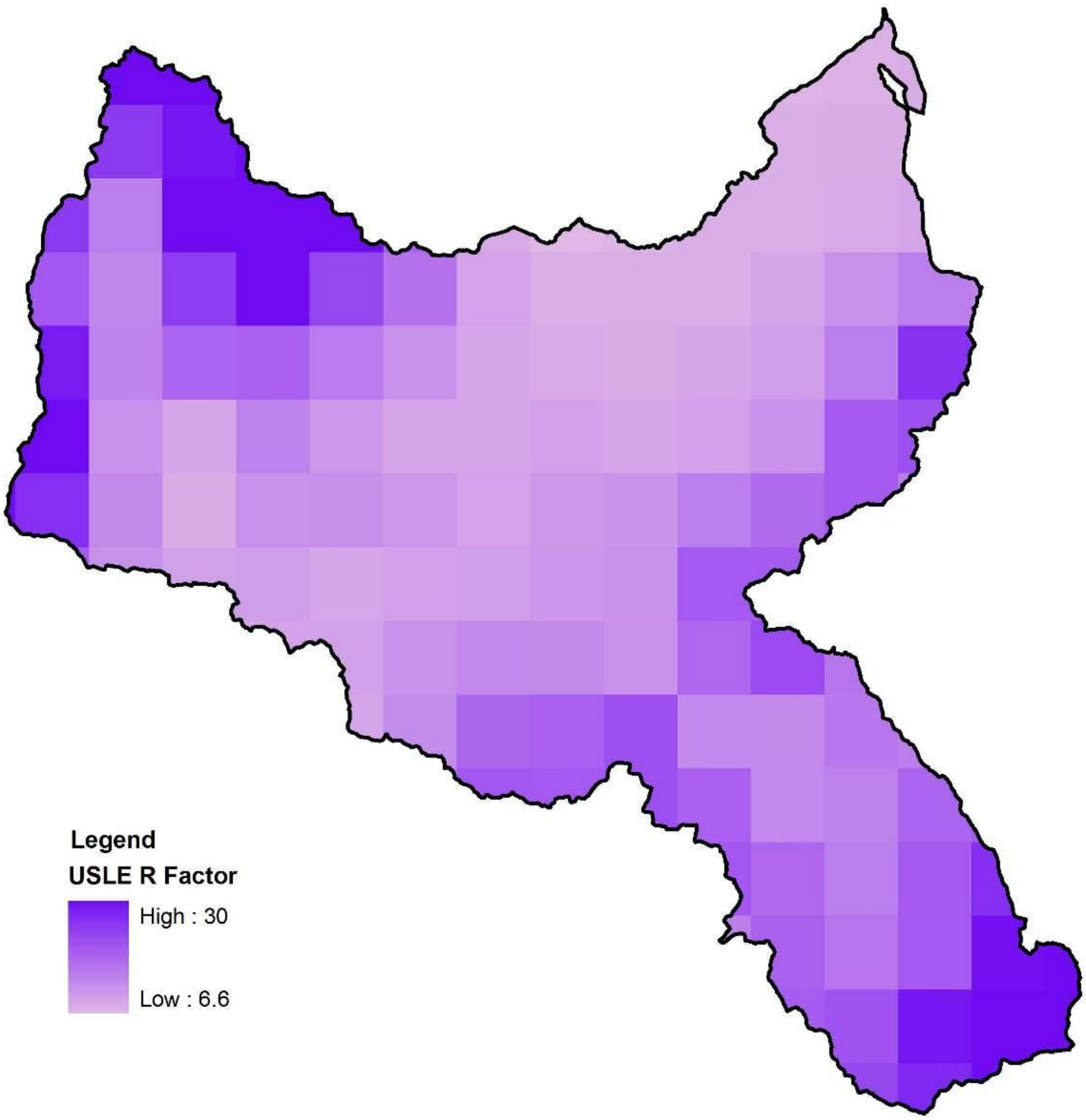

Figure F1-4. ULSE R-factor for the Beaverhead TPA.

F5.5 K-FACTOR

The soil erodibility factor grid was compiled from the 1:250K STATSGO and SSURGO data, as published by the NRCS. SSURGO data has higher resolution and is more current than the STATSGO data, however, the SSURGO data for the Beaverhead TPA did not contain the required K-factor for the entire watershed. STATSGO data was used to fill in the blanks (**Figure F1-5**). STATSGO and SSURGO database tables were queried to calculate a component weighted K value for all surface layers, which was then summarized by individual map unit. The map unit K values were then joined to a GIS polygon coverage of the map units, and the polygon coverage was converted to a 10m analytic grid for use in the model.

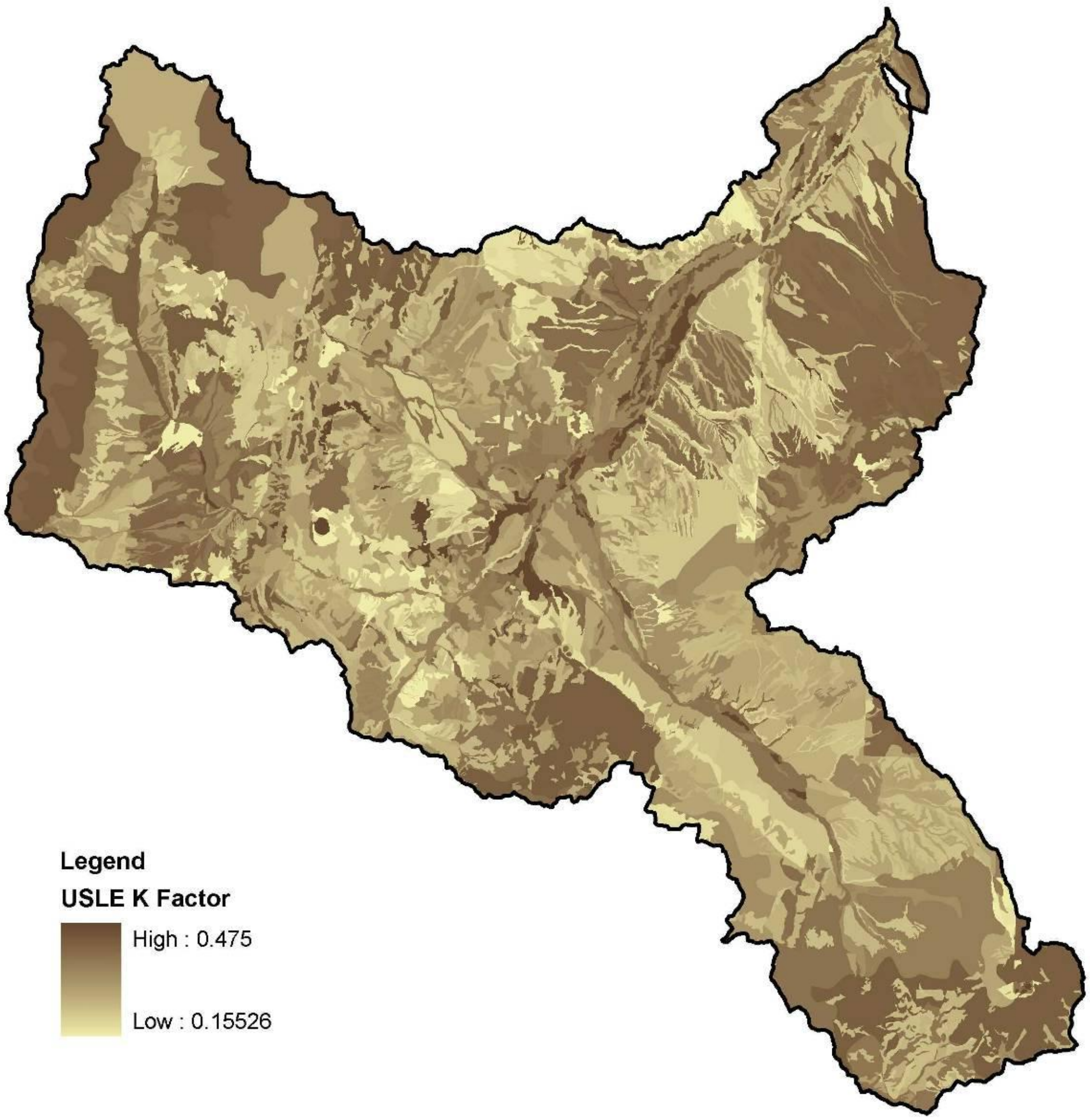

Figure F1-5. ULSE K-factor for the Beaverhead TPA

F5.6 LS-FACTOR

The equation used for calculating the slope length and slope factor was that given in the updated definition of RUSLE, as published in USDA handbook #703:

$$LS = S_i (\lambda_i^{m+1} - \lambda_{i-1}^{m+1}) / (\lambda_I - \lambda_{i-1}) (72.6)^m$$

Where:

λ_i = length in feet from top of slope to lower end of the segment. This value was determined by applying GIS based surface analysis procedures to the Beaverhead TPA DEM, calculating total upslope length for each 10m grid cell, and converting the results to feet from meters (**Figure F1-6**). In accordance with research that indicates that, in practice, the slope length rarely exceeds 400 ft, λ was limited to that maximum value.

Si = slope steepness factor for the ith segment.
= $10.8 \sin \theta + 0.03$ for $\theta < 9\%$
= $16.8 \sin \theta - 0.50$ for $\theta > 9\%$

m = a variable slope-length exponent.
= $\beta / (1 + \beta)$

and

B = ratio of rill to interrill erosion.
= $(\sin \theta / 0.0896) / [3.0 (\sin \theta)0.8 + 0.56]$

θ = slope angle as calculated by GIS based surface analysis procedures from the Beaverhead TPA DEM.

The LS factor grid was calculated from individual grids computed for each of these sub factors, using a simple ArcView Model Builder script.

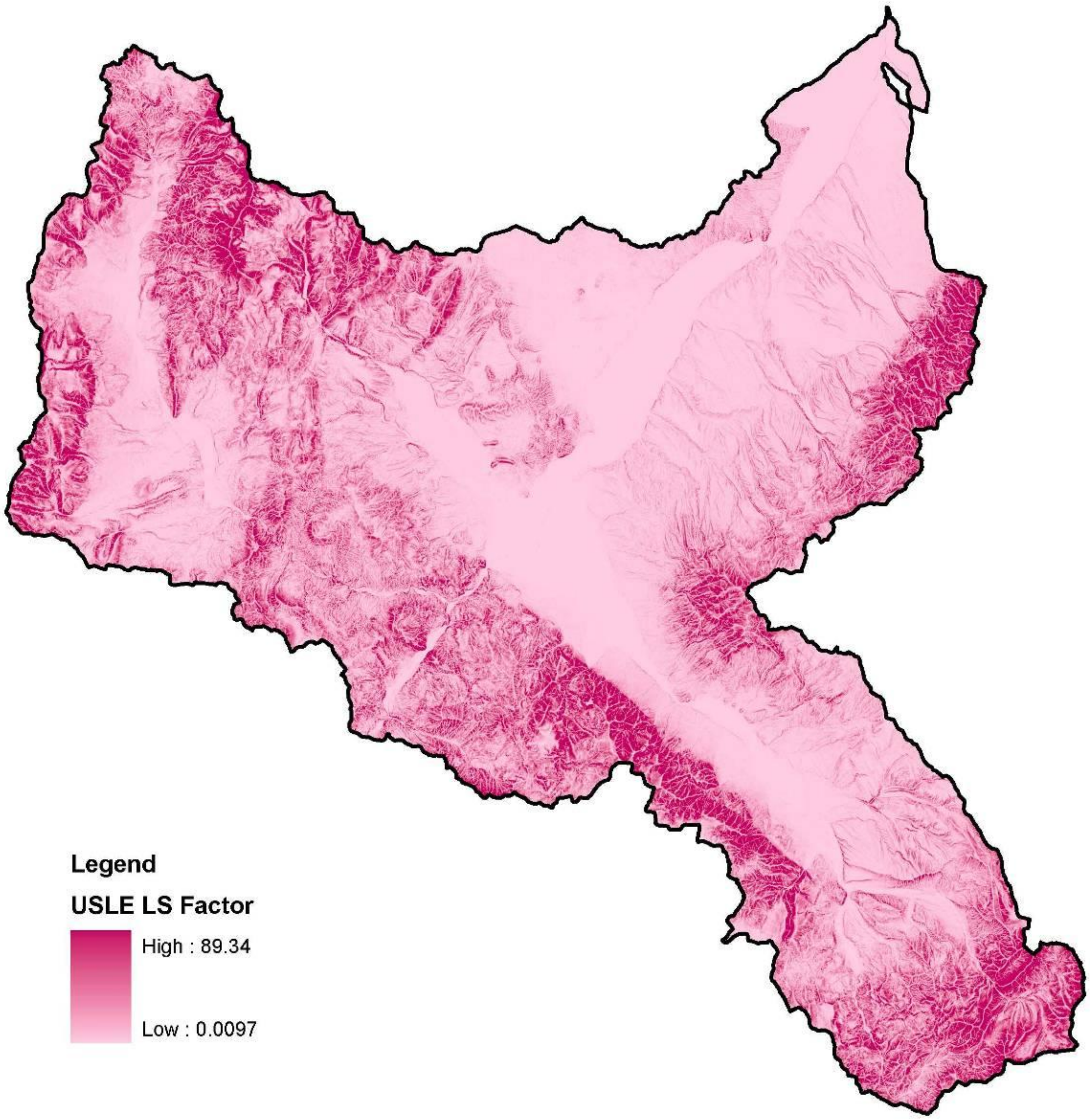

Figure F1-6. ULSE LS-factor for the Beaverhead TPA

F5.7 NLCD

The 2001 National Land Cover Dataset (NLCD) was obtained from USGS for use in establishing USLE C-factors for the Beaverhead TPA (**Figure F1-7**). The 2001 NLCD is the most current NLCD for the project are, and is a categorized 30 meter Landsat Thematic Mapper image shot in 2001. The NLCD image was reprojected to Montana State plane projection/coordinate system, and resampled to the project standard 10m grid. NLCD land cover classification codes for areas present in the Beaverhead TPA are described as follows:

11. Open Water - areas of open water, generally with less than 25 percent cover of vegetation or soil.

21. Developed, Open Space - Includes areas with a mixture of constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total

cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.

22. Developed, Low Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49 percent of total cover. These areas most commonly include single-family housing units.

23. Developed, Medium Intensity - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79 percent of the total cover. These areas most commonly include single-family housing units.

24. Developed, High Intensity – Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80 to 100 percent of the total cover.

31. Barren Land (Rock/Sand/Clay) – Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15 percent of total cover.

41. Deciduous Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.

42. Evergreen Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.

43. Mixed Forest - Areas dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.

52. Shrub/Scrub - Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20 percent of total vegetation. This class includes tree shrubs, young trees in an early successional stage or trees stunted from environmental conditions.

71. Grasslands/Herbaceous - Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80 percent of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.

81. Pasture/Hay - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.

82. Cultivated Crops - Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.

90. Woody Wetlands - Areas where forest or shrubland vegetation accounts for greater than 20 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

95. Emergent Herbaceous Wetlands - Areas where perennial herbaceous vegetation accounts for greater than 80 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

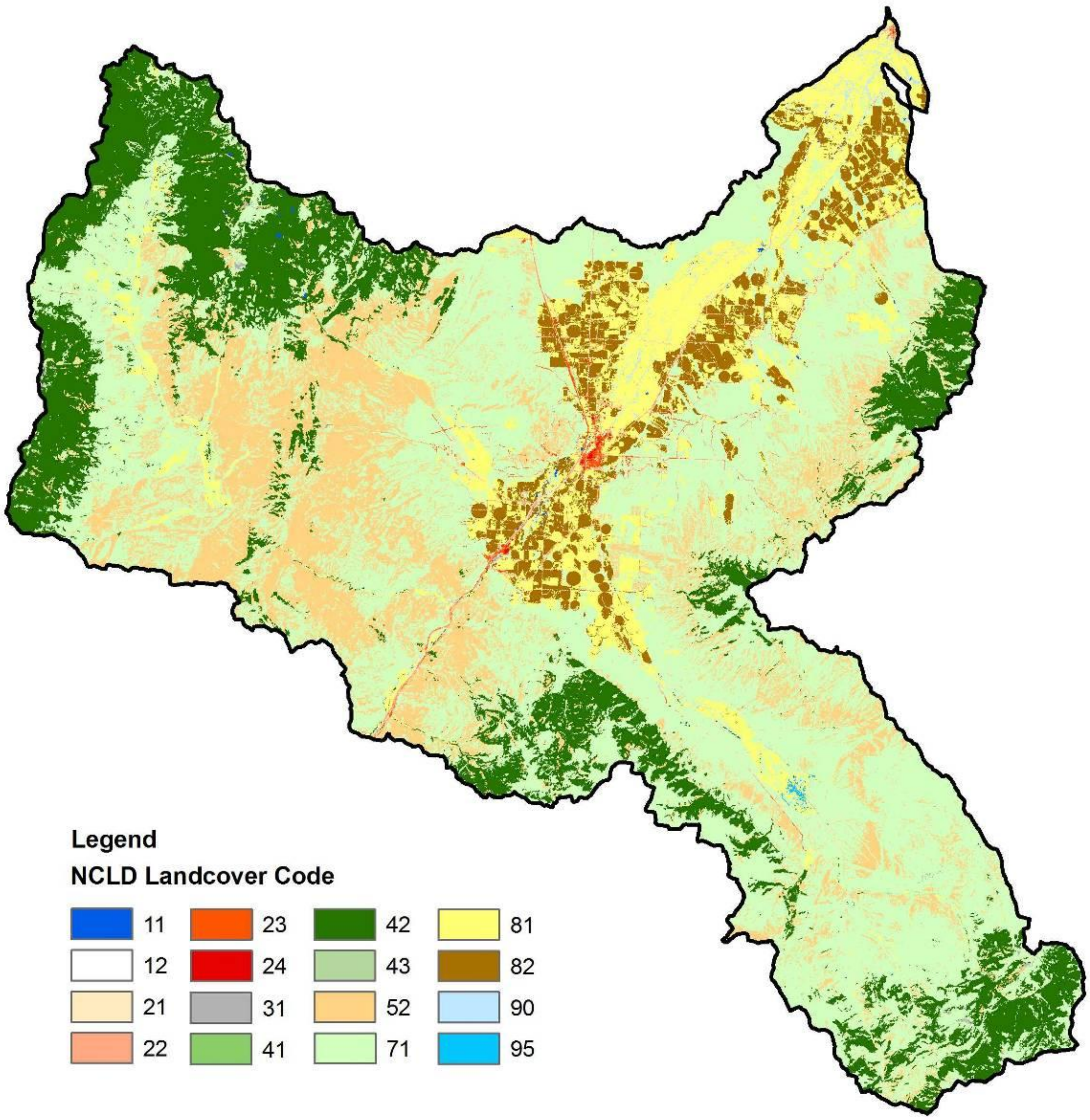

Figure F1-7. NLCD Landcover for the Beaverhead TPA.

F5.8 Logging and Fire Adjustment

In general, the land use classification of the NLCD was accepted as is, without ground truthing of original results or correction of changes that may have occurred since the NLCD image was shot. Given that we are looking for watershed and sub-watershed scale effects, the relative simplicity of the land use mix in the Beaverhead TPA, and the relative stability of that land use over the 10 years since the Landsat image that the NLCD is based on was taken, this was considered to be a reasonable assumption. One adjustment to the NLCD is necessary and appropriate, however. That is to quantify the amount of logging or fires that has occurred since 2001, and to also identify previously disturbed areas that are reforesting over that same period (**Figure F1-8**). As with other land uses in the valley, logging is a sustainable land use, but it is a land use that causes a land cover change that may affect sediment production.

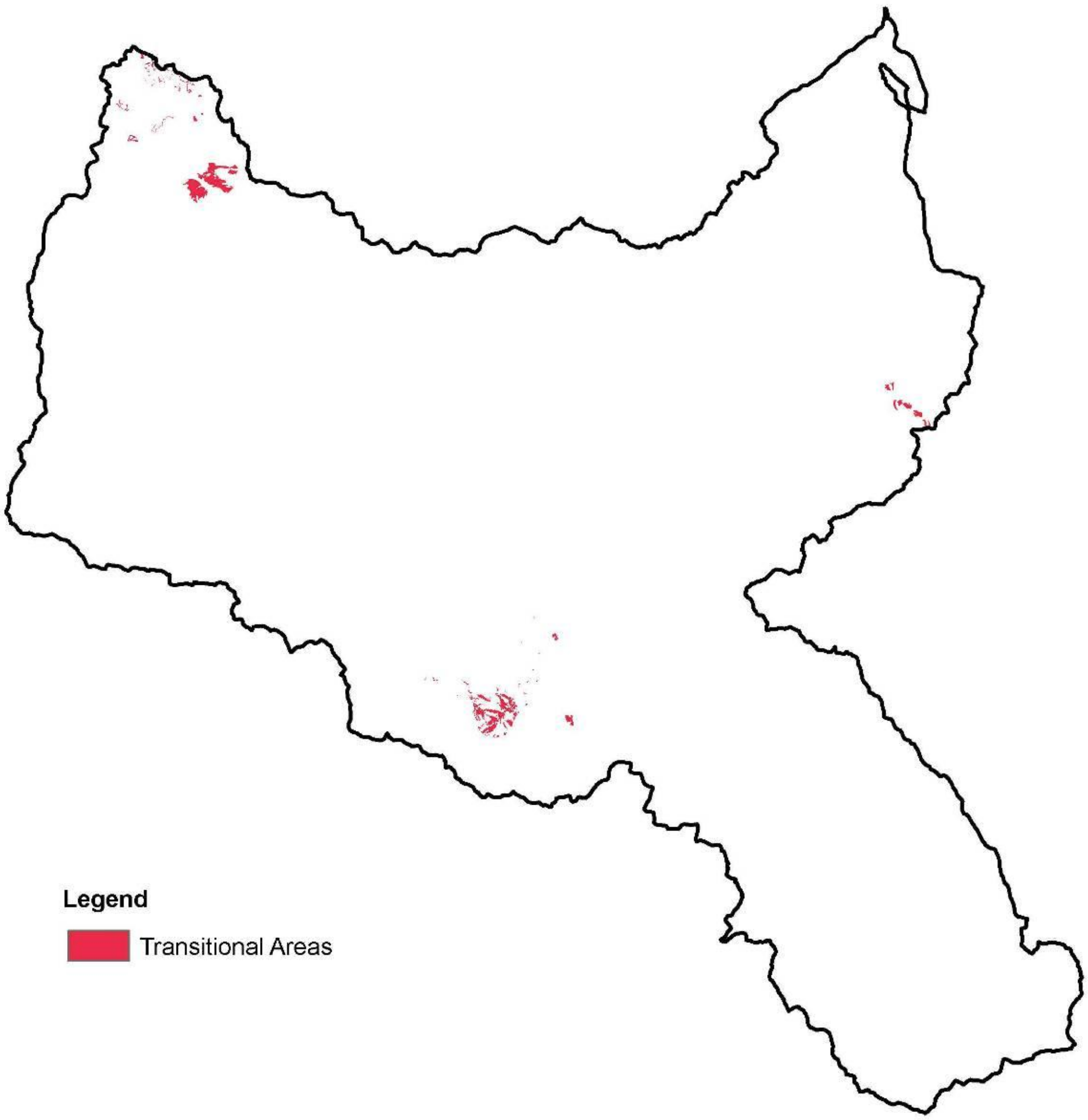

Figure F1-8. Logging and fire areas for the Beaverhead TPA.

Adjustment for logging was accomplished by using fire and harvest record polygons provided by the U.S. Forest Service. Polygons with a fire or harvest date of 2001 or later were selected. Adjustment for logging on non-USFS property was accomplished by comparing the 2001 NLCD grid for the Beaverhead TPA with the 2009 NAIP aerial photography. Areas which were coded as a forest type (41, 42 or 43) on the NLCD were digitized and coded as Type 1 (logged) if they appeared to be other than forested (typically bare ground, grassland, or shrubland) on the NAIP photos, if there were indications of logging activity (proximity to forest or logging roads, appearance of stands, etc), and if they were on non-USFS land. For the purposes of sediment generation estimation, Type 1 (logging) adjustment areas were treated as 'transitional' and classified with the corresponding C-factor.

Adjustment for reforestation was also accomplished by comparing the 2001 NLCD grid for the Beaverhead TPA with the 2009 NAIP aerial photography. Areas which were coded as something other than forest on the NLCD, but which appeared to be forested on the NAIP photos were digitized and coded as Type 2 (reforesting). However, no areas of reforestation were noted for the Beaverhead TPA.

F5.9 C-Factor Derivation

For purposes of the base (existing conditions) scenario, the following scheme of reclassification was used to derive annualized USLE C-factors from the NLCD land cover classes present in the Beaverhead TPA. This reclassification is based on the NRCS table "C-Factors for Permanent Pasture, Rangeland, Idle Land, and Grazed Woodland" and was developed with the assistance and input of local NRCS employees. A narrative description of the professional judgment involved in the selection of these factors and the NRCS table are provided in **Attachment FA**.

To estimate the potential reduction in sediment production that might be accomplished under the desired conditions scenario (application of best management practices), the model was re-run using a different C-factor reclassification scheme. Relative to the existing conditions C-factor scheme, the BMP C-factor for the 'transitional' land classification was changed to reflect the forest cover that most such areas are transitioning to in the Beaverhead TPA. The 'grasslands/herbaceous', 'shrub/scrub', 'pasture/hay', and 'woody wetlands' BMP C-factors were conservatively changed to reflect a 10 percent increase in ground cover over existing conditions. The 'cultivated crops' BMP C-factor was changed to reflect a 20 percent increase in ground cover over existing conditions. No change was applied to the other land use types within the Beaverhead TPA from the existing conditions scenario.

The C-factors for the two scenarios are presented in **Table F1-1 and F1-2.**

Table F1-1. C-factors in the Beaverhead TPA.

NLCD Code	Description	C-Factor Existing Condition	C-Factor Desired Condition	Percent of Watershed
71	Grasslands/Herbaceous	0.020	0.010	48.2%
52	Shrub/Scrub	0.020	0.010	18.0%
42	Evergreen Forest	0.003	0.003	16.2%
81	Pasture/Hay	0.020	0.010	9.5%
82	Cultivated Crops	0.200	0.100	4.6%
21	Developed, Open Space	0.003	0.003	1.5%
22	Developed, Low Intensity	0.001	0.001	0.7%
90	Woody Wetlands	0.013	0.006	0.4%
N/A	Transitional	0.006	0.003	0.3%
23	Developed, Medium Intensity	0.001	0.001	0.3%
31	Barren Land	0.001	0.001	0.1%
95	Emergent Herbaceous Wetlands	0.003	0.003	0.03%
24	Developed, High Intensity	0.001	0.001	0.02%
43	Mixed Forest	0.003	0.003	0.02%
41	Deciduous Forest	0.003	0.003	0.004%

Table F1-2. Changes in percent ground cover for agricultural land cover types between existing and improved management conditions.

Land Cover	Existing % Ground Cover	Improved % Ground Cover
Shrub/scrub	75	85
Grasslands/Herbaceous	75	85
Pasture/Hay	75	85
Transitional	90	95-100
Woody Wetlands	80	90
Cultivated Crops	20	40

F5.10 Riparian Health Assessment

Well vegetated riparian buffers have been shown to act as filters that remove sediment from overland flow. Because of this ability, the influence of riparian corridors on water quality is proportionately much greater than the relatively small area in the landscape they occupy. In general, the effectiveness of vegetated riparian buffers is proportional to their width and overall health. Thus, information regarding riparian zone health can be used to refine estimates of sediment delivery to streams from upstream sources. This section describes a Riparian Health Assessment of the Beaverhead TPA.

F5.10.1 DEQ Riparian Quality Assessment

The riparian corridor quality assessment was provided by DEQ. The assessment was based on the results of the DEQ aerial assessment and reach delineation. Reaches were delineated based on a combination of physical attributes (ecoregion, valley slope, valley confinement, and stream order) and the presence and degree of adjacent human activity. For each reach, a riparian corridor condition was estimated using aerial photos, field notes, and best professional judgment. DEQ designated riparian corridor as having poor, moderately poor, fair, moderately good, or good quality. These determinations were made with consideration of adjacent land use, streamside vegetation, and the presence or absence of human activities. The cumulative length of the reaches within each category was then tallied for each stream, and the percent of the length of stream in each category was calculated.

The results of the riparian corridor quality assessment from DEQ for the sub-basins are shown in **Table F1-3**.

Table F1-3. Percent of stream length in each riparian quality category.

Sub-basin	Existing Conditions					BMP Conditions				
	Good	Moderately Good	Fair	Moderately Fair	Poor	Good	Moderately Good	Fair	Moderately Fair	Poor
Beaverhead (upper)	0	94	0	0	6	94	0	6	0	0
Beaverhead (lower)	0	0	97	0	3	97	0	3	0	0
Blacktail Deer Creek	0	0	49	49	2	31.9	66.1	2	0	0
Clark Canyon Creek	27	70	0	0	3	97	0	3	0	0
Dyce Creek	19.2	0	80.8	0	0	100	0	0	0	0
East Fork Blacktail Deer Creek	24.1	75.6	0.2	0	0.1	99.9	0	0.1	0	0
Farlin Creek	31	0	0	62	7	93	0	7	0	0

Table F1-3. Percent of stream length in each riparian quality category.

Sub-basin	Existing Conditions					BMP Conditions				
	Good	Moderately Good	Fair	Moderately Fair	Poor	Good	Moderately Good	Fair	Moderately Fair	Poor
French Creek	24	76	0	0	0	100	0	0	0	0
Grasshopper Creek	7	0	93	0	0	100	0	0	0	0
Rattlesnake Creek (upper)	12	0	84	0	4	96	0	4	0	0
Rattlesnake Creek (lower)	0	0	50	50	0	32.5	67.5	0	0	0
Reservoir Creek	14	0	86	0	0	100	0	0	0	0
Scudder Creek	11	0	83	0	6	94	0	6	0	0
Spring Creek	2	0	0	94	4	2	94	4	0	0
Steel Creek	25	0	0	23	52	25	23	52	0	0
Stone Creek (upper)	2	0	98	0	0	100	0	0	0	0
Stone Creek (lower)	0	0	0	100	0	0	100	0	0	0
Taylor Creek	5	0	95	0	0	100	0	0	0	0
West Fork Blacktail Deer Creek	1	0	49.5	49.5	0	100	0	0	0	0
West Fork Dyce Creek	12	0	88	0	0	100	0	0	0	0

F5.10.2 Correcting for Differences in Sub-basin Delineation

The sub-basin division used for the DEQ riparian quality assessment varies slightly from the sub-basin division used for this TMDL assessment. Where the TMDL sub-basin encompassed more than one sub-basin in the DEQ riparian quality assessment, the TMDL riparian quality was taken to be the area weighted average of the contributing sub-basins.

For Dyce Creek and East Fork Blacktail Deer Creek, the TMDL sub-basin of interest for this report was defined by more than one sub-basin in the DEQ riparian quality assessment. The percent of the TMDL sub-basin in each riparian quality category for Dyce Creek is based on Lower Dyce Creek and East Fork Dyce Creek. The percent of the TMDL sub-basin in each riparian quality category for East Fork Blacktail Deer Creek is based on East Fork Blacktail Deer Creek less Indian Creek and Indian Creek. For these TMDL sub-basins, the riparian quality was weighted by the percent of sub-basin area. The calculations are shown in **Table F1-4**.

Table F1-4. Calculation of Area Weighted Riparian Quality for Dyce Creek and East Fork Blacktail Deer Creek.

Existing Riparian Quality	Percent of Stream Length	Weighted Percent of TMDL Sub-basin by Area	Percent of Stream Length	Weighted Percent of TMDL Sub-basin by Area	Sub-Total Percent of TMDL Sub-basin
	Lower Dyce Creek (2,553 acres)		East Fork Dyce Creek (3,841 acres)		Dyce Creek (6,394 acres)
Good	0	0 * 0.4 = 0	32	32 * 0.6 = 19.2	0 + 19.2 = 19.2
Moderately Good	0	0 * 0.4 = 0	0	0 * 0.6 = 0	0 + 0 = 0
Fair	100	100 * 0.4 = 40.0	68	68 * 0.6 = 40.8	40.0 + 40.8 = 80.8
Moderately Fair	0	0 * 0.4 = 0	0	0 * 0.6 = 0	0 + 0 = 0
Poor	0	0 * 0.4 = 0	0	0 * 0.6 = 0	0 + 0 = 0
Total	100		100		100
	East Fork Blacktail Deer Creek		Indian Creek (1,359 acres)		E.F. Blacktail Deer

Table F1-4. Calculation of Area Weighted Riparian Quality for Dyce Creek and East Fork Blacktail Deer Creek.

Existing Riparian Quality	Percent of Stream Length	Weighted Percent of TMDL Sub-basin by Area	Percent of Stream Length	Weighted Percent of TMDL Sub-basin by Area	Sub-Total Percent of TMDL Sub-basin
	less Indian Creek (37,598 acres)				Creek (38,957 acres)
Good	22	22 * 0.97 = 21.34	92	92 * 0.03 = 2.76	21.34 + 2.76 = 24.10
Moderately Good	78	78 * 0.97 = 75.66	0	0 * 0.03 = 0	75.66 + 0 = 75.66
Fair	0	0 * 0.97 = 0	5	5 * 0.03 = 0.15	0 + 0.15 = 0.15
Moderately Fair	0	0 * 0.97 = 0	0	0 * 0.03 = 0	0 + 0 = 0
Poor	0	0 * 0.97 = 0	3	3 * 0.03 = 0.09	0 + 0.09 = 0.09
Total	100		100		100

F5.11 Distance and Riparian Health Based Sediment Delivery Ratio

The USLE model (upon which this model is founded) is, as its name states, a soil loss (i.e. sediment production) model. Soil lost from one area due to erosive processes is typically re-deposited a short distance downslope, therefore not all of the sediment produced from a hillslope erosion event is delivered to a stream channel. As TMDL questions deal specifically with sediment delivered to the stream, a method of accounting for re-deposition and ultimate delivery to streams is required.

With USLE based models, this accounting of sediment re-deposition is typically achieved through the application of a sediment delivery ratio (SDR), a factor that estimates the percentage of sediment produced that is ultimately delivered to the stream. We apply a distance based sediment delivery ratio that reflects the relationship between downslope travel distance and ultimate sediment delivery.

Given that riparian zones can be effective sediment filters when wide and well vegetated, that riparian zone health is susceptible to anthropogenic impacts and thus to land management decisions, and that the effectiveness of riparian zones as sediment filters has been quantified in the literature (i.e. Wegner, 1999 and Knutson and Naef 1997), we incorporate riparian zone health and its effect on sediment delivery into our distance based sediment delivery ratio.

F5.11.1 Distance based SDR

Megahan and Ketcheson (1996) found that the relationship between the percentage (by volume) of a sediment mass that travels a given percentage of the maximum sediment travel distance of that sediment mass is as shown in **Figure F1-9**.

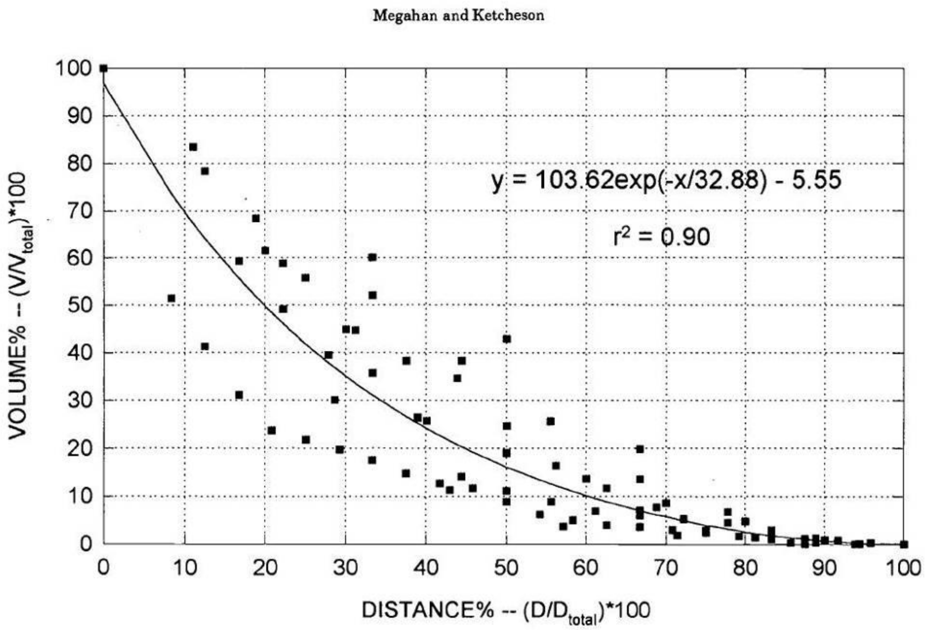

Figure 2. Dimensionless Plot of Sediment Volume Versus Travel Distance.

Figure F1-9. Figure 2 from Megahan and Ketcheson (1996), a dimensionless plot of sediment volume vs. travel distance.

This relationship was derived from a dataset of approximately 100 observations of sediment transport downslope from a known source (forest roads) that was not intercepted by a stream. It thus represents the 'typical' transport distribution along the maximum transport distance under a variety of field conditions.

Megahan and Ketcheson's logarithmic regression of the data permits this relationship to be expressed by the equation presented in **Figure F1-8**, which may be restated as a function of three variables:

Volume % = 103.62*EXP(-((D/Dtotal)/32.88))-5.55

where:

Volume% = the percentage of sediment mobilized from a source that travels at least distance D from that source

D = distance from the sediment source, and

Dtotal = the maximum distance that sediment travels from the source

As this equation is dimensionless, to serve as an SDR it must first be scaled to the field conditions of the study area. This is accomplished by evaluating the equation with site-specific values for D and Volume% at a single point, and solving for Dtotal. Having established a site-specific Dtotal, the M&K equation reduces to two unknowns, the two variables that define a distance based SDR: distance and percent sediment delivered beyond that distance. This SDR may be used to estimate sediment delivery at all points on the sediment delivery path, from streambank to a distance Dtotal.

The derivation of site-specific values of D and Volume % for use in scaling Megahan and Ketcheson's dimensionless equation is presented in **Section 1.5.10.2**

F5.11.2 Sub-basin specific Sediment Delivery Ratio scale factors.

Riparian zone sediment filtering capacity is typically expressed as a given percent reduction in delivery of sediment entering a riparian zone of a given width. This rating of a known percent delivery (Volume%) from a known distance from the stream (D) permits scaling of the Megahan and Ketcheson's dimensionless equation (**Section 1.5.11.1**) for use in predicting percent delivery from other distances.

Literature review (Wegner 1999, Knutson and Naef 1997) indicates that a 100 foot wide, well vegetated riparian buffer zone can be expected to filter 75-90% of incoming sediment from reaching its stream channel. Accordingly, this analysis conservatively assumes that a sediment reduction efficiency of 75% represents the performance of a 100 foot wide, high quality (good) vegetated riparian buffer in the Beaverhead TPA. Conversely, this analysis conservatively assumes that a 100 foot wide riparian zone without vegetation cover would only filter 10% of incoming sediment from reaching its stream. An approximately equal apportionment of the remaining range in sediment reduction efficiency between the 'poor', 'moderately fair', 'fair', and 'moderately good' riparian assessment categories results in the riparian health/sediment delivery relationship shown in **Figure F1-10**.

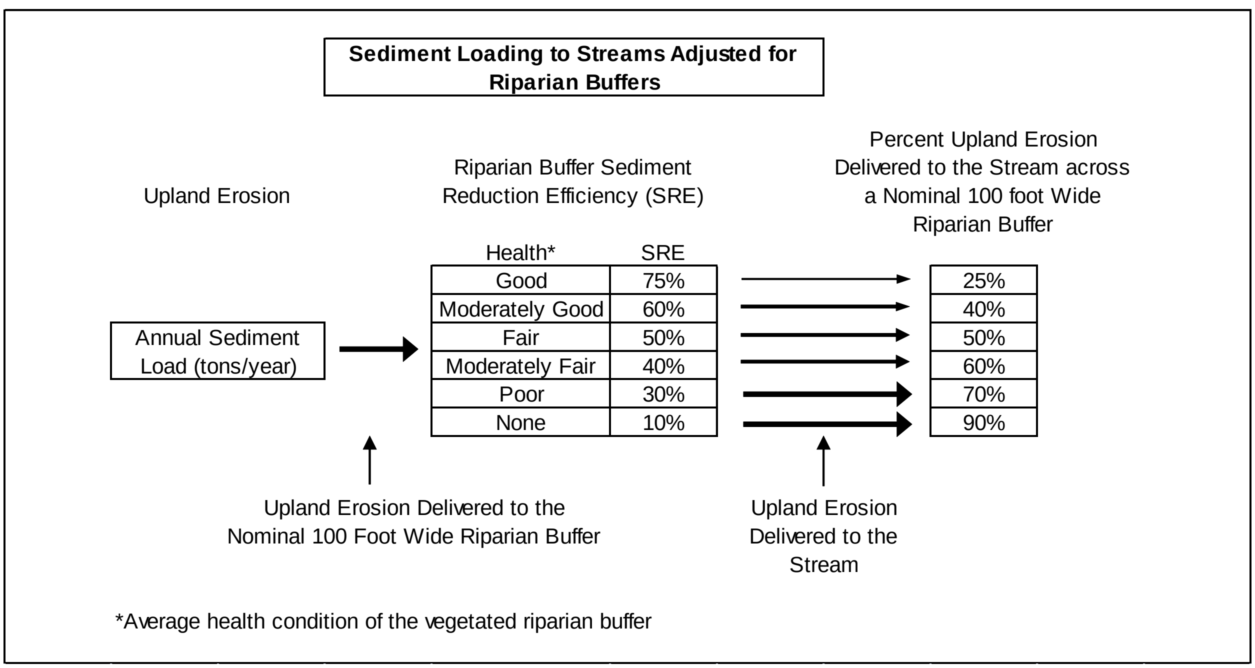

Figure F1-10. USLE Upland Sediment Load Delivery Adjusted for Riparian Buffer Capacity

Applying this relationship to the Beaverhead riparian assessment, we computed a riparian health score based sediment reduction percentage for each sub-basin of interest. This represents the percent reduction in delivery of sediment from a nominal 100 foot wide riparian zone. This was accomplished by taking the percentage of the stream length in each of the five riparian health classes, multiplying by the assumed sediment delivery efficiency reduction for each class (75% for good quality, 60% for moderately good quality, 50% for fair quality, 40% for moderately fair quality, and 30% for a poor quality) and summing for each stream.

The riparian health assessment based Sediment Reduction Percentage computed for each sub-basin of interest is presented in **Table F1-5**. Values are presented for both the existing conditions scenario and a BMP scenario. Under the BMP scenario, it is assumed that the implementation of BMPs on those activities that affect the overall health of the vegetated riparian buffer will increase an area with poor quality riparian health to fair quality. The increase for areas with an existing riparian health quality of better than poor varies for each sub-basin depending on the potential for improvement as determined by DEQ.

Table F1-5. Sediment reduction percentage based on riparian health assessment.

Sub-Basin	Riparian Quality	Percent of TMDL Stream Length for Existing Conditions	Weighted Sediment Reduction Percentage Existing Conditions	Percent of TMDL Stream Length for BMP Conditions	Weighted Sediment Reduction Percentage BMP Conditions	Change in Sediment Reduction Percentage	BMP Conditions
Farlin Creek	Good	31	23.3	93	69.8		-Mod. Fair to Good -Poor to Fair
	Mod. Good						
	Fair			7	3.5		
	Mod. Fair	62	24.8				
	Poor	7	2.1				
	Total		**50.2**		**73.3**	**23.1**	
Steel Creek	Good	25	18.8	25	18.8		-Mod. Fair to Mod. Good -Poor to Fair
	Mod. Good			23	13.8		
	Fair			52	26.0		
	Mod. Fair	23	9.2				
	Poor	52	15.6				
	Total		**43.6**				
Scudder Creek	Good	11	8.3	94	70.5		-Fair to Good -Poor to Fair
	Mod. Good						
	Fair	83	41.5	6	3.0		
	Mod. Fair						
	Poor	6	1.8				
	Total		**51.6**		**73.5**	**22.0**	
West Fork Dyce Creek	Good	12	9.0	100	75.0		-Fair to Good
	Mod. Good						
	Fair	88	44.0				
	Mod. Fair						
	Poor						
	Total		**53.0**		**75.0**		
Dyce Creek	Good	19.2	14.4	100	75.0		-Fair to Good
	Mod. Good						
	Fair	80.8	40.4				
	Mod. Fair						
	Poor						
	Total		**54.8**		**75.0**	**20.2**	

Table F1-5. Sediment reduction percentage based on riparian health assessment.

Sub-Basin	Riparian Quality	Percent of TMDL Stream Length for Existing Conditions	Weighted Sediment Reduction Percentage Existing Conditions	Percent of TMDL Stream Length for BMP Conditions	Weighted Sediment Reduction Percentage BMP Conditions	Change in Sediment Reduction Percentage	BMP Conditions
Taylor Creek	Good	5	3.8	100	75.0		-Fair to Good
	Mod. Good						
	Fair	95	47.5				
	Mod. Fair						
	Poor						
	Total		**51.3**		**75.0**	**23.8**	
Reservoir Creek	Good	14	10.5	100	75.0		-Fair to Good
	Mod. Good						
	Fair	86	43.0				
	Mod. Fair						
	Poor						
	Total		**53.5**		**75.0**	**21.5**	
Grasshopper Creek	Good	7	5.3	100	75.0		-Fair to Good
	Mod. Good						
	Fair	93	46.5				
	Mod. Fair						
	Poor						
	Total		**51.8**		**75.0**	**23.3**	
Clark Canyon Creek	Good	27	20.3	97	72.8		-Mod. Good to Good -Poor to Fair
	Mod. Good	70	42.0				
	Fair			3	1.5		
	Mod. Fair						
	Poor	3	0.9				
	Total		**63.2**		**74.3**	**11.1**	
Beaverhead River Upper	Good			94	70.5		-Mod. Good to Good -Poor to Fair
	Mod. Good	94	56.4				
	Fair			6	3.0		
	Mod. Fair						
	Poor	6	1.8				
	Total		**58.2**		**73.5**	**15.3**	
French Creek	Good	24	18.0	100	75.0		-Mod. Good to Good
	Mod. Good	76	45.6				
	Fair						
	Mod. Fair						
	Poor						
	Total		**63.6**		**75.0**	**11.4**	
Rattlesnake Creek Upper	Good	12	9.0	96	72.0		-Fair to Good -Poor to Fair
	Mod. Good						
	Fair	84	42.0	4	2.0		
	Mod. Fair						
	Poor	4	1.2				
	Total		**52.2**		**74.0**	**21.8**	

Table F1-5. Sediment reduction percentage based on riparian health assessment.

Sub-Basin	Riparian Quality	Percent of TMDL Stream Length for Existing Conditions	Weighted Sediment Reduction Percentage Existing Conditions	Percent of TMDL Stream Length for BMP Conditions	Weighted Sediment Reduction Percentage BMP Conditions	Change in Sediment Reduction Percentage	BMP Conditions
Rattlesnake Creek Lower	Good			32.5	24.4		-65% Fair to Good -35% Fair to Mod. Good -Mod. Fair to Mod. Good
	Mod. Good			67.5	40.5		
	Fair	50	25.0				
	Mod. Fair	50	20.0				
	Poor						
	Total		**45.0**		**64.9**	**19.9**	
West Fork Blacktail Deer Creek	Good	1	0.8	100	75.0		-Fair to Good -Mod. Fair to Good
	Mod. Good						
	Fair	49.5	24.8				
	Mod. Fair	49.5	19.8				
	Poor						
	Total		**45.3**		**75.0**	**29.7**	
East Fork Blacktail Deer Creek	Good	24.1	18.1	99.9	74.9		-Mod. Good to Good -Fair to Good -Poor to Fair
	Mod. Good	75.7	45.4				
	Fair	0.2	0.1	0.1	0.05		
	Mod. Fair						
	Poor	0.1	0.03				
	Total		**63.6**		**75.0**	**11.4**	
Blacktail Deer Creek	Good			31.9	23.9		-65% Fair to Good -35% Fair to Mod. Good -Mod. Fair to Mod. Good -Poor to Fair
	Mod. Good			66.1	39.7		
	Fair	49	24.5	2	1.0		
	Mod. Fair	49	19.6				
	Poor	2	0.6				
	Total		**44.7**		**64.6**	**19.9**	
Stone Creek Upper	Good	2	1.5	100	75.0		-Fair to Good
	Mod. Good						
	Fair	98	49.0				
	Mod. Fair						
	Poor						
	Total		**50.5**		**75.0**	**24.5**	
Stone Creek Lower	Good						-Mod. Fair to Mod. Good
	Mod. Good			100	60.0		
	Fair						
	Mod. Fair	100	40.0				
	Poor						
	Total		**40.0**		**60.0**	**20.0**	
Spring Creek	Good	2	1.5	2	1.5		-Mod. Fair to Mod. Good -Poor to Fair
	Mod. Good			94	56.4		
	Fair			4	2.0		
	Mod. Fair	94	37.6				
	Poor	4	1.2				
	Total		**40.3**		**59.9**		

Table F1-5. Sediment reduction percentage based on riparian health assessment.

Sub-Basin	Riparian Quality	Percent of TMDL Stream Length for Existing Conditions	Weighted Sediment Reduction Percentage Existing Conditions	Percent of TMDL Stream Length for BMP Conditions	Weighted Sediment Reduction Percentage BMP Conditions	Change in Sediment Reduction Percentage	BMP Conditions
Beaverhead River Lower	Good			97	72.8		-Fair to Good -Poor to Fair
	Mod. Good						
	Fair	97	48.5	3	1.5		
	Mod. Fair						
	Poor	3	0.9				
	Total		**49.4**		**74.3**	**24.9**	

F5.11.3 Sediment Delivery Ratio - Example Calculation

To create a final, sub-basin specific SDR, Megahan and Ketcheson's dimensionless equation relating percent sediment volume to percent travel distance (**Figure F1-9**) was scaled to each sub-basin by using its riparian health assessment based 100 ft Sediment Reduction Percentage to derive a site-specific maximum sediment travel distance. For each sub-basin, the following method was applied:

1. From the sub-basin's Riparian Health Assessment, determine the expected % sediment delivery across a nominal 100 foot wide riparian zone.

   Example:
   Per **Table F1-5**, the Beaverhead River Lower sub-basin's expected existing sediment delivery across a **100** foot wide riparian zone is (100% - 49.4% reduction) = **50.6%** delivered.

2. Substitute the expected % sediment delivery across a 100 foot wide riparian zone into Megahan and Ketcheson's dimensionless sediment volume vs. travel distance equation.

   Example:
   Volume% = 103.62exp(-((D/Dtotal)*100)/32.88) - 5.55 =

   50.6% = 103.62exp(-((**100**/Dtotal)*100)/32.88) - 5.55

3. Solve the M&K equation for Dtotal to arrive at a representative maximum sediment travel distance for that sub-basin.

   Example:
   50.6% = 103.62exp(-((**100**/Dtotal)*100)/32.88) - 5.55

   Dtotal = **100**/(-0.3288*ln((**50.6** + 5.55)/103.62))

   Dtotal = **496** feet

4. Restate the M&K equation using the sub-basin's calculated maximum sediment travel distance (Dtotal) to arrive at an integrated Distance and Riparian Health based Sediment Deliver Ratio (SDR) for that sub-basin.

Example:
Within the Beaverhead River Lower sub-basin, the SDR for an analytical pixel with a drainage path to the nearest stream of length **D** would be given by:

Volume% = 103.62exp(-((D/**496**)*100)/32.88) - 5.55

By this method, the Sediment Delivery Ratio for each analytical pixel in a Beaverhead TPA sub-basin is obtained by evaluating this equation:

SDR = 103.62*EXP(-((D/**Dtotal**)/32.88))-5.55

Where:

SDR = the percentage of sediment generated from the pixel that is delivered to a stream;
D = the downslope distance from the pixel to the nearest stream channel; and
Dtotal = the sub-basin specific Riparian Health derived maximum sediment travel distance.

The results of the calculation for the Dtotal variable based on the DEQ riparian health assessment for the sub-basins are shown in **Table F1-6**.

Table F1-6. Results of D total calculations.

Sub-basin	Existing Conditions			BMP Conditions		
	Sediment Reduction Percentage	Sediment Delivery Percentage	Dtotal (feet)	Sediment Reduction Percentage	Sediment Delivery Percentage	Dtotal (feet)
Farlin Creek	50.2	49.8	486	73.3	26.7	261
Steel Creek	43.6	56.4	592	58.6	41.4	385
Scudder Creek	51.6	48.4	467	73.5	26.5	259
West Fork Dyce Creek	53.0	47.0	448	75.0	25.0	249
Dyce Creek	54.8	45.2	426	75.0	25.0	249
Taylor Creek	51.3	48.7	471	75.0	25.0	249
Reservoir Creek	53.5	46.5	442	75.0	25.0	249
Grasshopper Creek	51.8	48.2	464	75.0	25.0	249
Clark Canyon Creek	63.2	36.8	340	74.3	25.7	254
Beaverhead River Upper	58.2	41.8	388	73.5	26.5	259
French Creek	63.6	36.4	336	75.0	25.0	249
Rattlesnake Creek Upper	52.2	47.8	458	74.0	26.0	256
Rattlesnake Creek Lower	45.0	55.0	566	65.0	35.0	324
East Fork Blacktail Deer Creek	63.6	36.4	336	75.0	25.0	249
West Fork Blacktail Deer Creek	45.3	54.7	561	75.0	25.0	249
Blacktail Deer Creek	44.7	55.3	571	64.7	35.3	327
Stone Creek Upper	50.5	49.5	481	75.0	25.0	249
Stone Creek Lower	40.0	60.0	664	60.0	40.0	370
Spring Creek	40.3	59.7	658	59.9	40.1	371
Beaverhead River Lower	49.4	50.6	496	74.3	25.7	254

F5.12 Model Assumptions

The following assumptions are made, concerning the applicability and accuracy of the model with respect to the intended use of the results:

1. That the USLE model is sufficiently accurate for TMDL purposes. Discussion: The USLE model has been in widespread use for more than thirty years, and has been found to be sufficient for natural resources management decision making at the field scale.
2. That it is appropriate to extend the field scale USLE model to watershed scale. Discussion: Many watershed scale implementations of the USLE model have been developed and presented in the peer reviewed literature. This model is a similar gridded USLE implementation, and it faithfully executes the methodology specified in USDA Agriculture Handbook No. 703. It operates in field scale on a 10 meter analytic pixel, and achieves watershed scale implementation through aggregation of field scale results.
3. That the data sources used are appropriate for USLE parameterization. Discussion: Data sources for USLE R and K factors were purpose built for that use. The USLE C factor is derived from Landsat thematic mapper imagery, classified by a rigorous process of peer reviewed methods into the NLCD landcover dataset. Specific assignment of C factors to landcover classes was performed under the guidance of natural resource professionals well versed in the application of USLE and USLE based sediment production models at the field scale. The USLE P factor was not used, as the best professional judgement of these same land managers is that the agricultural practices intended to be reflected by the USLE P factor are not in significant use in the Beaverhead TPA. The USLE L & S factors are mathematical constructs representing landform, and are derived here from Digital Terrain data. This analysis assumes that a 10 meter analytic pixel adequately describes the micro terrain slope and slope length at field scale. To the extent that this assumption is not met, results may deviate.
4. That the Riparian Health Assessment is of sufficient accuracy, resolution and coverage to serve as the basis for a sediment delivery ratio. Discussion: The Riparian Health Assessment only surveyed mainstem reaches. The condition of mainstem reaches is considered here to be broadly representative of overall watershed condition. To the extent that this assumption is not met, results may deviate proportionately.
5. That it is appropriate to use Megehan and Ketcheson's (1996) dimensionless equation relating sediment travel distance and delivered volume as the basis for a sediment delivery ratio. Discussion: Megehan and Ketcheson (1996) establishes that the purpose of the work is to provide an empirical alternative to process based modeling approaches for sediment delivery to streams. A decade later, Megehan and Ketcheson went on to produce the Washington Road Surface Erosion Model (WARSEM, 2004) which uses the Megehan and Ketcheson (1996) dimensionless equation as an SDR to account for delivery across fillslopes to streams. Here, we replicate Megehan and Ketcheson's use of the three variable dimensionless equation for the WARSEM SDR, evaluating that equation for a representative maximum sediment travel distance, and arriving at a scaled distance/sediment delivery relationship.

   A specific concern is that the Megehan and Ketcheson method, because it does not explicitly account for changes in vegetation as might be expected transitioning an upland/riparian zone boundary, may not adequately represent sediment delivery across a riparian zone. We note that whereas Megehan and Ketcheson used a single scaling of the dimensionless equation for all locations in an attempt to render the WARSEM model broadly applicable with minimum data collection needs, we take advantage of the available Beaverhead Riparian Health Assessment data to derive site-specific scalings of the dimensionless equation for Beaverhead sub-basins, based on riparian condition.

In this implementation, it is assumed that a significant difference in vegetation density between riparian and upland is unlikely to favor the upland, i.e. if there is a great difference, it is going to be a well vegetated near-stream zone paired with a sparsely vegetated upland. The most extreme instance of that would be reflected in this modeling approach as a 'good' riparian health category. For that category, we evaluate the dimensionless equation using the literature values of 75% sediment reduction at 100 feet, deriving a Dtotal value that may be used to estimate the percent sediment reduction at all distances. If failing to explicitly account for a significant change in vegetation produces a 'bust' in this procedure, it will be that it somewhat underestimates the sediment delivered from the upland portion of the delivery path. Given that:

- the maximum percent delivery for that portion of the path is 25%, declining to 0% at the outer bound, and
- that vegetation is only one component of the obstruction value, and
- that the obstruction value is only one of the factors predictive for sediment delivery,

we may conclude that the maximum effect of such a vegetation difference induced 'bust' is, in the most extreme case, some small fraction of 25%. Working down from that rare, most extreme case - if riparian condition and immediately adjacent upland condition are more similar, the potential magnitude of a 'bust' rooted in their difference becomes smaller as well. This places potential error in sediment due to the riparian transition well within the bounds of this effort.

6. That the uncalibrated watershed scale USLE model and sediment delivery ratio are sufficiently accurate for Beaverhead TMDL purposes. Discussion: The USLE is an empirical model developed initially for eastern US croplands, but has been extended via revised C factors and other means to be more broadly applicable. The C factors used for this effort were chosen to be as representative of Beaverhead conditions as professional judgement allows. The Megehan and Ketcheson dimensionless equation was similarly developed as an empirical method for sediment delivery accounting in watersheds similar to the Beaverhead. The implementation of that SDR method used here is further fit to the Beaverhead project area with the use of site-specific scaling factors. Both components of the model remain uncalibrated to local conditions however, in the sense that these attempts to better represent the Beaverhead TPA have not been tested empirically. Use of the results for relative comparison (as between sub-basins or alternative management scenarios) is well supported. Use of the results as predictors of absolute sediment load should be undertaken with care. Though both the USLE and the Megehan and Ketcheson SDR are currently in widespread use for absolute prediction of sediment load, local verification of predictive power is (as here) rarely undertaken.

F6.0 Results

F6.1 Management Scenarios

Figures F1-11 through **F1-14** present the USLE based hillslope model's prediction of existing and potential conditions graphically. **Table F1-7** presents the prediction of existing and potential conditions numerically, broken out by 6th code HUC (as modified to represent the 303(d) listed streams) and existing land cover type. **Table F1-8** presents the delivered sediment load cumulative totals within the watershed. The cumulative totals for a sub-basin are a sum of the results for that sub-basin plus the sub-basins upstream of it. For example, Blacktail Deer Creek is a sum of the results for that sub-basin plus the results for West Fork Blacktail Deer Creek and East Fork Blacktail Deer Creek.

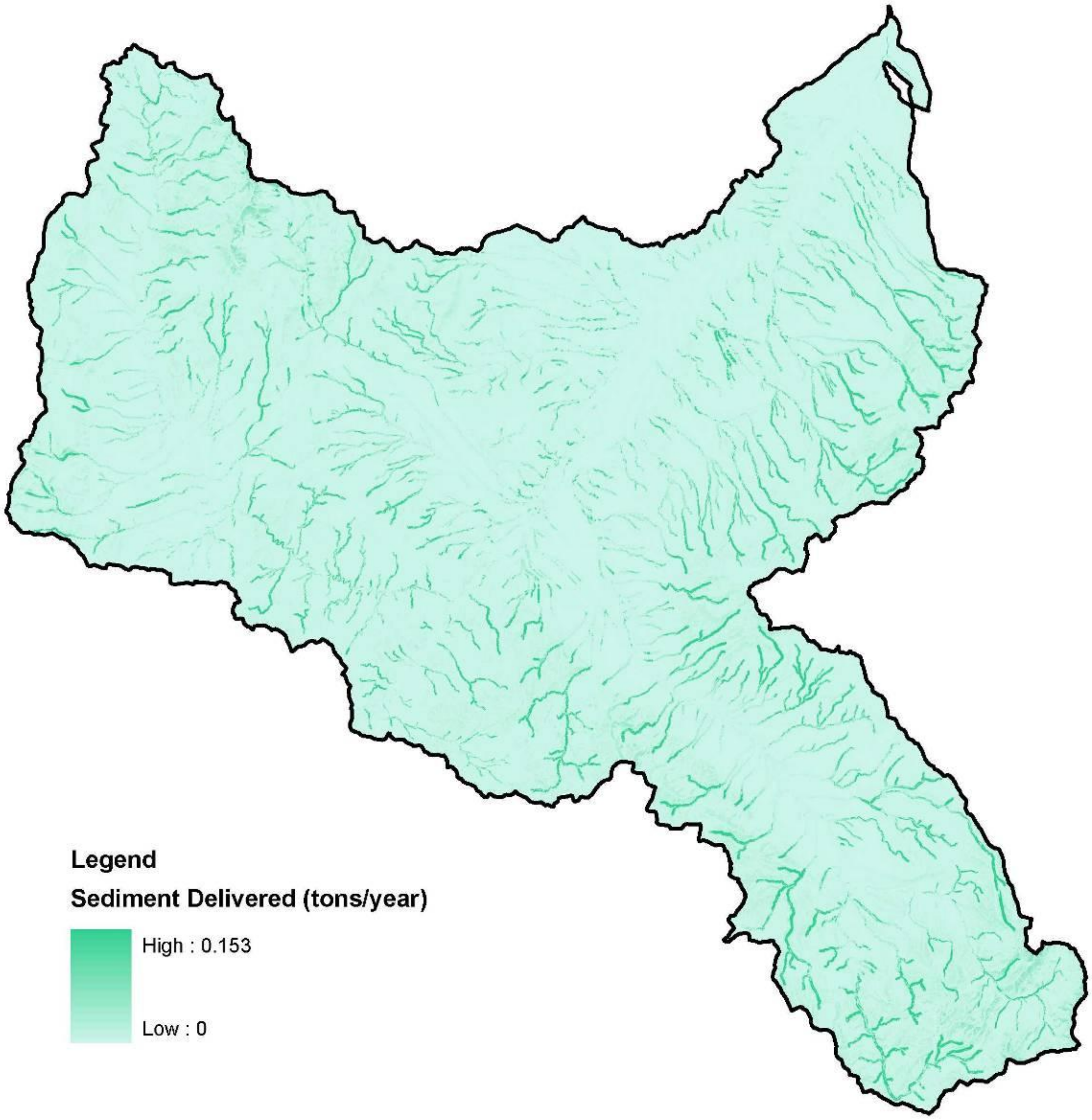

Figure F1-11. Upland Erosion Sediment Load for Existing Upland Conditions and Existing Riparian Health Conditions, Scenario 1.

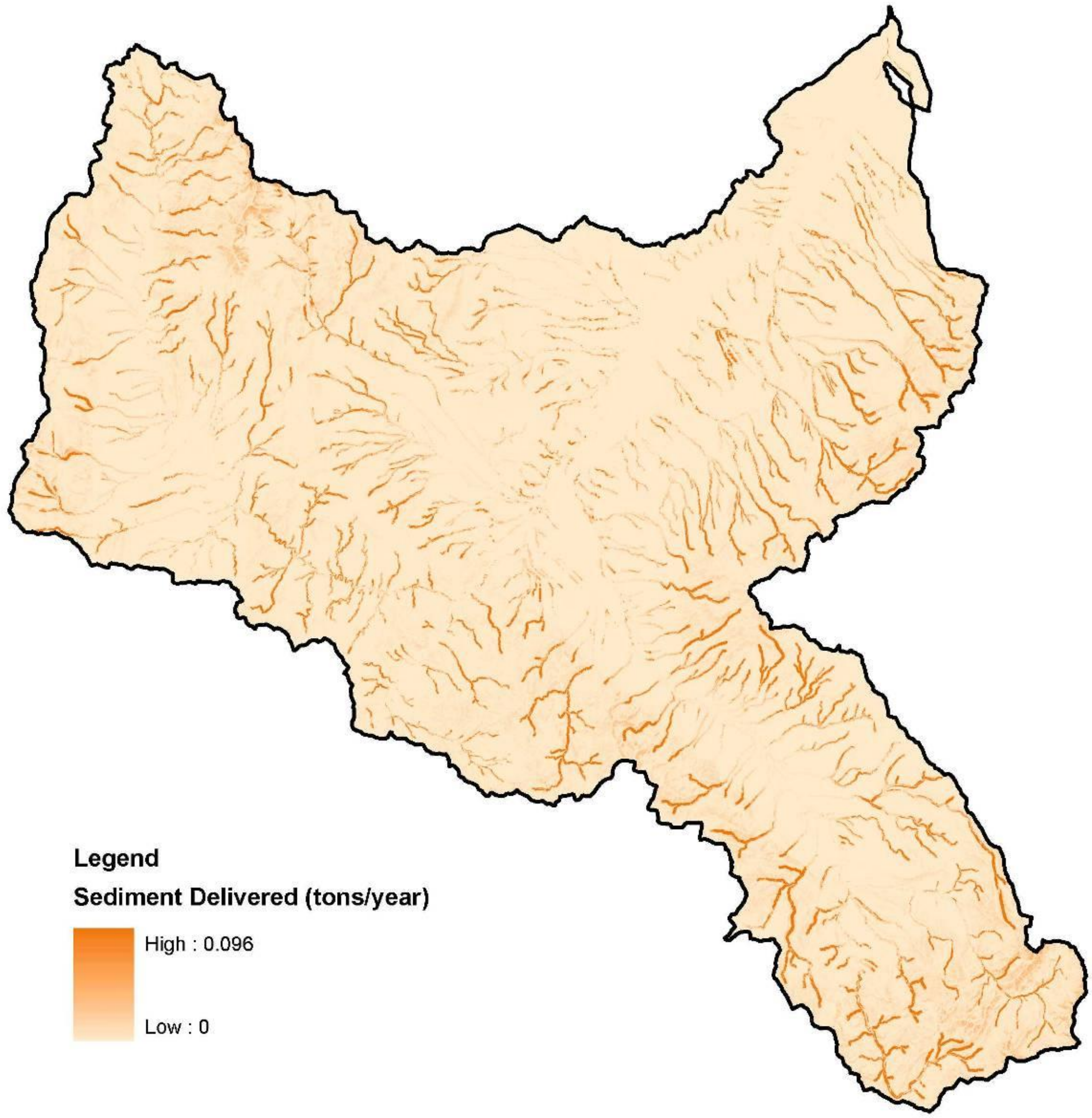

Figure F1-12. Upland Erosion Sediment Load for BMP Upland Conditions and Existing Riparian Health Conditions, Scenario 2.

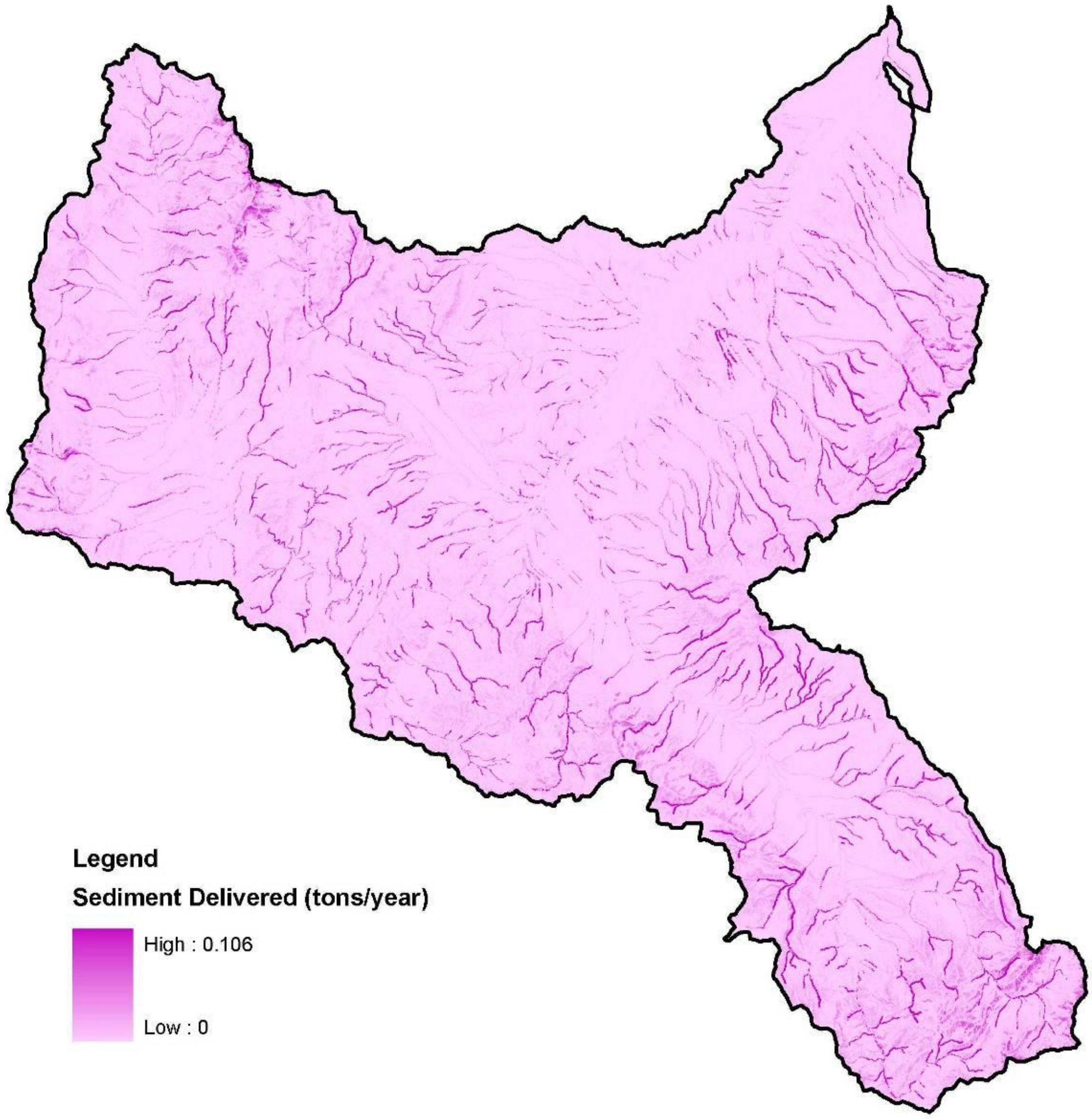

Figure F1-13. Upland Erosion Sediment Load for Existing Upland Conditions and BMP Riparian Health Conditions, Scenario 3.

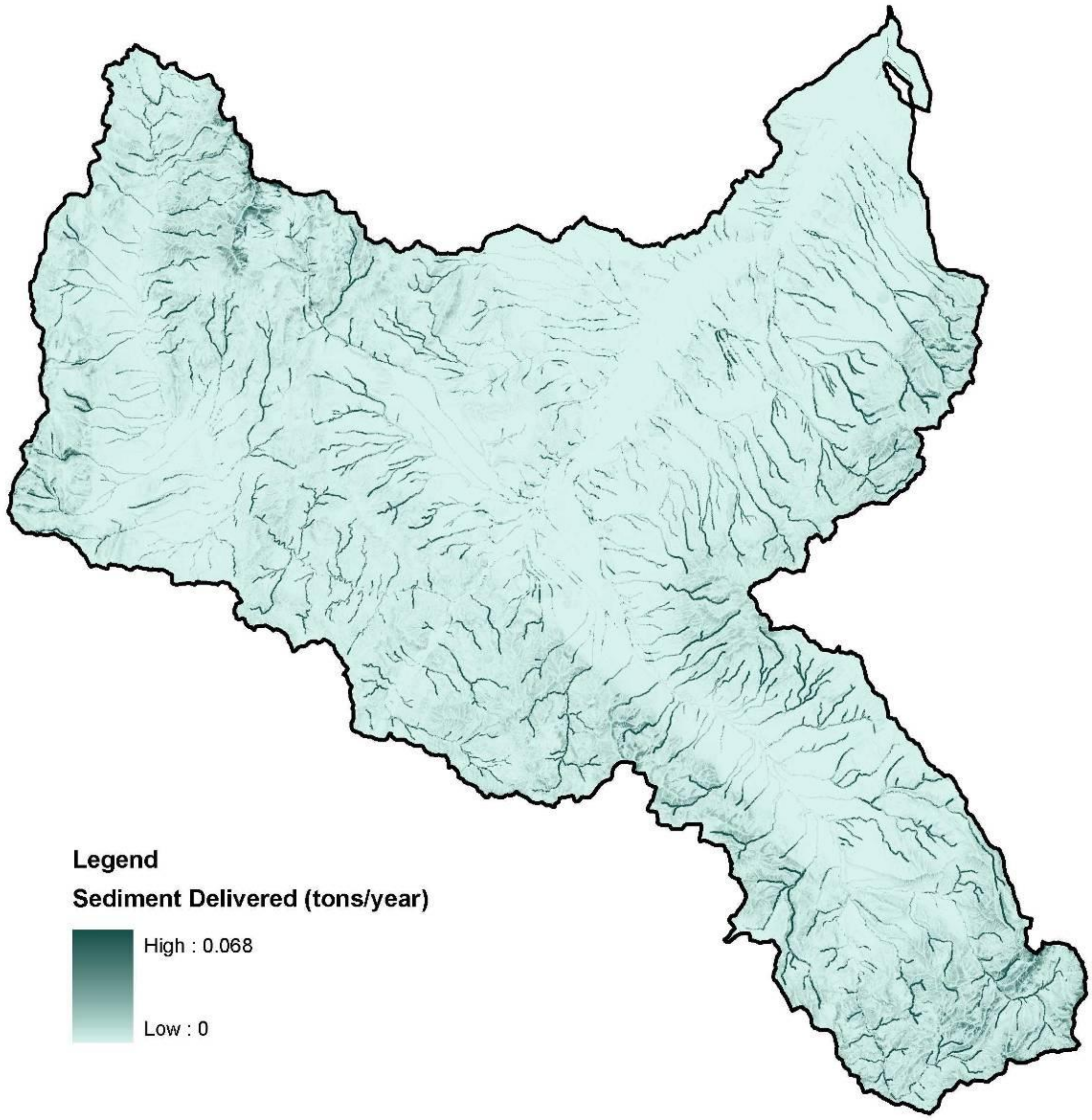

Figure F1-14. Upland Erosion Sediment Load for BMP Upland Conditions and BMP Riparian Health Conditions, Scenario 4.

Table F1-7. Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	**Land Cover Classification**	**Area (acres)**	**Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)**	**Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**
Farlin Creek	Grassland/herbaceous	905.2	46.5	23.3	50%	27.6	41%	13.8	70%
	Shrub/scrub	602.7	24.6	12.3	50%	17.8	28%	8.9	64%
	Evergreen forest	2,070.30	22.1	22.1	0%	12.9	42%	12.9	42%
	Pasture/Hay	28.4	<1	<1	0%	<1	0%	<1	0%
	Barren land	8.9	<1	<1	0%	<1	0%	<1	0%
	Total	**3,615.50**	**93.5**	**57.8**	**38%**	**58.4**	**38%**	**35.6**	**62%**
Steel Creek	Grassland/herbaceous	920.2	34.4	17.2	50%	23	33%	11.5	67%
	Shrub/scrub	703	22.3	11.1	50%	13.4	40%	6.7	70%
	Evergreen forest	746.1	4.4	4.4	0%	3	32%	3	32%
	Pasture/Hay	0.2	<1	<1	0%	<1	0%	<1	0%
	Total	**2,369.60**	**61.1**	**32.7**	**46%**	**39.4**	**35%**	**21.2**	**65%**
Scudder Creek	Grassland/herbaceous	668.7	68.8	34.4	50%	36.3	47%	18.2	74%
	Shrub/scrub	433	28.4	14.2	50%	11.5	59%	5.8	80%
	Evergreen forest	799.3	5.6	5.6	0%	2.9	48%	2.9	48%
	Pasture/Hay	26.8	<1	<1	0%	<1	0%	<1	0%
	Barren land	0.7	<1	<1	0%	<1	0%	<1	0%
	Total	**1,928.60**	**103**	**54.3**	**47%**	**50.9**	**51%**	**26.9**	**74%**
West Fork Dyce Creek	Grassland/herbaceous	723.5	49.3	24.6	50%	27.7	44%	13.9	72%
	Shrub/scrub	508.5	29	14.5	50%	13	55%	6.5	78%
	Evergreen forest	1,106.20	10	10	0%	5.1	50%	5.1	50%
	Barren land	0.4	<1	<1	0%	<1	0%	<1	0%
	Total	**2,338.50**	**88.3**	**49.1**	**44%**	**45.8**	**48%**	**25.4**	**71%**

Table F1-7. Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	**Land Cover Classification**	**Area (acres)**	**Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)**	**Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**
Dyce Creek	Grassland/herbaceous	1,692.40	90.1	45.1	50%	52.7	42%	26.3	71%
	Shrub/scrub	2,612.00	50.2	25.1	50%	28	44%	14	72%
	Evergreen forest	1,970.10	17.9	17.9	0%	10.4	42%	10.4	42%
	Pasture/Hay	84.9	3.1	1.5	50%	1.7	45%	0.8	72%
	Developed, open space	5.1	<1	<1	0%	<1	0%	<1	0%
	Developed, low intensity	4	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	1.1	<1	<1	0%	<1	0%	<1	0%
	Developed, medium intensity	4.4	<1	<1	0%	<1	0%	<1	0%
	Barren land	19.9	<1	<1	0%	<1	0%	<1	0%
	Total	**6,393.80**	**161.4**	**89.7**	**44%**	**92.9**	**42%**	**51.7**	**68%**
Taylor Creek	Grassland/herbaceous	4,087.80	178.7	89.3	50%	90.3	49%	45.1	75%
	Shrub/scrub	7,362.00	153.7	76.9	50%	72.8	53%	36.4	76%
	Evergreen forest	1,993.80	8.1	8.1	0%	4.8	41%	4.8	41%
	Pasture/Hay	135.1	3.2	1.6	50%	1.6	49%	0.8	74%
	Developed, open space	27.3	<1	<1	0%	<1	0%	<1	0%
	Developed, low intensity	6.6	<1	<1	0%	<1	0%	<1	0%
	Barren land	1.1	<1	<1	0%	<1	0%	<1	0%
	Total	**13,613.70**	**343.7**	**175.9**	**49%**	**169.5**	**51%**	**87.1**	**75%**
Reservoir Creek	Grassland/herbaceous	4,589.90	76.5	38.2	50%	39	49%	19.5	74%
	Shrub/scrub	2,971.80	22.9	11.5	50%	12.9	44%	6.4	72%
	Evergreen forest	1,066.00	14.8	14.8	0%	8.6	42%	8.6	42%
	Pasture/Hay	282.8	2	1	50%	1.1	45%	0.5	73%
	Barren land	2.9	<1	<1	0%	<1	0%	<1	0%
	Total	**8,913.50**	**116.1**	**65.4**	**44%**	**61.5**	**47%**	**35**	**70%**

Table F1-7. Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	**Land Cover Classification**	**Area (acres)**	**Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)**	**Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**
Grasshopper Creek	Grassland/herbaceous	72,395.80	1,293.90	646.9	50%	727	44%	363.5	72%
	Shrub/scrub	49,785.70	1,015.70	507.9	50%	519.7	49%	259.9	74%
	Evergreen forest	54,946.30	525.1	525.1	0%	312.5	40%	312.5	40%
	Pasture/Hay	5,687.30	29.1	14.6	50%	15.6	47%	7.8	73%
	Developed, open space	160.2	<1	<1	0%	<1	0%	<1	0%
	Developed, low intensity	77.5	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	67.6	<1	<1	0%	<1	0%	<1	0%
	Transitional	1,539.70	27.2	13.6	50%	16.8	38%	8.4	69%
	Developed, medium intensity	30.1	<1	<1	0%	<1	0%	<1	0%
	Barren land	356.4	<1	<1	0%	<1	0%	<1	0%
	Emergent Herbaceous Wetlands	8.9	<1	<1	0%	<1	0%	<1	0%
	Mixed forest	3.5	<1	<1	0%	<1	0%	<1	0%
	Deciduous forest	7.6	<1	<1	0%	<1	0%	<1	0%
	Total	**185,066.60**	**2,892.20**	**1,709.10**	**41%**	**1,592.50**	**45%**	**952.9**	**67%**
Clark Canyon Creek*	Grassland/herbaceous	4,159.10	64.6	48.5	25%	52.9	18%	39.8	38%
	Shrub/scrub	3,036.40	56.1	42.1	25%	42.8	24%	32	43%
	Evergreen forest	3,602.60	22.9	22.9	0%	18	21%	18	21%
	Pasture/Hay	67.8	1.8	0.9	50%	1.3	29%	0.6	65%
	Developed, open space	5.7	<1	<1	0%	<1	0%	<1	0%
	Developed, low intensity	7.3	<1	<1	0%	<1	0%	<1	0%
	Transitional	163.5	1	0.5	50%	0.9	5%	0.5	53%
	Developed, medium intensity	5.5	<1	<1	0%	<1	0%	<1	0%
	Total	**11,047.80**	**146.3**	**114.9**	**21%**	**116**	**21%**	**90.9**	**38%**

Table F1-7. Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	Land Cover Classification	Area (acres)	Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing
Beaverhead River Upper	Grassland/herbaceous	12,834.10	249.6	124.8	50%	171.1	31%	85.5	66%
	Shrub/scrub	9,811.30	184.4	92.2	50%	121.6	34%	60.8	67%
	Evergreen forest	240.3	2.2	2.2	0%	1.6	26%	1.6	26%
	Pasture/Hay	861	2.2	1.1	50%	1.4	36%	0.7	68%
	Developed, open space	580.2	2.3	2.3	0%	1.4	37%	1.4	37%
	Developed, low intensity	562	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	221.8	<1	<1	0%	<1	0%	<1	0%
	Transitional	778.1	8.1	4.1	50%	6.3	22%	3.2	61%
	Developed, medium intensity	112.7	<1	<1	0%	<1	0%	<1	0%
	Barren land	1.1	<1	<1	0%	<1	0%	<1	0%
	Total	**26,002.60**	**449.7**	**227.4**	**49%**	**304**	**32%**	**153.7**	**66%**
French Creek	Grassland/herbaceous	1,796.80	160.7	80.3	50%	114.2	29%	57.1	64%
	Shrub/scrub	666.8	26.5	13.2	50%	19.7	25%	9.9	63%
	Evergreen forest	4,286.00	32.8	32.8	0%	25.3	23%	25.3	23%
	Pasture/Hay	0.9	<1	<1	0%	<1	0%	<1	0%
	Total	**6,750.60**	**219.9**	**126.3**	**43%**	**159.2**	**28%**	**92.2**	**58%**
Rattlesnake Creek Upper	Grassland/herbaceous	7,294.20	233.1	116.6	50%	175	25%	87.5	62%
	Shrub/scrub	6,846.50	145	72.5	50%	88.8	39%	44.4	69%
	Evergreen forest	13,932.40	109.4	109.4	0%	66.4	39%	66.4	39%
	Pasture/Hay	211.2	4.8	2.4	50%	2.7	44%	1.4	72%
	Developed, open space	6.4	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	1.1	<1	<1	0%	<1	0%	<1	0%
	Developed, medium intensity	4.1	<1	<1	0%	<1	0%	<1	0%
	Barren land	125.7	<1	<1	0%	<1	0%	<1	0%
	Total	**28,421.50**	**492.8**	**301.3**	**39%**	**333.3**	**32%**	**200**	**59%**

Table F1-7. Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	Land Cover Classification	Area (acres)	Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing
Rattlesnake Creek Lower	Grassland/herbaceous	26,358.20	337.2	168.6	50%	195.7	42%	97.9	71%
	Shrub/scrub	20,279.10	382.8	191.4	50%	212.1	45%	106.1	72%
	Evergreen forest	960	2.3	2.3	0%	1.8	21%	1.8	21%
	Pasture/Hay	4,884.10	11.3	5.7	50%	6.8	40%	3.4	70%
	Cultivated Crops	2,431.80	39.3	19.6	50%	22.5	43%	11.2	71%
	Developed, open space	1,049.30	<1	<1	0%	<1	0%	<1	0%
	Developed, low intensity	518.4	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	5.1	<1	<1	0%	<1	0%	<1	0%
	Developed, medium intensity	268.2	<1	<1	0%	<1	0%	<1	0%
	Barren land	13.7	<1	<1	0%	<1	0%	<1	0%
	Total	**56,767.90**	**773.5**	**388.2**	**50%**	**439.2**	**43%**	**220.7**	**71%**
West Fork Blacktail Deer Creek	Grassland/herbaceous	21,176.00	967.2	483.6	50%	434.5	55%	217.3	78%
	Shrub/scrub	3,027.00	98.1	49	50%	42.8	56%	21.4	78%
	Evergreen forest	8,282.40	138.5	138.5	0%	62.9	55%	62.9	55%
	Pasture/Hay	74.9	2.4	1.2	50%	1	58%	0.5	79%
	Developed, open space	216.2	5.7	5.7	0%	1.7	70%	1.7	70%
	Developed, low intensity	1.1	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	2.2	<1	<1	0%	<1	0%	<1	0%
	Barren land	23.5	<1	<1	0%	<1	0%	<1	0%
	Mixed forest	7.1	<1	<1	0%	<1	0%	<1	0%
	Total	**32,810.50**	**1,212.10**	**678.2**	**44%**	**543**	**55%**	**303.8**	**75%**
East Fork Blacktail Deer Creek	Grassland/herbaceous	22,892.10	714	357	50%	575	19%	287.5	60%
	Shrub/scrub	2,623.70	50	25	50%	41.5	17%	20.7	59%
	Evergreen forest	12,801.80	148.2	148.2	0%	115.6	22%	115.6	22%
	Pasture/Hay	143.4	1.9	1	50%	1.3	30%	0.7	65%
	Woody Wetlands	6.9	<1	<1	0%	<1	0%	<1	0%
	Barren land	295.6	<1	<1	0%	<1	0%	<1	0%
	Emergent Herbaceous Wetlands	1.1	<1	<1	0%	<1	0%	<1	0%
	Mixed forest	127.7	<1	<1	0%	<1	0%	<1	0%
	Total	**38,892.40**	**915.6**	**532.6**	**42%**	**734.7**	**20%**	**425.7**	**54%**

Table F1-7. Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	**Land Cover Classification**	**Area (acres)**	**Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)**	**Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**
Blacktail Deer Creek	Grassland/herbaceous	113,640.40	3,273.90	1,636.90	50%	1,872.40	43%	936.2	71%
	Shrub/scrub	23,916.20	744.9	372.5	50%	372.4	50%	186.2	75%
	Evergreen forest	14,372.50	224.3	224.3	0%	130.5	42%	130.5	42%
	Pasture/Hay	10,735.50	39.8	19.9	50%	23.1	42%	11.5	71%
	Cultivated Crops	2,628.80	57.5	28.7	50%	32.9	43%	16.5	71%
	Developed, open space	1,929.60	3	3	0%	1.7	43%	1.7	43%
	Developed, low intensity	667.1	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	458.6	1.4	0.6	54%	0.8	40%	0.4	72%
	Developed, medium intensity	354.9	<1	<1	0%	<1	0%	<1	0%
	Barren land	79	<1	<1	0%	<1	0%	<1	0%
	Emergent Herbaceous Wetlands	303.6	<1	<1	0%	<1	0%	<1	0%
	Developed, high intensity	55.6	<1	<1	0%	<1	0%	<1	0%
	Mixed forest	14	<1	<1	0%	<1	0%	<1	0%
	Deciduous forest	23	<1	<1	0%	<1	0%	<1	0%
	Total	**169,178.80**	**4,345.10**	**2,286.30**	**47%**	**2,434.10**	**44%**	**1,283.20**	**70%**
Stone Creek Upper	Grassland/herbaceous	8,703.30	428.9	214.5	50%	221.1	48%	110.5	74%
	Shrub/scrub	5,394.40	255.1	127.5	50%	116.3	54%	58.2	77%
	Evergreen forest	1,356.90	23.2	23.2	0%	10.7	54%	10.7	54%
	Pasture/Hay	244.1	3.4	1.7	50%	1.9	46%	0.9	73%
	Cultivated Crops	105.1	4.8	2.4	50%	2.1	55%	1.1	78%
	Developed, open space	99.3	<1	<1	0%	<1	0%	<1	0%
	Developed, low intensity	7.8	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	2.7	<1	<1	0%	<1	0%	<1	0%
	Barren land	18.6	<1	<1	0%	<1	0%	<1	0%
	Total	**15,932.10**	**715.9**	**369.8**	**48%**	**352.3**	**51%**	**181.6**	**75%**

Table F1-7. Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	Land Cover Classification	Area (acres)	Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing
Stone Creek Lower	Grassland/herbaceous	4,179.40	68	34	50%	39.7	42%	19.9	71%
	Shrub/scrub	873.6	19.2	9.6	50%	10	48%	5	74%
	Pasture/Hay	2,508.70	12.8	6.4	50%	6.9	46%	3.5	73%
	Cultivated Crops	2,012.60	112.1	56	50%	63.2	44%	31.6	72%
	Developed, open space	289.6	<1	<1	0%	<1	0%	<1	0%
	Developed, low intensity	135.2	<1	<1	0%	<1	0%	<1	0%
	Developed, medium intensity	47.1	<1	<1	0%	<1	0%	<1	0%
	Total	**10,046.20**	**212.7**	**106.7**	**50%**	**120.2**	**44%**	**60.3**	**72%**
Spring Creek	Grassland/herbaceous	16,555.20	441.9	221	50%	240.2	46%	120.1	73%
	Shrub/scrub	3,865.10	133	66.5	50%	75.6	43%	37.8	72%
	Evergreen forest	5,660.80	108.4	108.4	0%	61.6	43%	61.6	43%
	Pasture/Hay	3,112.30	15.2	7.6	50%	8.7	43%	4.4	71%
	Cultivated Crops	1,605.70	51.4	25.7	50%	27.8	46%	13.9	73%
	Developed, open space	1,001.30	1.5	1.5	0%	0.8	46%	0.8	46%
	Developed, low intensity	197.6	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	9.9	<1	<1	0%	<1	0%	<1	0%
	Transitional	293	11.5	5.7	50%	5.8	50%	2.9	75%
	Developed, medium intensity	63.9	<1	<1	0%	<1	0%	<1	0%
	Barren land	6.9	<1	<1	0%	<1	0%	<1	0%
	Total	**32,371.60**	**763.1**	**436.5**	**43%**	**420.8**	**45%**	**241.6**	**68%**

Table F1-7. Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	Land Cover Classification	Area (acres)	Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing
Beaverhead River Lower	Grassland/herbaceous	129,130.40	2,200.00	1,100.00	50%	1,103.50	50%	551.7	75%
	Shrub/scrub	24,982.10	723.3	361.6	50%	349.7	52%	174.9	76%
	Evergreen forest	22,443.50	316.4	316.4	0%	164.4	48%	164.4	48%
	Pasture/Hay	60,943.30	103.6	51.8	50%	56.9	45%	28.5	73%
	Cultivated Crops	34,814.20	485	242.5	50%	249.4	49%	124.7	74%
	Developed, open space	8,424.70	8.9	8.9	0%	3.7	59%	3.7	59%
	Developed, low intensity	4,031.70	1.1	1.1	0%	0.5	55%	0.5	55%
	Woody Wetlands	3,310.60	3.9	1.8	54%	2.6	32%	1.2	69%
	Transitional	274.7	3.6	1.8	50%	2.1	42%	1	71%
	Developed, medium intensity	2,119.90	<1	<1	0%	<1	0%	<1	0%
	Barren land	68.5	<1	<1	0%	<1	0%	<1	0%
	Developed, high intensity	130.6	<1	<1	0%	<1	0%	<1	0%
	Mixed forest	1.2	<1	<1	0%	<1	0%	<1	0%
	Deciduous forest	2.7	<1	<1	0%	<1	0%	<1	0%
	Total	**290,677.90**	**3,846.20**	**2,086.40**	**46%**	**1,933.00**	**50%**	**1,050.80**	**73%**

*C factors for the desired condition of Grassland/Herbaceous and Shrub/Scrub were adjusted from .010 to .015 in Clark Canyon Creek to account for sections of highly erodable upland areas, within those land cover types, where vegetative cover is unlikely to improve. Adjustments were made after recommendations from a memorandum to the FWP from Applied Geomorphology regarding a Clark Canyon Creek field visit by several local stakeholders.

Table F1-8. Cumulative Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	**Land Cover Classification**	**Area (acres)**	**Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)**	**Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**
Scudder Creek Total (Steel Ck and Scudder Ck)	Grassland/herbaceous	1,588.9	103.2	51.6	50%	59.3	43%	29.6	71%
	Shrub/scrub	1,136.1	50.7	25.3	50%	25.0	51%	12.5	75%
	Evergreen forest	1,545.4	10.0	10.0	0%	5.9	41%	5.9	41%
	Pasture/Hay	27.1	<1	<1	0%	<1	0%	<1	0%
	Barren land	0.7	<1	<1	0%	<1	0%	<1	0%
	Total	**4,298.2**	**164.0**	**87.0**	**47%**	**90.3**	**45%**	**48.1**	**71%**
Dyce Creek Total (West Fork Dyce Ck and Dyce Ck)	Grassland/herbaceous	2,415.8	139.4	69.7	50%	80.4	42%	40.2	71%
	Shrub/scrub	3,120.5	79.2	39.6	50%	41.1	48%	20.5	74%
	Evergreen forest	3,076.3	27.9	27.9	0%	15.5	45%	15.5	45%
	Pasture/Hay	84.9	3.1	1.5	50%	1.7	45%	0.8	72%
	Developed, open space	5.1	<1	<1	0%	<1	0%	<1	0%
	Developed, low intensity	4.0	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	1.1	<1	<1	0%	<1	0%	<1	0%
	Developed, medium intensity	4.4	<1	<1	0%	<1	0%	<1	0%
	Barren land	20.3	<1	<1	0%	<1	0%	<1	0%
	Total	**8,732.3**	**249.6**	**138.8**	**44%**	**138.7**	**44%**	**77.1**	**69%**

Table F1-8. Cumulative Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	**Land Cover Classification**	**Area (acres)**	**Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)**	**Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**
Grasshopper Creek Total (Farlin Ck, Steel Ck, Scudder Ck, W.F. Dyce Ck, Dyce Ck, Taylor Ck, Reservoir Ck, and Grasshopper Ck)	Grassland/herbaceous	85,983.4	1,838.1	919.0	50%	1,023.5	44%	511.8	72%
	Shrub/scrub	64,978.7	1,346.8	673.4	50%	689.2	49%	344.6	74%
	Evergreen forest	64,698.1	607.9	607.9	0%	360.1	41%	360.1	41%
	Pasture/Hay	6,245.5	37.8	18.9	50%	20.2	47%	10.1	73%
	Developed, open space	192.6	<1	<1	0%	<1	0%	<1	0%
	Developed, low intensity	88.1	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	68.7	<1	<1	0%	<1	0%	<1	0%
	Transitional	1,539.7	27.2	13.6	50%	16.8	38%	8.4	69%
	Developed, medium intensity	34.5	<1	<1	0%	<1	0%	<1	0%
	Barren land	390.2	<1	<1	0%	<1	0%	<1	0%
	Emergent Herbaceous Wetlands	8.9	<1	<1	0%	<1	0%	<1	0%
	Mixed forest	3.5	<1	<1	0%	<1	0%	<1	0%
	Deciduous forest	7.6	<1	<1	0%	<1	0%	<1	0%
	Total	**224,239.6**	**3,859.2**	**2,234.1**	**42%**	**2,110.9**	**45%**	**1,235.9**	**68%**
Beaverhead River Upper Total (Clark Canyon C and Beaverhead River Upper)	Grassland/herbaceous	16,993.2	314.2	173.3	45%	224.00	29%	125.3	64%
	Shrub/scrub	12,847.7	240.4	134.3	44%	164.40	32%	92.8	66%
	Evergreen forest	3,842.9	25.1	25.1	0%	19.60	22%	19.6	22%
	Pasture/Hay	928.8	4.0	2	50%	2.70	33%	1.3	68%
	Developed, open space	585.9	2.3	2.3	0%	1.43	39%	1.4	39%
	Developed, low intensity	569.3	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	221.7	<1	<1	0%	<1	0%	<1	0%
	Transitional	941.6	9.1	4.5	51%	7.3	20%	3.6	60%
	Developed, medium intensity	118.2	<1	<1	0%	<1	0%	<1	0%
	Barren land	1.1	<1	<1	0%	<1	0%	<1	0%
	Total	**37,050.4**	**596.0**	**342.2**	**43%**	**420.0**	**30%**	**244.6**	**59%**

Table F1-8. Cumulative Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	Land Cover Classification	Area (acres)	Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)	Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing	Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)	Percent Change from Existing
Rattlesnake Creek Upper Total (French Ck and Rattlesnake Ck Upper)	Grassland/herbaceous	9,091.0	393.8	196.9	50%	289.2	27%	144.6	63%
	Shrub/scrub	7,513.2	171.5	85.8	50%	108.5	37%	54.2	68%
	Evergreen forest	18,218.4	142.2	142.2	0%	91.7	36%	91.7	36%
	Pasture/Hay	212.1	4.8	2.4	50%	2.7	44%	1.4	72%
	Developed, open space	6.4	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	1.1	<1	<1	0%	<1	0%	<1	0%
	Developed, medium intensity	4.1	<1	<1	0%	<1	0%	<1	0%
	Barren land	125.7	<1	<1	0%	<1	0%	<1	0%
	Total	**35,172.0**	**712.7**	**427.7**	**40%**	**492.4**	**31%**	**292.2**	**59%**
Rattlesnake Creek Total (Rattlesnake Ck Upper Total and Rattlesnake Ck Lower)	Grassland/herbaceous	35,449.2	731.0	365.5	50%	484.9	34%	242.4	67%
	Shrub/scrub	27,792.3	554.3	277.1	50%	320.6	42%	160.3	71%
	Evergreen forest	19,178.4	144.5	144.5	0%	93.5	35%	93.5	35%
	Pasture/Hay	5,096.2	16.2	8.1	50%	9.5	41%	4.7	71%
	Cultivated Crops	2,431.8	39.3	19.6	50%	22.5	43%	11.2	71%
	Developed, open space	1,055.6	<1	<1	0%	<1	0%	<1	0%
	Developed, low intensity	518.4	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	6.2	<1	<1	0%	<1	0%	<1	0%
	Developed, medium intensity	272.3	<1	<1	0%	<1	0%	<1	0%
	Barren land	139.4	<1	<1	0%	<1	0%	<1	0%
	Total	**91,939.9**	**1,486.3**	**815.9**	**45%**	**931.7**	**37%**	**512.9**	**65%**

Table F1-8. Cumulative Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	**Land Cover Classification**	**Area (acres)**	**Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)**	**Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**
Blacktail Deer Creek Total (W.F. Blacktail Deer Ck, E.F. Blacktail Deer Ck, and Blacktail Deer Ck)	Grassland/herbaceous	157,708.6	4,955.1	2,477.5	50%	2,881.9	42%	1,441.0	71%
	Shrub/scrub	29,566.9	893.1	446.5	50%	456.7	49%	228.3	74%
	Evergreen forest	35,456.7	511.0	511.0	0%	309.0	40%	309.0	40%
	Pasture/Hay	10,953.8	44.1	22.0	50%	25.4	42%	12.7	71%
	Cultivated Crops	2,628.8	57.5	28.7	50%	32.9	43%	16.5	71%
	Developed, open space	2,145.8	8.7	8.7	0%	3.4	61%	3.4	61%
	Developed, low intensity	668.2	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	467.7	1.6	0.7	54%	1.0	38%	0.4	72%
	Developed, medium intensity	354.9	<1	<1	0%	<1	0%	<1	0%
	Barren land	398.0	<1	<1	0%	<1	0%	<1	0%
	Emergent Herbaceous Wetlands	304.7	<1	<1	0%	<1	0%	<1	0%
	Developed, high intensity	55.6	<1	<1	0%	<1	0%	<1	0%
	Mixed forest	148.8	<1	<1	0%	<1	0%	<1	0%
	Deciduous forest	23.0	<1	<1	0%	<1	0%	<1	0%
	Total	**240,881.6**	**6,472.8**	**3,497.1**	**46%**	**3,711.8**	**43%**	**2,012.8**	**69%**
Stone Creek Total (Stone Ck Upper and Stone Ck Lower)	Grassland/herbaceous	12,882.6	496.9	248.5	50%	260.8	48%	130.4	74%
	Shrub/scrub	6,268.0	274.3	137.1	50%	126.3	54%	63.1	77%
	Pasture/Hay	1,356.9	23.2	23.2	0%	10.7	54%	10.7	54%
	Cultivated Crops	2,752.7	16.3	8.1	50%	8.8	46%	4.4	73%
	Developed, open space	2,117.6	116.8	58.4	50%	65.3	44%	32.7	72%
	Developed, low intensity	388.9	<1	<1	0%	<1	0%	<1	0%
	Developed, medium intensity	143.1	<1	<1	0%	<1	0%	<1	0%
	Woody Wetlands	2.7	<1	<1	0%	<1	0%	<1	0%
	Developed, medium intensity	47.1	<1	<1	0%	<1	0%	<1	0%
	Barren land	18.6	<1	<1	0%	<1	0%	<1	0%
	Total	**25,978.3**	**928.7**	**476.4**	**49%**	**472.5**	**49%**	**241.9**	**74%**

Table F1-8. Cumulative Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	**Land Cover Classification**	**Area (acres)**	**Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)**	**Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**
Beaverhead River Lower Total (Grasshopper Creek Total, Blacktail Deer Ck Total, Rattlesnake Ck Total, Stone Ck Total, Spring Ck, and Beaverhead River Lower)	Grassland/herbaceous	437,709.4	10,663.1	5,331.50	50%	5,994.8	44%	2,997.4	72%
	Shrub/scrub	157,453.0	3,924.7	1,962.40	50%	2,018.1	49%	1,009.1	74%
	Evergreen forest	148,794.3	1,711.3	1,711.20	0%	999.3	42%	999.3	42%
	Pasture/Hay	89,103.9	233.1	116.50	50%	129.5	44%	64.8	72%
	Cultivated Crops	43,598.1	750.0	375.00	50%	398.0	47%	199.0	73%
	Developed, open space	13,209.0	20.3	20.3	0%	8.5	58%	8.5	58%
	Developed, low intensity	5,647.1	1.5	1.5	0%	0.7	53%	0.7	53%
	Woody Wetlands	3,865.8	5.7	2.6	54%	3.7	35%	1.7	70%
	Transitional	2,107.4	42.3	21.20	50%	24.70	42%	12.3	71%
	Developed, medium intensity	2,892.6	<1	<1	0%	<1	0%	<1	0%
	Barren land	1,021.5	1.5	1.5	0%	1.4	7%	1.4	7%
	Emergent Herbaceous Wetlands	313.6	<1	<1	0%	<1	0%	<1	0%
	Developed, high intensity	186.3	<1	<1	0%	<1	0%	<1	0%
	Mixed forest	153.5	<1	<1	0%	<1	0%	<1	0%
	Deciduous forest	33.3	<1	<1	0%	<1	0%	<1	0%
	Total	**906,089.00**	**17,356.20**	**9,546.40**	**45%**	**9,580.70**	**45%**	**5,295.90**	**69%**

Table F1-8. Cumulative Delivered Sediment Load by Land Cover Type for the Beaverhead TPA.

			Scenario 1	Scenario 2		Scenario 3		Scenario 4	
Sub-basin	**Land Cover Classification**	**Area (acres)**	**Upland Erosion Sediment Load for Existing Conditions and Existing Riparian Health (tons/year)**	**Upland Erosion Sediment Load for BMP Conditions and Existing Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for Existing Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**	**Upland Erosion Sediment Load for BMP Conditions and BMP Riparian Health (tons/year)**	**Percent Change from Existing**
Beaverhead River Total (Beaverhead River Upper Total and Beaverhead River Lower Total)	Grassland/herbaceous	454,702.6	10,977.3	5,504.8	50%	6,218.8	43%	3,122.7	72%
	Shrub/scrub	170,300.8	4,165.2	2096.7	50%	2,182.5	48%	1,101.9	74%
	Evergreen forest	152,637.2	1,736.3	1,736.3	0%	1,018.9	41%	1,018.9	41%
	Pasture/Hay	90,032.8	237.1	118.5	50%	132.2	44%	66.1	72%
	Cultivated Crops	43,598.1	750.0	375.0	50%	398.0	47%	199.0	73%
	Developed, open space	13,794.9	22.9	22.8	0%	10.1	56%	10.1	56%
	Developed, low intensity	6,216.4	2.1	2.1	0%	1.1	49%	1.1	49%
	Woody Wetlands	4,087.5	6.3	2.9	54%	4.1	35%	1.9	70%
	Transitional	3,049.0	51.4	25.7	50%	32.0	38%	16.0	69%
	Developed, medium intensity	3,010.8	<1	<1	0%	<1	0%	<1	0%
	Barren land	1,022.7	2.3	2.3	0%	2.1	6%	2.1	6%
	Emergent Herbaceous Wetlands	313.7	<1	<1	0%	<1	0%	<1	0%
	Developed, high intensity	186.3	<1	<1	0%	<1	0%	<1	0%
	Mixed forest	153.5	<1	<1	0%	<1	0%	<1	0%
	Deciduous forest	33.2	<1	<1	0%	<1	0%	<1	0%
	Total	**943,139.4**	**17,952.2**	**9,888.6**	**45%**	**10,000.6**	**44%**	**5,540.6**	**69%**

F7.0 REFERENCES

Knutson, K and Naef, V. 1997. Management Recommendations for Washington's Priority Habitats Riparian. Washington Department of Fish and Wildlife.

Megahan, W.F.; Ketcheson, G.L. 1996. Predicting downslope travel of granitic sediments from forest roads in Idaho. Water Resources Bulletin. 32: 371-382.

Renard, K.G., G.R. Foster, G.A. Weesies, D.K. McCool, and D.C. Yoder. 1997. Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE). USDA Agriculture Handbook No. 703, 404 pp.

Wenger, S. 1999. A review of the Scientific Literature on Riparian Buffer Width, Extent, and Vegetation. Prepared for the Office of Public Service and Outreach, University of Georgia.

Wischmeier, W.H., and D.D. Smith. 1978. Predicting rainfall erosion losses, a guide to conservation planning. Agriculture Handbook No. 537, U.S. Department of Agriculture, Washington D.C.

ATTACHMENT FA. – ASSIGNMENT OF USLE C-FACTORS TO NLCD LANDCOVER VALUES

The NRCS table "C-Factors for Permanent Pasture, Rangeland, Idle Land, and Grazed Woodland" (**Figure FA-1**) was used to develop C-factors for the various land use types as defined by the NLCD database within the Lower Clark Fork Tributaries watershed. This table uses four sub-factors: the vegetative canopy type and height, the vegetative canopy percent cover, the type of cover that contacts the soil surface, and the percent ground cover to derive a C-factor. The resulting C-factor is very sensitive to the type and percent of ground cover and less sensitive to the type and percent of canopy cover.

The type and percent of canopy cover were determined based on the NLCD land use definition. In some cases the minimum percent canopy cover specified in the land use definition was used and resulted in a conservative C-factor. The type of ground cover was considered to be G (cover is grass, grasslike plants, decaying compacted duff, or litter at least 2 inches deep) for all of the land uses in the Beaverhead TPA. The percent ground cover not only includes the basal plant material, but also gravel and plant litter. The percent ground cover for each of the land uses within the Beaverhead TPA was estimated by Confluence.

Table FA-1 provides the C-factors for all land use types within the sub-basins of interest in the Beaverhead TPA for the existing conditions. The C-factors for the 'barren land', 'developed, low intensity', 'developed, medium intensity', and 'developed, high intensity' land uses are the same C-factors previously recommended by Richard Fasching, the former Montana State Agronomist, for other hillslope USLE modeling efforts.

Table FA-2 provides the C-factors for all land use types within the sub-basins of interest in the Beaverhead TPA for the desired well managed scenario. The percent ground cover was increased by 10% over the existing percentage for the 'grassland/herbaceous', 'shrub/scrub', 'pasture/hay', and 'woody wetlands' land uses to reflect a decrease in grazing. For the 'cultivated crops' land use, the percent ground cover was increased by 20% over the existing percentage to reflect improved agricultural practices. For the 'transitional' land use, the desired scenario assumed a return to a forest land use. The C-factors for the other land use types were not changed. This is similar to the methods used by the DEQ for the Shields River watershed TMDL and by Confluence for other hillslope USLE modeling efforts.

These tables were reviewed and approved by Kyle Tackett, an NRCS employee familiar with the Beaverhead TPA.

Exhibit MT510.03

"C" Factors for Permanent Pasture, Rangeland, Idle Land, and Grazed Woodland 1/

Vegetal Canopy			Cover that Contacts the Surface (Vegetation, living and dead)					
Type and Height of Raised Canopy 2/	Canopy Cover 3/ %	Type 4/	Percent Ground Cover					
			0	20	40	60	80	95-100
No appreciable canopy		G	.45	.20	.10	.042	.013	.003
		W	.45	.24	.15	.090	.043	.011
Canopy of tall grass, weeds or brushes with average drop fall height of less than 3 feet 5/	25	G	.36	.17	.09	.038	.012	.003
		W	.36	.20	.13	.082	.041	.011
	50	G	.26	.13	.07	.035	.012	.003
		W	.26	.16	.11	.075	.039	.011
	75	G	.17	.10	.06	.031	.011	.003
		W	.17	.12	.09	.067	.038	.011
Appreciable brush or bushes (2 m fall ht.)	25	G	.40	.18	.09	.040	.013	.003
		W	.40	.22	.14	.085	.042	.011
	50	G	.34	.16	.085	.038	.012	.003
		W	.34	.19	.13	.081	.041	.011
	75	G	.28	.14	.08	.036	.012	.003
		W	.28	.17	.12	.077	.040	.011
Trees but no appreciable low brush (4 m fall ht.)	25	G	.42	.19	.10	.041	.013	.003
		W	.42	.23	.14	.087	.042	.011
	50	G	.39	.18	.09	.040	.013	.003
		W	.39	.21	.14	.085	.042	.011
	75	G	.36	.17	.09	.039	.012	.003
		W	.36	.20	.13	.083	.041	.011

1/ All values shown assume: 1) random distribution of mulch or vegetation, and 2) mulch of appreciable depth where it exists. Idle land refers to land with undisturbed profiles for at least a period of three consecutive years. Also to be used for burned forest land and forest land that has been harvested less than three years ago.

For grazed woodland with high buildup of organic matter in the topsoil under permanent forest conditions, multiply the table values by 0.7.

2/ Average fall height of waterdrops from canopy to soil surface: m = meters.

3/ Portion of total-area surface that would be hidden from view by canopy in a vertical projection, (a bird's-eye view).

4/ G: Cover at surface is grass, grasslike plants, decaying compacted duff.
W: Cover at surface is mostly broadleaf herbaceous plants (as weeds with little lateral-root network near the surface), and/or undecayed residue.

5/ The portion of a grass or weed cover that contacts the soil surface during a rainstorm and interferes with water flow over the soil surface is included in "cover at the surface." The remainder is included in canopy cover.

Figure FA-1. NRCS C-factor table

Table FA-1. C-factors for land cover types in the Beaverhead TPA for existing conditions.

NLCD #	Name	Type and Height of Raised Canopy	Percent Canopy Cover	Type	Percent Ground Cover	C-factor
21	Developed, open space	no appreciable canopy	-	G	95-100	0.003
22	Developed, low intensity	-	-	-	-	0.001
23	Developed, medium intensity	-	-	-	-	0.001
24	Developed, high intensity	-	-	-	-	0.001
31	Barren land	-	-	-	-	0.001
41	Deciduous forest	trees	75	G	95-100	0.003
42	Evergreen forest	trees	75	G	95-100	0.003
43	Mixed forest	trees	75	G	95-100	0.003
52	Shrub/scrub	appreciable brush	25	G	75	0.020
71	Grassland/herbaceous	no appreciable canopy	-	G	75	0.020
81	Pasture/Hay	no appreciable canopy	-	G	75	0.020
82	Cultivated Crops	no appreciable canopy	-	G	20	0.200
90	Woody Wetlands	trees	25	G	80	0.013
95	Emergent Herbaceous Wetlands	tall grass	75	G	95-100	0.003
99	Transitional	trees	25	G	90	0.006

Notes: Canopy cover percents were selected based on the land cover class definition.
Low, medium, and high intensity development land uses are assumed to be the same as barren land.
Deciduous and mixed forest land uses are assumed to be the same as evergreen forest.

Table FA-2. C-factors for land cover types in the Beaverhead TPA for BMP conditions.

NLCD #	Name	Type and Height of Raised Canopy	Percent Canopy Cover	Type	Percent Ground Cover	C-factor
21	Developed, open space	no appreciable canopy	-	G	95-100	0.003
22	Developed, low intensity	-	-	-	-	0.001
23	Developed, medium intensity	-	-	-	-	0.001
24	Developed, high intensity	-	-	-	-	0.001
31	Barren land	-	-	-	-	0.001
41	Deciduous forest	trees	75	G	95-100	0.003
42	Evergreen forest	trees	75	G	95-100	0.003
43	Mixed forest	trees	75	G	95-100	0.003
52	Shrub/scrub	appreciable brush	25	G	85	0.010
71	Grassland/herbaceous	no appreciable canopy	-	G	85	0.010
81	Pasture/Hay	no appreciable canopy	-	G	85	0.010
82	Cultivated Crops	no appreciable canopy	-	G	40	0.100
90	Woody Wetlands	trees	25	G	90	0.006
95	Emergent Herbaceous Wetlands	tall grass	75	G	95-100	0.003
99	Transitional	trees	75	G	95-100	0.003

Notes: Canopy cover percents were selected based on the land cover class definition.
Low, medium, and high intensity development land uses are assumed to be the same as barren land.
Deciduous and mixed forest land uses are assumed to be the same as evergreen forest.