APPENDICES

APPENDIX A
HABITAT AND WATER QUALITY RESTORATION COMMITTEE (2003)

Name	Affiliation
Bob Anderson	Hydrometrics Consulting, Blackfoot Challenge Consultant
Duane Anderson	Natural Resources Information System
Nancy Anderson	Bureau of Land Management & Blackfoot Challenge Board
Tina Bernd-Cohen	Blackfoot Challenge Executive Director
Karin Boyd	Applied Geomorphology, Inc.
Stan Bradshaw	Trout Unlimited Western Water Project, BBCTU
Laura Burns	U.S. Forest Service
Bob Bushnell	Lewis & Clark Conservation District
Jo Christiansen	Bureau of Land Management
David Cochran	North Powell Conservation District & Blackfoot Challenge Board
Tara Comfort	Missoula Conservation District
Julie DalSoglio	Environmental Protection Agency
Bob Davis	U.S. Geological Service
Larry Dolan	Dept. of Natural Resources & Conservation
Carol Endicott	Confluence Consulting, Inc.
Craig Englehard	Natural Resource Conservation Service
Kevin Ertle	U.S. Fish and Wildlife Services
Chris Evans	Lewis & Clark Conservation Districts
Jeff Everett	U.S. Fish and Wildlife Services & BBCTU
Bruce Farling	Trout Unlimited
Steve Flood	Bureau of Land Management
Gary Franks	Department of Natural Resources & Conservation
Becky Garland	Lincoln Resident
Mindy Gauthier	Natural Resources Conservation Service, District Conservationist
Mark Gerlack	Greenough Resident & BBCTU
Hank Goetz	UM-Lubrecht Experimental Forest & Blackfoot Challenge Lands Director
Glen Greene	Natural Resources Conservation Service, District Conservationist
Renne Hanna	Dept. of Natural Resources & Conservation
Dave Helig	Natural Resources Conservation Service
Cora Helm	Montana Dept. of Transportation
George Hirschenberger	Bureau of Land Management
Gary Ingman	Land and Water Consulting

Name	Affiliation
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Amber Kamps	U.S. Forest Service & Blackfoot Challenge Board
Warren Kellogg	Dept. of Natural Resources & Conservation
John Lambing	U.S. Geological Service
Caroline Laws	Big Blackfoot Chapter of Trout Unlimited
Tony Liane	Dept. Natural Resources & Conservation & Blackfoot Challenge Board
Mack Long	MT Fish, Wildlife & Parks & Blackfoot Challenge Board
Tim Love	U.S. Forest Service & Blackfoot Challenge Board
Jim Lovell	Confluence Consulting, Inc.
David Mannix	Helmville Rancher & Blackfoot Challenge Board
Dave Marshall	DTM Consulting, Inc.
Mike McLane	Dept. of Natural Resources & Conservation
Alan McNeal	Blackfoot Challenge Land Steward
Rich Moy	Dept. of Natural Resources & Conservation
Greg Neudecker	U.S. Fish and Wildlife Service, Blackfoot Challenge Board, & BBCTU
Glen Phillips	Montana Fish, Wildlife & Parks
Tom Pick	Natural Resource Conservation Service
Ron Pierce	Montana Fish, Wildlife and Parks
Michael Pipp	Dept. of Environmental Quality
Harry Poett	Big Blackfoot Chapter of Trout Unlimited
Mike Roberts	Dept. of Natural Resources & Conservation
Jim Robinson	Dept. of Natural Resources & Conservation
Amy Rollins	U.S. Forest Service
Skip Rosquist	U.S. Forest Service
Rosie Sada	Dept. of Environmental Quality
Mike Sanctuary	Confluence Consulting, Inc.
Melanie Scott	U.S. Forest Service
Denny Sigars	Plum Creek Timber Company & Blackfoot Challenge Board
Ron Shields	Big Blackfoot Chapter of Trout Unlimited
Ron Steg	Environmental Protection Agency
Stan Sternberg	Montana Dept. of Transportation
Jim Stone	Ovando Rancher & Blackfoot Challenge Chair
Bo Stuart	U.S. Forest Service
Brian Sugden	Plum Creek Timber Company
Larry Urban	Montana Department of Transportation
Steve Wallance	Dept. of Natural Resources & Conservation, Clearwater State Forest

Name	Affiliation
Vicki Watson	University of Montana
Andy Welch	Dept. of Environmental Quality
Kathleen Williams	Montana Fish, Wildlife and Parks
Dean Yashan	Dept. of Environmental Quality
Laura Ziemer	Trout Unlimited Western Water Project

APPENDIX B
MACROINVERTEBRATE AND PERIPHYTON ASSESSMENTS

Evaluations of periphyton and macroinvertebrate community composition are commonly used methods of assessing beneficial use support for associated aquatic life. For the Blackfoot Headwaters Planning Area, a number of sources provide assessments of macroinvertebrate and periphyton assemblages. The most recent data are from a sampling effort conducted in June 2001 on the mainstem of the Blackfoot River and the listed tributaries (Bahls, 2001; Bollman, 2001). Macroinvertebrate assessment data from 1988 and 1989 augment information for the mainstem of the Blackfoot River (McGuire, 1991). This appendix addresses results from biological assessments that relate to siltation (or excess fines) and habitat alteration in the Blackfoot Headwaters Planning Area.

Periphyton assessments include analysis of diatom associations. For diatom associations, performance on the siltation index allows inference into the extent that deposition of fine sediment is impairing aquatic life (Bahls et al., 1992). This metric is a measure of the relative abundance of motile diatoms in the sample. Motile diatoms can maintain their position in depositional environments and theoretically have a competitive advantage when deposition of fine sediment is significant.

Metrics calculated for periphyton samples collected on the Blackfoot River suggested conditions ranging from minor impairment and full support of beneficial uses to severe impairment and non-support of beneficial uses (Table B-1). Relatively high proportions of abnormal cells indicated metals toxicity at the uppermost two stations on the Blackfoot River. None of the samples from the Blackfoot River indicated siltation as a limiting factor; however, metals contamination may have been masking other impairments at the upper two sites.

Diatom associations did not indicate siltation on Poorman Creek (Table B-1). The siltation index was well within the range of full support for the upper and lower sites. At the middle sampling station, the siltation index was slightly elevated and suggested minor impairment from siltation, a condition still consistent with full support of beneficial uses.

Diatom associations sampled on Arrastra Creek, Sandbar Creek, and Willow Creek did not give indications that siltation was a significant impairment to beneficial uses. Both Willow Creek stations indicated only minor impairment from siltation. Similar to the Blackfoot River samples, some of these samples did provide evidence for metals or other toxic constituents that may be masking other water quality problems in these streams.

Macroinvertebrate communities respond to siltation in several ways. For example, because fine sediment fills interstices where macroinvertebrates reside, it can limit biomass of invertebrates. In recent years, richness of clinger taxa emerged as means to assess impacts of siltation on benthic communities. These taxa have fixed retreats or adaptations for attachment to surfaces in flowing water (Merritt et al., 1996) and deposition of fine sediment limits habitat suitability for clingers. Preliminary metric development for Montana mountain streams suggests clinger taxa richness greater than 14 is consistent with non-impairment while clinger richness less than 6 indicates severe impairment and non-support of a beneficial use (Wease Bollman, Rhithron

Biological Assessments, personal communication). Values between 6 and 14 are consistent with moderate impairment and partial support of the aquatic life beneficial use.

Community level metrics calculated for macroinvertebrate associations collected on the Blackfoot River and selected tributaries suggest that these sites range from full support (non-impaired) to partial support (either slightly or moderately impaired) of beneficial uses (Table B-3). As with periphyton associations, metals contamination may be responsible for the relatively low scores on the upper Blackfoot and Sandbar Creek.

Table B-1. Results of Periphyton Analyses for the Blackfoot River and Poorman Creek (Bahls, 2001).

Species/Metric (Pollution Tolerance Class)	Station										
	BlkftR-01		BlkftR-02		BlkftR-03		PoorC-01		PoorC-02		PoorC-03
Achnanthidium minutissimum (3)	25.11		10.13		16.03		1.67		25.94		17.32
Diatoma vulgaris (3)					15.81						
Hannaea arcus (3)			10.13		0.00						
Meridion circulare (3)	2.01		4.00				46.77		1.01		14.84
Pseudostaurosira brevistriata (3)	11.72				3.14						
Staurosira construens (3)	8.26		12.00		8.41		0.84		0.10		3.38
Synedra rumpens (2)	28.35		10.13		1.57				0.30		6.54
Synedra ulna (2)	1.12		3.13		2.02		16.75		4.86		4.47
Number of Cells Counted	448.00		400.00		446.00		418.00		494.00		459.00
Shannon Species Diversity	3.37		4.47		4.56		2.83		4.33		4.42
Pollution Index	2.50		2.57		2.72		2.55		2.56		2.56
Siltation Index	13.06		15.75		18.16		13.64		26.85		16.12
Disturbance Index	25.11		10.13		16.03		1.67		25.94		17.32
Number of Species Counted	39.00		46.00		62.00		27.00		46.00		54.00
Percent Dominant Species	28.35		12.00		16.03		46.77		25.94		17.32
Percent Abnormal Species	11.40		6.63		0.90		1.08		2.23		0.76
Percent Epithemiaceae	0.00		1.37		1.91		0.60		0.00		0.00
Similarity Index		39.86		43.56				25.73		51.74	

Table B-2. Results of Periphyton Analyses for the Arrastra Creek, Sandbar Creek, and Willow Creek (Bahls, 2001).

Species/Metric (Pollution Tolerance Class)	Station										
	AraC-01		AraC-02		SbrC-01		SbrC-02		WilC-01		WilC-02
Achnanthidium minutissimum (3)	20.23		16.33		19.74		86.48		4.03		5.14
Diatoma mesodon (3)	3.04		0.20		51.91		1.75		2.65		7.55
Fragilaria vaucheriae (2)	0.21		3.37						0.42		24.40
Gomphonema angustatum (2)	25.58		4.80		0.12				0.53		0.66
Hannaea arcus (3)	1.26		49.18						1.70		1.53
Staurosira construens (3)	2.73		2.14		0.60		4.78		27.60		3.28
Synedra rumpens (2)	0.10		2.35		9.69		2.33		13.59		14.99
Number of Cells Counted	477.00		490.00		418.00		429.00		471.00		457.00
Shannon Species Diversity	3.86		2.78		2.36		0.96		4.01		4.12
Pollution Index	2.59		2.77		2.73		2.92		2.55		2.35
Siltation Index	2.94		1.94		7.54		2.80		21.02		15.32
Disturbance Index	20.23		16.33		19.74		86.48		4.03		5.14
Number of Species Counted	51.00		30.00		23.00		16.00		51.00		46.00
Percent Dominant Species	25.58		49.18		51.91		86.48		27.60		24.40
Percent Abnormal Species	3.67		0.51		3.71		10.26		0.64		0.22
Percent Epithemiaceae	0.21		0.00		0.24		0.00		0.00		0.00
Similarity Index		33.99				26.98				45.55	

Table B-3. Macroinvertebrate Association Metrics Calculated for Samples Collected on the Blackfoot River and Selected Tributaries.

	Blkft1	Sandbar1	Sandbar2	Willow1	Willow2	Blkft2	Poor1	Poor2	Poor3	Arrastra1	Arrastra2	Blkft3
METRICS	METRIC VALUES											
Ephemeroptera richness	0	6	0	5	7	7	8	6	9	6	8	10
Plecoptera richness	2	6	5	4	3	1	3	3	3	1	4	5
Trichoptera richness	2	3	0	5	6	5	3	10	6	1	4	6
Number of sensitive taxa	2	5	3	3	4	1	3	10	9	4	4	3
Percent Filterers	0	1	0	16	1	2	0	1	0	0	0	6
Percent tolerant taxa	16	2	0	9	18	2	4	3	4	0	4	6
	METRIC SCORES											
Ephemeroptera richness	0	3	0	2	3	3	3	3	3	3	3	3
Plecoptera richness	2	3	3	3	2	1	2	2	2	1	3	3
Trichoptera richness	1	2	0	3	3	3	2	3	3	0	2	3
Number of sensitive taxa	2	3	2	2	3	1	2	3	3	3	3	2
Percent filterers	3	3	3	1	3	3	3	3	3	3	3	2
Percent tolerant taxa	1	3	3	2	1	3	3	3	3	3	3	2
TOTAL SCORE (max+18)	9	17	11	13	15	14	15	17	17	13	17	15
PERCENT OF MAX	(50)	(94)	(61)	72	83	78	83	94	94	(72)	94	83
Impairment classification*	(MOD)	(NON)	(SLI)	SLI	NON	SLI	NON	NON	NON	(SLI)	NON	NON
USE SUPPORT	(PART)	(FULL)	(PART)	PART	FULL	PART	FULL	FULL	FULL	(PART)	FULL	FULL
*Classification: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired.												

Richness of clinger taxa as an indicator of siltation provided somewhat different results than periphyton associations. Numbers of clinger taxa were depressed at several sites including two on the Blackfoot, Sandbar Creek, Poorman Creek, and Arrastra Creek (Figure B-1). The Arrastra 1 results could be due to a small sample size versus an impairment (Bollman 2001), whereas the other locations had appropriate sample sizes (total number of organisms). Similar to periphyton metric results, metals contamination may be masking the impacts of siltation on the upper Blackfoot site and Sandbar Creek. Still, low richness of clinger taxa on the other streams may be an indication of accumulations of fine sediment limiting habitat for these organisms.

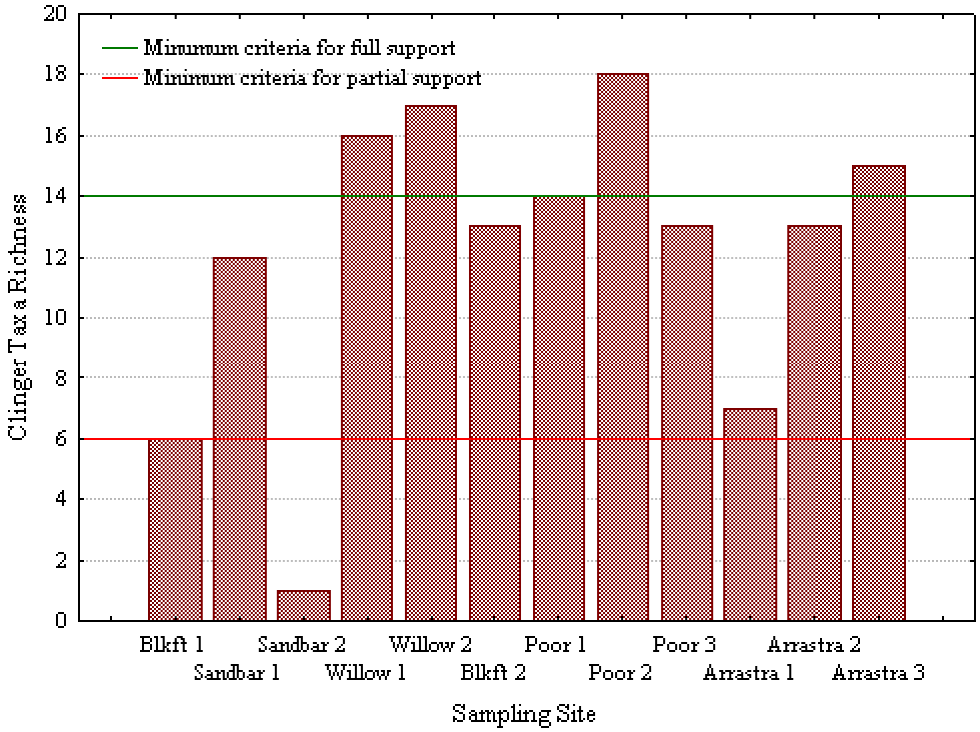

Figure B-1. Richness of Clinger Taxa Observed at Sampling Stations on the Upper Blackfoot River and its Tributaries (Bollman, 2001).

Macroinvertebrate assessments conducted by McGuire (1991) predate the use of richness of clinger taxa in evaluating siltation. Still, these analyses provide best professional judgment on biological integrity and potential impairments at two locations on the Blackfoot River (below Landers Fork and the Nevada-Ogden Road Bridge). At the station below the confluence with the Landers Fork, benthic macroinvertebrates demonstrated indications of drought-induced stress, probably the result of the natural tendency of flows to go subsurface in this losing reach, but no obvious indications of siltation.

In contrast, the sampling station at the Nevada-Ogden Road Bridge showed substantial impairment from deposition of fine sediment. McGuire (1991) considered the relatively low density of aquatic macroinvertebrates, low percentage of filter feeding invertebrates, and the relatively high abundance of the mayfly *Rhithrogena* sp. as indications of siltation at this location. Furthermore, he cited Spence (1975) who found similar faunal composition at this site in 1971 and 1972.

Based on results of the macroinvertebrate and periphyton samples collected in the upper Blackfoot River watershed, we made several conclusions with regard to indicators of siltation. For metals impacted streams (Sandbar Creek and the uppermost site on the Blackfoot River) metals contamination was the overwhelming influence on these communities and may have masked indications of siltation. For the other two sites on the mainstem of the Blackfoot River, biological indicators gave mixed results. Diatom associations did not demonstrate indications of siltation, although depressed richness of clinger taxa at the middle site supports a listing for siltation. Macroinvertebrate community composition in the 1970s and 1980s supported a determination of impairment from siltation at the lowest site. Biological indicators for Arrastra and Poorman creeks were similarly equivocal with some disagreement between the diatom and macroinvertebrate metrics for siltation.

Because DEQ uses a weight of evidence approach, the failure of one assemblage to indicate impairment does not necessarily preclude listing a stream for a given pollutant. These results are just one factor among many that DEQ uses in evaluating streams. For example, measures of streambed composition, and identification of potential sediment loading are other types of evidence used in these assessments. Note that streambed composition is an indicator of support of propagation of cold-water fisheries due to the relationship between percent fines and survival to emergence. Despite conflicting evidence for siltation, these assemblages should be monitored continually as part of the TMDL monitoring plan.

APPENDIX C
AERIAL PHOTO ASSESSMENT METHODS AND RESULTS

An aerial photo analysis conducted in early summer 2002 consisted of several components. Initial steps entailed acquisition and preparation of aerial imagery for the watershed. The available data supported a number of analyses including a Rosgen Level I Classification (Rosgen, 1996), percent cover of riparian vegetation, and an assessment of channel change over time. Finally, aerial assessment efforts conducted by several other investigators in the Blackfoot Headwaters Planning Area provided supplemental information on watershed conditions. This section provides a description of the methods and results of these analyses.

Imagery Acquisition, Preparation, and Interpretation

Aerial imagery from a number of sources provided the spatial data for aerial photo assessments in the basin. USGS digital orthophoto quarter quad quadrangles (DOQQ), obtained from Natural Resources Information Service (NRIS), were the primary data source for the aerial photo analyses. These data were available in MrSID compressed format, mosaiced by full quadrangle and covered the entire upper Blackfoot watershed using aerial photography collected during August 1995. In addition to electronically available data, hard copy aerial photos from the US Forest Service (USFS) and Natural Resources Conservation Service (NRCS) provided supplementary images for this analysis. USFS images included 1:15,640 scale, natural color aerial photography flown on August 19, 1988 covering much of the study area and 1:24,000 color aerial photography (flown on August 2, 1979) covering a smaller portion of the watershed. We used 1978 vintage black and white aerial photos obtained from the NRCS to fill gaps in the 1979 aerial photos. The NRCS provided black and white aerial photography from portions of the watershed collected in 1990. We limited hard copy photo acquisition to the reaches of the 303(d) listed streams as well as the Landers Fork.

There were several gaps in aerial photo coverage. Most notable was the first 10 miles of the main stem Blackfoot River upstream from the confluence with Nevada Creek. In addition, images from a small area around Lincoln, and a small area near the confluence of the Blackfoot River and Alice Creek were not available. We used 1999 panchromatic 5-meter resolution IRS satellite imagery obtained from the Helena National Forest to fill gaps in the lower reaches of the main stem upper Blackfoot River. In addition, these images were also useful in assessing upland areas for evidence of mass wasting.

The 1995 DOQQs served as a stable base for comparison of the three vintages of imagery. We scanned hard copy air photos scanned at 300-600 dpi, then georeferenced to the DOQQs. Since there is significant overlap of the scanned images, with photo distortion greatest at the edges, the photos were not edge matched or mosaiced. Digitizing features from the photos was therefore restricted to the central portion of the photos to minimize error. All photo preparation, digitizing, and analysis of results was performed using geographic information system (GIS).

Stream centerlines and the active stream channel area (active floodplain) were visually digitized for all three vintages of imagery where discernable. Because areas where streams were consistently less than 1-2 meters wide are generally not visible on this resolution of imagery, digitization efforts concentrated on the main stem of the Blackfoot River and the Landers Fork. Little digitizing was possible on Arrastra, Poorman, and Willow Creeks. For regions where digitization of streams was not possible, National Hydrography Network (NHD) digital data served as a surrogate. In some locations, the active stream channel was discernable but the stream centerline was not visible. This was most prevalent in losing reaches of the Blackfoot River and the Landers Fork. All digitized and NHD data were captured as GIS data layers in the Montana State Plane, NAD 83, meters coordinate system.

Data Analysis

Rosgen Classification

We applied the Rosgen Level 1 classification methods (Rosgen, 1996) within the GIS framework to all digitized stream centerlines as well as NHD data. Calculations of slope and sinuosity within the GIS also supported these classification efforts. Slope of the stream channels was calculated using 10 m DEM data compiled in the GIS for the Phase I TMDL Assessment. Sinuosity was calculated within the GIS as the ratio between the actual channel length and valley length. The level of incisement, and therefore width/depth ratio was not discernable on the imagery precluding its use as part of the Rosgen Level 1 classification.

An important product of Rosgen Level I Classification was the delineation of sub-reaches. Presence of significant infrastructure, such as bridges, was another factor used in delineation sub-reaches. This resulted in 44 sub-reaches covering the 103 miles of 303(d) listed streams and the Landers Fork for an average sub-reach length of 2.34 miles.

Riparian Canopy Cover

Assessing riparian cover was an important component of aerial photo analyses. We visually estimated riparian cover for both the right and left banks of the digitized and NHD streamlines using a buffer zone of 150 feet from the active stream channel. Riparian cover estimates were within four ranges or classifications (0-25%, 25-50%, 50-75%, or 75-100%). We recorded these visual estimates in the attribute tables of the digitized or NHD streamlines data layers along with comments regarding the nature of the vegetation.

Channel Change over Time

Digitization of active stream area polygons allowed for analysis of channel changes over time. Following completion of digitization, we split the active stream area polygons by reach breaks and calculated active stream channel areas were for each of the vintages of imagery by sub-reach. Comparisons among vintages permitted analysis of the change in these areas over time.

Review of Past Assessments

A brief review of several previously conducted assessments occurred concurrently with the aerial assessment. There were two objectives of this portion of the assessment. First was to determine if useful information was available in these sources. The second objective was to determine if a promising methodology for sediment TMDL development existed for streams similar in size and condition to the upper Blackfoot River watershed.

Whitehorse Associates

In 1996, Whitehorse Associates of Smithfield, Utah produced a report titled: *Ecological Classification, Upper Blackfoot River Basin, Montana for the Seven Up-Pete Joint Venture*. The purpose was to create an ecological framework for baseline monitoring of habitats and the effects of land use. The report drew heavily on GIS technology for analysis and map creation. Whitehorse Associates provided two GIS data layers for use in the Blackfoot Headwaters Phase I TMDL Assessment. These are: 1) valley bottom type, and 2) reach state. These investigators interpreted valley bottom type from aerial photography from both 1988 and 1995. Used in conjunction with general land type data, glacial and fluvial valley bottom types could be distinguished. Glacial valley bottom types delineate areas prone to erosion, particularly those in the upstream reaches of the Landers Fork. Reach state was also derived from aerial photography and was an attempt to characterize stream bank stability. The resolution of these data was too coarse to be useful for this study. Also of interest but unavailable was a GIS coverage of riparian vegetation types. However, this coverage was corrupt and unrecoverable. A few sample maps of this vegetation data from a hard copy of this report were georeferenced for comparison with the DOQQs. Correlation between easily identified vegetation stands on the DOQQs and the Whitehorse vegetation maps was inconsistent and determined to be unacceptable for this study.

Fish Wildlife and Parks

In 1999, Montana FWP, in conjunction with the BLM, conducted a reconnaissance level riparian health and eroding bank assessment of the lower half of the main stem of the Blackfoot River. A botanist and a fish biologist conducted this assessment from canoe, and focused on determining riparian community types, qualitative estimates of condition, and distribution of noxious weeds. This culminated in creation of two GIS data layers to record the distribution of natural and human eroding banks as well as overall riparian health. Both are included in the CD-ROM accompanying this technical memo and were used to guide location of eroding banks in the subsequent field assessment.

Helena National Forest

The Helena National Forest created a Microsoft Access database application designed to catalog and characterize the valley bottom areas within HNF jurisdiction. Unfortunately, most of the main stem Blackfoot River is on privately owned land and was not included in this inventory. As a result, these data have limited applicability for this study.

Field Assessments (Summer 2002)

The Blackfoot Headwaters physical assessment occurred from July 29 through August 16, 2002 with expertise provided by volunteers from state and federal agencies. The aerial photo assessment provided the basis for reach selection. The Confluence/DTM project team developed the study design and provided oversight and other technical assistance to assessment teams.

These field assessments included a number of methodologies designed to provide quantitative assessments of fluvial geomorphology, streambed composition, fish habitat, human influences, and riparian structural composition. Reconnaissance level geomorphic assessment provided supplemental information on a number of tributaries.

APPENDIX D
FIELD ASSESSMENT METHODS

Field assessment methods were conducted mainly following the Environmental Monitoring and Assessment Program (EMAP) protocols developed by the EPA (2001) for physical habitat characteristics and the layout of sampling reaches measuring 2000 feet in length. Field parameters included measurement of maximum bank full depth, bank full width, and percent cover in three riparian cover classes (over story, under story, and ground cover) on 10 transects per reach. In addition, this assessment included a proximity-weighted index of human influence for each cross sectional transect. Woody debris counts occurred between transects using standard EMAP protocols. Measurement of percent surface fines focused on pool tail outs using the grid toss method (Overton et al, 1997). The most significant modification of the EMAP method was applying thalweg profile measurements from the standard USFS fish habitat methodology (Overton et al, 1997) to measure proportion of habitat types in the reach.

Field crews conducted EMAP assessments on 21 reaches on the Blackfoot River, 2 on Poorman Creek, and one on Willow Creek. Of the Blackfoot River EMAP reaches, two were on reference reaches. These were reaches identified as “least-impaired” during aerial photo analyses. Field observations confirmed this status for the reference reaches.

Following methods described by Kaufmann et al (1999), data collected along cross sectional transects and the thalweg profile provided the basis for calculation of a series of reach-wide metrics or descriptors (Table D-1). These metrics are typically site level means for the various measurements and standard deviation. The sum of the lengths of different channel units within each 2000-foot reach described proportions of each reach comprised of riffles, pools, glides, and runs.

Table D-1: Metrics Calculated for Modified EMAP Reaches.

Category	Descriptors/Metrics	Description
Channel Morphology Summaries	% Pools % Riffles % Glides % Runs	Sum of the length of the different channel unit types divided by the reach length and multiplied by 100.
Channel Cross Section and Bank Morphology	Bank full Width Bar Width Width to Depth Ratio Entrenchment	Calculation of site level means, standard deviations, median, and upper and lower quartiles from data collected during channel/riparian cross section characterization.
Siltation	% fines (<0.06 mm)	Calculation of site level percentages of fine particles using the grid toss methodology.
Woody Debris	% big woody debris % small woody debris	Calculation of the total volume and number of pieces (in 4 size classes) within each site. Extrapolated to pieces and volume per 100ft.
Riparian Vegetation Structure	% big trees % small trees % woody shrubs and saplings % herbs, grasses, forbs (> 1.6 feet) % woody shrubs and seedlings (< 1.6 feet) % herbs, grasses, and forbs (< 1.6 feet)	Calculation of site level means for riparian vegetation cover types.
Human Influence	Disturbance index of each of the 11 human influence components.	Calculation of proximity weighted disturbance indices.

APPENDIX E
FIELD ASSESSMENT RESULTS

Channel Morphology Summaries

Proportions of EMAP reaches comprised of the various channel unit types varied among streams and reaches (Figure E-1). Typically, stream reaches possessing a mixture of channel unit types provide superior habitat for fish and aquatic life than reaches dominated by a single type. Glide habitat dominated reaches 6 and 7, including the least-impaired reference reach for 6. Glides are shallow, monotonous channel types that do not provide cover for fish. Similarly, these areas have poor sediment transport capabilities and have the potential to accumulate sediment.

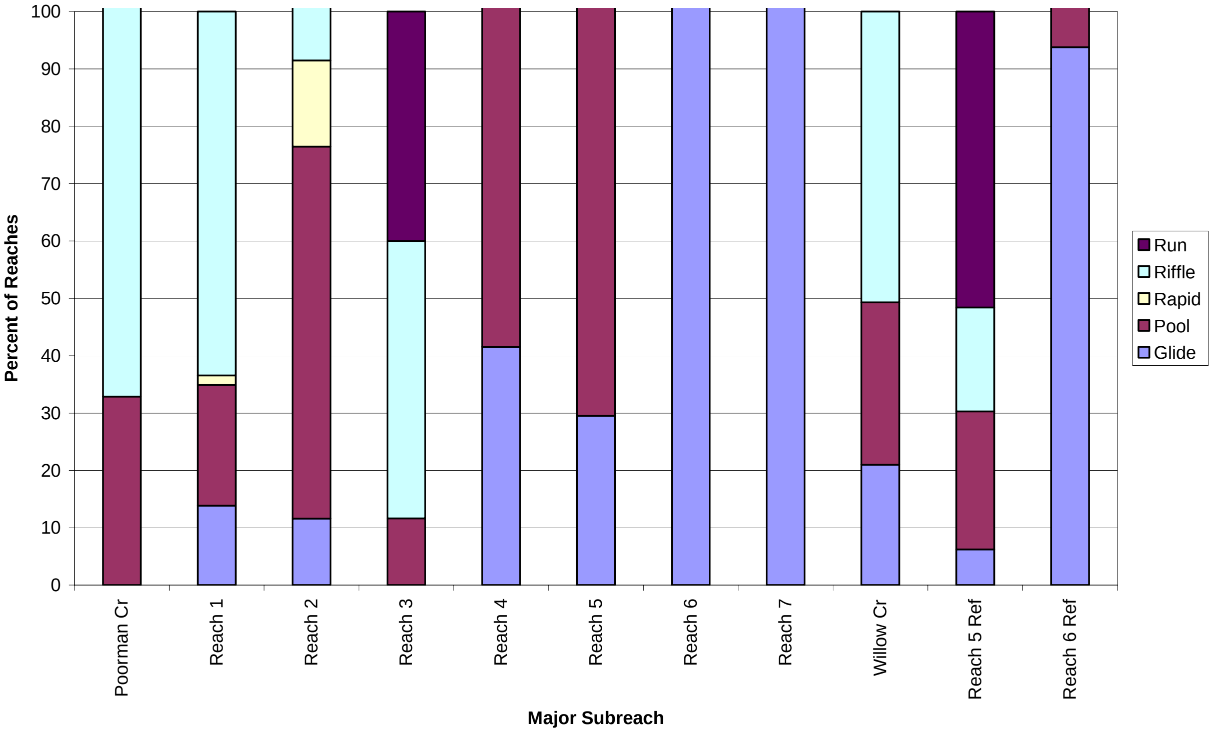

Figure E-1. Percent of Sub-Reaches Comprised of Different Channel Unit Types Using Data Collected During EMAP Reach Assessments.

Channel Cross Section Metrics

Metrics calculated for measurements made at channel cross sections illustrate differences in channel morphology among streams and among sites on streams. Bank full widths and width-to-maximum depth ratios measured on the uppermost portions of the Blackfoot River were relatively low (Figure E-2, Figure E-3). These conditions changed dramatically due to contributions from the Landers Fork then leveled off below Lincoln. Contributions from the Landers Fork were probably responsible for the large bar widths measured in this reach (Figure

E-4). Width-to-maximum depth ratios on Poorman and Willow Creeks were relatively low, which suggests that these channels are not overly wide where assessed.

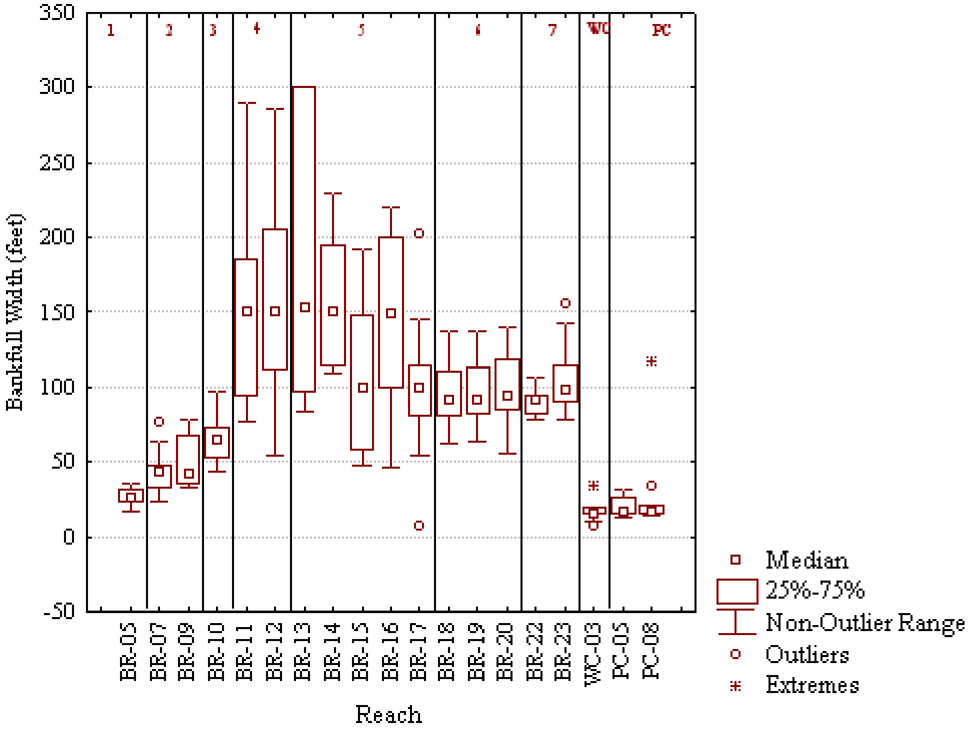

Figure E-2. Bank full Widths Measured on EMAP Reaches on the Upper Blackfoot River, Poorman Creek, and Willow Creek.

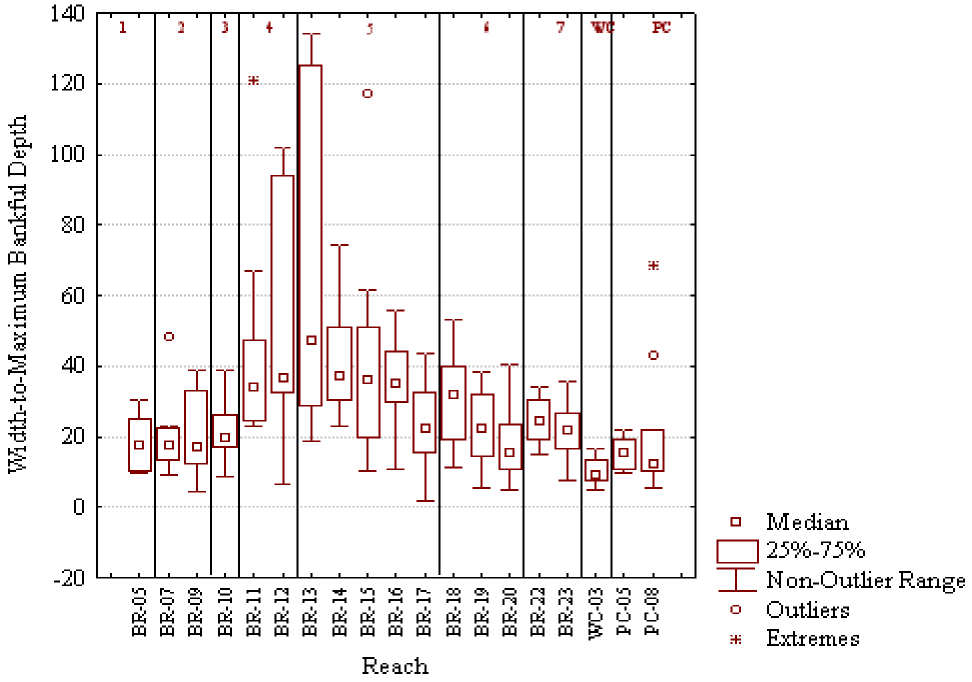

Figure E-3. Bank full Width to Maximum Bank full Depth Ratios Measured on EMAP Reaches on the Upper Blackfoot River, Poorman Creek, and Willow Creek.

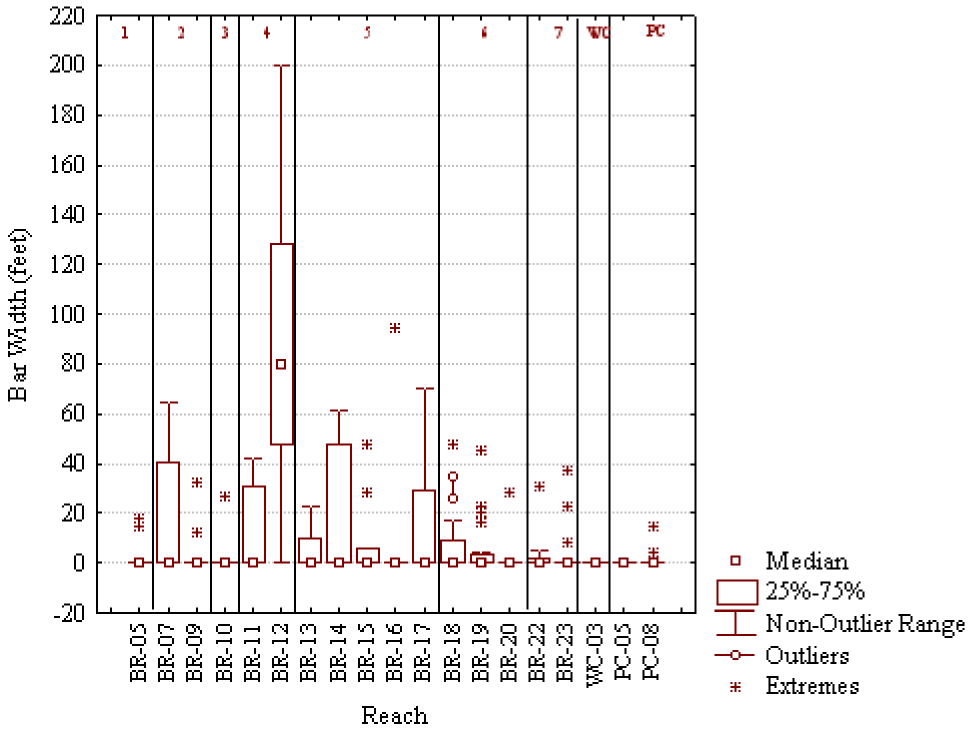

Figure E-4. Bar Widths Measured on EMAP Reaches on the Upper Blackfoot River, Poorman Creek, and Willow Creek.

Siltation

Sampling surface fines using a 49-point grid provides a quick way of assessing accumulations of fine sediment on streambed surfaces (Overton et al, 1997). We focused efforts on pool tails because these habitat types are preferred spawning areas for trout. Because pool habitat was limited in some reaches on the Blackfoot River, we combined percent fines estimates for the sub-reach of the stream.

Reaches of the Blackfoot River varied in terms of accumulations of fine sediment as measured with the surface fines grid (Figure E-5). The EMAP Reach 6 had the highest level of fine sediment, often exceeding 60% of the streambed sampled. Although this reach is identified as a reference reach, this would only apply to certain parameters such as riparian health. Using a reach of a potentially impaired stream segment for percent fines measures is typically not recommended due to the varying depositional nature of sediment. Reach 3 had the highest degree of siltation; however, this may be an artifact of sampling error due to the rarity of pools in this section. Surprisingly, Reach 7 had relatively low levels of surface fines. This finding contradicts field observations of thick accumulations of fine sediment throughout this reach.

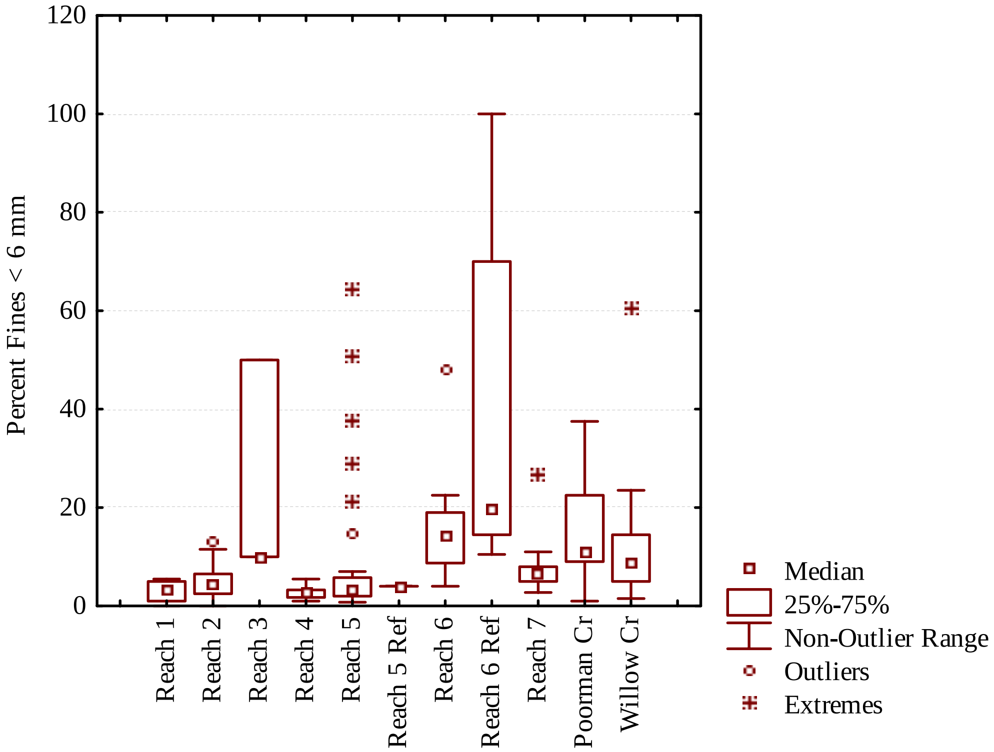

Figure E-5. Percent Fines < 6 mm in Diameter Sampled on EMAP Reaches on the Blackfoot River, Poorman Creek, and Willow Creek.

Volume of Woody Debris

The volume of woody debris of different size classes varied among EMAP sites and among streams in the Blackfoot Headwaters Planning Area (Figure E-6). The upper reaches of the Blackfoot River main stem, Poorman Creek, and Willow Creek had relatively low volumes of woody debris. On the Blackfoot River, volumes of wood increased below the confluence of the Landers Fork and persisted through sub-reach 6. Much of this wood occurred in debris jams associated with large pools. In the lower sub-reach, the volume of woody debris dropped markedly. Woody debris was not a significant component in Poorman and Willow creeks.

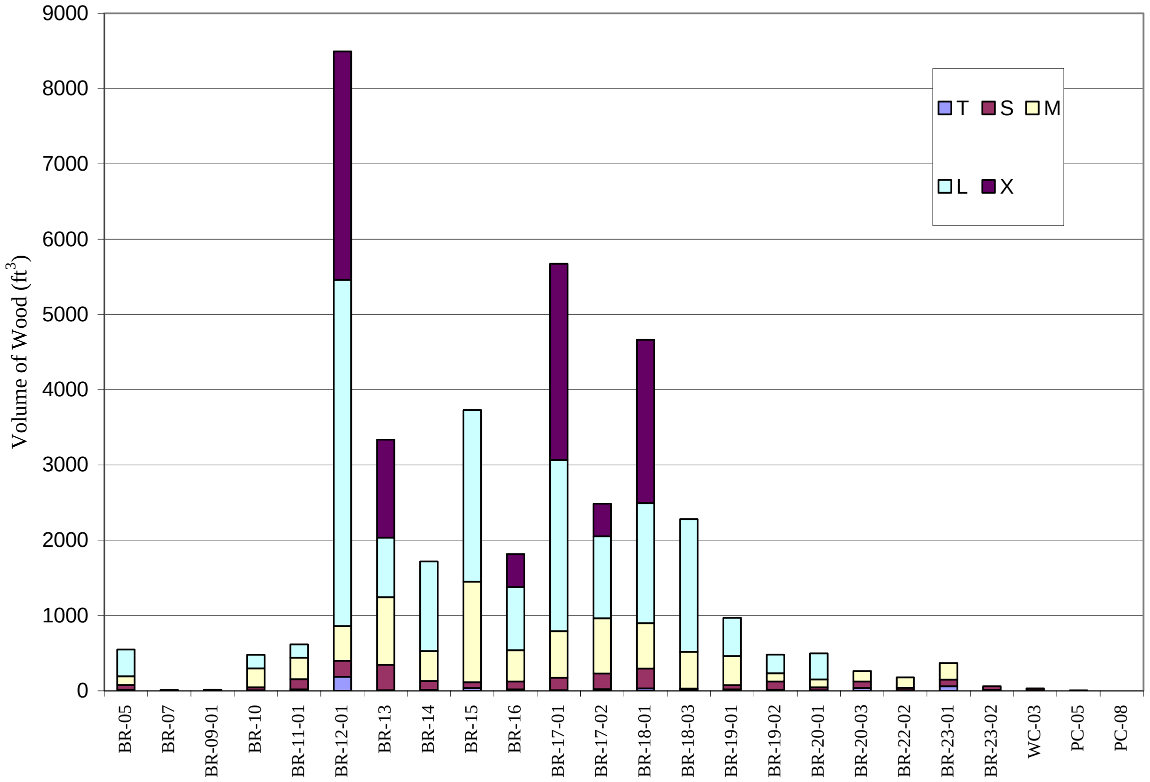

Figure E-6. Total Volume of Woody Debris in 5 Size Classes in EMAP Reaches on the Blackfoot River, Willow Creek, and Poorman Creek.
[T = very small (length 1.5m to 5m, diameter 0.1m to 0.3m); S = small (length 5m to 15m, diameter 0.3m to 0.8m); M = medium (length > 5m, diameter = 0.3m to 0.8m); L = large (length >5m, diameter >0.6m); X = very large (length >15m, diameter >0.8m)]

Structural Composition of Riparian Vegetation

EMAP riparian assessments evaluate the percent cover of three different cover classes (over story, under story, and ground cover). Over story canopy cover (big and small trees) comprised a relatively small component of the riparian vegetation (from 0% to 40%) along the upper Blackfoot River, Poorman Creek, and Willow Creek. Throughout the surveyed area, under story woody shrubs and non-woody groundcover (grasses and forbs) dominated riparian vegetation cover types (Figure E-7). Grasses and forbs do not provide substantial bank stabilization or protection due to the relatively shallow rooting depth. The predominance of bare ground in the riparian area varied considerably (between 5 and 35%) within the surveyed area of the Blackfoot River. Bare ground comprised 20% of the riparian area in Poorman Creek, and close to 15% in Willow Creek. Along the Blackfoot River, Reach 1 exhibits the highest degree of structural diversity (presence of all vegetative life forms), Reach 2 exhibiting the lowest.

There are a number of implications for reduction of cover types measured in this analysis. For example, relatively low cover of large and small trees may reflect a lack of potential large woody debris in a given reach. These cover classes also function to increase the structural integrity of banks and provide shading to the stream surface. Similarly, riparian shrubs, as measured cover of woody under story vegetation may reflect grazing pressure and indicate structural bank integrity. Low ground cover combined with relatively high levels of bare ground also suggests disruption of the sediment and nutrient filtering properties of streamside vegetation.

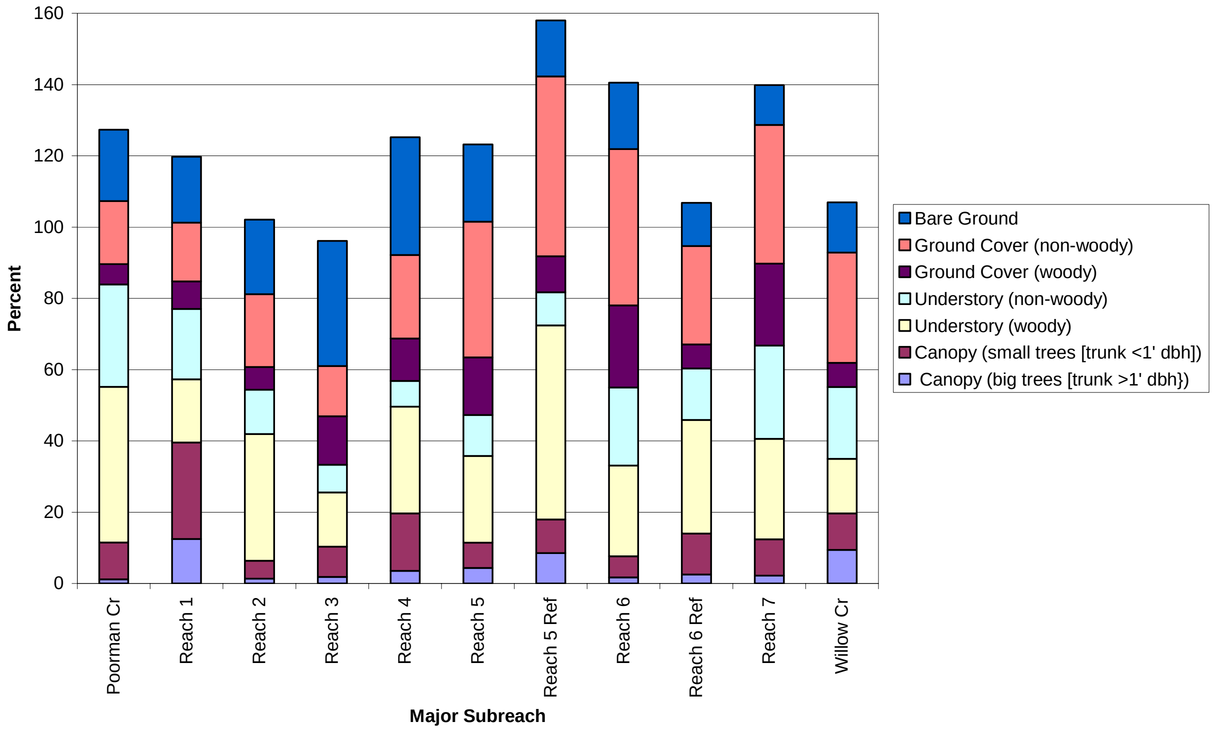

Figure E-7. Percent of Riparian Vegetation Types (Bare Ground, Ground Cover, Under story, Canopy) for EMAP Sites on the Upper Blackfoot River.

Human Influence

Human influences observed in the proximity of the EMAP sites include mining, logging, grazing, roads, pavement, and bank hardening (Figure E-8). Infrastructure such as roads, pavement, or buildings on the riverbank occurred at the majority of sites (80%) on the Blackfoot River. Infrastructure was also a factor on Willow Creek. Presence of roads or pavement also tended to correlate with the presence of bank hardening materials. Evidence of mining activity was only significant at one location on Poorman Creek. Evidence of logging activities was observed at four sites along the Blackfoot River, while evidence of agricultural activities was observed at 40% of sites along the Blackfoot.

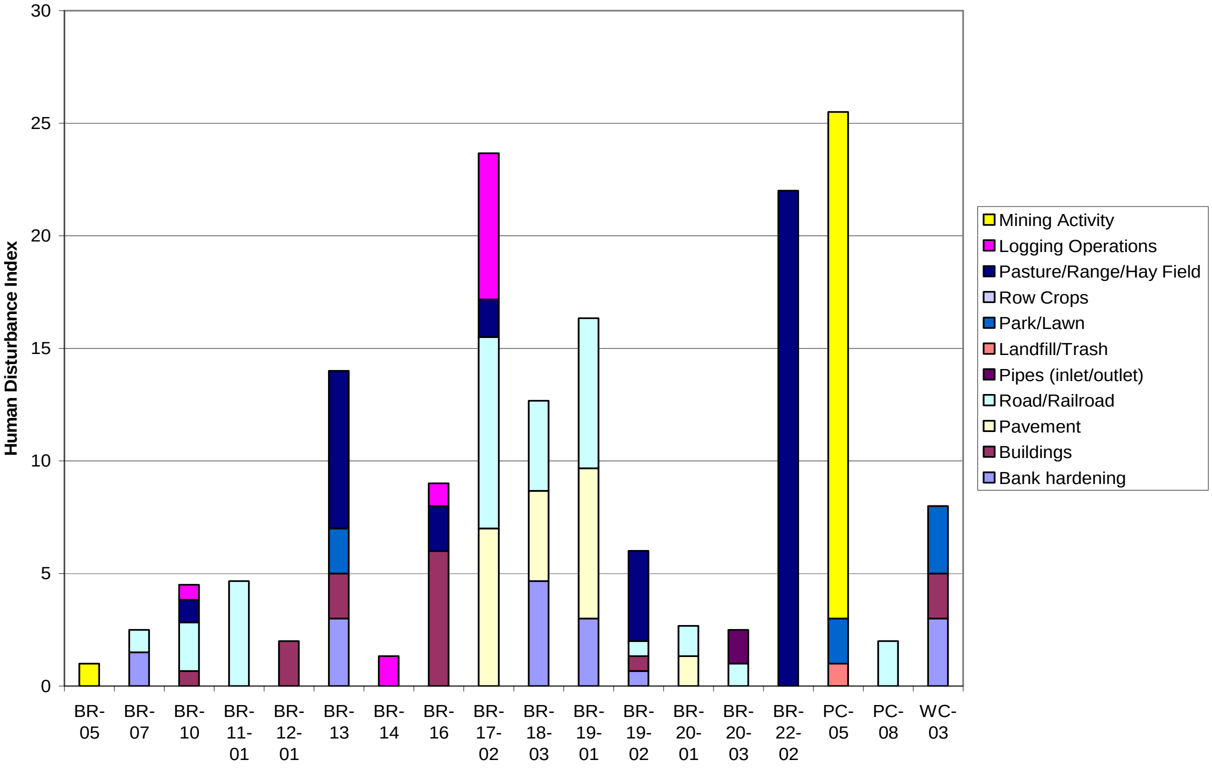

Figure E-8. Sum of the Proximity Weighted Human Disturbance Index for EMAP Sites Along the Upper Blackfoot River.

The human influence index is an interpretive tool in evaluating other observed conditions in assessed sub-reaches. For example, sub-reaches with a relatively high degree of livestock use and logging had low cover of most riparian cover types compared to an internal reference condition. This suggests that these land-uses may be responsible for reduced riparian cover and that management activities may increase riparian cover and the functional attributes of riparian vegetation.

Reconnaissance Stream Condition Inventory

Field crews conducted reconnaissance level investigations on several reaches of 303(d) listed tributary streams, including Poorman, Willow, and Arrastra creeks. Landers Fork was also the subject of a reconnaissance level investigation to assess the role of human activities in influencing sediment loading (see Appendix I). The objective of reconnaissance level investigations was to characterize these channel segments with regard to channel type, geomorphic stability, and potential impairment. The assessment included a documentation of channel stability indicators, verification or revision of Level 1 channel classification results, characterization of potential impairments, discussion of potential remedies, and identification of potential reference reach sites. On Willow and Arrastra Creeks, observers conducted a proper functioning condition (PFC) assessment (Prichard et al, 1998). Results of reconnaissance assessments are incorporated into geomorphic assessments.

Stream Geomorphology

Methods

Characterization of the fluvial geomorphic conditions and processes in the Blackfoot Headwaters Planning Area relied on synthesis and review of field data collected in 2002 and the analysis of aerial photos. The field data included information derived from erosion inventories, EMAP assessments, field reconnaissance, photographs, and commentary extracted from data collection forms and field maps. This information, in combination with sub-reach classifications and calculated channel gradients, was then utilized to consolidate the 23 preliminary field sub-reaches into major reaches of similar geomorphic character. The channel classifications reflect the results of a Rosgen Level 1 classification adjusted upon field review. This resulted in delineation of seven major reaches on the main stem Blackfoot River from RM 70 near the mouth of Anaconda Creek downstream to RM 0 at the confluence of Nevada Creek.

Results

Blackfoot River

The upper Blackfoot River watershed has characteristics typical of headwater environment, and as such, the geomorphic characteristics of the stream network are highly variable. On the main stem of the Blackfoot River, the upstream-most reaches evaluated (Reaches 1 and 2) are largely stable, single thread channels potentially impacted by a tailings pond failure upstream. Still, field observations suggest these reaches appear to have recovered from any historic sediment pulse. The lower end of Reach 2 extends to the Landers Fork confluence. The geomorphic character of the Blackfoot River changes markedly at this point, due the contribution of relatively large volumes of sediment from the Landers Fork. The increased sediment delivery owes to sourcing and transport of sediment derived from non-cohesive glacial deposits in the Landers Fork drainage area. For the first mile downstream of the confluence (Reach 3), the channel is moderately confined, and thereby capable of effectively transporting sediment. Downstream of that point, however, the channel widens significantly into a transitional meandering/braided system characterized by extensive sediment storage, lateral channel shift, and avulsion (Reach 4).

The most geomorphically complex segments of the system are located in Reaches 5-7, which are downstream of the zone of extensive sediment storage (Reach 4). Downstream of Reach 4, the bank full channel narrows and the channel transitions back to a single thread meandering stream (Reach 5). Reach 5 has extensive active bar deposition, lateral channel migration, and bank erosion, attributable to the delivery and storage of coarse bed load sediment. Both active floodplain and terrace surfaces, which commonly consist of relatively fine-grained over bank deposits, provide the boundaries of this reach. Erosion of these surfaces results in entrainment of fine sediment coupled with storage of coarse material on the bars. This process results on a continual downstream cycling of sediment via storage of coarse sediment in bar environments and concentration of fines derived from the channel banks. The sediment gradation becomes increasingly fine in the downstream direction, and deposition of this material is most notable in the lower portions of Reach 7, where it is especially deleterious to habitat for fish.

Table E-1 Summary of Blackfoot River Sub-Reach Characteristics.

Major Reach	River Miles	Channel Types	Average Slope	EMAP Data Sites	Erosion Inventory Data Sites	Average Bank Erosion Severity Rating	Total Fine Sediment Contribution
1	55.1-70.0	B, E	0.7%	BR-05	BR-05	3 (moderate-)	Slight
2	49.5-56.2	C, Cb, C4d	0.52%	BR-07, BR-09	BR-09	3.5 (moderate-)	Moderate
3	48.1-49.5	C4d	0.47%	BR-10	None		Slight
4	42.3-48.1	C4d, D4c	0.47%	BR-11, BR-12	BR-11, BR-12	8.2 (moderate+)	Moderate
5	32.1-42.3	C4, C4d	0.33%	BR-13, BR-14, BR-15, BR-16, BR-17(2)	BR-13, BR-17	8 (moderate+)	Severe
6	18.1-32.1	C4	0.09%	BR-18(2), BR-19(2), BR-20(3)	BR-19	8.8 (moderate+)	Severe
7	0-18.1	C5e	0.07%	BR-22, BR-23(2)	BR-22, BR-23	7.9 (moderate+)	Moderate

Reach 1

Reach 1 extends from the upstream extent of the assessment area near the mouth of Anaconda Creek, downstream to a point located just below the mouth of Willow Creek (Table E-1). This major reach unit consists of the uppermost seven sub-reaches of the main stem Blackfoot River (BR01-BR07). These sub-reaches reflect headwater environments, in which the channel is relatively small, as indicated by the mean bank full width of 27 ft (EMAP BR-05). The channel is also relatively steep, with an average slope of 0.70% through the entire reach. The alternating B and E channel types in Reach 1 reflect localized geomorphic variability with respect to channel confinement, sinuosity, slope, and floodplain access. Valley walls (B-channels) typically confine transport reaches. These transition into meadow areas (E-channels), characterized by low gradient, high sinuosity, and wide floodplain areas. Approximately 15% of the channel perimeter was bedrock according to the Erosion Inventory BR-05, which is a B-type channel segment.

The erosion inventory performed in sub-reach BR-05 rated the channel as geomorphically stable, although mine tailings were present in the reach (EMAP BR-05). In 1975, failure of a tailings impoundment at the Mike Horse Mine resulted in the release of an estimated 100,000 tons of mine tailings into the upper Blackfoot River. Within the assessed channel segments, there were no geomorphic indicators of systemic instability due to this event. However, in the uppermost sections of the main stem Blackfoot, near the mine, habitat degradation resulting from tailings deposition occurs within and along the channel margin. Downstream, it appears that the low gradient channel segments in open meadow areas have effectively absorbed excessive, short-term sediment loads, and thus limited historic destabilization of the reach. Currently, the severity of bank line erosion is moderate, with erosion/deposition patterns characterized by local sediment sourcing of sand and gravel- sized material. Storage of similar gradations in bar environments balances local sourcing of sediment.

Reach 2

Reach 2 extends from near the Willow Creek confluence downstream to the mouth of Landers Fork, and includes field sub-reaches BR-07 through BR-09. Within this reach, the Blackfoot consists of a single thread meandering channel (C), with local valley wall confinement (Cb-type), and local areas of bar deposition and split flow (Cd). A high valley wall on the south, and low sagebrush terraces to the north typically bound the river corridor in this reach. Noxious weeds were pervasive at both EMAP sites BR-07 and BR-09. Minor riprap and diking occurred at BR-07. The erosion inventory performed through the Aspen Grove Campground area identified significant bedrock control along the southern valley wall. Reach 2 had a largely stable to mildly aggrading channel, with a C4d channel classification (BR-09).

Reach 3

Reach 3 consists solely of project sub-reach BR-10, extending from the Landers Fork confluence downstream for approximately 1.5 miles. The mean width-to-depth ratio of the reach EMAP channel segment is 21.2, which is significantly less than reaches immediately downstream. Bedrock exposures on the south valley wall, and rock revetments and constructed berms/dikes on the north (right) bank are local confining features in this reach.

The relatively low width-to-depth ratio of Reach 3 (BR-10) indicates that the channel is largely capable of transporting sediment loads derived from the upper Blackfoot and Landers Fork. The relatively efficient transport capacity of the reach is likely due to lateral channel confinement, which narrows the channel corridor and maintains flow depths during discharge events. Locally, however, the channel corridor widens, and storage is evident in the form of multiple channel threads and very coarse grained bar formation, which results in the designation of the reach as a Cd channel type.

Reach 4

Reach 4 extends from the mouth of Swede Gulch to the Stemple Pass Road Bridge just south of Lincoln. This reach marks a significant increase in mean bank full width-to-depth ratios from 18 to 21 upstream in Reaches 1-3 to a range of 43 to 53 in Reach 4 (EMAP BR-11, BR-12). Reach 4 also had extensive sediment storage in bars, and secondary channels. The channel types range from C4d to D4c, which reflects the transitional meandering/braided conditions through the reach. The reach is somewhat steeper than downstream reaches; however, its average gradient (0.47%) is consistent with that of Reach 3 upstream. Bed substrate consists primarily of gravel and cobbles, however lower energy geomorphic environments (abandoned channels, high bar surfaces), are commonly capped with sand. Due to the coarse nature of the reach, fine sediment contributions to the river system are relatively minor.

Due to the extensive sediment storage in Reach 4, the bank full channel is relatively wide (150-160 ft). A several hundred-foot wide active channel corridor, which consists of coarse, variably vegetated sediment that is dissected by high flow channels, provides the boundary of the bank full channel. Erosion of the corridor margin and active channel migration and avulsion on lower floodplain surfaces downstream was significant against the steep southern valley wall in BR-11 as. This reach demonstrated extensive channel shifting in 2002 assessments relative to the 1995 base map aerial photography. Large woody debris was typically not a primary component of in-channel geomorphic features such as pools, as most LWD was stored outside of the primary channel thread.

Reach 4 has a dynamic plan form influenced by mobility of coarse substrate particles. The coarse nature of the substrate renders the sub-reach most susceptible to change during high flow events. Woody debris storage in the primary channel increases in the downstream direction through the reach; the lower portion of the reach has extensive woody debris stored both within and beyond the bank full channel. Secondary high flow channels are ubiquitous in over bank areas within the river corridor.

Reach 5

Downstream of Reach 4, the Blackfoot River transitions back to a single thread meandering channel in Reach 5. Reach 5 extends from the Stemple Pass Rd Bridge downstream to the upper section of the canyon near the Powell/Lewis and Clark County line. Reach 5 has a consistent slope of approximately 0.33%, and is a C4 channel type. Bank line erosion, mostly related to large-scale bend way migration, is relatively severe through the reach. Locally, however, extensive woody debris jams cause lateral instability that control bar locations and promote split flow. Relatively large amounts of woody debris are stored in Reach 5 in both the bankfull channel area, as well as in over bank environments.

Bank stratigraphy in the reach typically consists of lower bank gravels overlain by a cap of fine grained over bank deposits. Because of the fine-grained component of the actively eroding banks, there is significant contribution of fine sediment within this reach. Sediment gradations stored within bar environments consist primarily of gravel and cobbles. The abundance of fines in pool tail out environments provides evidence of the contribution of fine sediment from bank erosion.

Reach 5 consists of a highly dynamic corridor affected by the delivery of coarse sediment loads from upstream. Lateral channel migration and locally extensive erosion of the floodplain margin is evidence of ongoing widening of the active corridor in the reach. The active lateral erosion coupled with an intermediate channel slope results in transport conditions that entrain and effectively flush the majority of fines, resulting in gravel-dominated riffle/bar forms, with local accumulations of fines in pool environments.

Reach 6

The average channel slope of Reach 6 is 0.09%, which is an abrupt reduction from 0.33% in Reach 5. The reach extends through the canyon section of the project reach, from a point near the Powell/Lewis and Clark county line, to the point where lateral confinement is reduced just upstream of the Highway 141 bridge. Reach 6 is a single thread, sinuous C4 channel that shows distinct downstream trends in channel form. Sinuosity increases downstream through the reach, ranging from 1.5 (BR-18) to 2.1 (BR-20). Width-to-depth ratios decrease in the downstream direction, ranging from 31 (BR-18) to 18 (BR-20). The Blackfoot River locally abuts both Highway 200 and bedrock exposures as it flows intermittently along the north canyon wall. The valley bottom is confined.

Reach 6 has an extremely low slope, and relatively low-width-to-depth ratios maintain sediment transport capacities. The low slope in the confined canyon section suggests that a canyon obstruction or extensive beaver dam complexes may have historically impounded the sub-reach. The progressive development of a defined channel in the reach would explain the ongoing dynamics of sediment delivery, storage, and associated bank line erosion, channel migration, and corridor widening.

Reach 7

Reach 7 extends from the mouth of the canyon reach near the Highway 141 Bridge to the confluence with Nevada Creek. Within this reach, the Blackfoot River is extremely sinuous and fine-grained. Sinuosity ranges from 1.5 (BR-21), to 2.4 (BR22). The bank stratigraphy consists of fine sands and silts, buried woody debris, and secondary channel fills. Cohesive clays are commonly exposed in the channel bed and bank toe. Bank erosion is relatively severe, and is typically associated with bend way migration and pressure from point bar deposition. The most extensive bank erosion in Reach 7 occurred in the lowermost channel section (BR23). This reach was described as geomorphically unstable, with extensive deposition of fine sediment in pools and on bars.

The bank composition and form in Reach 7 suggests that fine grained over bank deposition in a low gradient environment historically dominated the system, perhaps in an expansive series of beaver dams. Currently, the fine-grained system can support a highly sinuous planform, and sediment storage in the tight bend ways imparts erosive pressure on the outer bank. Due to its fine-grained perimeter, sinuous planform, and low channel slope, Reach 7 is a storage zone for fine-grained material derived from upstream as well as from within the reach.

Arrastra Creek

Arrastra Creek is the western most tributary of the Blackfoot River within the Blackfoot Headwaters Planning Area. Both logging and livestock grazing have had a negative influence on Arrastra Creek. A summary of Arrastra Creek sub-reach characteristics is shown in Table E-2.

Table E-2. Summary of Arrastra Creek Sub-Reach Characteristics from Field Reconnaissance.

Reach	River Miles	Channel Types	EMAP Data Sub-reach	Erosion Inventory Data Sub-reach	General Channel Stability
AC1	2.0-4.7	Cb4	n/a	n/a	Aggradation
AC2	0.75-2.0	Cb4	n/a	n/a	Aggradation
AC3	0-0.75	C4/Ce5	n/a	n/a	Aggradation

Sub-reach AC1

Sub-reach AC1 extends from a locked gate at river mile 4.7 downstream to 2.0. Within this reach, Arrastra Creek consists of extensive point- and mid-channel bar deposits. Vegetation ranges from dense riparian to open lands in logged areas. Riparian communities typically consist of black cottonwood, alder, snowberry, dogwood, and occasional spruce and willow. At river mile 3.3, the Arrastra Main Road crosses the channel. The crossing consists of two culverts, each of which is 6 feet in diameter. For a distance of approximately 200 ft upstream of the culverts, the channel is braided (D4 channel type), which indicates that flow obstruction at the culverts has resulted in backwatering and sediment deposition upstream. Downstream of the crossing, the channel abruptly transitions to a C4b-type channel with few pools, diagonal bars, and primarily continuous shallow riffle bed forms. Width-to-depth ratios range from approximately 25-40, which suggests that the channel is over-widened due to high sediment loads. Infrequent woody debris jams create local pool and cover habitat. The riparian cover is variable; in areas where there has been historic logging and the riparian cover is limited, spotted knapweed infestations are extensive. Scattered areas of Canada thistle, hounds' tongue, and musk thistle were also present. This channel segment downstream of the road crossing had significantly less flow than upstream areas during the field assessment (August 2002). Local residents reported that this section of channel commonly goes dry from November through May.

At river mile 2.4, a large wetland/pond complex is present on the left bank floodplain area (Frenchy's Pond). This pond contributes flow to Arrastra Creek. Downstream of the pond outlet, the channel is a C4 type, with better channel development, and a lower width depth ratio of 20-25. Willow, alder, and dogwood dominate the riparian community in this section. These stands show indications of heavy browse pressure. The upland areas beyond the pond have been extensively logged in recent years.

Sub-reach AC2

Sub-reach AC2 extends from a bridge crossing at river mile 2.0 downstream to river mile 0.75. The bridge at the upstream end of the sub-reach is approximately 15 feet wide and 3 feet above the channel bed. The sub-reach is a Cb4-type channel with a high volume of bed load storage. Active deposition and braiding is common upstream of debris jams. Limited bank erosion occurs on bend ways. Pools are infrequent. Selective logging on adjacent terraces has occurred in the past several years. According to local reports, this channel segment typically goes dry by November of each year. Commonly, as the flows recede, fish are stranded in isolated pools.

Sub-reach AC3

Sub-reach AC3 is located immediately upstream of the Blackfoot River confluence, and consists of a wide, shallow channel that has an approximate width-to-depth ratio of 50-60. The reach is a depositional zone, where beaver dams magnify aggradational trends and small debris jams. The riparian zone consists of dense alders and willows, and the waters edge supports sedges. Canada thistle is common in the riparian zone, whereas spotted knapweed infestations are common on dry, open terraces. Near the mouth, the channel bottom is muddy with dense growths of macrophytes. Livestock have access to the reach, but deleterious impacts were not apparent.

Poorman Creek

Poorman Creek is a major tributary of the Blackfoot River. It joins the Blackfoot just downstream of the town of Lincoln. A summary of Poorman Creek sub-reach characteristics is shown in Table E-3.

Table E-3. Summary of Poorman Creek Sub-Reach Characteristics.

Reach	River Miles	Channel Types	EMAP Data Sub-reach	Erosion Inventory Data Sub-reach	General Channel Stability
PC1	12.7-14.0	A3	n/a	n/a	Stable
PC2	10.5-12.7	B4	n/a	n/a	Stable
PC3	8.6-10.5	B4	n/a	n/a	Stable
PC4	2.3-8.6	B4/C4	PC05, PC08	n/a	Stable
PC5	0-2.3	Cb4	n/a	n/a	Minor Degradation

Sub-reach PC1

Sub-reach PC1 is located in the upstream portion of the tributary watershed, extending from the first Stemple Pass Road crossing approximately 1 mile upstream. Within this reach, Poorman Creek is a moderately confined, relatively steep, stable, A-type channel. A thin riparian fringe consisting primarily of spruce, alder, and golden currant borders the channel. Channel segments upstream of this sub-reach were not assessed, and abandoned mines may affect that area of the upper watershed.

Sub-reach PC2

Sub-reach PC2 flows from the first Stemple Pass Road crossing downstream approximately 2 miles to the confluence with South Fork Poorman Creek. Within this reach, the channel is a B4 type channel, as it is relatively steep, coarse grained, and confined. The upstream end of this reach consists of a newly installed, arched, corrugated metal pipe (CMP) culvert reinforced by riprap on both the upstream and downstream ends. Velocity reduction baffles installed on the floor of culvert to facilitate fish passage.

At the downstream end of Sub-reach PC2, the South Fork of Poorman Creek enters Poorman Creek from the south. The South Fork of Poorman Creek is a B4-type channel, which flows through a 3-foot diameter culvert prior to entering Poorman Creek. Just upstream of the confluence, Poorman Creek flows through a 3-foot diameter CMP culvert located at the South Fork Road crossing. Both of these culverts are potentially insufficient for high flows and are either perched, in the case of the South Fork crossing, or too low, as in the case of the Poorman Creek crossing, thus making them susceptible to washout.

Sub-reach PC3

Sub-reach PC3 extends from the South Fork Poorman confluence downstream for approximately 1.75 miles to the mouth of Rochester Gulch. The channel is a B4-channel type, and is similar in form to Sub-reach PC2. The riparian zone varies in width from 20 ft in confined areas to over 100 ft in less confined segments. Black cottonwood is present in the riparian zone, along with conifer, willow, dogwood, and alder. Approximately ½ mile downstream of the South Fork confluence, Poorman Creek flows under Stemple Pass Road through a set of three apparently undersized, side-by-side culverts, each of which is perched 10-12 inches on their downstream ends. These culverts are at risk of washout and are potential barriers to fish migration.

Sub-reach PC4

Sub-reach PC4 extends from the mouth of Rochester Gulch downstream for approximately six miles where Poorman Creek emerges from its canyon onto the unconfined valley bottom of the Blackfoot River. Within this reach, placer mining has been extensive, and the channel flows through placer spoil piles, as well as locally confined canyon sections. In some placer-mined segments, the channel has short aggradational reaches, and high width-to-depth ratios. In other sections, the channel has down cut into tailings, although these incised channel segments tend to be well vegetated and relatively stable. Minor bank erosion is limited to bend way cut banks. The riparian zone consists primarily of willows and alders. The lower end of the reach contains a large wetland/beaver dam complex. Heavy infestations of spotted knapweed, Canada thistle, and musk thistle infestations occur in this reach. Cattle and horses graze much of this reach.

Residential development in the sub-reach includes landscaping and riparian clearing. Approximately 1.25 miles downstream of Rochester Gulch, an off-channel fishpond has an intake from Poorman Creek in the form of a 5-foot high rock check dam that creates a passage barrier. Because the pond margin is less than 10 feet from the creek, and is perched approximately 5 feet above the bed elevation, there is potential for breaching of the pond into the creek. In the lower end of the reach, the Stemple Pass Road crossing near Gehring’s Lumber consists of three culverts that may constitute a fish barrier. Downstream of the crossing, there is evidence of active grazing, and the channel width-to-depth ratio increases.

Sub-reach PC5

Sub-reach PC5 is the lowermost sub-reach on Poorman Creek, extending from the Poorman canyon mouth northward across an unconfined broad margin of the Blackfoot River valley, to its confluence with the Blackfoot River just downstream of Lincoln. Grantier Spring Creek, a tributary contributing to this reach, has a significant influence on the lower quarter mile of Poorman Creek resulting in flows and thermal regime typical of spring creeks. A short portion of the reach has a relatively coarse grained, moderately entrenched single thread channel (F4). This area is moderately incised, but there is little evidence of active down cutting. The total riparian corridor consists of juniper, black cottonwood, and Canada buffaloberry. Common weeds include musk thistle, Canada thistle, oxeye daisy, yellow toadflax, and spotted knapweed.

Active grazing and in-channel irrigation diversion structures are present in the lower portion of Sub-reach PC5. The first structure is located approximately ½ mile downstream of the mouth of Poorman Canyon. The second is located approximately ¼ mile further downstream. During the field investigation (August 2002), Poorman Creek was dry downstream of the second diversion structure. Bank erosion is active on outside banks along bend ways below the structures. Current plans are in place to reconstruct the irrigation system associated with these structures in an effort to reduce impacts associated with de-watering.

Willow Creek

Willow Creek is a tributary of the uppermost reach of the Blackfoot River. Mining activities and road development impact Willow Creek for some of its length. A summary of Willow Creek sub-reach characteristics is shown in Table E-4.

Table E-4. Summary of Willow Creek Sub-Reach Characteristics.

Reach	River Miles	Channel Types	EMAP Data Sub-reach	Erosion Inventory Data Sub-reach	General Channel Stability
WC1	2.8-6.1	Bc3-Cb4	n/a	n/a	Degradation
WC2	0.8-2.8	Cb4	WC01	n/a	Stable
WC3	0-0.8	Cb4	n/a	n/a	Stable

Sub-reach WC1

Sub-reach WC1 is extends from the Flesher Road Bridge crossing, which lies approximately 1.5 miles north of Flesher Pass, downstream to the Sandbar Creek confluence. At the Flesher Road crossing, the creek flows through a 5 ft diameter concrete pipe that is perched approximately 3 ft above its downstream plunge pool, creating a probable fish passage barrier. During the field investigation, fish were present in the plunge pool. Downstream of the crossing, the stream is a B3/B4 channel type, with an average width-to-depth ratio of 8-10. Black cottonwood, alder, with some willow, spruce, and lodgepole pine dominate the riparian corridor. Heavy infestations of spotted knapweed and lesser amounts of musk thistle and Canada thistle occur on terrace environments. In isolated areas, the channel margin consists of bedrock. Terraces have been locally cleared, and runoff from the highway has created isolated gully erosion on the highway embankment. Typically, the wide buffer present between the road and channel limits the delivery of sediment from the road to the channel.

At river mile 4.9, an underground cable lies across the channel course. A 6 ft wide swath of unreclaimed barren ground marks the path of the cable. Just downstream of the cable crossing, all of the channel flow (approximately 2 cfs during the field investigation) infiltrated, and the channel was dry for approximately 1500 ft, at which point the flow resurfaced. Willows exhibit heavy browsing from wildlife. Noxious weeds include Canada thistle, yellow toadflax, spotted knapweed, and musk thistle.

Approximately one mile downstream at river mile 4.0, the channel flows under West Flesher Road, through a 20 ft span timber bridge. The road embankment is perpendicular to the Willow Creek valley bottom, and forms a floodplain dike that is 7-8 ft in height. For a distance of approximately 0.5 miles upstream of the bridge, the channel bottom contains extensive wetlands and beaver activity. The riparian zone is 250-350 ft wide and dominated by willows. Downstream of the bridge, the channel is incised, and the riparian zone is limited to the entrenched channel margin. This area shows heavy pressure from grazing and browsing, with the most serious impacts apparently due to historical versus current grazing practices. During the field investigation, surface flows were infiltrating in this area, and resurfacing approximately ½ mile downstream. Riparian vegetation is severely limited in the dewatered reach, and becomes dense with willows where flow resurfaces. A single patch of common tansy occurred in an old corral.

Sub-reach WC2

Sub-reach WC2 extends from the Sandbar Creek confluence downstream for approximately 2.0 miles. The Sandbar Creek watershed was mined, and upland areas in the watershed have been disturbed locally. At the mouth of Sandbar Creek, Willow Creek consists of a wetland complex characterized by pools, multiple channels, and dense riparian vegetation. The riparian zone in this area varies in width from 100-600 ft. Approximately 1200 ft downstream from the confluence, the channel transitions to a single thread Cb4 channel type, with minor beaver activity. Noxious weed infestations are common.

Sub-reach WC3

Sub-reach WC3 extends from River mile 0.8 downstream to the confluence of Willow Creek with the Blackfoot River. This reach has a single thread, C4 channel dominated by pools and riffles. Recent, selective logging was evident in the over bank areas. Woody debris accumulations are common in the reach, and debris jams are locally present. Oxeye daisy is present in open areas along the channel margin.

Sandbar Creek

Mining activities have had a profound impact on Sandbar Creek. Mine tailings border the banks in the upper reaches and iron hydroxide covers much of the stream substrate. Remediation to address the source of these metals contaminated sediments is part of the metals TMDL (Hydrometrics et al., 2003). Mine wastes also have been used for road building purposes at a stream crossing, resulting in undesirable habitat alterations. Metals remediation work may also end up addressing these impacts as part of the effort to reduce metals loading to the stream. Near its mouth, Highway 279 channelizes approximately 200 ft of Sandbar Creek. Bank failure, flow impoundment, and loss of cross section definition characterize this channel segment.

APPENDIX F
CALCULATION OF SEDIMENT LOADS FROM ERODING BANKS

Methods

Estimation of sediment loads from eroding banks involved several steps and analyses. Field data collected during the erosion inventory of the field assessment of 2002 provided the basis for estimating sediment loading from eroding banks on the upper Blackfoot River. Teams of natural resource professionals inventoried a total of 23 miles, representing 32% of the total channel length. All eroding bank inventory data collected were digitized, attributed with information on length, height, and condition, and incorporated in the project GIS. To determine the yearly sediment load produced by eroding banks, we estimated an average rate of bank retreat using two methods. First, we determined rates based on a range of values from similar stream systems published in scientific literature. Second, we analyzed historic aerial photography and measured the offset in-stream centerline position between vintages of photography in select locations (see Appendix E). Results indicate general agreement between the two methodologies. This confirmation allowed using published retreat rates for analysis of sediment derived from eroding banks. These rates are presented in Table F-1.

Table F-1. Bank Retreat Rates Used for Banks of Varying Severity of Erosion.

	Migration Rate (m/y) Values in parentheses are in feet		
Condition	Zaroban and Sharp (2001)	Rosgen (2001)	Nanson and Hickin (1986)
Slight	0.032 (0.10)	0.061 (0.20)	0.10 (0.33)
Moderate	0.070 (0.23)	0.189 (0.62)	0.40 (1.31
Severe	0.183 (0.47)	0.335 (1.10)	0.70 (2.30)

Evaluation of the three sources of lateral migration rates of eroding banks indicates that the moderate values (Rosgen, 2001) are most appropriate to apply in this instance. The sediment TMDL described by Zaroban and Sharp (2001) was conducted in an area with a drier climate and lower discharge, than the upper Blackfoot. Nanson and Hickin (1986) conducted their analysis on 18 meandering river channels in western Canada. These rivers have non-cohesive substrate material, higher discharges than the upper Blackfoot, and relatively steep slopes. Rosgen (2001) examined lateral stream bank erosion rates for the Lamar River basin in Yellowstone National Park and a series of streams along the Colorado Front Range. These streams most closely resemble the upper Blackfoot in geomorphic setting.

The following are steps used to calculate total sediment load from eroding banks for all three of the published retreat rates:

- Retreat rates assigned to each eroding bank within the GIS;
- Extrapolate percentage of each type of bank, average height, and retreat rate to channel segments not inventoried;
- Determine bulk density of bank material from SSURGO soils databases for Powell and Lewis and Clark counties;

- Calculate tonnage of sediment produced yearly by each eroding bank (length × height × retreat rate × bulk density); and
- Sum the tonnage of sediment for the entire mainstem Blackfoot by sub-reach.

Results indicate eroding banks contribute a total of 34,492 tons/year of sediment to the Blackfoot River.

Figure F-1 and Figure F-2 illustrate the total sediment load by unit length for each erosion inventory site and the estimated total yearly sediment load contribution from each reach, respectively. In both figures, erosion inventory sites run from upstream (BR01) to downstream (BR23). BR01 through BR09 occur in the upper 303(d) listed reach of the Blackfoot River and sites BR10 through BR23 are in the lower listed reach (Figure F-2). Sites BR14 through BR23 cover the stretch from Poorman Creek to Nevada Creek, the reach identified in field assessments as being below the influence of the Landers Fork and potentially impaired by fine sediment. Sediment loads per mile were extrapolated from reaches inventoried (Figure F-1) to those not inventoried based on major reach break characteristics. This provided an estimated total yearly sediment load for each channel length along the Blackfoot River from Nevada Creek to the headwaters.

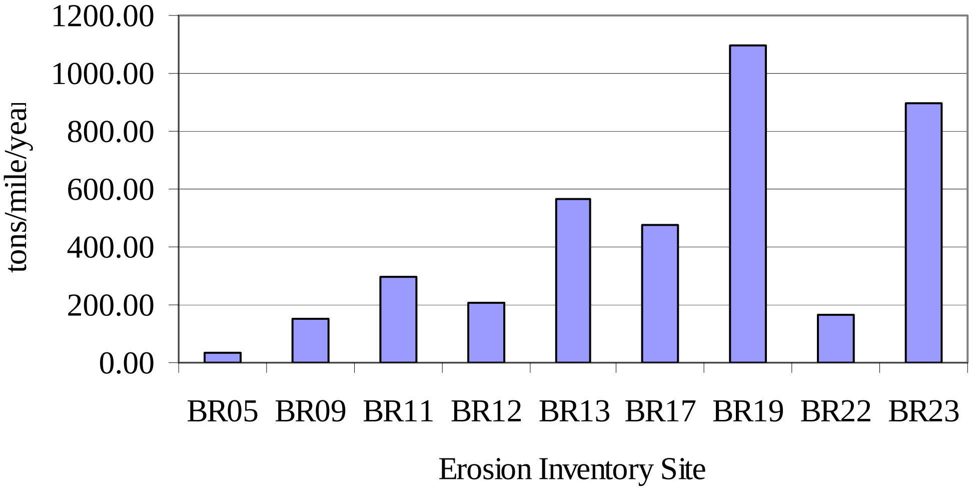

Figure F-1. Yearly Estimated Total Sediment Load by Erosion Inventory Site.

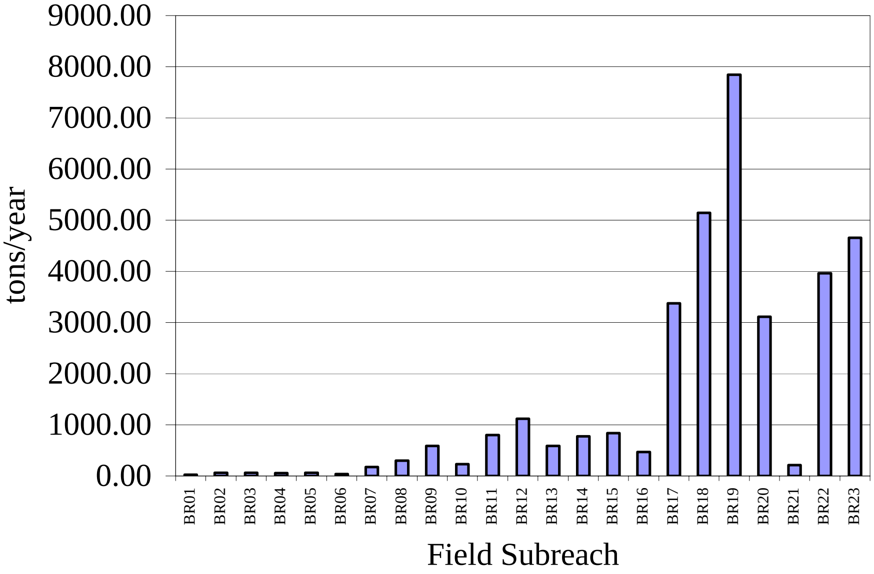

Figure F-2. Estimated Total Sediment Load by Channel Length.

Analysis of human influence data recorded during the 2002 field erosion inventories indicates a strong correlation between the cumulative human influence factor and eroding bank severity. (The cumulative human influence factor is the sum of the types of human influence at or near an eroding bank weighted by its proximity.) Figure F-3 illustrates this relationship. This strongly suggests that human influences are increasing sediment inputs along the stream corridor. The percentage of all eroding banks with an associated human disturbance ranges from approximately 6 to 47 percent by erosion inventory site (Figure F-4).

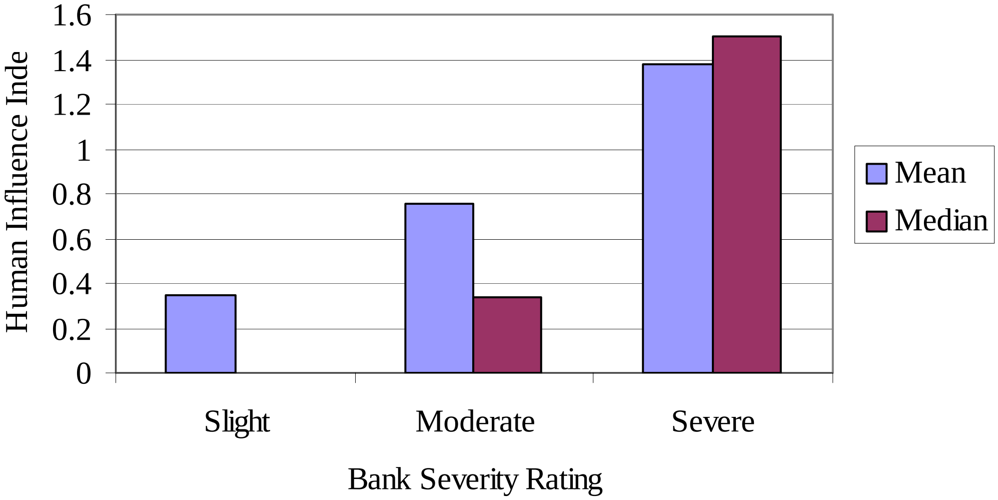

Figure F-3. Eroding Bank Severity Rating vs. Human Influence Index.

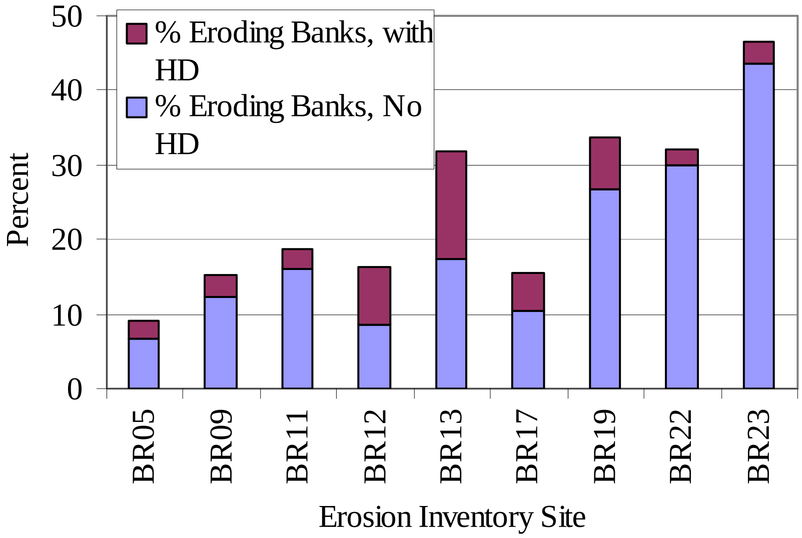

Figure F-4. Channel Length with Eroding Banks Associated with a Human Disturbance.

We used the percentage of banks with associated human disturbance to determine the maximum amount of human-induced sediment contributed by eroding banks on the mainstem Blackfoot River (Table F-2). These analyses attribute nearly 7,000 tons/year of the sediment to banks with moderate or high levels of human disturbance. Still, the proportion of this load that is due to human influences versus natural is unknown. In other words, these banks may have contributed some amount of sediment in the absence of human activities increasing bank erosion. In consultation with DEQ, we estimated between 50 and 75% of this sediment load is from controllable human activities based on best professional judgment. Therefore, we attributed up to 75% of the 7,000 tons (5,250 tons) of sediment per year to the Blackfoot River to controllable human activities increasing bank erosion.

Reaches of the Blackfoot River vary in sediment contributed from eroding banks associated with human disturbance. The reach below the Landers Fork influenced section contributes the largest amount of maximum human-induced sediment load from eroding banks, 5,764 tons/year (Table F-2). Tables F-3 and F-4 show the relative impacts for the several types of human activities noted. Human activities associated with potential bank erosion; however, livestock grazing and encroachment by roads are the predominate influences. Some of these activities, such as livestock grazing, are likely more controllable via BMPs than other, potentially more permanent impacts such as encroachment by roads. Another important factor than can influence erosion processes in rivers is the influence of sediment from upstream sources. Sediment deposited from upstream sources increase bank pressure along downstream reaches, which in turn, contributes to further bank erosion. Some of these upstream sources are due to controllable human activities, although it is difficult to quantify the impact that these upstream human sources have on downstream bank erosion. Allocations in Section 5 and recommended mitigation measures described in Section 6 of this document address reducing upstream sediment sources as well as reducing eroding banks in the impaired reach of the Blackfoot River.

Table F-2. Yearly Sediment Loads from Eroding Banks.

	Sediment Load from Eroding banks, mainstem Blackfoot River, using Rosgen (2000) lateral migration rates (tons/yr)		
	Upper Listed Reach (MT76F001_010) Headwaters to Landers Fork	Lower Listed Reach (MT76001_020b) Poorman Creek to Nevada Creek	Total
Human-induced (maximum)	284	6710	6,994
Natural	1085	26414	27,497
Sub Totals	1369	33124	34,492

Table F-3. Total Blackfoot River bank Lengths Affected by Human Sources by Reach; Percent Refers to the Percent of the Reach Affected by Each Type of Disturbance.

Human	**BR1**		**BR2**		**BR4**		**BR5**		**BR6**		**BR7**	
Influence	**Ft**	**%**	**Ft**	**%**	**Ft**	**%**	**Ft**	**%**	**Ft**	**%**	**Ft**	**%**
Revetment	319	0.6	173	0.5	726	2.2	1221	2	1844	2.4	1266	1.2
Buildings	0	0	0	0	1544	4.6	405	0.7	0	0	1505	1.4
Pavement	0	0	0	0	187	0.6	405	0.7	859	1.1	0	0
Road/Railroad	235	0.5	970	2.6	2249	6.7	5519	9.2	4253	5.5	2471	2.3
Pipes	0	0	0	0	0	0	0	0	351	0.5	325	0.3
Landfill/Trash	0	0	274	0.7	0	0	282	0.5	0	0	0	0
Park/Lawn	113	0.2	0	0	419	1.2	0	0	0	0	0	0
Grazing	85	0.2	0	0	1559	4.6	6465	10.8	16854	21.8	6617	6.3
Logging	0	0	0	0	997	3	3230	5.4	0	0	0	0
Mining	0	0	0	0	0	0	0	0	0	0	0	0
Total	752	1.5	1416	3.8	7681	22.8	17525	29.3	24161	31.2	12184	11.5

Table F-4. Total Combined Blackfoot River Bank Lengths Affected by Human Sources; Percent Refers to Relative Percentage of Each Type of Human Disturbance.

Human Influence	Total Eroding Bank Lengths	% of Total Eroding Banks; All Reaches
Revetment	5549	8.7
Buildings	3454	5.4
Pavement	1451	2.3
Road/Railroad	15697	24.6
Pipes	676	1.1
Landfill/Trash	556	0.9
Park/Lawn	532	0.8
Grazing	31580	49.6
Logging	4227	6.6
Mining	0	0
Total	63,722	100

APPENDIX G
USE OF SEDIMENT CORE DATA

A significant source of information on streambed composition in the Blackfoot Headwaters Planning Area is McNeil core samples (McNeil and Ahnell, 1960) collected by the US Forest Service. These data have several applications in making beneficial use support determinations and developing TMDL targets. Furthermore, core samples are a least-biased approach to assessing substrate composition (Young and Hubert, 1991). Another value of this particular dataset is the large number of replicates, spatial coverage, and temporal coverage. Monitoring has been ongoing from the late 1980s to the present with data available from 23 streams. Furthermore, the gradations measured using this technique allow assessment of several aspects of salmonid spawning gravel quality (Kondolf, 2000). This involves assessing life history requirements needed for successful reproduction: excavation of redds, incubation of embryos, and successful emergence of fry. Finally, fisheries biologists frequently use McNeil cores to evaluate survival to emergence of two key species, westslope cutthroat trout, and bull trout (Weaver and Fraley, 1991). Given these strengths, we evaluated this dataset as a means to make impairment determinations and develop numeric targets for streams in the Blackfoot Headwaters Planning Area.

Methods

Focusing on McNeil core data collected on the mainstem Blackfoot and 303(d) listed tributaries, we assessed the suitability of substrate composition for spawning by salmonids based on a procedure presented by Kondolf (2000). The first step in this analysis was to generate a size distribution for sampled particles. Due to the large number of samples collected, we represent size class distribution as box and whiskers of key particle size classes (< 6.35 mm, and < 2.38 mm) across years for each site.

The next step was to evaluate the ability of a female to excavate particles by examining the weighted mean of particles sampled for each core sample. This is a surrogate for the d_{50}, a commonly used statistic. These weighted averages provided the basis to generate box and whisker plots of d_{50} across years for each site. A general rule of thumb is that a fish can move particles up to 10% of her body length. Salmonids in the Blackfoot Headwaters Planning Area range up to 19 inches or 480 mm (Hillman et al., 1996), while most fish are between 9 and 15 inches (225 and 380 mm). Therefore, the median particle size in spawning microhabitats should range within 22.5 and 38 mm. Because all sites evaluated met this criterion, we will not include additional descriptions of these results.

Suitability for incubation relates to the percentage of grain sizes passing through the smaller gradations – such as the 0.85 mm sieves (Kondolf, 2000). Kondolf (2000) suggests that the 0.85 size gradation be less than 12-14% based on field observations by McNeil and Ahnell (1964) and Cederholm and Salo (1979). The percent fines measures for streams in the Blackfoot Headwaters TMDL planning area appear to satisfy this condition. Therefore, we used the 2.38 mm size gradation, in comparison to reference reaches, as an indicator of incubation success and as an additional indicator of successful fry emergence, discussed below.

In assessing whether fine sediment has the potential to block emergence of fry from redds, Kondolf (2000) recommended calculation of percentages finer than 3, 6, or 10 mm. Then, compare these percentages with values from laboratory and field studies. We selected the gradations less than 2.38 mm and 6.35 mm for analysis. The 6.35 mm was selected in order to make comparisons with survival-to-emergence studies conducted by Weaver and Fraley (1991) for westslope cutthroat trout and bull trout. These investigators found a strong linear relationship between survival-to-emergence and the proportion of fines less than 6.35 mm (Figure G-1 and Figure G-2). These relationships are used here justify the use of numeric endpoints by comparing impaired reaches to reference reaches to develop numeric targets for desired survival-to-emergence based on percent fines.

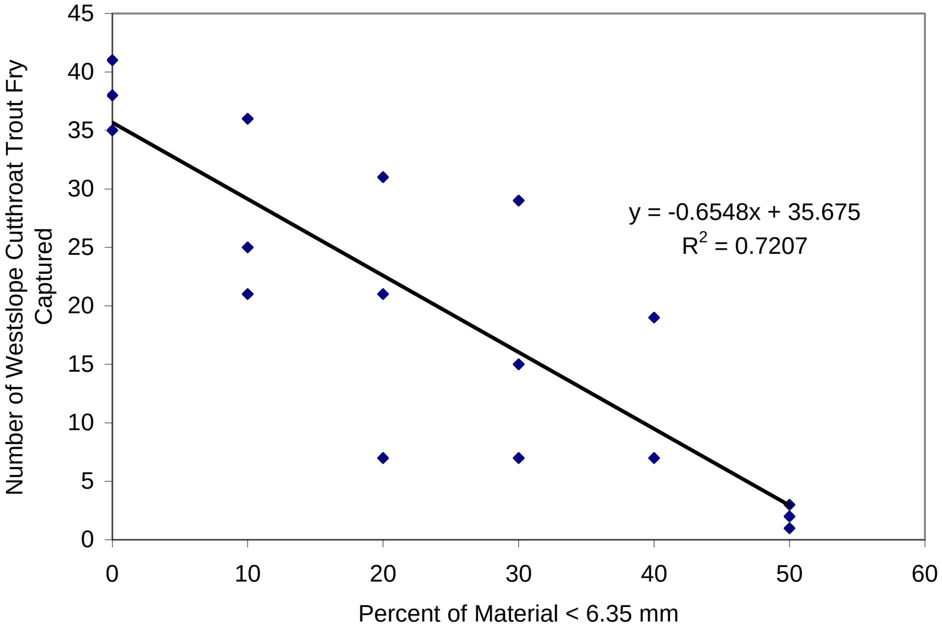

Figure G-1. Relationship Between Numbers of Westslope Cutthroat Trout Fry Successfully Emerging from Replicates of Six Gravel Mixtures and the Percentage of Material Smaller Than 6.35 mm in Each Mixture (Weaver and Fraley, 1991).

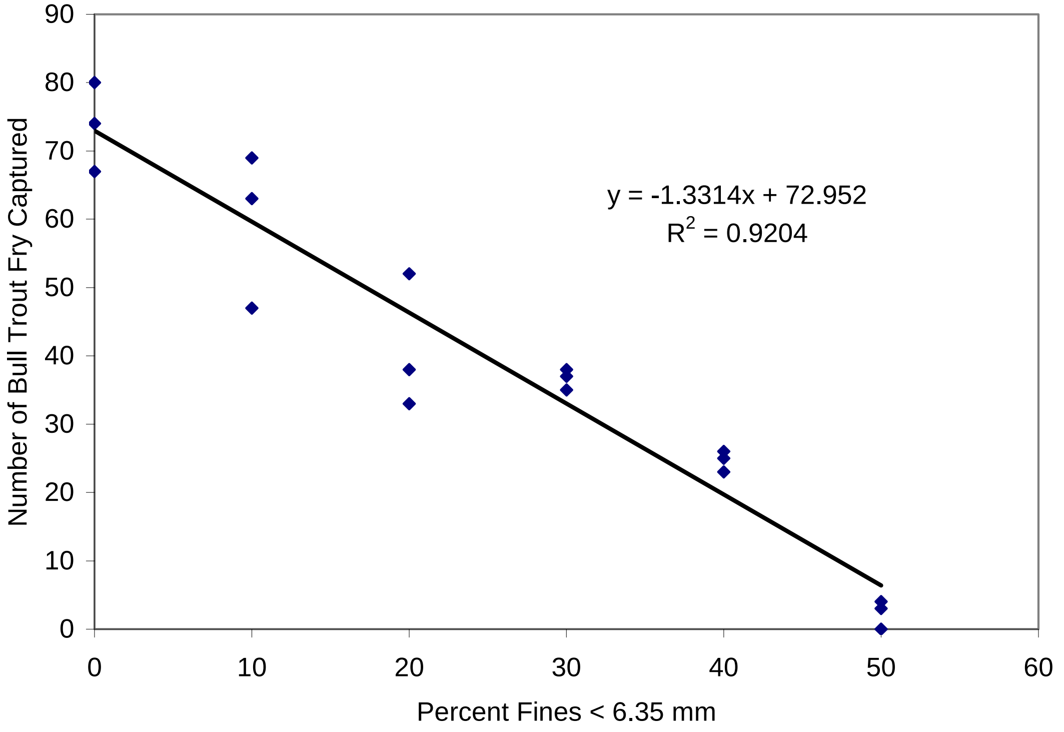

Figure G-2. Relationship Between Number of Bull Trout Fry Successfully Emerging from Replicates of Six Gravel Mixtures and the Percentage of Material Smaller Than 6.35 mm in Each Mixture (Weaver and Fraley, 1991).

The nature of the available data precluded assessment of other considerations in evaluating spawning gravel quality recommended by Kondolf (2000). These considerations include accounting for cleaning of gravels during redd excavation, accounting for accumulation of fine sediments during incubation, and effects of hydrologic events on bed composition. We assumed these would not result in a net change in substrate composition from excavation to emergence, and if there were any changes, they would be consistent between streams being evaluated and reference streams. Another recommendation was to assess intra-gravel flow within a pool tail. This requires detailed information on flow level, channel bed geometry and may be influenced by large-scale groundwater circulation patterns. The lack of data to assess fully these conditions precluded assessing this consideration as well, although this is partly addressed by the assessment of fines less than 0.85 and 2.38 mm.

A final step was development of targets for percent fines. To develop numeric criteria for TMDL targets we evaluated fine sediment levels from all available core samples of tributary streams in the Blackfoot Headwaters Planning Area and nearby drainages provided by the Helena National Forest. Then, we ranked each stream based on median values of the < 6.35 mm gradation. The five streams with the lowest median values were designated as least impaired streams to be used for reference conditions and became the basis of targets for tributaries in the Blackfoot Headwaters Planning Area (reference Section 1.4).

Results and Discussion

Reference Conditions

Generation of distribution statistics for percent fines < 6.35 mm in tributary streams in the Blackfoot Headwaters Planning Area and nearby drainages indicates high variability in proportions of fine particles among streams (Figure G-3). Percent fines < 2.38 mm showed similar trends to the percent fines < 6.35 mm for most streams (Figure G-4). The exception was Poorman Creek, which had proportionally less particles in the 2.38 mm gradation than the 6.35 mm. This suggests that fine sediment may not present a constraint on incubation of eggs in Poorman Creek; entombment of fry is a potential impairment.

Dry Creek, Buffalo Creek, the Blackfoot River above the Landers Fork, Copper Creek, and Humbug Creek ranked as the streams with lowest median fines less than 6.35 mm. These five streams were therefore used to represent least impaired or reference conditions for other streams. The 25th percentile for these five streams was 19.3%, the median 24.5%, and the 75th percentile was 29% (Figure G-5). The TMDL target based on this assessment is median values will not exceed the 75th percentile of the reference streams, or 29%. The use of the 75th percentile instead of the lower median value is in recognition of the natural variability around percent fines measures and target conditions. Based on distribution statistics for particles < 2.38 mm, the 75th percentile for the reference streams is 15% (Figure G-6). Similarly, for particles less than 2.38 mm in diameter, median values should not exceed the 75th percentile of the reference streams, or 15%.

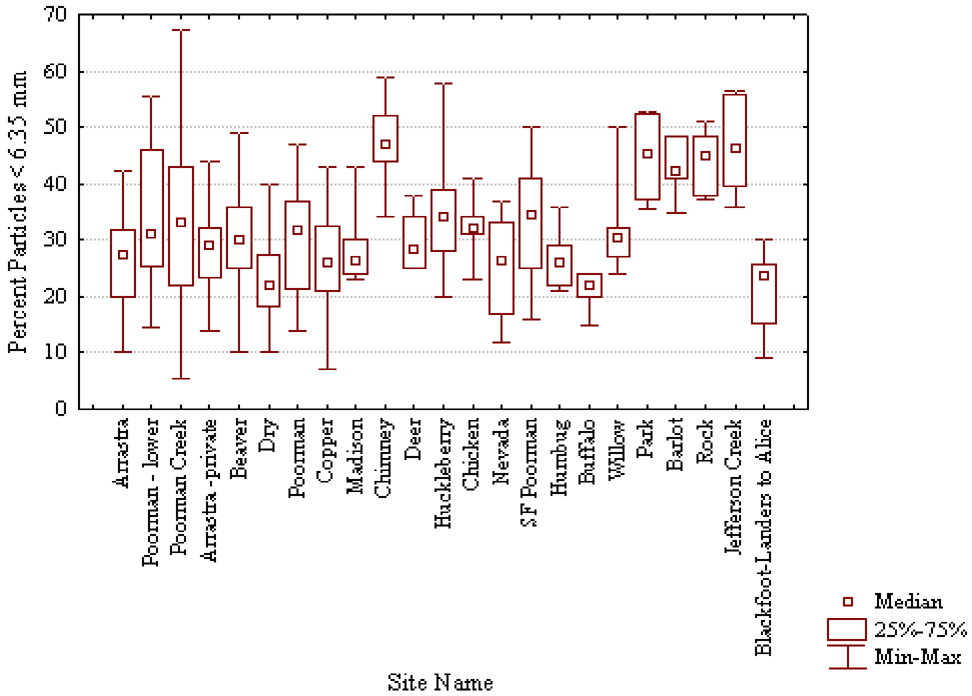

Figure G-3. Distribution Statistics for Percent Fines < 6.35 mm Measured on Tributary Streams in the Blackfoot River Drainage (Unpublished Data). Note that the Willow Creek in this Dataset is not the 303(d) Listed Stream.

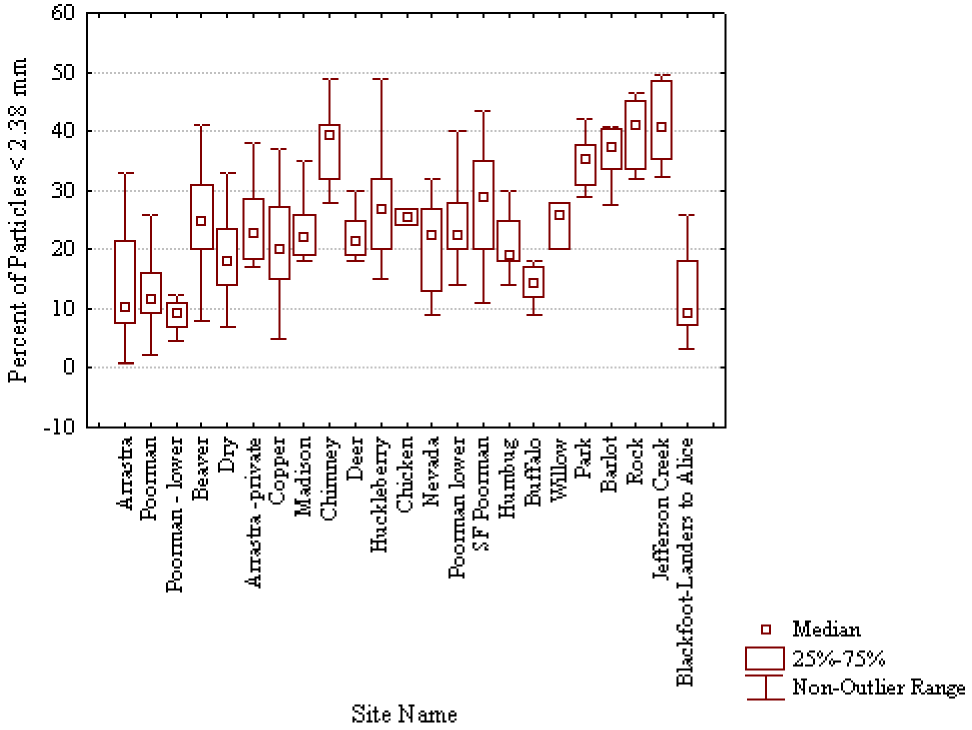

Figure G-4. Distribution Statistics for Percent Fines < 2.38 mm Measured on Tributary Streams in the Blackfoot River Drainage (Unpublished Data). Note that the Willow Creek in this Dataset is not the 303(d) Listed Stream.

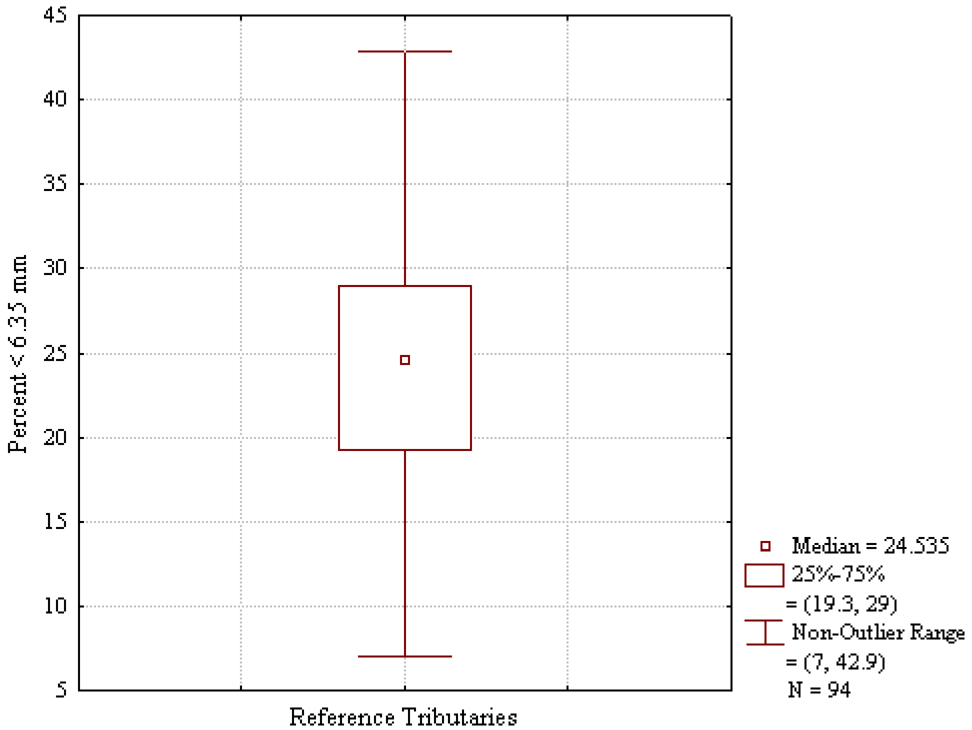

Figure G-5. Distribution Statistics for Percent Particles < 6.35 mm in Reference Streams in the Blackfoot River Drainage.

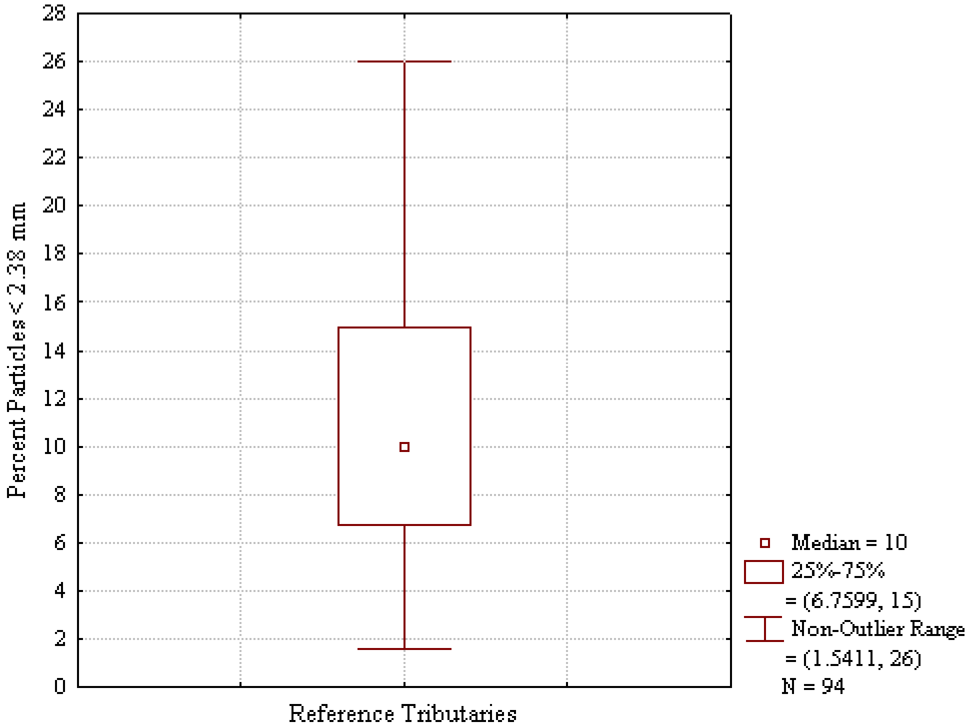

Figure G-6. Distribution Statistics for Percent Particles < 2.38 mm in Tributary Streams in the Helena National Forest.

Blackfoot River (Above Landers Fork)

Core samples collected on this reach of the Blackfoot River indicate relatively low levels of fine sediment in the most recent samples (Figure G-7 and Figure G-8). For the 6.35 mm gradation, the median was less than the 75th of the reference streams in all years. In fact, this segment of the Blackfoot River was used as a reference stream, suggesting that fine sediment does not impair beneficial uses in this portion of the Blackfoot River. For the 2.38 mm gradation, the median was substantially less than the 75th percentile of reference streams in the most recent two sampling events indicating full support. In 1986, this gradation exceeded the target considerably. It is difficult to determine the reason for these relatively high numbers; however, it may relate to the tailings dam failure in 1976. The lower values may reflect flushing and recovery from this event.

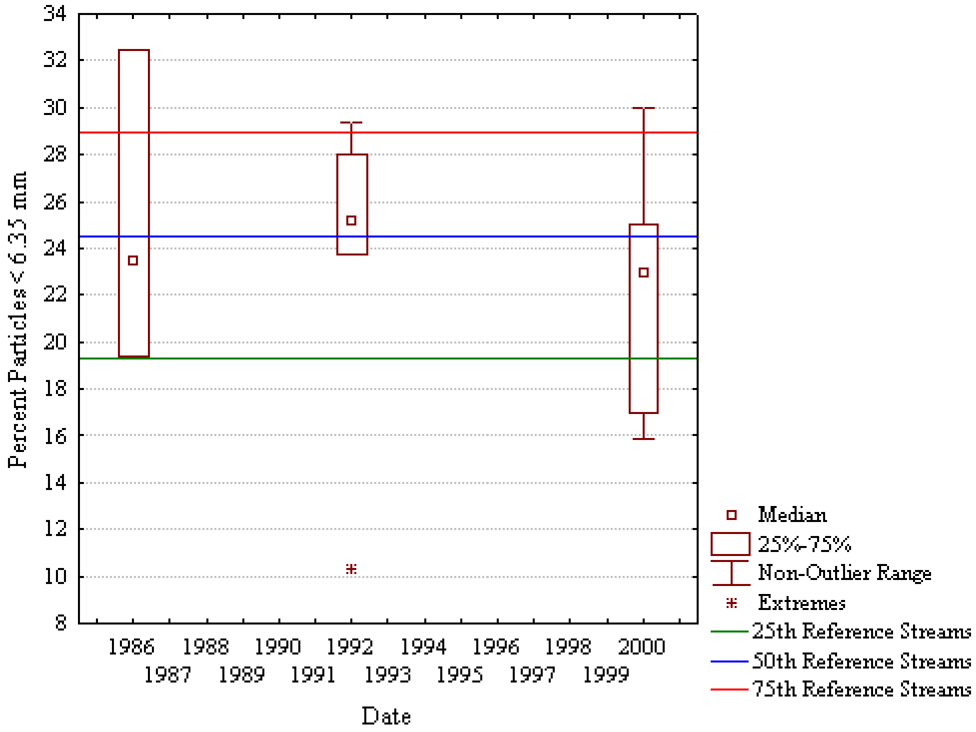

Figure G-7. Distribution Statistics and Criteria Based on Reference Stream Dataset for Particles Less Than 6.35 mm Measured on the Blackfoot River Above Landers Fork.

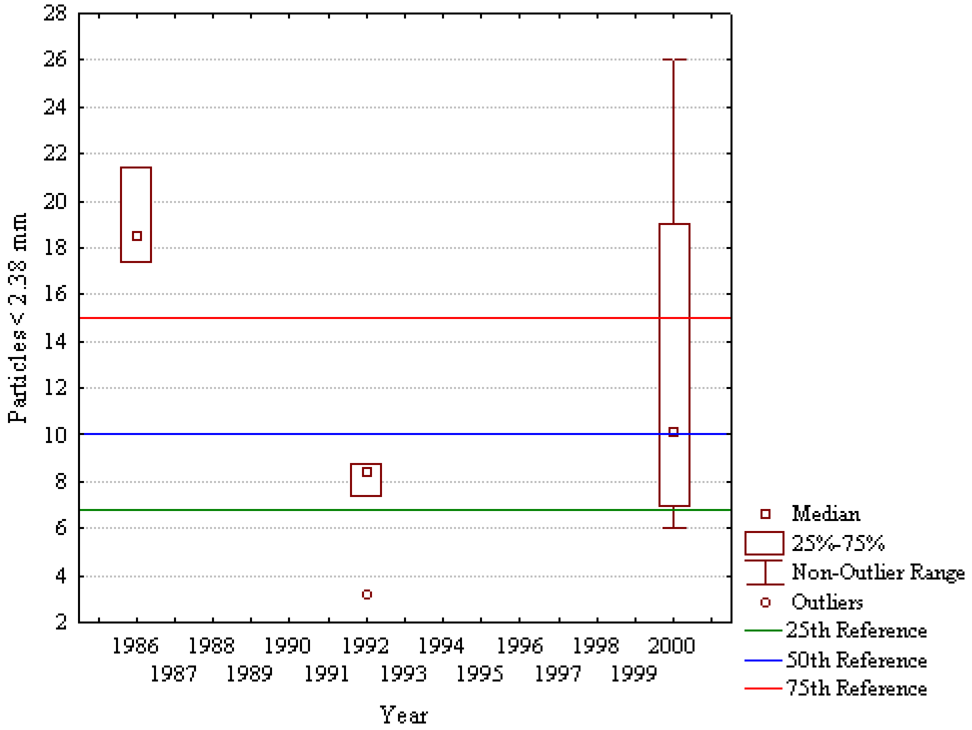

Figure G-8. Distribution Statistics and Criteria Based on Reference Stream Dataset for Particles Less Than 2.38 mm Measured on the Blackfoot River above Landers Fork.

Blackfoot River (Landers Fork to Nevada Creek)

USFS personnel have collected core samples at three locations on the Blackfoot River in the Landers Fork to Nevada Creek reach. Sampling occurred from the mid-1980s to 2000 with over 200 samples collected. Box and whisker plots generated from these data indicate that proportions of fine sediment in this reach of the Blackfoot River are at levels below the target conditions indicating harmful conditions to incubating eggs and embryos (Figure G-9 and Figure G-10). Moreover, there is an apparent trend of increased levels of sedimentation starting in the mid-1990s and persisting to 2000. The proportions of particles < 2.38 mm are highest at the Nevada/Ogden reach reflecting the high proportions of fine sediment observed during field investigations.

Criteria developed for tributary streams in this analysis should be applied to mainstem reaches with caution. These reaches tend to have finer bank materials and therefore naturally entrain a greater proportion of fine sediment. However, because mainstem sites demonstrated levels comparable to proposed targets for tributary streams, in some years, these targets are probably attainable for the mainstem of the Blackfoot River. Therefore, the targets established in tributary streams are applied to all stream segments in the Blackfoot Headwaters Planning Area.

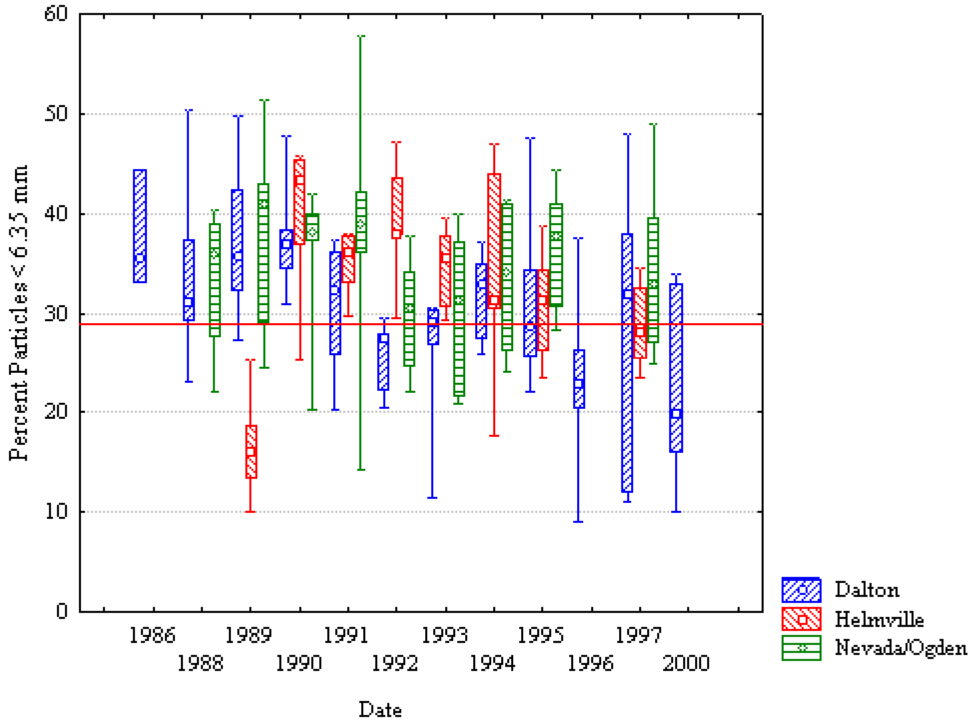

Figure G-9. Distribution Statistics and Criteria Based on Reference Stream Dataset for Particles Less Than 6.35 mm Measured on the Blackfoot River (Landers Fork to Nevada Creek Reach).

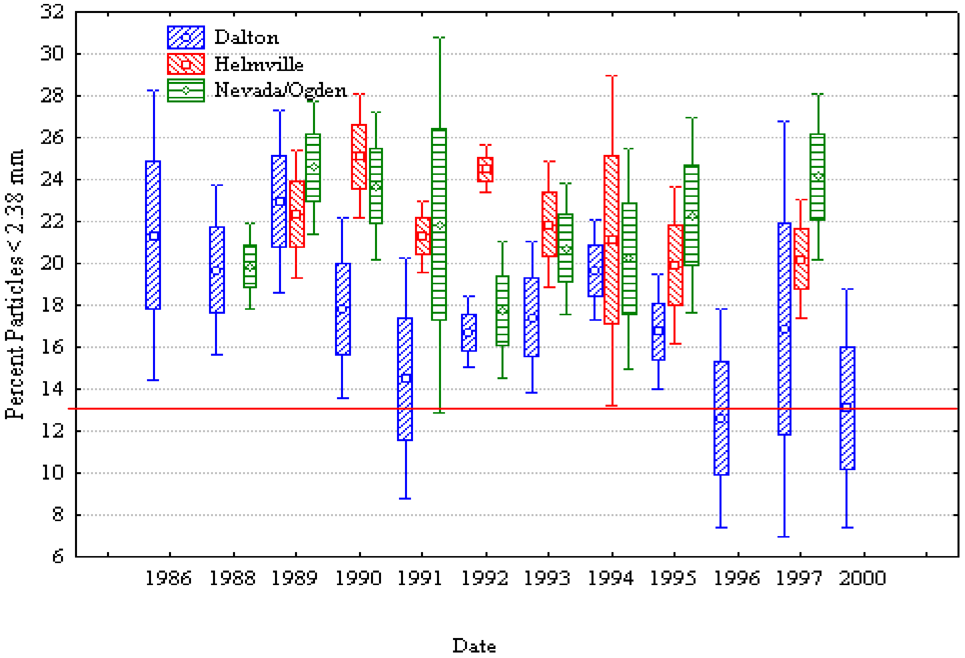

Figure G-10. Distribution Statistics and Criteria Based on Reference Stream Dataset for Particles Less Than 2.38 mm Measured on the Blackfoot River (Landers Fork to Nevada Creek Reach).

Arrastra Creek

Comparison of percent fines in the two gradations indicates percent fines exceed the target levels in some years at two locations in Arrastra Creek. For the 6.35 gradation, the median exceeded the target of 29% at both sampling locations for several years (Figure G-11). Despite an apparent improving trend for this size class, the target was exceeded at the lower sampling site in the most recent sampling year, 2001. For the 2.38 mm gradation (Figure G-12), the target was exceeded twice in eight years of sampling. These data suggest that fine sediment results just barely justify an impairment of beneficial uses based on these target conditions.

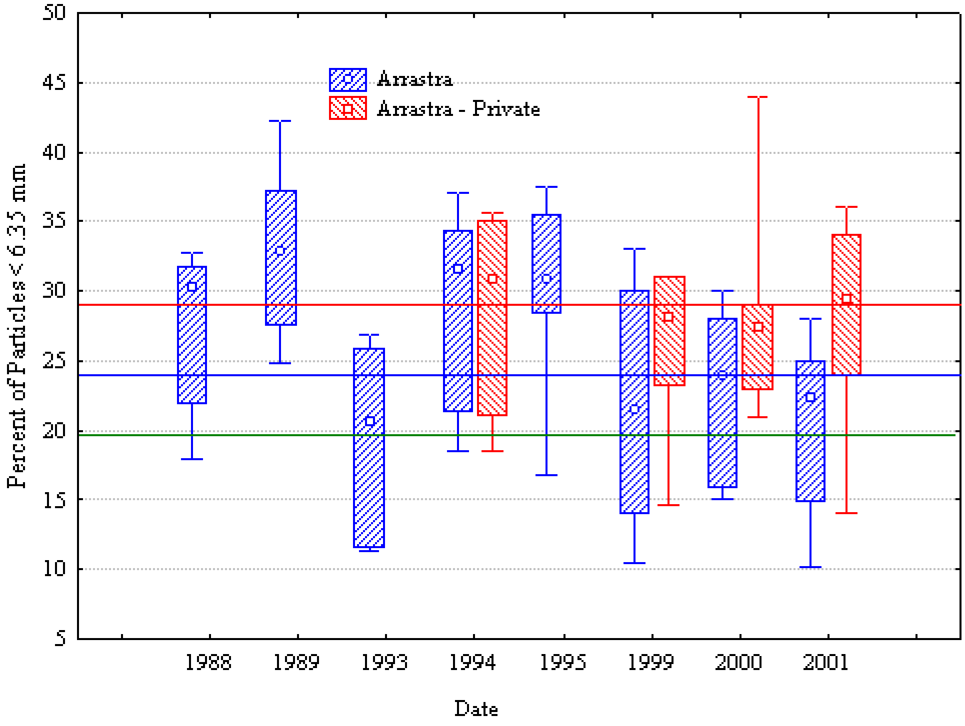

Figure G-11. Distribution Statistics and Criteria Based on Reference Stream Dataset for Particles Less Than 6.35 mm Measured on Arrastra Creek.

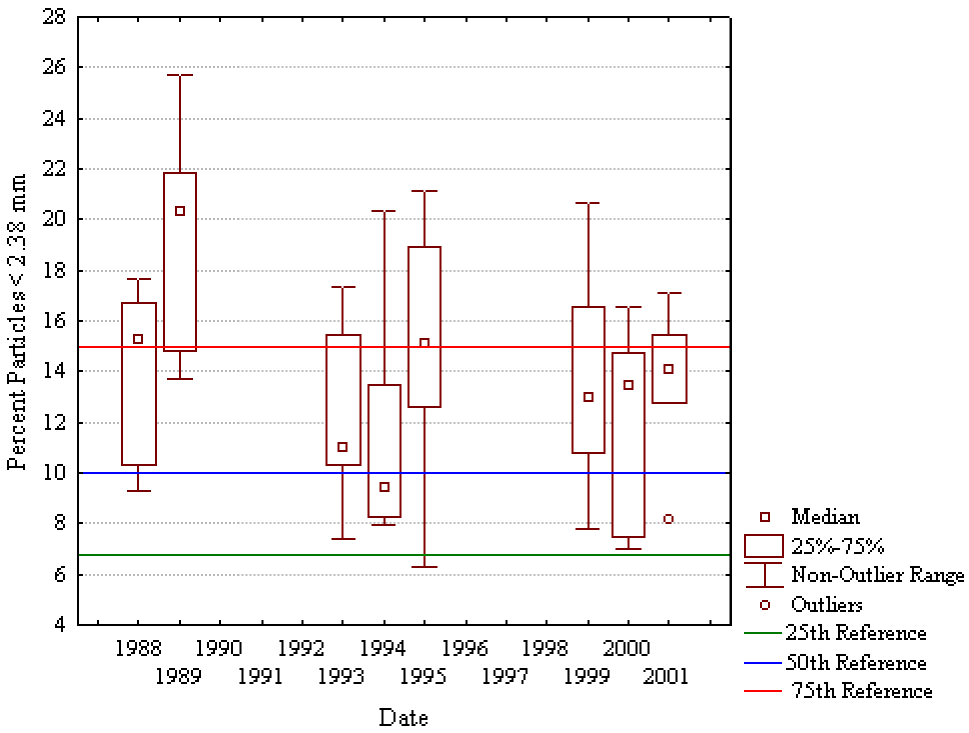

Figure G-12. Distribution Statistics and Criteria Based on Reference Stream Dataset for Particles Less than 2.38 mm Measured on Arrastra Creek.

Poorman Creek

Sediment monitoring in the Poorman Creek watershed includes collection of over 180 samples (Figure G-13). Analyses of these data indicate that fine sediment limits propagation of cold-water fish by substantially decreasing survival-to-emergence through entombment of fry when compared to reference conditions. Proportions of particles less than 6.35 mm were above criteria in most years and at several sampling stations in the basin. In contrast, the 2.38 mm gradation has frequently been within the criteria, especially over the last few years (Figure G-14). Nevertheless, these results corroborate an impairment determination for Poorman Creek for the propagation of salmonids, a designated beneficial use.

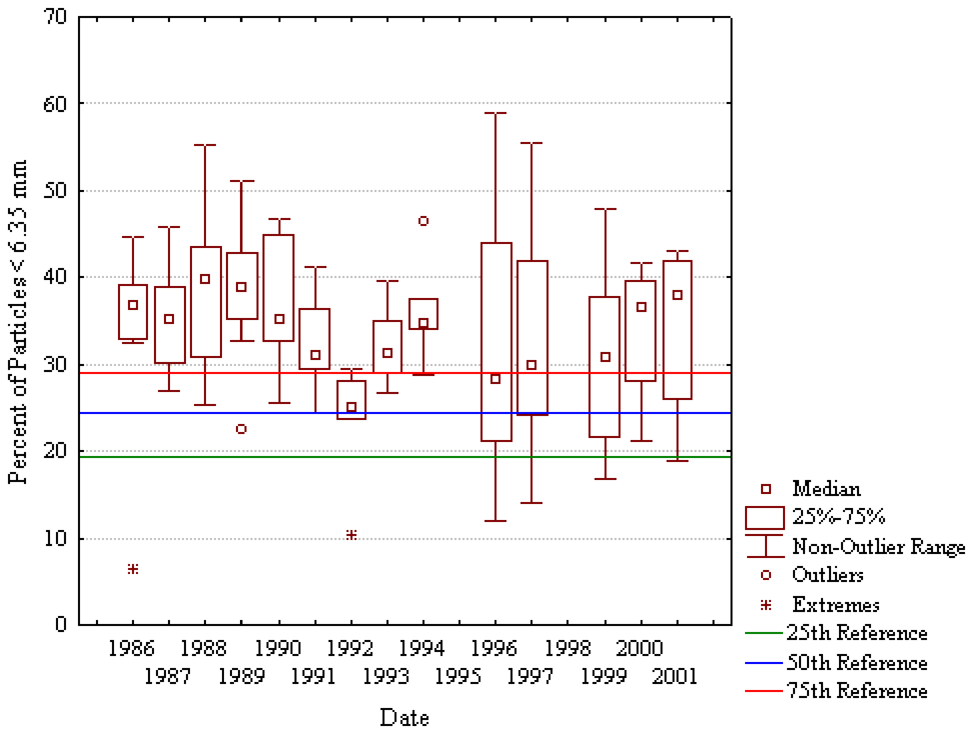

Figure G-13. Distribution Statistics and Criteria Based on Reference Stream Dataset for Particles Less Than 6.35 mm Measured on Poorman Creek.

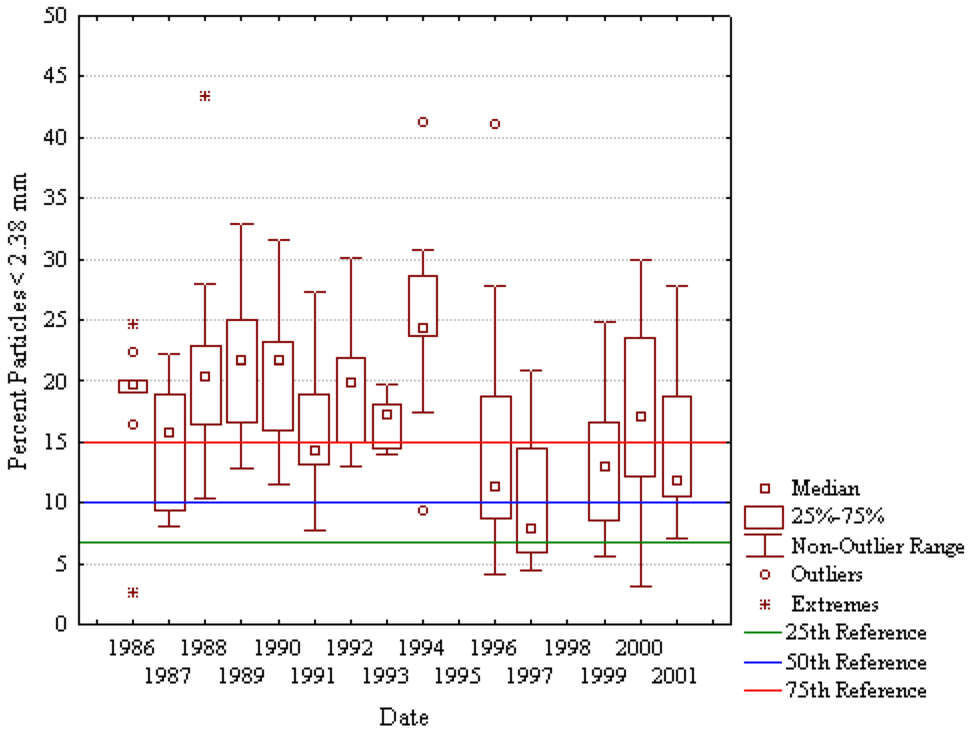

Figure G-14. Distribution Statistics and Criteria Based on Reference Stream Dataset for Particles Less Than 2.38 mm Measured on Poorman Creek.

APPENDIX H
RESULTS OF FISH HABITAT ASSESSMENTS CONDUCTED ON ARRASTRA CREEK

Existing assessments of physical habitat conditions in Arrastra Creek (USFS, unpublished data) provided a quantitative basis for assessing stream conditions and establishing targets. USFS field crews (Helena Ranger District) conducted a fish habitat assessment following protocols described by Hankin and Reeves (1988) on three reaches of Arrastra Creek in 1996. These reaches extended from the confluence with the Blackfoot River upstream approximately 5 miles. Reach 1 began at the confluence with the Blackfoot River, reach 2 began upstream at the confluence with an historic abandoned channel of the Blackfoot, and reach 4 begins at the upstream end of Frenchy's Pond. These data provide a surrogate for the modified EMAP assessments conducted during Phase II field assessments.

Reach 1 was a sedge/rush dominated section with a limited presence of riparian or upland trees. Reach 2 showed an increase in riparian shrubs and upland trees, and Reach 4 exhibited the lowest amount of bare ground and the highest percentage of riparian shrubs, riparian trees, and over story trees (Figure H-1). The presence of riparian trees was small to absent in all reaches, however the riparian shrub community was well developed in both Reach 2 and 4. It is important to emphasize that these data are from a 1996 survey, riparian and upland vegetation conditions are likely to have changed since that time.

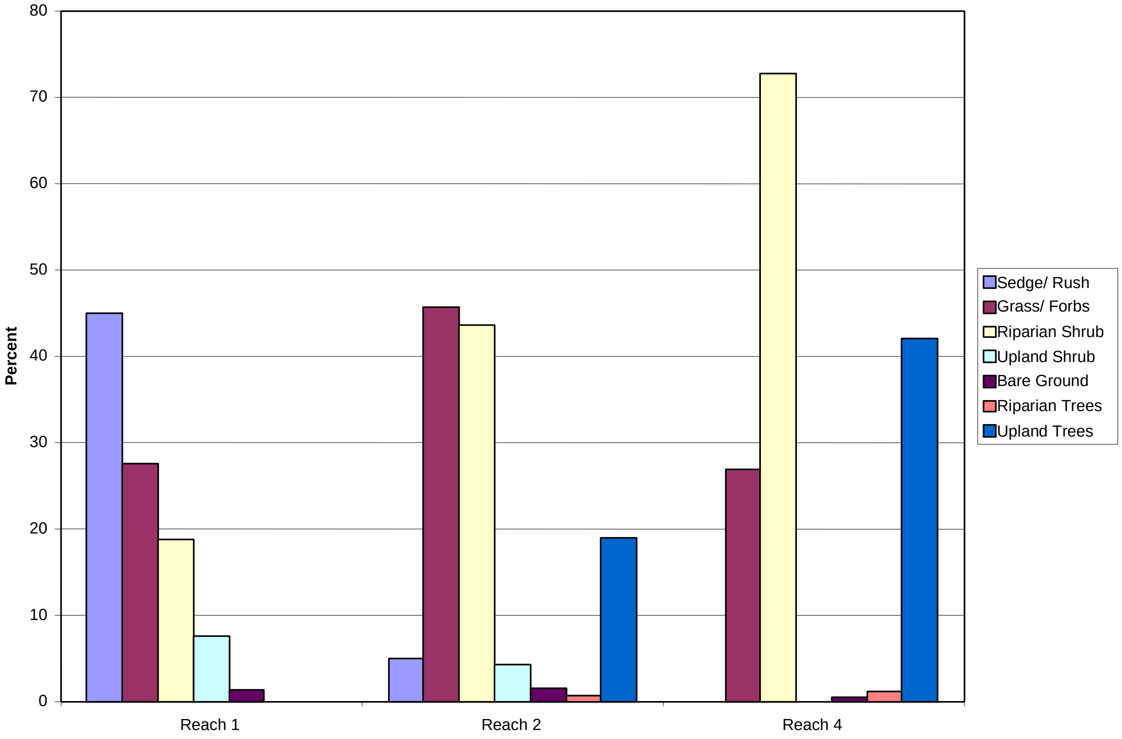

Figure H-1. Riparian and Upland Vegetation Along 3 Reaches of Arrastra Creek.

The banks in Arrastra Creek became progressively more unstable farther downstream. In Reach 4, nearly 100% of the banks were stable and well vegetated (Figure H-2). In contrast, only 50% of the banks in Reach 1 were vegetated and stable, while close to 40% were vegetated but unstable. Each reach exhibited a relatively high proportion of undercut banks, an important attribute for assessing available fish habitat.

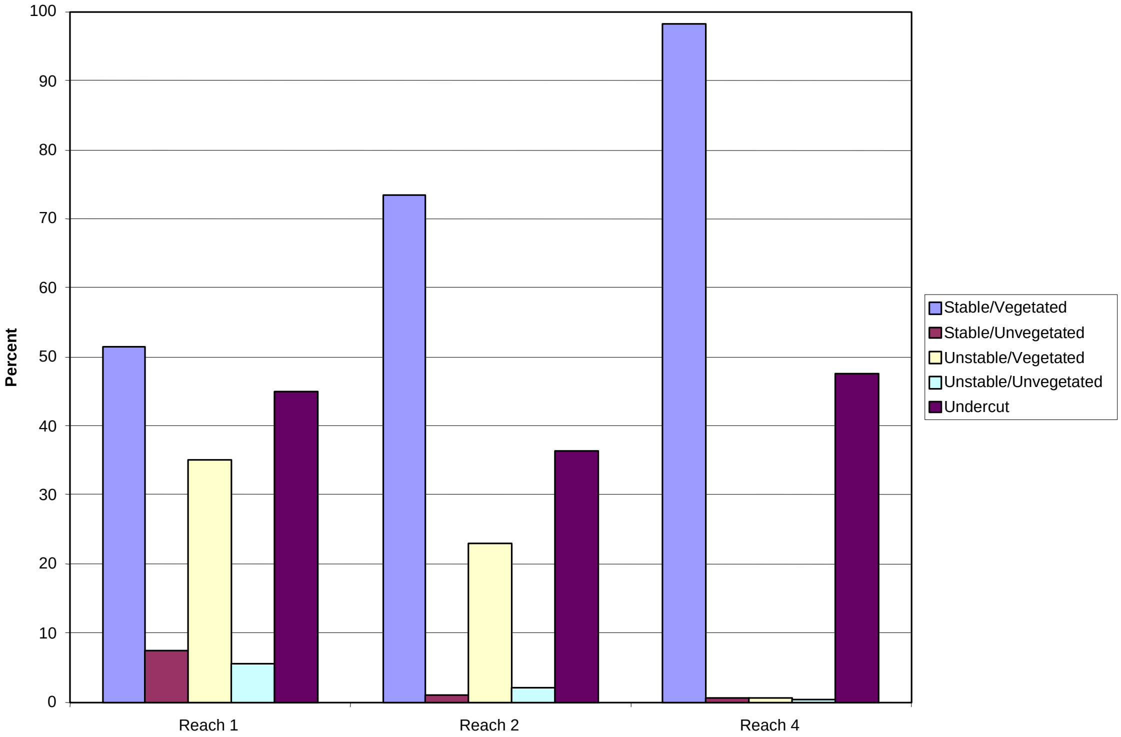

Figure H-2. Bank Stability Conditions (Stable/Vegetated, Stable/Unvegetated, Unstable/Vegetated, Unstable/Unvegetated, Undercut) in 3 Reaches of Arrastra Creek.

Gravel dominated streambed particles in Arrastra Creek, particularly in Reach 2 (Figure H-3). However, Reach 1 exhibited a high percentage of fine material based on pebble counts. Silt and sand accounted for 35% of particles. Upstream, fine material was present only in small quantities. Larger substrate material (rubble, cobble, and boulders) began to appear in Reach 2 and comprised a relatively high percentage in Reach 4.

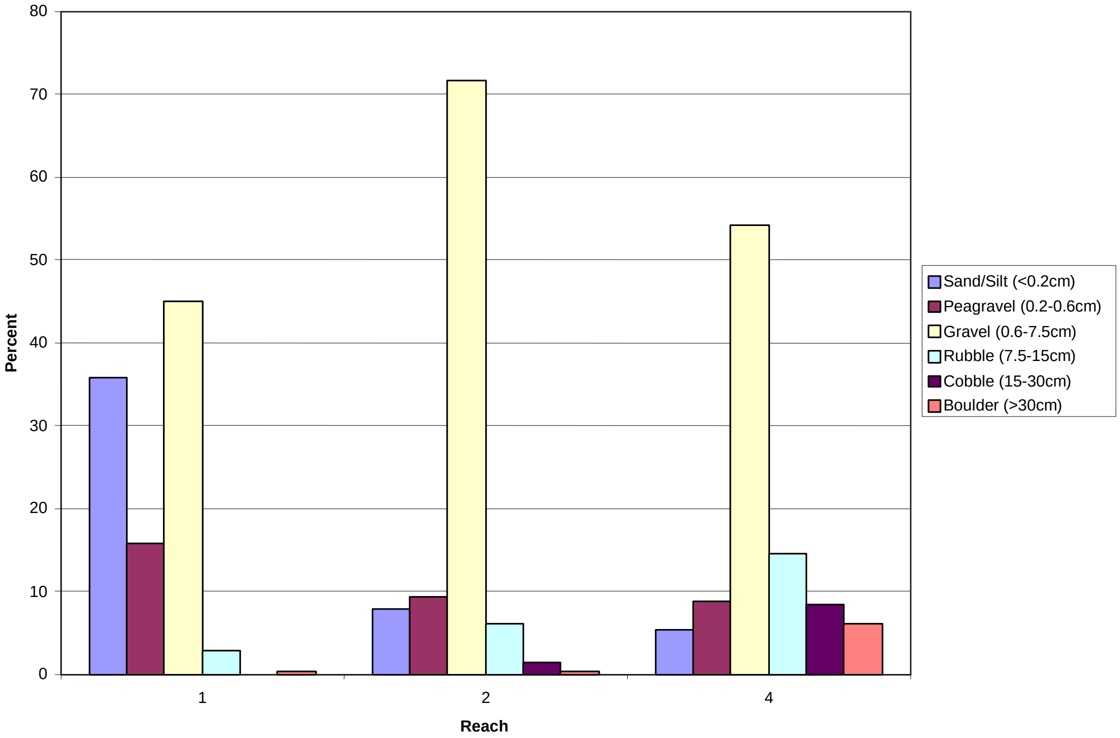

Figure H-3. Substrate Composition Within 3 Reaches of Arrastra Creek.

Fast and slow water habitat types were present throughout the length of the project reach (Figure H-4). The number of fast water habitat types, which included riffles, rapids, and runs were more prevalent in each reach. Slow water habitat types, such as pools, comprised a smaller proportion of the overall habitats in Arrastra Creek.

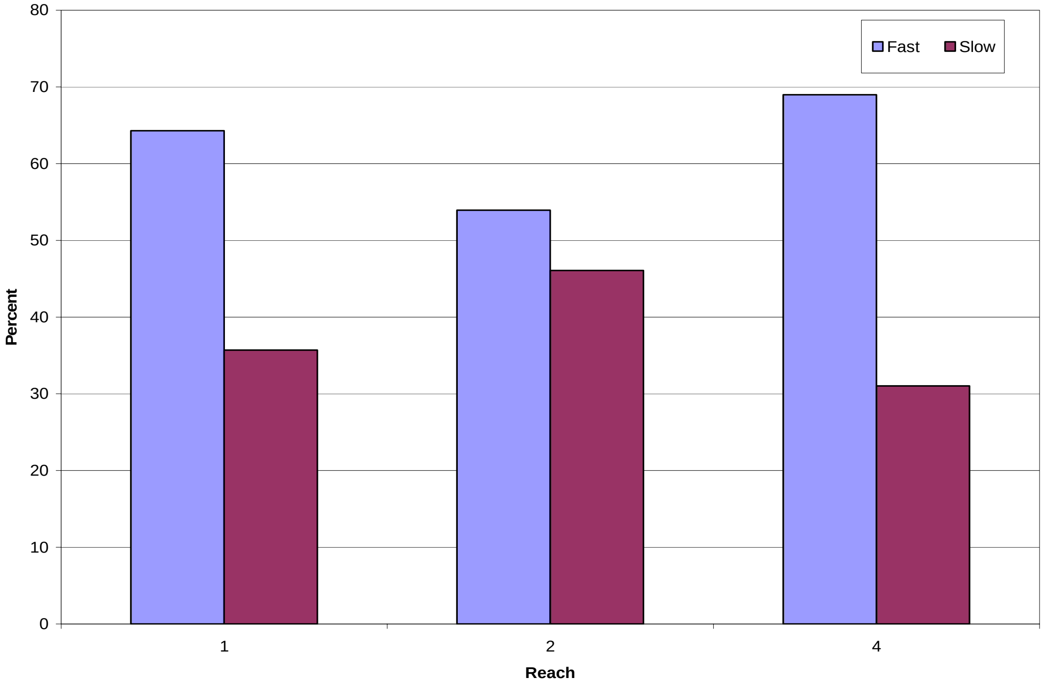

Figure H-4. Number of Fast and Slow Water Habitat Types in 3 Reaches of Arrastra Creek.

Conclusions

In conclusion, increasing the riparian over story component, thereby increasing the overall riparian structural diversity, particularly in Reach 2, will address the unstable and unvegetated bank conditions. Increasing the structural diversity will also increase the stability of those areas with unstable but vegetated banks. Reach 2 and 4 are dominated with high gravel substrate and an excessive bed load. Reach 1 also exhibits high fine sediment substrate, which may be a result of deposition from upstream sources. Improving upstream bank stability will also decrease the amount of sediment available for deposition.

APPENDIX I
LANDERS FORK INVESTIGATIONS

While not a 303(d) listed stream, TMDL planning efforts in the Blackfoot Headwaters Planning Area focused considerable effort to evaluate the role of the Landers Fork in influencing both geomorphology and water quality in the Blackfoot River. Geologic and hydrologic conditions unique to the Landers Fork prompted these investigations. Field observations indicated that the Landers Fork sub-watershed, approximately 131 square miles in area, is a significant contributor of sediment and flow to the Blackfoot River. The geology of the Landers Fork drainage basin includes highly erodible glacial deposits that commonly comprise the valley margin. Landers Fork investigations included field reconnaissance activities and an analysis of sediment transport capabilities.

Estimation of Sediment Transport Capacity of the Landers Fork

To estimate the relative sediment inputs from human and natural sources on the mainstem Blackfoot River, we assessed the sediment transport capacity of the Landers Fork at three locations. The selected sites consisted of one channel segment located just upstream of the Copper Creek confluence, and two locations downstream of the Highway 200 bridge, near the mouth of the channel. A number of activities provided data to support this analysis. The first step was the development of representative hydrology for the sites. Next, we surveyed channel cross-sections and longitudinal profiles at the three locations. We conducted pebble counts at these locations to describe sediment gradations. These data allowed calculations to estimate the average annual sediment transport capacities through each reach.

Daily stream flow data from USGS Gage 12335000 (Blackfoot River near Helmville MT) provided the basis for development a mean annual hydrograph for the sites. This gage, located near the Highway 141 Bridge, was operational from October 1940 to October 1953 and provided a 13-year record of mean daily flows. To scale the gage data to the sites on the Landers Fork, we employed regional regression equations (Omang, 1992) to estimate the 2-yr, 50-yr, and 100-yr peak flows at each site, with the daily flows proportioned based on those discharges. These discharges provided a basis of proportioning daily flows rather than simply drainage area, as the discharge calculations incorporate both precipitation and drainage area.

The estimated peak discharge events are shown in Table I-1. At the mouth of the Landers Fork, estimated peak flows ranged from 38% (2-yr) to 43% (100-yr) of those calculated at the Helmville gage. Just upstream of Copper Creek, the peaks range from 25% (2-yr) to 31% (100-yr) of those at the gage. The maximum-recorded mean daily discharge recorded for the period of record at the Helmville gauge was 5890 cfs in 1943. The estimated 2-year discharge of 3,926 cfs was exceeded a total of 4 days during that 13-yr time period. As such, the mean daily flows were proportioned according to the 2-yr flow relationship.

Table I-1. Flow Estimates Derived from Regional Regression Relationships.

Flow Event	Estimated Discharge (cfs)		
	Helmville Gage	Mouth Landers Fork (% of Gage)	Upstream Copper Cr Confluence (% of Gage)
2-yr	3926	1476 (38%)	993 (25%)
50-yr	15875	6274 (40%)	4450 (28%)
100-yr	20442	8700 (43%)	6345 (31%)

Mean annual hydrographs calculated for cross sections on the Landers Fork. The mean annual hydrographs determined for the cross section locations are shown in Figure I-1. The plot shows the mean daily discharges derived from the 13-year period of record, and proportioned to each site. These estimated mean daily flow values were then utilized to estimate the average annual sediment transport capacity at each cross section.

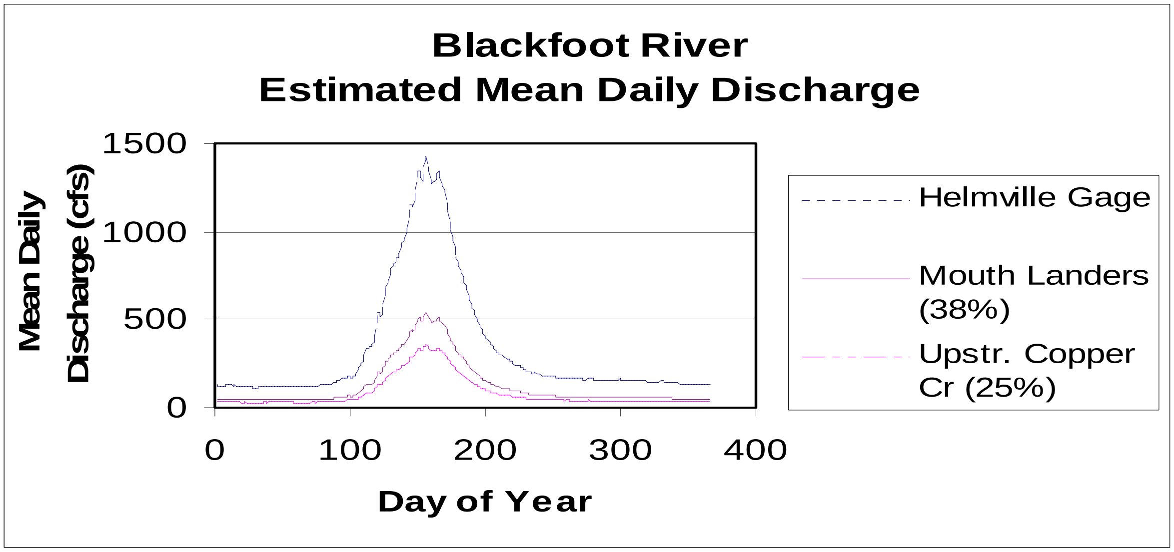

Figure I-1. Estimated Mean Annual Hydrographs for Cross Section Sites Based on Proportioned Helmville Gage Data.

In order to estimate the sediment transport capacity of each site, we utilized an at-a-station hydraulics software package, WinXSPRO, to determine hydraulic and sediment transport energy associated with each cross section/profile configuration. Next, we developed a sediment discharge rating curve (sediment transport rate vs. discharge) using the Meyer-Peter-Mueller transport function and bulk sediment gradation measurements. The annual flow hydrographs were then utilized to calculate daily transport volumes, and those cumulative daily transport volumes generated an average annual transport capacity estimate. See Table I-2 for results of the sediment transport capacity analysis.

Table I-2. Estimated Annual Sediment Transport Capacities, Landers Fork Cross Sections 1-3.

Cross Section	Location	DA (sq mi)	DA (acres)	Slope	D84 (bed) (mm)	D50 (bar) (mm)	Sed trans capacity (tons/yr)	Comments
1	Upstream of Copper Creek	84	53505	1.7%	90	16	1180227	Steep/Supply limited
2	Downstream Highway 200	131	83722	0.5%	100	16	173032	Transport Reach
3	Downstream Highway 200	131	83722	1.0%	100	9	1367844	Steep/Supply limited

The results of the assessment of sediment transport capacity include a range of transport volumes of approximately 173,000 to 1.4 million tons per year. These volumes reflect the capacity of the channel to convey sediment, but do not directly address the volume of sediment delivered. Finally, the results indicate that if large volumes of sediment are delivered to the Landers Fork channel there is sufficient transport energy available in the Landers Fork to convey that sediment to the Blackfoot River.

Field Reconnaissance

Field reconnaissance of the Landers Fork occurred concomitant with the 2002 field assessments. Activities included an erosion inventory supplemented with visual estimates of riparian cover and human influence. Field personnel used methodologies similar to those used for the modified EMAP assessments, with reduced rigor due to the extensive reach length. The assessed reach included the whole portion of the Landers Fork from the mouth to about ¼ mile above the Forest Service boundary at Forest Service Trail #438. The observers also recorded extensive field notes including observations of identifiable impairments and potential remedies. To further aid in interpreting field conditions, they viewed historic aerial photos that captured the impacts of a large flood event occurring sometime between 1937 and 1996, possibly in 1964. The objective of these investigations was to determine the relative roles of human activities, natural disturbance, or other natural factors in influencing the sediment load contributed to the Blackfoot River from the Landers Fork. If human activities were a significant factor in influencing sediment loading, this would have implications for impairment determinations and the ability to improve habitat conditions in both the Blackfoot River and the Landers Fork.

Comparison of the historic aerial photos suggests that a large flow event occurring in the mid-1960s resulted in significant alteration in geomorphology and floodplain vegetation. Note that several drainages in the region, such as the Teton River, experienced a 500-year event in 1964 that resulted in extensive alteration of channel morphology. On the Landers Fork, the photos from 1937 showed a relatively narrow active channel with bars well vegetated with trees for an upstream section near the current wilderness boundary. By 1966, the channel and vegetation characteristics changed dramatically. The active channel became considerably wider with bare, depositional bars along most of its length. Significantly, these alterations occurred in areas where human activities were negligible suggesting that many of the conditions that persist to this day were the result of natural disturbance in the basin. Nevertheless, the photos did indicate that some riparian harvest had taken place historically in some sections located further downstream.

Bank erosion is a significant source of sediment loading in the Landers Fork and was therefore a focus of the 2002 field assessment. The observers encountered 12 very large eroding banks mostly in the upper assessed reaches on the Landers Fork with each rating as severely eroding. Furthermore, review of aerial photos indicated that these types of eroding banks were common features in the upper reaches of the Landers Fork above the reach assessed in 2002. Fine sediment comprised between ¼ and ¾ of the particles contributed from the 12 banks, while cobbles and gravels were stored in aggradational areas. The observers rated each of these banks as major contributors of fine sediment. However, since these banks occurred where the stream abutted deposits of glacial till and were typically not associated with causative human activities, their sediment contributions were likely natural.

In addition to terrace banks comprised of highly erodible glacial till, field observers mapped and extensive number of additional eroding banks along the assessed reach and noted human influences in proximity of these banks. While human activities, notably livestock grazing, were likely causing increased bank erosion in some locations, the overall obvious contributions from human activities were likely nominal compared to the eroding terraces. Still, implementation of BMPs as part of the overall plan for the watershed should address the relatively minor contributions from eroding banks and help reduce overall loading to the Blackfoot River.

An overall conclusion of reconnaissance investigations on the Landers Fork was that the stream channel lacked woody debris and complex habitat features for fish. There were few deep pools and cover in the form of overhanging banks, riparian vegetation, and/or large woody debris was lacking. The exception was the reach of the Landers Fork downstream from the confluence of Copper Creek and upstream from the Highway 200 Bridge, which appeared to have some of the best pool habitat and a greater concentration of large woody debris. Other impacts identified by the 2002 reconnaissance team included impacts from three bridges and presence of noxious weeds, primarily knapweed.

Activities following floods during the mid-1960s and beyond may have had impacts on channel morphology, sediment transport, and fish habitat. Long time residents report that following these flood events, the Army Corps of Engineers commissioned removal of woody debris and dozing in both the Landers Fork and the aggraded reach of Blackfoot River to facilitate sediment transport in these streams (Ron Pierce, MFWP, personal communication). Note that during this period, fish habitat concerns were not a major consideration in river management. The long-term impacts from these channel alterations on channel form and function is unknown. Review of the bridge design and investigation of management practices to maintain these bridges (i.e. dredging with heavy equipment) are recommended actions to better assess the impacts of bridges. Furthermore, these investigations may shed light on the impact of channel dozing and woody debris removal conducted following the flood of 1964.

Due to the importance of the Landers Fork as a migration corridor for bull trout spawning in Copper Creek, a number of additional assessments and management activities are warranted. For example, monitoring of flow characteristics is recommended to provide information on connectivity for fish passage. Furthermore, the aggradational nature of this stream requires additional investigation. The extent that current aggradational processes can be attributed to the large flood event as well as the above-mentioned management practices is still uncertain, although these aggradational processes apparently contribute to subsurface flows. Coincidentally, a review of historical records indicates that flow conditions today are better than they were in the 1970s (Hagan, 1976). These increased flows are perhaps an indication of recovery from the heavy-handed "maintenance" from earlier years.

Another significant concern regarding human related impacts and/or threats on the Landers is associated with the dynamic nature of this laterally mobile channel. Comparison of field conditions in 2002 with the 1995 aerial photos indicated significant lateral movement at numerous locations in recent years. In some locations, the stream was moving toward clear-cut areas within the floodplain, which would result in less bank stability and a prolonged period of higher sediment loading for these reaches. As noted previously, aerial photos indicated some historical riparian harvest as well as significant logging activities within the stream corridor. This suggests that the existing streamside management zone requirements for a highly meandering system such as the Landers Fork do not provide adequate protection over the long term. Finally, noxious weed control was also recommended remedy to promote the overall health of the system.

Conclusions

The Landers Fork has considerable effect on the nature of the Blackfoot River below its confluence. From a water quality standards viewpoint, it is important to determine whether this influence is predominately "natural" or due to human-caused disturbance in the basin. A number of activities in the basin have the potential to increase sediment loading over natural including roads, bridges, timber harvest, and livestock grazing. However, these analyses support attributing geologic conditions and natural disturbance as the overwhelming influences on the Landers Fork. As a result, most of the load to the Blackfoot River from the Landers Fork is considered as natural, thus influencing fisheries habitat expectations in some of the Blackfoot reaches exhibiting significant negative impacts from Landers Fork. Also, sediment TMDL development is not required for the Landers Fork, consistent with the finding of full support of beneficial uses on the 2002 303(d) list. Still, there is potential for improvement or mitigation of existing and potential future human-related impacts through the provisions for water quality improvement included in this plan. These provisions include allocations developed in Section 5 and implementation measures in Section 6. Furthermore, as discussed in Section 8, impacts from bridges or other human activities should be closely scrutinized to evaluate and promote connectivity between the Blackfoot River and bull trout spawning grounds in Copper Creek, and to further verify the full support condition for Landers Fork.

APPENDIX J
ROAD SURFACE SEDIMENT ANALYSIS

The Helena National Forest and Plum Creek Timber Company conducted detailed analysis of sediment contributions from roads in a few select drainages in the upper Blackfoot River watershed (Helena National Forest and Plum Creek Timber Co., unpublished data, 2002). This analysis focused on surface erosion from roads including cut slopes, fill slopes and the roadbed. The analysis does not cover impacts from culvert failure, water routing/increased flows, or increased potential for mass wasting. Plum Creek and Helena National Forest personnel estimated loading from a subset of the analysis area on roads these entities controlled, and determined the average sediment delivery per mile of road. This average sediment delivery rate of 0.26 tons/mile of road was then applied to all roads within the portions of the study area where the majority of roads are unpaved forest roads. The actual sediment delivery rate may be underestimated in places since the Forest Service and Plum Creek already had a generally high level of BMP implementation, whereas the level of BMP implementation on small private and county roads was not evaluated for this assessment.

Table J-1 below lists results of road sediment delivered by sub-watershed. Based on this analysis, roads deliver a total of 302 tons/yr of sediment to tributary streams and ultimately to the Blackfoot River. Of this amount, 150 tons/yr are delivered to upstream reaches of the Blackfoot and 152 tons/yr are delivered directly to the lower reach from Poorman Creek to Nevada Creek, although all 302 tons have the potential to eventually reach this lower reach of the Blackfoot River.

Table J-1. Road Sediment Yields Listed by Sub-Watershed.

	Miles of Road	Road Density (length of road/mi2)	Sediment Delivery tons/yr
Arrastra Creek	73.73	3.10	19
Beaver Creek	40.42	2.25	11
Humbug Creek	65.42	2.50	17
Keep Cool Creek	72.50	5.10	19
Landers Fork	160.88	1.23	42
Lincoln Gulch	40.54	3.40	11
Mineral Hill	6.73	2.94	2
Moose Creek	20.65	1.76	5
Patterson Prairie	51.19	5.02	13
Poorman Creek	85.31	2.08	22
Sauerkraut Creek	58.92	4.12	15
Stonewall Creek	63.04	2.33	16
Upper Blackfoot	371.65	3.22	97
Willow Creek	71.12	3.84	18
Willow Creek 303(d) list	59.19	3.06	15

APPENDIX K
USFS ROAD INVESTIGATIONS IN POORMAN CREEK

Due to concerns regarding the potential of roads to contribute fine sediment to surface waters in the Poorman Creek drainage, the USFS conducted a number of investigations to guide remedial activities. These investigations occurred in the mid-1990s and involved identification of locations where roads deliver sediment to streams, locations of undersized culverts at risk of washing out, and prescriptions to rectify the observed conditions. This section summarizes several memos from the Helena National Forest fisheries biologist to the Lincoln District Ranger in July and November of 1996. Since this work was completed, concern for sediment delivery into Poorman Creek lead to a request for Federal Highways funding for paving at least a portion of the Poorman road. That effort is ongoing.

The first memo (July 31, 1996) described proposed road improvements for South Fork Poorman Creek. There were several problems identified on this tributary including delivery of sediment from road fords and road drainage as well as barriers to fish passage at culverts. The impetus for these investigations was a large-scale proposal to treat vegetation within the entire Poorman Creek drainage. Analyses associated with this project indicated the South Fork of Poorman Creek was important in conservation of both westslope cutthroat trout and bull trout. This memo described specific road improvements proposed to address sediment loading and fish barrier issues. See Table K-1 for a description of these improvements and their status as of December 2003.

Table K-1. Road Improvements Proposed for the South Fork of Poorman Creek Watershed and Update of Status (Laura Burns, Fisheries Biologist, USFS).

Location (Mileage from intersection of South Fork Road with Stemple Road)	Identified Problem	Delivered Sediment tons/year	Proposed Action	Status as of December 2003
0.001 (site #33)	Undersized culvert on Poorman Creek and partial fish passage barrier	0.01	Replace per INFISH	Culvert was replaced with a bridge in late summer of 2003
0.1 (site #34)	Undersized culvert and fish passage barrier	0.34	No action as barrier was desirable for prevention of colonization of brook trout	Culvert is no longer a barrier and should be replace per INFISH1 Culvert was replaced with a bridge in late summer of 2003

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1 Inland Native Fish Strategy

Table K-1. Road Improvements Proposed for the South Fork of Poorman Creek Watershed and Update of Status (Laura Burns, Fisheries Biologist, USFS).

Location (Mileage from intersection of South Fork Road with Stemple Road)	Identified Problem	Delivered Sediment tons/year	Proposed Action	Status as of December 2003
1.7 (site #41)	Undersized culvert and fish passage barrier	0.02	Installation of larger pipe with baffles	Completed
2.5 (site #42)	Undersized culvert and fish passage barrier	0.007	Install 36 to 42 inch arch pipe, filling of existing road ruts	Completed
2. (site #43)	Unreinforced ford		Install adequately sized culvert with baffles	Completed
2.5 – 2.7 (site #43)	Heavily rutted road		Erosion control to divert water off road	Completed
2.8 (site #43)	Poorly drained road	0.78	Provide road drainage to eliminate water delivering sediment to road crossing at mile 2.7	Completed

The next memos, dated November 14 and November 18, 1996, provide details of a similar investigation on Poorman Creek (Table K-2). These memos detail estimated sediment load from roads, culverts at risk of wash out during high flows, and culverts that present barriers to fish movement. The first table is a list of sediment delivery sites located along roads in the Poorman drainage. The amount of sediment predicted for delivery as each site was calculated using a field-applied model from The Guide for Predicting Sediment Yields from Forested Watersheds (Cline et al., 1981). The second table is an investigation of the culverts in the Poorman drainage including culvert capacity and ability to provide fish passage. Based on this investigation, the surveyed roads contribute over 7.6 tons of sediment per year to the Poorman Creek watershed. Note that completed remedies have decreased that amount in some places.

Table K-2. Sources, Estimated Sediment Loads, and Proposed Remedies to Decrease Sediment Loading to Poorman Creek from Roads.

Site Number	Mile	Identified Problem	Fish Barrier?	Delivered Sediment (tons/year)	Proposed Remedy	Status
1	Start at Helena Forest sign.1 mile from section 7 and 8 boundary T 13N R 8W 0.0	Stream abuts road fill	yes[2]	0.05	Use larger riprap material, ensure road grading does not disturb soil	
2	0.2	Road close to stream, blading practices		0.02	Install road delineators, improve blading practices	
22	0.3	Road borders stream, blading practices		0.02	Install road delineator, avoid grading material where it can wash into stream	
3	0.8	Stream close to road under old harvest unit, blading concerns		0.02	Install road delineators, improve grading practices, install silt fence	
4	1.2	Culvert, blading		0.18		
5	2.0	McClellan culvert, blading		0.06	Install road delineators, improve grading practices	
6	2.6	Bottomless culvert, soil disturbance, beaver/ water table problems, blading, culvert at risk of washout	No	0.03	Remove existing beaver dam	
6a		Improve blading practices				
7	5.1	Road crossing, blading		0.05		
8	5.1	Ditch drainage		0.34		
9		Road drainage at Little Davis culvert		0.33		

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[2] This fish barrier is desirable to prevent encroachment of brook trout.

Table K-2. Sources, Estimated Sediment Loads, and Proposed Remedies to Decrease Sediment Loading to Poorman Creek from Roads.

Site Number	Mile	Identified Problem	Fish Barrier?	Delivered Sediment (tons/year)	Proposed Remedy	Status
10	6.3	Multiple culvert crossing, blading practices, road drainage		0.32	Install road delineators, improve blading practices	
10a	6.7	Intermittent side drainage and cross drain, hillside erosion, road ditch drainage		0	Install silt fence below culvert outlet	
11	7.6	Culvert needs repair, blading practices, road drainage		0.03	Install road delineator at crossing, improve blading practices	
12	8.0	Road slope drains to stream, blading practices		0.06	Install road delineators, improve blading practices	
13	8.25	Road drainage to stream, blading practices		0.09		
14	8.35	Undersized culvert, road drainage		0.03		Culvert removed, road closed
15	8.5	Road drainage, blading practices		0.15		
16	8.55	Direct blading of material into stream, encroachment on channel		0.03		
17	8.6	Road crossing, erosion from old road fill		0.01		
18	8.7	Road drainage into wetland		0.09		
19	8.8	Culvert crossing, blading practices, culvert too short		0.01	Replace of repair culvert	

Table K-2. Sources, Estimated Sediment Loads, and Proposed Remedies to Decrease Sediment Loading to Poorman Creek from Roads.

Site Number	Mile	Identified Problem	Fish Barrier?	Delivered Sediment (tons/year)	Proposed Remedy	Status
20	9.1	Culvert crossing, extreme sediment delivery site from ditch and road drainage, blading practices, culvert too short		1.51		Culvert replaced with passage
21	9.6	Culvert crossing tributary, blading practices, road drainage, erosion from FS side of road		0.40		Cross drain culverts were installed
23		Fields Gulch culvert crossing		0.02		
23a		Ford on side tributary to Fields Gulch		0.		
24		Erosion at Baldy Culvert Crossing		0.16		
25		Culvert crossing		0.005		
26		Erosion from Silver Bell Mine Road		0.003		
27		Erosion from Silver Bell Mine Road		0.01		
28		Davis Gulch Road Fill exposed adjacent to stream		0.03		
29		Road drainage to tributary		0.08		
30		Seep wasting above road flows over road to stream		0.06		
31		Road drainage to stream		0.02		

Table K-2. Sources, Estimated Sediment Loads, and Proposed Remedies to Decrease Sediment Loading to Poorman Creek from Roads.

Site Number	Mile	Identified Problem	Fish Barrier?	Delivered Sediment (tons/year)	Proposed Remedy	Status
32		Road drainage and undersized culvert		0.02		
35		Erosion from two track road directly to stream		0.07		
36		Erosion entering at culvert crossing		0.04		
37		Erosion at existing ford on tributary		0.15		
38		Erosion at existing ford on South Fork Poorman Creek		0.18		
39		Erosion from road delivers to stream at ford crossing		0.30		
40		Erosion at existing ford		0.08		
44		Road erosion enters at existing ford		0.08		
45		Road erosion		0.08	Cross drains installed	Completed
46		Erosion and delivery at creek crossing		0.14		
47		Sediment delivery at pipe crossing		0.03		
48		Erosion entering at pipe crossing		0.14		
49		Sediment delivery from water running over road		0.20		
50		New seep site, water down road and delivery to stream		0.13		

Table K-2. Sources, Estimated Sediment Loads, and Proposed Remedies to Decrease Sediment Loading to Poorman Creek from Roads.

Site Number	Mile	Identified Problem	Fish Barrier?	Delivered Sediment (tons/year)	Proposed Remedy	Status
51		Ditch drainage at culvert		0.10	Install sediment fence at crossing, line ditch with rock, change shape of road prism to prevent diversion of water to ditch	
52		Road material grading into stream below forest boundary		0.10	Install delineators and change blading practices	
53		Road material graded into Poorman Creek, ditch drainage from county road below forest boundary		0.10	Install delineators and change blading practices	
54		Road material graded into Poorman Creek at culvert crossing, road drainage ditch delivering sediment		0.20	Install delineators, change blading practices, line ditch with rock, eliminate ditch, alter road prism	

Table K-3. Poorman Drainage Culvert Investigation (Only Crossings which Need to be Addressed are Listed in the Table).

Crossing Number	Mile	Identified Problem	Fish Barrier?	Priority	Status
1	0.0 (County road crossing of Poorman road in T14 N 8W section 36	Undersized culvert and partial barrier	Yes	Moderate – undersized	
2	0.4	Crossing providing access to private home has undersized culvert and presents a barrier to spring spawning salmonids	Yes	Moderate -undersized	
3	0.6	Culvert at county road crossing is undersized and presents fish barrier, risk of damage and extensive sediment delivery with a 10 year flood event	Yes	Very High – undersized	
5	On Fields Gulch Road	Culvert crossing Fields Gulch in section 18 is at risk of wash out with 50 year flood, fish barrier during spring and summer but this may be desirable to prevent brook trout encroachment	Yes	Low	
6	2.6	Undersized Culvert	No	High - undersized	
7	3.45	McClellan culvert, do not provide for fish passage due to likelihood of brook trout invasion	Yes	Moderate – undersized	
10	3.62	A road crossing providing access to a private home is susceptible to wash out during 10-year flow events. May be a barrier to spring spawning salmonids	Yes	Moderate – undersized	

Table K-3. Poorman Drainage Culvert Investigation (Only Crossings which Need to be Addressed are Listed in the Table).

Crossing Number	Mile	Identified Problem	Fish Barrier?	Priority	Status
18	5.7	Culvert with moderate risk of damage during a 50-year event, is probably a passage barrier for spring spawning salmonids	Yes	Moderate - Evaluate for passage capability in spring	
19	6.0	Culvert with high risk of damage during a 25 year event, likely passage barriers for cutthroat trout	Yes	High - Replace with pipe providing higher flows	
20	6.3	Bottomless concrete culvert crossing	No	Moderate	
21	6.3	Ford providing access to a private cabin. Not a preferred crossing for fisheries health	No	Moderate - Improve ford or replace with small bridge	
23	7.45	High risk of failure during a 10 year event	Yes	High - Replace with higher capacity culvert	
24	7.65	Velocity barriers to fish, high risk of flooding during 10 year flows	Yes	Very High - Install structure supporting 100 year events, provide fish passage	
25	8.1	Moderate risk of failure during 50 year flows, possible fish barrier		Assess fish passage in spring	Completed – Replaced with a bridge
26	8.2	Possible cutthroat velocity barrier, moderate risk of failure during 50 year flows		High - Replace with culvert capable of sustaining 100 year flows	Completed – Replaced with a bridge
36	8.7	High risk of failure during 10 year flows		High - Replace with bridge or larger culvert	

Table K-3. Poorman Drainage Culvert Investigation (Only Crossings which Need to be Addressed are Listed in the Table).

Crossing Number	Mile	Identified Problem	Fish Barrier?	Priority	Status
37	8.9	Velocity and vertical migration barrier for salmonids, however do not provide fish passage as there are no brook trout in the drainage. High risk of failure during ten year flows	Yes	Very High	Completed
38	9.55 Forest road crossing of Davis Gulch	High risk of failure during 10 year flows		High - Close road and reclaim	Completed
39A	9.75	Culvert crossing tributary		High- due to risk of washout	
40	10.0	Culvert crossing tributary		Moderate – no fish passage necessary	
41	10.5	High risk of failure during 25 year events		High - Replace with pipe able to sustain 100 year floods, provide for fish passage	Completed
42	11.1	High risk of failure during 25 year events reduce bedload above pipe	No	Moderate -Replace with pipe able to sustain 100 year floods, no fish passage as above distribution	
43	11.3	Undersized culvert crossing tributary	Yes	Moderate to High	Completed
44	Davis Gulch sec 17	Culvert crossing which provides fish passage. Moderate risk of washout during 50-year event	No	Low to Moderate	
47	Long Gulch crossing fs road #1838	Undersized culvert for the 25 year event	No	Moderate	

APPENDIX L
SEDIMENT CONTRIBUTED FROM ROAD TRACTION SANDING

Road traction sanding during winter months provides a potential source of sediment loading to streams. In the Blackfoot Headwaters Planning Area, this risk applies to stream segments adjacent to two state highways. Montana State Highway 200 parallels the main stem of the Blackfoot River for much of its 36-mile length. Highway 279 over Flesher Pass (8.3 miles) is also a major road in the watershed. Montana Department of Transportation (MDT) regularly sands these roads during winter months. Analysis of Highways 200 and 279 indicates these highways encroach within 200-feet of the Blackfoot River for 3.37 miles and 0.59 miles respectively (Table L-1).

Table L-1. Proximity of Sanded Highways to Streams in the Blackfoot Headwaters Planning Area.

Road	Length Within 100’ of Blackfoot River or Willow Creek	Length Within 200’ of Blackfoot River or Willow Creek	Total Length Within the Watershed
Highway 200	0.93 miles	3.37 miles	36 miles
Highway 279	0.15 miles	0.59 miles	8.3 miles

MDT personnel provided information on the amount of sand spread on the highways in question. The area receives sanding services from two separate MDT locations, one that covers Highway 200 from the junction of Highway 279 to Rogers Pass and Highway 279 from the junction with Highway 200 to Flesher Pass. The other covers Highway 200 from the junction of Highway 279 to all points west. Average traction sand application rates for the two areas are 73 tons/mile/year and 36 tons/mile/yr respectively. Using these application rates, the following table lists the amount of road sand applied on roads close to the Blackfoot River and Willow Creek (Table L-2).

Table L-2. Traction Sand Applied to Highways Near 303(d) Listed Streams.

Stream	Traction Sand Applied to Roads within 100’ of stream	Traction Sand Applied to Roads within 200’ of stream
Blackfoot River	35 tons/yr	128 tons/yr
Willow Creek	11 tons/yr	43 tons/yr

Assuming a conservatively high estimate of 10% delivery of traction sand from roads within 100 feet of the streams, and 5% delivery for roads within 100 to 200 feet of the stream, total sediment loads from road sanding are 3.3 tons/yr delivered to Willow Creek and 9.9 tons/yr delivered to the Blackfoot River, for a combined total load of about 12.2 tons/yr. Of the 3.96 miles of Highways 200 and 279 within 200 feet of the Blackfoot River or tributaries, 2.58 miles (65%) deliver sediment from traction sand directly to the impaired reach from Poorman Creek to Nevada Creek and 1.38 miles (35%) deliver sediment from traction sand directly to Willow Creek.

Several observations helped develop the 200-foot area of influence and the 5% and 10% delivery rates. Examination of highway segments within 200 feet of the Blackfoot River and Willow Creek reveals that in most places the roadbed has a low gradient. This suggests that 50% of traction sand side cast from the road surface will end up in the cut slope ditch. Since this ditch is also low gradient, little of this material will be transported along the ditch to culverts that reach the fill slope (streamside) of the highway. In addition, in all but two areas, side slopes adjacent to the highway are low gradient and would not likely deliver sediment downhill to a stream. Also, the two stretches of Highway 200 that are within 200 feet of the Blackfoot River are on steep side slopes with riprap placed along the riverbank to prevent channel migration. The coarse nature (1-3 ft. diameter boulders) of the riprap suggests it would trap most of the sediment coming from uphill sources before delivery to the Blackfoot River.

Comparison of these results with a study done on Vail Pass in Colorado (Lorch, 1998) suggests that the 10% value for sand application within 100 feet may be a low estimate. This study found that as much as 30% of traction sand was delivered into the nearby stream channel. On the other hand, the relatively low sanding rates and mitigating factors discussed above make the 10% value a reasonable estimate for this relatively low sediment load within this portion of the Blackfoot River watershed.

APPENDIX M
SEDIMENT CONTRIBUTED FROM UPLAND SOURCES

Hillslope erosion from upland sources is another potential source of sediment loading to streams in the Blackfoot Headwaters Planning Area. This typically occurs where erodible soils occupy sufficiently steep slopes that lack adequate protection by vegetation. Erosion of upland soils is a natural phenomenon in watersheds, however, human activities such as timber harvest, road construction, and livestock grazing, particularly in the absence of best management practices, can intensify sediment production. Similarly, natural disturbance such as wildfire may have a comparable impact. Another contributing factor is the increase in water yield from vegetation removal in a watershed. Essentially, a reduction in vegetative cover in a watershed decreases interception and evapotranspiration of precipitation resulting in greater water yield. A redistribution of snow into cleared openings also adds to increased water yield. Moreover, associated land disturbance can compact soils or remove protective organic or duff layers. The resultant increase in overland flow over altered soils promotes erosion of soil, which can ultimately enter streams. Furthermore, the increase in water yield can be linked to increased peak flows, which can place more stress on stream banks, thereby increasing bank erosion and in-stream sediment production.

To evaluate the significance of sediment production and delivery from hillslope erosion in the upper Blackfoot watershed, we developed a GIS based Sediment Source and Delivery Model (SSDM). The model involved three separate analyses: evaluation of the relative potential for the landscape to both produce and deliver sediment to streams, quantification of the change in high vegetation cover types over a seven year period (1992-1999), and a prediction of the increased water yield and associated peak flow that would result from any change in vegetation from 1992-1999.

The first SSDM model component of the model evaluates the impacts of vegetative cover, slope, precipitation, and soil erodibility with respect to sediment production. The model then evaluates the connectivity of areas with high sediment production potential to streams via steeply sloped, low cover areas. Using this model in development of numerical sediment loads requires calibration with empirical field data. This calibration is a goal of the monitoring plan. In the interim, the model was used to identify areas more likely to produce and deliver sediment to tributary streams and is used in developing restoration strategies discussed in Section 6.0.

The second SSDM model component evaluated vegetation change from 1992-1999 through analysis of 1999 imagery and spatial data on historic timber harvests. A two class vegetation data set was created by conducting a supervised classification of 1999 IRS (Indian Remote Sensing Satellite) imagery provided by the Helena National Forest. The two classes are high cover types (trees, riparian zones) and low cover types (grasses, rangeland, agricultural land, bare ground, recently timbered areas). The interpretation was conducted using the Feature Analyst software (www.vls-inc.com) running within ArcGIS 8.2. Percent high cover results are presented in Table M-1, Column C below. Reported timber harvests on USFS land (1992-1999), Plum Creek Timber Co. land (1997-1999), and Montana State land (1992-1995) were then added to the high cover land class. Recently harvested areas on other private lands and State lands not in the 1992-1995 dataset were visually interpreted from the imagery and added to the high cover land class as well. The resultant new high cover data then represents 1999 conditions with the prior seven years of harvest added back; in essence, 1992 high cover. The change in high cover land class is reported in the table as the recent vegetation change (Column D), with negative values representing reduced cover between 1992 and 1999 likely due to timber harvest. Table M-1 also lists the sub-watershed 1999 vegetation data (high and low cover) results in predicted areas more likely to produce and deliver sediment to streams (Columns E & F), along with the percent vegetative change in these areas due to harvest between 1992 and 1999 (Column G).

Finally, change in water yield was estimated by calculating the amount of precipitation that would no longer be intercepted by the reduced vegetation cover. Reductions in vegetative cover due to riparian degradation or silviculture activities have been shown to result in an increase in mean annual water yield due to increased accumulation of snowpack in open areas, as well as reduction in evapotranspiration and interception (EPA, 1980; Troendle et al., 2001; Zeimer, 2000). Depending on watershed conditions, the increased water yield can affect sediment production and delivery (Rice et al., 2000). An average annual runoff analysis was conducted within the project GIS using a flow accumulation algorithm. We evaluated two scenarios, one with 1999 vegetation conditions, and a second using interpreted pre-recent logging vegetation conditions (see description of vegetation interpretation in the section immediately above). We assigned vegetation a 25% interception rate such that 25% of the average annual precipitation was intercepted by areas with the high cover land cover class and was not allowed to run off in the calculation. The calculated increase in water yield is simply the amount of average annual precipitation not intercepted by the reduced high cover vegetation. Column H in Table M-1 identifies the modeled increase in water yield for sub-watersheds within the study area. This increased water yield can be linked to the potential increase in peak flow (Jones et al., 1996).

An example of how to interpret the results in Table M-1 is as follows: The Arrastra Creek sub-watershed is 15,218 in size, and is 66.8% covered by high cover vegetation types (tree canopy, riparian). High cover vegetation types were reduced by 1.9% from 1992-1999. A fairly large amount of area has a predicted elevated potential to produce and deliver sediment to streams, of which, 16.9% has high cover vegetation types, 3.9% has low vegetation cover types (grass, bare areas), and 0.5% has been harvested between 1992-1999. From the 1.9% change in high cover vegetation, a 1.2% increase in water yield is predicted.

The impact of increased water yield on sediment transport depends on both the sediment availability as well as the temporal distribution of the additional water on the flow hydrograph. Data derived from closely monitored, harvested watersheds characterized by spring snowmelt runoff have shown that the flow augmentation tends to be concentrated on the rising limb and peak of that spring snowmelt runoff event (Troendle et al., 2001). An increase in stream flow during the snowmelt period can result in a significant increase in sediment transport capacity, as spring runoff conditions commonly constitute the channel forming discharge, characterized by active sediment transport and channel adjustment (Andrews and Nankervis, 1995).

The potential effect of the increased water yield on sediment transport was evaluated for the mouth of the Landers Fork, as a baseline annual hydrograph and sediment transport condition have been developed for that location (Appendix I). In the Landers Fork drainage area, the estimated 1.4% reduction in vegetative cover has resulted in an increased annual water yield of approximately 1.3%. This increased yield would result in an increased sediment transport capacity of approximately 4.1%.

If upland-derived sediment is conveyed to the stream channels, the increased sediment transport capacity will result in an increased delivery of sediment to the Blackfoot River. Alternatively, if upland sediment is not available for transport, increased transport energy will result in sediment sourcing downstream from the channel perimeter due to bank and bed scour (Troendle et al., 2001). Therefore, the most effective means of preventing increased water yield and associated sediment delivery is to increase or maintain vegetative cover.

Table M-1. Vegetation Change, Elevated Potential Sediment Delivery, Increased Water Yield.

Column A	Column B	Column C	Column D	Column E	Column F	Column G	Column H
Sub-watershed Name	Area (acres)	Percent High Cover (1999)	Percent High Cover Change, 1992 to 1999	Percent of Area with Elevated Potential Sediment Yield and High Cover (1999)	Percent of Area with Elevated Potential Sediment Yield and Low Cover (1999)	Percent of Area with Elevated Potential Sediment Yield and Recent Harvest	Calculated % Change in Water Yield, 1992 to 1999
Arrastra Creek	15218	66.8	-1.9	16.9	3.9	0.5	1.2
Beaver Creek	11509	75.6	-1.3	6.9	2.7	0.0	0.8
Copper Creek	26663	83.2	-0.6	9.0	4.2	0.0	NA
Humbug Creek Area	16720	76.2	-3.3	2.9	0.4	0.0	1.0
Keep Cool Creek	9103	77.4	-5.5	1.5	0.1	0.0	1.6
Landers Fork	83722	73.4	-1.4	4.9	1.5	0.0	1.3
Lincoln Gulch	7628	79.9	-3.5	9.3	0.8	0.2	1.0
Mineral Hill	1464	28.6	0.0	0.4	2.5	0.0	0.3
Moose Creek Area	7497	84.1	-9.0	3.6	0.9	0.4	3.0
Patterson Prairie	6524	54.6	-5.0	7.2	4.5	1.2	1.4
Poorman Creek	26294	90.7	-1.4	15.5	0.8	0.0	0.6
Sauerkraut Creek	9150	74.6	-18.5	0.6	0.1	0.0	5.9
Stonewall Creek	17349	73.4	-1.3	12.8	1.8	0.0	0.4
Upper Blackfoot	73786	79.8	-1.1	9.8	1.5	0.0	0.5
Willow Creek	11854	77.5	-5.3	0.3	0.0	0.0	1.7
Willow Creek listed	12381	88.2	0.0	11.6	1.5	0.0	0.1

APPENDIX N
PUBLIC COMMENTS AND DEQ RESPONSE TO PUBLIC COMMENTS

Comment 1: While bank erosion rates along the Blackfoot River were estimated and included in the load allocation, there is no allocation for sediment coming from the Landers Fork. All we know is that the loads are likely to be quite large and mostly natural (see Appendix I). Based on the loading information we have, natural bank erosion along the Blackfoot is estimated to average about 27500 tons/yr. Human sources identified in the load allocation are estimated to contribute a total of 7700 tons/yr (6994 tons/yr from bank erosion along Blackfoot and 700 tons/yr from roads). As such, the human load allocation is estimated to be about 28% over the background load. However, the unquantified natural load from the Landers Fork is not included in the allocation. If it were, the human loading component (as a percentage of the total) could be trivially small, and sediment TMDL may have been found to be unnecessary. Additionally, it is critical to accurately account for the full background load, because if the instream targets for fine sediment in the mainstem Blackfoot are not met in the future, it is more than likely that this is due to natural sources. We recommend that the load allocation table (Table 5-2) have a line inserted that lists the Landers Fork as an identified natural source of pollutants that is presently unquantified. In the monitoring section of the document, we recommend that an investigation be undertaken to determine what the Landers Fork allocation is, and that the TMDL be revised as soon as possible afterward to reflect this new information. We believe this recognizes the "phased" nature of this TMDL.

> **DEQ Response to Comment 1**: As defined in Sections 5.1.2 and 5.1.3, the TMDL and allocations are based on a percent reduction in loading. The bank erosion allocation of Section 5.1.3.1 is specifically applied to accelerated stream bank erosion from human impacts along the Blackfoot River. The natural background bank erosion loads are not part of the allocation, which is consistent with the approach of only allocating load reductions to controllable sources. Because the Landers Fork load was determined to be predominately natural, no allocation is applied to the Landers Fork load. Therefore, it would not be appropriate to include a monitoring investigation or make any immediate commitments to modify the TMDL as suggested.
>
> Furthermore, the Blackfoot River targets (Section 5.1.1) are based on a fine sediment concern. The eroding banks along the Blackfoot River and erosion from roads within the watershed are both significant sources of fine sediment. Loading from the Landers Fork consists of both fine to very large size sediment. This significant portion of larger sediment makes much of the sediment load from the Landers Fork irrelevant for the purpose of this sediment TMDL and for comparison to background fine sediment loading conditions.
>
> Nevertheless, the Landers Fork does contribute a significant load of fine sediment, which is specifically noted in the last paragraph of the Section 5.1.1. This contribution is a consideration that must be taken into account when considering target achievability within the framework of adaptive management as discussed in Section 5.1.1 and Section 7.0. It is worth noting that the apparent reducing trends of percent fines in spawning gravels in the Blackfoot River and possibly other streams (Appendix G, Figures G-9

through G-14) imply that further reductions from improved management of fine sediment sources associated with human activities may indeed be achievable.

Based on the above response, no changes were made to the document to address this comment. The approach used for the TMDL and allocations does not require the requested changes. The target achievability concerns are already incorporated within the document and the existing adaptive management approach sufficiently addresses the uncertainty and phased nature of the TMDL.

Comment 2: The allocation related to the culvert in Arrastra Creek is inappropriate. Culverts are not pollutants. While this county road culvert sounds like it should be addressed in the watershed restoration (implementation) plan, it does not belong in the TMDL load allocation.

DEQ Response to Comment 2: A TMDL is required where a pollutant (e.g. sediment) is causing an impairment to an established beneficial use. Allocations, however, are established to reduce sources of sediment consistent with the TMDL. The culverts along the mainstem of Arrastra Creek have been repeatedly identified as a source of undesirable sediment accumulation and impairment to aquatic life. It is, therefore, appropriate to include these culverts within the sediment load allocations

Nevertheless, the allocation language within Section 5.2.3.1 and Table 5-5 has been modified to provide a clearer linkage between culverts, as well as other sources, and the desired pollutant loading reductions defined by the Arrastra Creek sediment TMDL. The culverts are now specifically included within a combined source category that includes sources that either contribute to eroding banks and/or the loss of sediment transport capabilities. The new sediment allocation language applied to this combined source category is a “30% reduction in sediment loading to the stream and sediment deposition within the channel.”

Comment 3: (DEQ Responses are embedded within the subcomments): Because of the lack of justification, the sections of the document related to “Land Use Indicators” for hillslope erosion and water yield should be removed from the load allocation section of the document. We recommend that hillslope erosion and water yield would be much better addressed as follows:

3a. Reinforce in Section 3 (source assessment section) that hillslope erosion and water yield are not presently believed to be an issue based on the available information and analysis (see Appendix M).

DEQ Response to Comment 3a: As suggested, wording has been added to Sections 3.1.3, 3.2.3, 3.3.3, 3.4.3, and 3.5.3 to reinforce the determination that hillslope erosion is not considered a significant source of sediment to the watersheds of concern. This is based on the assumption that timber harvest in these areas has been pursued at a high rate of BMP compliance consistent with forest practice audits. Water yield values are also considered low enough to not cause significant concerns at this time for the majority of the drainages.

3b. Add text to Section 8 (Monitoring) stating that these processes (hillslope erosion and water yield) will be re-evaluated by DEQ at the 5-year review to determine if their inclusion in the TMDL is warranted.

> **<u>DEQ Response to Comment 3b</u>:** The inclusion of these land use indicators within the allocations section is warranted. As discussed in Section 5.1.3.2, hillslope erosion and water yield increases could represent significant sources of sediment if BMPs and/or reasonable land, soil and water conservation practices are not applied. These land uses are not specifically included in the TMDL via load reduction allocations, but should be evaluated through time to validate the assumption that they are not significant sediment sources, specifically under conditions where the identified indicator levels are exceeded.
>
> The 5-year review identified in Section 8.0 is focused on evaluating whether or not targets are met. If targets are not met, the evaluation of hillslope erosion, water yield increases, and other land uses including those where allocations are applied can be a valuable tool to help understand whether or not water quality protection practices are in place and to help evaluate overall target achievability. As part of this 5-year review, DEQ can evaluate new information and determine if modifications are warranted for land use indicators, TMDLs, allocations and/or targets as they apply to hillslope erosion, water yield, or any aspect of the document.

3c. In Section 6 (Restoration Plan), amend text to state that the Blackfoot Challenge Cooperative Forest Stewardship Program will provide educational materials to landowners that will show where the higher-risk erosion areas are located in the watershed so landowners can factor this information to their land management planning.

> **<u>DEQ Response to Comment 3c</u>:** In consultation with the Blackfoot Challenge, the recommended language has been added to Section 6.1.1

3d. Remove all text related to the land use indicator “trigger values” related to the percentage of high risk areas with vegetation removal and for water yield. We believe the trigger value for land clearing is arbitrary and relates little to watershed impact. The trigger value for water yield is meaningless because changes in mean annual flow do not relate to shear stress on eroding banks. Removing the reference to the trigger values will also address the current problem that no particular party is assigned responsibly for tracking the trigger values (maybe DEQ was planning on tracking the trigger values on a quarterly basis?).

> **<u>DEQ Response to Comment 3d:</u>** The text will not be removed as suggested. As implied above, failure to implement BMPs and reasonable land, soil and water conservation practices can lead to significant erosion and sediment delivery in the high risk areas defined in Appendix M. The 10% trigger value is consistent with the highest levels of harvest in high risk areas over the past few decades as described in Section 5.1.3.2.1, and presumably represents a level of harvest where major hillslope erosion or mass wasting sediment loading issues have not been identified in a given watershed. Ideally, there would be no trigger and landowners would consistently evaluate all activities in these

high risk areas to ensure water quality protection via application of forestry BMPs and compliance with the SMZ law.

As identified within Appendix M and elsewhere, the water yield is used as a modeled indicator of potential increased peak flows that can contribute to increased shear stress on eroding banks. Sufficient description and references are provided within Appendix M to establish this relationship.

The State's nonpoint source program is focused primarily on voluntary implementation of BMPs and water protection practices. For the most part, the DEQ will not be tracking the land use trigger values, nor will DEQ be tracking the application of road BMPs to meet the road reduction allocation or efforts to implement grazing management practices along the Blackfoot River to reduce bank erosion. Limited resources are available to pursue these efforts, although some evaluation may be done consistent with the 5-year review and Section 8.0.

Comment #4: We would recommend dropping the water quality target for clinger taxa richness since a broader metric for macroinvertebrates is already included as a target. Taxa richness would seem to be too dependent on the intensity of the survey and lab sampling approach used. For example, doing a full identification of a given sample will yield a higher clinger taxa richness than doing taxanomic identifications on a sub-sample, since your probability of identifying new taxa is increased.

DEQ Response to Comment #4: While the broader metric evaluates overall stream condition with respect to aquatic life support, clinger taxa richness is an indicator of fine sediment deposition. It is possible that clinger taxa richness targets may be met without meeting the broader metric target, suggesting that impairment other than fine sediment deposition may affect aquatic biology and should be investigated. Using the two targets helps ensure that beneficial uses are supported prior to any findings of full support conditions.

Taxa richness can be dependent upon sampling methodology as identified in the comment. The sampling and analysis methodology must be consistent with DEQ's standard operating procedures (SOPs) as identified within Section 8.0 (Table 8-1) of the public comment draft. DEQ's SOP is designed to minimize both spatial and temporal sample bias (Bukantis, 1998), via a traveling kick net method. Similarly, sub-sampling protocols in the lab involve a random, grid-based approach. DEQ evaluated the variance associated with using the traveling kick net and lab sub-sampling protocols and found these to be statistically sound methods to evaluate benthic macroinvertebrate communities. In response to the above comments, additional language has been added to the targets section (Section 5.1.1) as well as the monitoring section (Section 8.0) to clarify the use of this DEQ SOP.

Comment #5: Lastly, we believe that the monitoring section needs to be improved to more clearly define expectations of who is going to do what. In the absence of any defined “responsible party” I can only assume that DEQ is taking the lead. And if not DEQ, then the Blackfoot Challenge?

> **DEQ Response to Comment #5:** Section 8.0 of the public review draft identifies responsible parties for most monitoring activities, particularly monitoring associated with target compliance and evaluating the status of allocations. In general, where DEQ is not the lead, then the Blackfoot Challenge will pursue most or all monitoring depending on resource availability and overall priorities. We have added some additional clarification to Section 8.0 in response to this comment.

Comments Noted (no response necessary):

Comment: In general, we believe that the TMDL allocation for sediment from roads (30% reduction from current) is defensible, and reasonable with implementation of Best Management Practices (BMPs).

Comment: The document does an adequate job of documenting uncertainty with regard to attainability of water quality targets (e.g., instream fine sediment targets). This is nicely improved from the stakeholder draft.

Comment: We believe the Implementation Plan is well done and have no specific recommended changes.