Little Blackfoot River Watershed TMDLs and Framework Water Quality Improvement Plan

December 2011

Brian Schweitzer, Governor
Richard Opper, Director DEQ

C01-TMDL-03A-F

Version 1.0

Prepared for:
Montana DEQ Water Quality Planning Bureau

Prepared by:
U.S. Environmental Protection Agency, Montana Operations Office

Contributors:
U.S. Environmental Protection Agency
Lisa Kusnierz, Project Manager
Peter Brumm, Metals Project Co-Manager

Water Quality Planning Bureau
Watershed Management Section
Banning Starr, Previous Sediment Project Manager

Information Management and Technical Services Section
Erik Makus, Project Modeler

U.S. Environmental Protection Agency, Region 8
10 West 15th Street, Suite 3200
Helena, MT 59626

Montana Department of Environmental Quality
Water Quality Planning Bureau
1520 E. Sixth Avenue
P.O. Box 200901
Helena, MT 59620-0901

Suggested citation: Montana DEQ and EPA Region 8. 2011. Little Blackfoot Watershed TMDLs and Framework Water Quality Improvement Plan. Helena, MT: Montana Dept. of Environmental Quality; U.S. Environmental Protection Agency, Region 8.

ACKNOWLEDGEMENTS

DEQ would like to acknowledge multiple entities for their contributions in the development of the TMDLs contained in this document. Various versions of sections of this document were sent to stakeholders for review and input. The involvement of all reviewers and members of the technical advisory group led to improvements in this document and is greatly appreciated. In particular, DEQ would like to thank Jeff Janke for sharing his knowledge of the watershed and assistance in obtaining access to sampling sites and Beth Ihle, Dave Callery, and Hans Oak of the Helena National Forest for their contributions as well as for sharing USFS data. Additionally, we would like to thank the Powell County Conservation District and the Montana Department of Transportation.

Eric Sivers, a water quality planner with DEQ, provided significant support for **Section 2.0**, Watershed Characterization. We would like to thank Carrie Greeley, an administrative assistant for the Watershed Management Section of DEQ, for her time and efforts formatting this document.

Multiple consultants provided significant contributions in the development of several appendices. Atkins (formerly PBS&J) provided contribution to the development of **Appendix C**, 2009 *Sediment and Habitat Assessment*. Water & Environmental Technologies provided contribution to the development of **Appendix E,** *Road Sediment Assessment*. HydroSolutions, Inc. collected nutrient and metals data in 2008 and 2009.

TABLE OF CONTENTS

Acronym List xi
Document Summary 1
1.0 Introduction 1-1
1.1 Background 1-1
1.2 Water Quality Impairments and TMDLs Addressed by this Document 1-2
1.3 Document Layout 1-6
2.0 Little Blackfoot River Watershed Description 2-1
2.1 Physical Characteristics 2-1
2.1.1 Location 2-1
2.1.2 Topography 2-1
2.1.3 Geology 2-1
2.1.4 Soil Erodibility and Slope 2-2
2.1.5 Surface Water 2-2
2.1.6 Groundwater 2-3
2.1.7 Climate 2-4
2.2 Ecological Parameters 2-4
2.2.1 Vegetation 2-4
2.2.2 Aquatic Life 2-4
2.2.3 Fires 2-5
2.3 Cultural Parameters 2-5
2.3.1 Population 2-5
2.3.2 Transportation Networks 2-5
2.3.3 Land Ownership 2-5
2.3.4 Land Use 2-5
2.3.5 Mining 2-6
2.3.6 Point Sources 2-6
2.3.7 Wastewater 2-7
3.0 Montana Water Quality Standards 3-1
3.1 Little Blackfoot TPA Stream Classifications and Designated Beneficial Uses 3-1
3.2 Little Blackfoot TPA Water Quality Standards 3-2
4.0 Defining TMDLs and Their Components 4-1
4.1 Developing Water Quality Targets 4-2
4.2 Quantifying Pollutant Sources 4-2

4.3 Establishing the Total Allowable Load 4-3
4.4 Determining Pollutant Allocations 4-3
5.0 Sediment TMDL Components 5-1
5.1 Mechanism of Effects of Excess Sediment on Beneficial Uses 5-1
5.2 Stream Segments of Concern 5-1
5.3 Information Sources and Assessment Methods to Characterize Sediment Conditions 5-2
5.3.1 DEQ Assessment Files 5-3
5.3.2 DEQ's 2009 Sediment and Habitat Assessments 5-3
5.3.3 Montana Fish, Wildlife and Parks/Natural Resource Damage Program: An Assessment of Fish Populations and Riparian Habitat in Tributaries of the Upper Clark Fork River Basin 5-5
5.3.4 Little Blackfoot River Physical Features Inventory and Riparian Assessment 5-6
5.3.5 PIBO Data 5-6
5.3.6 USFS Regional Reference Data 5-6
5.4 Water Quality Targets 5-7
5.4.1 Water Quality Target Summary 5-7
5.4.2 Fine Sediment 5-9
5.4.3 Channel Form and Stability 5-11
5.4.4 Instream Habitat Measures 5-12
5.4.5 Riparian Health 5-15
5.4.6 Human Sources 5-15
5.4.7 Macroinvertebrates 5-16
5.5 Existing Condition and Comparison to Water Quality Targets 5-16
5.5.1 Dog Creek, upper segment (MT76G004_071) 5-17
5.5.2 Dog Creek, lower segment (MT76G004_072) 5-18
5.5.3 Elliston Creek (MT76G004_040) 5-19
5.5.4 Little Blackfoot River, upper segment (MT76G004_020) 5-21
5.5.5 Little Blackfoot River, lower segment (MT76G004_010) 5-24
5.5.6 Snowshoe Creek (MT76G004_080) 5-27
5.5.7 Spotted Dog Creek, lower segment (MT76G004_032) 5-28
5.5.8 Telegraph Creek, upper segment (MT76G004_051) 5-30
5.5.9 Threemile Creek, lower segment (MT76G004_112) 5-32
5.5.10 Trout Creek (MT76G004_120) 5-33
5.6 Sediment TMDL Development Summary 5-35
5.7 Sediment Source Assessment and Quantification 5-35
5.7.1 Eroding Streambank Sediment Assessment 5-36

5.7.2 Upland Erosion and Riparian Buffering Capacity Assessment 5-38
5.7.3 Road Sediment Assessment 5-42
5.7.4 Permitted Point Sources 5-46
5.7.5 Source Assessment Summary 5-47
5.8 TMDL and Allocations 5-47
5.8.1 Application of Percent Reduction and Yearly Load Approaches 5-47
5.8.2 Development of Sediment Allocations by Source Categories 5-48
5.8.3 Allocations and TMDL for Each Stream 5-49
5.9 Seasonality and Margin of Safety 5-54
5.9.1 Seasonality 5-54
5.9.2 Margin of Safety 5-55
5.10 TMDL Development Uncertainties and Adaptive Management 5-55
5.10.1 Sediment and Habitat Data Collection and Target Development 5-56
5.10.2 Source Assessments and Load Reduction Analyses 5-57
6.0 Nutrient TMDL Components 6-1
6.1 Nutrient Impacts to Beneficial Uses 6-1
6.2 Stream Segments of Concern 6-1
6.3 Water Quality Data Sources 6-2
6.4 Nutrient Water Quality Targets and Comparison to Existing Conditions 6-3
6.4.1 Nutrient Water Quality Targets 6-4
6.4.2 Existing Conditions and Comparison to Water Quality Targets 6-4
6.4.3 Nutrient TMDL Development Summary 6-9
6.5 Nutrient Source Assessment and Quantification 6-10
6.5.1 SWAT Model 6-10
6.5.2 Source Categories 6-11
6.5.3 Modeled Existing Nutrient Load Summary 6-14
6.5.4 SWAT Model Scenarios and Result Summary 6-16
6.6 TMDLs and Allocations 6-19
6.6.1 Allocation Approach 6-21
6.6.2 Carpenter Creek, lower segment (MT76G004_092) 6-22
6.6.3 Dog Creek, lower segment (MT76G004_072) 6-23
6.6.4 Little Blackfoot River, lower segment (MT76G004_010) 6-23
6.6.5 Snowshoe Creek (MT76G004_080) 6-24
6.6.6 Spotted Dog Creek, lower segment (MT76G004_032) 6-25
6.6.7 Threemile Creek, lower segment (MT76G004_112) 6-26

6.6.8 Seasonality, Margin of Safety and Uncertainty 6-27
7.0 Metals TMDL Components 7-1
7.1 Mechanism of Effects of Excess Metals to Beneficial Uses 7-1
7.2 Stream Segments of Concern 7-1
7.3 Information Sources and Assessment Methods 7-2
7.3.1 Natural Background Loading 7-3
7.3.2 Abandoned Mines and Associated Wastes 7-3
7.4 Water Quality Targets and Supplemental Indicators 7-4
7.4.1 Targets 7-4
7.4.2 Supplemental Indicators 7-5
7.4.3 Metals TMDL Development Framework 7-6
7.5 Existing Condition and Comparison to Water Quality Targets 7-6
7.5.1 Un-named Creek (MT76G006_010) 7-7
7.5.2 Monarch Creek (MT76G004_060) 7-9
7.5.3 Ontario Creek (MT76G004_130) 7-10
7.5.4 Sally Ann Creek (MT76G004_055) 7-12
7.5.5 O'Keefe Creek (MT76G004_054) 7-14
7.5.6 Upper Telegraph Creek (MT76G004_051) 7-15
7.5.7 Lower Telegraph Creek (MT76G004_052) 7-17
7.5.8 American Gulch Creek (MT76G004_079) 7-19
7.5.9 Upper Dog Creek (MT76G004_071) 7-20
7.5.10 Lower Dog Creek (MT76G004_072) 7-22
7.5.11 Upper Little Blackfoot River (MT76G004_020) 7-24
7.5.12 Lower Little Blackfoot River (MT76G004_010) 7-26
7.5.13 TMDL Development Determination Summary 7-28
7.6 Metals TMDLs Approach 7-29
7.7 Metals Loading Summary, TMDLs and Allocations 7-37
7.7.1 Un-named Creek (MT76G006_010) 7-37
7.7.2 Monarch Creek (MT76G004_060) 7-38
7.7.3 Ontario Creek (MT76G004_130) 7-39
7.7.4 Sally Ann Creek (MT76G004_055) 7-41
7.7.5 O'Keefe Creek (MT76G004_054) 7-42
7.7.6 Telegraph Creek, Upper Segment (MT76G004_051) 7-43
7.7.7 Telegraph Creek, Lower Segment (MT76G004_052) 7-44
7.7.8 American Gulch Creek (MT76G004_079) 7-46

7.7.9 Dog Creek, Upper Segment (MT76G004_071) 7-47
7.7.10 Dog Creek, Lower Segment (MT76G004_072) 7-48
7.7.11 Little Blackfoot River, Upper Segment (MT76G004_020) 7-49
7.7.12 Little Blackfoot River, Lower Segment (MT76G004_010) 7-50
7.8 Seasonality and Margin of Safety 7-52
7.9 Uncertainty and Adaptive Management 7-53
8.0 Other Identified Issues or Concerns 8-1
8.1 Pollution Listings 8-1
8.1.2 Pollution Causes of Impairment Descriptions 8-2
8.1.3 Monitoring and BMPs for Pollution Affected Streams 8-3
8.2 Potential Pollutant Issues Not Addressed 8-3
8.2.1 Temperature 8-3
8.2.2 Aluminum 8-3
9.0 Restoration Objectives and Implementation Strategy 9-1
9.1 Water Quality Restoration Objectives 9-1
9.2 Agency and Stakeholder Coordination 9-2
9.3 Restoration Strategy By Pollutant 9-2
9.3.1 Sediment Restoration Strategy 9-2
9.3.2 Nutrient Restoration Strategy 9-3
9.3.3 Metals Restoration Strategy 9-4
9.3.4 Pollution Restoration Strategy 9-4
9.4 Restoration Approaches by Source Category 9-4
9.4.1 Grazing 9-5
9.4.2 Small Acreages 9-5
9.4.3 Animal Feeding Operations 9-6
9.4.4 Cropland 9-7
9.4.5 Irrigation 9-7
9.4.6 Riparian Areas and Floodplains 9-8
9.4.7 Unpaved Roads 9-8
9.4.8 Stormwater Construction Permitting and BMPs 9-10
9.4.9 Urban Area Stormwater BMPs 9-10
9.4.10 Beaver Populations and Sediment Yields 9-10
9.4.11 Forestry and Timber Harvest 9-11
9.4.12 Mining 9-11
9.5 Potential Funding Sources 9-13

9.5.1 Section 319 Nonpoint Source Grant Program 9-13
9.5.2 Future Fisheries Improvement Program 9-14
9.5.3 Watershed Planning and Assistance Grants 9-14
9.5.4 Environmental Quality Incentives Program 9-14
9.5.5 Resource Indemnity Trust/Reclamation and Development Grants Program 9-14
9.5.6 Upper Clark Fork River Basin Restoration Fund 9-14
10.0 Monitoring Strategy 10-1
10.1 Adaptive Management and Uncertainty 10-1
10.2 Tracking and Monitoring Restoration Activities and Effectiveness 10-2
10.3 Baseline and Impairment Status Monitoring 10-2
10.3.1 Sediment 10-3
10.3.2 Nutrients 10-3
10.3.3 Metals 10-3
10.4 Source Assessment Refinement 10-4
10.4.1 Sediment 10-4
10.4.2 Nutrients 10-5
10.4.3 Metals 10-5
11.0 Public Participation 11-1
11.1 Participants and Roles 11-1
11.2 Response to Public Comments 11-2
Section 12 - References 12-1

APPENDICES

Appendix A – Figures and Tables
Appendix B – Regulatory Framework and Reference Condition Approach
Appendix C – 2009 Sediment and Habitat Assessment
Appendix D –Little Blackfoot River Watershed Sediment and Nutrient Assessment
Appendix E – Road Sediment Assessment
Appendix F – Detailed Source Assessment and Data Review
Appendix G – Metals and Nutrient Water Quality Data
Appendix H – Response to Public Comments

LIST OF TABLES

Table DS-1. List of Impaired Waterbodies and their Impaired Uses in the Little Blackfoot TPA with Completed Sediment, Nutrient, and Metals TMDLs Contained in this Document 2

Table 1-1. Pollutant Impairment Causes for the Little Blackfoot TPA Addressed within this Document..... 1-3
Table 2-1. Monthly Climate Summary for Elliston. 2-4
Table 2-2. Land ownership in the Little Blackfoot watershed 2-5
Table 2-3. Land Use and Cover in the Little Blackfoot watershed. 2-5
Table 3-1. Impaired Waterbodies and their Designated Use Support Status on the "2010 Water Quality Integrated Report" in the Little Blackfoot TPA 3-2
Table 5-1. Waterbody segments in the Little Blackfoot TPA with sediment listings on the 2010 303(d) List 5-2
Table 5-2. Stratified reach types and sampling site representativeness within the Little Blackfoot TPA. 5-5
Table 5-3. Sediment Targets for the Little Blackfoot TPA 5-8
Table 5-4. 2009 DEQ Data Summary and BDNF Reference Dataset Median Percent Fine Sediment < 6 mm. Target values are indicated in bold. 5-10
Table 5-5. 2009 DEQ Data Summary and PIBO Reference Dataset Percent Fine Sediment < 2 mm. Target values are indicated in bold. 5-10
Table 5-6. PIBO Reference and 2009 DEQ Data Percentiles for Percent Fine Sediment < 6 mm via Grid Toss in Pool Tails and Riffles. Riffle and pool tail target values are indicated in bold. 5-11
Table 5-7. Width/depth and Entrenchment Ratio Targets Based on BDNF Reference Data.....5-12
Table 5-8. PIBO Reference and 2009 DEQ Sample Data Percentiles for Residual Pool Depth (ft). Targets are shown in bold.....5-13
Table 5-9. PIBO Reference and 2009 DEQ Sample Data Percentiles for Pool Frequency (pools/mile) and INFISH Riparian Management Objective Values. Targets are shown in bold. 5-14
Table 5-10. PIBO Reference and 2009 DEQ Sample Data Percentiles for Large Woody Debris Frequency (LWD/mile). Targets are shown in bold. 5-14
Table 5-11. Existing sediment-related data for lower Dog Creek relative to targets. Values that do not meet the target are in bold. 5-19
Table 5-12. Macroinvertebrate bioassessment data for lower Dog Creek. Values that do not meet the target threshold are in bold. 5-19
Table 5-13. Existing sediment-related data for Elliston Creek relative to targets. Values that do not meet the target are in bold. 5-21
Table 5-14. Macroinvertebrate Bioassessment Data for Elliston Creek. 5-21
Table 5-15. Existing sediment-related data for upper Little Blackfoot River relative to targets. Values that do not meet the target are in bold. 5-23
Table 5-16. Macroinvertebrate bioassessment data for upper Little Blackfoot River. Values that do not meet the target threshold are in bold. 5-23
Table 5-17. Existing sediment-related data for lower Little Blackfoot River relative to targets. Values that do not meet the target are in bold. 5-26
Table 5-18. Macroinvertebrate bioassessment data for lower Little Blackfoot River. Values that do not meet the target threshold are in bold. 5-26
Table 5-19. Existing sediment-related data for Snowshoe Creek relative to targets. Values that do not meet the target are in bold. 5-28
Table 5-20. Macroinvertebrate bioassessment data for Snowshoe Creek. Values that do not meet the target threshold are in bold. 5-28
Table 5-21. Existing sediment-related data for lower Spotted Dog Creek relative to targets. Values that do not meet the target are in bold. 5-30
Table 5-22. Existing sediment-related data for upper Telegraph Creek relative to targets. Values that do not meet the target are in bold. 5-31

Table 5-23. Macroinvertebrate Bioassessment Data for upper Telegraph Creek. Values that do not meet the target threshold are in bold. 5-31
Table 5-24. Existing sediment-related data for lower Threemile Creek relative to targets. Values that do not meet the target are in bold and shaded gray. 5-33
Table 5-25. Existing sediment-related data for Trout Creek relative to targets. Values that do not meet the target are in bold. 5-34
Table 5-26 Summary of Sediment TMDL Development Determinations 5-35
Table 5-27. Existing and Reduced Sediment Load from Eroding Streambanks within the Little Blackfoot TPA. 5-37
Table 5-28. SWAT HRU Categories and C-factors for the existing and improved condition scenarios 5-39
Table 5-29. Existing and Reduced Sediment Load from Upland Sources within the Little Blackfoot TPA 5-39
Table 5-30. Sediment Load from Upland Sources with Improved Upland and Riparian Conditions 5-41
Table 5-31. Annual Sediment Load (tons/year) from Unpaved Roads within the Little Blackfoot River Watershed 5-43
Table 5-32. Annual Sediment Load (tons/year) from Traction Sand within the Little Blackfoot River Watershed 5-44
Table 5-33. Sediment Loading and Reductions from Permitted Construction Sites 5-47
Table 5-34. Sediment Source Assessment, Allocations and TMDL for upper Dog Creek 5-49
Table 5-35. Sediment Source Assessment, Allocations and TMDL for lower Dog Creek 5-50
Table 5-36. Sediment Source Assessment, Allocations and TMDL for Elliston Creek 5-50
Table 5-37. Sediment Source Assessment, Allocations and TMDL for the upper Little Blackfoot River 5-51
Table 5-38. Sediment Source Assessment, Allocations and TMDL for the lower Little Blackfoot River 5-51
Table 5-39. Sediment Source Assessment, Allocations and TMDL for Snowshoe Creek 5-52
Table 5-40. Sediment Source Assessment, Allocations and TMDL for lower Spotted Dog Creek 5-52
Table 5-41. Sediment Source Assessment, Allocations and TMDL for upper Telegraph Creek 5-53
Table 5-42. Sediment Source Assessment, Allocations and TMDL for lower Threemile Creek 5-53
Table 6-1. Waterbody segments in the Little Blackfoot TPA with nutrient listings on the 2010 303(d) List 6-2
Table 6-2. Nutrient Targets for the Little Blackfoot TPA 6-4
Table 6-3. Nutrient Data Summary for Lower Carpenter Creek 6-5
Table 6-4. Assessment Method Evaluation Results for Lower Carpenter Creek 6-5
Table 6-5. Nutrient Data Summary for Lower Dog Creek 6-6
Table 6-6. Assessment Method Evaluation Results for Lower Dog Creek 6-6
Table 6-7. Nutrient Data Summary for the Lower Segment of the Little Blackfoot River 6-7
Table 6-8. Assessment Method Evaluation Results for the Lower Segment of the Little Blackfoot River 6-7
Table 6-9. Nutrient Data Summary for Snowshoe Creek 6-7
Table 6-10. Assessment Method Evaluation Results for Snowshoe Creek 6-8
Table 6-11. Nutrient Data Summary for Lower Spotted Dog Creek 6-8
Table 6-12. Assessment Method Evaluation Results for Lower Spotted Dog Creek 6-8
Table 6-13. Nutrient Data Summary for Lower Threemile Creek 6-9
Table 6-14. Assessment Method Evaluation Results for Lower Threemile Creek 6-9
Table 6-15. Summary of Nutrient TMDL Development Determinations 6-10
Table 6-16. Modeled Summer Nutrient Loads by Watershed (July 1 – September 30) 6-14

Table 6-17. Needed loading reductions relative to SWAT modeling scenario reductions. 6-18
Table 6-18. Total Phosphorus Allocations and TMDL for Carpenter Creek. 6-22
Table 6-19. Total Phosphorus Allocations and TMDL for Dog Creek. 6-23
Table 6-20. Total Phosphorus Allocations and TMDL for the lower Little Blackfoot River. 6-24
Table 6-21. Nitrate + Nitrate Allocations and TMDL for Snowshoe Creek. 6-24
Table 6-22. Total Phosphorus Allocations and TMDL for Spotted Dog Creek. 6-25
Table 6-23. Total Phosphorus Allocations and TMDL for Threemile Creek. 6-26
Table 6-24. Total Nitrogen Allocations and TMDL for Threemile Creek. 6-27
Table 7-1. Waterbody segments in the Little Blackfoot TPA with metals listings on the 2010 303(d) List. 7-1
Table 7-2. Screening level criteria for sediment metals concentrations that will be used as supplemental indicators in the Little Blackfoot TPA. 7-5
Table 7-3. Targets and Supplemental Indicators for Metals in the Little Blackfoot TPA. 7-6
Table 7-4. Un-named Creek TMDL Decision Factors 7-9
Table 7-5. Monarch Creek TMDL Decision Factors 7-10
Table 7-6. Ontario Creek TMDL Decision Factors 7-12
Table 7-7. Sally Ann Creek TMDL Decision Factors 7-14
Table 7-8. O'Keefe Creek TMDL Decision Factors 7-15
Table 7-9. Upper Telegraph Creek TMDL Decision Factors 7-17
Table 7-10. Lower Telegraph Creek TMDL Decision Factors 7-19
Table 7-11. American Gulch Creek TMDL Decision Factors 7-20
Table 7-12. Upper Dog Creek TMDL Decision Factors 7-22
Table 7-13. Lower Dog Creek TMDL Decision Factors 7-24
Table 7-14. Upper Little Blackfoot River TMDL Decision Factors 7-26
Table 7-15. Lower Little Blackfoot River TMDL Decision Factors 7-27
Table 7-16. Summary of Streams Requiring Metals TMDLs 7-28
Table 7-17. Detailed inputs for example TMDLs in the Little Blackfoot TPA 7-35
Table 7-18. Un-named Creek Metals TMDLs and Allocation Examples 7-38
Table 7-19. Monarch Creek Metals TMDLs and Allocation Examples 7-39
Table 7-20. Ontario Creek Metals TMDLs and Allocation Examples 7-40
Table 7-21. Flow Weighted WLA Calculations for Sally Ann Creek 7-41
Table 7-22. Sally Ann Creek Metals TMDLs and Allocation Examples 7-42
Table 7-23. O'Keefe Creek Metals TMDLs and Allocation Examples 7-43
Table 7-24. Flow Weighted WLA Calculations for Upper Telegraph Creek 7-44
Table 7-25. Upper Telegraph Creek Metals TMDLs and Allocation Examples 7-44
Table 7-26. Lower Telegraph Creek Metals TMDLs and Allocation Examples 7-45
Table 7-27. American Gulch Creek Metals TMDLs and Allocation Examples 7-47
Table 7-28. Upper Dog Creek Metals TMDLs and Allocation Examples 7-48
Table 7-29. Lower Dog Creek Metals TMDLs and Allocation Examples 7-49
Table 7-30. Upper Little Blackfoot River Metals TMDLs and Allocation Examples 7-50
Table 7-31. Lower Little Blackfoot River Metals TMDLs and Allocation Examples 7-52
Table 8-1. Waterbody segments with pollution listings on the 2010 303(d) List 8-1
Table 9-1. Priority Abandoned Mine Sites Identified as Potential Sources of Metals Impairments. 9-13
Table 10-1. Waterbody-Pollutant Combinations Where More Sampling is Needed 10-4

LIST OF FIGURES

Figure 2-1. Average monthly discharge based on the period of record (1972 – 2006).....2-3
Figure 4-1. Schematic Example of TMDL Development.....4-2
Figure 4-2. Schematic Diagram of a TMDL and its Allocations 4-4
Figure 5-1. DEQ 2009 Sampling Sites and Other Sediment-Related Sampling Sites 5-4
Figure 6-1. Nutrient sampling sites on the streams of concern. 6-3
Figure 6-2. Source Assessment Result Summary by Watershed for TP.....6-15
Figure 6-3. Source Assessment Result Summary by Watershed for Nitrogen.....6-16
Figure 6-4. Graph of the TN TMDLs for mean daily flows from zero to 50 cfs. 6-20
Figure 6-5. Flow duration curve based on a period of record from 2001-2010 for the Little Blackfoot River at USGS Station #12324590, partitioned by annual hydrologic condition. 6-20
Figure 6-6. Load duration curve showing TP TMDL and sample data for Carpenter Creek. 6-22
Figure 6-7. Load duration curve showing TP TMDL and sample data for Dog Creek. 6-23
Figure 6-8. Load duration curve showing TP TMDL and sample data for the Little Blackfoot River. 6-23
Figure 6-9. Load duration curve showing NO3 + NO2 TMDL and sample data for Snowshoe Creek. 6-24
Figure 6-10. Load duration curve showing TP TMDL and sample data for Spotted Dog Creek.....6-25
Figure 6-11. Load duration curve showing TP TMDL and sample data for Threemile Creek. 6-26
Figure 6-12. Load duration curve showing TN TMDL and sample data for Threemile Creek.....6-26
Figure 7-1. Un-named Creek Sample Sites.....7-7
Figure 7-2. Monarch Creek Sample Sites 7-9
Figure 7-3. Ontario Creek Sample Sites 7-11
Figure 7-4. Sally Ann Creek Sample Sites.....7-13
Figure 7-5. O'Keefe Creek Sample Sites.....7-15
Figure 7-6. Upper Telegraph Creek Sample Sites.....7-16
Figure 7-7. Lower Telegraph Creek Sample Sites.....7-18
Figure 7-8. American Gulch Creek Sample Sites 7-19
Figure 7-9. Upper Dog Creek Sample Sites 7-21
Figure 7-10. Lower Dog Creek Sample Sites 7-23
Figure 7-11. Upper Little Blackfoot River Sample Sites 7-24
Figure 7-12. Lower Little Blackfoot River Sample Sites.....7-26
Figure 7-13. Arsenic TMDL as a function of flow 7-30
Figure 7-14. Beryllium TMDL as a function of flow.....7-30
Figure 7-15. Cadmium TMDL as a function of flow.....7-31
Figure 7-16. Copper TMDL as a function of flow 7-31
Figure 7-17. Cyanide TMDL as a function of flow 7-32
Figure 7-18. Iron TMDL as a function of flow 7-32
Figure 7-19 Lead TMDL as a function of flow 7-33
Figure 7-20 Mercury TMDL as a function of flow 7-33
Figure 7-21 Selenium TMDL as a function of flow 7-34
Figure 7-22. Zinc TMDL as a function of flow 7-34

L

ACRONYM LIST

Acronym	Definition
AFDW	Ash Free Dry Weight
AFO	Animal Feeding Operation
AL	Aquatic Life
AML	Abandoned Mine Lands
ARARS	Applicable or Relevant and Appropriate Requirements and Standards
ARCO	Atlantic Richfield Company
ARM	Administrative Rules of Montana
BDNF	Beaverhead Deerlodge National Forest
BEHI	Bank Erosion Hazard Index
BFW	Bankfull Width
BLM	Bureau of Land Management (federal)
BMP	Best Management Practices
BNSF	Burlington Northern Santa Fe
CAFO	Concentrated (or Confined) Animal Feed Operations
CALA	Controlled Allocation of Liability Act
CECRA	[Montana] Comprehensive Environmental Cleanup and Responsibility Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CFS	Cubic Feet Per Second
CWA	Clean Water Act
DEQ	Department of Environmental Quality (Montana)
DNRC	Department of Natural Resources & Conservation
EPA	Environmental Protection Agency (US)
EQIP	Environmental Quality Initiatives Program
FWP	Fish, Wildlife, and Parks
GIS	Geographic Information System
GWIC	Groundwater Information Center
HBI	Hilsenhoff Biotic Index
HRU	Hydrologic Response Units
INFISH	Inland Native Fish Strategy
IR	Integrated Report
LA	Load Allocation
LULC	Land Use and Land Cover
LWD	Large Woody Debris
MBMG	Montana Bureau of Mines and Geology
MCA	Montana Codes Annotated
MDT	Montana Department of Transportation
MMI	Multi-Metric Index
MOS	Margin of Safety
MPDES	Montana Pollutant Discharge Elimination System
MSU	Montana State University
MWCB	Mine Waste Cleanup Bureau (DEQ)
NBS	Near Bank Stress
NHD	National Hydrography Data(set)

Acronym	Definition
NLCD	National Land Cover Dataset
NOAA	National Oceanographic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NPS	Nonpoint Source
NRCS	National Resources Conservation Service
NRDP	Natural Resource Damage Program
NRIS	Natural Resource Information System (Montana)
PELs	Probable Effects Levels
PIBO	PACFISH/INFISH Biological Opinion
RDG	Reclamation and Development Grants Program
RIT	Reach Indexing Tool
SAP	Sampling and Analysis Plan
SMCRA	Surface Mining Control & Reclamation Act
SMZ	Streamside Management Zone
STORET	EPA STOrage and RETrieval database
SWAT	Soil & Water Assessment Tool
SWPPP	Storm Water Pollution Prevention Plan
SWTS	Subsurface Wastewater Treatment System
TIE	TMDL Implementation Evaluation
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TPA	TMDL Planning Area
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection
USFS	United States Forest Service
USFWS	US Fish and Wildlife Service
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
VCRA	Voluntary Cleanup and Redevelopment Act
VFS	Vegetated Filter Strips
WEPP:Road	Water Erosion Prediction Project Methodology
WLA	Waste Load Allocation
WRP	Watershed Restoration Plans

DOCUMENT SUMMARY

This document presents a Total Maximum Daily Load (TMDL) and framework water quality improvement plan for 18 impaired waterbody segments in the Little Blackfoot River watershed. The document contains 62 TMDLs addressing impairments associated with sediment, nutrients, and metals (see **Table DS-1**). Future assessments may require additional TMDLs in this watershed.

The Montana Water Quality Act requires TMDLs to be developed for streams and lakes that do not meet, or are not expected to meet, Montana water quality standards. A TMDL is the maximum amount of a pollutant a waterbody can receive and still meet water quality standards. TMDLs provide an approach to improve water quality so that streams and lakes can support and maintain their state-designated beneficial uses.

The Little Blackfoot River TMDL Planning Area (TPA) is located in predominantly in Powell County, and contains a small portion in Lewis and Clark County. The TPA is bounded by the continental divide to the northeast and southeast, the Garnet Mountains to the northwest, and the divide between Spotted Dog Creek and the Clark Fork River to the southwest. The watershed area is approximately 264,124 acres, and includes the towns of Elliston and Avon. The watershed historically was an active area for mining, timber harvest, and agriculture. Today, the uplands are primarily forested and owned by the USFS, and the valley is primarily private land used for agricultural purposes.

Sediment - Sediment TMDLs are provided for ten waterbody segments in the Little Blackfoot TPA. Sediment is affecting beneficial uses in these streams by altering aquatic insect communities, reducing fish spawning success, and increasing turbidity. Water quality restoration goals for sediment were established on the basis of fine sediment levels in trout spawning areas and the stability of streambanks. DEQ believes that once these water quality goals are met, all water uses currently affected by sediment will be restored.

Sediment loads are quantified for natural background conditions and for the following sources: bank erosion, hillslope erosion, roads, and permitted point sources. The most significant sources include: streambank erosion associated with loss of riparian vegetation, upland erosion associated with grazing, and natural sources. The Little Blackfoot River watershed sediment TMDLs indicate that reductions in sediment loads ranging from 12% to 44% will satisfy the water quality restoration goals. Recommended strategies for achieving the sediment reduction goals are also presented in this plan. They include best management practices (BMPs) for building and maintaining roads, grazing, and harvesting timber, as well as improving riparian vegetation.

Nutrients – Seven nutrient TMDLs (nitrogen and/or phosphorus) are provided for six waterbody segments in the Little Blackfoot TPA. Nutrients are affecting beneficial uses in these streams by being present in concentrations that are linked to nuisance algal growth. Water quality restoration goals for nutrients were established based on concentrations that will prevent the formation of nuisance algal growth. DEQ believes that once these water quality goals are met, all water uses currently affected by nutrients will be restored.

Nutrient loads are quantified for the following sources: rangeland, cropland, forests, and suburban areas. A component of each source is the natural background load, but the natural background load is not estimated as a separate source category. The most significant sources include: livestock grazing,

haying, and natural sources. The Little Blackfoot River watershed nutrient TMDLs indicate that reductions in phosphorus loads ranging from 3% to 72% and nitrogen loads ranging from 9% to 68% will satisfy the water quality restoration goals. Recommended strategies for achieving the nutrient reduction goals are also presented in this plan. They include BMPs for livestock grazing and irrigation, as well as improving riparian vegetation.

Metals – Forty five metals TMDLs are provided for 12 waterbody segments in the Little Blackfoot TPA. There are also two waterbody segments with pH impairments; metals TMDLs for those streams are surrogates for pH TMDLs because providing pH TMDLs is not practical and addressing sources of metals impairments will also address sources of pH impairment. The metals of concern include: arsenic, beryllium, cadmium, copper, cyanide, iron, lead, mercury, selenium, and zinc. Water quality restoration goals for metals are established based on the numeric water quality criteria as defined in Circular DEQ-7. DEQ believes that once these water quality goals are met, all water uses currently affected by metals will be restored.

Metals loads are quantified for natural background conditions, abandoned mines, and permitted point sources. The Little Blackfoot River watershed metals TMDLs indicate that reductions in metals loads ranging from 5% to 95% will satisfy the water quality restoration goals. Achieving the metals reduction goals presented in this plan will mostly rely on abandoned mine reclamation. The state and federal programs as well as potential funding resources to address metals sources are summarized in this plan.

Implementation of most water quality improvement measures described in this plan is based on voluntary actions of watershed stakeholders. Ideally, local watershed groups and/or other watershed stakeholders will use this TMDL, and associated information, as a tool to guide local water quality improvement activities. Such activities can be documented within a watershed restoration plan consistent with DEQ and EPA recommendations.

A flexible approach to most nonpoint source TMDL implementation activities may be necessary as more knowledge is gained through implementation and future monitoring. The plan includes a monitoring strategy designed to track progress in meeting TMDL objectives and goals and to help refine the plan during its implementation.

Table DS-1. List of Impaired Waterbodies and their Impaired Uses in the Little Blackfoot TPA with Completed Sediment, Nutrient, and Metals TMDLs Contained in this Document

Waterbody Name & Location	Waterbody ID	TMDL Prepared	Pollutant Category	Impaired Use
AMERICAN CREEK, headwaters to mouth (Dog Creek)	MT76G004_079	Arsenic	Metals	Drinking Water
CARPENTER CREEK, Basin Creek to mouth (Little Blackfoot River)	MT76G004_092	Total Phosphorus	Nutrients	Aquatic Life, Cold Water Fishery, Primary Contact Recreation

Table DS-1. List of Impaired Waterbodies and their Impaired Uses in the Little Blackfoot TPA with Completed Sediment, Nutrient, and Metals TMDLs Contained in this Document

Waterbody Name & Location	Waterbody ID	TMDL Prepared	Pollutant Category	Impaired Use
DOG CREEK, headwaters to Meadow Creek	MT76G004_071	Sediment	Sediment	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Arsenic	Metals	Aquatic Life, Cold Water Fishery
		Lead	Metals	Aquatic Life, Cold Water Fishery
		Zinc	Metals	Aquatic Life, Cold Water Fishery
		Cadmium	Metals	Aquatic Life, Cold Water Fishery
		Copper	Metals	Aquatic Life, Cold Water Fishery
DOG CREEK, Meadow Creek to mouth (Little Blackfoot River)	MT76G004_072	Sediment	Sediment	Aquatic Life, Cold Water Fishery
		Total Phosphorus	Nutrients	Aquatic Life, Cold Water Fishery
		Copper	Metals	Aquatic Life, Cold Water Fishery
		Lead	Metals	Aquatic Life, Cold Water Fishery
ELLISTON CREEK, headwaters to mouth (Little Blackfoot River)	MT76G004_040	Sediment	Sediment	Aquatic Life, Cold Water Fishery
LITTLE BLACKFOOT RIVER, Dog Creek to mouth (Clark Fork River)	MT76G004_010	Sediment	Sediment	Aquatic Life, Cold Water Fishery
		Lead	Metals	Aquatic Life, Cold Water Fishery, Drinking Water
		Arsenic	Metals	Drinking Water
		Total Phosphorus	Nutrients	Aquatic Life, Cold Water Fishery
LITTLE BLACKFOOT RIVER, the headwaters to Dog Creek	MT76G004_020	Sediment	Sediment	Aquatic Life, Cold Water Fishery
		Arsenic	Metals	Aquatic Life, Cold Water Fishery
		Cyanide	Metals	Aquatic Life, Cold Water Fishery
		Cadmium	Metals	Aquatic Life, Cold Water Fishery
		Copper	Metals	Aquatic Life, Cold Water Fishery
		Lead	Metals	Aquatic Life, Cold Water Fishery

Table DS-1. List of Impaired Waterbodies and their Impaired Uses in the Little Blackfoot TPA with Completed Sediment, Nutrient, and Metals TMDLs Contained in this Document

Waterbody Name & Location	Waterbody ID	TMDL Prepared	Pollutant Category	Impaired Use
MONARCH CREEK, headwaters to mouth (Ontario Creek)	MT76G004_060	Copper	Metals	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Lead	Metals	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Mercury	Metals	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
O'KEEFE CREEK, headwaters to mouth (Telegraph Creek)	MT76G004_054	Cadmium	Metals	Aquatic Life, Cold Water Fishery
		Copper	Metals	Aquatic Life, Cold Water Fishery
		Zinc	Metals	Aquatic Life, Cold Water Fishery
ONTARIO CREEK, headwaters to mouth (Little Blackfoot River)	MT76G004_130	Cadmium	Metals	Aquatic Life, Cold Water Fishery
		Copper	Metals	Aquatic Life, Cold Water Fishery
		Lead	Metals	Aquatic Life, Cold Water Fishery
SALLY ANN CREEK, headwaters to mouth (O'Keefe Creek)	MT76G004_055	Cadmium	Metals	Aquatic Life, Cold Water Fishery
		Copper	Metals	Aquatic Life, Cold Water Fishery
		Zinc	Metals	Aquatic Life, Cold Water Fishery
SNOWSHOE CREEK, headwaters to mouth (Little Blackfoot River)	MT76G004_080	Sediment	Sediment	Aquatic Life, Cold Water Fishery
		Nitrate/Nitrite	Nutrients	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
SPOTTED DOG CREEK, forest boundary to mouth (Little Blackfoot River)	MT76G004_032	Sediment	Sediment	Aquatic Life, Cold Water Fishery
		Total Phosphorus	Nutrients	Aquatic Life, Cold Water Fishery
TELEGRAPH CREEK, Hahn Creek to mouth (Little Blackfoot River)	MT76G004_052	Lead	Metals	Drinking Water
		Mercury	Metals	Drinking Water
		Cadmium	Metals	Aquatic Life, Cold Water Fishery
		Copper	Metals	Aquatic Life, Cold Water Fishery
		Zinc	Metals	Aquatic Life, Cold Water Fishery

Table DS-1. List of Impaired Waterbodies and their Impaired Uses in the Little Blackfoot TPA with Completed Sediment, Nutrient, and Metals TMDLs Contained in this Document

Waterbody Name & Location	Waterbody ID	TMDL Prepared	Pollutant Category	Impaired Use
TELEGRAPH CREEK, headwaters to Hahn Creek	MT76G004_051	Sediment	Sediment	Aquatic Life, Cold Water Fishery
		Arsenic	Metals	Aquatic Life, Cold Water Fishery
		Beryllium	Metals	Aquatic Life, Cold Water Fishery
		Cadmium	Metals	Aquatic Life, Cold Water Fishery
		Copper	Metals	Aquatic Life, Cold Water Fishery
		Zinc	Metals	Aquatic Life, Cold Water Fishery
		Lead	Metals	Aquatic Life, Cold Water Fishery
THREEMILE CREEK, Quigley Ranch Reservoir to mouth (Little Blackfoot River)	MT76G004_112	Sediment	Sediment	Aquatic Life, Cold Water Fishery
		Total Phosphorus	Nutrients	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
		Total Nitrogen	Nutrients	Aquatic Life, Cold Water Fishery, Primary Contact Recreation
TROUT CREEK, headwaters to the mouth (Little Blackfoot River)	MT76G004_120	Sediment	Sediment	Aquatic Life, Cold Water Fishery
UN-NAMED CREEK, headwaters to mouth (Ontario Creek), T8N R6W S27	MT76G006_010	Arsenic	Metals	Drinking Water
		Cadmium	Metals	Aquatic Life, Cold Water Fishery
		Copper	Metals	Aquatic Life, Cold Water Fishery
		Lead	Metals	Aquatic Life, Cold Water Fishery
		Mercury	Metals	Drinking Water
		Zinc	Metals	Aquatic Life, Cold Water Fishery
		Iron	Metals	Aquatic Life, Cold Water Fishery

1.0 INTRODUCTION

This document presents an analysis of water quality information and establishes total maximum daily loads (TMDLs) for sediment, nutrients, and metals problems in the Little Blackfoot TPA. This document also presents a general framework for resolving these problems. **Figure A-1** in **Appendix A**, shows a map of waterbodies in the Little Blackfoot TPA with sediment, nutrients, and metals pollutant listings.

1.1 BACKGROUND

In 1972, the U.S. Congress passed the Water Pollution Control Act, more commonly known as the Clean Water Act (CWA). The CWA's goal is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The CWA requires each state to designate uses of their waters and to develop water quality standards to protect those uses. Each state must monitor their waters to track if they are supporting their designated uses.

Montana's water quality designated use classification system includes the following uses:

- fish and aquatic life
- wildlife
- recreation
- agriculture
- industry
- drinking water

Each waterbody has a set of designated uses. Montana has established water quality standards to protect these uses. Waterbodies that do not meet one or more standards are called impaired waters. Every two years DEQ must file a Water Quality Integrated Report (IR), which lists all impaired waterbodies and their identified impairment causes. Impairment causes fall within two main categories: pollutant and non-pollutant.

Montana's biennial IR identifies all the state's impaired waterbody segments. All waterbody segments within the IR are indexed to the National Hydrography Dataset (NHD). The 303(d) list portion of the IR includes all of those waterbody segments impaired by a pollutant, which require a TMDL. TMDLs are not required for non-pollutant impairments. **Table A-1** in **Appendix A** identifies impaired waters for the Little Blackfoot TPA from Montana's 2010 303(d) List, as well as non-pollutant impairment causes included in Montana's "2010 Water Quality Integrated Report." **Table A-1** provides the current status of each impairment cause, identifying whether it has been addressed by TMDL development.

Both Montana state law (Section 75-5-701 of the Montana Water Quality Act) and section 303(d) of the federal CWA require the development of total maximum daily loads for all impaired waterbodies when water quality is impaired by a pollutant. A TMDL is the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards.

Developing TMDLs and water quality improvement strategies includes the following components, which are further defined in **Section 4.0**:

- Determining measurable target values to help evaluate the waterbody's condition in relation to the applicable water quality standards
- Quantifying the magnitude of pollutant contribution from their sources

- Determining the TMDL for each pollutant based on the allowable loading limits for each waterbody-pollutant combination
- Allocating the total allowable load (TMDL) into individual loads for each source

In Montana, restoration strategies and monitoring recommendations are also incorporated in TMDL documents to help facilitate TMDL implementation.

Basically, developing a TMDL for an impaired waterbody is a problem-solving exercise: The problem is excess pollutant loading that impairs a designated use. The solution is developed by identifying the total acceptable pollutant load (the TMDL), identifying all the significant pollutant-contributing sources, and identifying where pollutant loading reductions should be applied to achieve the acceptable load.

1.2 Water Quality Impairments and TMDLs Addressed by this Document

Table 1-1 below lists all of the pollutant impairment causes from the "2010 Water Quality Integrated Report" that are addressed in this document. Each pollutant impairment falls within a TMDL pollutant category (e.g., metals, nutrients, or sediment), and this document is organized by those categories.

New data assessed during this project identified 31 new sediment, nutrient, and metals impairment causes for 15 waterbodies. These impairment causes are identified in **Table 1-1** as not being on the 2010 303(d) List (within the integrated report). Additionally, as shown in **Table 1-1**, new data evaluated during this project did not support the impairment listings for six pollutants and no TMDLs were developed for those pollutants.

TMDLs are completed for each waterbody – pollutant combination, and this document contains 62 TMDLs addressing 64 impairments (**Table 1-1**). There are several non-pollutant types of impairment that are also addressed in this document. As noted above, TMDLs are not required for non-pollutants, although in many situations the solution to one or more pollutant problems will be consistent with, or equivalent to, the solution for one or more non-pollutant problems. The overlap between the pollutant TMDLs and non-pollutant impairment causes is discussed in **Section 8.0. Section 8.0** also provides some basic water quality solutions to address those non-pollutant causes not specifically addressed by TMDLs in this document. **Table A-1** in **Appendix A** includes all 70 pollutant impairment causes as well as the 18 non-pollutant impairment causes that were addressed within this document.

Table 1-1. Pollutant Impairment Causes for the Little Blackfoot TPA Addressed within this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status	Included in 2010 IR
AMERICAN CREEK, headwaters to mouth (Dog Creek)	MT76G004_079	Arsenic	Metals	Metals TMDL contained in this document	No
CARPENTER CREEK, Basin Creek to mouth (Little Blackfoot River)	MT76G004_092	Total Phosphorus	Nutrients	TP TMDL contained in this document	No
DOG CREEK, headwaters to Meadow Creek	MT76G004_071	Sedimentation/ Siltation	Sediment	Sediment TMDL contained in this document	Yes
		Arsenic	Metals	Metals TMDL contained in this document	Yes
		Lead	Metals	Metals TMDL contained in this document	Yes
		Zinc	Metals	Metals TMDL contained in this document	Yes
		Cadmium	Metals	Metals TMDL contained in this document	No
		Copper	Metals	Metals TMDL contained in this document	No
DOG CREEK, Meadow Creek to mouth (Little Blackfoot River)	MT76G004_072	Sedimentation/ Siltation	Sediment	Sediment TMDL contained in this document	Yes
		Nitrate/Nitrite	Nutrients	No TMDL based on review of recent data	Yes
		Total Phosphorus	Nutrients	TP TMDL contained in this document	No
		Copper	Metals	Metals TMDL contained in this document	No
		Lead	Metals	Metals TMDL contained in this document	No
ELLISTON CREEK, headwaters to mouth (Little Blackfoot River)	MT76G004_040	Sedimentation/ Siltation	Sediment	Sediment TMDL contained in this document	No
LITTLE BLACKFOOT RIVER, Dog Creek to mouth (Clark Fork River)	MT76G004_010	Sedimentation/ Siltation	Sediment	Sediment TMDL contained in this document	Yes
		Copper	Metals	No TMDL based on review of recent data	Yes
		Lead	Metals	Metals TMDL contained in this document	Yes
		Arsenic	Metals	Metals TMDL contained in this document	No
		Nitrate/Nitrite	Nutrients	No TMDL based on review of recent data	Yes
		Total Phosphorus	Nutrients	TP TMDL contained in this document	No
LITTLE BLACKFOOT RIVER, the headwaters to Dog Creek	MT76G004_020	Sedimentation/ Siltation	Sediment	Sediment TMDL contained in this document	Yes
		Arsenic	Metals	Metals TMDL contained in this document	Yes
		Cyanide	Metals	Metals TMDL contained in this document	Yes
		Cadmium	Metals	Metals TMDL contained in this document	No
		Copper	Metals	Metals TMDL contained in this document	No
		Lead	Metals	Metals TMDL contained in this document	No

Table 1-1. Pollutant Impairment Causes for the Little Blackfoot TPA Addressed within this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status	Included in 2010 IR
MONARCH CREEK, headwaters to mouth (Ontario Creek)	MT76G004_060	Arsenic	Metals	No TMDL based on review of recent data	Yes
		Copper	Metals	Metals TMDL contained in this document	Yes
		Lead	Metals	Metals TMDL contained in this document	Yes
		Mercury	Metals	Metals TMDL contained in this document	Yes
		pH	Metals	Addressed by metals TMDLs in this document (surrogate)	Yes
		Selenium	Metals	No TMDL based on review of recent data	Yes
O'KEEFE CREEK, headwaters to mouth (Telegraph Creek)	MT76G004_054	Cadmium	Metals	Metals TMDL contained in this document	No
		Copper	Metals	Metals TMDL contained in this document	No
		Zinc	Metals	Metals TMDL contained in this document	No
ONTARIO CREEK, headwaters to mouth (Little Blackfoot River)	MT76G004_130	Cadmium	Metals	Metals TMDL contained in this document	No
		Copper	Metals	Metals TMDL contained in this document	No
		Lead	Metals	Metals TMDL contained in this document	No
SALLY ANN CREEK, headwaters to mouth (O'Keefe Creek)	MT76G004_055	Cadmium	Metals	Metals TMDL contained in this document	No
		Copper	Metals	Metals TMDL contained in this document	No
		Zinc	Metals	Metals TMDL contained in this document	No
SNOWSHOE CREEK, headwaters to mouth (Little Blackfoot River)	MT76G004_080	Sedimentation/ Siltation	Sediment	Sediment TMDL contained in this document	Yes
		Nitrate/Nitrite	Nutrients	Nitrate/Nitrite TMDL contained in this document	Yes
SPOTTED DOG CREEK, forest boundary to mouth (Little Blackfoot River)	MT76G004_032	Sedimentation/ Siltation	Sediment	Sediment TMDL contained in this document	Yes
		Total Phosphorus	Nutrients	TP TMDL contained in this document	Yes
TELEGRAPH CREEK, Hahn Creek to mouth (Little Blackfoot River)	MT76G004_052	Lead	Metals	Metals TMDL contained in this document	Yes
		Mercury	Metals	Metals TMDL contained in this document	Yes
		Cadmium	Metals	Metals TMDL contained in this document	No
		Copper	Metals	Metals TMDL contained in this document	No
		Zinc	Metals	Metals TMDL contained in this document	No

Table 1-1. Pollutant Impairment Causes for the Little Blackfoot TPA Addressed within this Document

Waterbody & Location Description	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status	Included in 2010 IR
TELEGRAPH CREEK, headwaters to Hahn Creek	MT76G004_051	Sedimentation/ Siltation	Sediment	Sediment TMDL contained in this document	Yes
		Arsenic	Metals	Metals TMDL contained in this document	Yes
		Beryllium	Metals	Metals TMDL contained in this document	Yes
		Cadmium	Metals	Metals TMDL contained in this document	Yes
		Copper	Metals	Metals TMDL contained in this document	Yes
		Iron	Metals	No TMDL based on review of recent data	Yes
		Zinc	Metals	Metals TMDL contained in this document	Yes
		Lead	Metals	Metals TMDL contained in this document	No
THREEMILE CREEK, Quigley Ranch Reservoir to mouth (Little Blackfoot River)	MT76G004_112	Sedimentation/ Siltation	Sediment	Sediment TMDL contained in this document	No
		Total Phosphorus	Nutrients	TP TMDL contained in this document	No
		Total Nitrogen	Nutrients	TN TMDL contained in this document	No
TROUT CREEK, headwaters to the mouth (Little Blackfoot River)	MT76G004_120	Sedimentation/ Siltation	Sediment	Sediment TMDL contained in this document	No
UN-NAMED CREEK, headwaters to mouth (Ontario Creek), T8N R6W S27	MT76G006_010	Arsenic	Metals	Metals TMDL contained in this document	Yes
		Cadmium	Metals	Metals TMDL contained in this document	Yes
		Copper	Metals	Metals TMDL contained in this document	Yes
		Lead	Metals	Metals TMDL contained in this document	Yes
		Mercury	Metals	Metals TMDL contained in this document	Yes
		pH	Metals	Addressed by metals TMDLs in this document (surrogate)	Yes
		Zinc	Metals	Metals TMDL contained in this document	Yes
		Iron	Metals	Metals TMDL contained in this document	No

1.3 DOCUMENT LAYOUT

This document addresses all of the required components of a TMDL and includes an implementation and monitoring strategy, as well as a strategy to address impairment causes other than [pollutant groups]. The TMDL components are summarized within the main body of the document. Additional technical details are contained in the appendices. In addition to this introductory section, this document includes:

Section 2.0 Little Blackfoot River Watershed Description:
Describes the physical characteristics and social profile of the watershed.

Section 3.0 Montana Water Quality Standards
Discusses the water quality standards that apply to the Little Blackfoot River watershed.

Section 4.0 Defining TMDLs and Their Components
Defines the components of TMDLs and how each is developed.

Sections 5.0 – 7.0 Sediment, Nutrients, and Metals TMDL Components (sequentially):
Each section includes (a) a discussion of the affected waterbodies and the pollutant's effect on designated beneficial uses, (b) the information sources and assessment methods used to evaluate stream health and pollutant source contributions, (c) water quality targets and existing water quality conditions, (d) the quantified pollutant loading from the identified sources, (e) the determined TMDL for each waterbody, (f) the allocations of the allowable pollutant load to the identified sources.

Section 8.0 Other Identified Issues or Concerns:
Describes other problems that could potentially be contributing to water quality impairment and how the TMDLs in the plan might address some of these concerns. This section also provides recommendations for combating these problems.

Section 9.0 Restoration Objectives and Implementation Strategy:
Discusses water quality restoration objectives and presents a framework for implementing a strategy to meet the identified objectives and TMDLs.

Section 10.0 Monitoring Strategy:
Describes a water quality monitoring plan for evaluating the long-term effectiveness of the "Little Blackfoot River Watershed TMDLs and Framework Water Quality Improvement Plan".

Section 11.0 Public Participation & Public Comments:
Describes other agencies and stakeholder groups who were involved with the development of the plan and the public participation process used to review the draft document. Addresses comments received during the public review period.

2.0 LITTLE BLACKFOOT RIVER WATERSHED DESCRIPTION

This report describes the general physical, ecological, and cultural characteristics of the Little Blackfoot River watershed and is intended to provide some background for the watershed to support total maximum daily load (TMDL) development.

2.1 PHYSICAL CHARACTERISTICS

The following information describes the physical characteristics of the Little Blackfoot River watershed.

2.1.1 Location

The majority of the Little Blackfoot TPA is within Powell County, with a minor area in Lewis & Clark County. The total extent is 264,124 acres, or approximately 413 square miles. The TPA is located in the Pend Oreille River Basin of western Montana, as shown on **Figure A-1**. The TPA is located within the Upper Clark Fork (17010201) hydrologic unit, and is coincident with the combined 170102015 and 170102016 fifth-code watersheds.

The TPA is located in the Middle Rockies Level III Ecoregion. Four Level IV Ecoregions are mapped within the TPA (Woods, et al., 2002), as shown on **Figure A-2**. These include: Deer Lodge-Philipsburg-Avon Grassy Intermontane Hills and Valleys (17ak), Eastern Divide Mountains (17aj), Elkhorn Mountains-Boulder Batholith (17ai), Rattlesnake-Blackfoot-South Swan-Northern Garnet-Sapphire Mountains (17x), and Southern Garnet Sedimentary-Volcanic Mountains (17al). The TPA is bounded by the continental divide to the northeast and southeast, the Garnet Mountains to the northwest, and the divide between Spotted Dog Creek and the Clark Fork River to the southwest.

2.1.2 Topography

Elevations in the Little Blackfoot TPA range from approximately 4,350 - 8,600 feet above mean sea level (**Figure A-3**). The lowest point is where the Little Blackfoot River drains into the Clark Fork River. The highest point is Thunderbolt Mountain, at the southernmost point of the TPA (8,597 feet). The uplands are characterized by steep-sided valleys with gently sloping ridgelines and peaks.

2.1.3 Geology

Figure A-4 provides an overview of the geology, based on the most recent geologic map of the Butte 1° x 2° quadrangle (Lewis, 1998).

Bedrock

The bedrock of the TPA includes Precambrian (i.e. Belt Series), Paleozoic and Mesozoic sedimentary rocks, granitic rocks of the Boulder batholith, and Cretaceous to Tertiary volcanic rocks (Schmidt, et al.,1994; Alden, 1953). The Mesozoic sedimentary rocks, and the Cretaceous age rocks in particular, are more susceptible to erosion, as they are not as hardened as the other units. The Cretaceous units include terrestrial, nearshore and offshore facies, and commonly feature weakly lithified fine-grained sediments. In contrast, the older sedimentary rocks, by virtue of their greater age, have been subject to further consolidation and lithification. In very general terms, the Precambrian sedimentary rocks and the granitic rocks of the batholith occupy the highest elevations in the TPA.

Basin Sediments

Tertiary and Quaternary sedimentary deposits are widespread in the Little Blackfoot TPA. The Tertiary sediments are commonly fine-grained with isolated bodies of coarser material. Tertiary sediments commonly occur in benches or dry terraces. Quaternary sediments include fluvial, colluvial, glacial and proglacial deposits. The most prominent glacial features in the TPA are the terminal moraines east of Elliston, in the broad valley bottom where Dog Creek meets the Little Blackfoot River. These features were deposited by glaciers descending from the Little Blackfoot headwaters (Ruppel,1962).

2.1.4 Soil Erodibility and Slope

The USGS Water Resources Division (Schwartz and Alexander, 1995) created a dataset of hydrology-relevant soil attributes, based on the USDA Natural Resources Conservation Service (NRCS) STATSGO soil database. Soil erodibility is based on the Universal Soil Loss Equation (USLE) K-factor (Wischmeier and Smith, 1978). K-factor values range from 0 to 1, with a greater value corresponding to greater potential for erosion. Susceptibility to erosion is mapped on **Figure A-5**, with soil units assigned to the following ranges: low (0.0-0.2), moderate-low (0.2-0.29) and moderate-high (0.3-0.4). Values of >0.4 are considered highly susceptible to erosion.

There are no values greater than 0.34 (moderate-high), and the majority of the TPA (65.5%) is mapped with moderate-low susceptibility soils. A sizeable percentage (31%) is mapped with moderate-high susceptibility, and only 3.3% is mapped with low susceptibility soils. Soils with low susceptibility to erosion are confined to bedrock uplands. The moderate-low susceptibility soils are generally found in the areas of higher elevation and steeper slope. The areas of lower slope (generally valleys) are associated with soils of moderate-high susceptibility to erosion. The exception to this pattern is that the soils along the Little Blackfoot River floodplain are mapped as moderate-low susceptibility soils. The majority of the TPA has slopes less than 20°, and that steeper slopes are limited to the edges of valleys (**Figure A-6**).

2.1.5 Surface Water

The TPA includes the entire Little Blackfoot River watershed. The river flows a distance of approximately 47 miles. Hydrography of the Little Blackfoot TPA is illustrated on **Figure A-7**. Stream mapping at 1:24,000 (Montana Department of Natural Resources and Conservation, 2008) includes 346 miles of named streams, with a total of 534 miles of streams mapped in the TPA.

USGS maintains one gage within the TPA (#12324590), which is located near Garrison (**Figure A-7**) and has been active since 1972. Flows in the Little Blackfoot River vary considerably over a calendar year but on average (over a 33-year period of record), low flows occur in September, and peak flows occur in May (**Figure 2-1**).

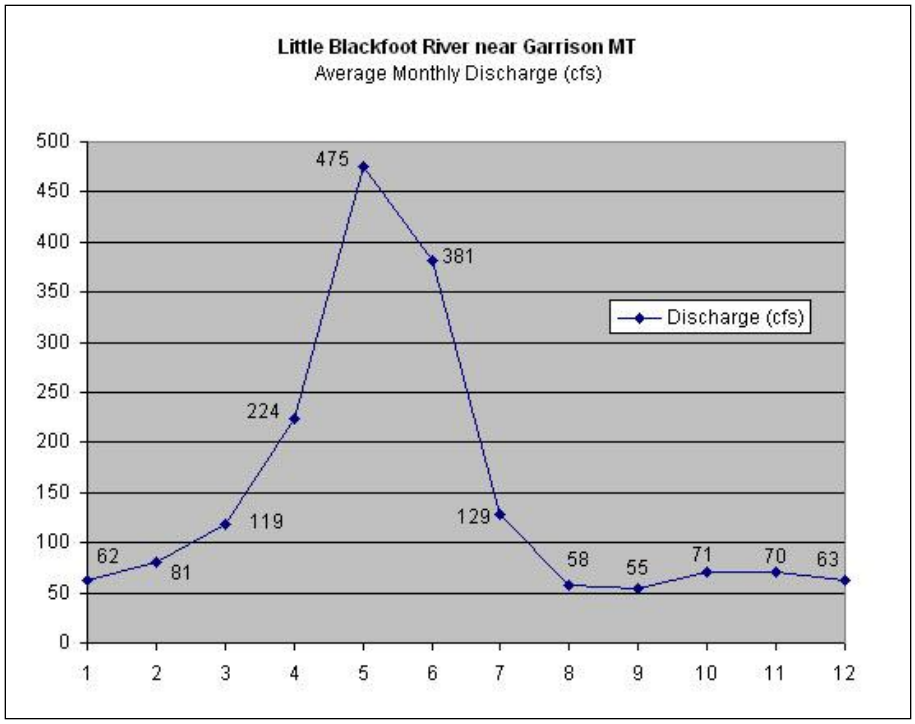


Figure 2-1. Average monthly discharge based on the period of record (1972 – 2006).

Peak annual discharges in the Little Blackfoot River vary over nearly two orders of magnitude. During the period of record, annual peaks ranged from 8,650 cfs (May 22, 1981) to 175 cfs (April 30, 1992). The mean peak annual discharge during the 33-year period of record is 1,505 cfs. Of the annual peak discharges, 13 occurred prior to May, and 7 occurred prior to April. Annual peaks have occurred as early as January 11 and late as July 4.

2.1.6 Groundwater

No basin-specific hydrogeology studies have been completed, but Kendy and Tresch (1996) described the groundwater system of the Avon Valley in general terms, assuming that groundwater flow within the valley is typical of intermontane basins and flows toward the center of the basin from the head and sides, and then down valley along the central axis. Kendy and Tresch (1996) report that groundwater of the Avon Valley is characterized by a calcium-bicarbonate chemistry, with dissolved solids generally less than 250 mg/L. Dissolved solids are higher (250-500 mg/L) in the glacial sediments north of Avon, and in water from Avon Warm Springs (650 mg/L). Low-hydraulic conductivity glacial sediments, combined with generally shallow bedrock, have created isolated bogs in the upper reaches of the Little Blackfoot and some of its tributaries in the Boulder Mountains. The average groundwater flow velocity in the bedrock is probably several orders of magnitude lower than in the valley fill sediments. However, carbonate and siliciclastic sedimentary rocks in the mountains may have zones of significant permeability. The hydrologic role of the structural geology (faults and folds) is uncertain because faults may act as flow conduits or barriers. Natural recharge occurs from infiltration of precipitation, stream loss, and flow out of the adjacent bedrock aquifers. Flood irrigation is an additional source of recharge to the valley aquifers, particularly along the floodplain.

The Montana Bureau of Mines and Geology (MBMG) Groundwater Information Center (GWIC) program monitors and samples a statewide network of wells (Montana Bureau of Mines and Geology, 2008). As

of August 2007, the GWIC database reports 401 wells within the TPA (Montana Department of Natural Resources and Conservation, 2008), and water quality data are available for 27 of the wells (**Figure A-8**). The water quality data include general physical parameters: temperature, pH and specific conductance, in addition to inorganic chemistry (common ions, metals and trace elements).

2.1.7 Climate

Climate in the area is typical of mid-elevation intermontane valleys in western Montana. Precipitation is most abundant in May and June and annual average precipitation ranges from 13-43 inches in the Little Blackfoot TPA (**Table 2-1**). The mountains receive most of the moisture, and the mouth of the TPA receives the least. The precipitation data (**Figure A-9**) is mapped by Oregon State University's PRISM Group, using records from NOAA stations (PRISM Group, 2004).

National Oceanographic and Atmospheric Administration (NOAA) currently operates three weather stations in the TPA, and several more have been discontinued (**Figure A-9**). The USDA Natural Resources Conservation Service (NRCS) operates twelve SNOTEL snowpack monitoring stations within the TPA (**Figure A-9**). Climate data are provided by the Western Regional Climate Center, operated by the Desert Research Institute of Reno, Nevada.

Table 2-1. Monthly Climate Summary for Elliston.

Elliston, Montana (242738) Period of Record : 4/25/1951 to 12/31/2005

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Ave. Max. Temp (F)	30.6	35.3	40.0	50.6	60.8	68.8	80.8	78.6	67.5	55.7	40.3	32.6	53.5
Ave. Min. Temp. (F)	9.3	12.7	16.2	25.5	33.2	39.7	43.9	41.7	34.0	26.5	17.6	11.8	26.0
Ave Tot. Precip. (in.)	1.04	0.67	0.94	1.46	2.03	2.90	1.15	1.47	1.30	1.06	0.86	0.89	15.78
Ave.. Snowfall (in.)	15.8	10.1	13.3	11.4	2.6	0.2	0.0	0.0	0.3	3.7	8.9	14.1	80.5
Ave Snow Depth (in.)	6	5	4	1	0	0	0	0	0	0	1	3	2

2.2 ECOLOGICAL PARAMETERS

2.2.1 Vegetation

The primary cover in the uplands is conifer forest. Conifers are dominated by Lodgepole pine, giving way to Douglas fir at lower elevations, with lesser amounts of White pine, Western larch and juniper. The valleys are characterized by grassland and irrigated agricultural land, with minor shrublands. Landcover is shown on **Figures A-10** and **A-11**. Data sources include the University of Montana's Satellite Imagery land Cover (SILC) project (University of Montana, 2002), and USGS National Land Cover Dataset (NLCD) mapping (Montana State Library, 1992).

2.2.2 Aquatic Life

Native fish species present in the TPA include: bull trout, westslope cutthroat trout, mountain whitefish, mottled sculpin, and slimy sculpin. Bull trout and westslope cutthroat trout are designated "Species of Concern" by Montana Department of Fish, Wildlife and Parks (FWP). Bull trout are further listed as "threatened" by the US Fish and Wildlife Service (USFWS). Introduced species are also present in streams, including: brook, rainbow and brown trout. Hybrids (rainbow-cutthroat and brook-bull) are reported in streams. Data on fish species distribution (**Figure A-12**) are collected, maintained and provided by FWP (2006).

2.2.3 Fires

The United States Forest Service (USFS) Region 1 office and the USFS remote sensing applications center provide data on fire locations from 1940 to the present, and no fires are mapped within the TPA for this period.

2.3 CULTURAL PARAMETERS

2.3.1 Population

An estimated 622 persons lived within the TPA in 2000 (Montana Department of Natural Resources and Conservation, 2008). Population estimates are derived from census data (United States Census Bureau, 2000), based upon the populations reported from census blocks within and intersecting the TPA boundary. Elliston and Avon had reported populations of 225 and 124 in the 2000 census, respectively, and the remainder of the population is sparsely distributed (**Figure A-13**).

2.3.2 Transportation Networks

The principal transportation route in the TPA is US Highway 12. Highway 12 connects Garrison Junction and I-90 to Helena. The network of unpaved roads on public and private lands will be further characterized as part of the sediment source assessment (**Section 5.7.3 and Appendix E**). The Burlington Northern Santa Fe (BNSF) railroad line between Helena and Missoula passes through the TPA.

2.3.3 Land Ownership

Land ownership data are provided by the State of Montana CAMA database via the NRIS website (Montana Department of Natural Resources and Conservation, 2008). Slightly more than one-half of the TPA is under private ownership. The dominant landholder is the USFS, which administers 37% of the TPA. Montana State Trust Lands occupy 6% of the TPA. Land ownership is shown on **Figure A-14**.

Table 2-2. Land ownership in the Little Blackfoot watershed

Owner	Acres	Square Miles	% of Total
Private	148,413	231.9	56%
USFS	98,016	153.1	37%
BLM	2,723	4.3	1%
State Trust Land	14,971	23.4	6%
Total	264,124	412.7	100%

2.3.4 Land Use

Land use within the TPA is dominated by forest and agriculture. Agriculture in the lowlands is primarily related to the cattle industry: irrigated hay and dry grazing. Information on land use is based on land use and land cover (LULC) mapping completed by the USGS in the 1980s. The data are at 1:250,000 scale, and are based upon manual interpretation of aerial photographs. Agricultural land use is illustrated on **Figure A-15**.

Table 2-3. Land Use and Cover in the Little Blackfoot watershed.

Land Use	Acres	Square Miles	% of Total
Evergreen Forest	132,807.2	207.5113	50.28%
Grasslands/Herbaceous	81,847.6	127.8869	30.99%
Shrubland	31,068.0	48.54367	11.76%
Pasture/Hay	11,998.0	18.74694	4.54%

Table 2-3. Land Use and Cover in the Little Blackfoot watershed.

Land Use	Acres	Square Miles	% of Total
Transitional	2,204.7	3.444848	0.83%
Woody Wetlands	1,749.4	2.733444	0.66%
Deciduous Forest	1,162.7	1.816717	0.44%
Emergent Herbaceous Wetlands	710.1	1.109537	0.27%
Open Water	204.6	0.319679	0.08%
Commercial/Industrial/Transportation	187.6	0.293113	0.07%
Small Grains	80.5	0.125792	0.03%
Bare Rock/Sand/Clay	37.2	0.058103	0.014%
Row Crops	21.6	0.033707	0.008%
Mixed Forest	12.5	0.01946	0.005%
Urban/Recreational Grasses	11.4	0.01788	0.004%
Low Intensity Residential	7.5	0.011676	0.003%
Perennial Ice/Snow	4.1	0.006466	0.002%
High Intensity Residential	2.4	0.003822	0.001%

Berkas et al.(2005) reported that roughly 11,000 acres upstream of the Garrison gage are irrigated with surface water diversions. Additional information on agricultural land use can be obtained from Department of Revenue data. The Department of Revenue assigns a predominant agricultural use only if more than 50% of a given parcel is so used. A total of 5,502 acres of irrigated land is reported in the TPA. The dominant designated agricultural use is grazing, corresponding to 95,140 acres (441 square miles), or 36%, of the TPA area (Montana Department of Natural Resources and Conservation, 2008).

2.3.5 Mining

Milling was widely performed within the TPA and waste rock and tailings are still present in many locations. Like many Montana mining districts, much of the metal production began in the 1860s with gold-bearing placers. Later, lode deposits of lead, zinc, gold, silver, and copper came to be of importance. Much of the mining was concentrated in the Elliston district, which is near the Little Blackfoot headwaters. MBMG completed an environmental survey of 468 abandoned mining sites in the Helena National Forest in the 1990s (Hargrave, et al., 1998); because the study was for the entire forest, it also included mines outside of the Little Blackfoot TPA. Twenty sites in the TPA were determined to have potential to adversely affect soil or water on USFS land. Based on public health risks, DEQ has identified 15 priority abandoned mines within the watershed. Priority and non-priority abandoned mine locations as recorded by DEQ and MBMG are plotted on **Figure A-16**. No active mines are present as of September 2011, according to DEQ Environmental Management Bureau files.

2.3.6 Point Sources

There are four point sources permitted under the Montana Pollution Discharge Elimination System (MPDES) within the TPA that will be addressed within this document (**Figure A-16**). None of the permits are for point sources that continuously discharge; three are under the general permit for construction stormwater (MTR100000) and one is under the general permit for suction dredging (MTG370000), which is a portable and seasonal operation.

2.3.7 Wastewater

The towns of Elliston and Avon are not sewered, and wastewater treatment within the TPA is provided by on-site septic tanks and drainfields. Septic system density is estimated from the 2000 census block data, based on the assumption of one septic tank and drainfield for each 2.5 persons (Montana Department of Natural Resources and Conservation, 2008). Septic system density is classified as low (<50 per square mile), moderate (51-300 per square mile) or high (>300 per square mile). Nearly all of the TPA is mapped as low septic system density, with very limited areas of moderate (245 acres) and high (67.5 acres) density. The high and moderate density locations are found primarily around Elliston and Avon (**Figure A-16**).

3.0 MONTANA WATER QUALITY STANDARDS

The federal Clean Water Act provides for the restoration and maintenance of the chemical, physical, and biological integrity of the nation's surface waters so that they support all designated uses. Water quality standards are used to determine impairment, establish water quality targets, and to formulate the TMDLs and allocations.

Montana's water quality standards include four main parts:

1. Stream classifications and designated uses
2. Numeric and narrative water quality criteria designed to protect designated uses
3. Nondegradation provisions for existing high-quality waters
4. Prohibitions of practices that degrade water quality

Those components that apply to this document are reviewed briefly below. More detailed descriptions of Montana's water quality standards that apply to the Little Blackfoot TPA streams can be found **Appendix B**.

3.1 LITTLE BLACKFOOT TPA STREAM CLASSIFICATIONS AND DESIGNATED BENEFICIAL USES

Waterbodies are classified based on their designated uses. All Montana waters are classified for multiple uses. All streams and lakes within the Little Blackfoot River watershed are classified as B-1, which specifies that the water must be maintained suitable to support all of the following uses:

- drinking, culinary, and food processing purposes after conventional treatment
- bathing, swimming, and recreation
- growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers
- agricultural and industrial water supply

While some of the waterbodies might not actually be used for a designated use (e.g., drinking water supply), their water quality still must be maintained suitable for that designated use. More detailed descriptions of Montana's surface water classifications and designated uses are provided in **Appendix B**.

Ten waterbody segments in the Little Blackfoot TPA are listed in the "2010 Water Quality Integrated Report" as not supporting or partially supporting one or more designated uses (**Table 3-1**). Waterbodies that are "not supporting" or "partially supporting" a designated use are impaired and require a TMDL. TMDLs are written to protect all designated uses for a waterbody and not just those identified as being non or partially supported. DEQ describes impairment as either partially supporting or not supporting, based on assessment results. Not supporting is applied to not meeting a drinking water standard, and is also applied to conditions where the assessment results indicate a severe level of impairment of aquatic life or coldwater fishery. A non-supporting level of impairment does not equate to complete elimination of the use. Detailed information about Montana's use support categories can be found in DEQ's water quality assessment methods(Montana Department of Environmental Quality, 2011).

Table 3-1. Impaired Waterbodies and their Designated Use Support Status on the "2010 Water Quality Integrated Report" in the Little Blackfoot TPA

Waterbody & Location Description	Waterbody ID	Use Class	Aquatic Life	Cold Water Fishery	Agriculture	Industry	Drinking Water	Primary Contact Recreation
DOG CREEK, headwaters to Meadow Creek	MT76G004_071	B-1	N	N	F	F	F	P
DOG CREEK, Meadow Creek to mouth (Little Blackfoot River)	MT76G004_072	B-1	P	P	F	F	F	F
LITTLE BLACKFOOT RIVER, Dog Creek to mouth (Clark Fork River)	MT76G004_010	B-1	P	P	F	F	P	P
LITTLE BLACKFOOT RIVER, the headwaters to Dog Creek	MT76G004_020	B-1	P	P	F	F	F	F
MONARCH CREEK, headwaters to mouth (Ontario Creek)	MT76G004_060	B-1	P	P	F	F	F	P
SNOWSHOE CREEK, headwaters to mouth (Little Blackfoot River)	MT76G004_080	B-1	P	P	F	F	F	P
SPOTTED DOG CREEK, forest boundary to mouth (Little Blackfoot River)	MT76G004_032	B-1	P	P	F	F	F	F
TELEGRAPH CREEK, Hahn Creek to mouth (Little Blackfoot River)	MT76G004_052	B-1	F	F	F	F	N	F
TELEGRAPH CREEK, headwaters to Hahn Creek	MT76G004_051	B-1	N	N	F	F	N	F
Un-Named Creek, headwaters to mouth (Ontario Creek), T8N R6W S27	MT76G006_010	B-1	N	N	P	F	N	P

F = Fully Supporting, P = Partially Supporting, N= Not Supporting, T = Threatened, X = Not Assessed

3.2 LITTLE BLACKFOOT TPA WATER QUALITY STANDARDS

In addition to the use classifications described above, Montana's water quality standards include numeric and narrative criteria that protect the designated uses. Numeric criteria define the allowable concentrations of specific pollutants so as not to impair designated uses. Narrative criteria are more "free form" descriptions, or statements, of unacceptable conditions. **Appendix B** defines both the numeric and narrative water quality criteria for the Little Blackfoot River watershed. For sediment and nutrient TMDL development in the Little Blackfoot TPA, only the narrative standards are applicable.

Numeric standards apply to pollutants that are known to have adverse effects on human health or aquatic life (e.g., metals, organic chemicals, and other toxic constituents). Human health standards are set at levels that protect against long-term (lifelong) exposure, as well as short-term exposure through direct contact such as swimming. Numeric standards for aquatic life include chronic and acute values. Chronic aquatic life standards prevent long-term, low level exposure to pollutants. Acute aquatic life standards protect from short-term exposure to pollutants. Chronic standards are usually more stringent than acute standards.

Narrative standards are developed when there is insufficient information to develop specific numeric standards. Narrative standards describe either the allowable condition or an allowable increase of a pollutant above "naturally occurring" conditions. DEQ uses the naturally occurring condition, called a "reference condition," to determine whether or not narrative standards are being met (see **Appendix B**).

Reference defines the condition a waterbody could attain if all reasonable land, soil, and water conservation practices were put in place. Reasonable land, soil, and water conservation practices usually include, but are not limited to, best management practices (BMPs).

4.0 DEFINING TMDLS AND THEIR COMPONENTS

A Total Maximum Daily Load (TMDL) is a tool for implementing water quality standards and is based on the relationship between pollutant sources and water quality conditions. More specifically, a TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive from all sources and still meet water quality standards.

Pollutant sources are generally defined as two categories: point sources and nonpoint sources. Point sources are discernible, confined and discrete conveyances, such as pipes, ditches, wells, containers, or concentrated animal feeding operations, from which pollutants are being, or may be, discharged. Some sources such as return flows from irrigated agriculture are not included in this definition. All other pollutant loading sources are considered nonpoint sources. Nonpoint sources are diffuse and are typically associated with runoff, streambank erosion, most agricultural activities, atmospheric deposition, and groundwater seepage. Natural background loading is a type of nonpoint source.

As part of TMDL development, the allowable load is divided among all significant contributing point and nonpoint sources. For point sources, the allocated loads are called “wasteload allocations” (WLAs). For nonpoint sources, the allocated loads are called “load allocations” (LAs).

A TMDL is expressed by the equation: $TMDL = \Sigma WLA + \Sigma LA$, where:

ΣWLA is the sum of the wasteload allocation(s) (point sources)
ΣLA is the sum of the load allocation(s) (nonpoint sources)

TMDL development must include a margin of safety (MOS), which can be explicitly incorporated into the above equation. Alternatively, the MOS can be implicit in the TMDL. A TMDL must also ensure that the waterbody will be able to meet and maintain water quality standards for all applicable seasonal variations (e.g., pollutant loading or use protection).

Development of each TMDL has four major components:

- Determining water quality targets
- Quantifying pollutant sources
- Establishing the total allowable pollutant load
- Allocating the total allowable pollutant load to their sources

Although the way a TMDL is expressed can vary by pollutant, these four components are common to all TMDLs, regardless of pollutant. Each component is described in further detail in the following subsections.

Figure 4-1 illustrates how numerous sources contribute to the existing load and how the TMDL is defined. The existing load can be compared to the allowable load to determine the amount of pollutant reduction needed.

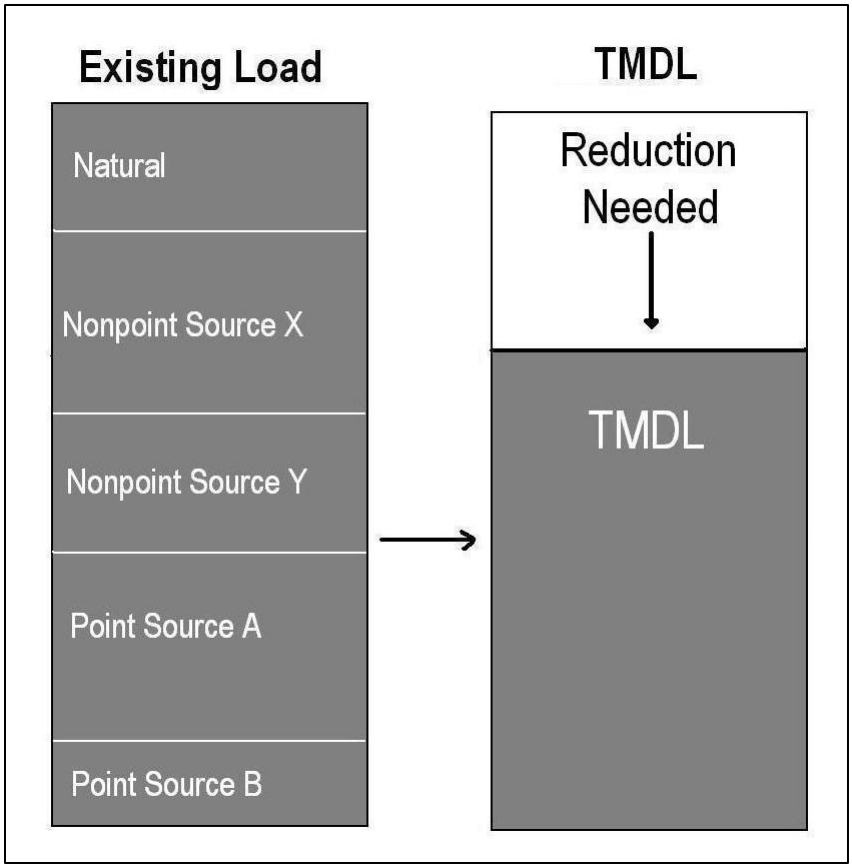


Figure 4-1. Schematic Example of TMDL Development

4.1 Developing Water Quality Targets

TMDL water quality targets are a translation of the applicable numeric or narrative water quality standard(s) for each pollutant. For pollutants with established numeric water quality standards, the numeric value(s) are used as the TMDL targets. For pollutants with narrative water quality standard(s), the targets provide a waterbody-specific interpretation of the narrative standard(s).

Water quality targets are typically developed for multiple parameters that link directly to the impaired beneficial use(s) and applicable water quality standard(s). Therefore, the targets provide a benchmark by which to evaluate attainment of water quality standards. Furthermore, comparing existing stream conditions to target values allows for a better understanding of the extent and severity of the problem.

4.2 Quantifying Pollutant Sources

All significant pollutant sources, including natural background loading, are quantified so that the relative pollutant contributions can be determined. Because the effects of pollutants on water quality can vary throughout the year, assessing pollutant sources must include an evaluation of the seasonal variability of the pollutant loading. The source assessment helps to define the extent of the problem by linking the pollutant load to specific sources in the watershed.

A pollutant load is usually quantified for each point source permitted under the Montana Pollutant Discharge Elimination System (MPDES) program. Nonpoint sources are quantified by source categories

(e.g., unpaved roads) and/or by land uses (e.g., crop production or forestry). These source categories and land uses can be divided further by ownership, such as federal, state, or private. Alternatively, most, or all, pollutant sources in a sub-watershed or source area can be combined for quantification purposes.

Because all potentially significant sources of the water quality problems must be evaluated, source assessments are conducted on a watershed scale. The source quantification approach may produce reasonably accurate estimates or gross allotments, depending on the data available and the techniques used for predicting the loading (40 CFR Section 130.2(I)). Montana TMDL development often includes a combination of approaches, depending on the level of desired certainty for setting allocations and guiding implementation activities.

4.3 Establishing the Total Allowable Load

Identifying the TMDL requires a determination of the total allowable load over the appropriate time period necessary to comply with the applicable water quality standard(s). Although "TMDL" implies "daily load," determining a daily loading may not be consistent with the applicable water quality standard(s), or may not be practical from a water quality management perspective. Therefore, the TMDL will ultimately be defined as the total allowable loading during a time period that is appropriate for applying the water quality standard(s) and which is consistent with established approaches to properly characterize, quantify, and manage pollutant sources in a given watershed. For example, sediment TMDLs may be expressed as an allowable annual load.

If a stream is impaired by a pollutant for which numeric water quality criteria exist, the TMDL, or allowable load, is typically calculated as a function of streamflow and the numeric criteria. This same approach can be applied when a numeric target is developed to interpret a narrative standard.

Some narrative standards, such as those for sediment, often have a suite of targets. In many of these situations it is difficult to link the desired target values to highly variable, and often episodic, instream loading conditions. In such cases the TMDL is often expressed as a percent reduction in total loading based on source quantification results and an evaluation of load reduction potential (**Figure 4-1**). The degree by which existing conditions exceed desired target values can also be used to justify a percent reduction value for a TMDL.

Even if the TMDL is preferably expressed using a time period other than daily, an allowable daily loading rate will also be calculated to meet specific requirements of the federal Clean Water Act. Where this occurs, TMDL implementation and the development of allocations will still be based on the preferred time period, as noted above.

4.4 Determining Pollutant Allocations

Once the allowable load (the TMDL) is determined, that total must be divided among the contributing sources. In addition to basic technical and environmental analysis, DEQ also considers economic and social costs and benefits when developing allocations. The allocations are often determined by quantifying feasible and achievable load reductions through application of a variety of best management practices and other reasonable conservation practices.

Under the current regulatory framework (40 CFR 130.2) for developing TMDLs, flexibility is allowed in allocations in that "TMDLs can be expressed in terms of either mass per time, toxicity, or other

appropriate measure." Allocations are typically expressed as a number, a percent reduction (from the current load), or as a surrogate measure (e.g., a percent increase in canopy density for temperature TMDLs).

Figure 4-2 illustrates how TMDLs are allocated to different sources using WLAs for point sources and LAs for natural and nonpoint sources. Although some flexibility in allocations is possible, the sum of all allocations must meet the water quality standards in all segments of the waterbody.

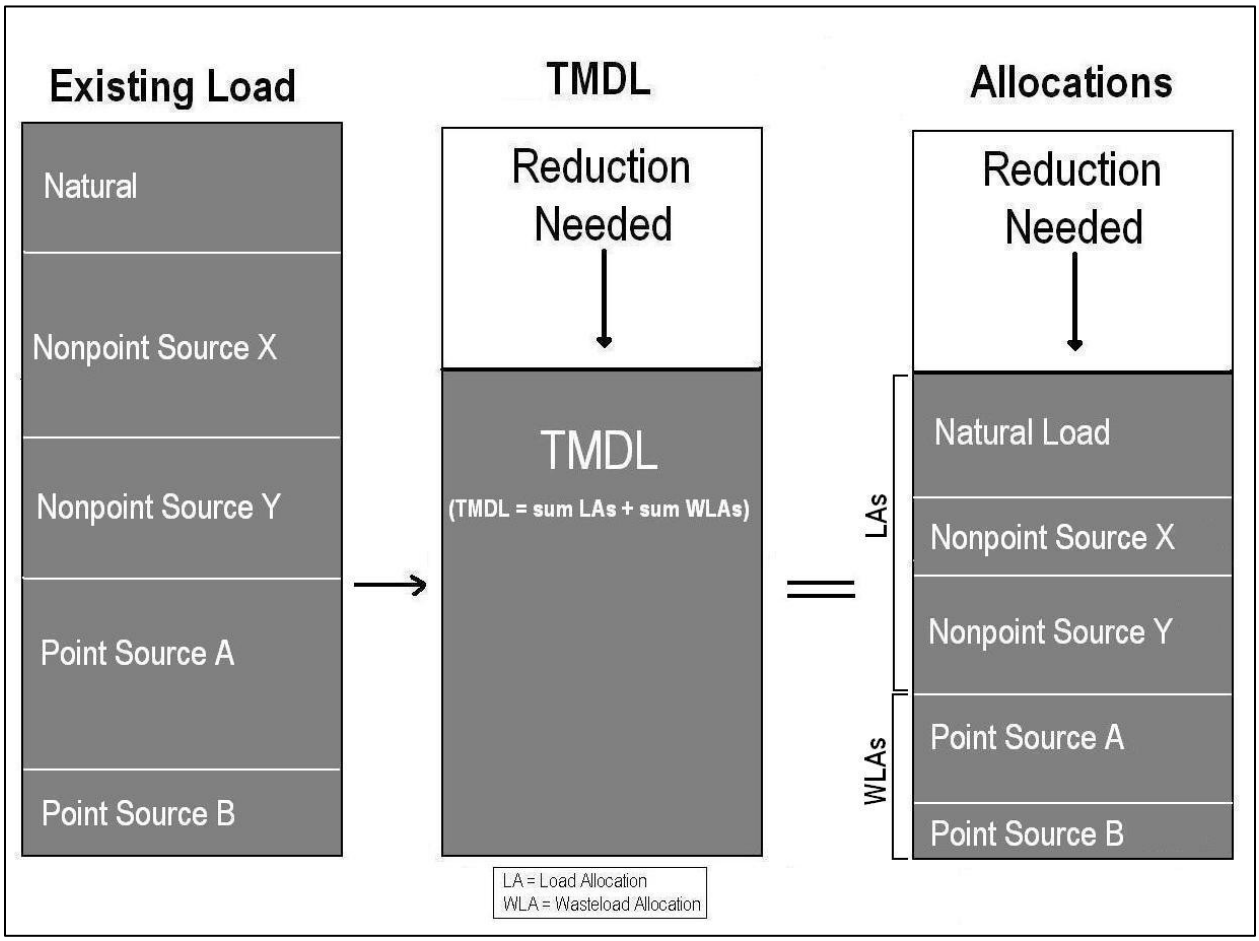


Figure 4-2. Schematic Diagram of a TMDL and its Allocations

Incorporating an MOS is required when developing TMDLs. The MOS accounts for the uncertainty between pollutant loading and water quality and is intended to ensure that load reductions and allocations are sufficient to support beneficial uses. The MOS may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading (U.S. Environmental Protection Agency, 1999b).

5.0 SEDIMENT TMDL COMPONENTS

This portion of the document focuses on sediment as a cause of water quality impairment in the Little Blackfoot TPA. It describes: 1) the mechanisms by which sediment can impair beneficial uses, 2) the specific stream segments of concern, 3) the presently available data pertaining to sediment impairment characterization in the watershed, including target development and a comparison of existing water quality to targets, 4) quantification of the various contributing sources of sediment based on recent studies, and 5) identification of and justification for the sediment TMDLs and the TMDL allocations.

5.1 MECHANISM OF EFFECTS OF EXCESS SEDIMENT ON BENEFICIAL USES

Sediment is a naturally occurring component of healthy and stable stream and lake ecosystems. Regular flooding allows sediment deposition to build floodplain soils and point bars, and it prevents excess scour of the stream channel. Riparian vegetation and natural instream barriers such as large woody debris, beaver dams, or overhanging vegetation help trap sediment and build channel and floodplain features. When these barriers are absent or excessive sediment loading enters the system from increased bank erosion or other sources, it may alter channel form and function and affect fish and other aquatic life by increasing turbidity and causing excess sediment to accumulate in critical aquatic habitat areas not naturally characterized by high levels of fine sediment.

More specifically, sediment may block light and cause a decline in primary production, and it may also interfere with fish and macroinvertebrate survival and reproduction. Fine sediment deposition reduces availability of suitable spawning habitat for salmonid fishes and can smother eggs or hatchlings. Effects from excess sediment are not limited to suspended or fine sediment; an accumulation of larger sediment (e.g. cobbles) can fill pools, reduce the percentage of desirable particle sizes for fish spawning, and cause channel overwidening (which may lead to additional sediment loading and/or increased temperatures). This larger sediment can also reduce or eliminate flow in some stream reaches where sediment aggrades within the channel, causing flow to go subsurface (May and Lee, 2004). Although fish and aquatic life are typically the most sensitive beneficial uses regarding sediment, excess sediment may also affect other uses. For instance, high concentrations of suspended sediment in streams can also cause water to appear murky and discolored, negatively impacting recreational use, and excessive sediment can increase filtration costs for water treatment facilities that provide safe drinking water.

5.2 STREAM SEGMENTS OF CONCERN

A total of seven waterbody segments in the Little Blackfoot TPA appeared on the 2010 Montana 303(d) List due to sediment impairments (**Table 5-1**): Dog Creek (upper and lower segments), Little Blackfoot River (upper and lower segments), Snowshoe Creek, Spotted Dog Creek (lower segment), and Telegraph Creek (upper segment). All waterbody segments listed for sediment impairment are also listed for habitat alterations (i.e., alteration in stream-side or littoral vegetative covers), which is a non-pollutant listing commonly associated with sediment impairment. TMDLs are limited to pollutants, but implementation of land, soil, and water conservation practices to reduce pollutant loading will inherently address some non-pollutant impairments.

Table 5-1. Waterbody segments in the Little Blackfoot TPA with sediment listings on the 2010 303(d) List

Stream Segment	Waterbody ID	Sediment Pollutant Listing
DOG CREEK, headwaters to Meadow Creek	MT76G004_071	Sedimentation/Siltation
DOG CREEK, Meadow Creek to the mouth (Little Blackfoot River)	MT76G004_072	Sedimentation/Siltation
LITTLE BLACKFOOT RIVER, the headwaters to Dog Creek	MT76G004_020	Sedimentation/Siltation
LITTLE BLACKFOOT RIVER, Dog Creek to the mouth (Clark Fork River)	MT76G004_010	Sedimentation/Siltation
SNOWSHOE CREEK, headwaters to the mouth (Little Blackfoot River)	MT76G004_080	Sedimentation/Siltation
SPOTTED DOG CREEK, forest boundary to the mouth (Little Blackfoot River)	MT76G004_032	Sedimentation/Siltation
TELEGRAPH CREEK, headwaters to Hahn Creek	MT76G004_051	Sedimentation/Siltation

Three additional waterbody segments were also identified as streams of concern and were evaluated as part of the sediment TMDL development process. They include Elliston Creek (MT76G004_040) and the lower segment of Threemile Creek (MT76G004_112), which are listed for habitat alterations, a non-pollutant impairment commonly linked to sediment impairment. Lastly, Trout Creek (MT76G004_120), which is a tributary to the Little Blackfoot River, has never been formally assessed for beneficial use support but was also evaluated based on stakeholder concerns regarding fish and aquatic life beneficial use support.

5.3 Information Sources and Assessment Methods to Characterize Sediment Conditions

For TMDL development, information sources and assessment methods fall within two general categories. The first category, discussed within this section, is focused on characterizing overall stream health with focus on sediment and related water quality conditions. The second category, discussed within **Section 5.6**, is focused on quantifying sources of sediment loading within the watershed.

To characterize sediment conditions for TMDL development purposes, a sediment data compilation was completed and additional monitoring was performed during 2009. The below listed data sources represent the primary information used to characterize water quality and/or develop TMDL targets.

- DEQ Assessment Files
- DEQ 2009 Sediment and Habitat Assessments
- Montana Fish, Wildlife and Parks and Natural Resource Damage Program fish and riparian habitat assessments from 2007 and 2008 (Lindstrom, et al., 2008; Liermann, et al., 2009)
- Little Blackfoot River Physical Features Inventory and Riparian Assessment report
- PACFISH/INFISH Biological Opinion Effectiveness (PIBO) Monitoring Program reference and non-reference data
- USFS Regional Reference Data
- GIS data layers

5.3.1 DEQ Assessment Files

The DEQ assessment files contain information used to make the existing sediment impairment determinations. The files include a summary of physical, biological, and habitat data collected between 1998 and 2005 as well as other historical information collected or obtained by DEQ. The most common quantitative data that will be incorporated from the assessment files are pebble counts and macroinvertebrate index scores. The files also include information on sediment water quality characterization and potentially significant sources of sediment, as well as information on non-pollutant impairment determinations and associated rationale. Files are available electronically on DEQ's Clean Water Act Information Center website: http://cwaic.mt.gov/.

5.3.2 DEQ's 2009 Sediment and Habitat Assessments

Field measurements of channel morphology and riparian and instream habitat parameters were collected in 2009 from 19 reaches to aid in TMDL development (**Figure 5-1**). Reaches were dispersed among the 10 segments of concern listed in **Section 5.2** as well as the lower segment of Telegraph Creek (MT76G004_052), which is listed as fully supporting but was evaluated to broaden the range of conditions in the sample dataset and so newer sediment-related data can be incorporated into the assessment file. Initially, all streams of interest underwent an aerial assessment procedure by which reaches were characterized by four main attributes not linked to human activity: stream order, valley gradient, valley confinement, and ecoregion. These four attributes represent main factors influencing stream morphology, which in turn influences sediment transport and deposition. The next step in the aerial assessment involved identification of near-stream land uses since land management practices can have a significant influence on stream morphology and sediment characteristics. The resulting product was streams stratified into reaches that allow for comparisons among those reaches of the same natural morphological characteristics, while also indicating stream reaches where land management practices may further influence stream morphology. The stream stratification, along with field reconnaissance, provided the basis for selecting the above-referenced monitoring reaches. Although ownership is not part of the reach type category, because of the distribution of private and federal land within the watershed, most reach type categories contain predominantly either private or public lands.

Monitoring reaches were chosen with the goal of being representative of various reach characteristics, land use categories, and anthropogenic influence. There was a preference toward sampling those reaches where anthropogenic influences would most likely lead to impairment conditions since it is a primary goal of sediment TMDL development to further characterize sediment impairment conditions. Thus, it is not a random sampling design intended to sample stream reaches representing all potential impairment and non-impairment conditions. Instead, it is a targeted sampling design that aims to assess a representative subset of reach types while ensuring that reaches within each [sediment] 303(d) listed waterbody with potential impairment conditions are incorporated into the overall evaluation. Typically, the effects of excess sediment are most apparent in low gradient, unconfined streams larger than 1st order (i.e. having at least one tributary); therefore, this stream type was the focus of the field effort (**Table 5-2**). Although the TMDL development process necessitates this targeted sampling design, it is acknowledged that this approach results in less certainty regarding conditions in 1st order streams and higher gradient reaches, and that conditions within sampled reaches are not necessarily representative of conditions throughout the entire stream.

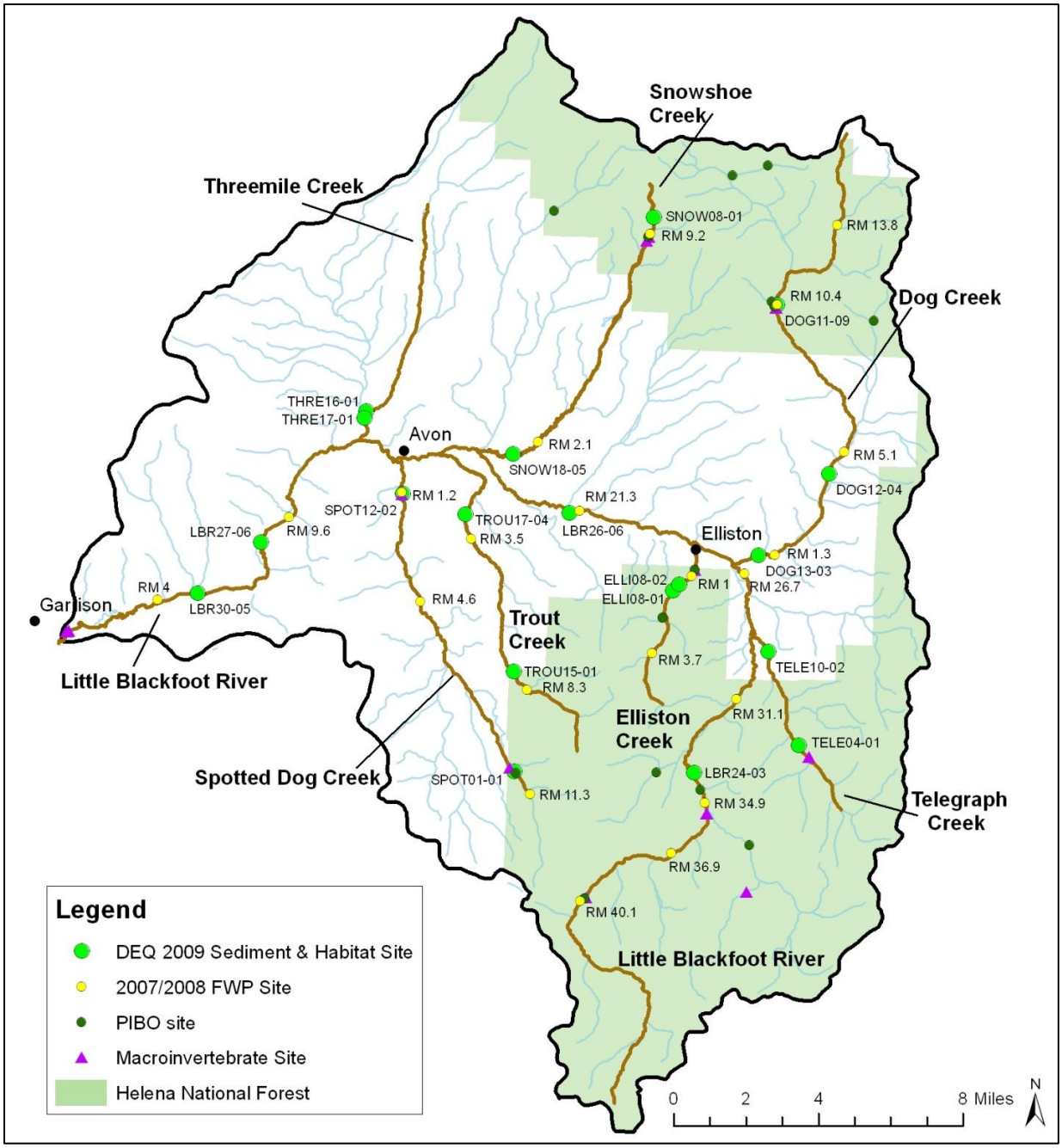


Figure 5-1. DEQ 2009 Sampling Sites and Other Sediment-Related Sampling Sites

The field parameters assessed in 2009 include standard measures of stream channel morphology, fine sediment, stream habitat, riparian vegetation, and streambank erosion. Although the sampling areas are frequently referred to as "sites" within this document, to help increase sample sizes and capture variability within assessed streams, they were actually sampling reaches ranging from 500 to 2000 feet (depending on the channel bankfull width) that were broken into five cells. Generally, channel morphology and fine sediment measures were performed in three of the cells, and stream habitat, riparian, and bank erosion measures were performed in all cells. Field parameters are briefly described in **Section 5.4**, and summaries of all field data and sampling protocols are contained in the 2009 Sediment and Habitat Assessment report (**Appendix C**).

Table 5-2. Stratified reach types and sampling site representativeness within the Little Blackfoot TPA.

Level III Ecoregion	Valley Gradient	Strahler Stream Order	Confinement*	Reach Type	Number of Reaches	Number of Monitoring Sites
Middle Rockies	0 - 2%	1	U	MR-0-1-U	1	
		2	C	MR-0-2-C	2	
			U	MR-0-2-U	28	2
		3	C	MR-0-3-C	4	
			U	MR-0-3-U	33	4
		4	U	MR-0-4-U	34	3
		5	U	MR-0-5-U	30	3
	2 - 4%	1	U	MR-2-1-U	5	
		2	C	MR-2-2-C	8	2
			U	MR-2-2-U	45	2
		3	C	MR-2-3-C	1	
			U	MR-2-3-U	11	1
	4 - 10%	1	C	MR-4-1-C	7	
			U	MR-4-1-U	21	1
		2	C	MR-4-2-C	9	
			U	MR-4-2-U	10	
		3	U	MR-4-3-U	5	1
	> 10%	1	C	MR-10-1-C	7	
			U	MR-10-1-U	14	
Totals:					**275**	**19**

*U = Unconfined, C = Confined per DEQs stratification methodology

5.3.3 Montana Fish, Wildlife and Parks/Natural Resource Damage Program: An Assessment of Fish Populations and Riparian Habitat in Tributaries of the Upper Clark Fork River Basin

In 2007 and 2008, FWP and NRDP assessed streams in the Upper Clark Fork River Basin to help prioritize stream and fishery restoration needs that are "1) focused in areas that will provide the most benefit to the target fisheries of Silver Bow Creek and the Upper Clark Fork River; and 2) focused on addressing factors that currently limit fish populations" (Lindstrom, et al., 2008). The need for prioritization was largely driven by a monetary settlement between the State of Montana and the Atlantic Richfield Company for natural resource damages caused by historic mining activities in the Upper Clark Fork River Basin.

"In addition to fishery data, riparian and fish habitat assessment data were collected. This data was collected to document current habitat conditions at locations where fish were sampled, as well as to highlight potential habitat deficiencies at these sites. This effort, however, was not aimed at identifying all potential impacts to riparian and fish habitat in the sample drainages, and was limited in its spatial and temporal scope" (Lindstrom, et al., 2008). FWP performed riparian assessments using a modified version of the Natural Resources Conservation Service Riparian Assessment Methodology. This information is based on qualitative analysis and best professional judgment of existing conditions. Results of the assessment are tallied and an overall score is determined of Sustainable (>80%), At Risk (50-80%), or Not Sustainable (<50%). These ratings serve as a benchmark for analysis of overall stream

condition and were not developed to provide direct interpretation of Montana state water quality standards. However, this information provides good qualitative supplemental information to the DEQ 2009 field effort, and allows for additional linkage to the analysis of aquatic life and fishery beneficial uses within this document. Within the Little Blackfoot TPA, the Little Blackfoot River and Dog, Elliston, Snowshoe, Spotted Dog, Telegraph, and Trout creeks are the relevant waterbodies that were evaluated (**Figure 5-1**).

5.3.4 Little Blackfoot River Physical Features Inventory and Riparian Assessment

Land and Water Consulting (now Atkins) performed a physical features inventory and riparian assessment along the Little Blackfoot River in 2001 under a contract with the Deer Lodge Valley Conservation District and the Little Blackfoot Watershed Group (Land & Water Consulting, 2002). The primary goals of the study were to document existing conditions and identify the most significant problems to help prioritize areas for implementation of habitat restoration projects. During this assessment, the Little Blackfoot River was divided into 16 contiguous reaches extending from the headwaters to the mouth. In August 2001, a detailed assessment was performed while walking reaches 7 through 16, which extend from the confluence of Dog Creek and the Little Blackfoot River downstream to its mouth at the Clark Fork River. The report contains detailed descriptions of conditions within each reach, data summaries, field and aerial photos, and a prioritization matrix. This document summarizes the reach descriptions and presents relevant data from the report. Pertinent data collected during this assessment include width/depth ratio, entrenchment ratio, Rosgen stream type, riffle pebble counts, pool frequency, large woody debris frequency, length of eroding streambank, and NRCS Riparian Assessments. In addition, sediment sources were identified along the mainstem of the Little Blackfoot River.

5.3.5 PIBO Data

The PACFISH/INFISH Biological Opinion Effectiveness (PIBO) monitoring program collects data from reference and managed (i.e., non-reference) stream sites on USFS and BLM land within the Columbia River basin. Reference sites are defined as having catchment road densities less than 0.5 km/km^2, riparian road densities less than 0.25 km/km^2, no grazing within 30 years, and no known in-channel mining upstream of the site. Within the Little Blackfoot TPA, data were collected in 2002 and 2007 at six non-reference sites on the Little Blackfoot River and Elliston, Snowshoe, and Spotted Dog creeks (**Figure 5-1**). There are 17 reference sites within the Helena National Forest, but because that is a small dataset for target development and ecoregion is a primary stratification category, all PIBO reference data from the Middle Rockies ecoregion were used for target development. This consists of all sites within the Helena National Forest as well as data from 56 other sites collected between 2001 and 2009. Data was collected following protocols described in *"Effectiveness Monitoring for Streams and Riparian Areas within the Pacific Northwest: Stream Channel Methods for Core Attributes" (USDA Forest Service, 2006).* Relevant data collected during these assessments include width/depth ratios, residual pool depths, pool frequency, large woody debris frequency, pebble counts, and the percentage of fine sediment in pool tails <6mm via grid toss.

5.3.6 USFS Regional Reference Data

Regional reference data are available from the Beaverhead Deerlodge National Forest (BDNF). BDNF data were collected between 1991 and 2002 from approximately two hundred reference sites: seventy of the sites are located in the Greater Yellowstone Area and the remaining sites are in the BDNF, which is also located in southwestern Montana (Bengeyfield, 2004). Applicable reference data are width/depth ratios, entrenchment ratios, and fine sediment <6mm from pebble counts.

5.4 WATER QUALITY TARGETS

The concept of water quality targets was presented in **Section 4.1**, but this section provides the rationale for each sediment-related target parameter and discusses the basis of the target values.

In developing targets, natural variation throughout the river continuum must be considered. As discussed in more detail in **Section 3.0** and **Appendix B**, DEQ uses the reference condition to gage natural variability and assess the effects of pollutants with narrative standards, such as sediment. The preferred approach to establishing the reference condition is utilizing reference site data, but modeling, professional judgment, and literature values may also be used. The DEQ defines "reference" as the condition of a waterbody capable of supporting its present and future beneficial uses when all reasonable land, soil, and water conservation practices have been applied. In other words, the reference condition reflects a waterbody's greatest potential for water quality given historic and current land use activities. Although sediment water quality targets typically relate most directly to the aquatic life use, the targets are protective of all designated beneficial uses because they are based on the reference approach, which strives for the highest achievable condition.

Waterbodies used to determine reference conditions are not necessarily pristine. The reference condition approach is intended to accommodate natural variations due to climate, bedrock, soils, hydrology and other natural physiochemical differences yet allow differentiation between natural conditions and widespread or significant alterations of biology, chemistry or hydrogeomorphology due to human activity.

The basis for each water quality target value varies depending on the availability of reference data and sampling method comparability to 2009 DEQ data. As discussed in **Appendix B**, there are several statistical approaches the DEQ uses for target development; they include using percentiles of reference data or of the entire sample dataset, if reference data are limited. For example, if low values are desired (like with fine sediment) and there is a high degree of confidence in the reference data, the 75th percentile of the reference dataset is typically used; if reference data are not available and the sample streams are predominantly degraded, the 25th percentile of the entire sample dataset is typically used. However, percentiles may be used differently depending on whether a high or low value is desirable, the representativeness and range of data variability, the severity of human disturbance to streams within the watershed, and size of the dataset. For each target, descriptive statistics were generated relative to any available reference data (e.g. BDNF or PIBO) as well as for the entire sample dataset. The preferred approach for setting target values is to use reference data, where preference is given towards the most protective reference dataset. Additionally, the target value for some parameters may apply to all streams in the Little Blackfoot watershed, whereas others may be stratified by bankfull width, reach type characteristics (i.e. ecoregion, gradient, stream order, and/or confinement), or by Rosgen stream type if those factors are determined to be important drivers for certain target parameters. Although the basis for target values may differ by parameter, the goal is to develop values that incorporate an implicit margin of safety (MOS) and are achievable. The MOS is discussed in additional detail in **Section 5.8.2**.

5.4.1 Water Quality Target Summary

The sediment water quality targets for the Little Blackfoot watershed are summarized in **Table 5-3** and described in detail in the sections that follow. Consistent with EPA guidance for sediment TMDLs (U.S. Environmental Protection Agency, 1999b), water quality targets for the Little Blackfoot watershed are comprised of a combination of measurements of instream siltation, channel form, biological health, and

habitat characteristics that contribute to loading, storage, and transport of sediment, or that demonstrate those effects. Water quality targets most closely linked to sediment accumulation or sediment-related effects to aquatic life habitat are given the most weight (i.e. fine sediment and biological indices).

Target parameters and values are based on the current best available information, but they will be assessed during future TMDL reviews for their applicability and may be modified if new information provides a better understanding of reference conditions or if assessment metrics or field protocols are modified. For all water quality targets, future surveys should document stable (if meeting criterion) or improving trends. The exceedance of one target value does not necessarily equate to a determination that the information supports impairment; the degree to which one or more targets are exceeded are taken into account (as well as the current 303(d) listing status), and the combination of target analysis, qualitative observations, and sound, scientific professional judgment is crucial when assessing stream condition. Site-specific conditions such as recent wildfires, natural conditions, and flow alterations within a watershed may warrant the selection of unique indicator values that differ slightly from those presented below, or special interpretation of the data relative to the sediment target values.

Table 5-3. Sediment Targets for the Little Blackfoot TPA

Parameter Type	Target Description	Criterion
Fine Sediment	Percentage of fine surface sediment in riffles via pebble count (reach average)	Comparable with reference values for the appropriate Rosgen stream type (**Tables 5-4** and **5-5**)
	Percentage of fine surface sediment < 6 mm in riffles and pool tails via grid toss (reach average)	≤ 9% for B/C streams ≤ 21% for E streams
Channel Form and Stability	Bankfull width/depth ratio (reach median)	B stream types with bankfull width < 30 ft: ≤ 16 C stream types with bankfull width < 30 ft: ≤ 23 C stream types with > 30 ft bankfull width: ≤ 35 E stream types: ≤ 8
	Entrenchment ratio (reach median)	B stream types: > 1.4
		C stream types: > 3.2
		E stream types: > 3.7
		C stream types with > 30 ft bankfull width : > 3.8
Instream Habitat	Residual pool depth (reach average)	< 15 ft bankfull width : ≥ 0.9 ft
		15 – 30 ft bankfull width : ≥ 1.4 ft
		> 30 ft bankfull width : ≥ 1.4 ft
	Pools/mile	< 15 ft bankfull width : ≥ 90
		15 – 30 ft bankfull width: ≥ 52
		> 30 ft bankfull width : ≥ 15
	LWD/mile	< 15 ft bankfull width : ≥ 222
		15 – 30 ft bankfull width : ≥ 186
		>30 ft bankfull width : ≥ 122
Riparian Health	Percent of streambank with understory shrub cover (reach average)	≥ 40% understory shrub cover (where potential exists) ≥ 10% understory shrub cover for conifer-dominated reaches

Table 5-3. Sediment Targets for the Little Blackfoot TPA

Parameter Type	Target Description	Criterion
Sediment Source	Significant and controllable sediment sources	Identification of significant and controllable anthropogenic sediment sources throughout the watershed
Biological Indices	Macroinvertebrate bioassessment impairment thresholds	Mountain MMI: ≥ 63 Low Valley MMI: ≥ 48
		O/E: ≥ 0.80

5.4.2 Fine Sediment

The percent of surface fines less than 6 mm and 2 mm is a measurement of the fine sediment on the surface of a streambed and is directly linked to the support of the cold water fish and aquatic life beneficial uses. Increasing concentrations of surficial fine sediment can negatively affect salmonid growth and survival, clog spawning redds, and smother fish eggs by limiting oxygen availability (Irving and Bjorn, 1984; Weaver and Fraley, 1991; Shepard, et al., 1984; Suttle, et al., 2004). Excess fine sediment can also decrease macroinvertebrate abundance and taxa richness (Mebane, 2001; Zweig and Rabeni, 2001). Because similar concentrations of sediment can cause different degrees of impairment to different species, and even age classes within a species, and because the particle size defined as "fine" is variable and some assessment methods measure surficial sediment while other measures also include subsurface fine sediment, literature values for harmful fine sediment thresholds are highly variable. Some studies of salmonid and macroinvertebrate survival found an inverse relationship between fine sediment and survival (Suttle, et al., 2004) whereas other studies have concluded the most harmful percentage falls within 10 to 40 % fine sediment (Bjorn and Reiser, 1991; Mebane, 2001; Relyea, et al., 2000). Bryce et al. (2010) evaluated the effect of surficial fine sediment (via reach transect pebble counts) on fish and macroinvertebrates and found that the minimum effect level for sediment < 2 mm is 13% for fish and 10% for macroinvertebrates. Literature values are taken into consideration during fine sediment target development, but because increasing concentrations of fine sediment are known to be harmful to aquatic life, targets are developed using a conservative statistical approach consistent with **Appendix B**, and consistent with Montana's water quality standard for sediment as described in **Section 3.2.1**.

5.4.2.1 Percent Fine Sediment < 6 mm and < 2 mm in Riffles via Pebble Count

Surface fine sediment measured in riffles by the modified Wolman (1954) pebble count indicates the particle size distribution across the channel width and is an indicator of aquatic habitat condition that can point to excessive sediment loading. Pebble counts in 2009 were performed in three riffles per sampling reach for a total of at least 300 particles. For DEQ data collected independently of the TMDL development process (i.e., prior to 2009) and the 2001 Physical Features Inventory (Land & Water Consulting, 2002), pebble counts at each reach were performed from bankfull to bankfull in a single representative riffle for a total of at least 100 particles.

<u>Less than 6 mm</u>

The BDNF reference dataset is broken out by Rosgen channel type and dominant particle size but the PIBO reference dataset is not. Because the dominant particle sizes in streams within the Little Blackfoot TPA range from cobble to sand, the fine sediment target for particles < 6 mm is based on BDNF reference data according to Rosgen channel type. The target for riffle substrate percent fine sediment < 6 mm is set at less than or equal to the median of the reference value based on the BDNF reference dataset (**bold** in **Table 5-4**). The median was chosen instead of the 75th percentile because pebble counts

in the BDNF reference dataset were performed using the "zigzag" method, which includes both riffles and pools, and likely results in a higher percentage of fines than a riffle pebble count, which was the method used for TMDL related data collection in the Little Blackfoot watershed. Because several assessed reaches are transitioning between a B or C and an E channel type, there is a separate category for those reaches (i.e., B/C/E4). The 2009 DEQ data are also summarized in **Table 5-4**, and in general, the 75th percentile of the sample dataset is comparable to the median of the reference dataset, indicating much of the sample dataset has low percent fines < 6 mm in riffles.

Table 5-4. 2009 DEQ Data Summary and BDNF Reference Dataset Median Percent Fine Sediment < 6 mm. Target values are indicated in bold.

Data Source	Parameter	All	B3/C3	B4/C4	B/C/E4	E3/E4	E4
BDNF	Sample Size (n)	129	26	27	59	75	63
	Median	20	**8**	**21**	**23**	**25**	**30**
Sample Data	Sample Size (n)	19	3	10	10	1	3
	Median	9	6	6	11	13	19
	75th	16	7	14	17	N/A	29

<u>Less than 2 mm</u>

For fine sediment < 2 mm, PIBO is the only reference data. Like the BDNF data, the PIBO pebble count data are also a composite of riffle and pool particles, and likely to be higher in fines than the DEQ riffle only pebble count. Also similarly to the BDNF reference dataset, the 75th percentile of the sample dataset compares favorably to the median of the PIBO reference dataset (**Table 5-5**). Therefore, because the sample dataset are broken out by channel type, the target is based on the 75th percentile of the sample dataset (**bold** in **Table 5-5**). Using this approach to target development acknowledges that fine sediment throughout assessed portions of the Little Blackfoot watershed are predominantly close to reference values, and that areas beyond the target value represent outlier conditions where excess fine sediment deposition may indicate a water quality problem. With the exception of E4 channels, which tend to have higher levels of fine sediment, all targets for < 2 mm are close to or less than the macroinvertebrate minimum effect level of 10% found by Bryce et al. (2010). Target values should be compared to the reach average value from pebble counts.

Table 5-5. 2009 DEQ Data Summary and PIBO Reference Dataset Percent Fine Sediment < 2 mm. Target values are indicated in bold.

Data Source	Parameter	All	B3/C3	B4/C4	B/C/E4	E3/E4	E4
PIBO	Sample Size (n)	64	Data not broken out by channel type				
	Median	11					
	75th	21					
Sample Data	Sample Size (n)	19	3	10	5	1	3
	Median	5	4	3	5	5	10
	75th	9	**5**	**7**	**10**	N/A*	**15**

*Because E3/E4 sample size is 1, use B/C/E4 target

5.4.2.2 Percent Fine Sediment < 6 mm in Riffle and Pool Tails via Grid Toss

Grid toss measurements in riffles and pool tails are an alternative measure to pebble counts that assess the level of fine sediment accumulation in macroinvertebrate habitat and potential fish spawning sites. A 49-point grid toss (Kramer, et al., 1993) was used to estimate the percent surface fine sediment < 6 mm in riffles and pool tails in the Little Blackfoot watershed, and three tosses, or 147 points, were performed and then averaged for each riffle and pool tail assessed.

Grid toss reference data are contained in the PIBO dataset but only for pool tails. The 75th percentile of the PIBO reference data for pool tails is 18% and the median is 9% (**Table 5-6**). In the 2009 Little Blackfoot sample dataset, pool tail grid toss values for the 75th percentile of the sample dataset for B and C channels was equal to the median of the PIBO dataset. Therefore, the PIBO reference median value and sample 75th percentile value of 9% is set as the pool grid toss target for B and C channels. The 75th percentile for E channels in the sample dataset is 21% and will be applied as the target for E channels.

Because there is no reference data to use as a basis for the riffle grid toss target and the 75th percentile of pool tail grid toss values in the sample dataset equaled the PIBO reference target value, the 75th percentile of the sample dataset was evaluated for the riffle grid toss target. The 75th percentile for B and C channels is 6% and for E channels is 33%. The B/C channel value seems reasonable but the E channel value does not seem protective of fisheries and aquatic life and is elevated due to much higher riffle fines in Elliston Creek than other E channel riffles. The E channel riffle median (22%) is similar to the E channel pool tail 75th percentile (21%). Therefore, to help simplify grid toss target values and because pool grid toss values seem achievable and protective of fisheries and aquatic life, the pool grid toss target values will also be applied as the riffle grid toss target (**bold** in **Table 5-6**). For each habitat area, the target should be assessed based on the reach average grid toss value.

Table 5-6. PIBO Reference and 2009 DEQ Data Percentiles for Percent Fine Sediment < 6 mm via Grid Toss in Pool Tails and Riffles. Riffle and pool tail target values are indicated in bold.

Data Source	Parameter	All	B/C	E
PIBO Pool Tail	Sample Size (n)	70	Data not broken out by channel type	
	Median	9		
	75th	18		
DEQ 2009 Sample Data Pool Tail	Sample Size (n)*	93	53	40
	Median	7	5	10
	75th	13	**9**	**21**
DEQ 2009 Sample Data Riffle	Sample Size (n)*	48	36	12
	Median	5	3	22
	75th	10	6	33

*Each grid toss was counted as a sample

5.4.3 Channel Form and Stability

5.4.3.1 Width/Depth Ratio and Entrenchment Ratio

The width/depth ratio and the entrenchment ratio are fundamental aspects of channel morphology and each provides a measure of channel stability, as well as an indication of the ability of a stream to transport and naturally sort sediment into a heterogeneous composition of fish habitat features (i.e. riffles, pools, and near bank zones). Changes in both the width/depth ratio and entrenchment ratio can be used as indicators of change in the relative balance between the sediment load and the transport capacity of the stream channel. As the width/depth ratio increases, streams become wider and shallower, suggesting an excess coarse sediment load (MacDonald, et al., 1991). As sediment accumulates, the depth of the stream channel decreases, which is compensated for by an increase in channel width as the stream attempts to regain a balance between sediment load and transport capacity. Conversely, a decrease in the entrenchment ratio signifies a loss of access to the floodplain. Low entrenchment ratios signify that stream energy is concentrated in-channel during flood events versus having energy dissipation on the floodplain. Accelerated bank erosion and an increased

sediment supply often accompany an increase in the width/depth ratio and/or a decrease in the entrenchment ratio (Rosgen, 1996; Knighton, 1998; Rowe, et al., 2003). Width/depth and entrenchment ratios were calculated for each 2009 assessment reach based on five riffle cross section measurements.

Width/Depth and Entrenchment Ratio Target Development

Although PIBO reference data exists for width/depth ratio, the target values for width/depth ratio and entrenchment ratio are based on the BDNF reference dataset because channel morphology tends to vary by Rosgen channel type. Width/depth ratios are measured the same way for the reference and sample dataset; the target for streams in the Little Blackfoot TPA is set at less than or equal to the 75th percentile of the reference value by Rosgen channel type (**Table 5-7**). The C channel target is too low for the Little Blackfoot River downstream of Ontario Creek, where it becomes a 4th order stream (and then a 5th order stream in the lower segment). Downstream of Ontario Creek, the Little Blackfoot width/depth ratio target is based on the 75th percentile of BDNF reference C channels with a bankfull width greater than 30 feet. The width/depth ratio target for the Little Blackfoot River downstream of Ontario Creek is less than or equal to 35.

For entrenchment ratio, because it is desirable to have a greater value, the target is based on the 25th percentile of the BDNF reference dataset (**Table 5-7**). When comparing assessment results to target values, more weight will be given to those values that fail to satisfy the identified target and fail to meet the minimum value associated with literature values for Rosgen stream type (i.e. B=1.4-2.2 ± 0.2, C & E>2.2 ± 0.2) (Rosgen, 1996) and reaches with multiple potential channel types will be evaluated using the lowest target value (e.g. Target for B3/C3 = 1.4). The target value applies to the median value for each sample reach.

Table 5-7. Width/depth and Entrenchment Ratio Targets Based on BDNF Reference Data.

Parameter	B	C	E	C channels bankfull width > 30 ft
Sample Size (n)	40	30	115	13
Width/Depth Ratio (75th percentile)	16	23	8	35
Entrenchment Ratio (25th percentile)	1.4	3.2	3.7	3.8

5.4.4 Instream Habitat Measures

For all instream habitat measures (i.e. residual pool depth, pool frequency, and large woody debris frequency), there is available reference data from PIBO. Because these parameters are largely influenced by stream size, target values will be expressed by bankfull width category. All of the instream habitat measures are important indicators of sediment input and movement as well as fish and aquatic life support, but they may be given less weight in the target evaluation if they do not seem to be directly related to sediment impacts. The use of instream habitat measures in evaluating or characterizing impairment needs to be considered from the perspective of whether these measures are linked to fine, coarse, or total sediment loading.

5.4.4.1 Residual Pool Depth

Residual pool depth, defined as the difference between the maximum depth and the tail crest depth, is a discharge-independent measure of pool depth and an indicator of pool habitat quality. Deep pools are important resting and hiding habitat for fish, and provide refugia during temperature extremes and high flow periods (Nielson, et al., 1994; Bonneau and Scarnecchia, 1998; Baigun, 2003). Similar to channel morphology measurements, residual pool depth integrates the effects of several stressors; pool depth can be decreased as a result of filling with excess sediment (fine or coarse), a reduction in channel

obstructions (such as large woody debris), and changes in channel form and stability (Bauer and Ralph, 1999). A reduction in pool depth from channel aggradation may not only alter surface flow during the critical low flow periods, but may also harm fish by altering habitat, food availability, and productivity (May and Lee, 2004; Sullivan and Watzin, 2010). Residual pool depth is typically greater in larger systems. During DEQ sampling in 2009, pools were defined as depressions in the streambed bounded by a "head crest" at the upstream end and "tail crest" at the downstream end with a maximum depth that was 1.5 times the pool-tail depth (Kershner, et al., 2004).

The definition of pools for the PIBO protocol is fairly similar to the definition used for the 2009 Little Blackfoot sample dataset; both use the same criterion to calculate the difference between the maximum depth and pool tail depth. However, the DEQ dataset could potentially have a greater pool frequency and more pools with a smaller residual pool depth because the DEQ protocol has no minimum pool size requirement whereas the PIBO protocol only counts pools greater than half the wetted channel.

In comparing the PIBO reference data to the sample data, the PIBO 25th percentile residual pool depth values are all less than the median from the sample dataset (**Table 5-8**), indicating the protocol differences likely did not result in smaller residual pool depths in the DEQ dataset, and that the median of the PIBO reference is a more appropriate target. The residual pool depth target is equal to or greater than the PIBO median value (**bold** in **Table 5-8**). Target comparisons should be based on the reach average residual pool depth value. Because residual pool depths can indicate if excess sediment is limiting pool habitat, this parameter will be particularly valuable for future trend analysis using the data collected in 2009 as a baseline. Future monitoring should document an improving trend (i.e. deeper pools) at sites which fail to meet the target criteria, while a stable trend should be documented at established monitoring sites that are currently meeting the target criteria.

Table 5-8. PIBO Reference and 2009 DEQ Sample Data Percentiles for Residual Pool Depth (ft). Targets are shown in bold.

Category	PIBO Reference			DEQ Sample Data		
	n	Median	25th	n	Median	75th
< 15 ft bankfull width	9	**0.9**	0.7	7	1.0	1.2
15 - 30 ft bankfull width	40	**1.4**	1.2	8	1.4	1.7
> 30 ft bankfull width	17	**1.4**	1.2	4	2.4	2.7

5.4.4.2 Pool Frequency

Pool frequency is another indicator of sediment loading that relates to changes in channel geometry and is an important component of a stream's ability to support the fishery beneficial use (Muhlfeld and Bennett, 2001). Sediment may limit pool habitat by filling in pools with fines. Alternatively, aggradation of larger particles may exceed the stream's capacity to scour pools, thereby reducing the prevalence of this critical habitat feature. Pool frequency generally decreases as stream size (i.e. watershed area) increases.

The PIBO 25th percentile pool frequency values compare favorably to the median and 75th percentile from the sample dataset, as well as to the USFS Inland Native Fish (aka. INFISH) Riparian Management Objectives (U.S. Department of Agriculture, Forest Service, 1995) (**Table 5-9**), indicating the protocol differences likely did not result in smaller residual pool depths in the DEQ dataset, and that the 25th percentile of PIBO values are an appropriate target. The pool frequency target is greater than or equal

to the 25th percentile of the PIBO dataset (**bold** in **Table 5-9**). Pools per mile should be calculated based the number of measured pools per reach and then scaled up to give a frequency per mile.

Table 5-9. PIBO Reference and 2009 DEQ Sample Data Percentiles for Pool Frequency (pools/mile) and INFISH Riparian Management Objective Values. Targets are shown in bold.

Category	PIBO Reference			DEQ Sample Data		
	N	Median	25th	n	Median	75th
< 15 ft bankfull width	9	108	**90**	7	111	121
15 - 30 ft bankfull width	40	62	**52**	8	45	65
> 30 ft bankfull width	17	17	**15**	4	20	24
INFISH Riparian Management Objectives	< 20 ft bankfull width: 96-56 25 ft bankfull width: 47			50 ft bankfull width: 26 100 ft bankfull width: 18		

5.4.4.3 Large Woody Debris

Large woody debris (LWD) is a critical component of stream ecosystems, providing habitat complexity, quality pool habitat, cover, and long-term nutrient inputs. LWD also constitutes a primary influence on stream function, including sediment and organic material transport, channel form, bar formation and stabilization, and flow dynamics (Bilby and Ward, 1989). LWD numbers generally are greater in smaller, low order streams, and then decrease as streams get larger and the composition of the riparian vegetation shifts. The application of a LWD target will carry very little weight for sediment impairment verification purposes, but may have significant implications as an indicator of a non-pollutant type of impairment.

For DEQ sampling in 2009, wood was counted as LWD if it was greater than 9 feet long or two-thirds of the wetted stream width, and 4 inches in diameter at the small end (Overton, et al., 1997). The LWD count for PIBO was compiled using a different definition of LWD; if measurements were conducted by DEQ and PIBO protocols within the same reach, the PIBO LWD count would likely be greater because it includes pieces 3 feet long and 4 inches in diameter. For streams with a bankfull width of less than 15 feet, the DEQ sample dataset 75th percentile was similar to the 25th percentile of the PIBO reference data, but for other channel widths, the sample dataset had much lower LWD counts than the PIBO dataset (**Table 5-9**). This difference for larger channel widths may partially be a result of different measurement protocols but is also likely a result of historic land conversion and riparian vegetation removal within the wider valley sections of streams. Given these considerations and the similarity of the reference 25th percentile to the sample dataset 75th percentile for streams with a bankfull width less than 15 feet, the PIBO 25th percentile is an appropriate target for streams with a bankfull width less than 30 feet (**bold** in **Table 5-10**). However, for streams greater than 30 feet, the PIBO value of 277 LWD/mile was determined to be an unfeasible target and the target value will be 122 LWD/mile based on the 75th percentile of the 2009 DEQ sample dataset.

Table 5-10. PIBO Reference and 2009 DEQ Sample Data Percentiles for Large Woody Debris Frequency (LWD/mile). Targets are shown in bold.

Category	PIBO Reference			DEQ Sample Data		
	n	Median	25th	n	Median	75th
< 15 ft bankfull width	9	315	**222**	7	53	246
15 - 30 ft bankfull width	40	319	**186**	8	24	85
> 30 ft bankfull width	17	438	277	4	75	**122**

5.4.5 Riparian Health

Interactions between the stream channel and the riparian vegetation along the streambanks are a vital component in the support of the beneficial uses of cold water fish and aquatic life. Riparian vegetation provides organic material used as food by aquatic organisms and supplies LWD that influences sediment storage and channel morphology. Riparian vegetation helps filter sediment from upland runoff, stabilize streambanks, and it can provide shading, cover, and habitat for fish. During DEQ assessments conducted in 2009, ground cover, understory shrub cover and overstory vegetation were cataloged at 10 to 20 foot intervals along the riparian zone (aka. greenline) at the bankfull channel margin along both sides of the stream channel for each monitoring reach. The percent of understory shrub cover is of particular interest in valley bottom streams historically dominated by willows and other riparian shrubs. While shrub cover is important for stream health, not all reaches have the potential for dense shrub cover and are instead well armored with rock or have the potential for a dense riparian community of a different composition, such as wetland vegetation or mature pine forest.

At the 2009 assessment sites, the understory shrub cover median value was 35% and the 75th percentile was 50%. The median of the sample dataset is a common target basis for understory shrub cover but a review of target values from other TMDLs within the Middle Rockies ecoregion indicate removal of riparian shrubs in the Little Blackfoot TPA has resulted in a median value that is too low for target setting; other target values range from 41-58% in the Upper Big Hole TPA and 49% in the Upper Jefferson TPA based on reference median values to 53% in the Bitterroot and 70% in the Upper Clark Fork tributaries and Flint TPAs based on sample data. Based on other target values, the 75th percentile may be a reasonable target, but field notes from the 2009 Little Blackfoot assessments indicate an Elliston Creek site (ELLI08-02) is meeting its potential because of riparian fencing; the median understory shrub cover at that site is 40%. Therefore, 40% will be applied as the target for understory shrub cover. This target value should be assessed based on the reach average greenline understory shrub cover value.

Because not all reaches have the potential for dense shrub cover, for any reaches that do not meet the target value, the greenline assessment results will be more closely examined to evaluate the potential for dense riparian shrub cover and identify if streambanks in the reach are stabilized instead by rocks, a mature pine forest, and/or wetland vegetation. For reaches that have less than 40% understory shrub cover because they are conifer-dominated, a target value of 10% is set based on the median value at a site on USFS land in upper Spotted Dog Creek (SPOT01-01) identified during the field assessment as having reference riparian conditions.

5.4.6 Human Sources

The presence of anthropogenic sediment sources does not always result in sediment impairment of a beneficial use. When there are no significant identified anthropogenic sources of sediment within the watershed of a 303(d) listed steam, no TMDL will be prepared since Montana's narrative criteria for sediment cannot be exceeded in the absence of human causes. There are no specific target values associated with sediment sources, but the overall extent of human sources will be used to supplement any characterization of impairment conditions. This includes evaluation of human induced and natural sediment sources, along with field observations and watershed scale source assessment information obtained using aerial imagery and GIS data layers. Because sediment transport through a system can take years or decades, and because channel form and stability can influence sediment transport and deposition, any evaluation of anthropogenic sediment impacts must consider both historical sediment loading as well as historical impacts to channel form and stability since the historical impacts still have

the potential to contribute toward sediment and/or habitat impairment. Source assessment analysis will be provided by 303(d) listed waterbody in **Section 5.6**, with additional information in **Appendices C, D**, and **E**.

5.4.7 Macroinvertebrates

Siltation exerts a direct influence on benthic macroinvertebrates assemblages by filling in spaces between gravel and by limiting attachment sites. Macroinvertebrate assemblages respond predictably to siltation with a shift in natural or expected taxa to a prevalence of sediment tolerant taxa over those that require clean gravel substrates. Macroinvertebrate bioassessment scores are an assessment of the macroinvertebrate assemblage at a site, and the DEQ uses two bioassessment methodologies to evaluate impairment condition and aquatic life beneficial use support. Aquatic insect assemblages may be altered as a result of different stressors such as nutrients, metals, flow, and temperature, and the biological index values must be considered along with other parameters that are more closely linked to sediment.

The two macroinvertebrate assessment tools are the Multi-Metric Index (MMI) and the Observed/Expected model (O/E). The rationale and methodology for both indices are presented in the DEQ Benthic Macroinvertebrate Standard Operating Procedure (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2006). Unless noted otherwise, macroinvertebrate samples discussed within this document were collected according to DEQ protocols. USFS data were collected according to the PIBO protocol, which is done with a kick net in two sections of the first four riffles/runs within a reach (Heitke, et al., 2010).

The MMI is organized based on different bioregions within Montana (i.e. Mountain, Low Valley, and Plains), and the Little Blackfoot River watershed falls within the Mountain and Low Valley MMI regions; in these regions, the macroinvertebrate community shift point that indicates impairment is an MMI score less than 63 and 48, respectively. These values are established as sediment targets in the Little Blackfoot TPA. The O/E model compares the taxa that are expected at a site under a variety of environmental conditions with the actual taxa that were found when the site was sampled and is expressed as a ratio of the Observed/Expected taxa (O/E value). The O/E community shift point that indicates impairment for all Montana streams is any O/E value <0.80. Therefore, an O/E score of ≥0.80 is established as a sediment target in the Little Blackfoot TPA.

Because the indices evaluate different aspects of the macroinvertebrate community, the MMI and O/E scores for a single site are evaluated independently. For both metrics, an index score greater than the threshold value is desirable, and the result of each sampling event is evaluated separately. Because index scores may be affected by other pollutants or forms of pollution such as habitat disturbance, they will be evaluated in consideration of more direct indicators of excess sediment. Additionally, because the macroinvertebrate sample frequency and spatial coverage is typically low for each watershed and because of the extent of research showing the harm of excess sediment to aquatic life, meeting both biological targets does not necessarily indicate a waterbody is fully supporting its aquatic life beneficial use. For these reasons, measures that indicate an imbalance in sediment supply and/or transport capacity will also be used for TMDL development determinations.

5.5 Existing Condition and Comparison to Water Quality Targets

This section includes a comparison of existing data to water quality targets along with a TMDL development determination for each stream segment of concern in the Little Blackfoot watershed

(**Section 5.2**). Most waterbodies reviewed within this section are listed for sediment impairment on the 2010 303(d) List, and although placement onto the 303(d) list indicates impaired water quality, a comparison of water quality targets to existing data helps define the level of impairment and establishes a benchmark to help evaluate the effectiveness of restoration efforts. For the three streams evaluated within this section not on the 2010 303(d) List, the data review is not a formal beneficial use assessment but provides information about the likelihood of impairment and justification for TMDL development (Note: a stream does not have to be on the 303(d) list to have a TMDL developed).

5.5.1 Dog Creek, upper segment (MT76G004_071)

The upper segment of Dog Creek (MT76G004_071) is listed for sedimentation/siltation on the 2010 303(d) List. In addition, this segment is also listed for alteration in stream-side or littoral vegetative covers, which is non-pollutant commonly linked to sediment impairment. Dog Creek is listed for sediment impairment based on sedimentation attributed to livestock trampling of banks, channelization from the road and railroad, and logging that included timber harvest up to the stream. Dredge dams and streamside tailings from historical mining in the drainage are also cited in the assessment file as potential sediment sources. The upper segment of Dog Creek flows 4.3 miles from the headwaters to its confluence with Meadow Creek.

Physical Condition and Sediment Sources

No data were collected in this segment by DEQ in 2009. During DEQ field assessments conducted in 1990 and 1998, field observations were similar; some sections of the stream and riparian habitat looked good but other sections were heavily trampled by livestock, accelerating bank erosion and increasing fine sediment in the channel. The largest grazing issues were observed within the Helena National Forest. Also, there were mine tailings within the channel in the vicinity of the Bald Butte Millsite, which is currently being remediated (see **Section 7.5.5**), but at the time had four instream impoundments that had been breached. In a pebble count conducted in 1998, the stream particles exhibited a bimodal distribution, with a large amount of silt/clay and very fine sand and a large amount of medium to coarse gravel. Beaver ponds were observed within the drainage and noted to be acting as sediment traps.

FWP evaluated a reach on USFS land (RM 13.8) within this segment in 2007 (**Figure 5-1**). Extensive beaver activity was present upstream and downstream of the reach in addition to throughout the reach itself. The reach was classified as a B channel and scored high in the geomorphology portion of the assessment. Pool habitat and riparian vegetation rated poorly, and cattle use in the riparian zone and hoof shear along the streambanks were observed. Evidence of historic logging within the riparian zone and placer mining were also noted. Fish habitat, riparian vegetation, and beaver activity were all more abundant upstream and downstream of the assessed reach, but mining and recreational activities were noted as common within the riparian area farther upstream from the site.

Summary and TMDL Development Determination

There are no macroinvertebrate samples and no recent DEQ data to compare to water quality targets but the 2007 assessment by FWP is consistent with DEQ assessments from the 1990s. Despite portions of the segment having beaver dams to retain sediment, healthy riparian vegetation, and fish habitat, bank erosion and channel sedimentation continue to be accelerated by grazing within the riparian area and legacy effects from historical logging and mining. Therefore, based on the listing status and remaining sediment sources, a sediment TMDL will be developed for upper Dog Creek.

5.5.2 Dog Creek, lower segment (MT76G004_072)

The lower segment of Dog Creek (MT76G004_072) is listed for sedimentation/siltation on the 2010 303(d) List. In addition, this segment is also listed for alteration in stream-side or littoral vegetative covers, which is non-pollutant commonly linked to sediment impairment. Lower Dog Creek is listed for sediment impairment based on overutilization of the riparian area by livestock, bank erosion associated with channelization from the railroad, and sediment inputs from the road. The lower segment of Dog Creek flows 12.4 miles from its confluence with Meadow Creek to the mouth at the Little Blackfoot River.

Physical Condition and Sediment Sources

In 2007, FWP performed assessments at three sites in lower Dog Creek (**Figure 5-1**). The uppermost site (RM 10.4) was on USFS land in an area that transitioned from abundant willows and beavers to a section with no beavers or woody vegetation. Bank erosion was observed on outside bends lacking woody vegetation and more extensive lateral and vertical erosion were observed upstream of the reach near the confluence with Hope Creek. Grazing in the reach was light during an August visit but much more noticeable during a visit in October. A small riparian exclosure was observed and noted to be part of a grazing allotment agreement. Fish habitat was marginal. The middle reach (RM 5.1) was a C channel with extensive beaver activity. Grazing pressure appeared to be managed appropriately as there was a healthy riparian community of mostly willows and sedges, and pools depth and fish habitat rated highly. At both this site and the lowermost site (RM 1.3), the railroad was encroaching on the channel and restricting the floodplain. The channel at the lowermost site was also confined by an access road. Within this reach, there was a good amount of mature cottonwoods, willows, and dogwoods, but limited recruitment of cottonwoods. Woody debris was limited within the channel, pools were shallow, and fine sediment accumulation was observed throughout the reach.

DEQ performed sediment and habitat assessments at three monitoring sites on lower Dog Creek in 2009 (**Figure 5-1**). The uppermost site (DOG11-09) was in a meandering section of stream with extensive beaver complexes observed upstream and downstream of the reach. The assessment length was reduced from five to two cells due to a property boundary in the middle of the reach. Portions of the reach had either slumping banks falling into the channel or the stream was eroding into the hillslope, but other parts of the reach had undercut banks stabilized by wetland vegetation and willows. Upstream of the assessed portion, one section of stream had riparian fencing to exclude grazing along the channel and was associated with dense riparian vegetation and stable banks, whereas another section that was being actively grazed had extensive bank erosion and some channel overwidening. The middle site (DOG12-04) was in a section of the creek confined by the railroad. Some dense wetland vegetation was observed, but generally the streambanks were tall and eroding along the side abutting the railroad that lacked riprap and actively retreating along the opposite bank from channelization and shifts in energy caused by the riprap. The lowermost site (DOG13-03) was in an irrigated field and was channelized with return flows seeping back into the stream from both banks. Bank erosion was attributed to areas where return flows had oversaturated the banks and also potentially to historic grazing practices.

Comparison to Water Quality Targets

The existing data in comparison to the targets for lower Dog Creek are summarized in **Table 5-11** and the macroinvertebrate bioassessment data are located in **Table 5-12**. All bolded cells are above target thresholds.

Table 5-11. Existing sediment-related data for lower Dog Creek relative to targets. Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Greenline % Shrub Cover
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	
DOG11-09	2009	15.0	E4	E3/4	13	5	3	ND	9.4	8.8	1.5	40	26	24
DOG12-04	2009	23.4	B4c/C4/E4/F4	C4	7	3	4	4	16.4	6.4	1.7	32	11	45
DOG13-03	2009	28.7	B4/F4b	C4	6	2	5	7	20.6	1.3	0.8	11	5	32

Table 5-12. Macroinvertebrate bioassessment data for lower Dog Creek. Values that do not meet the target threshold are in bold.

Station ID	Location	Collection Date	Collection Method	Site Type	MMI	O/E
C01DOGC01	1.1 miles d/s of Hope Creek	8/12/2004	EMAP - Reach	Mountain	**55.9**	**0.47**

Summary and TMDL Development Determination

All sites met the fine sediment targets. Given the amount of beaver activity observed at all reaches, this is likely a result of the beaver ponds acting as sediment traps. In areas where beaver activity was observed, pool habitat and woody debris counts were greater, and streambanks were stabilized by healthy riparian vegetation communities. However, effects from confinement by the railroad and roads, as well as current and historical grazing practices, are evident in the habitat measures. Reach DOG11-09 was overwidened and DOG13-03 was entrenched, and all DEQ reaches failed to meet targets for pools and LWD frequency. Additionally, the residual pool depth at DOG13-03 was much less than the other two reaches and failed to meet the target, and two of the reaches were below the target for riparian shrub cover. The macroinvertebrate sample, which was collected near FWP site RM 10.4, failed to meet both metrics. Although all fine sediment targets were met, extensive bank erosion was noted in this area, and impairment of the macroinvertebrate community is likely associated with excess sediment. Several portions of the segment appear to be recovering from historical land management practices, however, overgrazing, removal of riparian vegetation, and channelization are accelerating bank erosion and likely limiting support of fish and aquatic life. This information supports the 303(d) listing and a sediment TMDL will be developed for lower Dog Creek.

5.5.3 Elliston Creek (MT76G004_040)

Elliston Creek (MT76G004_040) is listed for alteration in stream-side or littoral vegetative covers on the 2010 303(d) List, which is a non-pollutant form of impairment commonly linked to sediment impairment. The habitat listing is based on channelization, riprap, and riparian habitat removal near Elliston. Based on a cursory source assessment review during project scoping, Elliston Creek was included in the 2009 DEQ data collection and will be evaluated relative to the sediment targets. Elliston Creek flows 5 miles from its headwaters to the mouth at the Little Blackfoot River.

Physical Condition and Sediment Sources

In 2008, FWP performed assessments at two sites on USFS land on Elliston Creek (**Figure 5-1**). The upper site (RM 3.7) was in an intermittent stretch near the headwaters within a grazing allotment and appeared to be part of a historical beaver pond complex. The channel was classified as a Bc, and some small eroding banks were observed on bends without deep-rooted vegetation but the channel appeared fairly stable. Evidence of grazing was observed, noxious weeds were common, and overhead cover for fish was low. There were some decent pools but naturally low flow was identified as a limiting factor for fish within this reach. Downstream of the reach, the channel was noted as highly unstable, predominantly dry, and containing several headcuts 3-4 feet high with extensive lateral erosion. The other site was closer to the mouth (RM 1.0) within a fenced livestock exclosure. The channel was slightly entrenched and classified as a B channel. There were some actively eroding banks lacking deep-rooted vegetation but it appeared to be recovering. Historical livestock access points were also still recovering but woody shrub density was rated as good and young plant recruitment was observed. Fish habitat was noted to be limited by a lack of deep pools and woody debris but overall got a good score because of the improving riparian habitat and abundance of spawning habitat.

DEQ performed sediment and habitat assessments at two monitoring sites on Elliston Creek in 2009 (**Figure 5-1**). The upper site (ELLI08-01) was a meandering section of the stream with pugging and hummocking along the valley bottom and channel margins resulting from grazing and evidence of historic timber harvest along the channel. Riparian vegetation was a mix of willows, grass, and wetland vegetation. Pool habitat was extensive but spawning potential was noted as being potentially limited by fines and embeddedness in the pool tails. Despite evidence of overgrazing in the riparian, the riparian grasses were dense and limiting bank erosion. The other site (ELLI08-02) was in a small valley bottom between fairly steep valley walls and had riparian fencing to limit grazing pressure along the stream. Spawning gravels were observed in pool tails and streambanks were densely vegetated with wetland grasses, willow, and alder. Bank erosion was limited to sharp bends where the channel was cutting into the hillslope and was attributed to natural sources. This reach was noted as achieving its potential. These observations are consistent with the mixed management practices observed during a 1998 DEQ assessment.

Comparison to Water Quality Targets

The existing data in comparison to the targets for Elliston Creek are summarized in **Table 5-13**. The macroinvertebrate bioassessment data for Elliston Creek is located in **Table 5-14**. All bolded cells are above target thresholds.

Table 5-13. Existing sediment-related data for Elliston Creek relative to targets. Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Greenline % Shrub Cover
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	
ELLI08-01	2009	7.9	E4	E4	38	20	35	17	9.2	5.2	0.8	169	370	21
ELLI08-02	2009	8.8	E4/C4/B4c	B/E4	23	9	33	8	11.9	4.9	0.8	116	201	38
231 (PIBO)	2002	8.1	--	--	--	--	--	--	8.6	--	0.8	114	0	--
	2007	9.0	--	--	28	27	--	28	9.7	--	0.7	117	156	--

Table 5-14. Macroinvertebrate Bioassessment Data for Elliston Creek.
Values that do not meet the target threshold are in bold.

Station ID	Location	Collection Date	Collection Method	Site Type	MMI	O/E
231 (PIBO)	0.8 miles upstream of mouth	2002	KICK - PIBO	Low Valley	**45.2**	**0.79**
		2007			**41.7**	**0.65**

Summary and TMDL Development Determination

There were several exceedances of fine sediment targets in riffles and one exceedance of the pool tail target. The macroinvertebrate sample, which was collected at the PIBO site with elevated fine sediment, failed to meet both metric targets in 2002 and in 2007. All sites were slightly below the residual pool depth target, which agrees with the FWP observation at the lower site regarding a lack of deep pools. One reach was slightly overwidened but with the exception of observations near FWP site RM 3.7, the channel morphology was fairly stable. The PIBO site and lowermost FWP site are closer to the town of Elliston and lacking LWD. Field notes indicate riparian shrub cover was meeting its potential at site ELLI08-02 but shrub cover at the upper DEQ site has been limited by overgrazing within the riparian zone. Collectively, the field measurements and observations indicate management changes are improving instream and riparian habitat in portions of the stream but the impairment of the riparian habitat caused by historical activities and current overgrazing remains and is linked to excess sediment loading to the stream that is likely limiting its ability to support fish and aquatic life. Therefore, a sediment TMDL will be prepared for Elliston Creek.

5.5.4 Little Blackfoot River, upper segment (MT76G004_020)

The upper segment of the Little Blackfoot River (MT76G004_020) is listed for sedimentation/siltation on the 2010 303(d) List. In addition, this segment is also listed for alteration in stream-side or littoral vegetative covers, which is a non-pollutant commonly linked to sediment impairment. The upper Little Blackfoot River is listed based on sedimentation attributed to channelization by the road and railroad, road erosion, channel modifications, historic mine disturbances and waste rock/tailings, logging, removal of riparian vegetation, and livestock grazing. The upper segment of the Little Blackfoot River flows 21.6 miles from its headwaters to its confluence with Dog Creek.

Physical Condition and Sediment Sources

As part of the Physical Features Inventory (Land & Water Consulting, 2002), the 5 mile section of the upper Little Blackfoot from the USFS boundary to Dog Creek was evaluated in 2001. Upstream of Telegraph Creek, stream banks, riparian health, and aquatic habitat were predominantly in good condition and there were no signs of excessive sedimentation in the channel. In this upper portion of the reach, there was evidence of historical riparian logging, beaver activity, and two large naturally eroding banks where the river was cutting into the hillslope. Channel morphology was stable within most of the upper reach but overutilization by livestock was noted within the vicinity of Telegraph Creek. Downstream of Telegraph Creek, streambank trampling and increasing effects from grazing within the riparian zone were observed; only about half of stream banks had deep-rooted vegetation, the frequency and severity of bank erosion increased, width/depth ratios increased, and fine sediment accumulation was observed in pools and on point bars.

In 2007 and 2008, FWP performed assessments on five sites in the upper segment of the Little Blackfoot River (**Figure 5-1**). The uppermost site (RM 40.1) transitioned from a B to a meandering C channel and had an optimal riparian zone with a coniferous overstory and willow/alder understory in some sections and wetland grasses in areas with fewer conifers. Fish habitat was rated as excellent as the reach contained deep pools, undercut banks, and frequent large woody debris. The next site (RM 36.9) was a B channel in a narrow, high-gradient canyon. The riparian zone was narrow but largely intact and noxious weeds were primarily associated with a road cut along part of the reach. The substrate was large boulders and fish habitat was mostly pocket pools but rated highly. Large woody debris was limited but recruitment potential was rated as high because of beetle-killed timber near the channel. The next site (RM 34.9) was a fairly high gradient B channel with a coniferous overstory and a sparse understory of alder and willow dominated by noxious weeds. Pool habitat was mostly pocket pools and large woody debris was low but identified as having high potential recruitment. Human disturbances to the reach included a rock check dam, confinement by recreational roads, and a frequently-used ford. The next site (RM 31.1) was in a narrow canyon near the mouth of Slate Creek. It was classified as a C channel with a high width-depth ratio with fish habitat limited by a lack of deep pools, and woody debris. The channel was slightly incised in sections and riparian buffer width was noted to be limited from the reduced access to the floodplain. Small rock check dams were noted to be potential barriers to upstream fish movement had been constructed in the channel near a campsite along the reach.

The lowermost site (RM 26.7) was just upstream of the Dog Creek confluence and classified as an overwidened C channel with some incisement and significant bank erosion. This site was the only one that overlapped with the reach evaluated as part of the 2001 Physical Features Inventory (Land & Water Consulting, 2002). Riparian vegetation was mostly willows but density was limited by noxious weeds and grasses associated with disturbance. Grazing pressure was light and young willow recruitment was noted as improving. Fine sediment deposition was noted in pools throughout the segment and fish habitat was rated as fair due to shallow pools, limited large woody debris, and cover. Although grazing management practices seem to have improved since the 2001 assessment, the prevalence of disturbance-induced grasses within the riparian zone, numerous eroding banks, and accumulation of fine sediment in pools indicates recovery is occurring very slowly and likely limited by remaining sediment sources.

DEQ performed one sediment and habitat assessment in the upper segment of the Little Blackfoot River in 2009 (**Figure 5-1**). The site (LBR24-03) was in a semi-confined valley section on USFS land. The area appeared to have been altered historically by placer mining or some other large scale disturbance. The reach was predominantly a riffle with large gravel bar deposits; few pools and no potential spawning

gravels were observed. The road and historical channel disturbances were noted as bank erosion sources but erosion was predominantly attributed to natural sources.

Comparison to Water Quality Targets

The existing data in comparison to the targets for upper Little Blackfoot River are summarized in **Table 5-15**. The macroinvertebrate bioassessment data for upper Little Blackfoot River is located in **Table 5-16.** All bolded cells are above target thresholds.

Table 5-15. Existing sediment-related data for upper Little Blackfoot River relative to targets. Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Greenline % Shrub Cover
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	
LBR24-03	2009	38.6	C3b	C3b	6	4	14	1	20.0	7.4	1.7	8	58	63
233 (PIBO)	2002	23.1	--	--	--	--	--	18	18.0	--	1.9	39	266	--
233 (PIBO)	2007	22.6	--	--	8	4	--	3	19.9	--	0.9	27	222	--
2799 (PIBO)	2009	45.6	--	--	11	15	--	6	34.6	--	2.4	25	115	--

Table 5-16. Macroinvertebrate bioassessment data for upper Little Blackfoot River. Values that do not meet the target threshold are in bold.

Station ID	Location	Collection Date	Collection Method	Site Type	MMI	O/E
C01LTBRLR02	Just upsteam of Ontario Cr confluence	08/09/2004	EMAP Reach	Low Valley	64.6	1.02
233 (PIBO)	7.5 miles downstream from the headwaters	2002	KICK - PIBO	Mountain	74.2	0.93
		2007	KICK - PIBO		75.8	**0.73**

Summary and TMDL Development Determination

All fine sediment targets were met except for the riffle grid toss at LBR24-03. None of the fine sediment data in **Table 5-15** were collected downstream of Telegraph Creek, however, which is where excess sedimentation was observed in pools in both 2001 and 2007. One of the six macroinvertebrate indices did not meet target values, but similarly to the fine sediment values, they were not collected in the areas most affected by excess sediment. All channel morphology targets were met, which also corresponds to observations from the 2001 assessment indicating channel dimensions are within the expected range until downstream of Telegraph Creek. One site failed to meet the target for residual pool depth, and the DEQ site failed to meet the targets for pool and large woody debris frequency. The PIBO and DEQ reach data correlate well with the observations from the 2001 Physical Features Inventory; controllable human sources were observed and there are some localized areas where habitat measures are not achieving potential or fine sediment is elevated, but overall there are minimal indicators of increased sediment loading from human sources upstream of Telegraph Creek. Although the recent FWP assessment indicates conditions downstream of Telegraph Creek have improved since 2001, high width/depth ratios, human caused bank erosion, and fine sediment accumulation in pools

continue to be problems. This information supports the 303(d) listing and a sediment TMDL will be developed for the upper segment of the Little Blackfoot River.

5.5.5 Little Blackfoot River, lower segment (MT76G004_010)

The lower segment of the Little Blackfoot River (MT76G004_010) is listed for sedimentation/siltation on the 2010 303(d) List. In addition, the lower segment of the Little Blackfoot River is also listed for alteration in stream-side or littoral vegetative covers, which is a non-pollutant commonly linked to sediment impairment. The lower Little Blackfoot River is listed based on sedimentation attributed to channelization by the road and railroad, channel modifications, haying near the channel, removal of riparian vegetation, and livestock grazing. The lower segment of the Little Blackfoot River flows 26.2 miles from its confluence with Dog Creek to its mouth at the Clark Fork River.

Physical Condition and Sediment Sources

As part of the Physical Features Inventory (Land & Water Consulting, 2002), the entire lower segment of the Little Blackfoot River was assessed in 2001. Within the vicinity of Elliston, streambanks, riparian vegetation, and fish habitat were rated highly (i.e., scored well). Between Elliston and North Trout Creek, overgrazing of riparian vegetation was apparent and the portions of the channel were incised and isolated from the floodplain. Historical channel movement and erosion, as well as periodic riprap, were observed along the railroad bed, but large woody debris was common and pools were fairly deep. Between North Trout Creek and Snowshoe Creek Road, there were some localized issues associated with riprap along the railroad but habitat and grazing management were highly rated. From Snowshoe Creek Road to Homestead Gulch (which is downstream of Threemile Creek), some portions of the channel had minimal sediment sources, but overall poor quality riparian vegetation, actively eroding banks, and limited pool habitat were commonplace. Additionally, much of the channel had been historically altered or straightened and contained riprap and gravel dikes; the railroad, Highway 12, the irrigation network, and management of private land were all cited as sources. Several small tributaries had silt deposits near their mouth, and near Spotted Dog Creek, there was evidence that downcutting of the river had caused a headcut and some incisement of the creek.

From Homestead Gulch to Beck Hill Road (~4.5 miles upstream of the mouth), the river ranged from near-optimal riparian and channel habitat conditions to severely degraded and channelized conditions. Riprap and actively eroding banks were fairly common, as was confinement of the channel by the railroad, highway, or both. The last several miles of the river had minimal riprap and the most extensive active bank erosion of any reach; this section was noted as being a substantial sediment source to the Clark Fork River, and sedimentation within the channel was common, particularly downstream of the most significant eroding streambanks. Within the entire assessed segment, streambank erosion worsened downstream of Avon and the section from there to Homestead Gulch had the highest frequency of streambank alterations. In a comparison of conditions in 2001 relative to 1979, the frequency of streambank alterations, gravel dikes, and eroding banks was much lower and signs of recovery were observed throughout the river corridor; riprap and irrigation diversions had increased slightly; no new channelization was noted; and despite some localized recovery and lengthening, the overall river length did not change.

In 2007, FWP performed assessments at three sites on the lower segment of the Little Blackfoot River (**Figure 5-1**). The upper site (RM 21.3) was upstream of North Trout Creek and was a C channel with active erosion on several meander bends and evidence of historical erosion. Riprap was common, particularly along the railroad. Woody plant density was inconsistent, cottonwood recruitment was

limited, and noxious weeds and grasses associated with disturbance were common in the riparian zone. A riparian exclosure was observed and cattle had entered it, however, riparian grazing pressure was still light in the area. There were numerous deep pools and large woody debris accumulations, but fish habitat was limited in several areas where cover was lacking and the channel was shallow and braided. The next site (RM 9.6) was a meandering C channel. The site had limited erosion where riparian vegetation was lacking but most bank erosion was associated with the riprap and the channel abutting Highway 12. The density of woody vegetation in the riparian zone was limited by noxious weeds and disturbance-induced grasses. Pool habitat was limited by constriction of the channel from the highway and railroad but was rated highly and noted to be at its "practical potential." The lowermost site (RM 4.0) was a C channel with significant bank erosion associated with banks lacking vegetation with deep roots. There was a substantial amount of riprap along the railroad within the reach and on meander bends along hay fields upstream of the reach. Similar to the other reaches, woody riparian vegetation was sparse and noxious weeds and shallow-rooted grasses were common. Livestock overwinter in the pasture adjacent to the reach but browse pressure and effects along the channel were minimal. There were several deep scour pools but the habitat potential was limited by a low amount of large woody debris.

DEQ performed three sediment and habitat assessments in the lower segment of the Little Blackfoot River in 2009 (**Figure 5-1**). Both the upper (LBR 26-06) and middle (LBR 27-06) sites were in meandering sections of river lined by cottonwoods and reed canary grass that were slightly encroached upon by the railroad, and both sites had deep pools and LWD aggregates. The upper site was near FWP site RM 21.3 and channelization from the railroad appeared to be altering channel migration by cutting off meander bends and contributing to the formation of transverse riffles. Some fine sediment accumulations were observed in slow water areas. The middle site was about one mile downstream of FWP site RM 9.6 and flowed through an area used for hay production; several large eroding banks were observed on meander bends that were also documented in the 2001 study. The lowest site (LBR 30-05) was 5 miles upstream from the mouth near the confluence with McDonald Creek in a channelized section that paralleled the railroad. The reach had some pocket pools but was predominantly riffle habitat. Riparian vegetation consisted of periodic shrubs, mature cottonwoods, and herbaceous groundcover. Most of the active streambank erosion was observed in the straight portion of the reach and was attributed to livestock access.

Comparison to Water Quality Targets

The existing data in comparison to the targets for the lower segment of the Little Blackfoot River are summarized in **Table 5-17**. The macroinvertebrate bioassessment data for the lower Little Blackfoot River is located in **Table 5-18.** All bolded cells are above target thresholds.

Table 5-17. Existing sediment-related data for lower Little Blackfoot River relative to targets. Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Greenline % Shrub Cover
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	
LBR26-06	2009	69.9	C3/C4	C4	4	2	4	5	36.5	4.9	2.5	26	211	52
LBR27-06	2009	83.9	C3/C4	C4	2	2	6	1	45.1	6.5	3.2	24	92	41
LBR30-05	2009	76.2	B3/B4c/C3	C4	3	1	2	ND	35.9	2.0	2.4	16	40	27

Table 5-18. Macroinvertebrate bioassessment data for lower Little Blackfoot River. Values that do not meet the target threshold are in bold.

Station ID	Location	Collection Date	Collection Method	Site Type	MMI	O/E
CFR10.2	USGS gage	08/17/2000	Hess	Low Valley	50.8	1.00
CFR10.2		08/04/2001			76.6	0.82
C01LTBLR01		08/21/2001	Unknown		60.9	1.00
		06/28/2002	Hess		59.1	1.00
		06/18/2003	Hess		57.2	1.14
		06/30/2004	Kick		56.7	1.29
		07/21/2005	Unknown		57.5	1.00

Summary and TMDL Development Determination

In general, recent data indicate conditions in the lower segment have vastly improved since the 1970s, and even since the 2001 assessment. All fine sediment, macroinvertebrate, residual pool depth, and pool frequency targets were met. These measurements combined with documented observations indicate that much of the river has limited accumulations of fine sediment, deep pool habitat, and adequate amounts of large woody debris. However, in 2001 and in recent FWP and DEQ assessments, large actively eroding banks and riparian vegetation lacking deep roots were noted throughout the segment, particularly downstream of Avon. Accelerated bank erosion was attributed to a combination of human sources including the highway and railroad, cropland, grazing, channelization and bank alterations, and removal of riparian vegetation.

Although excess fine sediment was not reflected in the measurements at the three DEQ sites, indications of the sediment supply exceeding the river's transport capacity were observed within the channel at numerous locations; accumulations were observed in slow water areas at the uppermost DEQ site (LBR26-06), areas of shallow water and channel braiding at the nearby FWP site RM 21.3 was noted to be limiting habitat, and sedimentation at tributary outlets and within the last several miles of the segment were observed during the 2001 assessment. The effects of extensive bank erosion are also apparent in the channel morphology; all three assessment sites were overwidened and exceeded the target for width/depth ratio. The uppermost site met the target for LWD, but the middle site failed to meet the LWD target, and the most downstream site failed to meet both the LWD and riparian shrub

targets. This downstream decrease in riparian shrub cover is consistent with observations from 2001. Although changes in management practices have resulted in improvement throughout the segment and meeting potential in some sections, based on significant controllable sediment sources and the listing status, a sediment TMDL will be developed for the lower segment of the Little Blackfoot River.

5.5.6 Snowshoe Creek (MT76G004_080)

Snowshoe Creek (MT76G004_080) is listed for sedimentation/siltation on the 2010 303(d) List. In addition, this segment is also listed for alteration in stream-side or littoral vegetative covers and low flow alterations, which are non-pollutants commonly linked to sediment impairment. Snowshoe Creek is listed based on sedimentation attributed to logging, road construction, mining, grazing, and hay production. Snowshoe Creek extends 10.7 miles from the headwaters its mouth at the Little Blackfoot River.

Physical Condition and Sediment Sources

In 2007, FWP performed assessments at two sites on Snowshoe Creek (**Figure 5-1**). The uppermost site (RM 9.2) was an E channel on USFS land in a canyon area upstream of Lois Lake with substantial historical mining activity. The site was noted as having altered channel morphology and a variable gradient because of mining, but the riparian vegetation has recovered well and consisted of dense wetland vegetation and willows. Two riparian exclosures were present at the site but had been compromised due to inadequate maintenance. Also, a water gap between the enclosures was not functioning as designed and was identified as a significant sediment source. The channel was deep and there were several high quality pools but there was a lack of large woody debris. The lower site (RM 2.1) was downstream of Lois Lake. The reach was an incised G channel that was establishing a new lower floodplain. There were some willows along the channel, but most meander bends without woody vegetation were eroding, and hay meadows and disturbance-induced grasses were dominant in the reach. Fish habitat was rated as good, but fine sediment accumulation was noted throughout the reach and the absence of willows was cited as a limiting factor. There was some beaver activity along the reach. There are two non-reference PIBO sites on Snowshoe Creek that are located within 0.1 miles downstream of FWP site RM 9.2 (**Figure 5-1**). The closer site (2261) was sampled in 2007 and the other site (230) was sampled in 2002 and 2007.

DEQ performed sediment and habitat assessments at two sites on Snowshoe Creek in 2009 (**Figure 5-1**). The upper site (SNOW08-01) was on USFS land upstream of all FWP and PIBO sites in a narrow valley section downstream of a section that was formerly impounded. A road parallels much of the stream, including this reach, and the hillslope on the opposite bank had been previously harvested. Pugging and hummocking was observed at the site from grazing but conifers and shrubs lined most of the channel and bank erosion was minimal. LWD created small pools and potential spawning gravels were observed. The lower site (SNOW18-05) was approximately 1.5 miles upstream of the mouth, and the stream was quite sinuous and flowed through a hayed meadow with a substantial buffer. The substrate was predominantly fine in this reach, and the stream had wetland vegetation along its margins and frequent pools and deep undercut on meander bends. Streambank erosion at SNOW18-05 was minimal and attributed to natural sources.

Comparison to Water Quality Targets

The existing data in comparison to the targets for the Snowshoe Creek are summarized in **Table 5-19**. The macroinvertebrate bioassessment data for the Snowshoe Creek is located in T**able 5-20**. All bolded cells are above target thresholds.

Table 5-19. Existing sediment-related data for Snowshoe Creek relative to targets. Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Greenline % Shrub Cover
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	
SNOW08-01	2009	6.2	E4b	E4b	9	5	10	16	5.6	3.6	0.6	79	290	54
SNOW18-05	2009	11.2	E4	E4	19	11	19	14	9.0	5.0	1.5	111	37	24
230 (PIBO)	2002	9.0	--	--	--	--	--	40	8.7	--	0.5	76	172	--
230 (PIBO)	2007	10.4	--	--	74	67	--	69	15.0	--	0.7	75	166	--
2261 (PIBO)	2007	17.7	--	--	--	--	--	--	20.8	--	0.8	64	--	--

Table 5-20. Macroinvertebrate bioassessment data for Snowshoe Creek. Values that do not meet the target threshold are in bold.

Station ID	Location	Collection Date	Collection Method	Site Type	MMI	O/E
C01SNOWC10	1.5 miles from headwaters	08/19/2004	Kick	Mountain	**50.3**	**0.60**
230 (PIBO)		2002	PIBO - Kick	Mountain	71.2	**0.53**
230 (PIBO)		2007	PIBO - Kick	Mountain	77.8	**0.53**

Summary and TMDL Development Determination

Fine sediment targets were met at the DEQ sites but PIBO 230 exceeded pebble count targets in 2007 and pool tail grid toss targets in 2002 and 2007. The PIBO site with elevated fines is just downstream of FWP site RM 9.2, where riparian exclosures were not functioning properly and a water gap was noted as a significant sediment source in 2007. The DEQ sites were meeting the entrenchment ratio target but the lower site was slightly exceeding the target for width/depth ratio. No Rosgen channel type was recorded for the PIBO sites but given their proximity to the FWP site, they are likely E channels; all sites exceeded the width/depth ratio target for E channels. Also, in 2007, PIBO 230 had a much higher percentage of pool fines and almost twice the width/depth ratio than in 2002. All sites upstream of Lois Lake did not meet the targets for residual pool depth and pool frequency, which could associated with the mining-related changes to channel morphology noted by FWP. Consistent with FWP observations, LWD and riparian shrub cover were lacking near the PIBO sites and RM 9.2, as well as closer to the mouth (i.e., RM 2.1 and SNOW18-05). Macroinvertebrate samples were all collected at the same location upstream of Lois Lake (near PIBO 230 and RM 9.2); one sample failed to meet the MMI target and all failed to meet the O/E target, which indicates impairment. Although fine sediment accumulations closer to the mouth observed by FWP may be associated with the channel type and beaver activity, excess sediment sources and high fines in the upper watershed, as well as low macroinvertebrate index scores, residual pool depths, LWD frequency, and riparian shrub cover all support the listing and a sediment TMDL will be developed for Snowshoe Creek.

5.5.7 Spotted Dog Creek, lower segment (MT76G004_032)

Lower Spotted Dog Creek (MT76G004_032) is listed for sedimentation/siltation on the 2010 303(d) List. In addition, this segment is also listed for alteration in stream-side or littoral vegetative covers, which is

a non-pollutant commonly linked to sediment impairment. Lower Spotted Dog is listed for sediment impairment based on sedimentation attributed to agriculture and livestock grazing. The lower segment of Spotted Dog Creek extends 10.7 miles from the US Forest Service boundary to its mouth at the Little Blackfoot River.

Physical Condition and Sediment Sources

Recent data collection occurred at several sites either within or upstream of the upper segment of Spotted Dog Creek (**Figure 5-1**). Although only the lower segment is listed for sediment impairment, the sites are discussed here because they are within the watershed for the lower segment and the TMDL must evaluate all sediment sources to an impaired segment. In 2007, FWP performed an assessment at RM 11.3, which is on USFS land near the headwaters of Spotted Dog Creek, which is upstream of both Spotted Dog Creek segments. Evidence of cattle grazing was observed but the riparian vegetation, LWD, pool habitat, and fish cover were all rated as excellent. Riparian vegetation was primarily alders with a coniferous overstory. Flow appeared naturally low and substantial deposition of fine sediment was noted. In 2009, DEQ performed an assessment at the downstream end of the upper segment of Spotted Dog Creek on USFS property (SPOT01-01). The upstream end of the site appeared to represent reference conditions for upper elevation streams flowing through conifer dominated valley bottoms. Evidence of historic timber harvest was observed along the downstream end. Extensive LWD spanned the channel and led to localized LWD aggregates; the LWD as well as root wads from fallen trees were the cause for many of the observed pools and also provided fish cover. Some fine sediment was observed in slow water areas. Streambank erosion was minimal, with one eroding bank associated with the historic land uses. Riparian shrub density was naturally limited along this reach due to the dense coniferous overstory. In 2007, one non-reference PIBO site was sampled in the upper segment of Spotted Dog Creek just downstream of SPOT01-01.

In 2007, FWP performed assessments at two sites within the lower segment of Spotted Dog Creek (**Figure 5-1**). The upper site (RM 4.6) was a B channel within a canyon. A recent timber harvest had occurred near the left side of the channel and cattle were observed throughout the reach. Fish habitat was rated as fair because pools were mostly shallow pocket water, and LWD and fish cover were sparse within the reach. Riparian vegetation was mostly grasses, some alders, and a coniferous overstory. The downstream site (RM 1.2) was a C channel in a hay meadow. The riparian vegetation was primarily disturbance-induced grasses and the occasional mature willow, but no recruitment of young willows was observed. Lateral erosion of the streambanks was observed throughout the reach and the channel appeared to have downcut historically. Fine sediment accumulations were observed throughout the reach and flow was limited. The fish habitat rated highly but could be improved by more LWD/rootwads and streambank vegetation to improve shading and fish cover.

DEQ performed one sediment and habitat assessment (SPOT12-02) on the lower segment of Spotted Dog Creek in 2009 (**Figure 5-1**). The site was in close proximity to RM 1.2 and was a meandering channel in a meadow. Bank erosion was observed at the outsides of meander bends and the channel appeared to be actively downcutting. Field notes indicated bank erosion and downcutting may be related to streambed degradation along the Little Blackfoot mainstem, which corresponds to observations made along the Little Blackfoot Physical Features Inventory in 2001 (see discussion in **Section 5.5**). Compound pools were formed by channel meanders and overhanging shrubs and included some potential spawning gravel. Management pressure appeared to be light within this meadow. Riparian vegetation was primarily reed canary grass with occasional willows; however, wetland vegetation was colonizing the insides of meander bends, which is indicative of channel recovery. Extensive streambank erosion of tall (4-5 feet) banks and active retreat was observed.

Comparison to Water Quality Targets

The existing data in comparison to the targets for Spotted Dog Creek are summarized in **Table 5-21** (Note: only SPOT12-02 is within the lower segment). No macroinvertebrate bioassessment data are available for lower Spotted Dog Creek. All bolded cells fail to meet (exceed) target thresholds.

Table 5-21. Existing sediment-related data for lower Spotted Dog Creek relative to targets. Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Greenline % Shrub Cover
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	
SPOT01-01	2009	15.7	B4/C4/E4	B4	18	11	6	7	18.5	3.1	1.0	106	449	12
SPOT12-02	2009	22.2	B4/C4b	C4	4	1	5	7	16.0	6.5	1.7	42	26	7
PIBO (2274)	2007	13.7	--	--	26	22	--	17	13.4	--	0.95	144	1067	--

Summary and TMDL Development Determination

Both the PIBO site and DEQ site in the upper segment failed to meet one or more fine sediment targets, which corresponds to the DEQ and FWP observations of fine sediment deposition within that part of the watershed. Fine sediment accumulations could be natural, related to the low flow in the upper watershed, or could also be associated with historical or existing land uses. Although SPOT01-01 also failed to meet the target for W/D ratio and percent riparian shrub cover, the coniferous overstory at that site precludes dense riparian shrub cover, and bank erosion observations as well as other sediment and habitat parameters in that portion of the watershed indicate it is providing excellent habitat for fish and other aquatic life.

SPOT12-02 met all targets for fine sediment and channel form but failed to meet the habitat related targets of pool and LWD frequency and riparian shrub cover. This corresponds to observations at RM 1.2 and RM 4.6, and shows the extent of habitat alterations that have occurred along the lower segment. Although fine sediment targets were met at this site, excess sediment deposition was noted by FWP at RM 1.2, and both DEQ and FWP noted channel downcutting and active streambank erosion. Improvements in management practices have resulted in some channel recovery, but the channel instability and actively eroding banks associated with a lack of woody riparian vegetation and channel downcutting supports the listing and a sediment TMDL will be prepared for the lower segment of Spotted Dog Creek.

5.5.8 Telegraph Creek, upper segment (MT76G004_051)

Upper Telegraph Creek (MT76G004_051) is listed for sedimentation/siltation on the 2010 303(d) List. In addition, this segment is also listed for physical substrate habitat alterations. Upper Telegraph Creek is listed based on sedimentation attributed to roads, tailings and channel disturbances associated with mining, and logging. The upper segment of Telegraph Creek extends 5.4 miles from its headwaters to its confluence with Hahn Creek.

Physical Condition and Sediment Sources

In 2007, FWP performed assessments at three sites on upper Telegraph Creek (**Figure 5-1**). All sites (i.e., RM 3.6, RM 4.9, and RM 6.7) were classified B channels and showed evidence of historic placer mining; the channel was slightly incised at each site and the substrate was dominated by large cobbles and boulders. The riparian vegetation scored highly at all sites but spawning habitat was noted to be limited by a lack of deep pools and LWD.

DEQ performed a sediment and habitat assessment at one site on upper Telegraph Creek (TELE04-01) in 2009 (**Figure 5-1**). The site was approximately 0.3 miles upstream of FWP site RM 3.6, and site visit notes contained observations similar to RM 3.6 associated with historical mining such as an entrenched channel and large substrate. Additionally, large berms, which are also likely remnants from placer mining, were observed along the channel corridor at TELE04-01. The field notes also mentioned potential effects from historic logging and roads but did not cite any sources within the reach associated with existing land uses. However, in an assessment of unpaved roads within the entire Little Blackfoot watershed (discussed in **Section 5.7.3** and **Appendix E**), upper Telegraph Creek had the highest unpaved road density per mile (i.e., 3.31), and four of six assessed crossings had a contributing length greater than 200 feet, indicating roads may still potentially be a significant source of sediment within the drainage. Pool habitat was predominantly pocket pools, but spawning sized gravels were observed. Streambank erosion was typically limited due to armoring by the cobble substrate but one berm along the left bank was eroding near the downstream end of the reach.

Comparison to Water Quality Targets

The existing data in comparison to the targets for upper Telegraph Creek are summarized in **Table 5-22**. The macroinvertebrate bioassessment data for upper Telegraph Creek is located in **Table 5-23**. All bolded cells are above target thresholds.

Table 5-22. Existing sediment-related data for upper Telegraph Creek relative to targets. Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Greenline % Shrub Cover
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	
TELE04-01	2009	22.1	B3/F3b	B3	5	2	5	1	15.1	2.0	1.4	53	132	36

Table 5-23. Macroinvertebrate Bioassessment Data for upper Telegraph Creek. Values that do not meet the target threshold are in bold.

Station ID	Location	Collection Date	Collection Method	Site Type	MMI	O/E
C01TGRPC01	1.8 miles downstream of headwaters	08/09/2004	EMAP - Reach	Mountain	63.4	**0.61**

Summary and TMDL Development Determination

All targets were met at the DEQ site except for LWD and greenline cover, which is likely associated with historic logging and mining-related disturbances to the riparian area. This assessment reach indicates most habitat parameters have recovered from historical disturbances to the channel, but observations

at the DEQ and FWP sites indicate the particle size distribution in the channel still has not recovered (i.e., it is lacking gravel and small cobbles). Inadequate smaller cobbles and gravel can reduce the habitat for macroinvertebrates, which is the primary food source for fish. The macroinvertebrate sample indicates impairment, as it was barely meeting the MMI target of 63 and was well below the O/E target. In addition to unpaved roads remaining a potential sediment source, data discussed for the metals TMDLs (**Section 7.5.3**) indicate there are still a significant amount of tailings and waste rock along the stream and its tributaries in the upper watershed, which could also be a substantial source of sediment. This information supports the listing and a sediment TMDL will be developed for upper Telegraph Creek.

5.5.9 Threemile Creek, lower segment (MT76G004_112)

Lower Threemile Creek (MT76G004_112) is listed for alteration in stream-side or littoral vegetative covers and low flow alterations on the 2010 303(d) List, which are non-pollutant forms of impairment commonly linked to sediment impairment. The habitat listings based on livestock trampling of the banks and channel and partial to complete dewatering of sections of the stream. Based on a cursory source assessment review during project scoping, lower Threemile Creek was included in the 2009 DEQ data collection and will be evaluated relative to the sediment targets. Lower Threemile Creek flows 7 miles from Quigley Ranch Reservoir to the mouth at the Little Blackfoot River.

Physical Condition and Sediment Sources

DEQ performed sediment and habitat assessments at two sites on lower Threemile Creek in 2009 (**Figure 5-1**). Due to access issues, both assessment sites were within the lower mile of the segment. The upper site (THRE16-01) was upstream of the confluence with Sixmile Creek in a meandering section. Pools were associated with meander bends with woody shrubs and bank erosion was observed on meander bends lacking deep rooted vegetation. Some pugging and hummocking was observed but grazing pressure appeared light. Riparian vegetation was grass and wetland plants with occasional woody shrubs. The lower site (THRE17-01) was downstream of Sixmile Creek near the mouth at the Little Blackfoot River and contained a rock irrigation dam at the downstream end. The site was similar to the upper site in that it was used for grazing but only light effects were observed. The reach was an almost continuous riffle and only contained three pools. Subsurface fines were observed during pool grid toss measurements. Riparian vegetation was mostly grasses and wetland plants.

Comparison to Water Quality Targets

The existing data in comparison to the targets for lower Threemile Creek are summarized in **Table 5-24**. No macroinvertebrate bioassessment data are available for lower Threemile Creek. All bolded cells are above target thresholds.

Table 5-24. Existing sediment-related data for lower Threemile Creek relative to targets. Values that do not meet the target are in bold and shaded gray.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Greenline % Shrub Cover
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	
THRE16-01	2009	16.1	C4/E4	C4	16	12	2	2	19.6	11.1	1.0	100	69	39
THRE17-01	2009	24.2	C3/C4	C3	9	5	1	6	19.0	10.1	3.1	18	9	7

Summary and TMDL Development Determination

The lower site exceeded the pebble count target for fine sediment less than 2mm and upper site exceeded the pebble count target for fine sediment less than 6mm. Although all grid tosses met the target values, elevated fine sediment was noted in the subsurface layer of pool tails at site THRE17-01. Channel form targets were within the expected range at both sites. The upper site failed to meet the residual pool depth target and the lower site, which was mostly a riffle, failed to meet the pool frequency target. Both sites failed to meet the LWD and riparian greenline targets, although values were much lower at the downstream site. Based on recent data indicating excess sediment as well as field observations of numerous human sediment sources associated with upland land management and bank erosion in the upper watershed, a sediment TMDL will be developed for lower Threemile Creek.

5.5.10 Trout Creek (MT76G004_120)

Trout Creek (MT76G004_120) has never been formally assessed for beneficial use support but was assessed along with the sediment impaired streams based on stakeholder concerns regarding fish and aquatic life use support and potentially significant sediment sources identified during project scoping. Trout Creek flows 11.5 miles from its headwaters to the mouth at the Little Blackfoot River.

Physical Condition and Sediment Sources

In 2008, FWP performed assessments at two sites on Trout Creek (**Figure 5-1**). The upper site (RM 8.3) was a Bc channel on USFS land in a confined canyon that was a steeper A channel upstream and downstream. Woody vegetation in the riparian zone was limited and attributed to upland grasses and weeds being common. Bank trampling and overutilization by livestock was also noted to have increased bank erosion and resulted in an overwidened and shallow channel. Fish habitat was rated as fair and most pools were shallow and filled with fine sediment. Most fish found during electrofishing were contained within the few deeper pools. Flow appeared naturally low within the reach. Effects from livestock were also observed on private land downstream of the reach; the channel appeared unstable, and was actively widening and downcutting in sections. The lower site (RM 3.5) was a Bc channel that was surrounded by two small hay meadows. There was evidence the channel had downcut in the past but is recovering and had established a new floodplain. The riparian zone contained a narrow strip of woody shrubs and cottonwoods and bank erosion was limited to sections with shallow-rooted grasses. Pools, woody debris, and vegetative cover rated highly but excess fine sediment accumulation was noted to be reducing habitat quality by limiting pool depth and altering spawning gravel composition.

DEQ performed sediment and habitat assessments at two sites on Trout Creek in 2009 (**Figure 5-1**). The upper site (TROU15-4) was located on USFS land approximately 0.5 miles downstream of RM 8.3. The site was in an area heavily impacted by historic and ongoing land uses, including logging in the upper watershed, grazing, and potentially some sort of mining. It appeared to be an area of restoration or recent shifts in grazing management, as there was a riparian exclosure fence and areas that seemed to be former cattle access sites were filled with angular cobbles. The channel was a relatively straight and nearly continuous riffle that was deeply entrenched and lined with alders. Spawning potential was limited and the substrate was noted as embedded. The lower site (TROU17-04) was located in grazed section of valley bottom approximately 0.7 miles downstream of RM 3.5 and near the confluence with the Little Blackfoot River. Pugging and hummocking was observed and dewatering was identified as a potential concern. The meandering channel had frequent pools and brook trout were observed clustered in a couple of the pools. Pool tails-outs contained relatively fine sediment, which may limit spawning potential for certain species. Undercut banks were identified at the outsides of meander bends but likely contribute relatively little sediment due to the low stream power. The channel was overwidened in places that were used for cattle access, though some of these spots appeared to be recovering. The riparian vegetation consisted of willows with grass and wetland plants. Downstream of the reach, irrigation diversions ran along the base of the valley wall the valley appeared to contain relatively dense willows.

Comparison to Water Quality Targets

The existing data in comparison to the targets for Trout Creek are summarized in **Table 5-25**. No macroinvertebrate bioassessment data are available for Trout Creek. All bolded cells are above target thresholds.

Table 5-25. Existing sediment-related data for Trout Creek relative to targets. Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean BFW (ft)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)		Channel Form (median)		Instream Habitat			Greenline % Shrub Cover
					% <6mm	% <2mm	Riffle % <6mm	Pool % <6mm	W/D Ratio	Entrenchment Ratio	Residual Pool Depth (ft)	Pools / Mile	LWD / Mile	
TROU15-01	2009	11.6	B4/C4b/F4b	B4	11	6	5	10	14.6	2.2	0.8	48	53	59
TROU17-04	2009	10.5	C4/E4	C4/E4	15	9	7	36	11.1	17.7	0.9	127	21	20

Summary and TMDL Development Determination

Both sites met the riffle fine sediment targets, however, both sites exceeded the pool tail grid toss target. The upper DEQ site also failed to meet the target for residual pool depth and pool frequency. This combined with FWP observations that fine sediment was filling pools, most pools were shallow, and fish were predominantly found in deeper pools are all indications that excess fine sediment is limiting the stream's ability to fully support fish. Both sites met the channel form targets, however, localized channel widening was observed by DEQ at the lower site and more widespread channel overwidening was observed by FWP at the upper site as a result of livestock stream access and overgrazing in the riparian zone. Neither site was meeting the LWD target, and the lower site was not meeting the target for riparian shrub cover. Although riparian habitat and eroding streambanks appear to be recovering in

some portions of the stream as a result of land management changes, overall, recent data indicate that human sediment sources combined with a limited transport capacity are resulting in excess sediment within Trout Creek that is diminishing the quantity and quality of fish habitat and likely impairing its ability to fully support fish and other aquatic life. Therefore, a sediment TMDL will be prepared for Trout Creek.

5.6 Sediment TMDL Development Summary

Based on the comparison of existing conditions to water quality targets, 10 sediment TMDLs will be developed in the Little Blackfoot TPA. **Table 5-26** summarizes the sediment TMDL development determinations and corresponds to the waterbodies of concern identified in **Section 5.3**.

Table 5-26 Summary of Sediment TMDL Development Determinations

Stream Segment	Waterbody #	TMDL Development Determination (Y/N)
DOG CREEK, headwaters to Meadow Creek	MT76G004_071	Y
DOG CREEK, Meadow Creek to the mouth (Little Blackfoot River)	MT76G004_072	Y
ELLISTON CREEK, headwaters to the mouth (Little Blackfoot River)	MT76G004_040*	Y
LITTLE BLACKFOOT RIVER, the headwaters to Dog Creek	MT76G004_020	Y
LITTLE BLACKFOOT RIVER, Dog Creek to the mouth (Clark Fork River)	MT76G004_010	Y
SNOWSHOE CREEK, headwaters to the mouth (Little Blackfoot River)	MT76G004_080	Y
SPOTTED DOG CREEK, forest boundary to the mouth (Little Blackfoot River)	MT76G004_032	Y
TELEGRAPH CREEK, headwaters to Hahn Creek	MT76G004_051	Y
THREEMILE CREEK, Quigley Reservoir to the mouth (Little Blackfoot River)	MT76G004_112*	Y
TROUT CREEK, headwaters to the mouth (Little Blackfoot River)	MT76G004_120*	Y

* Not on Montana's 2010 303(d) List

5.7 Sediment Source Assessment and Quantification

This section summarizes the assessment approach, current sediment load estimates, and the rationale for load reductions and allocations within the Little Blackfoot TPA. The focus is on the following four potentially significant sediment source categories and associated controllable human loading associated with each of these sediment source categories.

- streambank erosion
- upland erosion and riparian health
- unpaved roads
- permitted point sources

EPA sediment TMDL development guidance for source assessments states that the basic source assessment procedure includes compiling an inventory of all sources of sediment to the waterbody and using one or more methods to determine the relative magnitude of source loading, focusing on the primary and controllable sources of loading (U.S. Environmental Protection Agency, 1999b). Additionally, regulations allow that loadings "may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading" (Water quality planning and management, 40 CFR § 130.2(G)). The source assessments evaluated loading from the primary sediment sources using standard DEQ methods, but the sediment loads presented herein represent relative loading estimates within each source category, and should not be

considered as actual loading values. Rather, relative estimates provide the basis for percent reductions in loads that can be accomplished via improved land management practices for each source category. These estimates of percent reduction provide a basis for setting load or wasteload allocations. As better information becomes available and the linkages between loading and instream conditions improve, the loading estimates presented here can be further refined in the future through adaptive management.

For each impaired waterbody segment, sediment loads from each source category were estimated based on field surveys, watershed modeling, and load extrapolation techniques (described below). The results include a mix of sediment sizes, particularly for bank erosion that involves both fine and coarse sediment loading to the receiving water, whereas loads from roads, upland erosion, and permitted point source discharges are predominately fine sediment.

The complete methods and results for source assessments for streambank erosion, upland erosion, and roads are located in **Appendices C, D,** and **E.** The following sections provide a summary of the load assessment results along with the basis for load reductions via improved land management practices. This load reduction basis provides the rationale for the TMDL load and wasteload allocations defined in **Section 5.8**.

5.7.1 Eroding Streambank Sediment Assessment

Streambank erosion was assessed in 2009 at the 19 full assessment reaches discussed in **Section 5.3**. At each site, eroding streambanks were classified as either actively or slowly eroding, the susceptibility to erosion was assessed by performing Bank Erosion Hazard Index (BEHI) measurements, and the erosive force was determined by evaluating the Near Bank Stress (NBS) (Rosgen, 1996; 2004). BEHI scores were determined at each eroding streambank based on the following parameters: bank height, bankfull height, root depth, root density, bank angle, and surface protection. In addition to BEHI data collection, the source of streambank erosion was evaluated based on observed human-caused disturbances and the surrounding land-use practices based on the following near-stream source categories:

- transportation
- riparian grazing
- cropland
- mining
- silviculture
- irrigation-shifts in stream energy
- natural sources
- other

Based on the aerial assessment process (described in **Section 5.3**) in which each 303(d) listed waterbody segment is divided into different reaches, streambank erosion data from each 2009 monitoring site was used to extrapolate to the reach scale. Then, the average value for each unique reach category was applied to unmonitored reaches within the corresponding category to estimate loading associated with bank erosion at the listed stream segment and watershed scales.

The potential for sediment load reduction via riparian BMPs was estimated based on the ratio of actively to slowly eroding banks from five reaches with greater than 75% natural erosion sources. That ratio (i.e., 70% active vs. 30% slowly) was applied to each reach category and extrapolated to all similar reach types for reaches with predominantly human sources. The most appropriate BMPs will vary by site, but streambank stability and erosion rates are largely a factor of the health of vegetation near the stream,

and the application of riparian BMPs are anticipated to lower the amount of actively eroding banks and result in the estimated reductions. Although the reduction may not be achievable in all areas, greater reductions will likely be achievable in some areas. Because channel parameters and other variables must be altered within the SWAT model (see **Section 5.7.3** and **Appendix D**) to reduce loading associated with bank erosion and it is difficult to get a certain percentage for each impaired watershed, loading reductions achievable via the implementation of riparian BMPs were applied to the existing loads from the SWAT model based on reductions identified in the *Sediment and Habitat Assessment* (**Appendix C**). Additionally, the percentage of streambank erosion from natural versus human sources is based on the streambank assessment (**Appendix C**).

Assessment Summary

Because the SWAT model used to estimate loading from upland erosion (see **Section 5.7.3** and **Appendix D**) is calibrated to flow at the USGS gage near Garrison and to a sediment rating curve based on data at the gage, bank erosion loads summarized here and used in the TMDL are from the model, but the allocations and percent reductions are based on the bank erosion source assessment (**Table 5-27**). Based on the model output, streambank erosion contributes an estimated 2,187 tons of sediment per year to the Little Blackfoot TPA. Sediment loads due to streambank erosion range from 0.9 tons/year in the upper Dog Creek watershed to 261 tons per year in the upper Little Blackfoot River watershed. Implementation of riparian BMPs could decrease annual bank erosion 20% within the Little Blackfoot River watershed. Significant sources of streambank erosion include riparian grazing, riparian clearing, hay production, and transportation. **Appendix C** contains additional information about sediment loads from eroding streambanks in the Little Blackfoot TPA by subwatershed.

Table 5-27. Existing and Reduced Sediment Load from Eroding Streambanks within the Little Blackfoot TPA.

Subbasin	Existing Sediment Load (tons/year)	Allowable Sediment Load with Riparian BMPs (tons/year)	Percent Reduction
Dog Creek, upper segment	0.9	0.8	7%
Dog Creek, lower segment	234	197	16%
Elliston Creek	3.3	2.8	16%
Little Blackfoot River, upper segment	261	235	10%
Little Blackfoot River, lower segment	2,654	2,123	20%
Snowshoe Creek	34	27	21%
Spotted Dog Creek, lower segment	84	46	45%
Telegraph Creek, upper segment	24	22	8%
Threemile Creek, lower segment	41	39	8%
Trout Creek	112	84	25%

5.7.1.1 Streambank Assessment Assumptions

The following is a summary of the significant assumptions used during the eroding streambank assessment:

- Because the SWAT model integrates all sediment sources and loading is based on a sediment rating curve developed using data from the USGS gage on the Little Blackfoot River near Garrison, it is assumed that the streambank erosion load from the model is a better estimate of the existing load than that from the field assessment
- The ratio of actively to slowly eroding streambanks at sites with predominantly natural sources is an appropriate and achievable rate in reaches where all reasonable land, soil, and water conservation practices are applied.

- The average annual load per Reach Type is applicable to other reaches within the same category.
- Sources of bank erosion at the assessed stream segment scale are representative of sources for that watershed.
- The annual streambank erosion rates used to develop the sediment loading numbers were based on Rosgen BEHI studies along the Lamar River in Yellowstone National Park. While the predominant geologies differ between the Wyoming research sites and the Little Blackfoot watershed, the rates are applicable to the Little Blackfoot and suitable for helping estimate the percentage in streambank associated loading reductions achievable with the implementation of riparian BMPs.

5.7.2 Upland Erosion and Riparian Buffering Capacity Assessment

The hydrologic simulation model known as SWAT (Soil and Water Assessment Tool) was used to determine the existing sediment loads and potential reductions from upland sources in the Little Blackfoot TPA. SWAT is a river basin scale model developed to quantify the impact of land management practices in large, complex watersheds. It incorporates hydrologic, climactic, and water chemistry data with detailed land cover/land use and topography information to predict pollutant loading for seasonal and annual time frames.

To simulate pollutant loading at the watershed scale, SWAT first partitions a watershed into a number of subbasins. Each subbasin delineated within the model is simulated as a homogeneous area in terms of climatic conditions, but with additional subdivisions within each subbasin to represent various soils and land use types. Each of these subdivisions is referred to as a hydrologic response unit (HRU) and is assumed to be spatially uniform in terms of soils, land use, topographic and climatic data. Once the HRU categories have been defined, the model then introduces the hydrologic and land management information in order to generate the sediment loads from the landscape. Data over a four year period of record (2002 through 2005) from the USGS gage on the Little Blackfoot River near Garrison (#12324590) was used to calibrate the hydrology for this model.

SWAT uses a complicated approach but is built around the widely used Universal Soil Loss Equation (USLE). USLE uses five main factors by which to estimate soil erosion: R * K* LS * C * P, where:

R = rainfall/intensity
K = erodibility
LS = length/slope
C = vegetation cover
P = field practices

Values for these factors applied to each of the HRUs in each of the subbasins. All values except “P” and “C” are environmental factors; therefore, they are not management factors and are not modified for the existing or desired condition scenarios. Per the NRCS state agronomist, the P value was set at 1 for all HRUs for both scenarios. The C-factor, which represents the amount of ground cover, was set per HRU category for the existing condition and for an improved conditions scenario associated with the implementation of upland BMPs. C-factors for both scenarios were based on literature values, estimates of existing field conditions in the watershed determined through site visits, communication with local stakeholders, and comparisons to previous SWAT model efforts in the Upper Clark Fork and Bitterroot River watersheds.

HRU categories and C-factors used in the Little Blackfoot River SWAT model for both scenarios are listed in **Table 5-28**. The land use categories that were modified are range-brush and pasture. C-factor changes equate to roughly a 10% improvement in ground cover per category. A C-factor slightly higher than a deciduous/evergreen forest was used for logged areas within the forested category because logging intensity within the watershed is generally low and because practices, such as riparian clearcutting, that tend to produce high sediment yields have not been used since at least 1991, when the MT Streamside Management Zone (SMZ) law was enacted. Additionally, the USLE model is intended to reflect long-term average sediment yield, and while a sediment pulse typically occurs in the first year after logging, sediment production after the first year rapidly declines (Elliot, 2006; Elliot.W.J. and Robichaud, 2001; Rice, et al., 1972). The logging C-factor, which is incorporated into the forest category, is the same for both management scenarios to indicate that logging will continue sporadically on public and private land within the watershed and will produce sediment at a rate slightly higher than an undisturbed forest. This is not intended to imply that additional best management practices beyond those in the SMZ law should not be used for logging activities. Additional details about the SWAT model and the upland erosion assessment are in **Appendix D**.

Table 5-28. SWAT HRU Categories and C-factors for the existing and improved condition scenarios

SWAT Code	Land Cover/Land Use Description	Percent Watershed Area	Existing C-factor	Improved Condition C-factor
SWRN	Southwestern US (Arid) Range	0.01%	0.310	0.310
FRSE	Forest-Evergreen	55.42%	0.005	0.005
RNGB	Range-Brush	38.94%	0.034	0.031
PAST	Pasture	4.45%	0.013	0.008
WETF	Wetlands-Forested	0.50%	0.002	0.002
URBN	Residential	0.55%	0.018	0.018

Assessment Summary

From the model output, an average annual sediment load delivered to the stream is determined for each listed stream's watershed. The average annual upland sediment load is the sum of the average annual loads from each land cover/land use type (HRU category). This sediment load represents the best estimation of current loading from upland sources. **Table 5-29** presents the modeled existing sediment load as well as the loading reductions achievable with improvement of upland management practices. Additional details about the SWAT model and the achievable reductions by land cover category for each listed stream's watershed are in **Appendix D**.

Table 5-29. Existing and Reduced Sediment Load from Upland Sources within the Little Blackfoot TPA

Subbasin	Existing Delivered Sediment Load (tons/year)	Normalized Existing Load (tons/mile^2/year)	Improved Upland Conditions Sediment Load (tons/year)	Normalized Improved Upland Condition Load (tons/mile^2/year)	Percent Reduction
Dog Creek, upper segment	130	17.8	114	15.6	12.1%
Dog Creek, lower segment	2,183	37.3	2,044	35.0	6.4%
Elliston Creek	117	19.1	102	16.7	12.3%
Little Blackfoot River, upper segment	4,056	40.6	3,828	38.3	5.6%
Little Blackfoot River, lower segment	12,046	29.2	10,999	26.7	8.7%
Snowshoe Creek	348	19.3	300	15.1	13.8%

Table 5-29. Existing and Reduced Sediment Load from Upland Sources within the Little Blackfoot TPA

Subbasin	Existing Delivered Sediment Load (tons/year)	Normalized Existing Load (tons/mile^2/year)	Improved Upland Conditions Sediment Load (tons/year)	Normalized Improved Upland Condition Load (tons/mile^2/year)	Percent Reduction
Spotted Dog Creek, lower segment	1,686	38.0	1,549	34.9	8.1%
Telegraph Creek, upper segment	151	9.4	148	9.2	2.4%
Threemile Creek, lower segment	691	13.5	538	10.5	22.1%
Trout Creek	422	24.2	388	22.2	8.2%

5.7.1.1 Improved Riparian Condition Scenario

The SWAT model scenario for existing conditions and loading associated with upland sources incorporates the current capacity of riparian buffers within the Little Blackfoot TPA to filter sediment and prevent it from entering streams. However, riparian vegetation can greatly alter sediment loading to streams, and based on a riparian assessment performed by DEQ in 2009, there is significant opportunity for improved riparian health in the Little Blackfoot watershed. Therefore, in conjunction with the upland loading reductions achievable via implementing BMPs to improve ground cover, a scenario of improved riparian health was incorporated in the SWAT model to estimate the additional upland reductions achievable via the implementation of riparian BMPs.

NRCS recommends a minimum buffer width of 30 feet (Natural Resource Conservation Service, 2011b; 2011a), and the ability of riparian buffers to effectively filter sediment increases with increasing buffer width. For instance, a 100 foot wide, well-vegetated riparian buffer is a common recommended buffer width(Mayer, et al., 2005; Cappiella, et al.,2006) and has been found to filter 75-90% of incoming sediment from reaching the stream channel (Wegner, 1999; Knutson and Naef, 1997). Although sediment removal efficiency is affected by factors such as ground slope, buffer health, and buffer composition, the literature values were used as the basis for applying filter strips of varying widths (i.e., 30, 50, and 100 feet) to estimate additional sediment upland loading reductions that could be achieved with improved riparian conditions.

Different buffer widths were used based on a riparian health classification performed by DEQ during the stratification process described in **Section 5.3.2**. Using aerial photos, delineated reaches were given a riparian condition category of good, fair, or poor based on land use adjacent to the stream, riparian vegetation type and density, and the presence or absence of human related activities near the stream corridor. Based on this, each stream investigated was given corresponding percentages of condition based on the total length of stream assessed. The desired condition is 75% good/25 % fair buffer and because each watershed was estimated to already be at least 25% fair, a ratio of buffer widths was applied within SWAT to HRUs within each impaired stream's watershed depending on the existing amount of poor/fair/good buffers. Given that poor buffers need the most improvement, under the improved condition scenario, buffer widths classified as poor were assigned a width of 100 feet, fair buffers were assigned a width of 50 feet, and good buffers were assigned a width of 30 feet. Because SWAT groups areas of similar soils, land use, and slope into HRUs, single HRUs are often spread throughout a subwatershed. Since a riparian buffer is applied by HRU, it is difficult to only apply the buffer along the extent of each stream. Therefore, the distribution of HRUs was evaluated for each

watershed in need of a TMDL and filter strips were added to land types that tend to occur along streams and will benefit the most from improved riparian vegetation. This was typically pasture but also included rangeland, especially in areas with heavy grazing. In areas such as upper Telegraph Creek, where there is a substantial amount of forest but the effects of logging or presence of mine tailings in the riparian area represent a potential sediment source, filter strips were added to the forest category as a surrogate for reductions that could occur from improving the riparian vegetation and/or stabilizing tailings. It is assumed that additional reductions could occur within all land cover categories by improvement of the riparian vegetation. Additional information about the improved riparian condition scenario is provided in **Appendix D**.

Assessment Summary

Based on improvements in riparian health, the model indicated that additional reductions in sediment loading ranging from 6 to 24% are achievable. **Table 5-30** shows the difference between the existing upland load and the allowable load with improved upland and riparian conditions.

Table 5-30. Sediment Load from Upland Sources with Improved Upland and Riparian Conditions

Subbasin	Existing Delivered Sediment Load (tons/year)	Normalized Existing Load (tons/mile^2/year)	Allowable Delivered Sediment Load with Improved Upland and Riparian Conditions (tons/year)	Normalized Allowable Load (tons/mile^2/year)	Percent Reduction
Dog Creek, upper segment	130	17.8	100	13.6	23.2%
Dog Creek, lower segment	2,183	37.3	1,876	32.1	14.1%
Elliston Creek	117	19.1	85	13.8	27.5%
Little Blackfoot River, upper segment	4,056	40.6	3,575	35.8	11.8%
Little Blackfoot River, lower segment	12,046	29.2	9,891	24.0	17.9%
Snowshoe Creek	348	19.3	267	14.7	23.1%
Spotted Dog Creek, lower segment	1,686	38.0	1,336	30.1	20.7%
Telegraph Creek, upper segment	151	9.4	128	7.9	15.6%
Threemile Creek, lower segment	691	13.5	373	7.3	46.0%
Trout Creek	422	24.2	325	18.6	23.1%

5.7.1.2 Upland Assessment Assumptions

As with any modeling effort, and especially when modeling at a watershed scale, there are a number of assumptions that must be accepted. For upland erosion source assessment, here are the major assumptions:

- The input variables used in the USLE calculations are representative of their respective land use conditions.

- The land management practices (grazing duration, hay cutting, etc) for certain land use categories that define the vegetative cover throughout the year are relatively consistent and representative of practices throughout the watershed.
- The application of riparian filtering is applicable only to the improved conditions and the current model inherently incorporates existing conditions across the landscape.
- The riparian condition as estimated through the aerial assessment is representative of on-the-ground conditions.
- Applying filter strips within SWAT is an acceptable surrogate for improved riparian condition. Filter strips were applied to the land cover categories where they will be most effective, but estimated reductions may not be achievable in all areas and additional reductions may be achievable in some areas where filter strips were not applied.
- The improvement scenarios to riparian condition and land management are reasonable and achievable.
- A substantial portion of upland load after improvements in management practices for each land use category is a component of the "natural upland load." The assessment methodology did not differentiate between sediment loads with all reasonable BMPs and "natural" loads.

5.7.3 Road Sediment Assessment

5.7.3.1 Unpaved Roads

Sediment loading from unpaved roads was assessed using GIS, field data collection, and sediment modeling. The results of the roads assessment was then incorporated into the SWAT model. Each identified unpaved road crossing and near-stream parallel road segment was assigned attributes for road name, surface type, road ownership, stream name, subwatershed, and landscape type (i.e., mountain, foothill, or valley). Twenty two crossings and five near-stream parallel segments representing the range of conditions within the watershed were field assessed in 2009, and sediment loading was estimated using the Water Erosion Prediction Project Methodology (WEPP:Road). The average sediment contribution from unpaved road crossings and near-stream road segments were extrapolated to all unpaved roads in the watershed based on landscape setting (i.e., mountain, foothill, and valley). To address sediment from unpaved roads in the TMDLs and allocations that follow in **Section 5.6**, the WEPP:Roads analysis was also run using BMPs to reduce the road contributing length to 200 feet. The 200-foot BMP scenario is used in this document as a general approximation of an achievable modeled loading reduction to help develop the road crossing allocations. The intent is to ensure that all road crossings have the appropriate BMPs in place to protect water quality via reduced sediment loading. Other potential BMPs include the installation of full structural BMPs at existing road crossings (drive through dips, culvert drains, settling basins, silt fence, etc), road surface improvement, reduction in road traffic levels (seasonal or permanent road closures), and timely road maintenance to reduce surface rutting. Because parallel segments contributed less than 0.1% of the loading associated with unpaved roads, and well-maintained culvert drains were observed on parallel segments in several drainages (i.e., Snowshoe, Telegraph, and Elliston), no BMP reduction scenarios were applied to the load from near-stream parallel segments. A more detailed description of this assessment can be found in *Road Sediment Assessment and Modeling (Water & Environmental Technologies, P.C., 2010)* (**Appendix E**).

The existing road conditions and sediment loadings from the assessment were introduced into the SWAT model through use of a point source. Since roads are not a separate land use in this model (i.e., they are not explicitly modeled), each sub-basin had a sediment point source added to simulate the road loadings. These loads were reported on an annual basis in the assessment but are distributed within SWAT based on monthly rainfall totals, so that the sediment loading is greater in high rainfall months.

Assessment Summary
Based on the source assessment, unpaved roads are estimated to contribute 38 tons of sediment per year to the Little Blackfoot River watershed. Sediment loads due to unpaved roads range from <1 ton/year in the Elliston Creek watershed to 5.2 tons/year in the Dog Creek watershed. Thirty six percent of the private crossings already have a contributing length less than 200 feet and 27% of federal crossings are already meeting the goal; however, private crossings averaged a greater contributing length (561 feet versus 401) and a greater load (0.085 tons versus 0.07 tons), indicating how a few crossings with inadequate BMPs can influence loading to streams.

Out of the 22 crossings evaluated in the field, 12 had at least one BMP installed. Observed BMPs were graveled surface, water bars, culverts drains, and drive through dips. Factors influencing sediment loads from unpaved roads at the watershed scale include the overall road density within the watershed and the configuration of the road network, along with factors related to road construction and maintenance. **Table 5-31** contains annual sediment loads from unpaved roads in the watersheds where TMDLs are developed within this document as well as the reduced load and percent reduction based on the BMP conditions described above. **Appendix E** contains additional information about sediment loads from unpaved roads in the Little Blackfoot TPA. Note: The USFS may have decommissioned some unpaved roads since the road network information was obtained (spring 2009) and those changes are not reflected in the source assessment.

Table 5-31. Annual Sediment Load (tons/year) from Unpaved Roads within the Little Blackfoot River Watershed.

Watershed	Total Load (tons/year)	Percent Load Reduction After BMP Application	Total Sediment Load After BMP Application
Dog Creek, upper segment	1.4	70%	0.4
Dog Creek, lower segment	5.2	71%	1.5
Elliston Creek	0.5	70%	0.1
Little Blackfoot River, upper segment	9.8	71%	2.9
Little Blackfoot River, lower segment	38.4	75%	9.7
Snowshoe Creek	2.3	74%	0.6
Spotted Dog Creek, lower segment	4.0	79%	0.8
Telegraph Creek, upper segment	3.8	71%	1.1
Threemile Creek, lower segment	2.2	79%	0.5
Trout Creek	0.8	76%	0.2

*Due to rounding, differences in loads presented in this table may not correspond to the percent reduction.

5.7.3.2 Traction Sand

Traction sand applied to paved roads in the winter can be a significant source of sediment loading to streams. A study by the Montana Department of Transportation (MDT) (Staples, et al., 2004) found that traction sand predominantly contains particles less than 6mm and 2mm, which are size fractions that can be detrimental to fish and other aquatic life as in-stream concentrations increase(Irving and Bjorn, 1984; Mebane, 2001; Weaver and Fraley, 1991; Shepard, et al., 1984; Suttle, et al., 2004; Zweig and Rabeni, 2001).

Sediment loading associated with traction sand was estimated based on application rates multiplied by contributing distances and a delivery ratio. Annual application rates were provided by MDT for Highway

12 and 141 and the Powell County Roads Department for secondary roads. Contributing lengths were identified by querying the GIS database for paved roads within 100 feet of streams. The Powell County Road Department applies traction sand to a few steep gravel roads but these were excluded from the traction sand estimate. Based on a range of delivery ratios in the Prospect Creek TMDL and literature values for the effectiveness of vegetated buffers (Asmussen, et al., 1976; Hall, et al., 1983; Han, et al., 2005; Mickelson, et al., 2003; Montana Department of Environmental Quality, 2009), a 15% delivery rate was assumed. The delivery rate equates to a buffer length of 50 to 100 feet with 50% vegetative cover.

The loading reduction potential was estimated by assuming that BMPs could reduce the annual delivery rate to 10% (which equates to 60% vegetative cover). This could be achieved by a combination of BMPs, which may include a lower application rate, street sweeping, improving maintenance of existing BMPs, altering plowing speed at crossings, and structural control measures. It is acknowledged that public safety is a primary factor in the usage of traction sand, and the reduction in loading from traction sand is anticipated to be achieved by improving BMPs without sacrificing public safety. Additional details regarding the traction sand assessment are provided in **Appendix E**.

Assessment Summary

Based on the source assessment, traction sand was identified as a potentially significant source in three tributaries to the Little Blackfoot River and contributes approximately 39 tons of sediment per year to the Little Blackfoot TPA (**Table 5-32**). Additional BMPs are estimated to reduce traction sand loading by 33% to all affected waterbodies.

Table 5-32. Annual Sediment Load (tons/year) from Traction Sand within the Little Blackfoot River Watershed.

Watershed	Total Load (tons/year)	Percent Load Reduction After BMP Application	Total Sediment Load After BMP Application
Elliston Creek	0.4	33%	0.3
Little Blackfoot River, lower segment	39.0	33%	26.0
Threemile Creek, lower segment	7.0	33%	4.6
Trout Creek	9.8	33%	6.5

*Due to rounding, differences in loads presented in this table may not correspond to a 33 percent reduction.

5.7.3.3 Culvert Failure and Fish Passage

Undersized or improperly installed culverts may be a chronic source of sediment to streams or a large acute source during failure, and they may also be passage barriers to fish. Therefore, during the roads assessment, the flow capacity and potential to be a fish passage barrier was evaluated for each culvert. Due to fords at four road crossings and conditions preventing full measurements at four crossings, the culvert analysis was performed at 14 of the 22 road crossings. The assessment incorporated bankfull width measurements taken upstream of each culvert to determine the stream discharge associated with different flood frequencies (e.g. 2, 5, 10, 25, 50, and 100 year) as well as measurements to estimate the capacity and amount of fill material of each culvert. It is assumed that fill above an undersized culvert will periodically erode into the channel but the culvert will not completely fail; therefore, the annual amount of sediment at-risk was set at a 25% probability for the loading analysis.

A common BMP for culverts is designing them to accommodate the 25-year storm event; this capacity is specified as a minimum in Water Quality BMPs for Montana Forests (Montana State University, Extension Service, 2001), and it is typically the minimum used by the USFS. Therefore, fill was only

assumed to be at-risk in culverts that cannot convey a 25-year event. However, other considerations such as fish passage, the potential for large debris loads, and the level of development and road density upstream of the culvert should also be taken into consideration during culvert installation and replacement, and may necessitate the need for a larger culvert. For instance, the USFS typically designs culverts to pass the 100-year event and be suitable for fish and aquatic organism passage on fish bearing streams (U.S. Department of Agriculture, Forest Service, 1995). Therefore, the BMP scenario for culverts is no loading from culverts as a result of being undersized, improperly installed, or inadequately maintained. At a minimum, culverts should meet the 25-year event, but for fish-bearing streams or those with a high level of road development upstream, meeting the 100-year event is recommended.

Fish passage assessments were performed on 15 culverts; bridges and sites where all measurements could not be collected were excluded. The assessment was based on the methodology defined in **Appendix E**, which is geared toward assessing passage for juvenile salmonids. Considerations for the assessment include stream flow, the culvert slope, culvert perch/outlet drop, culvert blockage, and constriction ratio (i.e. culvert width to bankfull width). The assessment is intended to be a coarse level evaluation of fish passage that quickly identifies culverts that are likely fish passage barriers and those that need a more in-depth analysis. The culvert assessment in **Appendix E** contains information that may help land managers focus restoration efforts on those culverts that were concluded as being fish barriers and/or undersized per this analysis.

Assessment Summary

Out of the 14 culverts assessed for failure risk, 11 (79%) were estimated to pass a 25-year event and 6 (43%) were estimated to pass the 100-year event. All culverts evaluated on USFS land were estimated to pass at least a 25-year event but only two of seven were estimated to be designed for Q100. On private lands, culvert capacity was quite varied with half being estimated to pass a 100-year event and the other half estimated to only be built for a two-year event. Assuming a 25% probability of failure annually (for culverts meeting less than Q25), it was estimated that 196 tons of sediment are at-risk; this load is presented to give an estimate of the potential loading associated with undersized culverts in the Little Blackfoot Watershed but because of the sporadic natural and uncertainty regarding timing of culvert failures, the estimated load at-risk is not including in the existing loads estimates for each impaired stream. For the fish passage assessment, all 15 assessed culverts were determined to pose a significant passage risk to juvenile fish at all flows. The predominant reason cited as a barrier to fish passage was a steep culvert gradient.

5.7.3.4 Road Assessment Assumptions

The following is a summary of the significant assumptions used during the roads assessment:

- The road crossings and parallel segments assessed in the field are representative of conditions throughout the watershed.
- Although ownership may affect the level of BMP implementation, landscape setting was assumed to be the largest determinant of loading per crossing. Field sites were selected to have a representative number per ownership type, but the loads were extrapolated based on landscape setting (i.e., mountain, foothill, and valley).
- Using a modeling scenario that focuses on reducing the contributing length near road crossings will effectively reduce the majority of the sediment load from roads and is an effective way to represent loading reductions associated with the implementation of all reasonable, land, soil, and water conservation practices.

- BMPs may have already have been implemented on many roads and therefore the reductions necessary in some locations may be less than described in this document.

5.7.4 Permitted Point Sources

As of September 14, 2011, there were four Montana Pollutant Discharge Elimination System (MPDES) permitted point sources within the Little Blackfoot Watershed (**Figure A-16**). Three of the permits are general permits (MTR100000) for construction stormwater and the fourth is a general permit for suction dredging (MTG370000). To provide the required wasteload allocation for permitted point sources, a source assessment was performed for these point sources. However, because of the nature of sediment loading associated with these permits and because effluent limits are not contained within the existing permits, the WLAs are not intended to add load limits to the permits; it is assumed that the WLAs will be met by adherence to the General Permit requirements (MTR100000 and MTG370000).

5.7.4.1 Construction Stormwater Permits

Since construction activities at a site are relatively temporary and short term in nature, the number of construction sites covered by the general permit at any given time varies. Collectively, these areas of severe ground disturbance have the potential to be significant sediment sources if proper BMPs are not implemented and maintained. Each construction stormwater permittee is required to develop a SWPPP that identifies the stormwater BMPs that will be in place during construction. Prior to permit termination, disturbed areas are required to have a vegetative density equal to or greater than 70% of the pre-disturbed level (or an equivalent permanent method of erosion prevention). Inspection and maintenance of BMPs is required, and although Montana stormwater regulations provide the authority to require stormwater monitoring, water quality sampling is typically not required (Heckenberger, Brian, personal communication 2009).

To estimate the disturbed acreage associated with construction stormwater permits, the permit files were reviewed for anticipated acres to be disturbed. One permit for construction stormwater is for a 3 acre gravel borrow pit in the Dog Creek watershed and the others are for bridge replacements over the Little Blackfoot River at Highway 12 (33 acres) and at Beck Hill Road (<1 acre). Due to similarities in the amount of ground cover, potential sediment loading for the construction sites if adequate BMPs are not followed were calculated using annual erosion rate for the Southwestern US range category from the SWAT model (**Appendix H**). That land use category represents barren lands in the NLCD and is defined as areas of bedrock as well as glacial debris, strip mines, gravel pits, and other accumulations of earthen material that generally have less than 15% of total cover. The average erosion rate from this category (which only represents 23 acres within the watershed) was multiplied by the amount of disturbed area due to construction for each permit. To estimate the reduction in loading associated with following proper BMPs and adhering to permit requirements, a 65% reduction was applied based on studies from the U.S. EPA and the International Stormwater Best Management Practices Database (Geosyntec Consultants and Wright Water Engineers, Inc., 2008; EPA, 2009b). The reduced loads will be the used to set the wasteload allocations for construction stormwater permits. Because following permit conditions meets the intent of the WLA for construction stormwater, any future permits will meet the TMDL by following all permit conditions, including the SWPPP.

Assessment Summary

Based on the source assessment, construction stormwater permits in the Little Blackfoot watershed have the potential to contribute up to 50.7 tons of sediment per year (**Table 5-33**). That load can be reduced to 17.7 tons by adhering to permit conditions and following all necessary BMPs.

Table 5-33. Sediment Loading and Reductions from Permitted Construction Sites

Watershed	Loading rate based on SWAT (T/Acre/ Year)	Annual Disturbed Acres	Estimated Load Without Adequate BMPs (T/Year)	BMP Sediment Load (T/Year)	Percent Reduction
Dog Creek	1.37	3	4.1	1.4	65%
Little Blackfoot	1.37	37	50.7	17.7	65%

5.7.4.2 Suction Dredge Permit

The suction dredge permit (MTG370318) is in the Carpenter Creek drainage. Because no sediment TMDL is being presented for Carpenter Creek, the WLA for the suction dredge permit will be part of the TMDL for the lower segment of the Little Blackfoot River. The general permit has special conditions to minimize harmful conditions caused by elevated suspended sediment concentrations including no disturbance of streambanks, dredging only within the wetted channel, no wheeled equipment in the stream while dredging, and avoiding dredging areas where silt and clay are concentrated. Additionally, no visual increase in turbidity is allowed at the end of the mixing zone (i.e., 10 stream widths downstream), and the permittee must keep a daily log to demonstrate compliance with this condition.

Assessment Summary

Because only sediment within the wetted channel is permitted and no visual increase is allowed beyond the mixing zone, if the permit conditions are followed, no sediment loading is anticipated from this permit and a WLA of 0 will be provided.

5.7.5 Source Assessment Summary

The estimated annual sediment load from all identified sources throughout the Little Blackfoot River watershed is 14,828 tons. Each source category has different seasonal loading rates, and the relative percentage of the total load from each source category does not necessarily indicate its importance as a loading source. Instead, due to the coarse nature of the source assessment work and the unique uncertainties involved with each source assessment category, the intention is to separately evaluate source impacts within each assessment category (e.g., bank erosion, upland erosion, roads). Results for each source assessment category provide an adequate tool to focus waters quality restoration activities in the Little Blackfoot TPA by indicating the relative contribution of different subwatersheds or landcover types for that source category and the percent loading reductions that can be achieved with the implementation of improved management practices (**Appendices C, D,** and **E**).

5.8 TMDL AND ALLOCATIONS

5.8.1 Application of Percent Reduction and Yearly Load Approaches

The sediment TMDLs for the Little Blackfoot TPA will be based on a percent reduction approach as discussed in **Section 4.0.** This approach will apply to the loading allocated among sources as well as to the TMDL for each waterbody. An implicit margin of safety will be applied as further discussed in **Section 5.9**. (Cover, et al., 2008) observed a correlation between sediment supply and instream measurements of fine sediment in riffles and pools; it is assumed that a decrease in sediment supply, particularly fine sediment, will correspond to a decrease in the percent fine sediment deposition within the streams of interest and result in attainment of the sediment related water quality standards. A percent-reduction approach is preferable because there is no numeric standard for sediment to calculate the allowable load and because of the uncertainty associated with the loads derived from the source assessment

(which are used to establish the TMDL), particularly when comparing different load categories such as road crossings to bank erosion. Additionally, the percent-reduction TMDL approach is more applicable for restoration planning and sediment TMDL implementation because this approach helps focus on implementing water quality improvement practices (i.e., BMPs), versus focusing on uncertain loading values.

An annual expression of the TMDLs was determined as the most appropriate timescale because sediment generally has a cumulative effect on aquatic life and other designated uses, and all sources in the watershed are associated with periodic loading. Each sediment TMDL is stated as an overall percent reduction of the average annual sediment load that can be achieved after summing the individual annual source allocations and dividing them by the existing annual total load. EPA encourages TMDLs to be expressed in the most applicable timescale but also requires TMDLs to be presented as daily loads (Grumbles, B., personal communication 2006). Daily loads are provided in **Appendix D**.

5.8.2 Development of Sediment Allocations by Source Categories

The percent-reduction allocations are based on the modeled BMP scenarios for each major source type (e.g., streambank erosion, upland erosion, roads and permitted point sources). These BMP scenarios are discussed within **Section 5.7** and associated appendices, and reflect reasonable reductions as determined from literature, agency and industry documentation of BMP effectiveness, and field assessments. Sediment loading reductions can be achieved through a combination of BMPs, and the most appropriate BMPs will vary by site. Sediment loading was evaluated at the watershed scale and associated sediment reductions are also applied at the watershed scale based on the fact that many sources deliver sediment to tributaries that then deliver the sediment load to the impaired waterbodies.

It is important to recognize that the first critical step toward meeting the sediment allocations involves applying and/or maintaining the land management practices or BMPs that will reduce sediment loading. Once these actions have been completed at a given location, the landowner or land manager will have taken action consistent with the intent of the sediment allocation for that location. For many nonpoint source activities, it can take several years to achieve the full load reduction at the location of concern, even though full BMP implementation is in effect. For example, it may take several years for riparian areas to fully recover after implementing grazing BMPs or allowing re-growth in areas of historic riparian harvest. It is also important to apply proper BMPs and other water quality protection practices for all new or changing land management activities to limit any potential increased sediment loading.

Progress towards TMDL and individual allocation achievement can be gauged by adherence to point source permits, BMP implementation for nonpoint sources, and improvement in or attainment of water quality targets defined in **Section 5.4**. Any effort to calculate loads and percent reductions for purposes of comparison to TMDLs and allocations in this document should be accomplished via the same methodology and/or models used to develop the loads and percent reductions presented within this document.

The following subsections present additional allocation details for each sediment source category.

5.8.2.1 Streambank Erosion

Sediment loads associated with bank erosion were identified by separate source categories (e.g., transportation, grazing, natural) in **Appendix C**. Because of the inherent uncertainty in extrapolating this level of detail to the watershed scale, and also because of uncertainty regarding impacts from historical

land management activity, all human caused sources of bank erosion were combined for the purpose of expressing the TMDL and allocations. Streambank stability and erosion rates are very closely linked to the health of the riparian zone; reductions in sediment loading from bank erosion are expected to be achieved by applying BMPs within the riparian zone.

5.8.2.2 Upland Erosion

No reductions were allocated to natural sources, which are a significant portion of all upland land use categories. The allocation to upland sources includes application of BMPs to present land use activities as well as recovery from past land use influences such as riparian harvest. For all upland sources, the largest percent reduction will be achieved via riparian improvements.

5.8.2.3 Roads

The unpaved road allocation can be met by incorporating and documenting that all road crossings and parallel segments with potential sediment delivery to streams have the appropriate BMPs in place. Routine maintenance of the BMPs is also necessary to ensure that sediment loading remains consistent with the intent of the allocations. At some locations, road closure or abandonment alone may be appropriate and, due to very low erosion potential linked to native vegetation growth on the road surface, additional BMPs may not be necessary.

5.8.2.4 Permitted Point Sources

Due to the limited number of permitted point sources within the watershed, WLAs are only presented in the TMDLs for lower Dog Creek and the lower segment of the Little Blackfoot River. WLAs are expected to be met by adherence to permit conditions.

5.8.3 Allocations and TMDL for Each Stream

The following subsections present of the existing quantified sediment loads, allocations and TMDL for each waterbody.

5.8.3.1 Dog Creek, upper segment (MT76G004_071)

Table 5-34. Sediment Source Assessment, Allocations and TMDL for upper Dog Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	**Unpaved Roads Total**	**1.4**	**0.4**	**70%****
Streambank Erosion	Human Caused	0.8	0.7	8%
	Natural Background	0.1	0.1	0%
	Total	**0.9**	**0.8**	**7%**
Upland Sediment Sources	Forest	10	10	0%
	Range	120	90	25%
	Total	**130**	**100**	**23%**
Total Sediment Load		**132**	**101**	**23%**

*Sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.

**The allocation to roads also includes no loading from undersized, improperly installed, or inadequately maintained culvert. The 25-year event is considered the minimum but the 100-year event is recommended for fish-bearing streams.

5.8.3.2 Dog Creek, lower segment (MT76G004_072)

Note: Because TMDLS are presented on a watershed basis, the TMDL for Lower Dog Creek also includes all loading to the upper segment.

Table 5-35. Sediment Source Assessment, Allocations and TMDL for lower Dog Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	**Unpaved Roads Total**	**5.2**	**1.5**	**71%****
Streambank Erosion	Human Caused	212	175	18%
	Natural Background	22	22	0%
	Total	**234**	**197**	**16%**
Upland Sediment Sources	Forest	504	504	0%
	Range	1,579	1,299	18%
	Pasture	31	4	87%
	Developed	68	68	0%
	Total	**2,182**	**1,876**	**14%**
Point Sources	**Construction Stormwater Permit (MTR103849)**	**4.1**	**1.4**	**65%**
Total Sediment Load		**2,426**	**2,076**	**14%**

*Sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.
**The allocation to roads also includes no loading from undersized, improperly installed, or inadequately maintained culvert. The 25-year event is considered the minimum but the 100-year event is recommended for fish-bearing streams.

5.8.3.3 Elliston Creek (MT76G004_040)

Table 5-36. Sediment Source Assessment, Allocations and TMDL for Elliston Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	Unpaved Roads	0.5	0.1	70%
	Traction Sand	0.4	0.3	33%
	Total	**0.9**	**0.4**	**56%****
Streambank Erosion	Human Caused	2.4	1.9	22%
	Natural Background	0.9	0.9	0%
	Total	**3.3**	**2.8**	**16%**
Upland Sediment Sources	Forest	41	41	0%
	Range	49	38	22%
	Pasture	25	5	80%
	Developed	2	2	0%
	Total	**117**	**85**	**27%**
Total Sediment Load		**121**	**88**	**27%**

*Sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.
**The allocation to roads also includes no loading from undersized, improperly installed, or inadequately maintained culvert. The 25-year event is considered the minimum but the 100-year event is recommended for fish-bearing streams.

5.8.3.4 Little Blackfoot River, upper segment (MT76G004_020)

Table 5-37. Sediment Source Assessment, Allocations and TMDL for the upper Little Blackfoot River

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	**Unpaved Roads Total**	**9.8**	**2.9**	**71%****
Streambank Erosion	Human Caused	207	181	13%
	Natural Background	54	54	0%
	Total	**261**	**235**	**13%**
Upland Sediment Sources	Forest	857	836	2%
	Range	3,179	2,735	14%
	Pasture	18	2	89%
	Developed	1	1	0%
	Total	**4,056**	**3,575**	**12%**
Total Sediment Load		**4,326**	**3,813**	**12%**

*Sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.

**The allocation to roads also includes no loading from undersized, improperly installed, or inadequately maintained culvert. The 25-year event is considered the minimum but the 100-year event is recommended for fish-bearing streams.

5.8.3.5 Little Blackfoot River, lower segment (MT76G004_010)

Note: Because TMDLS are presented on a watershed basis, the TMDL for the Lower Little Blackfoot River also includes all loading to the upper segment.

Table 5-38. Sediment Source Assessment, Allocations and TMDL for the lower Little Blackfoot River

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	Unpaved Roads	38	10	75%
	Traction Sand	39	26	33%
	Total	**77**	**36**	**54%****
Streambank Erosion	Human Caused	2,420	1,890	22%
	Natural Background	234	234	0%
	Total	**2,654**	**2,123**	**21%**
Upland Sediment Sources	Forest	1,832	1,811	1%
	Range	9,117	7,721	15%
	Pasture	894	156	83%
	Developed	204	204	0%
	Total	**12,046**	**9,891**	**18%**
Point Sources	**Construction Stormwater Permits (MTR100000)**	**51**	**18**	**65%**
	Suction Dredge Permit (MTG370318)	**0**	**0**	**0%**
Total Sediment Load		**14,828**	**12,068**	**19%**

*Sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.

**The allocation to roads also includes no loading from undersized, improperly installed, or inadequately maintained culvert. The 25-year event is considered the minimum but the 100-year event is recommended for fish-bearing streams.

5.8.3.6 Snowshoe Creek (MT76G004_080)

Table 5-39. Sediment Source Assessment, Allocations and TMDL for Snowshoe Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	**Unpaved Roads Total**	**2.3**	**0.6**	**74%****
Streambank Erosion	Human Caused	32	25	23%
	Natural Background	2	2	0%
	Total	**34**	**27**	**20%**
Upland Sediment Sources	Forest	26	26	0%
	Range	241	208	14%
	Pasture	80	33	59%
	Total	**348**	**267**	**23%**
Total Sediment Load		**384**	**295**	**23%**

*Sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.
**The allocation to roads also includes no loading from undersized, improperly installed, or inadequately maintained culvert. The 25-year event is considered the minimum but the 100-year event is recommended for fish-bearing streams.

5.8.3.7 Spotted Dog Creek, lower segment (MT76G004_032)

Note: Because TMDLS are presented on a watershed basis, the TMDL for Lower Spotted Dog Creek also includes all loading to the upper segment.

Table 5-40. Sediment Source Assessment, Allocations and TMDL for lower Spotted Dog Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	**Unpaved Roads Total**	**4.0**	**0.8**	**79%****
Streambank Erosion	Human Caused	81	43	47%
	Natural Background	3	3	0%
	Total	**84**	**46**	**45%**
Upland Sediment Sources	Forest	203	203	0%
	Range	1,395	1,118	20%
	Pasture	88	15	83%
	Total	**1,686**	**1,336**	**21%**
Total Sediment Load		**1,774**	**1,383**	**22%**

*Sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.
**The allocation to roads also includes no loading from undersized, improperly installed, or inadequately maintained culvert. The 25-year event is considered the minimum but the 100-year event is recommended for fish-bearing streams.

5.8.3.8 Telegraph Creek, upper segment (MT76G004_051)

Table 5-41. Sediment Source Assessment, Allocations and TMDL for upper Telegraph Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	**Unpaved Roads Total**	**3.8**	**1.1**	**71%**
Streambank Erosion	Human Caused	17	15	11%
	Natural Background	7	7	0%
	Total	**24**	**22**	**8%**
Upland Sediment Sources	Forest	113	95	16%
	Range	35	33	6%
	Pasture	3	0.4	87%
	Total	**151**	**128**	**15%**
Total Sediment Load		**179**	**151**	**16%**

*Sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.
**The allocation to roads also includes no loading from undersized, improperly installed, or inadequately maintained culvert. The 25-year event is considered the minimum but the 100-year event is recommended for fish-bearing streams.

5.8.3.9 Threemile Creek, lower segment (MT76G004_112)

Note: Because TMDLS are presented on a watershed basis, the TMDL for Lower Threemile Creek includes all loading to the upper segment.

Table 5-42. Sediment Source Assessment, Allocations and TMDL for lower Threemile Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	Unpaved Roads	2.2	0.5	79%
	Traction Sand	7.0	4.6	33%
	Total	**9.2**	**5.1**	**45%****
Streambank Erosion	Human Caused	43	39	8%
	Natural Background	1	1	0%
	Total	**44**	**40**	**8%**
Upland Sediment Sources	Forest	45	44	2%
	Range	303	283	7%
	Pasture	334	37	89%
	Total	**691**	**373**	**46%**
Total Sediment Load		**744**	**418**	**44%**

*Sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.
**The allocation to roads also includes no loading from undersized, improperly installed, or inadequately maintained culvert. The 25-year event is considered the minimum but the 100-year event is recommended for fish-bearing streams.

5.8.3.10 Trout Creek (MT76G004_120)

Table 5-43. Sediment Source Assessment, Allocations and TMDL for Trout Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Roads	Unpaved Roads	0.8	0.2	76%
	Traction Sand	9.8	6.5	33%
	Total	**11**	**6.7**	**37%****
Streambank Erosion	Human Caused	105	77	27%
	Natural Background	7	7	0%
	Total	**112**	**84**	**28%**
Upland Sediment Sources	Forest	46	46	0%
	Range	322	267	17%
	Pasture	47	5	89%
	Developed	7	7	0%
	Total	**422**	**325**	**23%**
Total Sediment Load		**545**	**416**	**24%**

*Sediment loads and percent reductions were rounded and may not exactly match the loads presented in the appendices.
**The allocation to roads also includes no loading from undersized, improperly installed, or inadequately maintained culvert. The 25-year event is considered the minimum but the 100-year event is recommended for fish-bearing streams.

5.9 Seasonality and Margin of Safety

Seasonality and margin of safety are both required elements of TMDL development. This section describes how seasonality and margin of safety were applied during development of the Little Blackfoot TPA sediment TMDLs.

5.9.1 Seasonality

All TMDL documents must consider the seasonal applicability of water quality standards as well as the seasonal variability of pollutant loads to a stream. Seasonality was addressed in several ways as described below.

- The applicable narrative water quality standards (**Appendix B**) are not seasonally dependent, although low flow conditions provide the best ability to measure harm to use based on the selected target parameters. The low flow or base flow condition represents the most practical time period for assessing substrate and habitat conditions, and also represents a time period when high fine sediment in riffles or pool tails will likely influence fish and aquatic life. Therefore, meeting targets during this time frame represents an adequate approach for determining standards attainment.
- The substrate and habitat target parameters within each stream are measured during summer or autumn low flow conditions consistent with the time of year when reference stream measurements are conducted. This time period also represents an opportunity to assess effects of the annual snow runoff and early spring rains, which is the typical time frame for sediment loading to occur.
- The DEQ sampling protocol for macroinvertebrates identifies a specific time period for collecting samples based on macroinvertebrate life cycles. This time period coincides with the low flow or base flow condition.

- All assessment modeling approaches are standard approaches that specifically incorporate the yearly hydrologic cycle specific to the Little Blackfoot watershed. The resulting loads are expressed as average yearly loading rates to fully assess loading throughout the year.
- Allocations are based on average yearly loading and the preferred TMDL expression is as an average yearly load reduction, consistent with the assessment methods.

5.9.2 Margin of Safety

Natural systems are inherently complex. Any approach used to quantify or define the relationship between pollutant loading rates and the resultant water quality impacts, no matter how rigorous, will include some level of uncertainty or error. To compensate for this uncertainty and ensure water quality standards are attained, a margin of safety is required as a component of each TMDL. The MOS may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading (U.S. Environmental Protection Agency, 1999b). This plan incorporates an implicit MOS in a variety of ways:

- By using multiple targets to assess a broad range of physical and biological parameters known to illustrate the effects of sediment in streams and rivers. These targets serve as indicators of potential impairment from sediment and also help signal recovery, and eventual standards attainment, after TMDL implementation. Conservative assumptions were used during development of these targets.
- TMDL development was pursued for all streams evaluated, even though some streams were close to meeting all target values. This approach addresses some of the uncertainty associated with sampling variability and site representativeness, and recognizes that sediment source reduction capabilities exist throughout the watershed.
- By using standards, targets, and TMDLs that address both coarse and fine sediment delivery.
- By properly incorporating seasonality into target development, source assessments, and TMDL allocations.
- By using an adaptive management approach to evaluate target attainment and allow for refinement of load allocation, targets, modeling assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development (discussed below in **Section 5.10** and in **Sections 9.0** and **10.0**).
- By using naturally occurring sediment loads as described in ARM 17.30.602(17) (see **Appendix B**) to establish the TMDLs and allocations based on reasonably achievable load reductions for each source category. Specifically, each major source category must meet percent reductions to satisfy the TMDL because of the relative loading uncertainties between assessment methodologies.
- TMDLs are developed at the watershed scale addressing all potentially significant human related sources beyond just the impaired waterbody segment scale. This approach should also reduce loading and improve water quality conditions within other tributary waterbodies throughout the watershed.

5.10 TMDL Development Uncertainties and Adaptive Management

A degree of uncertainty is inherent in any study of watershed processes. While uncertainties are an undeniable fact of TMDL development, mitigation and reduction of uncertainty through adaptive management is a key component of TMDL implementation. The process of adaptive management is predicated on the premise that TMDLs, allocations and their supporting analyses are not static, but are processes that can be subject to periodic modification or adjustment as new information and

relationships are better understood. Within the Little Blackfoot TPA, adaptive management for sediment TMDLs relies on continued monitoring of water quality and stream habitat conditions, continued assessment of impacts from human activities and natural conditions, and continued assessment of how aquatic life and coldwater fish respond to changes in water quality and stream habitat conditions.

As noted in **Section 5.9.2**, adaptive management represents an important component of the implicit margin of safety. This document provides a framework to satisfy the MOS by including sections focused on TMDL implementation, monitoring and adaptive management (**Sections 9.0** and **10.0**). Furthermore, state law (ARM 75-5-703), requires monitoring to gauge progress toward meeting water quality standards and satisfying TMDL requirements. These TMDL implementation monitoring reviews represent an important component of adaptive management in Montana.

Perhaps the most significant uncertainties within this document involve the accuracy and representativeness of 1) field data and target development and 2) the accuracy and representativeness of the source assessments and associated load reductions. These uncertainties and approaches used to reduce uncertainty are discussed in following subsections.

5.10.1 Sediment and Habitat Data Collection and Target Development

Some of the uncertainties regarding accuracy and representativeness of the data and information used to characterize existing water quality conditions and develop water quality targets are discussed below.

Data Collection

The stream sampling approach used to characterize water quality is described within **Appendix C**. To control sampling variability and improve accuracy, the sampling was done by trained environmental professionals using a standard DEQ procedure developed for the purpose of sediment TMDL development (Montana Department of Environmental Quality, 2010b). This procedure defines specific methods for each parameter, including sampling location and frequency to ensure proper representation and applicability of results. Prior to any sampling, a sampling and analysis plan (SAP) was developed to ensure that all activity was consistent with applicable quality control and quality assurance requirements. Site selection was a major component of the SAP, and was based on a stratification process described in **Appendix C**. The stratification work ensured that each stream included one or more sample sites representing a location where excess sediment loading or altered stream habitat could affect fish or aquatic life.

Even with the applied quality controls, a level of uncertainty regarding overall accuracy of collected data will exist. There is uncertainty regarding whether or not the appropriate sites were assessed and whether or not an adequate number of sites were evaluated for each stream. Also, there is the uncertainty of the representativeness of collecting data from one sampling season. These uncertainties are difficult to quantify and even more difficult to eliminate given resource limitations and occasional stream access problems.

Target Development

DEQ evaluated several data sets to ensure that the most representative information and most representative statistic was used to develop each target parameter consistent with the reference approach framework outlined in **Appendix B**. Using reference data is the preferred approach for target setting, however, some uncertainty is introduced because of differing protocols between the available reference data and DEQ data for the Little Blackfoot TPA. These differences were acknowledged within

the target development discussion and taken into consideration during target setting. For each target parameter, DEQ stratified the Little Blackfoot sample results and target data into similar categories, such as stream width or Rosgen stream type, to ensure that the target exceedance evaluations were based on appropriate comparison characteristics.

The established targets are meant to apply under median conditions of natural background and natural disturbance. It is recognized that under some natural conditions such as a large fire or flood event, it may be impossible to satisfy one or more of the targets until the stream and/or watershed recovers from the natural event. The goal, under these conditions, is to ensure that management activities are undertaken in a way that the achievement of targets is not significantly delayed in comparison to the natural recovery time. Also, human activity should not significantly increase the extent of water quality impacts from natural events. For example, extreme flood events can cause a naturally high level of sediment loading that could be significantly increased from a large number of road crossing or culvert failures.

Because sediment target values are based on statistical data percentiles, DEQ recognizes that it may be impossible to meet all targets for some streams even under normal levels of disturbance. On the other hand, some target values may underestimate the potential of a given stream and it may be appropriate to apply more protective targets upon further evaluation during adaptive management. It is important to recognize that the adaptive management approach provides the flexibility to refine targets as necessary to ensure protection of the resource and to adapt to new information concerning target achievability.

5.10.2 Source Assessments and Load Reduction Analyses

Each assessment method introduces uncertainties regarding the accuracy and representativeness of the sediment load estimates and percent load reduction analyses. For each source assessment, assumptions must be made to evaluate sediment loading and potential reductions at the watershed scale, and because of these uncertainties, conclusions may not be representative of existing conditions and achievable reductions at all locations within the watershed. Uncertainties are discussed independently for the three major source categories of bank erosion, upland erosion, and unpaved road crossings.

<u>Bank Erosion</u>

Bank erosion loads were initially quantified using the DEQ protocols (Montana Department of Environmental Quality, 2010b) and the standard BEHI methodology as defined within **Appendix C**. Prior to any sampling, a SAP was developed to ensure that all activity was consistent with applicable quality control and quality assurance requirements. Site selection was a major component of the SAP, and was based on a stratification process described in **Appendix C**. The results were then extrapolated across the Little Blackfoot watershed as defined in **Appendix C** to provide an estimate of the relative bank erosion loading from various streams and associated stream reaches. Based on this process, the relative contribution from human versus natural sources as well as the potential for reduction with the implementation of riparian BMPs was estimated and used for TMDL allocations. Stratifying and assessing each unique reach type was not practical, therefore adding to uncertainty associated with the load extrapolation results.

The final quantification of bank erosion loads was derived from the SWAT model; because the model integrates all sediment sources, it was assumed that load estimates from the model are more accurate than the field estimates. There is some uncertainty with the bank erosion loads from the model because

insufficient data were available to truly calibrate the model and the calibration period was run using a sediment rating curve developed from available data. Additional uncertainty comes from the model because streambank erosion is not directly estimated but is calculated based on the difference between the load at the outlet for each stream and the sum of upland and in-channel loading.

There is additional uncertainty regarding the amount of bank erosion linked to human activities and the specific human sources, as well as the ability to reduce the human related bank erosion levels. This uncertainty is largely associated with historic disturbances, which are extremely difficult to identify the level to which they are still affecting streambank erosion, how much is associated with human sources, and what the dominant human sources are. Even if difficult to quantify, the linkages between human activity such as riparian clearing and bank erosion, are well established and these linkages clearly exist at different locations throughout the Little Blackfoot watershed. Evaluating bank erosion levels, particularly where best management practices have been applied along streams, is an important part of adaptive management that can help define the level of human-caused bank erosion as well as the relative impact that bank erosion has on water quality throughout the Little Blackfoot watershed.

Upland Erosion

A professional modeler determined upland erosion loads by applying a landscape soil loss equation (USLE) within the SWAT model as defined in **Appendix D**. As with any model, there will be uncertainty in the model input parameters including uncertainties regarding land use, land cover and assumptions regarding existing levels of BMP application. For example, only one vegetative condition was assigned per land cover type (i.e., cannot reflect land management practices that change vegetative cover from one season to another), so an average condition is used for each scenario in the model. However, the model uses factors such as plant growth and surface residue to alter the cover slightly on a daily basis. Although limited land use changes occurred over the model simulation period (or since) and it is believed that the model is representative of conditions within the watershed, the recent change in land ownership the Spotted Dog Creek drainage (see FWP land in **Figure A-14**) was not incorporated into the model.

The upland erosion model integrates sediment delivery based on riparian health, with riparian health evaluations linked to the stream stratification work discussed above. The potential to reduce sediment loading was based on modest land cover improvements to reduce the generation of eroded sediment particles in combination with riparian improvements. The uncertainty regarding existing erosion prevention BMPs and ability to reduce erosion with additional BMPs represents a level of uncertainty. Also, because model is not spatial, the riparian health improvement was simulated with the use of filter strips, which are applied by unique land category (HRU) and include both riparian and upland areas. An attempt was made to minimize uncertainty by looking at the HRU distribution and applying filter strips to HRUs with a substantial amount of riparian area. Additionally, filter strips were primarily applied to HRUs where grazing is most abundant or those where field observations indicate sediment loading could be decreased through improved riparian vegetation. Although some uncertainty is introduced by simulating riparian improvements in this manner, the exercise was performed within the model so that the pollutant removal capacity of the filters could be simulated and because the filter strips were used as a BMP for both sediment and nutrient TMDLs. Even with these uncertainties, the ability to reduce upland sediment erosion and delivery to nearby waterbodies is well documented in literature, the filter strips widths used are based on literature values, and the estimated reductions are consistent with literature values for riparian buffers.

Roads

The most significant road sediment load was linked to unpaved road crossings. As described in **Appendix E**, the road crossings sediment load was estimated via a standardized simple yearly model developed by the U.S. Forest Service. This model relies on a few basic input parameters that are easily measured in the field, as well as inclusion of precipitation data from local weather stations. A total of 22 sites were randomly selected for evaluation, representing about 5% of the total population of roads. The results from these 22 sites were extrapolated to the whole population of roads stratified by landscape type. The reduction potential for all roads was also based on data collected from the 22 sites taking into consideration existing BMP conditions. Random selection of the stratified sites was intended to capture a representative subset of the road crossings for existing conditions and level of BMP implementation, but some uncertainty is introduced because of the small sample size relative to the total number of road crossings. There is some uncertainty about if the needed reductions are comparable across ownership categories; as discussed in **Section 5.7.3.1**, the USFS roads typically had a shorter contributing length and lower load than the private crossings. Although this suggests lower reductions may be needed on federal roads, because of the distribution of federal roads across the landscape and extrapolation of loads by landscape setting, it is believed that the load estimates and reductions are reasonable. There is a high potential for loading from unpaved roads throughout the watershed and ultimately, the needed reductions will vary by road, regardless of ownership.

6.0 NUTRIENT TMDL COMPONENTS

This portion of the document focuses on nutrients (nitrogen and phosphorus forms) as a cause of water quality impairments in the Little Blackfoot River TPA. It includes: 1) the mechanisms by which nutrients can impair beneficial uses, 2) the specific stream segments of concern, 3) the presently available data pertaining to nutrients impairment characterization in the watershed, including target development and a comparison of existing water quality to targets, 4) quantification of the various contributing sources of nutrients based on recent studies, and 5) identification of and justification for the nutrients TMDLs and the TMDL allocations.

6.1 NUTRIENT IMPACTS TO BENEFICIAL USES

Nitrogen and phosphorus are naturally occurring chemical elements required for the healthy and stable functioning of aquatic ecosystems. Streams in particular are dynamic systems that are dependent on a balance between nutrient additions, consumption by autotrophic organisms, cycling of biologically fixed nitrogen and phosphorus into higher trophic levels, and cycling of organically fixed nutrients into inorganic forms with biological decomposition. Nutrient additions to streams from natural landscape erosion, groundwater discharge and in-stream biological decomposition maintain a balance between organic and inorganic nutrient forms. Human influences may alter nutrient cycling pathways causing damage to biological stream function and water quality degradation.

Excess nitrogen in the form of dissolved ammonia (which is typically associated with wastewater) can be toxic to fish and other aquatic life, and elevated nitrate in drinking water can inhibit normal hemoglobin function in infants. The current drinking water nitrate limit is 10 mg/L (Montana Department of Environmental Quality, 2010a). Beside the direct effects of excess nitrogen, elevated inputs of nitrogen and phosphorus from human sources can accelerate aquatic algal growth to nuisance levels. Respiration and decomposition of excessive algal biomass depletes the supply of dissolved oxygen, which can cause mortality of fish and other forms of aquatic life. Nutrient concentrations in surface water are considered controlling factors in formation of blue-green algae blooms (Priscu, 1987), which can produce toxins that can be lethal to aquatic life, wildlife, livestock and humans. Aside from the toxicity effects, nuisance algae tend to be less palatable and can cause shifts in the macroinvertebrate community structure, which may also affect fish, who feed on macroinvertebrates (U.S. Environmental Protection Agency, 2010). Additionally, changes in water clarity, fish community structure, and aesthetics can detract from recreational uses such as fishing, swimming, and boating (Suplee, et al., 2009). Nuisance algae can also increase treatment costs of drinking water or pose health risks if ingested in drinking water (World Health Organization, 2003).

6.2 STREAM SEGMENTS OF CONCERN

A total of four waterbody segments in the Little Blackfoot TPA appeared on the 2010 Montana 303(d) List due to phosphorus and/or nitrogen impairments (**Table 6-1**): Dog Creek (lower segment), Little Blackfoot River (lower segment), Snowshoe Creek, and Spotted Dog Creek (lower segment). Stream segments of concern in the Little Blackfoot River watershed are those streams listed as impaired for phosphorus and/or nitrogen on the 2010 303(d) List and include:

Table 6-1. Waterbody segments in the Little Blackfoot TPA with nutrient listings on the 2010 303(d) List

Stream Segment	Waterbody ID	Nutrient Pollutant Listing
DOG CREEK, Meadow Creek to the mouth (Little Blackfoot River)	MT76G004_072	Nitrate+Nitrite
LITTLE BLACKFOOT RIVER, Dog Creek to the mouth (Clark Fork River)	MT76G004_010	Nitrate+Nitrite
SNOWSHOE CREEK, headwaters to the mouth (Little Blackfoot River)	MT76G004_080	Nitrate+Nitrite
SPOTTED DOG CREEK, forest boundary to the mouth (Little Blackfoot River)	MT76G004_032	Total Phosphorus

Two additional waterbody segments were also identified as streams of concern based on data collected to assist with the source assessment for the lower Little Blackfoot River and were evaluated as part of the nutrient TMDL development process. They include the lower segment of Carpenter Creek (MT76G004_092) and the lower segment of Threemile Creek (MT76G004_112).

6.3 Water Quality Data Sources

To characterize nutrient conditions for TMDL development purposes, a nutrient data compilation was completed and additional monitoring was performed by DEQ. The following data sources represent the primary information used to characterize water quality.

1) **DEQ TMDL Sampling**: DEQ conducted water quality sampling from 2008 through 2010 in support of nutrient TMDL development. Water samples were collected and analyzed for nutrients at 22 sites during 1 high flow and 2 growing season (i.e., July-September) events in 2008 and at 23 sites during 1 growing season event in 2009. To provide additional supporting information regarding summer nutrient concentrations and potential sources, 27 sites were sampled during 3 growing season events in 2010 (**Figure 6-1**).

   Sample locations bracketed tributaries and changes in land use type or management. In addition to water quality samples, algal samples were collected during growing season sampling in 2008 through 2010 and analyzed for chlorophyll-*a* concentration and ash free dry weight (AFDW). AFDW is a measurement that captures living and dead algal biomass, and is particularly helpful for streams where some or all of the algae are dead (because chlorophyll-*a* only measures the living algae).
2) **DEQ Assessment Files**: The files contain information used to make the existing nutrient impairment determinations. This includes water quality and algal data collected between 1998 and 2005, as well as other historical information collected or obtained by DEQ. Macroinvertebrate data were collected on some streams in 2004 (**Figure 6-1**).
3) **USGS gage on the Little Blackfoot River near Garrison**: Nutrient samples were collected throughout the year by USGS and the Tri-State Water Quality Council (to evaluate loading to the Clark Fork River), primarily between 1998 and 2002 (**Figure 6-1**).
4) **Watershed Health Clinic at University of Montana**: Nutrient samples were collected at four locations monthly along the Little Blackfoot River between May and September from 1999 to 2002 for the Missoula Water Quality District.

Growing season nutrient data used for the data review and TMDL development are included in **Appendix G**. Other nutrient data from the watershed is publicly available through EPA's STORET water quality database and the DEQ's EQuIS water quality database.

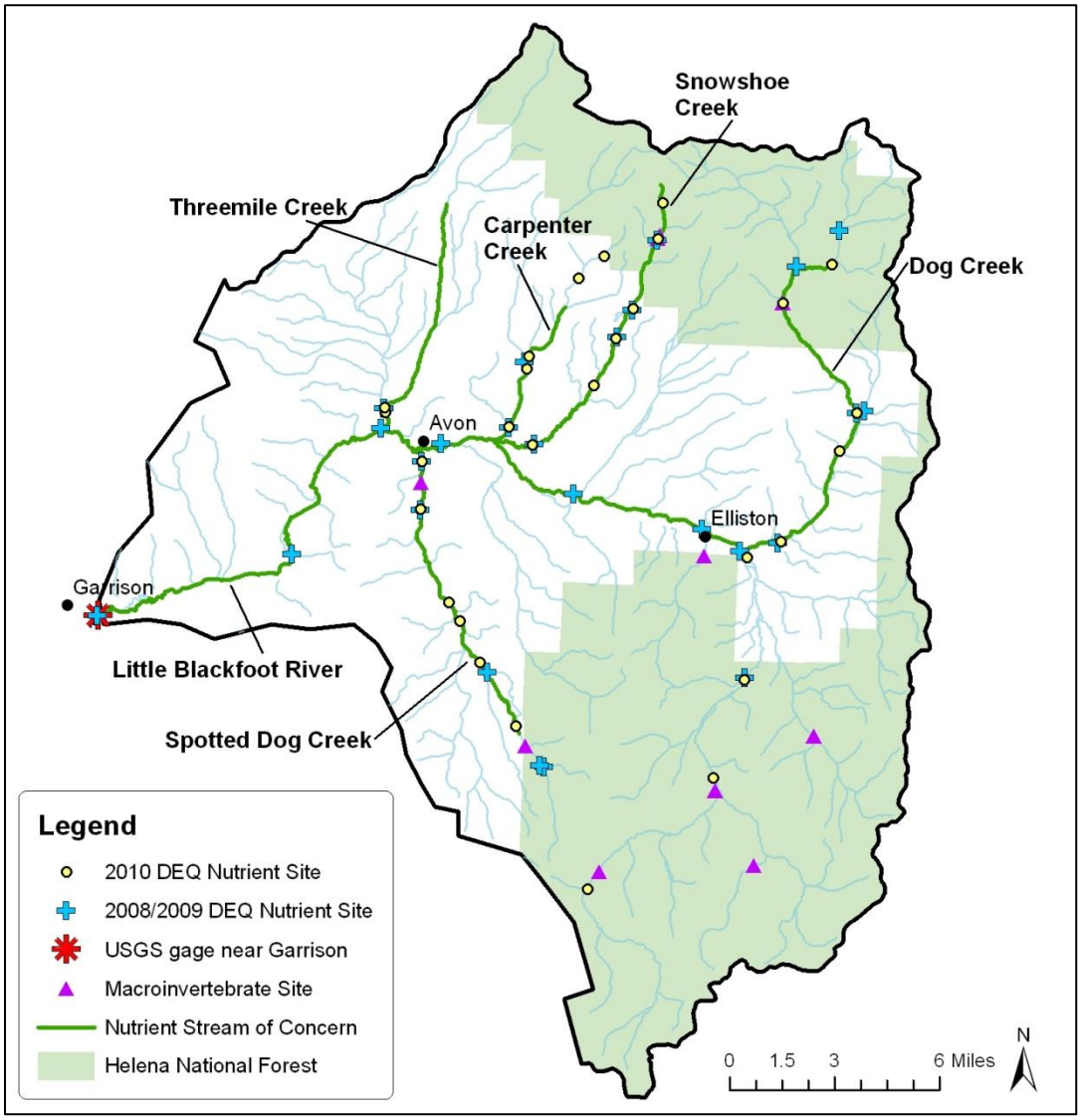


Figure 6-1. Nutrient sampling sites on the streams of concern.

6.4 Nutrient Water Quality Targets and Comparison to Existing Conditions

TMDL water quality targets are numeric indicator values used to evaluate attainment of water quality standards, and are discussed conceptually in **Section 4.0**. The following section presents nutrient water quality targets, and compares those target values to recently collected nutrient data in the Little Blackfoot River watershed following DEQ's draft assessment methodology *(Suplee and Sada de Suplee, 2011)*. To be consistent with DEQ's draft assessment methodology and because of improvements in analytical methods, only data from the past 10 years (2001-2011) are included in the review of existing data. Additionally, many of the nutrient samples collected prior to 2005 were analyzed for Total Kjeldahl

Nitrogen (TKN), which has since been replaced by DEQ with Total Persulfate Nitrogen as the preferred analytical method for total nitrogen; samples analyzed for TKN may have a bias and are excluded from the data review.

6.4.1 Nutrient Water Quality Targets

Although Montana's water quality standards for nutrients are currently narrative, draft numeric nutrient criteria have been developed by the DEQ, and are the basis of the nutrient water quality targets for the Little Blackfoot TPA. The draft nutrient criteria are the result of research initiated by DEQ in 2001 and are based on 1) the results of a public perception survey regarding what level of algae was perceived as 'undesirable' (Suplee, et al., 2009), 2) stressor-response studies performed by DEQ to determine the maximum nutrient concentrations that will maintain algal growth below undesirable levels, 3) a literature review of stressor-response studies, and 4) a comparison of nutrient stressor-response thresholds to eco-regionally stratified reference data from Montana (Suplee, et al., 2008).

Nutrient targets for nitrate+nitrite (NO_3+NO_2), total nitrogen (TN), total phosphorus (TP), and chlorophyll-*a* are presented in **Table 6-2** and based on the draft nutrient criteria for the Middle Rockies level 3 ecoregion, which encompasses the Little Blackfoot River watershed. Both the nutrient criteria and the nutrient targets within this document apply during the summer growing season from July 1st through Sept 30th, when algal growth has the highest potential to affect beneficial uses.

Table 6-2. Nutrient Targets for the Little Blackfoot TPA

Parameter	Target Value
Nitrate+Nitrite (NO_3+NO_2)	≤ 0.100 mg/L
Total Nitrogen (TN)	≤ 0.300 mg/L
Total Phosphorus (TP)	≤ 0.030 mg/L
Chlorophyll-*a* (or Ash Free Dry Weight)	≤ 120 mg/m² (≤35 g AFDW/m^2)

6.4.2 Existing Conditions and Comparison to Water Quality Targets

Evaluation of nutrient target attainment is conducted by comparing existing water quality conditions to the water quality targets in **Table 6-2** following the methodology in the DEQ draft guidance document, *2011 Assessment Methodology for Determining Wadeable Stream Impairment due to Excess Nitrogen and Phosphorus Levels (Suplee and Sada de Suplee, 2011)*. For each waterbody segment, a data summary will be presented along with a comparison of existing data to targets using the assessment methodology and a TMDL development determination. Because most of the impairment listings are based on older data or were listed prior to development of numeric criteria, each stream segment will be evaluated for impairment from NO_3+NO_2, TN, and TP. Although the data review in this section does not constitute an official impairment determination, data were evaluated following the assessment methodology and TMDL development determinations will be dependent on the outcome of the data evaluation.

The assessment methodology utilizes two statistical tests (Exact Binomial Test and the One-Sample Student's T-test for the Mean) to evaluate water quality data for compliance with established target values. In general, compliance with water quality targets is <u>not</u> attained when nutrient chemistry data demonstrates a target exceedance rate of >20% (Exact Binomial Test), when mean water quality nutrient chemistry results exceed target values (Student T-test), or when a single chlorophyll-*a* result exceeds benthic algal target concentrations (120 mg/m^2 or 35 g AFDW/m^2). Where water chemistry and algae data do not provide a clear determination of impairment status, or other limitations exist,

macroinvertebrate biometrics (HBI >4.0) are considered in further evaluating compliance with nutrient targets, as directed by the assessment methodology. Lastly, inherent to any impairment determination is the existence of human sources of pollutant loading anthropogenic sources of nutrients must be present for a stream to be considered impaired. Note: to ensure a higher degree of certainty for removing an impairment determination and making any new impairment determination, the statistical tests are configured differently for an unlisted nutrient form versus a listed nutrient form, which may result in a different number of allowable exceedances for nutrients within a single stream segment. This helps assure that assessment reaches do not vacillate between listed and delisted status by the change in results from a single additional sample.

6.4.2.1 Carpenter Creek, lower segment (MT76G004_092)

Lower Carpenter Creek is not listed on the 2010 303(d) List for nutrient impairment but is included in this review because data collected to assist with TMDL development for the Little Blackfoot River indicated elevated nutrient concentrations. The lower segment of Carpenter Creek extends 4.9 miles from the confluence with Basin Creek to the mouth at the Little Blackfoot River. Prior to recent monitoring, nutrient data had not been collected on Carpenter Creek since 1983.

Between 2008 and 2010, nine growing season nutrient samples were collected on lower Carpenter Creek (**Figure 6-1**). Algal samples were analyzed for chlorophyll-*a* and AFDW between 2008 and 2010, but no recent macroinvertebrate data are available for this segment. Summary nutrient data statistics and assessment method evaluation results for lower Carpenter Creek are provided in **Tables 6-3** and **6-4**, respectively. Of the samples, NO_3+NO_2 and TN passed both statistical tests, but TP failed both statistical tests and all TP samples exceeded the target value. Although the chlorophyll samples met the target value, TP failing both statistical tests indicates impairment and a TP TMDL will be developed.

Table 6-3. Nutrient Data Summary for Lower Carpenter Creek

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2008-2010	9	0.005	0.01	0.007	0.01
TN	2008-2010	9	0.10	0.31	0.24	0.28
TP	2008-2010	9	0.039	0.061	0.049	0.055
Chlorophyll-*a*	2008-2010	2	8	16	12	NA
AFDW	2008-2010	1	NA	18	NA	NA

Table 6-4. Assessment Method Evaluation Results for Lower Carpenter Creek

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a Test Result	Indicates Impairment?
Nitrate+Nitrite	9	0.100	0	Pass	Pass	Pass	No
TN	9	0.300	1	Pass	Pass	Pass	No
TP	9	0.030	9	Fail	Fail	Pass	Yes

6.4.2.2 Dog Creek, lower segment (MT76G004_072)

Lower Dog Creek is listed on the 2010 303(d) List for NO_3+NO_2 nutrient impairment. The lower segment of Dog Creek flows 12.4 miles from its confluence with Meadow Creek to the mouth at the Little Blackfoot River. Lower Dog Creek is listed for NO_3+NO_2 based on nutrient, chlorophyll-*a*, and macroinvertebrate samples from 1998 and attributed to grazing and other agricultural sources.

Between 2007 and 2010, 17 growing season nutrient samples were collected on lower Dog Creek (**Figure 6-1**). Algal samples were analyzed for chlorophyll-*a* and AFDW in between 2007 and 2010, and one

macroinvertebrate sample was collected in 2004. Summary nutrient data statistics and assessment method evaluation results for lower Dog Creek are provided in **Tables 6-5** and **6-6**, respectively. The data for all nutrient forms passed both statistical tests; neither nitrogen form (NO_3+NO_2 nor TN) had a single sample that exceeded the target value but four TP samples exceeded the target value. One algal sample exceeded the AFDW target, which indicates excess algae are impairing beneficial uses. Additionally, a macroinvertebrate sample from 2004 had a HBI score greater than 4, which also indicates nutrient impairment. This situation is typically the result of excess algae taking up nutrients at a high rate and causing low instream nutrient concentrations. Based on there being no target exceedances for nitrogen but four target exceedances for TP, this indicates that the impairment is due to TP instead of NO_3+NO_2 and a TP TMDL will be developed for lower Dog Creek.

Table 6-5. Nutrient Data Summary for Lower Dog Creek

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2007-2010	17	0.005	0.010	0.006	0.010
TN	2007-2010	17	0.025	0.290	0.142	0.198
TP	2007-2010	17	0.011	0.038	0.025	0.031
Chlorophyll-*a*	2007-2010	9	6	37	19	NA
AFDW	2010	4	8	145	46	NA
Macroinvertebrate HBI	2004	1	NA	4.16	NA	NA

Table 6-6. Assessment Method Evaluation Results for Lower Dog Creek

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a Test Result	Indicates Impairment?
Nitrate+Nitrite	17	0.100	0	Pass	Pass	Fail	No
TN	17	0.300	0	Pass	Pass	Fail	No
TP	17	0.030	4	Pass	Pass	Fail	Yes

6.4.2.3 Little Blackfoot River, lower segment (MT76G004_010)

The lower segment of the Little Blackfoot River is listed on the 2010 303(d) List for NO_3+NO_2 nutrient impairment. The lower segment of the Little Blackfoot River flows 26.2 miles from its confluence with Dog Creek to its mouth at the Clark Fork River. The lower Little Blackfoot River was originally listed based on data from the late 1970s and remained listed based on elevated algal and NO_3+NO_2 concentrations in the 1990s and early 2000s, particularly downstream of Avon. The impairment is attributed to grazing and other agricultural sources.

Between 2001 and 2010, 40 growing season nutrient samples were collected on the lower segment of the Little Blackfoot River (**Figure 6-1**). Algal samples were analyzed for chlorophyll-*a* and AFDW in 2008 and 2009, but no recent macroinvertebrate data are available for this segment. Summary nutrient data statistics and assessment method evaluation results for the lower Little Blackfoot River are provided in **Tables 6-7** and **6-8**, respectively. The NO_3+NO_2 and TN data passed both statistical tests and had no samples exceed the target value, but the TP data failed the binomial test and 14 samples exceeded the target value. One algal sample exceeded the AFDW target, which indicates excess algae are impairing beneficial uses. Based the elevated AFDW value, TP failing the binomial test, and the 14 target exceedances for TP, this indicates that the impairment is due to TP instead of NO_3+NO_2, and a TP TMDL will be developed for the lower segment of the Little Blackfoot River.

Table 6-7. Nutrient Data Summary for the Lower Segment of the Little Blackfoot River

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2001-2010	40	0.003	0.050	0.010	0.010
TN	2001-2010	15	0.050	0.160	0.103	0.150
TP	2001-2010	40	0.010	0.044	0.026	0.034
Chlorophyll-*a*	2008-2009	10	0.1	40	15	NA
AFDW	2009	1	NA	81	NA	NA

Table 6-8. Assessment Method Evaluation Results for the Lower Segment of the Little Blackfoot River

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a Test Result	Indicates Impairment?
Nitrate+Nitrite	40	0.100	0	Pass	Pass	Fail	No
TN	15	0.300	0	Pass	Pass	Fail	No
TP	40	0.030	14	Fail	Pass	Fail	Yes

6.4.2.4 Snowshoe Creek (MT76G004_080)

Snowshoe Creek is listed on the 2010 303(d) List for NO_3+NO_2 nutrient impairment. Snowshoe Creek extends 10.7 miles from the headwaters to its mouth at the Little Blackfoot River. The NO_3+NO_2 listing is based on nutrient, algal, and macroinvertebrate data from a 2004 DEQ assessment and is attributed to riparian grazing and unknown sources.

Between 2004 and 2010, 29 growing season nutrient samples were collected on Snowshoe Creek (**Figure 6-1**). Algal samples were analyzed for chlorophyll-*a* and AFDW between 2008 and 2010, and one macroinvertebrate sample was collected in 2004. Summary nutrient data statistics and assessment method evaluation results for Snowshoe Creek are provided in **Tables 6-9** and **6-10**, respectively. The NO_3+NO_2 data failed the binomial test and seven samples exceeded the target value. The TN data passed both statistical tests and had zero exeedances of the target value, and the TP data passed both statistical tests but had seven exceedances of the target value. One algal sample exceeded the AFDW target and another sample exceeded the chlorophyll-*a* target value, which indicates excess algae are impairing beneficial uses. The macroinvertebrate sample from 2004 was meeting the target and had a HBI score less than 4. Although seven samples exceeded the TP target value, because it passed both statistical tests and Snowshoe Creek is currently listed for NO_3+NO_2 (but not TP), this indicates the excess algal growth is associated with NO_3+NO_2. Therefore, the data support the existing listing and a NO_3+NO_2 TMDL will be developed for Snowshoe Creek. Note, a TN TMDL would typically be written to address a NO_3+NO_2 problem, but because the excess NO_3+NO_2 in the stream is not reflected in the TN data, the TMDL will be for NO_3+NO_2.

Table 6-9. Nutrient Data Summary for Snowshoe Creek

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2004-2010	29	0.005	0.140	0.056	0.110
TN	2004-2010	28	0.080	0.230	0.150	0.206
TP	2004-2010	29	0.002	0.064	0.018	0.031
Chlorophyll-*a*	2008-2010	9	1	486	89	NA
AFDW	2010	4	5	64	26	NA
Macroinvertebrate HBI	2004	1	NA	3.00	NA	NA

Table 6-10. Assessment Method Evaluation Results for Snowshoe Creek

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a Test Result	Indicates Impairment?
Nitrate+Nitrite	29	0.100	7	Fail	Pass	Fail	Yes
TN	28	0.300	0	Pass	Pass	Fail	No
TP	29	0.030	7	Pass	Pass	Fail	No

6.4.2.5 Spotted Dog Creek, lower segment (MT76G004_032)

Lower Spotted Dog Creek is listed on the 2010 303(d) List for TP nutrient impairment. The lower segment of Spotted Dog Creek extends 10.7 miles from the US Forest Service boundary to its mouth at the Little Blackfoot River. The TP listing is based on nutrient, algal, and macroinvertebrate data from a 2005 DEQ assessment and is attributed to riparian grazing.

Between 2005 and 2010, 28 growing season nutrient samples were collected on lower Spotted Dog Creek (**Figure 6-1**). Algal samples were analyzed for chlorophyll-*a* and AFDW in between 2008 and 2010, and one macroinvertebrate sample was collected in 2004. Summary nutrient data statistics and assessment method evaluation results for lower Spotted Dog Creek are provided in **Tables 6-11** and **6-12**, respectively. The TP data failed both statistical tests and 20 of the 28 samples exceeded the target value. The data for both nitrogen forms (NO_3+NO_2 and TN) passed both statistical tests; no NO_3+NO_2 samples exceeded the target value and only one TN sample exceeded the target value. Two algal samples exceeded the AFDW target, which indicates excess algae are impairing beneficial uses. The macroinvertebrate sample from 2004 was meeting the target and had a HBI score less than 4. Based on the data review, excess algal growth is a result of excess TP and not nitrogen. The data support the current listing and a TP TMDL will be developed for lower Spotted Dog Creek.

Table 6-11. Nutrient Data Summary for Lower Spotted Dog Creek

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2005-2010	28	0.005	0.01	0.006	0.009
TN	2005-2010	28	0.025	0.320	0.167	0.248
TP	2005-2010	28	0.017	0.061	0.036	0.043
Chlorophyll-*a*	2008-2010	11	0.1	31	14	NA
AFDW	2010	6	18	634	133	NA
Macroinvertebrate HBI	2004	1	NA	2.59	NA	NA

Table 6-12. Assessment Method Evaluation Results for Lower Spotted Dog Creek

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a Test Result	Indicates Impairment?
Nitrate+Nitrite	28	0.100	0	Pass	Pass	Fail	No
TN	28	0.300	1	Pass	Pass	Fail	No
TP	28	0.030	20	Fail	Fail	Fail	Yes

6.4.2.6 Threemile Creek, lower segment (MT76G004_112)

Lower Threemile Creek is not listed on the 2010 303(d) List for nutrient impairment but is included in this review because data collected to assist with TMDL development for the Little Blackfoot River indicated elevated nutrient concentrations. Lower Threemile Creek flows 7 miles from Quigley Ranch Reservoir to the mouth at the Little Blackfoot River. The DEQ assessment file mentions excess algae observed during a 1991 assessment but contains no nutrient data.

Between 2008 and 2010, nine growing season nutrient samples were collected on lower Threemile Creek (**Figure 6-1**). Algal samples were analyzed for chlorophyll-*a* and AFDW between 2008 and 2010, but no recent macroinvertebrate data are available for this segment. Summary nutrient data statistics and assessment method evaluation results for lower Threemile Creek are provided in **Tables 6-13** and **6-14**, respectively. The data for TP and TN failed both statistical tests; all TP samples exceeded the target value and 8 of the 9 TN samples exceeded the target value. The NO_3+NO_2 data passed both statistical tests and two of the samples exceeded the target value. One of the algal samples exceeded the AFDW target, which indicates excess algae are impairing beneficial uses. Therefore, the recent data indicate excess nutrients are limiting beneficial uses in lower Threemile Creek and nutrient TMDLs will be developed for TP and TN.

Table 6-13. Nutrient Data Summary for Lower Threemile Creek

Nutrient Parameter	Sample Timeframe	n	min	max	mean	80th percentile
Nitrate+Nitrite	2008-2010	9	0.005	0.17	0.058	0.094
TN	2008-2010	9	0.22	0.94	0.541	0.612
TP	2008-2010	9	0.050	0.077	0.067	0.074
Chlorophyll-*a*	2008-2010	5	9	47	19	NA
AFDW	2010	3	7	161	65	NA

Table 6-14. Assessment Method Evaluation Results for Lower Threemile Creek

Nutrient Parameter	n	Target Value (mg/l)	Target Exceedances	Binomial Test Result	T-test Result	Chl-a Test Result	Indicates Impairment?
Nitrate+Nitrite	9	0.100	2	Pass	Pass	Fail	No
TN	9	0.300	8	Fail	Fail	Fail	Yes
TP	9	0.030	9	Fail	Fail	Fail	Yes

6.4.3 Nutrient TMDL Development Summary

Although most of the 2010 303(d) listings in the Little Blackfoot TPA are for NO_3+NO_2, recent data indicate excess phosphorus is the primary cause of nutrient impairment. The only NO_3+NO_2 listing supported by recent data is for Snowshoe Creek. However, five TP TMDLs will be developed, including two for unlisted segments. Additionally, a TN TMDL will be developed for a currently unlisted segment. Overall, these changes are the result of limited data at the time the waterbody segments were listed and different criteria that were used as the listing basis. **Table 6-15** summarizes the 2010 nutrient 303(d) listings for the Little Blackfoot TPA and TMDL development determinations for the waterbodies of concern identified in **Section 6.3**.

Table 6-15. Summary of Nutrient TMDL Development Determinations

Stream Segment	Waterbody ID	2010 303(d) Nutrient Impairments	TMDLs Prepared
CARPENTER CREEK, Basin Creek to the mouth (Little Blackfoot River)	MT76G004_092	none	TP
DOG CREEK, Meadow Creek to the mouth (Little Blackfoot River)	MT76G004_072	NO_3+NO_2	TP
LITTLE BLACKFOOT RIVER, Dog Creek to the mouth (Clark Fork River)	MT76G004_010	NO_3+NO_2	TP
SNOWSHOE CREEK, headwaters to the mouth (Little Blackfoot River)	MT76G004_080	NO_3+NO_2	NO_3+NO_2
SPOTTED DOG CREEK, forest boundary to the mouth (Little Blackfoot River)	MT76G004_032	TP	TP
THREEMILE CREEK, Quigley Reservoir to the mouth (Little Blackfoot River)	MT76G004_112	none	TP, TN

6.5 Nutrient Source Assessment and Quantification

This section summarizes the assessment approach, current nutrient load estimates, and the rationale for load reductions and allocations within the Little Blackfoot TPA. The nutrient data discussed in **Section 6.3** were used to identify whether nitrogen and/or phosphorus are causing impairment, however, the primary tool for evaluating loading contributions from different sources was the Soil and Water Assessment Tool (SWAT), which is a watershed scale model. An overview of the model is provided below followed by a discussion of each source category.

6.5.1 SWAT Model

SWAT is a physically based watershed-scale loading model and was used to model the Little Blackfoot watershed. SWAT models the nitrogen and phosphorus cycles in soil. Precipitation dissolves mineral nitrogen and phosphorus from the soil surface and transports it in surface runoff. Water percolates through the soil and dissolves mineral nitrogen and phosphorus, which is then carried into streams via lateral (soil) flow and shallow groundwater flow. Rainfall deposits nitrogen (but not phosphorus) on the land surface due to atmospheric deposition. Dead and dying biomass is picked up by surface runoff and carried into receiving streams as well. Additionally, other nutrient sources such as cattle manure and fertilizer application are present within the watershed. These processes affect each land-use type to differing degrees based on the amount of biomass, infiltration capacity, soil types, and size of each land-use type, as well as the external loading applied.

SWAT also models a number of in-stream processes, including algal growth and uptake, the nitrogen and phosphorus cycles, organic settling, and carbonaceous biological oxygen demand, to name a few. These processes depend on many variables such as water quality, climatic data, point sources, and sub-basin specific loading rates.

6.5.1.1 Model Setup Overview

The Little Blackfoot watershed was divided into sub-basins within the model, with a sub-basin for each stream segment requiring a TMDL. Each sub-basin was further divided into areas with unique land use, management, slope, and soil attributes called hydrologic response units (HRUs). HRUs are not spatially connected within each sub-basin, and all HRUs route directly into the stream reach. The model

hydrology was calibrated to the USGS gage near Garrison using discharge and climatic data. Because sediment and nutrient data were limited at the gage, rating curves were developed using discharge measurements and the available sediment/nutrient data in lieu of calibration as a predictive tool for sediment/nutrient concentrations across various flows. The model uses daily inputs and can generate outputs on timescales ranging from daily to annual. Because the nutrient targets apply from July 1 through September 30, model outputs summarized in this section are for that time frame only.

6.5.2 Source Categories

No nutrient point sources exist in the watershed and agriculture is the primary source category in the Little Blackfoot TPA. The model evaluated loading from the following sources:

- Agriculture (pasture and rangeland)
- Forest (and wetlands)
- Residential Development
- Septic

Source assessment information for natural background as well as all sources evaluated within the SWAT model is described in detail within this section. Note: Although road-related sediment was incorporated into the model for the sediment TMDLs, it is not discussed within this section because it is not a significant nutrient source; only a small fraction of phosphorus is bound to the sediment and overall the road-related sediment was a small fraction of the total sediment load.

6.5.2.1 Natural Background

The natural background component of nutrient loading was not explicitly evaluated by the model, but a significant component of the forest category and portions of all other categories are associated with background loading.

Geology

Portions of the watershed near the mouth of the Little Blackfoot River and near Elliston, Gimlet Creek in the Sixmile Creek portion of the Threemile Creek drainage, and the lower half of Dog Creek are underlain by the Phosphoria Formation (Swanson, 1973) (denoted in pink in **Figures A-17** and **A-18**). This formation has the potential to cause elevated phosphorus concentrations in groundwater and surface water, and it was historically mined for phosphate in the Dog and Threemile creek watersheds. Dissolved phosphorus concentrations from GWIC monitoring wells are available for 27 locations within the watershed, including lower Dog Creek, upper Threemile Creek, and along the mainstem Little Blackfoot River (**Figure A-8**). All samples were below the detection limit (0.05mg/L) except for a single sample on lower Snowshoe Creek. Well depths ranged from 35 to 500 feet (averaging 113 feet), indicating the formation is not likely influencing groundwater in these locations, even at shallow depths.

A study of the geologic contribution of the Phosphoria Formation to Gold Creek in the nearby Upper Clark Fork drainage found a significant geologic influence (Carey, 1991). In that study as well as in research by Pringle and Triska (1991), dissolved phosphorus concentrations increased during the summer as flow decreased. In a review of nutrient data collected by the University of Montana between 1999 and 2002 on the mainstem Little Blackfoot River near Elliston and the mouth, dissolved phosphorus concentrations did not tend to increase during low flow. Additionally, dissolved and total phosphorus concentrations in Gold Creek were typically more than triple the concentration in the Little Blackfoot River and Dog Creek. Both of these differences between Gold Creek and the Little Blackfoot watershed indicate that although geologic phosphorus may be elevating the background phosphorus

concentration in Dog Creek and portions of the Little Blackfoot River relative to other streams in the watershed, human sources are the main factor in phosphorus water quality target exceedances in those areas.

It is more difficult to determine the influence of the Phosphoria Formation on phosphorus concentrations within Threemile Creek because no dissolved phosphorus data is available for Threemile Creek and due to access issues, the most upstream water samples were near the outlet of Sixmile Creek (approximately 0.8 miles upstream where Threemile Creek flows into the Little Blackfoot River). Total phosphorus concentrations at the mouth of Threemile Creek were greater during high flow sampling in 2008 than during low flow sampling that year but the particulate fraction of total phosphorus tends to be greater during high flow, making it difficult to draw conclusions from the 2008 data. In a comparison of low flow total phosphorus data from 2009 and 2010 at the mouth of Sixmile Creek and in Threemile Creek just upstream of its confluence with Sixmile Creek, all concentrations were greater than the target but values were similar and there was no consistent trend of higher concentrations in Sixmile Creek. Because the Phosphoria Formation is only present in the upper portion of the Sixmile Creek drainage and controllable human phosphorus sources are present in the Sixmile Creek drainage and the Threemile Creek drainage upstream of Sixmile Creek, it is assumed that geology alone is not causing the water quality target exceedances. Future monitoring of total and dissolved phosphorus is recommended during the growing and non-growing season in multiple locations within the Threemile Creek watershed to better evaluate phosphorus sources and the geologic contribution.

It is important to note that mining increased the exposure of the formation to the environment, which could also increase loading of phosphorus (and other associated minerals) to surface and groundwater. Due to access issues and sampling limitations, the effect of mining was not evaluated and is recommended to be addressed in the sampling scheme for future monitoring.

Wildlife

The effect of wildlife grazing and waste on nutrient loading is considered part of the natural background load. The contribution of wildlife was not evaluated during this project and may be greater in more heavily used areas of the watershed, however, in a multi-state study with varying densities of wildlife and livestock, wildlife were estimated to contribute a minimal nutrient load relative to livestock (Moffitt, 2009).

6.5.2.2 Forest

The forested areas in the Little Blackfoot watershed are heavily timbered. Additionally, coniferous forests do not lose a large percentage of their biomass each fall (as a deciduous forest does). Therefore, overall runoff values are low for forested areas due to their capacity to infiltrate, transpire, and otherwise capture rainfall. Additionally, the amount of soil exposed to erosion for forested areas, which is referred to as the C factor, is low. However, some of the forested areas in the Little Blackfoot watershed are grazed, and a few have a legacy of mining in the form of tailings piles and unvegetated areas near streams. To account for these, the c factor for forested areas was near the higher end of a typical undisturbed forested area.

To simulate the forest grazing that occurs between June and October, grazed forested areas have daily biomass removals due to eating and trampling, and daily manure deposits for these time periods based on cattle densities listed on the grazing permits. Both of these affect runoff and nutrient deposition. Grazing had to be applied at the HRU scale and was applied on HRUs that were predominantly within grazing allotments on the Helena National Forest. It was assumed that the same number of cow/calf

pairs grazing in forest or rangeland over the summer were moved to pasture during the rest of the year (October – May).

Wetlands
Wetlands have high biomass quantities (and thus high transpiration capacities), but low infiltration rates. Although they are mixed in with the forested areas, it was assumed they are not grazed. Therefore, natural nutrient processes are the only contributors in the wetland areas. Because wetlands make up such a small percentage of the loading and are considered a natural sources of nutrients, modeled loads from this source were aggregated into the load for forests.

6.5.2.3 Agriculture
Although the majority of cattle are typically not grazing along the valley bottoms during the growing season, there are several possible mechanisms for the transport of nutrients from agricultural land to surface water during the growing season. The potential pathways include: the effect of winter grazing on vegetative health and its ability to uptake and nutrients and minimize erosion in upland and riparian areas, breakdown of excrement and loading via surface and subsurface pathways, delivery from grazed forest and rangeland during the growing season, transport of fertilizer applied in late spring via overland flow and groundwater, and the increased mobility of phosphorus caused by irrigation-related saturation of soils in pastures (Green and Kauffman, 1989).

Pasture
Pasture is managed for hay production during the summer, and for grazing feed during the fall and spring. Hay pastures are fairly thickly vegetated in the summer, less so in the fall through spring. The winter grazing period is long (October – May) and through trampling and consumption reduces biomass at a time of the year when it is already low. Commercial fertilizers are used infrequently in the watershed, but cattle manure is applied naturally from October through May in larger quantities (higher cattle density) than on the range and forested areas. Livestock manure and consumption input values were based on literature values.

Rangeland
Rangeland has much less biomass than other land uses, and therefore contributes fewer nutrients from biomass decay. However, grazing impacts (manure deposition) do factor in. Similar to the forest areas, rangeland is grazed during the summer months in the watershed. This grazing is handled similar to the grazing in the forest areas.

6.5.2.4 Development
Developed areas contribute nutrients to the watershed by runoff from impervious surfaces, deposition by machines/automobiles, application of fertilizers, and increased irrigation on lawns. Although developed areas often have the highest nutrient loading rates, in the Little Blackfoot River watershed developed areas make up a very small percentage of the overall area.

6.5.2.5 Septic
Septic systems in the Little Blackfoot watershed model were represented as point sources. The number of septic systems in the watershed was estimated based on land uses and cadastral data. The daily load from each system was based on literature values and conservative assumptions used during permitting for subdivisions in Montana (Montana Department of Environmental Quality, 2009). Because a complete system failure is typically addressed very quickly, conservative assumptions were used for the load

estimates (i.e. low nutrient removal efficiency), and no site-specific septic data were available, it was assumed that all septic tanks are conventional systems that are working properly (i.e. 0% failure rate). The typical loading rate to stream was estimated based on the soils and geology and then added to the model as daily point sources. These point sources were calculated independently for each sub-basin based on the number of septic tanks assigned to the specific sub-basin.

6.5.3 Modeled Existing Nutrient Load Summary

Based on the SWAT model, existing total summer nutrient loading is presented by watershed in **Table 6-16** and source assessment results by land use category are presented for each watershed in **Figures 6-2** and **6-3**. The presented load represents the summer season average for a typical year.

Table 6-16. Modeled Summer Nutrient Loads by Watershed (July 1 – September 30)

	Summer Nutrient Load (lbs)	
Watershed	**TP**	**N**
Carpenter Creek	35	NA
Dog Creek, lower segment	145	NA
Little Blackfoot River, lower segment	524	NA
Snowshoe Creek	NA	703 ($NO_{3/2}$)
Spotted Dog Creek, lower segment	104	NA
Threemile Creek, lower segment	41	1,103 (TN)

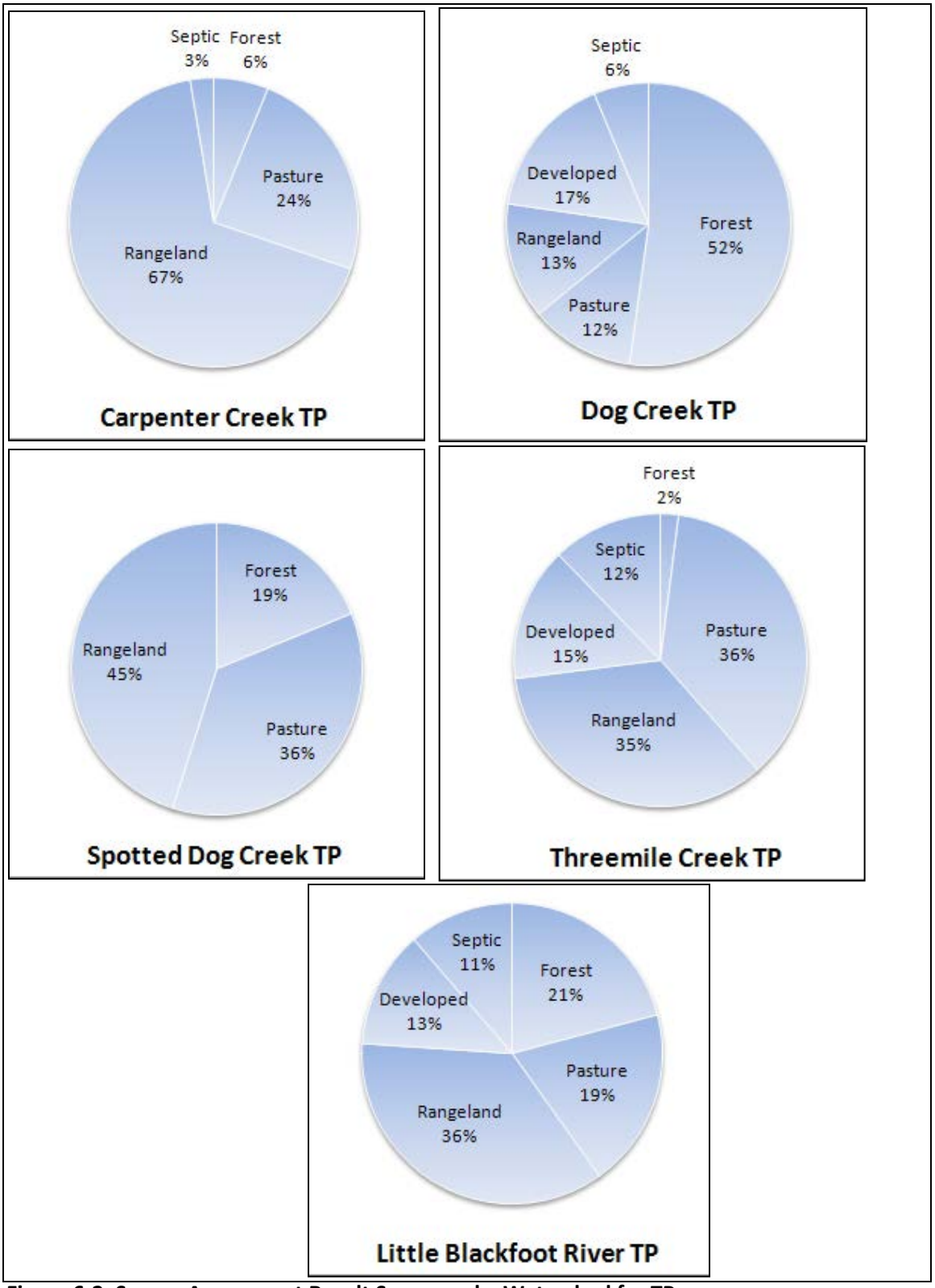


Figure 6-2. Source Assessment Result Summary by Watershed for TP.

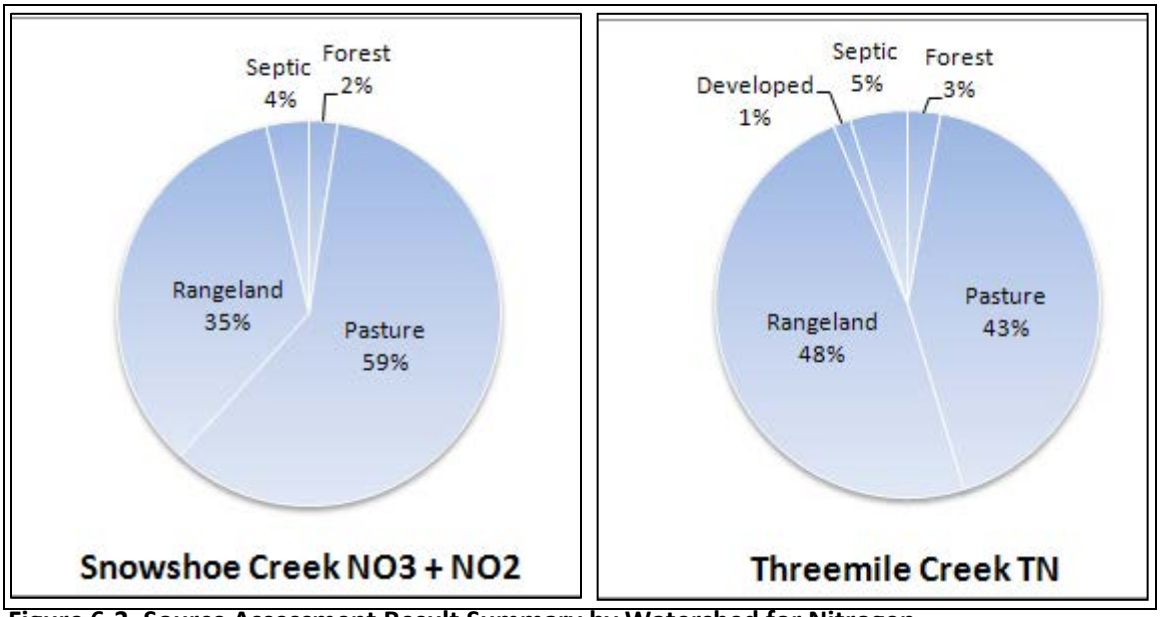


Figure 6-3. Source Assessment Result Summary by Watershed for Nitrogen.

The source assessment results (**Figures 6-2** and **6-3**) indicate that most TP is coming from rangeland and pasture; the existing load ranges from 55% to 91% in all watersheds except Dog Creek (25%). In Dog Creek, forest is the dominant TP source category at 52% of the current load; in that watershed, however, concentrations were typically just over the water quality target and limited reductions are needed to meet the TMDL. In other watersheds, the TP loading contribution from forests ranges from 2% to 21%. Septic and developed lands contribute little to no TP to Carpenter and Spotted Dog creeks and are close to 25% of the load in the other watersheds. For TN, the contribution from septic, developed lands, and forests is much smaller than for TP; the combined load from rangeland and pasture is greater than 90% for both Snowshoe and Threemile creek. Overall, the source assessment results are consistent with the land use patterns in the watershed and indicate that the majority of nutrient loading is coming from agricultural sources.

6.5.4 SWAT Model Scenarios and Result Summary

Because nutrient loading reductions are necessary to meet the TMDLs and water quality standards, the SWAT model was also used to evaluate loading reductions that can be achieved by improving land management practices. Changes in land management practices were simulated by running scenarios within the model to see how much implementing different BMPs will reduce nutrient loading relative to the reductions needed to meet the TMDLs.

The four scenarios that were simulated in SWAT are: 1) riparian buffer improvements, 2) increasing channel protection, 3) rotational grazing, and 4) improvements in irrigation efficiency. Each scenario is briefly described below. More detailed explanations of each scenario and the model inputs are provided in the SWAT Modeling Report, **Appendix D**.

6.5.4.1 Riparian Buffer Improvements

Riparian buffers are important zones for filtering and taking up nutrients from surface and groundwater but also function to slow surface runoff, disperse channelized runoff, improve streambank stability, and act as a barrier against flood flows. As described in **Section 5.7.2** and **Appendix D**, vegetative filter strips

were applied as a surrogate for riparian buffers. This was done because single HRUs are often spread throughout a subwatershed, making it difficult to only apply the buffer along the extent of each stream. Therefore, the distribution of HRUs was evaluated for each watershed in need of a TMDL and filter strips were added to land types that tend to occur along streams and will benefit the most from improved riparian vegetation. The filter strip width applied within the scenario varied for each sub-basin depending on the existing condition of the riparian zone (as classified in the riparian health assessment described in **Section 5.3.2**).

6.5.4.2 Increased Channel Protection

Increased channel protection means improved streambank stability. This scenario was used because streambank stability is strongly tied to riparian health and because phosphorus loading associated with streambank erosion will likely be reduced via reducing streambank erosion. Within SWAT, however, modifying this parameter resulted in sediment reductions ranging from 0.1% to 9.8% but did not alter nutrient loading. Because the model balances inputs from all sources and includes in-stream nutrient processing when calibrating to nutrient concentrations at the gage station, streambank erosion reductions applied externally to the model for sediment TMDLs were not used for nutrients. Therefore, although improved streambank stability was not explicitly incorporated into the scenarios, improving the riparian buffer will also enhance streambank stability and likely result in greater phosphorus reductions than those estimated in the riparian buffer scenario.

6.5.4.3 Rotational Grazing

Rotational grazing should result in improved vegetative cover and plant vigor in currently overgrazed areas as well as providing a better environment for manure to breakdown in-place and improving the forage utilization efficiency for livestock. Rotational grazing was simulated in SWAT by adjusting the vegetative cover, C factor, on grazed land cover types (i.e., pasture and rangeland), which was also done for the sediment TMDLs and is described in **Section 5.7.2**. The adjustment in C factor values equates to a 10% improvement in ground cover per category and the values were set based on literature values, estimates of existing field conditions in the watershed determined through site visits, communication with local stakeholders, and comparisons to previous SWAT model efforts in the Upper Clark Fork and Bitterroot River watersheds.

6.5.4.4 Improved Irrigation Efficiency

Surface runoff as well as subsurface flow associated with the irrigation network may increase the transport of nutrients to streams, and improvements to irrigation efficiency may reduce nutrient (and sediment) inputs to surface water (Ciotti, et al., 2010). Irrigation studies in other watersheds in western Montana have found that up to a 15% improvement in efficiency in the diverted water can be made with small adjustments and upgrades to ditches (Van Mullen, 2006; Kron, et al., 2009); although these findings indicate a similar reduction may be achievable in the Little Blackfoot watershed, a conservative irrigation improvement scenario was run by improving irrigation efficiency by 5%. Likely because the scenario altered subsurface flow and TP is typically transported in surface runoff, irrigation changes did not reduce TP loads. However, because nitrogen is more mobile in groundwater, irrigation improvements resulted in a 8% reduction in TN in Snowshoe Creek and a 2% reduction in Threemile Creek. However, because no irrigation study has been conducted to determine reasonable improvement efficiencies within the Little Blackfoot and because reductions associated with riparian buffer improvements and rotational grazing are anticipated to achieve greater than necessary reductions in most cases, this scenario is included primarily for informational purposes.

6.5.4.5 Model Scenario Results and Comparison to Existing Loads

Because the draft numeric nutrient criteria include a 20 percent exceedance rate, the sample data were used to calculate a load that corresponds to the 80th percentile of the growing season sample dataset. The 80th percentile represents a concentration that incorporates the 20% exceedance rate. Although the needed reductions vary from day to day depending on streamflow and nutrient concentrations, it was assumed the implementing BMPs that will achieve loading reductions corresponding to the 80th percentile of the sample dataset will result in TMDL attainment over the growing season. Also, because the necessary reduction does vary from day to day, the 80th percentile reduction served as a comparison tool when running the model scenarios to see how the estimated scenario reductions compare to the needed reductions, to help gauge if the scenarios needed to be modified, and as an indicator of the achievability of meeting the water quality targets.

A summary of the needed growing season reduction range as well as the 80th percentile reduction based on sample data is provided in **Table 6-17** along with the estimated achievable reductions associated with the two main scenarios and the scenarios combined. Typically a single scenario will not be sufficient to achieve the necessary reductions and combining the scenarios should achieve more than the necessary reductions. This indicates that the TMDLs should be attainable and that the appropriate solution will likely be a combination of these scenarios. Also, given that all scenarios combined results in reductions well over the needed reduction for most streams, this provides a margin of safety that implementing the scenarios will result in attainment of water quality targets and the TMDL.

In a few instances, the modeled scenarios fall short of the reduction goal. All of these instances were on tributaries, and this could be because the model was calibrated to the gauge and has a lesser degree of certainty on the tributaries, the existing condition or scenarios are not accurately reflected in the model, or the sample data are not representative of typical growing season conditions. Model uncertainty is described in more detail in **Appendix D**. Based on the estimated reductions for scenarios in most streams and the well known ability of improvements in grazing management and riparian buffers to decrease nutrient loading to streams, it is assumed that the necessary reduction can be achieved in all waterbody segments. The scenarios were set up at the watershed scale and it is acknowledged that each scenario is not necessary and applicable in all locations.

Table 6-17. Needed loading reductions relative to SWAT modeling scenario reductions.

Waterbody Segment	Needed Reduction Range	80th Percentile Reduction (Scenario Goal)	Riparian Buffers	Rotational Grazing	Riparian Buffers and Rotational Grazing
	Total Phosphorus				
Carpenter Creek	25-51%	46%	29%	10%	34%
Dog Creek, lower segment	0-21%	2%	28%	9%	37%
Little Blackfoot River, lower segment	0-14%	9%	30%	11%	38%
Spotted Dog Creek, lower segment	0-51%	30%	46%	13%	50%
Threemile Creek, lower segment	39-72%	59%	48%	9%	49%
	Total Nitrogen				
Snowshoe Creek*	0-29%	9%	12%	18%	25%
Threemile Creek, lower segment	0-68%	51%	39%	8%	43%

*Because reducing TN will reduce NO_{3+2} loading and there is a higher level of uncertainty pertaining to dissolved fractions within the model because it was calibrated to total fractions, TN reductions were evaluated even though the TMDL is for NO_{3+2}

6.6 TMDLS AND ALLOCATIONS

Nutrient TMDLs will be developed for the nutrient pollutant causes identified for each waterbody in **Table 6-15**. The TMDL equation for each nutrient form is based on flow and the nutrient targets and provided in **Equation 6-1** through **Equation 6-3**. The target values are based on the most sensitive uses; therefore, the nutrient TMDLs are protective of all designated beneficial uses. Future conditions will be considered meeting the TMDL if there is less than a 20 percent exceedance rate as long as exceedances are spatially and temporally random during the summer months. This exceedance rate allows for natural variability yet should protect against nutrient conditions that impact any use of the water. The TMDLs are applied only to the summer growing season (July 1st through Sept 30th).

Equation 6-1.
Total Nitrogen TMDL (lbs/day) = CFS*1.62
Where: CFS = Average daily discharge in cubic feet per second
1.62 = Conversion factors combined with total nitrogen target from **Table 6-2**

Equation 6-2.
Nitrate + Nitrite TMDL (lbs/day) = CFS*0.54
Where: CFS = Average daily discharge in cubic feet per second
0.54 = Conversion factors combined with total nitrogen target from **Table 6-2**

Equation 6-3.
Total Phosphorus TMDL (lbs/day) = CFS*0.162
Where: CFS = Average daily discharge in cubic feet per second
0.162 = Conversion factors combined with total phosphorus target from **Table 6-2**

TMDL examples are provided for each waterbody segment using growing season sample data; the examples show the maximum and minimum measured existing load based on the sample data, as well as the load based on the 80th percentile of the data. The TMDL can be displayed as a line graph of allowable loading with increasing flow. **Figure 6-4** is the graph of a TN TMDL for the range of mean daily flows from zero to 48 cfs. The vertical dotted lines intersect the graph at the points corresponding to the three stream flow values of 10, 25 and 45 cfs. The horizontal dotted lines, extending from the diagonal TMDL graph to the y-axis, identify the maximum TN load allowed for these three discharge rates.

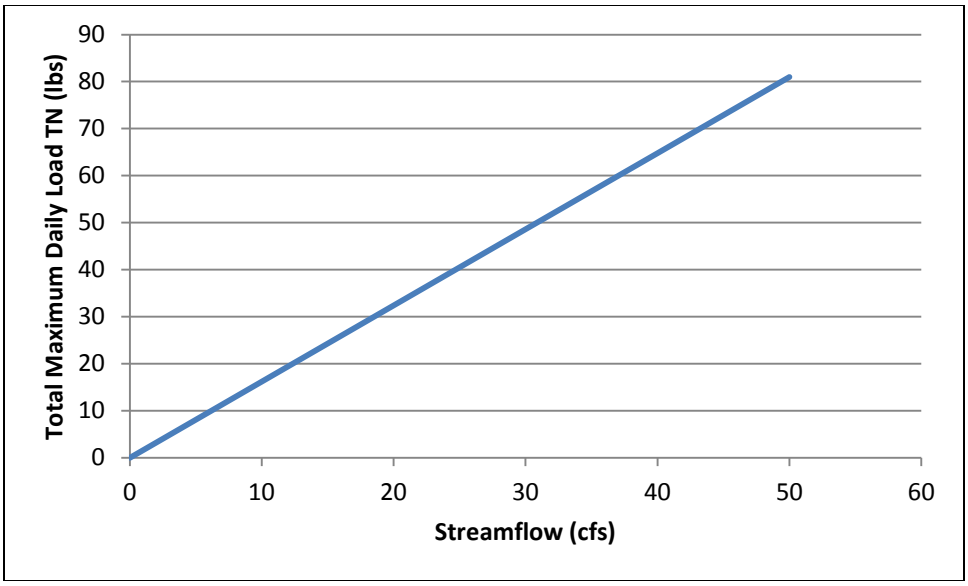


Figure 6-4. Graph of the TN TMDLs for mean daily flows from zero to 50 cfs.

Flow duration curves express stream flows in terms of the percentage of time that flows are equaled or exceeded. **Figure 6-5** is the flow duration curve for mean daily discharge in the Little Blackfoot River at USGS station 12324590 and is grouped by prevailing hydrologic condition (U.S. Environmental Protection Agency, 2007).

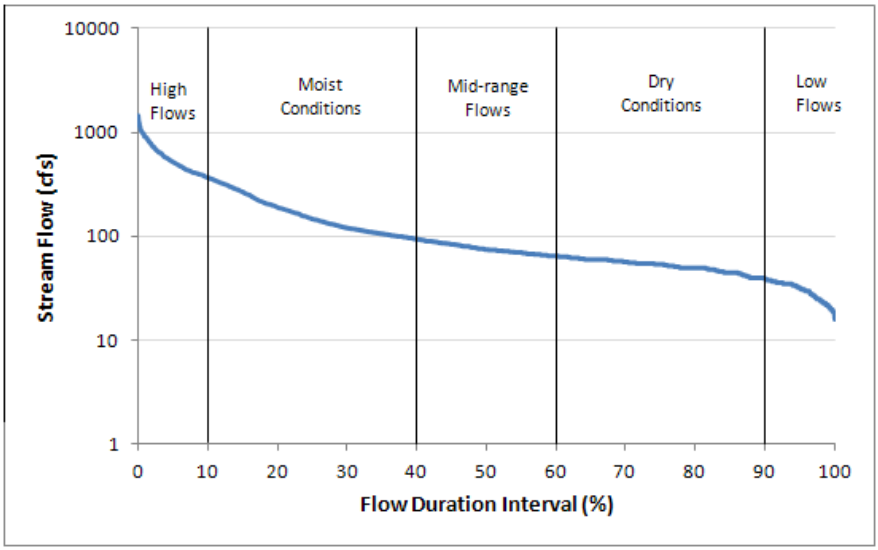


Figure 6-5. Flow duration curve based on a period of record from 2001-2010 for the Little Blackfoot River at USGS Station #12324590, partitioned by annual hydrologic condition.

The relationship between flow and loading can be used to illustrate the seasonal loading distribution so that loading controls can be developed and implemented to target the most critical loading periods. A flow duration curve can be converted to a load duration curve showing the TMDL by replacing values for mean daily flow on the y-axis with the allowable daily load derived by using **Equations 6-1** through **6-3**. A load duration curve illustrating the TMDL along with loads determined from field measurements is a useful tool for correlating existing loads with hydrologic conditions, and will be used to graphically

display the TMDL and existing loading conditions for each waterbody segment. Although there is only one USGS gage in the watershed with mean daily flows, flow durations curves were developed within the SWAT model for each waterbody with a nutrient TMDL. Based on the flow duration curves, load duration curves were developed and will be used to display the TMDL(s) for each waterbody segment as well as exceedances based on the sample data summarized in **Section 6.4**. All load duration curves only contain water quality data collected during the summer growing season.

6.6.1 Allocation Approach

Because agriculture is the predominant source category and all sources are nonpoint, the TMDL allocations are composited into a single load allocation to all nonpoint sources, including natural background sources. Therefore, the equation for all nutrient TMDLs is as follows: TMDL = LA. Because there are no point sources, the wasteload allocation (WLA) is 0. All nutrient TMDLs include an implicit margin of safety, which is based on conservative assumptions as described in **Section 6.6.8.3**.

Allocations are intended to be met by implementation of additional BMPs. In recent years, some improvements have been made such as the installation of riparian fencing and changes in grazing management, but additional and more widespread improvements are needed to decrease nutrient loading and meet TMDLs. Necessary BMPs may include but are not limited to those used in the model scenarios, which were improved riparian buffers and rotational grazing. The scenarios did not alter the current livestock density, but instead focused on the distribution, usage, and timing on the landscape. For instance, limiting livestock access to streams via fencing, providing alternate water sources, and/or installation of hardened crossings will reduce direct nutrient inputs to streams, increase streambank stability, and improve the riparian buffer health, which are factors that will be essential to meeting both the nutrient and sediment TMDLs. Although the modeled BMP scenarios discussed within **Section 6.5** and **Appendix D** reflect reasonable reductions as determined from literature, agency and industry documentation of BMP effectiveness, and field assessments, nutrient loading reductions can be achieved through a combination of BMPs, and the most appropriate BMPs will vary by site. Septic loading is typically a fairly small portion of existing nutrient loading (**Figures 6-2** and **6-3**) and because no failure rate was assumed for the existing condition, no loading reductions are anticipated from septic sources; however, the allocation to septic, which addresses both current and future loading, is expected to be met by proper placement, maintenance, and cleaning of septic systems.

Although the needed reductions (based on sample data) and the estimated reductions from the model shown in **Table 6-17** only apply to the growing season, because all sources are nonpoint, it is anticipated that TMDL implementation will result in reductions in nutrient loading year-round. This will address sources of nutrients that tend to be introduced to streams during runoff but stored in channel and become available during the summer growing season. As shown in **Appendix D,** typical annual reductions in nutrient loading from implementation of the modeling scenarios is expected to result in greater reduction percentages than those shown for the growing season. **Appendix D** includes the anticipated summer and annual loading reductions associated with BMP implementation.

6.6.1.1 Meeting Allocations

It is important to recognize that the first critical step toward meeting the nutrient allocations involves applying and/or maintaining the land management practices or BMPs that will reduce nutrient loading. Once these actions have been completed at a given location, the landowner or land manager will have taken action consistent with the intent of the nutrient allocation for that location. For many nonpoint source activities, it can take several years to achieve the full load reduction at the location of concern,

even though full BMP implementation is in effect. For example, it may take several years for riparian areas to fully recover and decrease nutrient loading after implementing grazing BMPs. It is also important to apply proper BMPs and other water quality protection practices for all new or changing land management activities to limit any potential increased nutrient loading.

Progress towards TMDL and individual allocation achievement can be gauged by BMP implementation and improvement in or attainment of water quality targets defined in **Section 6.4.1**. Any effort to calculate loads and percent reductions for purposes of comparison to TMDLs and allocations in this document should be accomplished via the same methodology and/or models used to develop the loads and percent reductions presented within this document.

TMDLs are shown graphically using load duration curves in **Figures 6-6** through **6-12** and example TMDLs using sample data to show the range of needed loading reductions are provided by waterbody segment in **Tables 6-18** through **6-24**.

6.6.2 Carpenter Creek, lower segment (MT76G004_092)

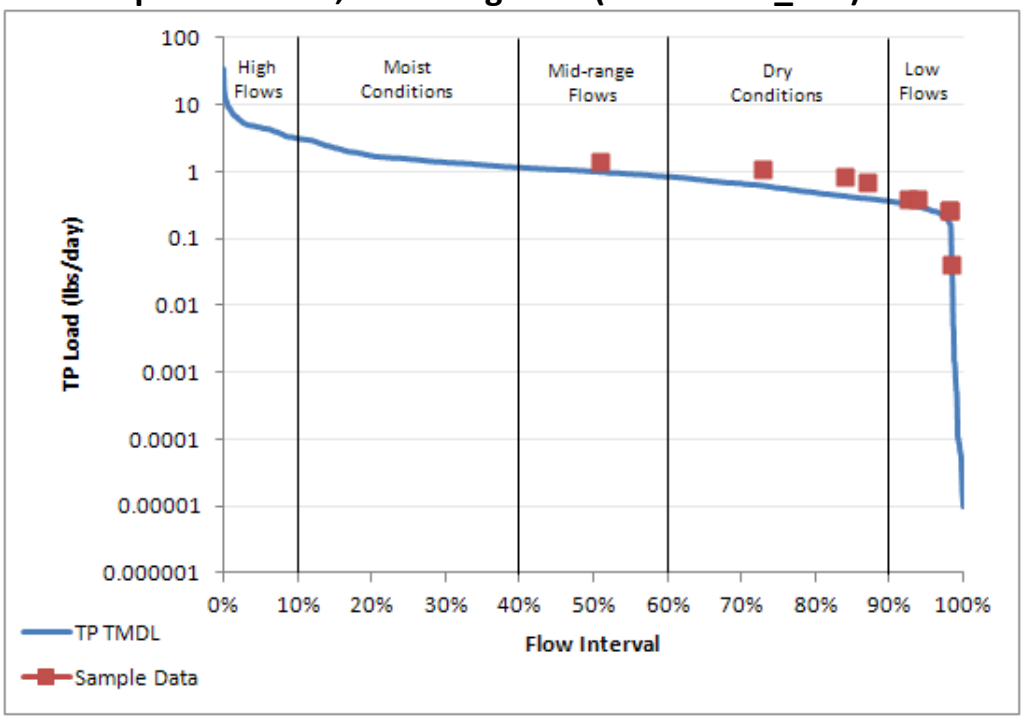


Figure 6-6. Load duration curve showing TP TMDL and sample data for Carpenter Creek.

Table 6-18. Total Phosphorus Allocations and TMDL for Carpenter Creek.

Sample Data	TP Concentration	Existing Load (lbs/day)	TMDL (lbs/day)	% Reduction
Minimum	0.039	0.40	0.31	23%
Maximum	0.061	0.86	0.42	51%
80th Percentile	0.055	0.91	0.49	46%

6.6.3 Dog Creek, lower segment (MT76G004_072)

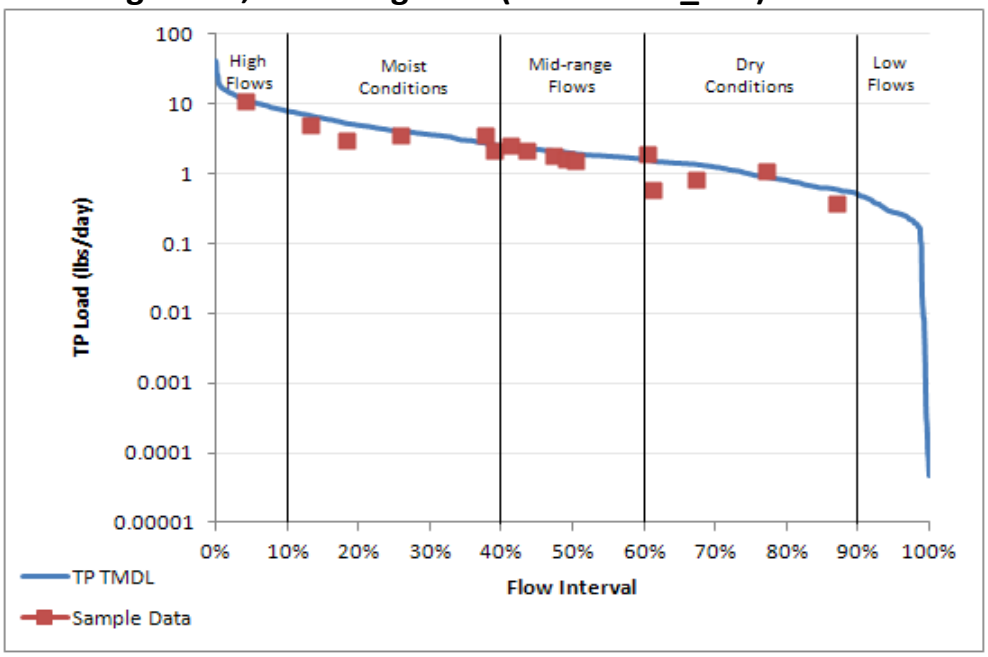


Figure 6-7. Load duration curve showing TP TMDL and sample data for Dog Creek.

Table 6-19. Total Phosphorus Allocations and TMDL for Dog Creek.

Sample Data	TP Concentration	Existing Load (lbs/day)	TMDL (lbs/day)	% Reduction
Minimum	0.011	0.58	1.57	0%
Maximum	0.038	3.56	2.81	21%
80th Percentile	0.031	4.27	4.19	2%

6.6.4 Little Blackfoot River, lower segment (MT76G004_010)

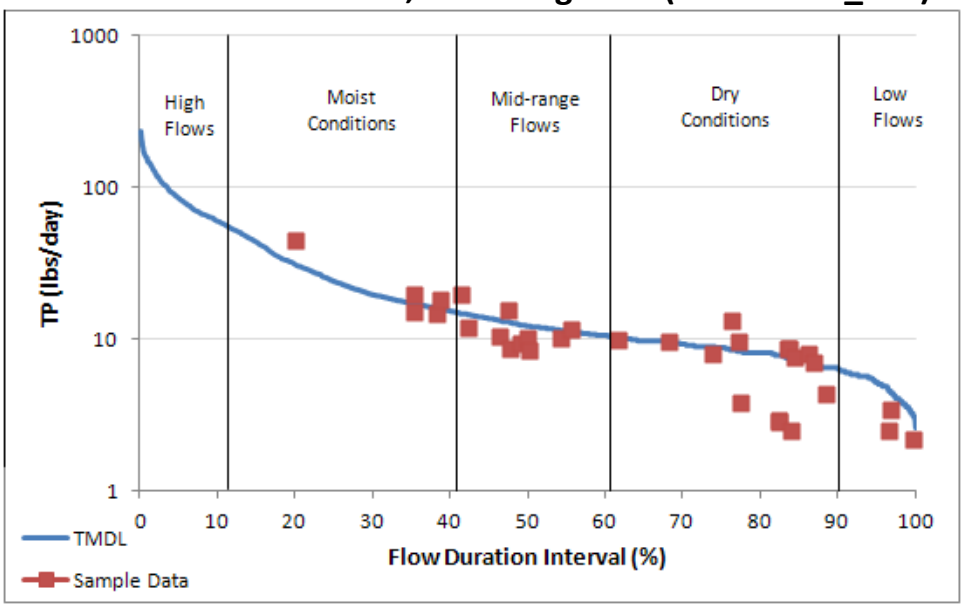


Figure 6-8. Load duration curve showing TP TMDL and sample data for the Little Blackfoot River.

Table 6-20. Total Phosphorus Allocations and TMDL for the lower Little Blackfoot River.

Sample Data	TP Concentration	Existing Load (lbs/day)	TMDL (lbs/day)	% Reduction
Minimum	0.011	2.90	7.92	0%
Maximum	0.035	18.4	15.77	14%
80th Percentile	0.033	15.25	13.95	9%

6.6.5 Snowshoe Creek (MT76G004_080)

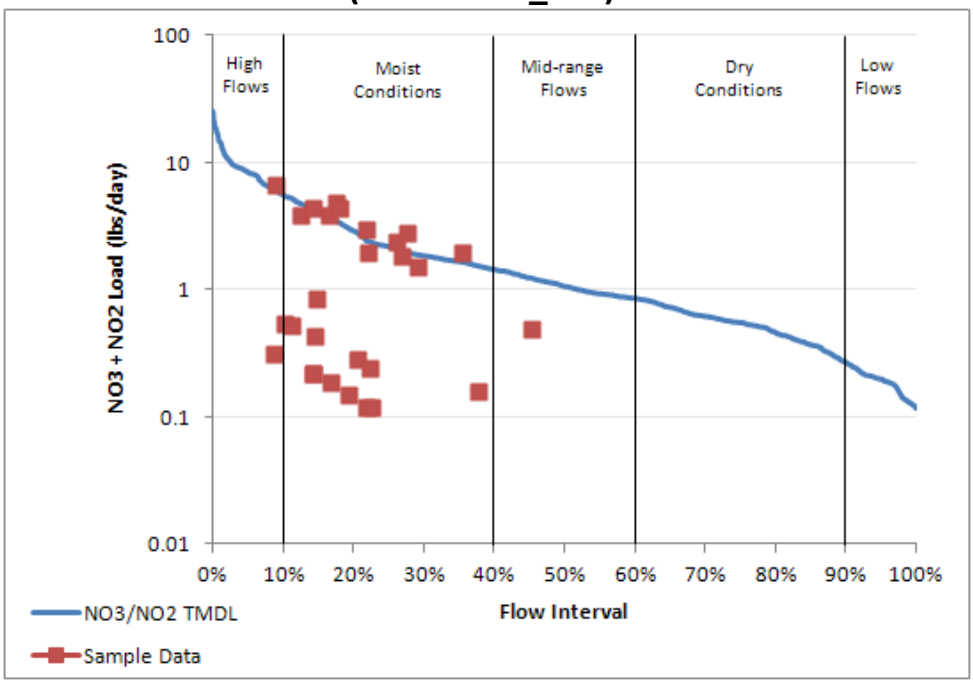


Figure 6-9. Load duration curve showing NO3 + NO2 TMDL and sample data for Snowshoe Creek.

Table 6-21. Nitrate + Nitrate Allocations and TMDL for Snowshoe Creek.

Sample Data	NO3+2 Concentration	Existing Load (lbs/day)	TMDL (lbs/day)	% Reduction
Minimum	0.005	0.22	4.38	0%
Maximum	0.14	4.89	3.49	29%
80th Percentile	0.11	4.82	4.38	9%

6.6.6 Spotted Dog Creek, lower segment (MT76G004_032)

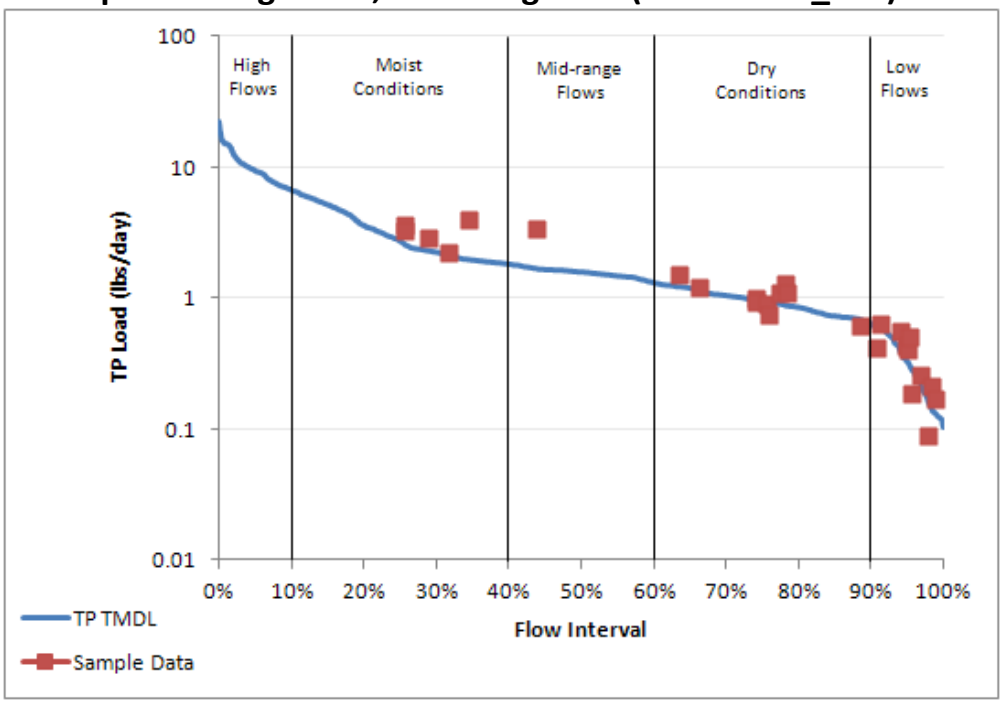


Figure 6-10. Load duration curve showing TP TMDL and sample data for Spotted Dog Creek.

Table 6-22. Total Phosphorus Allocations and TMDL for Spotted Dog Creek.

Sample Data	TP Concentration	Existing Load (lbs/day)	TMDL (lbs/day)	% Reduction
Minimum	0.017	0.09	0.16	0%
Maximum	0.061	4.00	1.97	51%
80th Percentile	0.043	2.27	1.59	30%

6.6.7 Threemile Creek, lower segment (MT76G004_112)

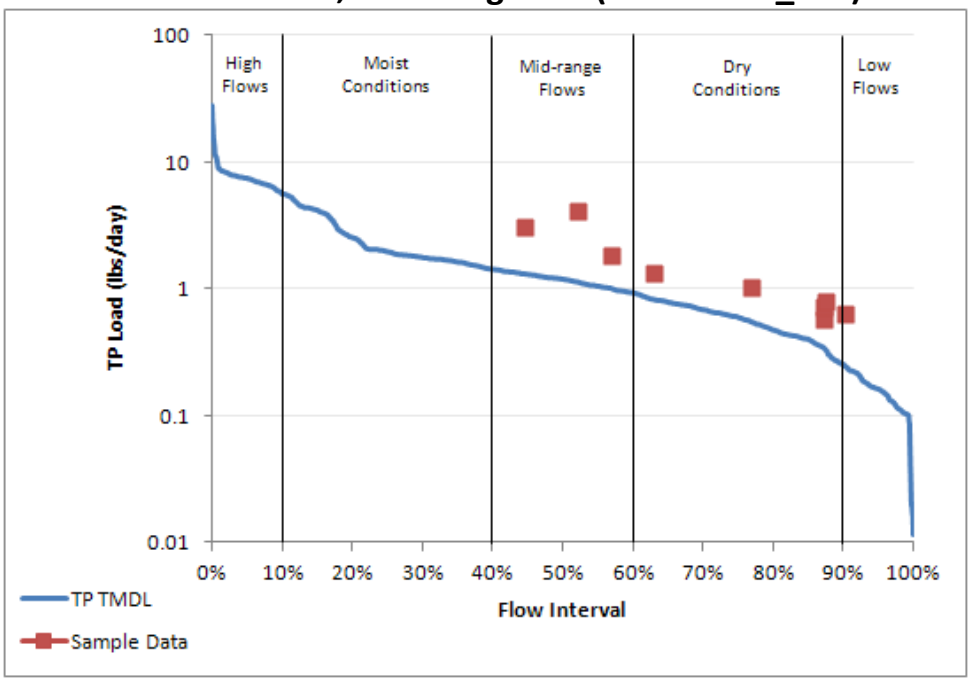


Figure 6-11. Load duration curve showing TP TMDL and sample data for Threemile Creek.

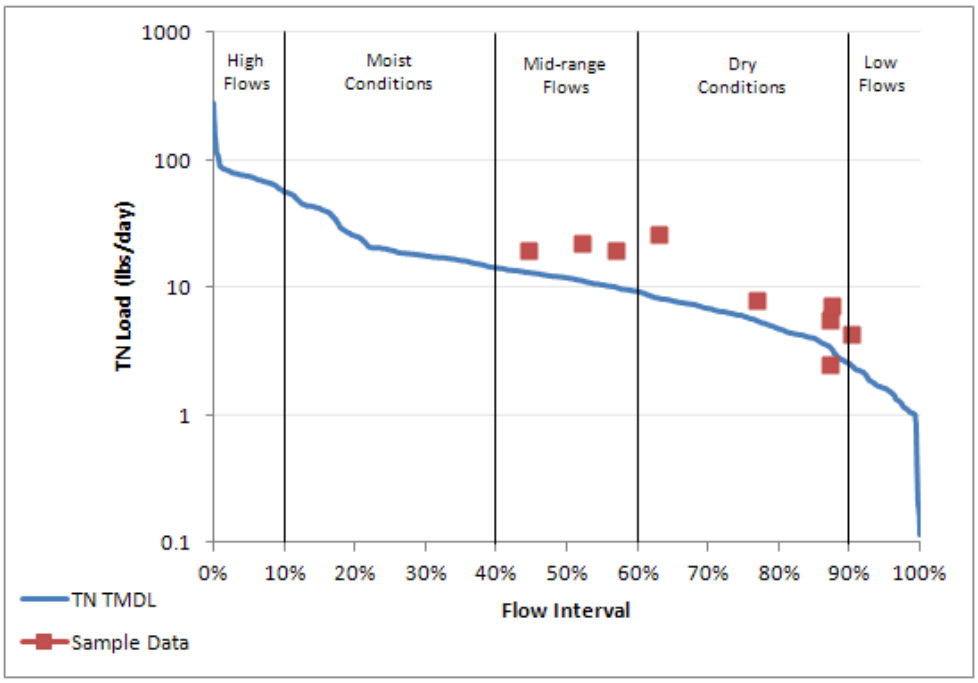


Figure 6-12. Load duration curve showing TN TMDL and sample data for Threemile Creek.

Table 6-23. Total Phosphorus Allocations and TMDL for Threemile Creek.

Sample Data	TP Concentration	Existing Load (lbs/day)	TMDL (lbs/day)	% Reduction
Minimum	0.049	1.35	0.82	39%
Maximum	0.109	4.14	1.14	72%
80th Percentile	0.074	2.61	1.06	59%

Table 6-24. Total Nitrogen Allocations and TMDL for Threemile Creek.

Sample Data	TN Concentration	Existing Load (lbs/day)	TMDL (lbs/day)	% Reduction
Minimum	0.22	2.49	3.40	0%
Maximum	0.94	25.84	8.25	68%
80th Percentile	0.61	21.61	10.59	51%

6.6.8 Seasonality, Margin of Safety and Uncertainty

TMDL documents must consider the seasonal variability, or seasonality, on water quality impairment conditions, maximum allowable pollutant loads in a stream (TMDLs), and load allocations. TMDL development must also incorporate a margin of safety to account for uncertainties between pollutant sources and the quality of the receiving waterbody, and to ensure (to the degree practicable) that the TMDL components and requirements are sufficiently protective of water quality and beneficial uses. This section describes seasonality and margin of safety in the Little Blackfoot watershed nutrient TMDL development process.

6.6.8.1 Seasonality

Addressing seasonal variations is an important and required component of TMDL development and throughout this plan seasonality is an integral consideration. Water quality and particularly nitrogen concentrations are recognized to have seasonal cycles. Specific examples of how seasonality has been addressed within this document include:

- Water quality targets and subsequent allocations are applicable for the summer-time growing season (July1st – Sept 30th), to coincide with seasonal algal growth targets.
- Nutrient data used to determine compliance with targets and to establish allowable loads was collected during the summertime period to coincide with applicable nutrient targets
- Load duration curves were developed to demonstrate the typical seasonal flow regimes when nutrients become a problem.

6.6.8.2 Margin of Safety

A margin of safety is a required component of TMDL development. The margin of safety (MOS) accounts for the uncertainty about the pollutant loads and the quality of the receiving water and is intended to protect beneficial uses in the face of this uncertainty. The MOS may be applied implicitly by using conservative assumptions in the TMDL development process or explicitly by setting aside a portion of the allowable loading (U.S. Environmental Protection Agency, 1999a). This plan addresses MOS implicitly in a variety of ways:

- Static nutrient target values (0.030 mg/L TP, 0.100 mg/L NO_3+NO_2, 0.300 mg/L TN) were used to calculate allowable loads (TMDLs). Allowable exceedances of nutrient targets (see **Section 6.4.3**) were not incorporated into the calculation of allowable loads, thereby adding a MOS to established allocations.
- Target values were developed to err on the conservative side of protecting beneficial uses.
- By considering seasonality (discussed above) and variability in nutrient loading.
- Model scenarios were developed to be reasonable and achievable, and the scenarios estimate greater than necessary reductions for nutrients in most streams.
- Modeled loading reductions are shown for the growing season when nutrient targets apply but practices will be implemented year round, resulting in even greater reductions in nutrient loading.

- By using an adaptive management approach to evaluate target attainment and allow for refinement of load allocation, assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development.

6.6.8.3 Uncertainty and Adaptive Management

Uncertainties in the accuracy of field data, nutrient targets, source assessments, loading calculations, and other considerations are inherent when assessing and evaluating environmental variables for TMDL development. However, mitigation and reduction of uncertainties through adaptive management approaches is a key component of ongoing TMDL implementation and evaluation. The process of adaptive management is predicated on the premise that TMDL targets, allocations, and the analyses supporting them are not static, but are processes subject to modification and adjustment as new information and relationships are understood. Uncertainty is inherent in both the water quality-based and model-based modes of assessing nutrient sources and needed reductions. The main sources of uncertainty are summarized below.

Water Quality Conditions

It was assumed that sampling data for each waterbody segment is representative of conditions in each segment. Most segments have more than the desired 12 samples but Carpenter and Dog creeks but have a smaller dataset, which increases the uncertainty of the representativeness of the data. Additionally, macroinvertebrate data are a supplementary indicator, and most waterbody segments have little to no macroinvertebrate data. Particularly in situations where nutrient and algal data indicate borderline impairment, additional macroinvertebrate data may help decrease the uncertainty. Data for all waterbody segments with a nutrient TMDL clearly indicate the targets are not being attained, however, future monitoring as discussed in **Section 10.0** should help reduce the uncertainty regarding data representativeness, improve the understanding of the effectiveness of BMP implementation, and increase the understanding of the loading reductions needed to meet the TMDLs.

It was assumed that background concentrations are less than the target values, and based on sample data upstream of known sources, this appears to be true. However, it is possible that target values are naturally exceeded during certain times or at certain locations in the watershed. There is a greater level of uncertainty in areas underlain by the Phosphoria Formation; available data were reviewed to assess the geologic phosphorus contribution and indicated it is not the primary cause of target exceedances. However, based on the limited amount of dissolved phosphorus data, additional monitoring is recommended (particularly in the Threemile Creek watershed) to further evaluate the geologic contribution to phosphorus concentrations in surface water. Additionally, phosphate was mined in the Dog Creek and Threemile Creek watershed, which could accelerate the background loading rate in these drainages and should be investigated during future monitoring.

Source Assessment and SWAT Model

Much of the uncertainty associated with the nutrient TMDLs relates to the SWAT model and how existing conditions were represented. A detailed description of the model inputs, assumptions, and uncertainty is contained in **Appendix D**; this section provides an overview of the assumptions made and aspects of the model inputs with the greatest uncertainty.

Efforts were made to work with agency representatives familiar with the watershed as well as landowners to make the model inputs as realistic as possible. Based on this, general trends in the timing of the irrigation season and haying as well as fertilizer usage were obtained. There is some uncertainty regarding the typical total number of cow/calf pairs in the watershed as livestock numbers were based

on limits for grazing allotments within the Helena National Forest and assumed to represent the numbers for the watershed; the Agricultural Statistics Service provides numbers summarized by county but they could not be parsed to the watershed scale to verify the assumption of livestock numbers. As discussed in **Appendix D**, several windshield surveys were conducted during the winter to count cattle; while a very coarse estimate, this effort indicated the assumption for the watershed is reasonable. For livestock with stream access, there is potential for increased nutrient loading from direct input of excrement. This is a nutrient source that was not accounted for in the model and has the likelihood of increasing nutrient concentrations quite a bit, particularly during the growing season when runoff events are sporadic.

DEQ conducted a limited field assessment of vegetative cover in different areas of the watershed to assist with the C factor values used to represent existing conditions and also to identify to potential change in C factor with improved management practices. This reduced some of the uncertainty associated with characterizing existing conditions; however, it is important to acknowledge that for each cover type, the same condition was applied throughout the watershed. Because the source assessment was performed at this watershed scale, livestock density and vegetative conditions were not adjusted to account for field scale variability.

Riparian vegetation is well known to be an important factor in maintaining streambank stability and filtering nutrients and other pollutants from runoff and groundwater as it migrates to surface water; because land cover units within SWAT are not spatially related, a true riparian buffer scenario could not be simulated. Vegetative cover strips were used as a surrogate and the estimated reductions are in line with literature values for buffers, but because of the spatial limitations of the model there is some uncertainty regarding the total reduction potential per sub-basin. Also, additional reductions may be possible in some areas where filter strips were not applied.

The model was calibrated for hydrology, sediment, and nutrients. The hydrologic calibration includes some irrigation components as well as reservoirs on Threemile, Spotted Dog, and Snowshoe creeks. Limited knowledge of the irrigation network and reservoir operation introduces some uncertainty into the hydrologic calibration, which may affect the nutrient routing and the source assessment. Some uncertainty is also associated with the sediment and nutrient calibrations because they were completed with rating curves because of the limited amount of water quality at the gage near Garrison. This uncertainty as well as the fact that the calibration was done to a point near the mouth and applied to tributaries as well as the mainstem Little Blackfoot most likely affected existing nutrient concentrations predicted within the model. However, this does not detract from the model results because it was primarily used to identify achievable reductions in nutrient loading via the implementation of BMPs.

One other area of uncertainty is the contribution from septic systems. Based on the age of septic systems within the watershed, there are probably some failing systems, and depending on their proximity or connectivity to surface water, they could be point sources of nutrient loading. However, a completely failing system has obvious symptoms and will be addressed quickly, and a partially failing system will likely result in similar loading as a functioning system, unless it’s in close proximity to surface water. This source could be investigated further, particularly in segments with nearby septic systems and elevated nutrient concentrations that cannot be explained by other sources; however, based on the low septic density within the watershed and conservative loading estimates used, even with this uncertainty, septic systems will typically be a minor source of nutrient loading.

Despite the uncertainty associated with the loading contributions from the various nonpoint sources in the watershed, based on the modeling, literature, and field observations there is a fairly high level of certainty that improvements in land management practices discussed in this document will reduce nutrient loading sufficiently to meet the TMDLs.

7.0 METALS TMDL COMPONENTS

This portion of the document focuses on metals as an identified cause of water quality impairments in the Little Blackfoot TPA. It describes: 1) the mechanisms by which metals impair beneficial uses of those streams, 2) the specific stream segments of concern, 3) the presently available data pertaining to metals impairments in the watershed, 4) the various contributing sources of metals based on recent data and studies, and 5) the metals TMDLs and allocations.

7.1 MECHANISM OF EFFECTS OF EXCESS METALS TO BENEFICIAL USES

Waterbodies with metals concentrations exceeding the aquatic life and/or human health standards can impair support of numerous beneficial uses including aquatic life, cold water fisheries, drinking water, and agriculture. Within aquatic ecosystems, elevated concentrations of heavy metals can have a toxic, carcinogenic, or bioconcentrating effect on biota. Humans and wildlife can suffer acute and chronic effects from consuming drinking water or fish with elevated metals concentrations. Because elevated metals concentrations can be toxic to plants and animals, high metals concentrations in irrigation or stock water may affect agricultural uses.

7.2 STREAM SEGMENTS OF CONCERN

A total of seven waterbody segments in the Little Blackfoot TPA were listed as impaired due to metals-related causes on the 2010 Montana 303(d) List (**Table 7-1**). Sampling performed as part of TMDL development found five additional waterbody segments impaired by metals not currently on the 303(d) List. All 2010 303(d) listings are included in **Table 1-1** and the beneficial use support status of listed segments is presented in **Table 3-1**. Metals-related listings include arsenic, beryllium, cadmium, copper, cyanide, iron, lead, mercury, pH, selenium, and zinc. Cyanide is not a metal but the 303(d) listing is addressed within this document because it is frequently associated with metals and mining sources.

Table 7-1. Waterbody segments in the Little Blackfoot TPA with metals listings on the 2010 303(d) List.

Stream Segment	Waterbody Segment ID	Probable Causes of Impairment
DOG CREEK, headwaters to Meadow Creek	MT76G004_071	Arsenic, Lead, Zinc
LITTLE BLACKFOOT RIVER, the headwaters to Dog Creek	MT76G004_020	Arsenic, Cyanide
LITTLE BLACKFOOT RIVER, Dog Creek to the mouth (Clark Fork River)	MT76G004_010	Copper, Lead
MONARCH CREEK, headwaters to the mouth (Ontario Creek)	MT76G004_060	Arsenic, Copper, Lead, Mercury, Selenium; pH
TELEGRAPH CREEK, headwaters to Hahn Creek	MT76G004_051	Arsenic, Beryllium, Cadmium, Copper, Iron, Zinc
TELEGRAPH CREEK, Hahn Creek to the mouth (Little Blackfoot River)	MT76G004_052	Lead, Mercury
UN-NAMED CREEK, headwaters to mouth (Ontario Creek)*	MT76G006_010*	Arsenic, Cadmium, Copper, Lead, Mercury, Zinc; pH

*Formerly identified on the 303(d) List as the Ontario Mine Wetland.

7.3 INFORMATION SOURCES AND ASSESSMENT METHODS

The total metals load entering a waterbody is equal to the sum of all contributing source areas. In general, this means that headwater areas will have fewer potential source areas (although they frequently have a high concentration of abandoned mines), whereas locations lower in the watershed will have numerous potential source areas. To determine the location and magnitude of general sources, GIS layers, historical water quality data, and aerial photos were used.

GIS data included the DEQ High Priority Abandoned Hardrock Mine sites, the DEQ Abandoned Hardrock Mines database, the DEQ Active Hardrock Mine sites, the Montana Bureau of Mines and Geology (MBMG) Abandoned and Inactive Mines database, and permitted point sources (i.e. Montana Pollutant Discharge Elimination System permits) (**Appendix A, Figure A-16).** A query of applicable databases showed there are no active hardrock mines in the Little Blackfoot TPA. The only permitted point source is a general permit for suction dredging (MTG370000) on Carpenter Creek, a tributary to the lower segment of Little Blackfoot River. The permit conditions specify an effluent limit for turbidity but do not explicitly set limitations for metals. This permit is discussed further in **Section 7.5.12**. DEQ abandoned mine assessment files were also reviewed for notes about potential sources including discharging adits, unstable tailings, and mining wastes in the floodplain. Additionally, the potential for mines in the MBMG database to affect surface water quality in metals-listed streams within the Little Blackfoot TPA was assessed by reviewing the MBMG assessment of abandoned mines in the Helena National Forest (Hargrave, et al., 1998). Because geology and soil can influence water quality, geologic data from the USGS General Surficial Geology of Montana 1:500,000 scale map and soils data from the State Soil Geographic (STATSGO) database was also examined.

Conditions of many mine sites in the TPA and their continued effects on surface water were investigated as part of a risk assessment and reclamation prioritization by DEQ's Abandoned Mine Lands (AML) Program and MBMG in the early 1990s. Many of the 303(d) listings are based on water column and sediment metals data from either the 1970s or the 1990s. Data collected earlier than 10 years ago (i.e. 2001) were used to aid in the initial coarse level source assessment, to help determine sampling locations for additional data collection, and to provide background concentrations, but are not used within this document in the existing data review due to potential data quality and reliability issues (e.g. reporting limits higher than water quality standards and uncertainty regarding collection, analysis and recording methods) and because conditions may have changed substantially since data collection. For certain waterbodies, reclamation activities have occurred since 2001, and only data collected post-reclamation will be evaluated as part of the data review characterizing existing conditions. If the timeframe for the data review is shorter than the previous 10 years, that will be indicated in the waterbody-specific discussion.

Information used for the data review and TMDL development includes DEQ's assessment data collected since 2001, samples collected at the USGS gaging station on the Little Blackfoot River near Garrison, and samples collected by the USFS. Information DEQ AML collected evaluating conditions before and after reclaiming abandoned mines will also be use. To add to the historical dataset and document seasonal variability, DEQ conducted metals water quality and sediment monitoring in 2008 and 2009 in the listed watersheds during spring runoff and base flow conditions. Sediment metals data was collected during base flow to aid in the source assessment. Metals-rich sediment can be a source of metals at mine sites as it is carried downstream and deposited in the stream channel or floodplain. Field and analytical protocols for the samples collected in 2008/2009 are described in the Little Blackfoot TMDL Planning Area Chemistry and Chlorophyll Monitoring Sampling and Analysis Plan (Hydrosolutions Inc., 2009;

Hydrosolutions Inc., 2010), and raw data is contained in **Appendix G**. For all data reviewed, samples collected between April 15th and June 30th are assumed to represent high flow and all other samples are low flow (unless otherwise specified in a sampling report).

The effect of runoff on metals concentrations can vary, as spring runoff may dilute metals sources that enter the stream through groundwater or may increase erosion and erode soils/tailings containing metals. Mining areas may contribute metals through groundwater discharge, which occurs year-round, but tend to be more apparent during low flow when surface water inputs are minimal. Examining water quality data under various hydrologic conditions is necessary to characterize water chemistry metal conditions.

Based on the review of GIS and water quality data, potential sources of metals loading in the Little Blackfoot TPA include:

- Natural background loading from mineralized geology
- Abandoned mines, including adit discharge/drainage from abandoned mines and runoff/drainage from abandoned mine tailings
- Upland, in-stream, and floodplain metals deposits from historical mining operations
- Permitted point sources

7.3.1 Natural Background Loading

Natural background loading of metals occurs as a result of geologic conditions. Therefore, the degree of loading can vary considerably among subwatersheds in the planning area, as geologic conditions vary throughout (**Figure A-4**). When possible, background loading will be accounted for separately from human-caused sources. However, because mining has affected all of the streams that are listed for metals impairment to some extent, the natural background loading may not be expressed separately from other loading. The underlying assumption is that natural background sources alone would not result in the exceedance of TMDL target concentrations of metals in the water column, or in sediments. If future monitoring proves this to be incorrect, these TMDLs may need to be revised in accordance with the Adaptive Management strategy provided in **Section 7.9**.

7.3.2 Abandoned Mines and Associated Wastes

Due to intensive historic mining, there are an estimated 250 abandoned mines within the Little Blackfoot TPA according to the DEQ and MBMG databases (**Figure A-16**). Fifteen have been ranked by DEQ as high priority abandoned mines, most of which are located in the southeast portion of the TPA (**Figure A-16**). As of September 2011, reclamation work has been conducted at six of the 15 priority sites. Abandoned mine types included in the databases are placer, hard rock/lode, mineral deposits, and quarries. Because of the different mine types in the databases, abandoned mine sites may range from small ground disturbances to areas with adits (which can be dry or discharging) and/or tailings and waste rock piles of different sizes. Waste rock dumps and tailings may be in upland areas, in the floodplain or streamside, or in the stream channel. Depending on the parent geology, stability and level of re-vegetation, and capacity to leach metals and/or generate acid mine drainage, the effects of mining wastes on stream water quality can vary greatly.

There is typically not enough data near individual mining sources to allocate a specific percentage of the TMDL to an individual site relative to other abandoned mine sources. In instances where there is adequate data, loading from abandoned mines, adits, and tailings will be evaluated as separate unpermitted point sources and provided distinct wasteload allocations (WLA). Otherwise, the

contribution from all abandoned mine sources (e.g. adits, waste rock, tailings) in a contributing area or entire watershed is grouped into a composite WLA from abandoned mines. This approach is based on the assumption that reductions in metals loading can be achieved through the remediation of these abandoned mines and associated waste rock/tailings.

7.4 WATER QUALITY TARGETS AND SUPPLEMENTAL INDICATORS

7.4.1 Targets

Water Column Metals Concentrations

For pollutants with numeric standards, such as metals, the established state numeric water quality standard, as defined in Circular DEQ-7 (Montana Department of Environmental Quality, 2010a), is typically adopted as the water quality target. DEQ-7 (Montana Department of Environmental Quality, 2010a) contains numeric water quality standards for Montana's surface and ground waters that are set at concentrations necessary to protect the beneficial uses of the waters. Acute and chronic toxicity aquatic life standards are designed to protect aquatic life uses, while the human health standard is designed to protect drinking water uses. As defined in DEQ-7, compliance with chronic water quality standards is based on an average water quality metals concentration over a 96 hour period and the acute water quality standard is based on a one hour average concentration, and both are not to be exceeded more than once in a three year period.

Water quality standards (acute and chronic aquatic life, human health) for each parameter of concern in the Little Blackfoot TPA at a water hardness of 25 and mg/L are shown in **Appendix B, Table B2-5**. The numeric aquatic life standards for many metals are dependent upon water hardness values, and as the hardness increases, the water quality standards for a specific metal also increases (i.e. becomes less stringent). Consequently, where the aquatic life numeric standards are used as the target, the water quality target values for specific metals will vary with water hardness. The acute and chronic aquatic life standards for cadmium, copper, lead, and zinc are hardness-dependent.

Water quality targets for metals are the State of Montana human health and acute and chronic aquatic life standards as defined in Circular DEQ-7. Based on DEQ's draft assessment methodology (Montana Department of Environmental Quality, 2011), a pollutant waterbody combination will be considered not in compliance with the metals target if any of these circumstances are met:

- The exceedance rate of chronic aquatic life standards is > 10%. Note: the desired minimum sample size for this evaluation is 8; if there are less than 8 samples, at least 2 samples must exceed the chronic aquatic life standard to be considered not meeting the target.
- ≥ 1 sample exceeds twice the acute aquatic life water quality standard
- ≥ 1 sample exceeds the human health water quality standard

As discussed in **Section 3.0**, the aquatic life numeric standards will be used as a target for iron, because the human health standard is a secondary maximum contaminant level based on aesthetic properties and would likely be removed via conventional treatment. If the data indicate that the human health guidance values for iron would be consistently exceeded after conventional treatment, use of the waterbody for drinking water is considered impaired for this constituent.

<u>pH</u>

As discussed in **Section 3.0** and detailed in **Appendix B**, both narrative and numeric standards apply to pH. The numeric standard for B-1 waters, which allows for a pH variation of 0.5 within the range of 6.5

to 8.5 and maintaining a pH of greater than 7.0 for waterbodies naturally above 7.0, will be applied as the water quality target. An additional component of the numeric standard that will apply as the target is that waterbodies with a natural pH outside this range (6.5-8.5) must be maintained without change. For waterbodies that do not meet this target and the cause is attributable to metals sources, no pH TMDL will be written. Instead, metals TMDLs will be written as surrogates to address the address the pH impairment because acid mine drainage associated with metals sources should be addressed in conjunction with reclamation activities needed to meet metals TMDLs.

7.4.2 Supplemental Indicators

Sediment Metals Concentrations

As discussed in **Section 3.0**, narrative standards found in Montana's general water quality prohibitions apply to metals concentrations that are found in stream bottom sediments. Stream sediment data may also be indicative of beneficial use impairment caused by elevated metals and are used as supplementary indicators of impairment. In addition to directly impairing aquatic life that interacts with the elevated metals in the sediment, the elevated sediment values can also be an indicator of elevated concentrations of metals during runoff conditions. This can be a particularly important supplemental indicator when high flow data is lacking or limited.

The National Oceanic and Atmospheric Administration (NOAA) has developed Screening Quick Reference Tables that contain metals concentration guidelines for freshwater sediments (National Oceanic and Atmospheric Administration, 2008). Screening criteria concentrations come from a variety of toxicity studies and are expressed in Probable Effects Levels (PELs) (**Table 7-2**). PELs represent the sediment concentration above which toxic effects frequently occur, and are calculated as the geometric mean of the 50th percentile concentration of the toxic effects dataset and the 85th percentile of the no-effect dataset. Although the State of Montana does not currently have criteria that define impairment condition based on sediment quality data, PELs provide a screening tool to evaluate the potential for impacts to aquatic life and will be used as a supplemental indicator to assist in impairment determinations where water chemistry data are limited. Because numeric standards exist for metals in water and sediment standards are narrative, sediment metals information will be used as a supplemental indicator to water column data.

Table 7-2. Screening level criteria for sediment metals concentrations that will be used as supplemental indicators in the Little Blackfoot TPA.

Metal of Concern	PEL (µg/g dry weight)
Arsenic	17
Cadmium	3.53
Copper	197
Lead	91.3
Mercury	0.486
Selenium*	2.0
Zinc	315

*The screening value for selenium is based on the BC Ministry of Environment sediment standard (British Columbia Ministry of Water, Land and Air Protection, 2001)

Human Metals Sources

The presence of human metals sources does not always result in impairment of a beneficial use. When there are no significant identified human sources of metals within the watershed of a 303(d) listed stream, no TMDL will be prepared since Montana's narrative standards for metals relate to human

causes. Human and natural sources will be evaluated using recently collected data, field observations and watershed scale source assessment information obtained using aerial imagery, GIS data layers, and other relevant information sources.

7.4.3 Metals TMDL Development Framework

The metals targets and supplemental indicators are summarized in **Table 7-3**. TMDL determination is based on the following assumptions:

- Unless background data are available to show otherwise, natural levels of metals are below the water quality standards for aquatic life under all flow conditions.
- Single water quality samples represent a 96-hour average water quality condition.

Whether or not a TMDL is developed depends on target and supplemental indicator compliance, human sources, pollutant waterbody listing status, and dataset size as follows:

- For a currently listed pollutant waterbody combination:
  - A TMDL will be developed if all water quality targets and sediment supplemental indicator values are met and the sample size is less than eight but the source assessment indicates human sources.
  - A TMDL will not be developed if all water quality targets and sediment supplemental indicator values are met and the sample size is at least eight.
  - A TMDL will be developed if data are not in compliance with water quality targets and human sources are identified. This also applies if human sources are identified but data indicate natural background conditions may exceed water quality targets under certain flow conditions. Additional monitoring may be recommended in lieu of TMDL development if background conditions exceed water quality targets and human sources are not identified.
- For an unlisted pollutant waterbody combination:
  - A TMDL will be developed if there are at least eight recent samples, human sources are identified, and water quality samples are not in compliance with targets.
  - If there are at least eight recent water quality samples and data are in compliance with targets but sediment samples exceed supplemental indicator values, TMDL development will be determined on a case by case basis depending on human sources and the severity and extent of elevated sediment metals concentrations.
  - Monitoring may be recommended in lieu of TMDL development if water quality targets or sediment supplemental indicators are not met but the sample size is less than eight.

Table 7-3. Targets and Supplemental Indicators for Metals in the Little Blackfoot TPA.

Water Quality Targets	**Proposed Criterion**
Montana's numeric water quality standards	As described in Circular DEQ-7
Supplemental Indicators	**Proposed Criterion**
Sediment metal concentrations (µg/g dry weight)	Not impeding aquatic life use support: Comparable to PEL guidance values (see **Section 7.4.2**)
Human metals sources	No significant human sources

7.5 Existing Condition and Comparison to Water Quality Targets

For each waterbody segment with available data human sources will be reviewed first, after which recent water quality and sediment data will be evaluated relative to the water quality targets and

supplemental indicators to make a TMDL development determination. Segments will be discussed relative to their location in the TPA, with segments higher in the watershed discussed first.

7.5.1 Un-named Creek (MT76G006_010)

Prior to the 2010 303(d) List, this waterbody ID was associated with a wetland that surrounds the un-named creek. However, based on historical sampling locations, the fact that the creek flows through the wetland, and the creek's relation to metals sources, the ID and impairment listings were transferred to Un-named creek. Un-named Creek was listed for arsenic, cadmium, copper, lead, mercury, pH, and zinc on the 2010 303(d) List. The segment extends 0.8 miles from the headwaters to the mouth at Ontario Creek (**Figure 7-1**.)

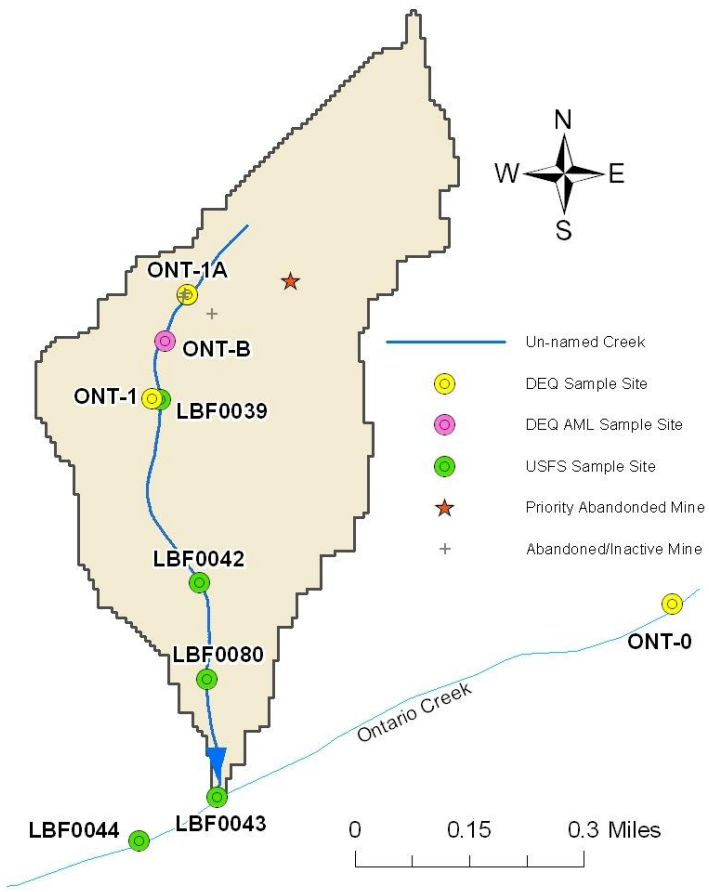


Figure 7-1. Un-named Creek Sample Sites

Sources and Available Data

The Un-named Creek basin contains a few prospect mines and two abandoned hardrock mines in the upper watershed (**Figure 7-1**). Major mining activity spanned the early to mid-20th century. One of the abandoned mines, the Amanda Mine, lacks description in any of the references and like the prospects, it is suspected to be an insignificant source of metals impairment. The other mine in the watershed, the Ontario Mine and Millsite, is the most probable impairment source. Ontario Mine is on DEQ's priority abandoned mine list and has been the subject of two reclamation projects and two university studies.

Prior to reclamation, the Ontario Mine site consisted of multiple discharging adits, waste rock piles and tailings extending a distance down Ontario Creek. In 2003, the USFS removed tailings on Forest Service property and two years later the DEQ AML program addressed waste rock on private property (Tetra Tech, 2006). DEQ's reclamation activities included removing bare tailings piles and armoring the adit drainage channel with rock, but it did not stop or treat the adit discharge and tailings that had naturally re-vegetated were left in place (Olsen, 2004).

Sources of metals impairment have been investigated in numerous reports and sampling studies. The waterbody was first listed as impaired by metals and pH in 2000 based on data collected in the 1990s. A master's thesis by Elizabeth Milodragovich investigated the site before reclamation in an attempt to determine if the wetland was improving surface water quality. The wetland's influence was shown to vary by metal constituent and season. Overall, only three metals were shown to consistently decrease in both load and concentration; lead concentrations actually increased significantly in the wetland. Groundwater was also investigated but it was found to have very little influence on surface water due to the low permeability of wetland soils (Milodragovich, 2003). The USFS also collected samples in 2001 and 2002 prior to reclamation, note however, that only data collected after the conclusion of both reclamation efforts (i.e. >2005) will be used for Un-named Creek's TMDL determinations and calculations. This distinction assures that the conditions described in this document are current and reflect any modifications to Un-named Creek caused by reclamation. Another master's thesis investigated the interaction of metals and plant uptake at the Ontario Mine site following initial remediation performed by the USFS but before the 2005 DEQ reclamation (Olsen, 2004). This research found that plants accumulated significantly more aluminum, cadmium, copper and zinc following remediation. The Olsen study reiterated that abandoned mine land reclamation is a complex process, and that in some cases it may be more economically and environmentally advantageous to leave tailings in place and allow natural revegetation to occur.

Post-reclamation sampling includes a site established in 2008 by DEQ AML, ONT-B (**Figure 7-1**), located directly below the rock lined channel and considered the first site on Un-named Creek. This site often had the highest metals concentrations because it was closest to the adit discharge. More recent sediment samples and high and low flow water samples were collected by DEQ in 2008 and 2009 at one Un-named Creek site, ONT-1, to aid with TMDL development. DEQ also tested the adit discharge at site ONT-1A on one occasion. The most recent samples were collected by the USFS from four sites on Un-named Creek in 2008 and 2010. A more comprehensive description of abandoned mines found in this watershed is provided in **Section F.1** of **Appendix F**.

Comparison to Water Quality Targets and TMDL Development Determination

The rationale for deciding if a TMDL was developed for each Un-named Creek pollutant depended on a combination of factors displayed in **Table 7-4** in accordance with the process explained in **Section 7.4**. Note, although an entire suite of metals was sampled, only listed metals or those with target/supplemental indicator exceedances are presented. Based on the data review described in **Appendix F**, TMDLs were developed for all six of the metals-related pollutants on the 2010 303(d) List as well as one metal not previously listed (iron). Numerous recent mercury samples could not be used for target comparisons because they were not analyzed using a detection limit below the human health standard and unless detection limits are below water quality standards, exceedances cannot be determined. Even though no samples detected mercury, because it is a listed pollutant with less than eight samples, a mercury TMDL was written. Additionally, recent data support the pH listing; the metals TMDLs will be used as a surrogate for a pH TMDL because reclamation activities needed to meet the metals TMDLs will address sources of acid mine drainage causing the pH impairment.

Table 7-4. Un-named Creek TMDL Decision Factors

Parameter	Arsenic	Cadmium	Copper	Iron	Lead	Mercury	Zinc
Number of samples	9	9	9	9	9	1	9
Chronic AL exceedance rate > 10%	Yes	Yes	Yes	Yes	Yes	No	Yes
Greater than twice the acute AL exceeded	No	Yes	Yes	NA	Yes	No	Yes
Human health criterion exceeded	Yes	Yes	No	NA	Yes	No	Yes
NOAA sediment PELs exceeded	Yes	No	No	NA	Yes	Not tested	No
Human-caused sources present	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2010 303(d) listing status	Listed	Listed	Listed	Not listed	Listed	Listed	Listed
TMDL Developed?	Yes	Yes	Yes	Yes	Yes	Yes	Yes

7.5.2 Monarch Creek (MT76G004_060)

Monarch Creek was listed for arsenic, copper, lead, mercury, selenium and pH on the 2010 303(d) List. The segment extends 4.7 miles from the headwaters to the mouth at Ontario Creek (**Figure 7-2**).

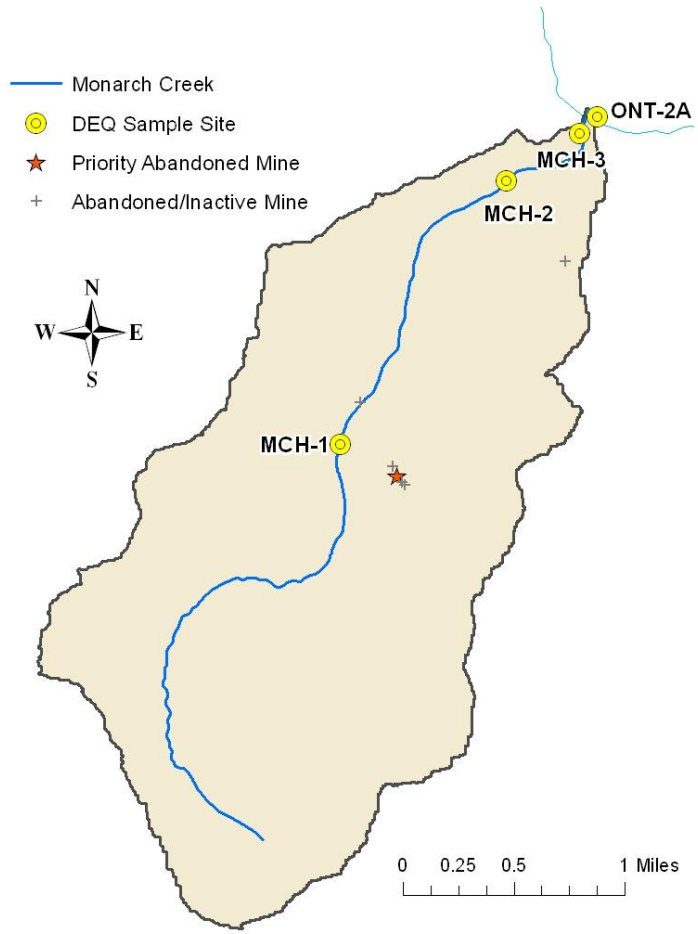


Figure 7-2. Monarch Creek Sample Sites

Sources and Available Data

The Monarch Creek basin contains a few prospect mines but only one abandoned hardrock mine, the Monarch Mine (**Figure 7-2**). The Monarch Mine appears on DEQ's priority abandoned mines list and was

most active at the turn of the 20th century although sporadic mining activity occurred as recently 1995 (Hargrave, et al., 1998). Monarch Mine is the likely source of metals impairment in Monarch Creek as the mine site consists of discharging adits, tailing piles in the floodplain and ferric-hydroxide-stained pools between the mill and creek (Hargrave, et al., 1998). A more comprehensive description of abandoned mines found in this watershed is located in **Section F.2** of **Appendix F**.

Sources of metals impairment to Monarch Creek have been investigated in numerous reports and sampling studies. Monarch Creek was first listed as impaired by metals and pH in 1988 based on data collected in the 1970s. Environmental impacts from the Monarch Mine were later investigated in 1995 by MBMG while inventorying abandoned mines in the area. DEQ subsequently collected surface water and benthic sediment data in 2004 as part of a reassessment of Monarch Creek. More recent sediment samples and high and low flow water samples were collected by DEQ in 2008 and 2009 at two Monarch Creek sites (**Figure 7-2**) to aid with TMDL development. A third site, MCH-3, was created in 2009 when the previously established sites were inaccessible due to early season conditions.

Comparison to Water Quality Targets and TMDL Development Determination
The rationale for deciding if a TMDL was developed for each Monarch Creek pollutant depended on a combination of factors displayed in **Table 7-5** in accordance with the process explained in **Section 7.4**. Note, although an entire suite of metals was sampled, only listed metals or those with target/supplemental indicator exceedances are presented. Based on the data review described in **Appendix F**, TMDLs were developed for three of the five metals-related pollutants on the 2010 303(d) List. Numerous recent mercury samples could not be used for target comparisons because they were not analyzed using a detection limit below the human health standard and unless detection limits are below water quality standards, exceedances cannot be determined. Even though no samples detected mercury, because it is a listed pollutant with less than eight samples, a mercury TMDL was written. Because no recent samples exceeded arsenic or selenium water quality targets, no TMDLs were developed for arsenic or selenium. The 303(d) listing status for these metals will be formally reevaluated by DEQ in the future. Additionally, recent data support the pH listing; the metals TMDLs will be used as a surrogate for a pH TMDL because reclamation activities needed to meet the metals TMDLs will address sources of acid mine drainage causing the pH impairment.

Table 7-5. Monarch Creek TMDL Decision Factors

Parameter	Arsenic	Copper	Lead	Mercury	Selenium
Number of samples	8	8	8	1	8
Chronic AL exceedance rate > 10%	No	Yes	Yes	No	No
Greater than twice the acute AL exceeded	No	No	No	No	No
Human health criterion exceeded	No	No	No	No	No
NOAA sediment PELs exceeded	Yes	No	Yes	No	Yes
Human-caused sources present	Yes	Yes	Yes	Yes	Yes
2010 303(d) listing status	Listed	Listed	Listed	Listed	Listed
TMDL Developed?	No	Yes	Yes	Yes	No

7.5.3 Ontario Creek (MT76G004_130)

Ontario Creek was not included on the2010 303(d) List as impaired by metals but synoptic sampling as part of TMDL development for other streams in the TPA found elevated concentrations of cadmium, copper and lead. The segment extends 6.0 miles from the headwaters to the mouth at the Little Blackfoot River (**Figure 7-3**).

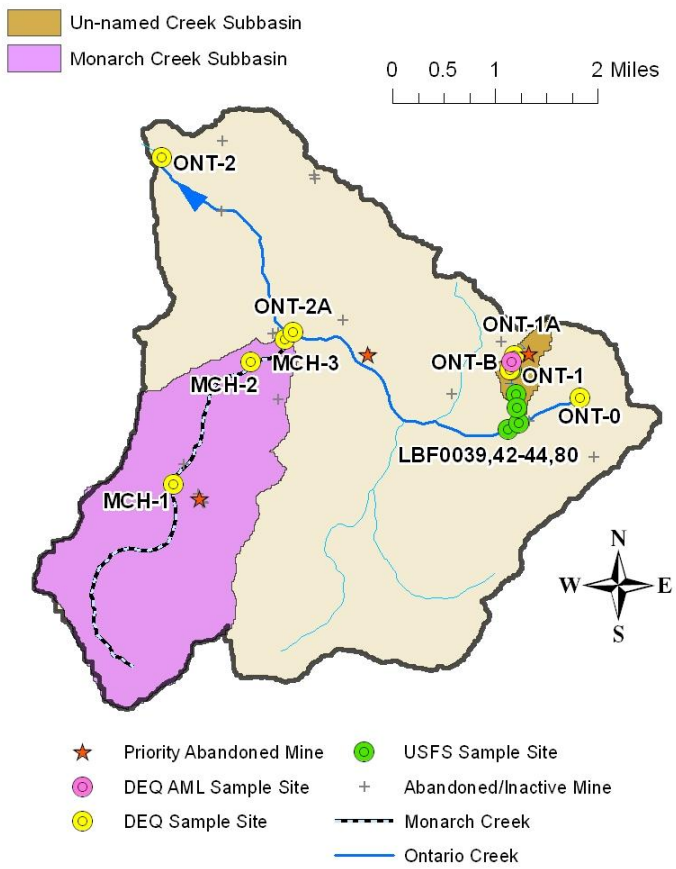


Figure 7-3. Ontario Creek Sample Sites

Sources and Available Data

The Ontario Creek basin contains approximately 20 abandoned mines including three that appear on DEQ's priority abandoned mines list. A description of metal sources and available data for two tributaries, Un-named Creek and Monarch Creek, is provided in **Sections 7.5.1** and **7.5.2**. Additional metals sources in the basin include the Hard Luck Mine, which potentially contributes metals to the mainstem Ontario Creek. This priority abandoned mine is located within 1,000 feet of Ontario Creek and is comprised of three waste rock piles and two discharging adits (Pioneer Technical Services, Inc., 1993). Operation and production dates are unknown. When visited in 1993, the adit discharge was being piped around the waste rock dump but no surface water samples were collected. A review of abandoned mine land records housed at DEQ identified three additional non-priority mines (SW NW Section 20, SW NW Section 26 and West Ontario) where water had been observed flowing out of mine adits and could potentially impact water quality in Ontario Creek. A more comprehensive description of abandoned mines found in this watershed is located in **Section F.3** of **Appendix F**.

Sources of metals impairment to Ontario Creek had not been intensely sampled before the start of this TMDL process. While the USFS collected samples with elevated metals concentrations on Ontario Creek in an effort that focused near the Un-named Creek confluence in the early 1990s and the early 2000s, the stream remained unlisted. More recent sediment samples and high and low flow water samples were collected by DEQ in 2008 and 2009 at one Ontario Creek site, ONT-2 (**Figure 7-3**), to aid with TMDL

development. Another site in the headwaters region, ONT-0, was sampled during one low event and a third site, ONT-2A, was sampled during both flow conditions in 2009. The most recent samples were collected by the USFS from one site, LBF0044, on Ontario Creek in 2008 and 2010.

Comparison to Water Quality Targets and TMDL Development Determination
The rationale for deciding if a TMDL was developed for each Ontario Creek pollutant depended on a combination of factors displayed in **Table 7-6** in accordance with the process explained in **Section 7.4**. Note, although an entire suite of metals was sampled, only metals with target/supplemental indicator exceedances are presented. Based on the data review described in **Appendix F**, TMDLs were developed for three metals-related pollutants not included on the 2010 303(d) List.

Table 7-6. Ontario Creek TMDL Decision Factors

Parameter	Cadmium	Copper	Lead
Number of samples	9	9	9
Chronic AL exceedance rate > 10%	Yes	Yes	Yes
Greater than twice the acute AL exceeded	Yes	No	No
Human health criterion exceeded	No	No	No
NOAA sediment PELs exceeded	Yes	No	Yes
Human-caused sources present	Yes	Yes	Yes
2010 303(d) listing status	Not listed	Not listed	Not listed
TMDL Developed?	**Yes**	**Yes**	**Yes**

7.5.4 Sally Ann Creek (MT76G004_055)

Sally Ann Creek was not included on the2010 303(d) List as impaired by metals but synoptic sampling as part of TMDL development for other streams in the TPA found elevated concentrations of cadmium, copper and zinc. The segment extends 1.6 miles from the headwaters to the mouth at O'Keefe Creek (**Figure 7-4**).

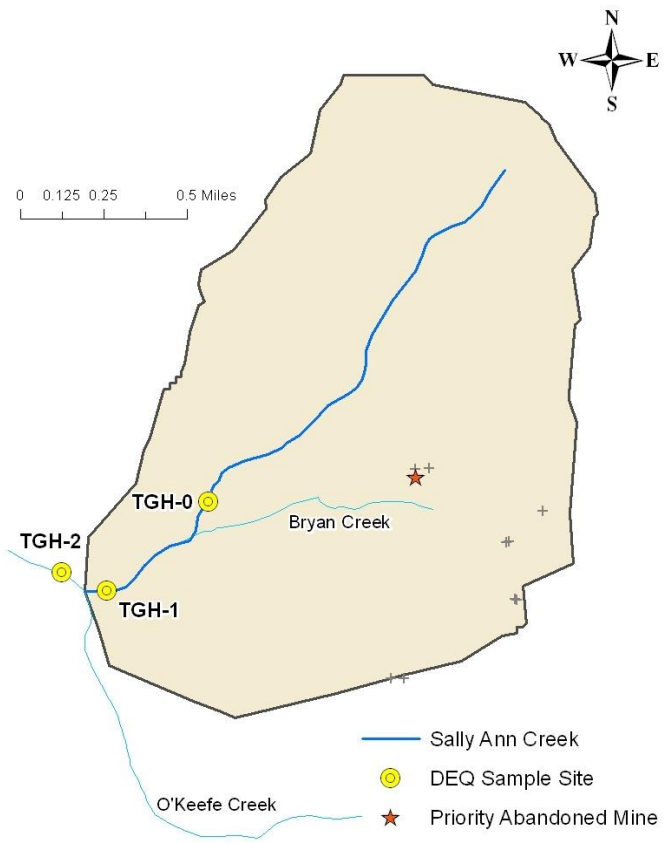


Figure 7-4. Sally Ann Creek Sample Sites

Sources and Available Data

The Sally Ann Creek basin contains approximately five abandoned mines, including the Telegraph Mine which appears on DEQ's priority abandoned mines list. Additionally, placer mining is known to have occurred in a tributary to Sally Ann Creek. Major mining activity occurred in the 1920s and 1930s. One of the abandoned mines, the Bullion Mine, was visited by MBMG in 1993 and noted as having no visible impacts (Hargrave, et al., 1998). A review of abandoned mine land records housed at DEQ identified two additional non-priority mines (Home Stake and Excelsior) in the basin with waste rock piles or standing water in mine shafts which could also potentially impact water quality in Sally Ann Creek. In 1995 the Telegraph Mine had a discharging adit and water flowing through waste rock and tailings that tested very acidic and high in metals concentrations (Hargrave, et al., 1998). Some mine waste was removed from the Telegraph Mine in 2005 by the USFS (Ihle, Beth, personal communication 2008). A more comprehensive description of abandoned mines found in this watershed is located in **Section F.4** of **Appendix F**.

Sources of metals impairment to Sally Ann Creek had not been intensely investigated before the start of this TMDL process. The only available data is sediment samples and high and low flow water samples collected by DEQ in 2008 and 2009 at one Sally Ann Creek site, TGH-1 (**Figure 7-4**). Another site, TGH-0, was established in 2009.

Comparison to Water Quality Targets and TMDL Development Determination
The rationale for deciding if a TMDL was developed for each Sally Ann Creek pollutant depended on a combination of factors displayed in **Table 7-7** in accordance with the process explained in **Section 7.4**. Note, although an entire suite of metals was sampled, only metals with target/supplemental indicator exceedances are presented. Based on the data review described in **Appendix F**, TMDLs were developed for three metals-related pollutants not included on the 2010 303(d) List.

Table 7-7. Sally Ann Creek TMDL Decision Factors

Parameter	Cadmium	Copper	Zinc
Number of samples	6	6	6
Chronic AL exceedance rate > 10%	Yes	Yes	Yes
Greater than twice the acute AL exceeded	Yes	No	No
Human health criterion exceeded	No	No	No
NOAA sediment PELs exceeded	Yes	No	Yes
Human-caused sources present	Yes	Yes	Yes
2010 303(d) listing status	Not listed	Not listed	Not listed
TMDL Developed?	**Yes**	**Yes**	**Yes**

7.5.5 O'Keefe Creek (MT76G004_054)

O'Keefe Creek was not included on the2010 303(d) List as impaired by metals but synoptic sampling as part of TMDL development for other streams in the TPA found elevated concentrations of cadmium, copper and zinc. The segment extends 2.0 miles from the headwaters to the mouth at Telegraph Creek (**Figure 7-5**).

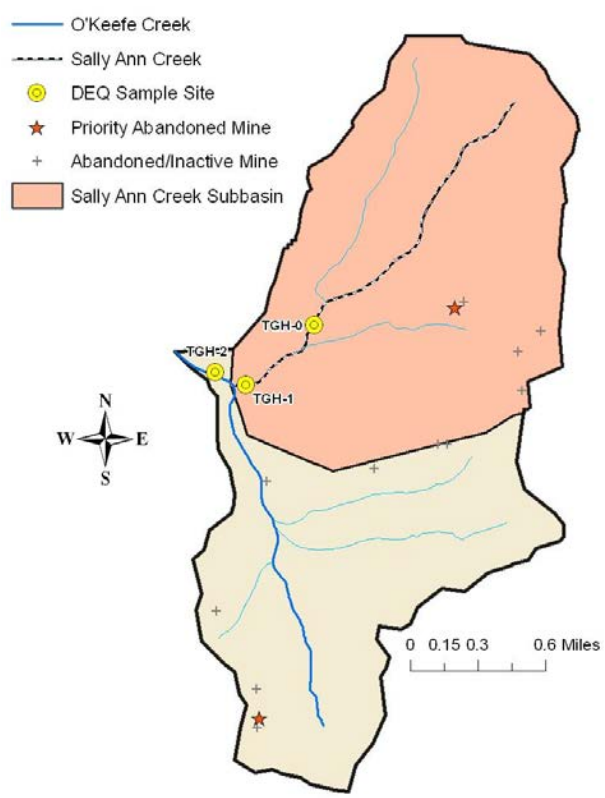


Figure 7-5. O'Keefe Creek Sample Sites

Sources and Available Data

The O'Keefe Creek basin contains approximately 15 abandoned mines. A description of metal sources and available data from Sally Ann Creek, a tributary to O'Keefe Creek, is provided in **Section 7.5.4**. Additional sources include the Sure Thing Mine which appears on DEQ's priority abandoned mines list and was the site of major mining activity throughout the first half of the 20th century. The Sure Thing Mine site has a discharging adit that flows through tailings and waste rock that exceeded many metal human health standards (Pioneer Technical Services, Inc., 1993). Starting in 2001, the Sure Thing Mine was the site of a four year field demonstration investigating the effectiveness of using sulfate-reducing bacteria to mitigate the impacts of acid mine drainage. The study found metals concentrations in the adit discharge were reduced and pH increased, but after the study period the treatment system was removed (Nordwick, 2008a). Another potential source of metals in the basin is the O'Keefe Creek/Copper King Mine, which is adjacent to O'Keefe Creek and has mine wastes in contact with the stream and several impoundments (Hargrave, et al., 1998). A more comprehensive description of abandoned mines found in this watershed is located in **Section F.5** of **Appendix F**.

Sources of metals impairment to O'Keefe Creek had not been intensely sampled before the start of this TMDL process. The only available data is one stream sediment sample and high and low flow water samples collected by DEQ in 2008 and 2009 at a single O'Keefe Creek site, TGH-2 (**Figure 7-5**). Note all data used for TMDL determinations was collected after the temporary treatment system at the Sure Thing Mine site was removed.

Comparison to Water Quality Targets and TMDL Development Determination

The rationale for deciding if a TMDL was developed for each O'Keefe Creek pollutant depended on a combination of factors displayed in **Table 7-8** in accordance with the process explained in **Section 7.4**. Note, although an entire suite of metals was sampled, only metals with target/supplemental indicator exceedances are presented. Based on the data review described in **Appendix F**, TMDLs were developed for three metals-related pollutants not included on the 2010 303(d) List.

Table 7-8. O'Keefe Creek TMDL Decision Factors

Parameter	Cadmium	Copper	Zinc
Number of samples	4	4	4
Chronic AL exceedance rate > 10%	Yes	Yes	Yes
Greater than twice the acute AL exceeded	Yes	No	No
Human health criterion exceeded	No	No	No
NOAA sediment PELs exceeded	Yes	No	Yes
Human-caused sources present	Yes	Yes	Yes
2010 303(d) listing status	Not listed	Not listed	Not listed
TMDL Developed?	**Yes**	**Yes**	**Yes**

7.5.6 Upper Telegraph Creek (MT76G004_051)

The upper segment of Telegraph Creek was listed for arsenic, beryllium, cadmium, copper, iron, and zinc on the 2010 303(d) List. It extends 5.4 miles from the headwaters to the mouth at Hahn Creek (**Figure 7-6**).

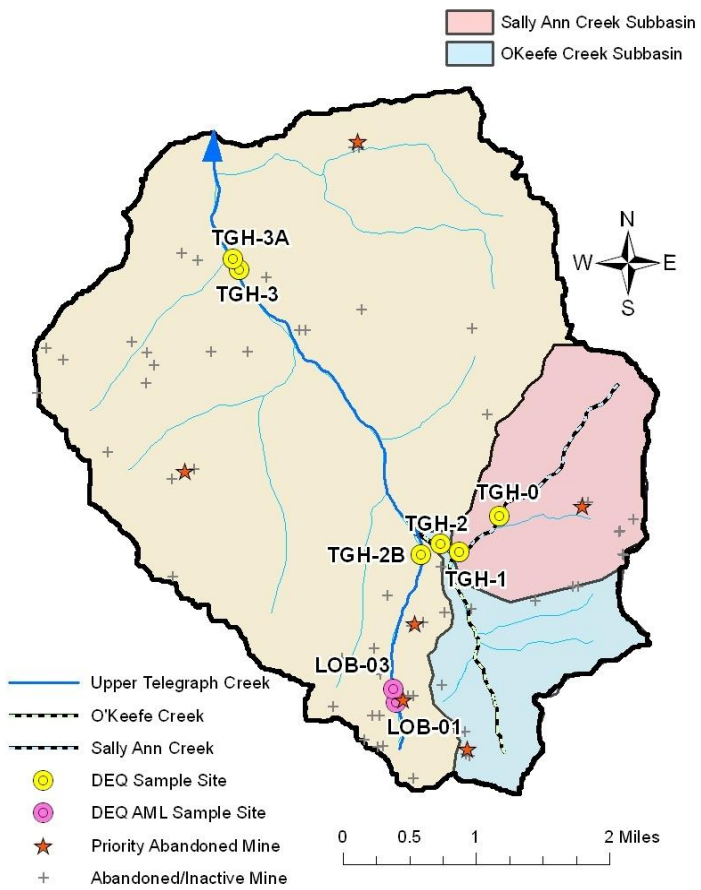


Figure 7-6. Upper Telegraph Creek Sample Sites

Sources and Available Data

The upper Telegraph Creek basin contains approximately 50 abandoned mines, half of which are located in the tributary basins of Sally Ann Creek and O'Keefe Creek. Descriptions of metal sources and available data for Sally Ann Creek and O'Keefe Creek are provided in **Sections 7.5.4** and **7.5.5**.

Metals sources exclusive to the upper Telegraph basin include four mines that appear on DEQ's priority abandoned mines list. A review of abandoned mine land records housed at DEQ identified three additional non-priority mines (SW SE Section 10, Champion, and Moonlight Cabin Mine) in the basin with waste rock piles or standing water in mine shafts which could impact water quality in upper Telegraph Creek. One of the priority abandoned mines, the Third Term Mine, had an adit tunnel backfilled and the surrounding land re-sloped in 1993 by DEQ AML (Clark, P., personal communication 2010). However, two years later the adit had subsided and the reclaimed area still lacked soils or vegetation (Hargrave, et al., 1998). The USFS removed some mine waste from the Third Term and Viking, Hub Camp and Hope mines in 2005 (Ihle, Beth, personal communication 2008). Another priority site, the Lily/Orphan Boy Mine, has discharging adits and waste rock spanning Telegraph Creek (Tetra Tech, 2009b). Starting in 1994 the Lily/Orphan Boy Mine was the site of a ten year field demonstration investigating the effectiveness of using sulfate-reducing bacteria to mitigate the impacts of acid mine drainage. The study found metals concentrations in the adit discharge were reduced and pH increased, but after the study period the treatment system was removed (Nordwick, 2008b). DEQ's AML Program recently completed a reclamation investigation assessing conditions and detailing the site's potential for reclamation (Tetra Tech, 2009a). Phase II of the report, in which a detailed engineering and cost analysis

is performed, is forthcoming (Clark, P., personal communication 2010). Other potential sources of metals in the basin are the Julia, Anna R/Hattie M, Hub Camp and Viking Mines with their associated adits and mine waste piles as close as 500 feet from Telegraph Creek (Hargrave, et al., 1998; Pioneer Technical Services, Inc., 1993). A more comprehensive description of abandoned mines found in this watershed is located in **Section F.6** of **Appendix F**.

Sources of metals impairment to upper Telegraph Creek have been investigated in numerous reports and sampling studies. Telegraph Creek was first listed for metals impairment in 1988 based on data collected by DEQ in the late 1970s. A number of water and sediment samples were collected near abandoned mines in 1993 and 1995 by MBMG and DEQ AML (Hargrave, et al., 1998; Pioneer Technical Services, Inc., 1993).DEQ AML collected samples in 2008 at LOB-01 and LOB-03 (**Figure 7-6**) near the Lily/Orphan Boy Mine site for the reclamation investigation report. The most recent sediment samples and high and low flow water samples were collected by DEQ in 2008 and 2009 to aid with TMDL development. Three sites, TGH-2B, TGH-3 and TGH-3A (**Figure 7-6**), were sampled during both flow conditions for one year. Note: all data used for TMDL determinations was collected after the temporary treatment system at the Lily/Orphan Boy Mine site was removed.

Comparison to Water Quality Targets and TMDL Development Determination
The rationale for deciding if a TMDL was developed for each upper Telegraph Creek pollutant depended on a combination of factors displayed in **Table 7-9** in accordance with the process explained in **Section 7.4**. Note, although an entire suite of metals was sampled, only listed metals or those with target/supplemental indicator exceedances are presented. Based on the data review described in **Appendix F**, TMDLs were developed for five of the six metals-related pollutants on the 2010 303(d) List in addition to one metal not previously listed (lead). Even though beryllium was not detected in any samples, because it is a listed pollutant with less than eight samples, a beryllium TMDL was written. Because no recent samples exceeded iron water quality targets, no TMDL was developed and the 303(d) listing status for iron will be formally reevaluated by DEQ in the future.

Table 7-9. Upper Telegraph Creek TMDL Decision Factors

Parameter	Arsenic	Beryllium	Cadmium	Copper	Iron	Lead	Zinc
Number of samples	8	4	8	8	8	6	8
Chronic AL exceedance rate > 10%	No	No	Yes	Yes	No	Yes	Yes
Greater than twice the acute AL exceeded	No	No	Yes	No	NA	No	Yes
Human health criterion exceeded	Yes	No	No	No	NA	No	No
NOAA sediment PELs exceeded	Yes	NA	Yes	No	NA	Yes	Yes
Human-caused sources present	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2010 303(d) listing status	Listed	Listed	Listed	Listed	Listed	Not listed	Listed
TMDL Developed?	**Yes**	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**Yes**

7.5.7 Lower Telegraph Creek (MT76G004_052)

The lower segment of Telegraph Creek was listed for lead and mercury on the 2010 303(d) List and extends 2.5 miles from the bottom of the upper segment (confluence with Hahn Creek) to the mouth at the Little Blackfoot River (**Figure 7-7**).

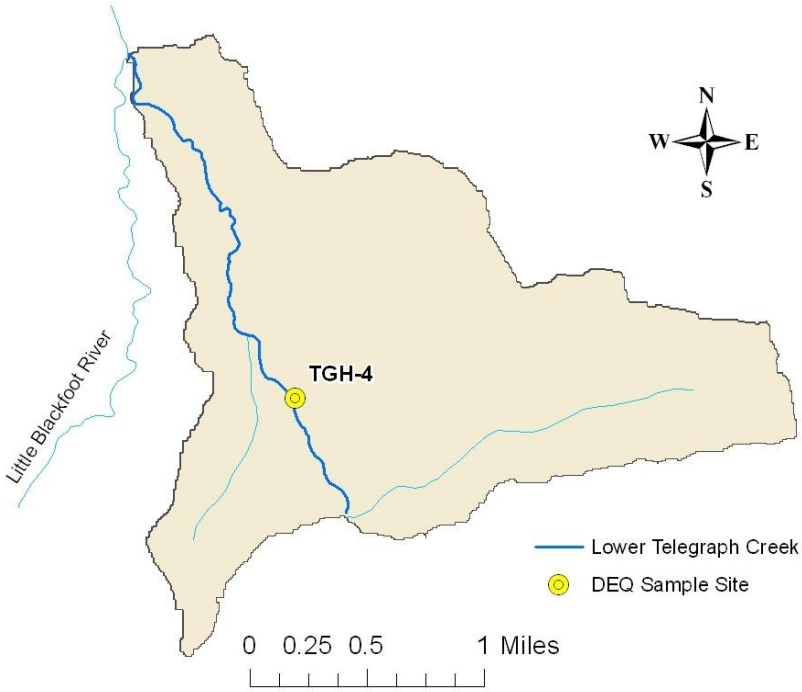


Figure 7-7. Lower Telegraph Creek Sample Sites

Sources and Available Data

The lower Telegraph Creek basin contains no abandoned mines. The sources of human-related metals inputs to lower Telegraph Creek are abandoned mines in the upper Telegraph Creek basin described separately in **Section 7.5.6** and **Appendix F**.

Sources of metals impairment to lower Telegraph Creek have been investigated in numerous sampling studies. Telegraph Creek was first listed for metals on the 1988 303(d) List based on data collected by DEQ in 1977. Until 1999, the two Telegraph Creek segments were combined as one (MT76G004-20). Historic data from the Third Term Mine in the upper Telegraph Creek basin indicate elevated mercury levels, which could be the source of the mercury listing for lower Telegraph Creek. The most recent sediment samples and high and low flow water samples were collected by DEQ in 2008 and 2009 at one site, TGH-4 (**Figure 7-7**), to aid with TMDL development.

Comparison to Water Quality Targets and TMDL Development Determination

The rationale for deciding if a TMDL will be developed for each lower Telegraph Creek pollutant depends on a combination of factors displayed in **Table 7-10** in accordance with the process explained in **Section 7.4**. Note, although an entire suite of metals was sampled, only listed metals or those with target/supplemental indicator exceedances are presented. Based on the data review described in **Section F.7** of **Appendix F**, TMDLs were developed for the two metals-related pollutants on the 2010 303(d) List as well as three metals not previously listed (cadmium, copper and zinc). Numerous recent mercury samples could not be used for target comparisons because they were not analyzed using a detection limit below the human health standard and unless detection limits are below water quality standards, exceedances cannot be determined. Even though mercury was not detected in any samples, because it is a listed pollutant with less than eight samples, a mercury TMDL was written.

Table 7-10. Lower Telegraph Creek TMDL Decision Factors

Parameter	Cadmium	Copper	Lead	Mercury	Zinc
Number of samples	4	4	4	1	4
Chronic AL exceedance rate > 10%	Yes	Yes	Yes	No	Yes
Greater than twice the acute AL exceeded	No	No	No	No	No
Human health criterion exceeded	No	No	No	No	No
NOAA sediment PELs exceeded	Yes	No	No	Not tested	Yes
Human-caused sources present	Yes	Yes	Yes	Yes	Yes
2010 303(d) listing status	Not listed	Not listed	Listed	Listed	Not listed
TMDL Developed?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

7.5.8 American Gulch Creek (MT76G004_079)

American Gulch Creek was not included on the2010 303(d) List as impaired by metals but synoptic sampling as part of TMDL development for other streams in the TPA found elevated concentrations of arsenic. The segment extends 2.7 miles from the headwaters to the mouth at Dog Creek (**Figure 7-8**).

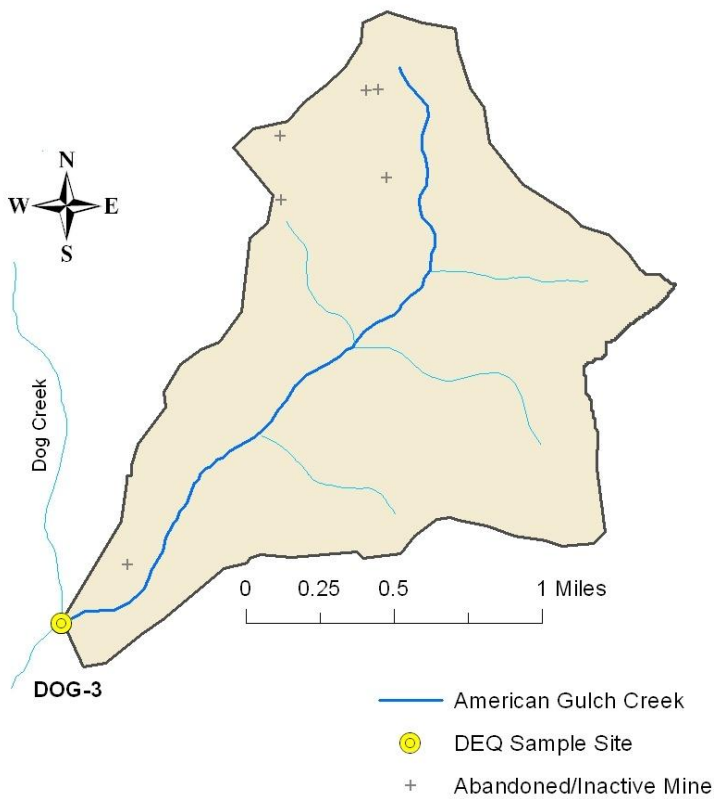


Figure 7-8. American Gulch Creek Sample Sites

Sources and Available Data

The American Gulch Creek basin contains approximately six abandoned lode and prospect mines, none of which appear on DEQ's priority abandoned mines list. A review of abandoned mine land records housed at DEQ identified two additional non-priority mines (Neenan and NE SE Section 10) in the basin with associated tailings that could impact water quality in American Gulch Creek. The abandoned mine databases lacked descriptive information on the remaining mines. Additionally, DEQ AML (Pioneer

Technical Services, Inc., 1993) and MBMG (Hargrave, et al., 1998) sampling efforts that investigated abandoned mines in the region failed to study mines specific to American Gulch Creek.

Sources of metals impairment to American Gulch Creek had not been intensely sampled before the start of this TMDL process. The only available data is one stream sediment sample and high and low flow water samples collected by DEQ in 2008 and 2009 at a single American Gulch Creek site, DOG-3 (**Figure 7-8**).

Comparison to Water Quality Targets and TMDL Development Determination
The rationale for deciding if a TMDL was developed for each American Gulch Creek pollutant depended on a combination of factors displayed in **Table 7-11** in accordance with the process explained in **Section 7.4**. Note, although an entire suite of metals was sampled, only metals with target/supplemental indicator exceedances are presented. Based on the data review described in **Appendix F**, TMDLs were developed for one metals-related pollutant not included on the 2010 303(d) List.

Table 7-11. American Gulch Creek TMDL Decision Factors

Parameter	Arsenic
Number of samples	4
Chronic AL exceedance rate > 10%	No
Greater than twice the acute AL exceeded	No
Human health criterion exceeded	Yes
NOAA sediment PELs exceeded	Yes
Human-caused sources present	Yes
2010 303(d) listing status	Not listed
TMDL Developed?	**Yes**

7.5.9 Upper Dog Creek (MT76G004_071)

The upper segment of Dog Creek was listed for arsenic, lead and zinc on the 2010 303(d) List and extends 4.3 miles from the headwaters to the confluence with Meadow Creek (**Figure 7-9**).

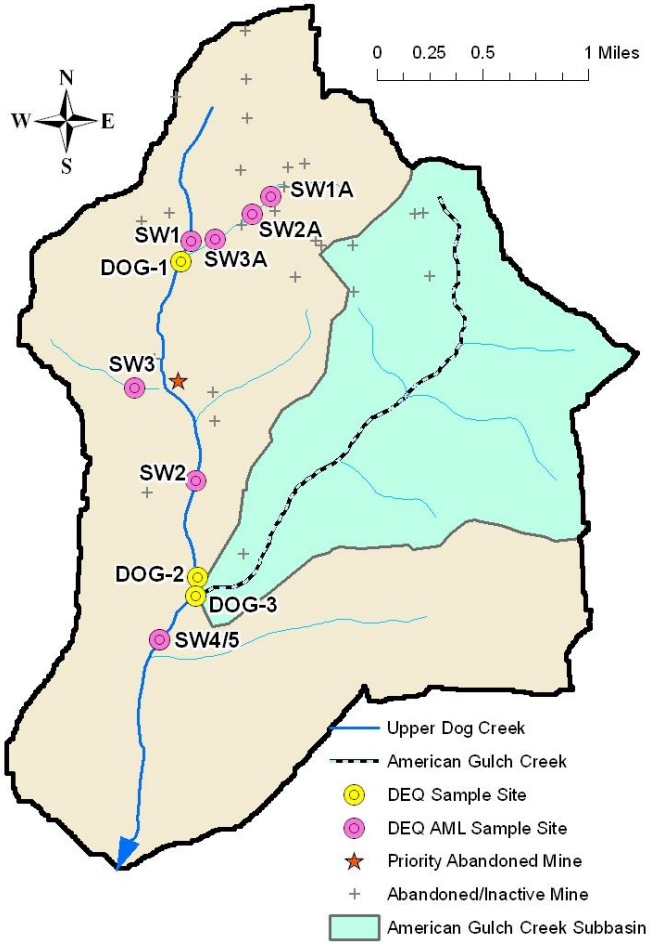


Figure 7-9. Upper Dog Creek Sample Sites

Sources and Available Data

The upper Dog Creek basin contains approximately 25 abandoned mines including one (Bald Butte) that appears on DEQ's priority abandoned mines list. A review of abandoned mine land records housed at DEQ identified six additional non-priority mines (Black Hawk Janette, Black Douglas, Kenawa, Larson, Rose Bud, and Rose Densmore) in the basin with waste rock piles or standing water in mine shafts which could impact water quality in upper Dog Creek. Major mining activity took place from the early to mid-20th century. A description of metal sources and available data for a tributary to Dog Creek, American Gulch Creek, is provided in **Section 7.5.8**. In 2010, DEQ AML started a three year reclamation project on the Bald Butte Mine to limit the mobility of contaminants. The project will also remove mine waste from two other mines in the area (Devon/Sterling and Albion) and place all of the material in a secure repository (Olympus Technical Services, Inc., 2004). Currently, waste rock and tailings are present in the floodplain of Dog Creek and its tributaries. In addition, numerous abandoned and inactive mines in the area are discharging metal-laden water into nearby streams either directly or through groundwater flow (Hargrave, et al., 1998; Pioneer Technical Services, Inc., 1993). A more comprehensive description of abandoned mines found in this watershed is located in **Section F.9** of **Appendix F**.

Sources of metals impairment to upper Dog Creek have been investigated in numerous reports and sampling studies. Dog Creek's upper segment was originally included on the 303(d) List in 2000 based on

data collected in 1998. DEQ AML collected more than 50 stream sediment samples of Dog Creek in 2003, many of them more than double the PEL value, making it unique among streams in the Little Blackfoot TPA for its abundance of sediment samples. At the same time, water quality data were collected to help evaluate the reclamation potential of Bald Butte Mine and the surrounding area. The most recent metals data was collected by DEQ in 2008 and 2009 at two sample sites, DOG-1 and DOG-2, to aid with TMDL development (**Figure 7-9**). A third site, DOG-3, was established on American Gulch, a tributary to Dog Creek's upper segment. Note all Dog Creek data was collected before the start of reclamation on Bald Butte Mine. Water quality conditions could change from what is presented in this document as a result.

Comparison to Water Quality Targets and TMDL Development Determination

The rationale for deciding if a TMDL was developed for each upper segment Dog Creek pollutant depended on a combination of factors displayed in **Table 7-12** in accordance with the process explained in **Section 7.4**. Note, although an entire suite of metals was sampled, only listed metals or those with target/supplemental indicator exceedances are presented. Based on the data review described in **Appendix F**, TMDLs will be developed for the three metals-related pollutants on the 2010 303(d) List as well as two metals not previously listed (cadmium and copper). Supplemental indicator values for mercury were exceeded in all sediment samples, with 89% being more than twice the PEL, but no surface water samples have been collected; future water quality monitoring is recommended to determine if mercury is causing metals impairment.

Table 7-12. Upper Dog Creek TMDL Decision Factors

Parameter	Arsenic	Cadmium	Copper	Lead	Zinc
Number of samples	12	12	9	12	12
Chronic AL exceedance rate > 10%	No	Yes	Yes	Yes	Yes
Greater than twice the acute AL exceeded	No	No	No	No	Yes
Human health criterion exceeded	Yes	No	No	Yes	No
NOAA sediment PELs exceeded	Yes	Yes	Yes	Yes	Yes
Human-caused sources present	Yes	Yes	Yes	Yes	Yes
2010 303(d) listing status	Listed	Not listed	Not listed	Listed	Listed
TMDL Developed?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

7.5.10 Lower Dog Creek (MT76G004_072)

Lower Dog Creek Creek was not included on the 2010 303(d) List as impaired by metals but synoptic sampling as part of TMDL development for other streams in the TPA found elevated concentrations of copper and lead. The segment extends 13.6 miles from Meadow Creek to the mouth at the Little Blackfoot River (**Figure 7-10**).

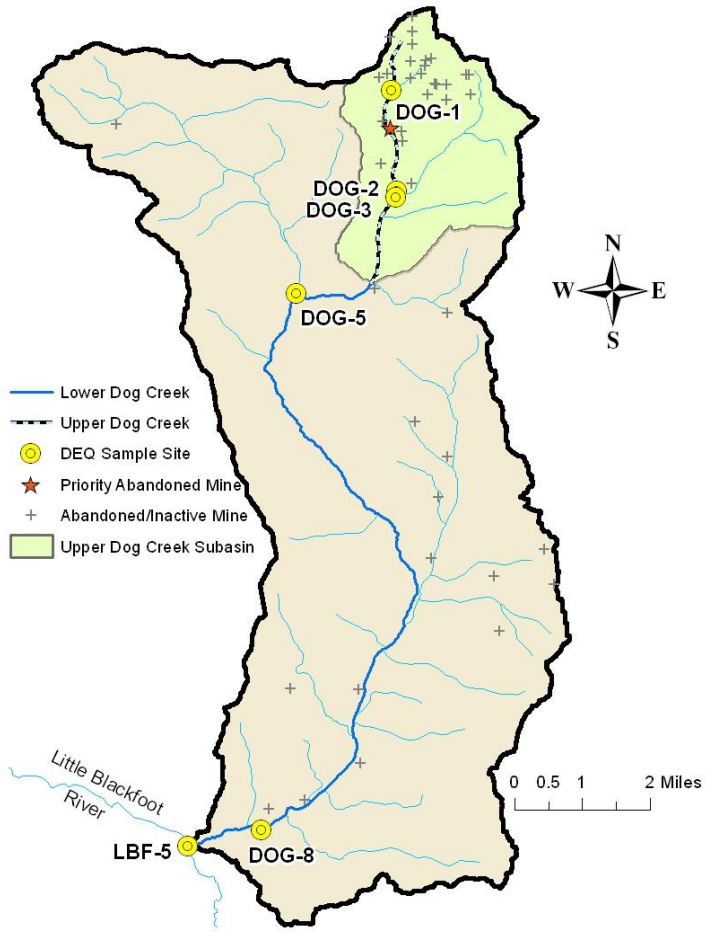


Figure 7-10. Lower Dog Creek Sample Sites

Sources and Available Data

The Dog Creek basin contains approximately 45 abandoned mines, 30 of which are located in the upper Dog Creek basin. A description of metal sources and available data from upper Dog Creek is provided in **Section 7.5.9** and **Appendix F**. The remaining 15 mines lacked description in abandoned mine databases besides listing copper, gold and silver as commodities produced (Hargrave, et al., 1998). Additionally, DEQ AML (Pioneer Technical Services, Inc., 1993) and MBMG (Hargrave, et al., 1998) sampling efforts that investigated abandoned mines in the region failed to study mines specific to lower Dog Creek.

Sources of metals impairment to lower Dog Creek had not been intensely sampled before the start of this TMDL process. The only available data is one stream sediment sample and high and low flow water samples collected by DEQ in 2008 and 2009 at a single lower Dog Creek site, DOG-8 (**Figure 7-10**). A second site (DOG-5) was established on Hope Creek, a tributary to lower Dog Creek.

Comparison to Water Quality Targets and TMDL Development Determination

The rationale for deciding if a TMDL was developed for each lower Dog Creek pollutant depended on a combination of factors displayed in **Table 7-13** in accordance with the process explained in **Section 7.4**. Note, although an entire suite of metals was sampled, only metals with target/supplemental indicator exceedances are presented. Based on the data review described in **Section F.10** of **Appendix F**, TMDLs were developed for two metals-related pollutants not included on the 2010 303(d) List.

Table 7-13. Lower Dog Creek TMDL Decision Factors

Parameter	Copper	Lead
Number of samples	4	4
Chronic AL exceedance rate > 10%	Yes	Yes
Greater than twice the acute AL exceeded	No	No
Human health criterion exceeded	No	No
NOAA sediment PELs exceeded	No	Yes
Human-caused sources present	Yes	Yes
2010 303(d) listing status	Not listed	Not listed
TMDL Developed?	**Yes**	**Yes**

7.5.11 Upper Little Blackfoot River (MT76G004_020)

The upper segment of the Little Blackfoot River was listed for arsenic and cyanide on the 2010 303(d) List and extends 22.5 miles from the headwaters to the confluence with Dog Creek (**Figure 7-11**).

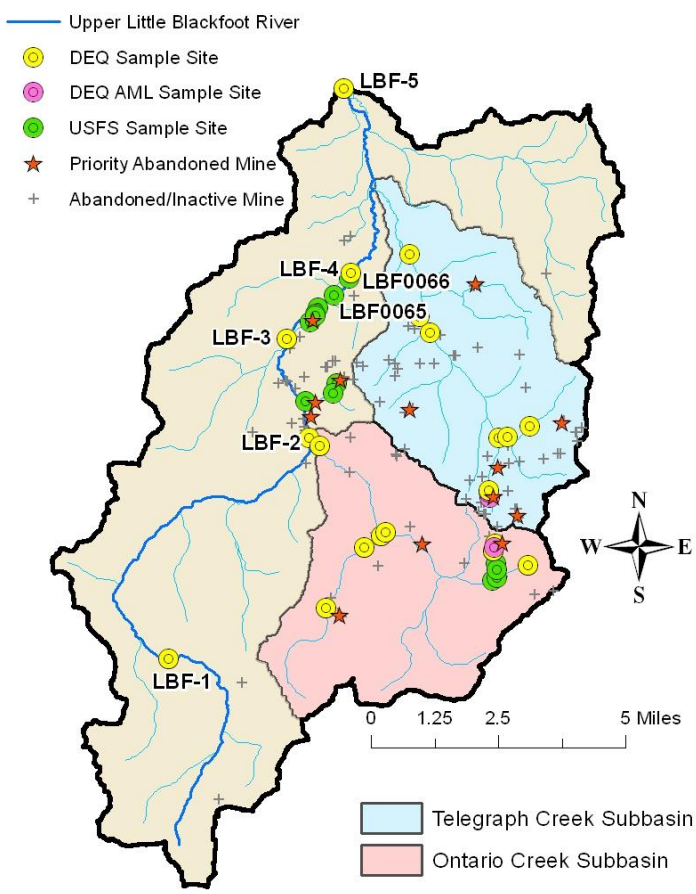


Figure 7-11. Upper Little Blackfoot River Sample Sites

Sources and Available Data

The upper Little Blackfoot River basin contains an estimated 110 abandoned mines, approximately 70 of which are located in the tributary basins of Ontario and Telegraph Creek. Descriptions of metal sources and available data for Ontario and Telegraph Creek are provided in **Sections 7.5.3** and **7.5.7** and

Appendix F. The upper Little Blackfoot basin contains a majority (13/15) of the priority abandoned mines in the TPA; four are located in the upper Little Blackfoot watershed outside the Ontario and Telegraph Creek subbasins. A review of abandoned mine land records housed at DEQ identified five additional non-priority mines (Negroes, NE NW Section 12, SE NW Section 12, SW NE Section 12 and SW SE Section 1) in the basin with associated adits (one observed discharging) that could impact water quality in the Little Blackfoot River. Major mining activity took place from the early to mid-20th century.

The four priority abandoned mines located outside of the Ontario and Telegraph creek watersheds are the Charter Oak, Kimball, Mountain View and Golden Anchor Mines. In 1996/1998 the USFS removed waste material and conducted adit treatment at the Charter Oak Mine: it is now listed on the National Register of Historic Places and open for interpretative tours (USDA Forest Service, 2007). Even though recent data has not detected cyanide, the Charter Oak Mine is potential source because empty barrels of sodium cyanide and sprayer equipment used for cyanide application were found at the site. After reclamation, in 2009 and 2010, the Forest Service collected water samples from three wells downstream of the mine site, two discharging adits and two beaver pond sites that all had metals exceedances, thus Charter Oak Mine is still introducing metals into the Little Blackfoot River. The Kimball, Mountain View, and Golden Anchor Mines are within a mile of each other and all have mine wastes near surface waters. These three remaining priority abandoned mines are potential sources of metals to the Little Blackfoot River even though the USFS removed mine wastes from these sites in 2006 (Ihle, Beth, personal communication 2008). Five additional mines in the basin have adits possibly impacting water quality. In November 2008, the formerly plugged Golden Anchor Mine adit blew-out, sending forth a large volume of orange-colored water into Tramway Creek, a tributary to the Little Blackfoot River (Byron, 12/4/2008). After the blow-out, both DEQ and USFS collected water quality data. No fish-kills were documented (Byron, 1/17/2009), and based on the data, the incident only resulted in a temporary spike in metals concentrations in the Little Blackfoot River. A more comprehensive description of abandoned mines found in this watershed is located in **Section F.11** of **Appendix F**.

Sources of metals impairment to the upper Little Blackfoot River have been investigated in numerous reports and sampling studies. The Little Blackfoot River's upper segment was first listed for metals impairment in 1990 based on data collected by DEQ in the late 1970s. A number of water and sediment samples were collected near abandoned mines in 1993 and 1995 by MBMG and DEQ AML (Hargrave, et al., 1998; Pioneer Technical Services, Inc., 1993). In 2008, the USFS collected metals data on two Little Blackfoot River sites, LBF0065 and LBF0066 (**Figure 7-11**). The most recent sediment samples and high and low flow water samples were collected at five sites by DEQ in 2008 and 2009 to aid with TMDL development (**Figure 7-11**). Note data collected immediately following the Golden Anchor Mine blowout was not used for TMDL determinations because it was deemed non-representative of current conditions.

Comparison to Water Quality Targets and TMDL Development Determination

The rationale for deciding if a TMDL was developed for each Little Blackfoot River (upper segment) pollutant depended on a combination of factors displayed in **Table 7-14** in accordance with the process explained in **Section 7.4**. Note, although an entire suite of metals was sampled, only listed metals or those with target/supplemental indicator exceedances are presented. Based on the data review described in **Appendix F**, TMDLs will be developed for the two metals-related pollutants on the 2010 303(d) List as well as three metals not previously listed (cadmium, copper, and lead).

Table 7-14. Upper Little Blackfoot River TMDL Decision Factors

Parameter	Arsenic	Cadmium	Copper	Cyanide	Lead
Number of samples	20	20	20	8	20
Chronic AL exceedance rate > 10%	No	Yes	Yes	Yes	Yes
Greater than twice the acute AL exceeded	No	Yes	No	No	No
Human health criterion exceeded	Yes	No	No	No	Yes
NOAA sediment PELs exceeded	Yes	No	No	NA	Yes
Human-caused sources present	Yes	Yes	Yes	Yes	Yes
2010 303(d) listing status	Listed	Not listed	Not listed	Listed	Not listed
TMDL Developed?	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**

7.5.12 Lower Little Blackfoot River (MT76G004_010)

The lower segment of Little Blackfoot River was listed for copper and lead on the 2010 303(d) List and extends 26.5 miles from the bottom of the upper segment (confluence of Dog Creek) to the mouth at the Clark Fork River (**Figure 7-12**).

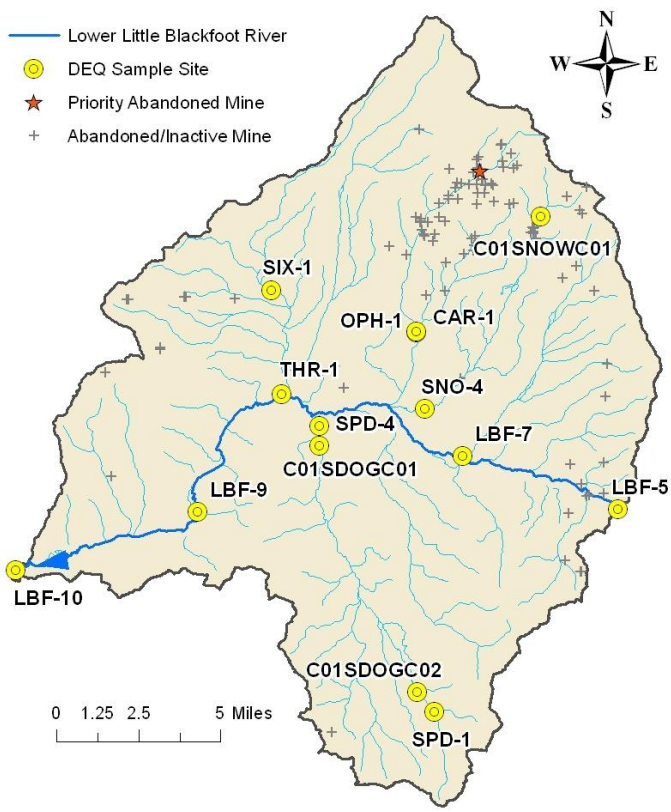


Figure 7-12. Lower Little Blackfoot River Sample Sites

Sources and Available Data

The lower Little Blackfoot River basin contains an estimated 100 abandoned mines, including the Victory/Evening Star Mine which appears on DEQ's priority abandoned mines list. Another factor influencing water quality in the lower segment is approximately 110 abandoned mines and thirteen priority abandoned mines located in the upper Little Blackfoot River basin. A description of metal sources and available data for the Little Blackfoot River's upper segment is provided in **Section 7.5.11**

and **Appendix F**. Major mining activity took place from the early to mid-20th century. Like most mining in the lower Little Blackfoot River basin, the Victory/Evening Star Mine is located in the Ophir Creek drainage. When MBMG visited the mine site in 1995 there were tailings in the Ophir Creek floodplain but they did not appear to be actively eroding (Hargrave, et al., 1998). A review of abandoned mine land records housed at DEQ identified nine additional non-priority mines (Blue Speckled Adit, Cow Spring Cabin, Esmeralda Hill, Gimlet, NE NE Section 19, NE NW Section 29, Ophir Cabin, SE NW Section 20 and Upsetti) in the basin with waste rock piles or standing water in mine shafts which could impact water quality in the Little Blackfoot River. A more detailed description of abandoned mines found in this watershed is located in **Section F.12** of **Appendix F**.

As of October 2011, there was an active general permit for suction dredging (MTG370318) on Carpenter Creek. The general permit has special conditions to minimize harmful conditions caused by elevated suspended sediment concentrations, however metals loading is not specifically addressed; DEQ sampled stream sediments at CAR-1 (**Figure 7-12**) and found all metal concentrations to be below secondary targets. Based on permit conditions that limit suspended sediment and low metals concentrations in the stream sediment, the suction dredging operation is not expected to result in the exceedance of metals water quality targets.

Sources of metals impairment to the lower Little Blackfoot River have been investigated in numerous reports and sampling studies. The lower segment of the Little Blackfoot River was first listed for metals in 2000 based on data collected in the 1970s and 1980s. Additionally, a USGS gage on the Little Blackfoot River near the town of Garrison has collected discharge data since 1972 and intermittent water quality data since 1982. More recent sediment samples and high and low flow water samples were collected by DEQ in 2008 and 2009 at three sites on the Little Blackfoot River, LBF-7, LBF-9 and LBF-10 (**Figure 7-12**), to aid with TMDL development. A fourth site, LBF-5, was established on the upper segment directly before the start of the lower segment. DEQ also established sample sites in six tributary streams.

Comparison to Water Quality Targets and TMDL Development Determination

The rationale for deciding if a TMDL was developed for each Little Blackfoot River (lower segment) pollutant depended on a combination of factors displayed in **Table 7-15** in accordance with the process explained in **Section 7.4**. Note, although an entire suite of metals was sampled, only listed metals or those with target/supplemental indicator exceedances are presented. Based on the data review described in **Appendix F**, a TMDL will be developed for one of the two metals-related pollutants on the 2010 303(d) List as well as one metal not previously listed (arsenic). Because no recent samples exceeded copper water quality targets, no TMDL was developed and the 303(d) listing status for copper will be formally reevaluated by DEQ in the future.

Table 7-15. Lower Little Blackfoot River TMDL Decision Factors

Parameter	Arsenic	Copper	Lead
Number of samples	34	34	34
Chronic AL exceedance rate > 10%	No	No	Yes
Greater than twice the acute AL exceeded	No	No	No
Human health criterion exceeded	Yes	No	No
NOAA sediment PELs exceeded	Yes	No	Yes
Human-caused sources present	Yes	Yes	Yes
2010 303(d) listing status	Not listed	Listed	Listed
TMDL Developed?	**Yes**	**No**	**Yes**

7.5.13 TMDL Development Determination Summary

Twelve individual stream segments were found to have metals-related impairments in the Little Blackfoot River TMDL Planning Area. A review of metals target exceedances verified most metals impairments on the 2010 303(d) List, however, four listings were shown not to be representative of current conditions and TMDLs were not developed in these cases. Additionally, recent sampling identified elevated concentrations for 23 metals not identified on the 2010 303(d) List. Included in **Table 7-16** is a summary of existing metals impairment causes and an overview of which TMDLs were prepared based on observed target exceedances. A total of 45 metals TMDLs are required as well as two pH impairments that will be addressed via surrogate metals TMDLs. TMDLs and allocations for these parameters are given in the following section.

Table 7-16. Summary of Streams Requiring Metals TMDLs

Stream Segment	Waterbody Segment ID	Metals-related 2010 303(d) Listings	Metals TMDLs Prepared
AMERICAN GULCH CREEK, headwaters to mouth (Dog Creek)	MT76G004_079	-	Arsenic
DOG CREEK, headwaters to Meadow Creek	MT76G004_071	Arsenic, Lead, Zinc	Arsenic, Cadmium, Copper, Lead, Zinc
DOG CREEK, Meadow Creek to mouth (Little Blackfoot River)	MT76G004_072	-	Copper, Lead
LITTLE BLACKFOOT RIVER, headwaters to Dog Creek	MT76G004_020	Arsenic, Cyanide	Arsenic, Cadmium, Copper, Cyanide, Lead
LITTLE BLACKFOOT RIVER, Dog Creek to mouth (Clark Fork River)	MT76G004_010	***Copper***, Lead	Arsenic, Lead
MONARCH CREEK, headwaters to mouth (Ontario Creek)	MT76G004_060	***Arsenic***, Copper, Lead, Mercury, pH, ***Selenium***	Copper, Lead, Mercury, pH*
O'KEEFE CREEK, headwaters to mouth (Telegraph Creek)	MT76G004_054	-	Cadmium, Copper, Zinc
ONTARIO CREEK, headwaters to mouth (Little Blackfoot River)	MT76G004_130	-	Cadmium, Copper, Lead
SALLY ANN CREEK, headwaters to mouth (O'Keefe Creek)	MT76G004_055	-	Cadmium, Copper, Zinc
TELEGRAPH CREEK, headwaters to Hahn Creek	MT76G004_051	Arsenic, Beryllium, Cadmium, Copper, ***Iron***, Zinc	Arsenic, Beryllium, Cadmium, Copper, Lead, Zinc
TELEGRAPH CREEK, Hahn Creek to mouth (Little Blackfoot River)	MT76G004_052	Lead, Mercury	Cadmium, Copper, Lead, Mercury, Zinc
UN-NAMED CREEK, headwaters to mouth (Ontario Creek)	MT76G006_010	Arsenic, Cadmium, Copper, Lead, Mercury, pH, Zinc	Arsenic, Cadmium, Copper, Iron, Lead, Mercury, pH*, Zinc

*pH listings are addressed via surrogate metals TMDLs
Bold Italics: recent data does not support listing. Listing status will be reevaluated.

7.6 METALS TMDLS APPROACH

TMDLs for metals represent the maximum amount (lbs/day) of each metal that a stream can receive while maintaining water quality standards. A stream's ability to assimilate metal pollutants is based on stream discharge (i.e. its ability to dilute metal concentration), and for many metals, the water hardness (which can effect toxicity and determines the numeric water quality standard). Because both of these variables (streamflow and hardness) vary seasonally, the TMDL for a metal must be established so that it maintains protection of beneficial uses for the anticipated range of flow and hardness conditions. Metals TMDLs are calculated using the equation below:

TMDL = (X) (Y) (k)

TMDL = Total Maximum Daily Load in lbs/day
X = lowest applicable metals water quality target in µg/L for a specific hardness value
Y = streamflow in cubic feet per second (cfs)
k = conversion factor of 0.0054

All metals TMDLs are calculated using the most stringent target value, which ensures that the TMDLs are protective off all designated beneficial uses. Note that the more stringent chronic aquatic life standards are used to calculate most TMDLs. Using the chronic standard to calculate an allowable daily load, rather than a 96-hour load limit (see **Section 7.4.1**), affords an implicit margin of safety in calculating the TMDL and also establishes a daily load limit expression. For some metals the human health standard is used in calculating TMDL because it is more stringent than the chronic aquatic life standard. This is the case for lead (under high water hardness conditions) and arsenic and mercury (under all conditions). Although the TMDL is often derived from the chronic standards, acute aquatic life standards are also established as water quality targets, and are applied as an instantaneous in-stream pollutant concentration that shall not be exceeded (see **Section 7.4.1**). Remediation will be needed to address the sources of metals loading that contribute to the exceedance of water quality targets and to meet the allocations defined in **Section 7.7**.

Figures 7-13 through **7-22** show TMDLs for arsenic, beryllium, cadmium, copper, cyanide, iron, lead, mercury, selenium and zinc under various flow conditions. These curves are applicable to all metals TMDLs in this document. Where aquatic life criteria are variable based on water hardness, TMDLs at a hardness of 25 mg/L and 400 mg/L are shown. TMDLs based on human health criteria are also shown where appropriate. Example TMDLs are shown in **Table 7-17** for the 12 waterbody segments in the Little Blackfoot TPA requiring metals TMDLs.

Where data is available, TMDLs are calculated based on high and low flow sampling events. High flows are assumed to be between April 15th and June 30th while low flow samples are those collected at all other times. The existing loads, percent reductions and TMDL components displayed in this document should not be considered rigid numbers; rather, they should be seen as best approximations portraying the existing variability inherent to these calculations. Existing loads for each waterbody segment are calculated using sample data from sites with the greatest exceedance of the applicable water quality target for most metals unless otherwise stated because it is assumed that addressing the sources needed to meet the TMDL at the location with the greatest exceedance will result in attainment of water quality standards throughout the waterbody. However, in some instances where a portion of the TMDL is allocated to an upstream segment, the upstream segment's TMDL will be calculated at the site lowest in the basin. Also, non-detect samples are considered to be ½ the detection limit when used in calculations.

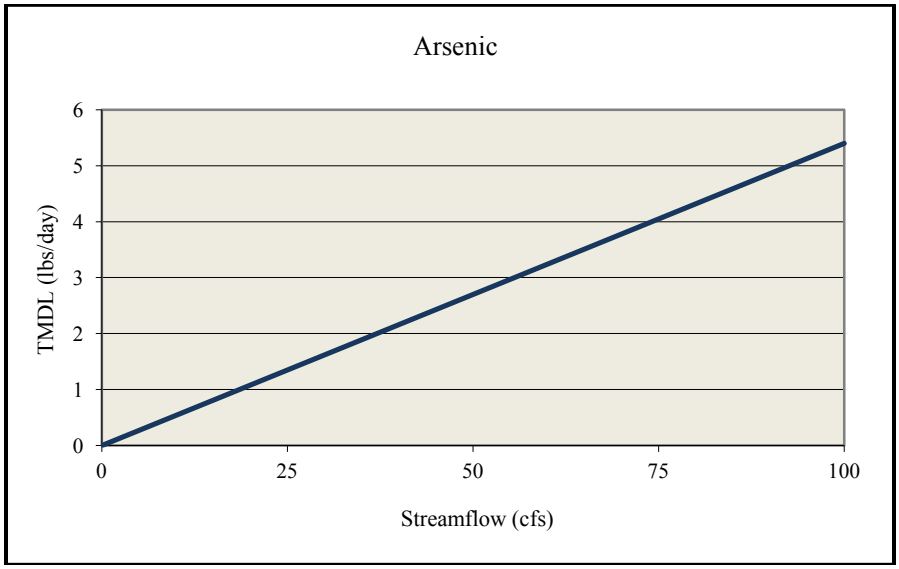


Figure 7-13. Arsenic TMDL as a function of flow

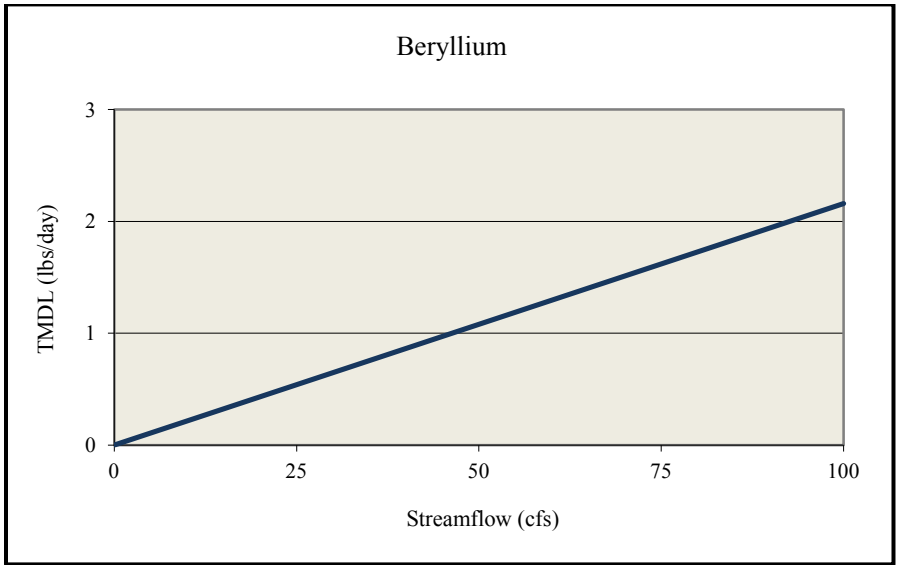


Figure 7-14. Beryllium TMDL as a function of flow

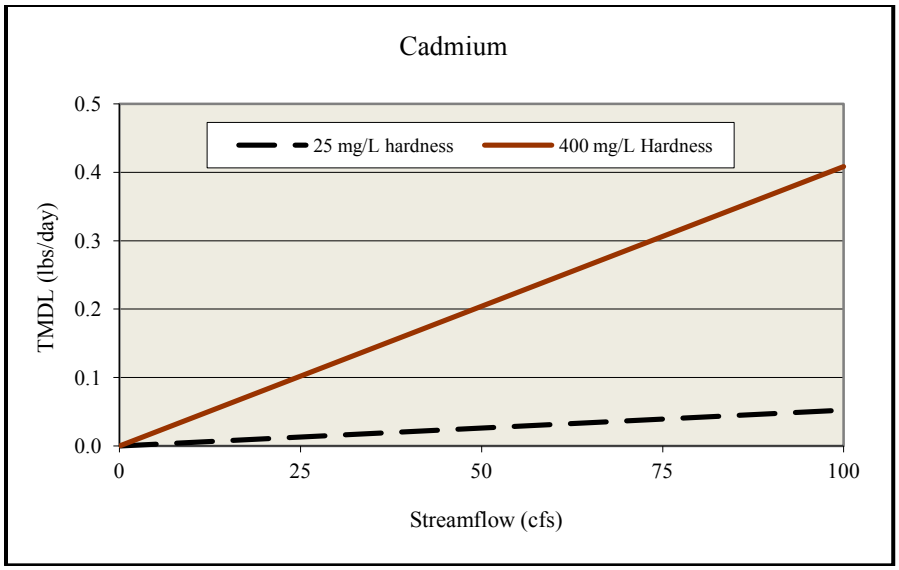


Figure 7-15. Cadmium TMDL as a function of flow

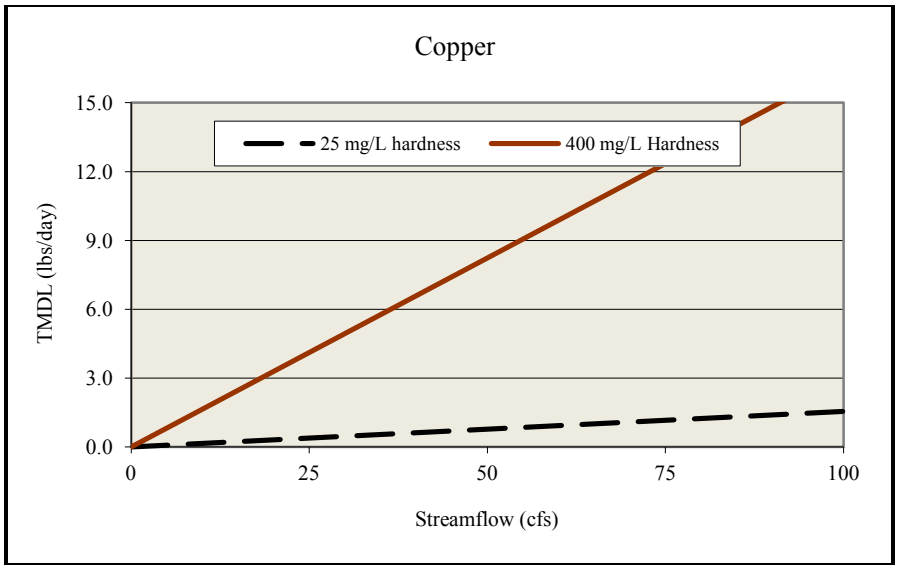


Figure 7-16. Copper TMDL as a function of flow

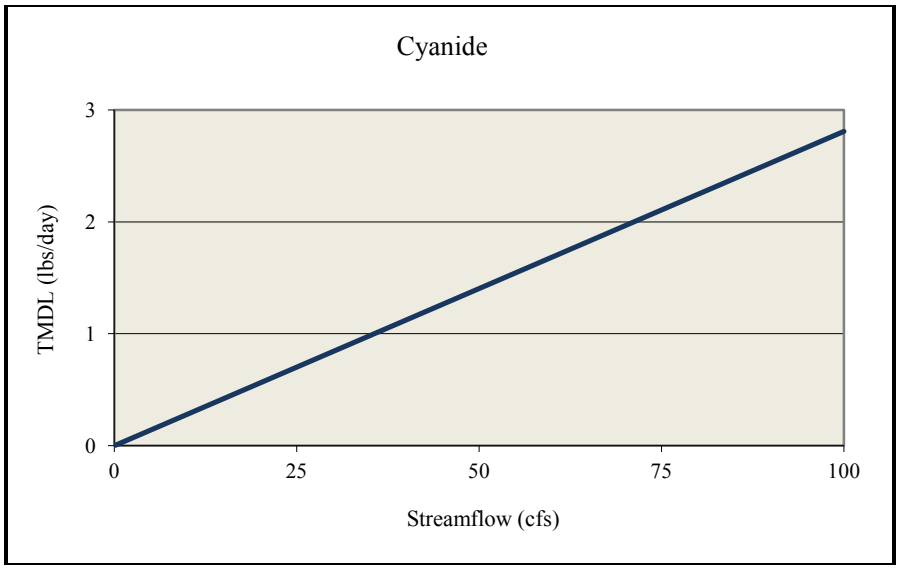


Figure 7-17. Cyanide TMDL as a function of flow

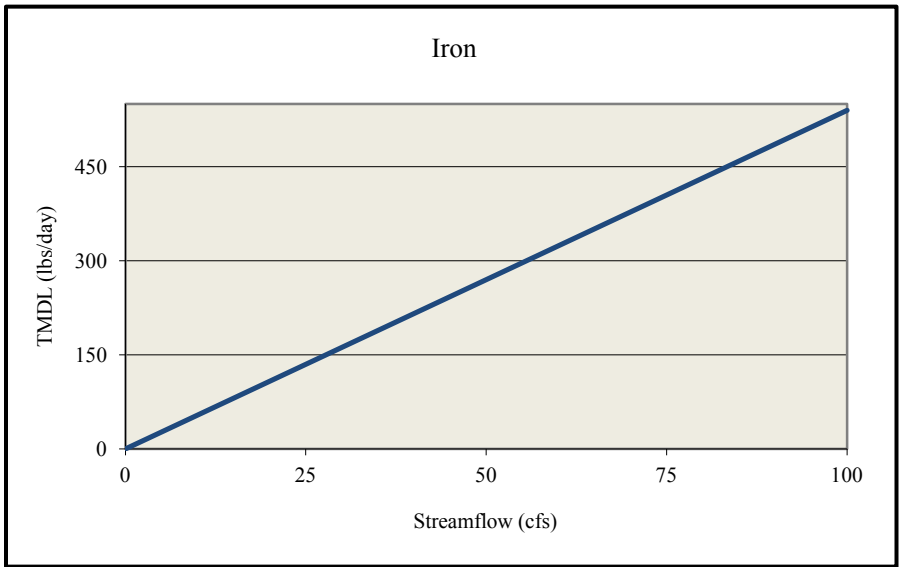


Figure 7-18. Iron TMDL as a function of flow

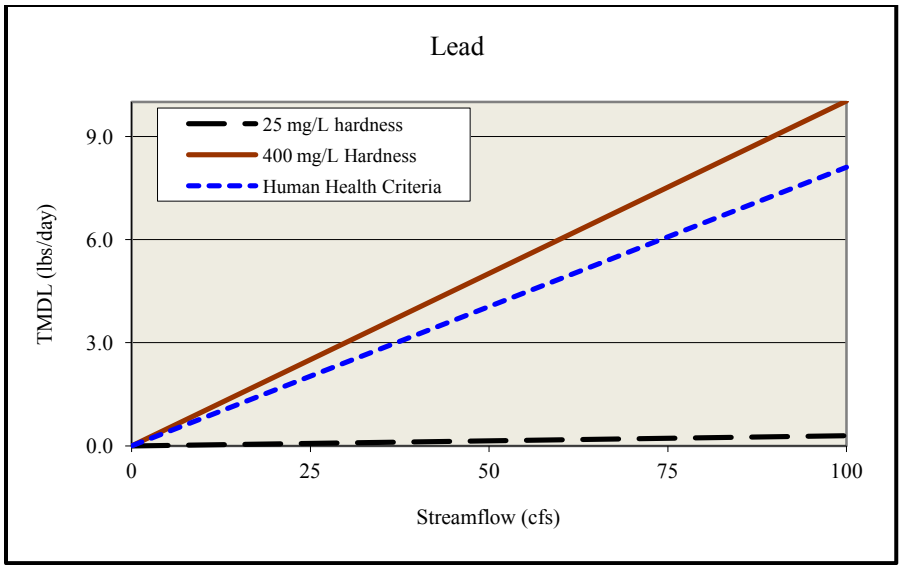


Figure 7-19 Lead TMDL as a function of flow

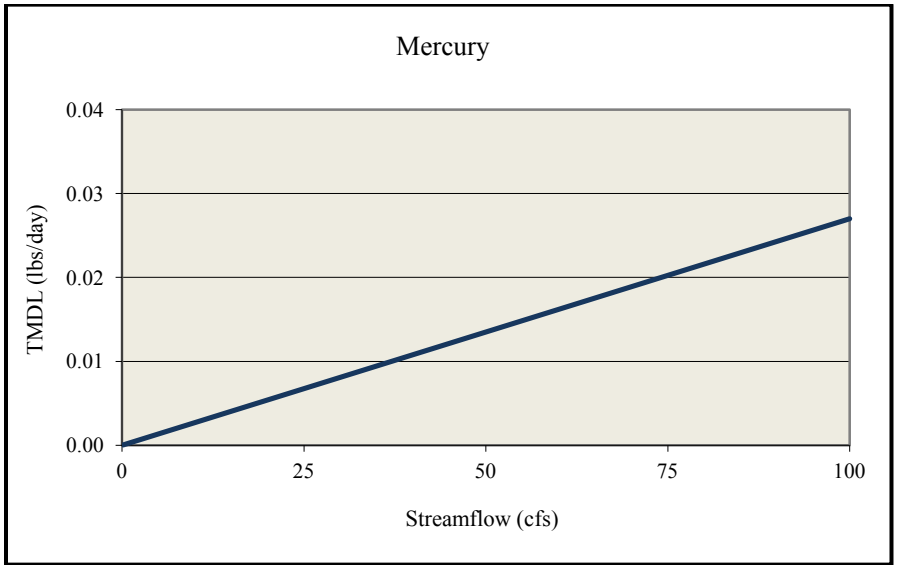


Figure 7-20 Mercury TMDL as a function of flow

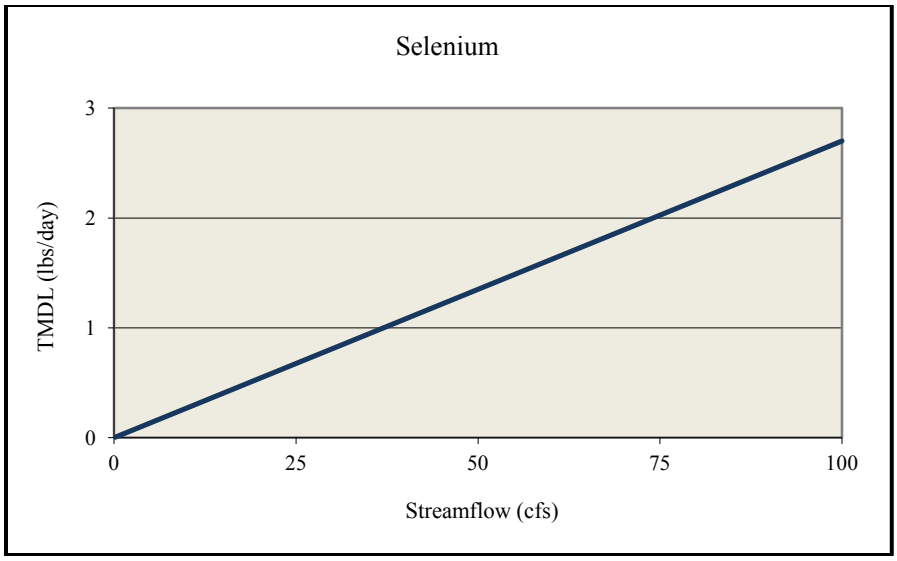


Figure 7-21 Selenium TMDL as a function of flow

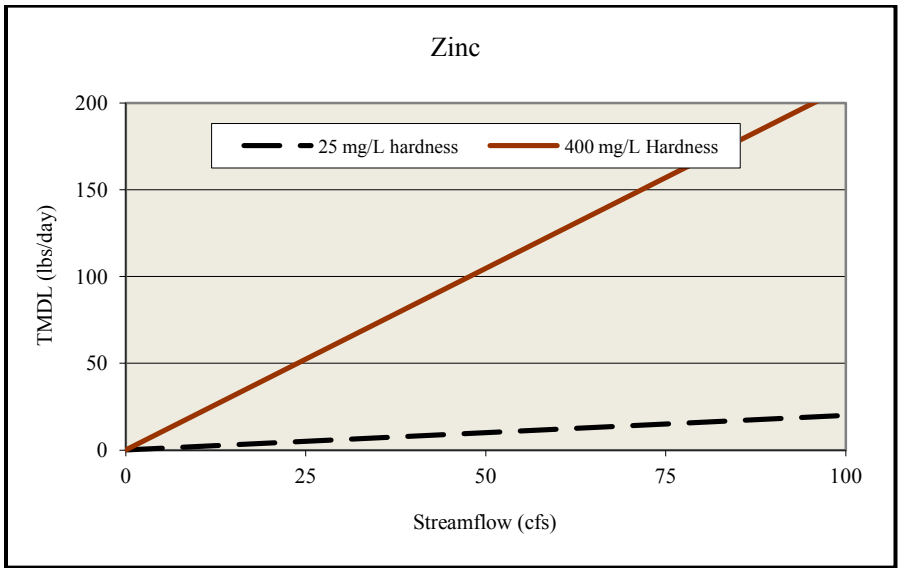


Figure 7-22. Zinc TMDL as a function of flow

Table 7-17. Detailed inputs for example TMDLs in the Little Blackfoot TPA

Stream Segment	Station	Discharge (cfs)		Hardness		Metal	Target Conc. (µg/L)		TMDL (lbs/day)		% Reduction Based on Sample Target Exceedances	
		High Flow	Low Flow	High Flow	Low Flow		High Flow	Low Flow	High Flow	Low Flow	High Flow	Low Flow
American Gulch Creek(MT76G004_079)	DOG-3	13.37	0.85	99	149	Arsenic	10	10	0.722	0.046	23%	38%
Dog Creek, Upper (MT76G004_071)	*	26.65	1.8	99	156.5	Arsenic	10	10	1.439	0.097	23%	62%
						Cadmium	0.27	0.38	0.039	0.004	62%	0%
						Copper	9.25	13.68	1.331	0.133	0%	0%
						Lead	3.14	5.63	0.452	0.055	68%	30%
						Zinc	118.8	175.12	17.097	1.702	0%	0%
Dog Creek, Lower (MT76G004_072)	DOG-8	247.6	12.17	49	134	Copper	5.07	11.98	6.779	0.787	28%	0%
						Lead	1.28	4.62	1.711	0.304	80%	0%
Little Blackfoot River, Upper (MT76G004_020)	LBF-5	908.13	35.9	33	65	Arsenic	10	10	49.039	1.930	38%	0%
						Cadmium	0.12	0.2	0.588	0.039	25%	0%
						Copper	3.62	6.46	17.752	1.252	48%	0%
						Cyanide	5.2	5.2	25.500	1.008	77%	0%
						Lead	0.78	1.84	3.825	0.357	92%	0%
Little Blackfoot River, Lower (MT76G004_010)	LBF-10	1555.5	58.2	67	138	Arsenic	10	10	83.997	3.143	29%	0%
						Lead	1.91	4.79	16.043	1.505	79%	0%
Monarch Creek (MT76G004_060)	MCH-2	13.79	1.49	9	15	Copper	2.85	2.85	0.212	0.023	5%	0%
						Lead	0.54	0.54	0.04	0.004	33%	0%
						Mercury	0.05	0.05	0.004	0.0004	0%	0%
O'Keefe Creek (MT76G004_054)	TGH-2	40.21	0.8	10	28	Cadmium	0.1	0.11	0.022	0.001	95%	0%
						Copper	2.85	3.14	0.619	0.014	43%	0%
						Zinc	37.02	40.75	8.038	0.176	47%	0%
Ontario Creek (MT76G004_130)	ONT-2	238.09	5.39	9	15	Cadmium	0.1	0.1	0.129	0.003	55%	0%
						Copper	2.85	2.85	3.664	0.083	29%	0%
						Lead	0.54	0.54	0.694	0.016	89%	0%
Sally Ann Creek (MT76G004_055)	TGH-1	33.43	0.49	10	31	Cadmium	0.1	0.11	0.018	0.0003	93%	0%
						Copper	2.85	3.43	0.514	0.009	29%	0%
						Zinc	37.02	44.42	6.683	0.118	26%	0%

Table 7-17. Detailed inputs for example TMDLs in the Little Blackfoot TPA

Stream Segment	Station	Discharge (cfs)		Hardness		Metal	Target Conc. (µg/L)		TMDL (lbs/day)		% Reduction Based on Sample Target Exceedances	
		High Flow	Low Flow	High Flow	Low Flow		High Flow	Low Flow	High Flow	Low Flow	High Flow	Low Flow
Telegraph Creek, Upper (MT76G004_051)	TGH-3A	90.16	1.91	13	38	Arsenic	10	10	4.869	0.103	0%	0%
						Beryllium	4	4	1.947	0.041	0%	0%
						Cadmium	0.1	0.13	0.049	0.001	17%	0%
						Copper	2.85	4.08	1.388	0.042	43%	0%
						Lead	0.54	0.93	0.263	0.010	61%	0%
						Zinc	37.02	52.87	18.024	0.544	26%	0%
Telegraph Creek, Lower (MT76G004_052)	TGH-4	93.5	4.36	16	42	Cadmium	0.1	0.14	0.050	0.003	9%	0%
						Copper	2.85	4.45	1.439	0.105	43%	0%
						Lead	0.54	1.05	0.273	0.025	61%	0%
						Mercury	0.05	0.05	0.025	0.0012	0%	0%
						Zinc	32.07	57.45	18.691	0.506	26%	0%
Un-named Creek (MT76G006_010)	ONT-1	-	0.07	-	43	Arsenic	-	10	-	0.004	-	82%
						Cadmium	-	0.14	-	0.0001	-	94%
						Copper	-	4.54	-	0.002	-	82%
						Iron	-	1000	-	0.378	-	36%
						Lead	-	1.09	-	0.004	-	88%
						Mercury	-	0.05	-	0.00002	-	0%
						Zinc	-	58.61	-	0.022	-	84%

*TMDL calculated for Dog Creek below confluence with American Gulch Creek

7.7 METALS LOADING SUMMARY, TMDLS AND ALLOCATIONS

Proceeding from the upper watershed to the lower, loading summaries and source allocations are provided for each waterbody-pollutant combination with a TMDL in the sections that follow. Metals TMDLs are allocated to point (wasteload) and nonpoint (load) sources. The TMDL is comprised of the sum of all significant point and nonpoint metals sources (natural and human-caused), plus a margin of safety (MOS) that accounts for uncertainties in loading and receiving water analyses. In addition to metals load allocations, the TMDL must also take into account the seasonal variability of metals loads and adaptive management strategies in order to address uncertainties inherent in environmental analysis. The aim of the loading summaries is to discuss seasonal loading trends and significant loading sources and pathways.

These elements are combined in the following equation:

TMDL = ∑WLA + ∑LA + MOS

WLA = Wasteload Allocation or the portion of the TMDL allocated to metals point sources
LA = Load Allocation or the portion of the TMDL allocated to nonpoint metals sources and natural background
MOS = Margin of Safety or an accounting of uncertainty about the relationship between metals loads and receiving water quality

WLAs are allowable pollutant loads that are assigned to point sources (permitted and non-permitted). The only permitted point source with a potential to affect metals loading in the basin is a general suction dredge permit (MTG3700000) on Carpenter Creek addressed in the lower segment Little Blackfoot River TMDL (**Section 7.7.12**). Waste sources associated with historic mining such as adit discharges, tailings, and waste rock piles are considered non-permitted point sources (and subject to a WLA). Where adequate data is available to evaluate loading from individual mining sources, these non-permitted point sources will be given separate WLAs. Otherwise, the contribution from all abandoned mines (e.g. adits, waste rock, tailings) in a contributing area or entire watershed is grouped into a composite WLA from abandoned mines. LAs are allowable pollutant loads assigned to nonpoint sources and may include the cumulative pollutant load from naturally occurring and human-caused sources. As defined in ARM 17.30.602, naturally occurring sources also include *"those sources from developed areas where all reasonable land, soil and water conservation practices have been applied."* Within the Little Blackfoot TMDL planning area, naturally-occurring metals concentrations are established by using data upstream of mining sources. An attempt is made to find such sites within each listed segment's basin, but if a basin is heavily impacted by human related metals sources or no site was established upstream of mining activity, LAs to background sources will be calculated using other sites in the planning area deemed representative.

7.7.1 Un-named Creek (MT76G006_010)

Loading Summary

The Ontario Mine is the primary source of metals loading to Un-named Creek. Because deep snow prevented access to the 1st order stream during recent DEQ sampling, only low flow metals data (i.e., July-October) were reviewed for the loading analysis. It is difficult to evaluate spatial or year-to-year loading trends in the basin because only one flow measurement (an estimate) is contained in the available dataset. Metal concentrations were elevated at all sites but did not have a consistent downstream trend; site ONT-B (**Figure 7-1**), located directly downstream of the rock-lined adit channel, had the highest exceedances for all metals of concern except arsenic.

In general, the two reclamation projects on Ontario Mine have not reduced metals concentrations in the creek; the highest observed concentrations of many metals occurred post reclamation. This is likely because mining activities altered the headwaters of the drainage, and the adit discharge, which was left untreated, is now the source water of the creek (Pioneer Technical Services, Inc., 1993). The only modification made to the adit discharge was armoring the channel to mitigate headcutting. Because the lined channel is somewhat of a treatment area, all samples collected downstream of the armored channel are considered Un-named Creek sample sites within this document.

TMDLs and Allocations

Because all human-related metals loading to Un-named Creek is associated with the Ontario Mine, a single wasteload allocation to the mine is provided, $\mathbf{WLA_{Ontario}}$. Metals concentrations found at ONT-0, located upstream of mining activity and above Un-named Creek's confluence with Ontario Creek (**Figure 7-10**), were used to calculate the natural background load allocation, $\mathbf{LA_{Nat}}$. The average annual precipitation and underlying geology at ONT-0 is comparable to that of Un-named Creek's basin (**Figures A-4 and A-9**). Although concentrations at ONT-B were usually the highest, since there was no corresponding flow data, data from ONT-1 were used to calculate existing loads and example TMDLs. A **MOS** is addressed through implicit considerations (**Section 7.8**). **Table 7-18** summarizes TMDL components and shows example TMDLs and allocations for low flow conditions for Un-named Creek. No reduction is shown in the example for mercury because no exceedances were observed during recent sampling, however, reductions may be necessary under certain flow conditions. Metals TMDLs will act as a surrogate for a pH TMDL because setting loads for pH is not practical and reclamation activities needed to meet the metals TMDLs will address sources of acid mine drainage causing the pH impairment.

$$\mathbf{TMDL_{Un\text{-}named} = WLA_{Ontario} + LA_{Nat}}$$
$$\mathbf{MOS = Implicit}$$

Table 7-18. Un-named Creek Metals TMDLs and Allocation Examples

Metal	Flow	TMDL (lbs/day)	Existing Load (lbs/day)	Percent Reduction	LA_{Nat} (lbs/day)	$WLA_{Ontario}$ (lbs/day)
Arsenic	Low flow	0.004	0.021	82%	0.001	0.003
Cadmium	Low flow	0.0001	0.0008	94%	0.0000	0.0001
Copper	Low flow	0.002	0.009	82%	0.001	0.001
Iron	Low flow	0.378	0.590	36%	0.053	0.325
Lead	Low flow	0.0004	0.0035	88%	0.0001	0.0003
Mercury	Low flow	0.00002	0.00000	0%	0.00001	0.00001
Zinc	Low flow	0.022	0.136	84%	0.002	0.020

Low flow: 0.07 cfs, 43 mg/L hardness

7.7.2 Monarch Creek (MT76G004_060)

Loading Summary

The Monarch Mine is the primary source of metals loading to Monarch Creek. Concentrations of metals in Monarch Creek only exceeded water quality targets during high flow conditions. During spring runoff, copper and lead loads increased three to four times from the site upstream of the Monarch Mine (MCH1) to the site below (MCH2) (**Figure 7-2**). Further downstream at MCH-2 and MCH-3, copper and mercury concentrations were the same but lead was more elevated at MCH-3. While most loading is occurring between the upper two sites, additional lead loading is occurring between MCH-2 and MCH-3,

possibly related to the high concentrations of lead observed in stream sediments observed at MCH-2. Water samples collected from the discharging adit were at the detection limit for copper and below the detection limit for lead and mercury, and all stream water samples were below detection limits during low flow events. The tendency of high flow exceedances indicate that metals loading to Monarch Creek is associated with surface runoff over the tailings within the floodplain and/or mobilization of sediments within the channel.

TMDLs and Allocations

Because all human-related metals loading to Monarch Creek is associated with the Monarch Mine, a single wasteload allocation to the mine is provided, $\mathbf{WLA_{Monarch}}$. Metal concentrations found at MCH-1, located upstream of mining activity, were used to calculate the natural background load allocation, $\mathbf{LA_{Nat}}$. All samples at this site were below the detection limit for the three metals of concern, except for a high flow copper sample that was at the detection limit. Metal concentrations were slightly more elevated at MCH-3 yet since there was no low flow data at this site, data from MCH-2 were used to calculate existing loads and example TMDLs. A **MOS** is addressed through implicit considerations (**Section 7.8**). **Table 7-19** summarizes TMDL components and shows example TMDLs and allocations for high and low flow conditions for Monarch Creek. No reduction is shown in the example for mercury because no exceedances were observed during recent sampling, however, reductions may be necessary under certain flow conditions. While TMDLs are currently being met during low flow conditions, reductions are necessary during high flow. Metals TMDLs will act as a surrogate for a pH TMDL because setting loads for pH is not practical and reclamation activities needed to meet the metals TMDLs will address sources of acid mine drainage causing the pH impairment.

$$\mathbf{TMDL_{Monarch} = WLA_{Monarch} + LA_{Nat}}$$
$$\mathbf{MOS = Implicit}$$

Table 7-19. Monarch Creek Metals TMDLs and Allocation Examples

Metal	Flow	TMDL (lbs/day)	Existing Load (lbs/day)	Percent Reduction	LA_{Nat} (lbs/day)	$WLA_{Monarch}$ (lbs/day)
Copper	High flow	0.212	0.223	5%	0.074	0.138
	Low flow	0.023	0.004	0%	0.004	0.019
Lead	High flow	0.040	0.060	33%	0.019	0.022
	Low flow	0.004	0.002	0%	0.002	0.002
Mercury	High flow	0.004	0.002	0%	0.002	0.002
	Low flow	0.0004	0.0002	0%	0.0002	0.0002

High flow: 13.79 cfs, 9 mg/L hardness
Low flow: 1.49 cfs, 15 mg/L hardness

7.7.3 Ontario Creek (MT76G004_130)

Loading Summary

Due to extensive historic mining in the basin, there are numerous sources of metals loading to Ontario Creek, including two tributaries, Un-named and Monarch creeks (described separately in **Sections 7.7.1** and **7.7.2**). Concentrations of metals in Ontario Creek only exceeded water quality targets during high flow conditions. There is no available high flow data at ONT-0 (**Figure 7-3**), but from ONT-2A to ONT-2 flows increased nearly three-fold and while concentrations of copper and lead remained constant or increased downstream, the concentration of cadmium was reduced by 84%. Because of this reduction in cadmium concentrations, even though flows were much higher, the cadmium load decreased from ONT-2A to ONT-2 while loads of copper and lead significantly increased. Even if loading inputs from Un-

named Creek and Monarch Creek were reduced to meet TMDLs, water quality targets would still be exceeded at ONT-2. Therefore, reductions are required throughout the watershed such as near the Hard Luck Mine that has discharging adits and waste rock piles near Ontario Creek. The tendency of high flow exceedances plus high metal concentrations in stream sediments indicate that metal loading to Ontario Creek is associated with surface runoff over mine waste and/or mobilization of sediments within the channel.

TMDLs and Allocations

Because human-related metals loading to Ontario Creek is associated with numerous sources, the wasteload has been broken into three allocations: one representing Un-named Creek's contribution (**$WLA_{Un\text{-}named}$**), another for Monarch Creek (**$WLA_{Monarch}$**) and a third assigned to Ontario Creek (**$WLA_{Ontario}$**). The **$WLA_{Un\text{-}named}$** is equivalent to the low flow Un-named Creek TMDL provided in **Section 7.7.1**, which was also applied to the high flow **$WLA_{Un\text{-}named}$** because no high flow data is available. Although having high flow data is preferable, this was determined to be reasonable because Un-named Creek is a 1st order stream dominated by groundwater inputs (Hargrave, et al., 1998; Pioneer Technical Services, Inc., 1993) and conditions are assumed to be relatively constant throughout the year. **$WLA_{Monarch}$** is conceptually the same as the Monarch Creek TMDL provided in **Section 7.7.2**, but differs slightly because sample data from the same sampling event were used for all WLAs within the Ontario Creek TMDL and flow and hardness conditions differed some from that used for the Monarch Creek TMDL. **$WLA_{Ontario}$** was calculated by subtracting the **WLA**s and **LA_{Nat}** from the TMDL. Metals concentrations from site ONT-0, located upstream of mining activity, were used to calculate the natural background load allocation, **LA_{Nat}**. However, because ONT-0 was only sampled during low flow, data from LBF-1 on the Little Blackfoot River were used to calculate the **LA_{Nat}** for high flows. The average annual precipitation and underlying geology at LBF-1 is comparable to that of Ontario Creek's basin (**Figures A-4** and **A-9**). Data from ONT-2 were used to calculate existing loads and example TMDLs for Ontario Creek. A **MOS** is addressed through implicit considerations (**Section 7.8**). **Table 7-20** summarizes TMDL components and shows example TMDLs and allocations for high and low flow conditions for Ontario Creek. While TMDLs are currently being met during low flow conditions, reductions are necessary during high flow.

$$\mathbf{TMDL_{Ontario} = WLA_{Un\text{-}named} + WLA_{Monarch} + WLA_{Ontario} + LA_{Nat}}$$

MOS = Implicit

Table 7-20. Ontario Creek Metals TMDLs and Allocation Examples

Metal	Flow	TMDL (lbs/day)	Existing Load (lbs/day)	Percent Reduction	LA_{Nat} (lbs/day)	$WLA_{Un\text{-}named}$ (lbs/day)	$WLA_{Monarch}$ (lbs/day)	$WLA_{Ontario}$ (lbs/day)
Cadmium	High flow	0.129	0.283	55%	0.043	0.0001	0.008	0.077
	Low flow	0.003	0.001	0%	0.0009	0.0001	0.0002	0.0017
Copper	High flow	3.664	5.143	29%	2.159	0.002	0.586	0.917
	Low flow	0.083	0.029	0%	0.047	0.002	0.015	0.019
Lead	High flow	0.694	6.300	89%	0.270	0.0004	0.111	0.313
	Low flow	0.016	0.007	0%	0.006	0.0004	0.003	0.007

High flow: 238.09 cfs, 9 mg/L hardness
Low flow: 5.39 cfs, 15 mg/L hardness

7.7.4 Sally Ann Creek (MT76G004_055)

Loading Summary

The Telegraph Mine is the primary source of metals loading to Sally Ann Creek. Concentrations of metals in Sally Ann Creek only exceeded water quality targets during high flow conditions. Placer and hardrock mining occurred in the watershed near Bryan Creek, an intermittent tributary to Sally Ann Creek. Bryan Creek contributed flows during 2008/2009 DEQ sampling but 1995 MBMG records noted the creek ran dry late in the year (Hargrave, et al., 1998). DEQ established sites on Sally Ann Creek above (TGH-0) and below Bryan Creek's confluence (TGH-1) (**Figure 7-4**). Concentrations of zinc at the upper site were always below detection, but cadmium and copper exceeded targets during high flow, indicating some loading is occurring in the headwaters; however, larger inputs of cadmium and copper must be occurring between the two sample sites because concentrations remained uniform even as flows doubled or tripled. For zinc, Telegraph Mine is assumed to be the sole source of human-related loading because zinc was not detected at TGH-0 yet exceeded targets downstream at TGH-1. The tendency of high flow exceedances indicate that metal loading to Sally Ann Creek is dependent upon inputs from Bryan Creek and associated to a lesser degree with surface runoff over mine wastes in the headwaters. Another potential loading mechanism is the mobilization of sediments within the channel since metal concentrations in stream sediments exceeded secondary targets at TGH-1 but not TGH-0.

TMDLs and Allocations

Because most human-related metals loading to Sally Ann Creek is associated with the Telegraph Mine, one wasteload allocation is provided for the mine, $\mathbf{WLA_{TeleMine}}$, and a separate wasteload allocation is established for the Sally Ann Creek mainstem, $\mathbf{WLA_{Mainstem}}$. As shown in **Table 7-21**, flows were used to derive wasteload allocations. The increase in discharge observed between TGH-0 and TGH-1 (**Figure 7-4**) was attributed to Bryan Creek and the percentage of total flow contributed by Bryan Creek was calculated as the difference in flows divided by the flow at TGH-1. Flow weighted wasteload allocations were then identified as the flow contribution percentage multiplied by the difference between the TMDL and the $\mathbf{LA_{Nat}}$.

Table 7-21. Flow Weighted WLA Calculations for Sally Ann Creek

Stream Segment	% of Total High Flow	High Flow WLA Calculation	% of Total Low Flow	Low Flow WLA Calculation
Sally Ann Mainstem	33%	$WLA_{Mainstem} = 0.33 * (TMDL_{SallyAnn} - LA_{Nat})$	45%	$WLA_{Mainstem} = 0.45 * (TMDL_{SallyAnn} - LA_{Nat})$
Bryan Creek	67%	$WLA_{TeleMine} = 0.67 * (TMDL_{SallyAnn} - LA_{Nat})$	55%	$WLA_{TeleMine} = 0.55 * (TMDL_{SallyAnn} - LA_{Nat})$

Due to historic mining in the basin, no Sally Ann site accurately depicts natural background levels of metals. Thus, concentrations from a site on the Little Blackfoot River located upstream of mining activity, LBF-1 (**Figure 7-11**), were used to calculate the natural background load allocation, $\mathbf{LA_{Nat}}$. The average annual precipitation and underlying geology at LBF-1 is comparable to that of Sally Ann Creek's basin (**Figures A-4** and **A-9**). Data from TGH-1 were used to calculate existing loads and example TMDLs for Sally Ann Creek. A **MOS** is addressed through implicit considerations (**Section 7.8**). **Table 7-22** summarizes TMDL components and shows example TMDLs and allocations for high and low flow conditions for Sally Ann Creek. While TMDLs are currently being met during low flow conditions, reductions are necessary during high flow.

$$\mathbf{TMDL_{SallyAnn} = WLA_{Mainstem} + WLA_{TeleMine} + LA_{Nat}}$$

MOS = Implicit

Table 7-22. Sally Ann Creek Metals TMDLs and Allocation Examples

Metal	Flow	TMDL (lbs/day)	Existing Load (lbs/day)	Percent Reduction	LA_{Nat} (lbs/day)	$WLA_{Mainstem}$ (lbs/day)	$WLA_{TeleMine}$ (lbs/day)
Cadmium	High flow	0.018	0.244	93%	0.007	0.004	0.007
	Low flow	0.0003	0.0001	0%	0.0001	0.0001	0.0001
Copper	High flow	0.514	0.722	29%	0.361	0.051	0.103
	Low flow	0.009	0.003	0%	0.001	0.003	0.004
Zinc	High flow	6.683	9.026	26%	0.903	1.908	3.873
	Low flow	0.118	0.053	0%	0.013	0.047	0.057

High flow: 33.43 cfs, 10 mg/L hardness
Low flow: 0.49 cfs, 31 mg/L hardness

7.7.5 O'Keefe Creek (MT76G004_054)

Loading Summary

The primary sources of metals loading to O'Keefe Creek are the Sure Thing Mine and Sally Ann Creek, which is described separately in **Sections 7.7.4**. Cadmium and copper water quality targets in O'Keefe Creek were only exceeded during high flow conditions; zinc targets were exceeded in both high flow samples and in one of two low flow samples. At certain times of the year, Sally Ann Creek contributed over 80% of the flow to O'Keefe Creek. Flows increased between the lowest Sally Ann Creek site and TGH-2 (**Figure 7-5**) and metals concentrations were similar or slightly higher at TGH-2, resulting in consistently larger loads at TGH-2. Even if loading inputs from Sally Ann Creek were reduced to meet TMDLs, water quality targets would still be exceeded at TGH-2; thus, a significant load of metals is coming from the Sure Thing and O'Keefe Creek/Copper King Mines and reductions are required throughout the entire watershed. Zinc concentrations were extremely elevated in adit samples of the Sure Thing Mine (82 times the acute aquatic life standard) which could be the source of the low flow zinc exceedance observed in O'Keefe Creek. The tendency of high flow exceedances plus high metal concentrations in stream sediments indicate that metals loading to O'Keefe Creek is primarily associated with surface runoff over mine waste and/or mobilization of sediments within the channel, however, the Sure Thing Mine adit is likely a source of loading during low flow conditions.

TMDLs and Allocations

Because human-related metals loading to O'Keefe Creek is associated with multiple sources, the wasteload has been broken into two allocations: one representing Sally Ann Creek's contribution (**$WLA_{SallyAnn}$**) and another for the mainstem O'Keefe Creek (**$WLA_{O'Keefe}$**). The **$WLA_{SallyAnn}$** is equivalent to the TMDL calculated for Sally Ann Creek and **$WLA_{O'Keefe}$** was calculated by subtracting **$WLA_{SallyAnn}$** and **LA_{Nat}** from the TMDL. Due to historic mining in the basin, no O'Keefe Creek site accurately depicts natural background levels of metals, thus concentrations from a site on the Little Blackfoot River located upstream of mining activity, LBF-1 (**Figure 7-11**), were used to calculate the natural background load allocation, **LA_{Nat}**. The average annual precipitation and underlying geology at LBF-1 is comparable to that of O'Keefe Creek's basin (**Figures A-4** and **A-9**). Data from TGH-2 were used to calculate existing loads and example TMDLs for O'Keefe Creek. A **MOS** is addressed through implicit considerations (**Section 7.8**). **Table 7-23** summarizes TMDL components and shows example TMDLs and allocations for high and low flow conditions for O'Keefe Creek. While TMDLs are currently being met during low flow conditions, reductions are necessary during high flow.

$TMDL_{O'Keefe} = WLA_{SallyAnn} + WLA_{O'Keefe} + LA_{Nat}$
MOS = Implicit

Table 7-23. O'Keefe Creek Metals TMDLs and Allocation Examples

Metal	Flow	TMDL (lbs/day)	Existing Load (lbs/day)	Percent Reduction	LA_{Nat} (lbs/day)	$WLA_{SallyAnn}$ (lbs/day)	$WLA_{O'Keefe}$ (lbs/day)
Cadmium	High flow	0.022	0.417	95%	0.001	0.018	0.002
	Low flow	0.0005	0.0004	0%	0.0001	0.0003	0.0001
Copper	High flow	0.619	1.086	43%	0.073	0.514	0.031
	Low flow	0.014	0.004	0%	0.001	0.009	0.004
Zinc	High flow	8.038	15.199	47%	0.183	6.683	1.172
	Low flow	0.176	0.130	0%	0.008	0.118	0.050

High flow: 40.21 cfs, 10 mg/L hardness
Low flow: 0.8 cfs, 28 mg/L hardness

7.7.6 Telegraph Creek, Upper Segment (MT76G004_051)

Loading Summary

Due to extensive historic mining in the basin, there are numerous sources of metals loading to upper Telegraph Creek. A review of the data shows that O'Keefe Creek, described separately in **Sections 7.7.5** and **Appendix F**, transports a larger metals load than Telegraph Creek above their confluence. This is due primarily to the fact that O'Keefe Creek's flows were five to eight times greater. Metals water quality targets were exceeded in O'Keefe Creek but only during high flow, whereas Telegraph Creek's headwaters had low flow exceedances for cadmium and zinc and had high flow exceedances that were greater than those observed in O'Keefe Creek. Arsenic concentrations were highest in Telegraph Creek's headwaters near the Lily Orphan Boy Mine, which has mine wastes spanning the active stream channel.

Metal loads generally increased downstream during high flows. Numerous tributaries affected by historical mining join the mainstem between TGH-2B and TGH-3A (**Figure 7-6**) resulting in additional loading; while concentrations remained similar across the two sites, flows doubled. Even if loading inputs from O'Keefe Creek and Telegraph Creek's headwaters were reduced to meet TMDLs, cadmium, copper and lead would still exceed targets at TGH-3A; thus, reductions are required throughout the entire watershed. While low flow exceedances were observed in the headwaters, no metals exceeded water quality targets during these times at the downstream sites TGH-3 or TGH-3A. The tendency of high flow exceedances plus high metal concentrations in stream sediments indicate that metal loading to upper Telegraph Creek is primarily associated with surface runoff over mine waste and/or mobilization of sediments within the channel, however, low flow exceedances indicate there is also likely a discrete metals source in the upper watershed (i.e. upstream of TGH-2B) .

TMDLs and Allocations

Because human-related metals loading to upper Telegraph Creek is associated with numerous sources, the wasteload has been broken into three allocations: one for the headwaters region above Telegraph Creek's confluence with O'Keefe Creek (**$WLA_{Headwaters}$**), one capturing the inputs below the confluence (**WLA_{Mid}**) and a third representing metals loading from O'Keefe Creek, which includes loads from Sally Ann Creek (**$WLA_{O'Keefe}$**). The **$WLA_{O'Keefe}$** is equivalent to the TMDL calculated for O'Keefe Creek. As shown in **Table 7-24**, flows were used to derive the other wasteload allocations. **$WLA_{Headwaters}$** and **WLA_{Mid}** are the product of that stream segment's percent contribution to the remaining discharge at TGH-3A after removing O'Keefe Creek flows, multiplied by the difference between the TMDL and the **LA_{Nat}**.

Table 7-24. Flow Weighted WLA Calculations for Upper Telegraph Creek

Stream Segment	% of Total High Flow	High Flow WLA Calculation	% of Total Low Flow	Low Flow WLA Calculation
Telegraph Creek Headwaters	15.5%	$WLA_{Headwaters} = 0.155 * (TMDL_{UpTele} - LA_{Nat} - WLA_{O'Keefe})$	9%	$WLA_{Headwaters} = 0.09 * (TMDL_{UpTele} - LA_{Nat} - WLA_{O'Keefe})$
Telegraph Creek Mid	84.5%	$WLA_{Mid} = 0.845 * (TMDL_{UpTele} - LA_{Nat} - WLA_{O'Keefe})$	91%	$WLA_{Mid} = 0.91 * (TMDL_{UpTele} - LA_{Nat} - WLA_{O'Keefe})$

Due to extensive historic mining in the Telegraph Creek basin, no Telegraph site accurately depicts natural background levels of metals; thus, concentrations from a site on the Little Blackfoot River located upstream of mining activity, LBF-1 (**Figure 7-11**), were used to calculate the natural background load allocation for upper Telegraph Creek, $\mathbf{LA_{Nat}}$. The average annual precipitation and underlying geology at LBF-1 is comparable to that of Telegraph Creek's basin (**Figures A-4** and **A-9**). Data from TGH-3A were used to calculate existing loads and example TMDLs for Telegraph Creek's upper segment. A **MOS** is addressed through implicit considerations (**Section 7.8**). **Table 7-25** summarizes TMDL components and shows example TMDLs and allocations for high and low flow conditions for the upper segment of Telegraph Creek. No reduction is shown in the example for arsenic or beryllium because no exceedances were observed during recent sampling, however, reductions may be necessary under certain flow conditions. While TMDLs are currently being met during low flow conditions, reductions are necessary during high flow.

$$\mathbf{TMDL_{UpTele} = WLA_{Headwaters} + WLA_{Mid} + WLA_{O'Keefe} + LA_{Nat}}$$
MOS = Implicit

Table 7-25. Upper Telegraph Creek Metals TMDLs and Allocation Examples

Metal	Flow	TMDL (lbs/day)	Existing Load (lbs/day)	Percent Reduction	LA_{Nat} (lbs/day)	$WLA_{Headwaters}$ (lbs/day)	WLA_{Mid} (lbs/day)	$WLA_{O'Keefe}$ (lbs/day)
Arsenic	High flow	4.869	1.461	0%	0.342	0.365	1.990	2.171
	Low flow	0.103	0.015	0%	0.008	0.005	0.047	0.043
Beryllium	High flow	1.947	0.243	0%	0.114	0.150	0.815	0.869
	Low flow	0.041	0.005	0%	0.003	0.002	0.019	0.017
Cadmium	High flow	0.049	0.058	17%	0.009	0.003	0.015	0.022
	Low flow	0.001	0.000	0%	0.000	0.000	0.001	0.000
Copper	High flow	1.388	2.434	43%	0.456	0.049	0.265	0.619
	Low flow	0.042	0.021	0%	0.003	0.002	0.023	0.014
Lead	High flow	0.263	0.682	61%	0.057	0.014	0.075	0.117
	Low flow	0.010	0.003	0%	0.001	0.000	0.005	0.003
Zinc	High flow	18.024	24.343	26%	1.139	1.371	7.475	8.038
	Low flow	0.544	0.206	0%	0.027	0.031	0.310	0.176

High flow: 90.16 cfs, 13 mg/L hardness
Low flow: 1.91 cfs, 38 mg/L hardness

7.7.7 Telegraph Creek, Lower Segment (MT76G004_052)

Loading Summary

The primary source of metals loading to lower Telegraph Creek is the load transported from sources in the upper Telegraph Creek watershed (**Section 7.7.6**). The abandoned mine databases indicate that there are no human sources of metals in the lower Telegraph Creek watershed, however, the upper

Telegraph Creek watershed has numerous abandoned mines as described in **Section 7.5.6**. Concentrations of metals in lower Telegraph Creek only exceeded water quality targets during high flow conditions, which differs slightly from the upper segment (which also had low flow exceedances); this is likely due to dilution occurring as the distance increases from metals sources along the upper segment. During the May 2009 sampling event, over 90% of the loading for all metals of concern observed at TCH-4 (**Figure 7-7**) were present in the upper segment site TGH-3A (**Figure 7-6**). The upper segment's influence is likely even higher because TGH-3A is upstream from some of the abandoned mines in the upper watershed (**Figure 7-6**). For example, a tributary potentially impacted by the Third Term Mine (a priority abandoned mine) enters upper Telegraph Creek below TGH-3A. Surface water samples of the tributary, although over ten years old, had target exceedances for all metals of concern including mercury. Thus, the Third Term Mine could be a source of mercury to lower Telegraphs Creek and should be investigated further. Because metal concentrations and flows remain relatively constant between TGH-3A and TGH-4, over all flow conditions, the resulting loads were similar and there is no significant downstream loading trend. Addressing the human-caused metals sources in the upper Telegraph Creek basin will result in the loading reductions necessary to meet the TMDLs and water quality targets in the lower segment.

TMDLs and Allocations

Because there are no known point sources of metals in lower Telegraph Creek, a $\mathbf{WLA_{LwrTele}}$ was not established. Instead, the TMDL was broken into two allocations: one corresponding to the TMDL attributed to upper Telegraph Creek ($\mathbf{WLA_{UpTele}}$), and another representing the combined load from naturally occurring and historic mining-related nonpoint sources in the lower Telegraph basin ($\mathbf{LA_{LwrTele}}$). The $\mathbf{LA_{LwrTele}}$ was identified as the load remaining after subtracting the $\mathbf{WLA_{UpTele}}$ from the TMDL. Data from TGH-4 in 2009 had the highest target exceedances and were used to calculate existing loads and example TMDLs for Telegraph Creek's lower segment. However, high flow data from 2009 showed a slight reduction between the last upper Telegraph site and TGH-4 (1.91 cfs vs. 1.63 cfs) that was not present in the 2008 data (1.96 cfs vs. 4.47 cfs). It is assumed this reduction is human induced (e.g. irrigation withdrawal or measurement error), and a corrected TGH-4 flow for May 2009 was estimated to be 4.36 cfs by applying the same percent increase that was observed in 2008. A **MOS** is addressed through implicit considerations (**Section 7.8**). **Table 7-26** summarizes TMDL components and shows example TMDLs and allocations for high and low flow conditions for the lower segment of Telegraph Creek. No reduction is shown in the example for mercury because no exceedances were observed during recent sampling, however, reductions may be necessary under certain flow conditions. While TMDLs are currently being met during low flow conditions, reductions are necessary during high flow.

$$\mathbf{TMDL_{LwrTele} = WLA_{UpTele} + LA_{LwrTele}}$$
$$\mathbf{MOS = Implicit}$$

Table 7-26. Lower Telegraph Creek Metals TMDLs and Allocation Examples

Metal	Flow	TMDL (lbs/day)	Existing Load (lbs/day)	Percent Reduction	$LA_{LwrTele}$ (lbs/day)	WLA_{UpTele} (lbs/day)
Cadmium	High flow	0.050	0.056	9%	0.002	0.049
	Low flow	0.003	0.001	0%	0.002	0.001
Copper	High flow	1.439	2.525	43%	0.051	1.388
	Low flow	0.105	0.047	0%	0.063	0.042
Lead	High flow	0.273	0.707	61%	0.010	0.263
	Low flow	0.025	0.006	0%	0.015	0.010

Table 7-26. Lower Telegraph Creek Metals TMDLs and Allocation Examples

Metal	Flow	TMDL (lbs/day)	Existing Load (lbs/day)	Percent Reduction	$LA_{LwrTele}$ (lbs/day)	WLA_{UpTele} (lbs/day)
Mercury	High flow	0.025	0.013	0%	0.001	0.024
	Low flow	0.0012	0.000	0%	0.001	0.0005
Zinc	High flow	18.691	25.245	26%	0.668	18.024
	Low flow	1.353	0.471	0%	0.808	0.544

High flow: 93.5 cfs, 16 mg/L hardness
Low flow: 4.36 cfs, 42 mg/L hardness

7.7.8 American Gulch Creek (MT76G004_079)

Loading Summary

The primary source of metals loading to American Gulch Creek is a cluster of abandoned mines in the headwaters region. The single American Gulch Creek sample site, DOG-3 (**Figure 7-8**), does not allow downstream loading along the segment to be analyzed but all four samples collected over both flow conditions at DOG-3 had arsenic concentrations that exceeded water quality targets. Between May and July 2008, arsenic concentrations remained the same (14 µg/L); in the second year of sampling the concentration of arsenic was higher during low flow (16 µg/L vs. 13 µg/L). Unlike most stream segments in the Little Blackfoot TPA, metals target exceedances were consistently observed in American Gulch Creek during both flow conditions. In addition, water hardness values, which are strongly influenced by groundwater inputs, were higher as a consequence of the unique geology underlying the greater Dog Creek Watershed (**Figure A-4**). However, hardness did fluctuate between flow conditions indicating that the creek is not entirely controlled by groundwater. Recent sampling did not involve testing for the dissolved fraction of arsenic, which could help identify the arsenic source. Loading to American Gulch Creek includes a discrete source such as groundwater or an adit in addition to the loading associated with surface runoff over mine waste. Another likely source of arsenic loading is the mobilization of sediments within the channel which greatly exceeded secondary targets.

TMDLs and Allocations

Because all human-related metals loading to American Gulch Creek is associated with mines whose influence cannot be separated, a single wasteload allocation is provided to abandoned mining sources, $\mathbf{WLA_{American}}$. The $\mathbf{WLA_{American}}$ was calculated by subtracting $\mathbf{LA_{Nat}}$ from the TMDL. Concentrations from DOG-5 (**Figure 7-10**), a site on Hope Creek located upstream of mining activity in a tributary basin to lower Dog Creek, were used to calculate the natural background load allocation, $\mathbf{LA_{Nat}}$. Data from DOG-3 were used to calculate existing loads and example TMDLs for American Gulch Creek. A **MOS** is addressed through implicit considerations (**Section 7.8**). **Table 7-27** summarizes TMDL components and shows example TMDLs and allocations for high and low flow conditions for American Gulch Creek. Existing loads are not meeting TMDLs during low or high flow conditions, thus reductions are necessary during both scenarios.

$$\mathbf{TMDL_{American} = WLA_{American} + LA_{Nat}}$$
$$\mathbf{MOS = Implicit}$$

Table 7-27. American Gulch Creek Metals TMDLs and Allocation Examples

Metal	Flow	TMDL (lbs/day)	Existing Load (lbs/day)	Percent Reduction	LA_{Nat} (lbs/day)	$WLA_{American}$ (lbs/day)
Arsenic	High flow	0.722	0.939	23%	0.108	0.614
	Low flow	0.046	0.073	38%	0.007	0.039

High flow: 13.37 cfs, 99 mg/L hardness
Low flow: 0.85 cfs, 149 mg/L hardness

7.7.9 Dog Creek, Upper Segment (MT76G004_071)

Loading Summary

Due to extensive historic mining in the basin, there are numerous sources of metals loading to upper Dog Creek. A review of the data shows that in addition to loading along the mainstem, metals sources also exist on two tributaries, an un-named stream and American Gulch Creek (**Figure 7-9**). DEQ AML collected samples of the un-named tributary and Dog Creek above their confluence in September 2003 that found target exceedances in both streams, but overall load inputs were small due to low flows values. The lowest un-named tributary site, SW3A (**Figure 7-9**), had the highest cadmium and zinc exceedances of any site in the upper Dog Creek basin, but a TMDL for the tributary was not developed due to a lack of samples and spatial/temporal independence; however it is assumed sources in the tributary basin will need to be addressed in order for upper Dog Creek's TMDLs to be met. Although American Gulch Creek discharged more water, had greater arsenic exceedances and supplied a larger load of metals when compared to the un-named tributary, it still did not match Dog Creek's load or target exceedances before their union.

Sites along Dog Creek had arsenic, cadmium, copper, lead and zinc water quality target exceedances during high flow conditions and arsenic, cadmium and lead exceedances during low flow. Between sample sites DOG-1 and DOG-2 (**Figure 7-9**) the concentrations of metals varied but individual metals trended the same regardless of flow conditions; arsenic and lead concentrations increased significantly downstream (indicating the Bald Butte Mine as the primary source of these metals) while cadmium, copper and zinc decrease but remained elevated (indicating the un-named tributary as the primary source of these three metals). Cadmium, copper and zinc also greatly exceeded water quality targets in the Devon/Sterling Mine's adit discharge; zinc was nearly 15 times over the human health standard and nearly all of the zinc recovered in Dog Creek was the dissolved fraction. These exceedances in the adit water discharging into the un-named tributary support the identification of the un-named tributary as the principal source of cadmium, copper and zinc. Discharging adits are likely a source of loading during low flow conditions as well as leaching of metals into the groundwater from Bald Butte Mine wastes located in the Dog Creek floodplain (Olympus Technical Services, Inc., 2004). These floodplain materials can also contribute to loading when they are inundated during high flows, at which time mobilization of metals in stream channel sediments (which were extensively sampled and consistently tested high) likely occurs. Note all Dog Creek data used for example TMDL calculations were collected before the start of reclamation on the Bald Butte and Devon/Sterling Mine sites. Water quality conditions could change from what is presented in this document as a result.

TMDLs and Allocations

Because human-related metals loading to upper Dog Creek is associated with numerous sources, the wasteload has been broken into two allocations: one for contributions from American Gulch Creek (**$WLA_{American}$**) and a second representing metals loading from the upper Dog Creek mainstem (**WLA_{UpDog}**). The **$WLA_{American}$** is equivalent to the American Gulch Creek TMDL provided in **Section 7.7.8** and **WLA_{UpDog}**

was calculated by subtracting $\mathbf{WLA_{American}}$ and $\mathbf{LA_{Nat}}$ from the TMDL. Concentrations from DOG-5 (**Figure 7-10**), a site on Hope Creek located upstream of mining activity in a tributary basin to lower Dog Creek, were used to calculate the natural background load allocation, $\mathbf{LA_{Nat}}$. Data from DOG-2 and DOG-3 were combined to estimate existing loads and example TMDLs below the confluence of American Gulch Creek and upper Dog Creek. No reductions are shown in the example for copper or zinc because of restrictions applied on data collection dates as a result of calculating TMDLs below American Gulch Creek, however, exceedances of these metals were observed at other times during recent sampling and reductions may be necessary under certain conditions. A **MOS** is addressed through implicit considerations (**Section 7.8**). **Table 7-28** summarizes TMDL components and shows example TMDLs and allocations for high and low flow conditions for upper Dog Creek. Existing loads are not meeting TMDLs during low or high flow conditions, thus reductions are necessary during both scenarios.

$$\mathbf{TMDL_{UpDog} = WLA_{UpDog} + WLA_{American} + LA_{Nat}}$$
$$\mathbf{MOS = Implicit}$$

Table 7-28. Upper Dog Creek Metals TMDLs and Allocation Examples

Metal	Flow	TMDL (lbs/day)	Existing Load (lbs/day)	Percent Reduction	LA_{Nat} (lbs/day)	WLA_{UpDog} (lbs/day)	$WLA_{American}$ (lbs/day)
Arsenic	High flow	1.439	1.871	23%	0.108	0.610	0.722
	Low flow	0.097	0.253	62%	0.008	0.044	0.046
Cadmium	High flow	0.039	0.103	62%	0.003	0.016	0.019
	Low flow	0.004	0.002	0%	0.000	0.002	0.002
Copper	High flow	1.331	1.079	0%	0.143	0.520	0.668
	Low flow	0.133	0.043	0%	0.003	0.070	0.060
Lead	High flow	0.452	1.430	68%	0.036	0.189	0.227
	Low flow	0.055	0.079	30%	0.001	0.029	0.024
Zinc	High flow	17.097	10.791	0%	0.359	8.161	8.577
	Low flow	1.702	0.228	0%	0.026	0.905	0.771

High flow: 26.65 cfs, 99 mg/L hardness
Low flow: 1.8 cfs, 156.5 mg/L hardness

7.7.10 Dog Creek, Lower Segment (MT76G004_072)

Loading Summary

While there are abandoned mines in the lower Dog Creek basin, the primary source of metals loading is the load transported from upper Dog Creek (**Section 7.7.9**). During low flow conditions, copper and lead concentrations in lower Dog Creek were above natural background levels but did not exceed targets; the only time exceedances occurred was during spring runoff. Between DOG-2 (**Figure 7-10**), the lowest site on the upper segment, and DOG-8, metal concentrations decreased in all scenarios; over this same reach loads increased because flows increased by an average factor of nine for low flows and 14 for high flows. Although most of the loading is coming from the upper segment, even if loading inputs from upper Dog Creek were reduced to meet TMDLs, water quality targets would still be exceeded at DOG-8; thus, reductions are also required within the lower watershed. The tendency of high flow exceedances plus high lead concentrations in stream sediments indicate that metal loading to Dog Creek is associated with surface runoff over mine waste and/or mobilization of sediments within the channel.

TMDLs and Allocations

Because human-related metals loading to lower Dog Creek is associated with multiple sources, the wasteload has been broken into two allocations: one for contributions from upper Dog Creek ($\mathbf{WLA_{UpDog}}$)

and a second for lower Dog Creek (**WLA_{LwrDog}**). The **WLA_{UpDog}** is equivalent to the upper Dog Creek TMDL provided in **Section 7.7.9** and **WLA_{LwrDog}** was calculated by subtracting **WLA_{UpDog}** and **LA_{Nat}** from the TMDL. Concentrations from DOG-5 (**Figure 7-10**), a site on Hope Creek located upstream of mining activity, were used to calculate the natural background load allocation, **LA_{Nat}**. Data from DOG-8 were used to calculate existing loads and example TMDLs for lower Dog Creek. A **MOS** is addressed through implicit considerations (**Section 7.8**). **Table 7-29** summarizes TMDL components and shows example TMDLs and allocations for high and low flow conditions for lower Dog Creek. While TMDLs are currently being met during low flow conditions, reductions are necessary during high flow.

$$TMDL_{LwrDog} = WLA_{LwrDog} + WLA_{UpDog} + LA_{Nat}$$
MOS = Implicit

Table 7-29. Lower Dog Creek Metals TMDLs and Allocation Examples

Metal	Flow	TMDL (lbs/day)	Existing Load (lbs/day)	Percent Reduction	LA_{Nat} (lbs/day)	WLA_{LwrDog} (lbs/day)	WLA_{UpDog} (lbs/day)
Copper	High flow	6.779	9.359	28%	2.386	3.061	1.331
	Low flow	0.787	0.197	0%	0.028	0.626	0.133
Lead	High flow	1.711	8.557	80%	0.597	0.663	0.452
	Low flow	0.304	0.112	0%	0.014	0.235	0.055

High flow: 247.6 cfs, 49 mg/L hardness
Low flow: 12.17 cfs, 134 mg/L hardness

7.7.11 Little Blackfoot River, Upper Segment (MT76G004_020)

Loading Summary

Due to extensive historic mining in the basin, there are numerous sources of metals loading to the Little Blackfoot River's upper segment. A review of the data shows that among other sources, Ontario Creek (**Section 7.7.3**) and Telegraph Creek (**Section 7.7.7**) contribute significant loading. Water quality standards in the upper Little Blackfoot River were only exceeded during high flows, except for two arsenic samples collected below the Charter Oak Mine that exceeded standards during low flow. No metal water quality targets were exceeded at LBF-1 (**Figure 7-11**) above Ontario Creek's confluence but concentrations and loads increased downstream. The highest exceedances were observed at LBF-4, below the Kimball and Golden Anchor Mines, which have piles of fine-grain waste rock in the floodplain (Hargrave, et al., 1998). During the 2008 high flow sampling event, flows between sites LBF-3 and LBF-4 decreased. This anomaly can be explained by a combination of factors including errors in using the float method to estimate velocity when streams were deemed unsafe to wade (Hydrosolutions Inc., 2010), effects of irrigation withdrawals and/or naturally loosing reaches. A study investigating groundwater-surface water interactions between Elliston and Avon on the Little Blackfoot River's lower segment found the mainstem had sections of both seasonally loosing and gaining reaches; similar variation is expected on the upper segment (PBS&J, 2009).

The temporary spike in metals delivered to the Little Blackfoot River associated with the Golden Anchor Mine blowout cannot be converted into loads for further analysis because flow measurements were not collected, and metals concentrations collected by the USFS in the three months following the November 2008 blowout were not used to calculate example TMDLs. Although DEQ samples following the blowout exceeded targets for arsenic, cadmium and copper not seen in the previous spring, 2009 low flow concentrations were much reduced and similar to 2008 low flow concentrations. Primarily because of greater flows, Ontario Creek contributes more loading than Telegraph Creek but the metals concentrations were higher in Telegraph Creek for all metals of concern besides lead. As with the Little

Blackfoot River, metals loading from these tributaries is predominantly occurring during high flow conditions. Even if loading inputs from these two tributaries were reduced to meet TMDLs, water quality targets would still be exceeded at LBF-5 (near Dog Creek); thus, additional metals loading is coming from mining sources along the Little Blackfoot mainstem and reductions are required throughout the entire watershed. The largest metals load input occurred between sites LBF-2 and LBF-4 on the mainstem, over which distance the stream receives contributions from the Charter Oak, Golden Anchor, Kimball, and Mountain View Mines. This source area requires major reductions. The tendency of high flow exceedances plus high metal concentrations in stream sediments and waste rock in the floodplain indicate that metals loading to upper Little Blackfoot River is associated with surface runoff over mine waste and/or mobilization of sediments within the channel.

TMDLs and Allocations

Because human-related metals loading to the upper Little Blackfoot River is associated with numerous sources, the wasteload has been broken into three allocations: one for Ontario Creek (**$WLA_{Ontario}$**), one representing inputs from Telegraph Creek (**WLA_{Tele}**) and a third capturing metals loading from remaining sources (**WLA_{UpLBF}**). The **$WLA_{Ontario}$** and **WLA_{Tele}** are equivalent to the TMDL calculated for those streams (**Sections 7.7.3** and **7.7.7**). **WLA_{UpLBF}** was calculated by subtracting the **WLA**s and **LA_{Nat}** from the TMDL. Metals concentrations from site LBF-1, located upstream of mining activity, were used to calculate the natural background load allocation, **LA_{Nat}**. While concentrations at LBF-4 were slightly higher, data from LBF-5 were used to calculate existing loads and example TMDLs for the upper Little Blackfoot River in order to incorporate loading for the entire basin. A **MOS** is addressed through implicit considerations (**Section 7.8**). **Table 7-30** summarizes TMDL components and shows example TMDLs and allocations for high and low flow conditions for the Little Blackfoot River's upper segment. While TMDLs are currently being met during low flow conditions, reductions are necessary during high flow.

$$\mathbf{TMDL_{UpLBF} = WLA_{Ontario} + WLA_{Tele} + WLA_{UpLBF} + LA_{Nat}}$$

MOS = Implicit

Table 7-30. Upper Little Blackfoot River Metals TMDLs and Allocation Examples

Metal	Flow	TMDL (lbs/day)	Existing Load (lbs/day)	Percent Reduction	LA_{Nat} (lbs/day)	$WLA_{Ontario}$ (lbs/day)	WLA_{Tele} (lbs/day)	WLA_{UpLBF} (lbs/day)
Arsenic	High flow	49.039	78.462	38%	4.670	12.857	2.020	29.493
	Low flow	1.939	1.551	0%	0.212	0.291	0.035	1.400
Cadmium	High flow	0.588	0.785	25%	0.125	0.129	0.050	0.285
	Low flow	0.039	0.008	0%	0.006	0.003	0.003	0.027
Copper	High flow	17.752	34.327	48%	6.227	3.664	1.439	6.422
	Low flow	1.252	0.388	0%	0.071	0.083	0.105	0.994
Cyanide	High flow	25.500	112.790	77%	7.783	3.214	1.262	13.241
	Low flow	1.008	0.485	0%	0.353	0.073	0.059	0.523
Lead	High flow	3.825	47.077	92%	0.778	0.694	0.273	2.080
	Low flow	0.357	0.048	0%	0.035	0.016	0.025	0.281

High flow: 908.13 cfs, 33 mg/L hardness
Low flow: 35.9 cfs, 65 mg/L hardness

7.7.12 Little Blackfoot River, Lower Segment (MT76G004_010)

Loading Summary

While there are abandoned mines in the lower Little Blackfoot River basin, the primary source of metals loading to the lower segment is the load transported from the upper segment (**Section 7.7.11**). All

arsenic and lead standard exceedances in the mainstem occurred during high flow conditions except for one lead exceedance in July 2008. Within the lower Little Blackfoot River basin, mining was concentrated in the Carpenter and Ophir Creek drainages; however, recent surface water data collected in that area at CAR-1 and OPH-1 (**Figure 7-12**) did not exceed targets.

Arsenic and lead concentrations generally decrease in the downstream direction. Dissolved lead was identified as a minor portion of the total recoverable concentration, indicating that lead loading is primarily associated with particulates. Samples on six tributaries were also collected to help identify sources and while lead was generally not detected, three out of four arsenic samples on Threemile Creek at THR-1 (**Figure 7-12**) had concentrations equivalent to, but not in excess of the human health standard. Since no target exceedances were observed in these tributaries and because the site highest in the watershed (LBF-7) had the most elevated metal concentrations, it is assumed the upper segment is the primary contributor of metals loading to the Little Blackfoot River's lower segment. That said, even if loading inputs from the upper segment were reduced to meet TMDLs, water quality would still slightly exceeded targets near the mouth of the Little Blackfoot River at LBF-10; thus reductions are required throughout the entire watershed. While abandoned mine databases do not indicate an obvious source, during the high flow 2009 event, metal concentrations increased between LBF-9 and LBF-10. Additional monitoring in the area could help distinguish where the remaining loading is coming from. Similar to the upper segment, flows downstream did not consistently increase or decrease likely due to a combination of factors including errors in using the float method to estimate velocity when streams were deemed unsafe to wade (Hydrosolutions Inc., 2010), effects of irrigation withdrawals and/or naturally losing reaches. A study investigating groundwater-surface water interactions between Elliston and Avon found the Little Blackfoot River had sections of both seasonally losing and gaining reaches (PBS&J, 2009). The tendency of high flow exceedances plus high metal concentrations in stream sediments indicate that metal loading to lower Little Blackfoot River is associated with surface runoff over mine waste and/or mobilization of sediments within the channel. As of October 2011 there was an active general permit for suction dredging (MTG370318) on Carpenter Creek. As discussed in the data review in **Section 7.5.12**, this activity is not anticipated to be a source of metals loading, and it is provided a WLA of 0. This WLA is anticipated to be met by adherence to permit conditions.

TMDLs and Allocations

Because human-related metals loading to the lower Little Blackfoot River is associated with multiple sources, the wasteload has been broken into three allocations: one for contributions from the upper segment of the Little Blackfoot River ($\mathbf{WLA_{UpLBF}}$), a second representing loads associated with the suction dredge permit on Carpenter Creek ($\mathbf{WLA_{Suction}}$) and a third capturing metals loading from other sources within the lower Little Blackfoot River ($\mathbf{WLA_{LwrLBF}}$). The $\mathbf{WLA_{UpLBF}}$ is equivalent to the upper Little Blackfoot River TMDL provided in **Section 7.7.11** and $\mathbf{WLA_{LwrLBF}}$ was calculated by subtracting $\mathbf{WLA_{UpLBF}}$ and $\mathbf{LA_{Nat}}$ from the TMDL. Concentrations from SPD-1 (**Figure 7-12**), a site on Spotted Dog Creek, were used to calculate the natural background load allocation, $\mathbf{LA_{Nat}}$. While concentrations at LBF-7 were slightly higher, data from LBF-10 were used to calculate existing loads and example TMDLs for the lower Little Blackfoot River in order to incorporate loading for the entire basin. A **MOS** is addressed through implicit considerations (**Section 7.8**). **Table 7-31** summarizes TMDL components and shows example TMDLs and allocations for high and low flow conditions for the lower Little Blackfoot River. While TMDLs are currently being met during low flow conditions, reductions are necessary during high flow.

$$\mathbf{TMDL_{Lwr\ LBF} = WLA_{UpLBF} + WLA_{Suction} + WLA_{LwrLBF} + LA_{Nat}}$$

MOS = Implicit

Table 7-31. Lower Little Blackfoot River Metals TMDLs and Allocation Examples

Metal	Flow	TMDL (lbs/day)	Existing Load (lbs/day)	Percent Reduction	LA_{Nat} (lbs/day)	WLA_{UpLBF} (lbs/day)	$WLA_{Suction}$ (lbs/day) MTG370318	WLA_{LwrLBF} (lbs/day)
Arsenic	High flow	83.997	117.596	29%	13.983	49.039	0.000	20.975
	Low flow	3.143	1.571	0%	0.361	1.939	0.000	0.843
Lead	High flow	16.043	77.277	79%	0.874	3.825	0.000	11.344
	Low flow	1.505	0.079	0%	0.030	0.357	0.000	1.118

High flow: 1555.5 cfs, 67 mg/L hardness
Low flow: 58.2 cfs, 138 mg/L hardness

7.8 Seasonality and Margin of Safety

All TMDL documents must consider the seasonal variability, or seasonality, on water quality impairment conditions, maximum allowable pollutant loads in a stream (TMDLs), and load allocations. TMDL development must also incorporate a margin of safety into the load allocation process to account for uncertainties in pollutant sources and other watershed conditions, and ensure (to the degree practicable) that the TMDL components and requirements are sufficiently protective of water quality and beneficial uses. This section describes the considerations of seasonality and a margin of safety in the Little Blackfoot TPA metal TMDL development process.

Seasonality

Seasonality addresses the need to ensure year round beneficial use support. Seasonality was considered for assessing loading conditions and for developing water quality targets, TMDLs, and allocation schemes. For metals TMDLs, seasonality is critical due to varying metals loading pathways and varying water hardness during high and low flow conditions. Loading pathways associated with overland flow and erosion of metals-contaminated soils and wastes tend to be the major cause of elevated metals concentrations during high flows, with the highest concentrations and metals loading typically occurring during the rising limb of the hydrograph. Loading pathways associated with groundwater transport and/or adit discharges tend to be the major cause of elevated metals concentrations during low or base flow conditions. Hardness tends to be lower during higher flow conditions, thus leading to lower water quality standards for some metals during the runoff season. Seasonality is addressed in this document as follows:

- Metals concentrations and loading conditions are evaluated for both high flow and low flow conditions.
- Metals TMDLs incorporate streamflow as part of the TMDL equation.
- Metals targets apply year round, with monitoring criteria for target attainment developed to address seasonal water quality extremes associated with loading and hardness variations.
- TMDLs and load reduction needs are developed for high and low flow conditions.

Margin of Safety (MOS)

The margin of safety is to ensure that TMDLs and allocations are sufficient to sustain conditions that will support beneficial uses. All metals TMDLs incorporate an implicit MOS in several ways. The implicit margin of safety is applied by using conservative assumptions throughout the TMDL development process and is addressed by the following:

- Target attainment, refinement of load allocations, and, in some cases, impairment validations and TMDL-development decisions are all based on an adaptive management approach that relies on future monitoring and assessment for updating planning and implementation efforts.

- Chronic standards were used to calculate a daily load limit rather than a 96-hour load limit
- Load allocations to background sources were set using sample data from the same sampling event/hydrologic period as the example TMDL, often resulting in a greater allocation to background sources under high flow conditions.
- Sediment metals concentration criteria were used as secondary indicators.

7.9 Uncertainty and Adaptive Management

Uncertainties in the accuracy of field data, applicable target values, source assessments, loading calculations, modeling assumptions, and other considerations are inherent when assessing and evaluating environmental variables for TMDL development. While uncertainties are an undeniable fact of TMDL development, mitigation and reduction of uncertainties through adaptive management approaches is a key component of ongoing TMDL implementation and evaluation. Uncertainties, assumptions, and considerations are addressed throughout this document and point to the need to refine analysis, conduct further monitoring, and address unknowns in order to develop better understanding of impairment conditions and the processes that affect impairment. This process of adaptive management is predicated on the premise that targets, TMDLs, allocations, and the analyses supporting them are not static, but are processes subject to modification and adjustment as new information and relationships are understood.

The adaptive management process allows for continual feedback on the progress of restoration activities and status of beneficial uses. It provides the flexibility to refine targets as necessary to ensure protection of the resource or to adapt to new information concerning target achievability. For instance, as a result of additional monitoring and source refinement discussed in the **Section 10.0**, additional WLAs may be necessary for abandoned mines that are found to be discrete sources and the allocations and margin of safety may be modified. Components may be changed to improve ways of achieving and measuring success. A restoration and monitoring plan is closely linked to the adaptive management process and is described in detail in **Sections 10.1**.

The water quality restoration targets and associated metals TMDLs developed for the Little Blackfoot TPA are based on future attainment of the B-1 classification water quality standards. In order to achieve attainment, all significant sources of metal loading must be addressed via all reasonable land, soil, and water conservation practices. It is recognized however, that in spite of all reasonable efforts, attainment of restoration targets may not be possible due to the potential presence of unalterable human-caused sources and/or natural background sources of metals loading. For this reason, an adaptive management approach is adopted for all metals targets described within this document. Under this adaptive management approach, all metals identified in this plan as requiring TMDLs will ultimately fall into one of the three categories identified below:

- Implementation of restoration activities resulting in full attainment of restoration targets for all parameters;
- Implementation of restoration activities fails to result in target attainment due to underperformance or ineffectiveness of restoration actions. Under this scenario the waterbody remains impaired and will require further restoration efforts associated with the pollutants of concern. The target may or may not be modified based on additional information, but conditions still exist that require additional pollutant load reductions to support beneficial uses and meet applicable water quality standards. This scenario would require some form of additional, refocused restoration work.

- Implementation of restoration activities fails to result in target attainment, but target attainment is deemed unachievable even though all applicable monitoring and restoration activities have been completed. Under this scenario, site-specific water quality standards and/or the reclassification of the waterbody may be necessary. This would then lead to a new target (and TMDL) for the pollutant(s) of concern, and the new target could either reflect the existing conditions at the time or the anticipated future conditions associated with the restoration work that has been performed.

The DEQ Remediation Division and/or DEQ Standards Program personnel will lead this effort within DEQ to make determinations concerning the appropriateness of specific mine cleanup activities relative to expectations for mining cleanup efforts for any impairment condition associated with mining impacts. This includes consideration of appropriate evaluation of cleanup options, actual cleanup planning and design, as well as the appropriate performance and maintenance of the cleanup activities. Where NPDES permitted point sources are involved, the DEQ Permitting Program will also be involved. Determinations on the performance of all aspects of restoration activities, or lack thereof, will then be used along with available in-stream data to evaluate the appropriateness of any given target and beneficial use support. Reclamation activities and monitoring conducted by other parties, including but not limited to the USFS, should be incorporated into the process as well. The information will also help determine any further cleanup/load reduction needs for any applicable waterbody and will ultimately help determine the success of water quality restoration.

It is acknowledged that construction or maintenance activities related to restoration, construction/maintenance, and future development may result in short term increase in surface water metals concentrations. For any activities that occur within the stream or floodplain, all appropriate permits should be obtained before commencement of the activity. Federal and State permits necessary to conduct work within a stream or stream corridor are intended to protect the resource and reduce, if not completely eliminate, pollutant loading or degradation from the permitted activity. The permit requirements typically have mechanisms that allow for some short term impacts to the resource, as long as all appropriate measures are taken to reduce impact to the least amount possible.

8.0 Other Identified Issues or Concerns

8.1 Pollution Listings

Water quality issues are not limited simply to those streams where TMDLs are developed. In some cases, streams have not yet been reviewed through the assessment process and do not appear on the 303(d) List. In other cases, streams in the Little Blackfoot TPA may appear on the 303(d) List but may not always require TMDL development for a pollutant, but do have pollution listings such as "alteration in stream-side or littoral vegetation covers" that could be linked to a pollutant. These habitat related pollution causes are often associated with sediment issues, may be associated with nutrient or temperature issues, or may be having a deleterious effect on a beneficial use without a clearly defined quantitative measurement or direct linkage to a pollutant to describe that impact. Nevertheless, the issues associated with these streams are still important to consider when working to improve water quality conditions in individual streams, and the Little Blackfoot River watershed as a whole. In some cases, pollutant and *pollution* causes are listed for waterbody, and the management strategies as incorporated through the TMDL development for the pollutant, inherently address some or all of the pollution listings. **Table 8-1** presents the *pollution* listings in the Little Blackfoot TPA, and notes those streams listed that either do not have any associated pollutant listings or a TMDL in this document.

Table 8-1. Waterbody segments with pollution listings on the 2010 303(d) List

Waterbody ID	Stream Segment	2010 Probable Causes of Impairment
MT76G004_010	LITTLE BLACKFOOT RIVER, Dog Creek to the mouth (Clark Fork River)	Alteration in stream side or littoral vegetation covers; Low flow alterations
MT76G004_020	LITTLE BLACKFOOT RIVER, the headwaters to Dog Creek	Alteration in stream side or littoral vegetation covers
MT76G004_032	SPOTTED DOG CREEK, forest boundary to the mouth (Little Blackfoot River)	Alteration in stream side or littoral vegetation covers
MT76G004_040	ELLISTON CREEK, headwaters to the mouth (Little Blackfoot River)	Alteration in stream side or littoral vegetation covers
MT76G004_051	TELEGRAPH CREEK, headwaters to Hahn Creek	Alteration in stream side or littoral vegetation covers
MT76G004_071	DOG CREEK, headwaters to Meadow Creek	Alteration in stream side or littoral vegetation covers
MT76G004_072	DOG CREEK, Meadow Creek to the mouth (Little Blackfoot River)	Alteration in stream side or littoral vegetation covers
MT76G004_080	SNOWSHOE CREEK, headwaters to the mouth (Little Blackfoot River)	Alteration in stream side or littoral vegetation covers; Low flow alterations
MT76G004_091	CARPENTER CREEK, headwaters to Basin Creek*	Alteration in stream side or littoral vegetation covers; Physical substrate habitat alterations; Other anthropogenic substrate alterations
MT76G004_092	CARPENTER CREEK, Basin Creek to the mouth (Little Blackfoot River)	Physical substrate habitat alterations
MT76G004_100	WOODSON GULCH, Trib to Carpenter Creek T11N, R7W, Sec 29*	Physical substrate habitat alterations
MT76G004_112	THREEMILE CREEK, Quigley Ranch Res. to mouth (Little Blackfoot River)	Alteration in stream side or littoral vegetation covers

* Streams listed for *pollution* only, with no pollutant listings or no TMDL in this document.

8.1.2 Pollution Causes of Impairment Descriptions

Pollution listings are often used as a probable cause of impairment when available data at the time of assessment does not necessarily provide a direct quantifiable linkage to a specific pollutant, however non-pollutant sources or indicators do indicate impairment. In some cases the pollutant and pollution categories are linked and appear together in the cause listings, however a pollution category may appear independent of a pollutant listing. The following discussion provides some rationale for the application of the identified pollution causes to a waterbody, and thereby provides additional insight into possible factors in need of additional investigation or remediation.

Alteration in Stream-side or Littoral Vegetation Covers

Alteration in stream-side or littoral vegetation covers refers to circumstances where practices along the stream channel have altered or removed riparian vegetation and subsequently affected channel geomorphology and/or stream temperature. Such instances may be riparian vegetation removal for a road or utility corridor, or overgrazing by livestock along the stream. As a result of altering the stream-side vegetation, destabilized banks from loss of vegetative root mass could lead to overwidened stream channel conditions, elevated sediment and/or nutrient loads, and the resultant lack of canopy cover can lead to increased water temperatures.

Physical Substrate Habitat Alterations

Physical substrate habitat alterations generally describe cases where the stream channel has been physically altered or manipulated, such as through the straightening of the channel or from human-influenced channel downcutting, resulting in a reduction of morphological complexity and loss of habitat (riffles and pools) for fish and aquatic life. For example, this may occur when a stream channel has been straightened to accommodate roads, agricultural fields, or through placer mine operations.

Other Anthropogenic Substrate Alterations

Streams may be listed for other anthropogenic substrate alterations when data indicates impacts to the stream channel have resulted from apparent anthropogenic activities, but parameters related to substrate (pebble counts) do not appear high, and morphological characteristics such as width/depth or entrenchment are also within expected values. For example, this would take place in a system where the reduction or historic reduction of vegetation capable of producing large woody debris has occurred, in a system where large woody debris is integral to pool development (quality and quantity) and channel function.

Low Flow Alterations

Streams are typically listed for low flow alterations when irrigation withdrawal management leads to base flows that are too low to support the beneficial uses designated for that system. This could result in dry channels or extreme low flow conditions unsupportive of fish and aquatic life. It could also result in lower flow conditions which absorb thermal radiation more readily and increase stream temperatures, which in turn creates dissolved oxygen conditions too low to support some species of fish.

It should be noted that while Montana law states that TMDLs cannot impact Montana water rights and thereby affect the allowable flows at various times of the year, the identification of low flow alterations as a probable source of impairment does not violate any state or federal regulations or guidance related to stream assessment and beneficial use determination. Subsequent to the identification of this as a probable cause of impairment, it is up to local users, agencies, and entities to improve flows through water and land management.

8.1.3 Monitoring and BMPs for Pollution Affected Streams

Streams listed for *pollution* as opposed to a pollutant should not be overlooked when developing watershed management plans. Attempts should be made to collect sediment, nutrient, and temperature information where data is minimal and the linkage between probable cause, pollution listing, and effects to the beneficial uses are not well defined. The monitoring and restoration strategies that follow in **Sections 9.0** and **10.0** are presented to address both pollutant and non-pollutant issues for streams in the Little Blackfoot TPA with TMDLs in this document, and they are equally applicable to streams listed for the above pollution categories.

8.2 POTENTIAL POLLUTANT ISSUES NOT ADDRESSED

Although this document addresses all pollutant listings on the 2010 303(d) List, there are a couple issues where additional investigation is recommended that may warrant TMDL development in the future.

8.2.1 Temperature

Although Snowshoe Creek and the lower segment of the Little Blackfoot River are listed for low flow alterations, which is commonly associated with temperature impairment, no temperature data evaluation or TMDLs were included within this document because no waterbodies are listed for temperature impairment. However, temperature data collected in 2007 by DEQ, in 2007/2008 by FWP (Lindstrom, et al., 2008; Liermann, et al., 2009), and over several years at the USGS gage near Garrison indicate temperatures in the Little Blackfoot River may be elevated above temperatures that are harmful to fish at certain times during the summer. It is recommended that existing data be reviewed and additional data be collected if necessary to fully evaluate temperature conditions and sources within the Little Blackfoot River watershed.

8.2.2 Aluminum

Metals sampling for TMDL development revealed dissolved aluminum concentrations during runoff conditions that were occasionally slightly above the chronic aquatic life standard. This occurred only during runoff and in drainages with a known history of mining and those without, indicating concentrations may naturally be elevated. Any stream with a history of mining in its watershed that had elevated dissolved aluminum concentrations has numerous metals TMDLs within this document, so if human sources exist, associated loading should be addressed during implementation of those TMDLs. It is recommended that additional monitoring and source characterization be conducted for dissolved aluminum.

9.0 RESTORATION OBJECTIVES AND IMPLEMENTATION STRATEGY

While certain land uses and human activities are identified as sources and causes of water quality impairment during TMDL development, the management of these activities is of more concern than the activities themselves. This document does not advocate for the removal of land and water uses to achieve water quality restoration objectives, but instead for making changes to current and future land management practices that will help improve and maintain water quality. This section describes an overall strategy and specific on-the-ground measures designed to restore beneficial water uses and attain water quality standards in Little Blackfoot TPA streams. The strategy includes general measures for reducing loading from each significant identified pollutant source.

9.1 WATER QUALITY RESTORATION OBJECTIVES

The following are general water quality goals provided in this TMDL document:

- Provide technical guidance for full recovery of aquatic life beneficial uses to all impaired streams within the Little Blackfoot TPA by improving sediment, nutrient, and metal water quality conditions. This technical guidance is provided by the TMDL components in the document which include:
    - water quality targets,
    - pollutant source assessments, and
    - a restoration and TMDL implementation strategy.

A watershed restoration plan (WRP) can provide a framework strategy for water quality restoration and monitoring in the Little Blackfoot TPA, focusing on how to meet conditions that will likely achieve the TMDLs presented in this document, as well as other water quality issues of interest to local communities and stakeholders. Watershed restoration plans identify considerations that should be addressed during TMDL implementation and should assist stakeholders in developing a more detailed adaptive plan in the future. A locally developed WRP will likely provide more detailed information about restoration goals and spatial considerations but may also encompass more broad goals than this framework includes. A WRP would serve as a locally organized “road map” for watershed activities, sequences of projects, prioritizing of projects, and funding sources for achieving local watershed goals, including water quality improvements. The WRP is intended to be a living document that can be revised based on new information related to restoration effectiveness, monitoring results, and stakeholder priorities. The following are key elements suggested for the WRP:

- Support for implementing restoration projects to protect water conditions so that all streams in the watershed maintain good water quality, with an emphasis on waters with TMDLs completed.
- Detailed cost/benefit analysis and spatial considerations for water quality improvement projects.
- Develop an approach for future BMP installment and efficiency results tracking.
- Provide information and education components to assist with stakeholder outreach about restoration approaches, benefits, and funding assistance.
- Other various watershed health goals, such as weed control initiatives.
- Other local watershed based issues.

9.2 Agency and Stakeholder Coordination

Successful implementation requires collaboration among private landowners, land management agencies, and other stakeholders. The DEQ does not implement TMDL pollutant reduction projects for nonpoint source activities, but can provide technical and financial assistance for stakeholders interested in improving their water quality. The DEQ will work with participants to use the TMDLs as a basis for developing locally-driven WRPs, administer funding specifically to help fund water quality improvement and pollution prevention projects, and can help identify other sources of funding.

Because most nonpoint source reductions rely on voluntary measures, it is important that local landowners, watershed organizations, and resource managers continue to work collaboratively with local and state agencies to achieve water quality restoration which will progress toward meeting water TMDL targets and load reductions. Specific stakeholders and agencies that have been, and will likely continue to be, vital to restoration efforts include the Little Blackfoot Watershed Group, Watershed Restoration Coalition of the Upper Clark Fork, Clark Fork Coalition, Deer Lodge Conservation District, USFS, NRCS, DNRC, FWP, NRDP, EPA and DEQ. Other organizations and non-profits that may provide assistance through technical expertise, funding, educational outreach, or other means include Montana Water Center, University of Montana Watershed Health Clinic, and MSU Extension Water Quality Program.

9.3 Restoration Strategy By Pollutant

This section summarizes the primary restoration strategy for each pollutant with TMDLs in this document as well as some general information on restoration of non-pollutant impairments.

9.3.1 Sediment Restoration Strategy

The goal of the sediment restoration strategy is to prevent the availability, transport, and delivery of sediment by a combination of minimizing sediment delivery, reducing the rate of runoff, and intercepting sediment transport. Streamside riparian vegetation restoration and long term riparian area management are vital restoration practices that must be implemented across the watershed to achieve the sediment TMDLs. Vigorous native streamside riparian vegetation filters sediment from upland runoff and improves streambank stability and slows bank erosion. Sediment is also deposited more heavily in healthy riparian zones during flooding because water velocities slow in these areas enough for excess sediment to settle out.

Improved grazing management is another major component of the sediment restoration approach. This may include adjusting the timing and duration of grazing, the development of multi-pasture systems that include riparian pastures, and the development of off-site watering areas. Additionally, grazing management, combined with some additional fencing costs in many riparian areas, would promote natural recovery. Active vegetation planting along with bank sloping may increase costs, but still remains within a reasonable and relatively cost effective restoration approach. When stream channel restoration work is needed because of altered stream channels, costs increase and projects should be assessed on a case by case basis. In general, these are sustainable agricultural practices that promote attainment of conservation objectives while meeting agricultural production goals. The appropriate BMPs will differ by landowner and are recommended to be part of a comprehensive farm/ranch plan.

Although roads may be a small source of sediment at the watershed scale, sediment derived from roads may cause significant localized impact in some stream reaches. Restoration approaches for unpaved

roads near streams should be to divert water off of roads and ditches before it enters the stream. The diverted water should be routed through natural healthy vegetation, which will act as filter zones for the sediment laden runoff before it enters streams. Sediment loads from culvert failure and culvert caused scour were not assessed by the TMDL source assessment, but should be considered in road sediment restoration approaches.

Historic placer mining activities may have very localized impacts that affect sediment production within the watershed. If found, mining caused sediment sources that can be restored at reasonable costs could be prioritized into the WRP. Any other unknown sediment sources could also be incorporated into the WRP while considering cost and sediment reduction benefits.

All of these best management practices are considered reasonable restoration approaches due to their benefit and generally low costs. Riparian restoration and road erosion control are standard best management practices identified by NRCS, and are not overly expensive to our society. Although the appropriate BMP will vary by waterbody and site, controllable sources and BMP types can be prioritized by watershed to reduce sediment loads in individual streams.

9.3.2 Nutrient Restoration Strategy

The goal of the nutrient restoration strategy is to reduce nutrient input to stream channels by increasing the filtering and uptake capacity of riparian vegetation areas, decreasing the amount of bare ground, and limiting the transport of nutrients from rangeland and cropland. Cropland filter strip extension, vegetative restoration, and long-term filter area maintenance are vital BMPs for achieving nutrient TMDLs in predominantly agricultural watersheds. Grazing systems with the explicit goal of increased vegetative post-grazing ground cover are needed to address the same nutrient loading from rangelands. Grazing prescriptions that enhance the filtering capacity of riparian filter areas offer a second tier of controls on the sediment content of upland runoff. Grazing and pasture management adjustments should consider:

1. The timing and duration of near-stream grazing,
2. The spacing and exposure duration of on-stream watering locations,
3. Provision of off-stream site watering areas to minimize near-stream damage and allow impoundment operations that minimize salt accumulations,
4. Active reseeding and rest rotation of locally damaged vegetation stands,
5. Improved management of irrigation systems and fertilizer applications, and
6. Incorporation of streamside vegetation buffer to irrigated croplands and confined feeding areas

Seasonal livestock confinement areas have a historic precedent for placement near or adjacent to flowing streams. Stream channels were the only available livestock water sources prior to the extension of rural electicity. Although limited in size, their repeated use generates high nutrient concentrations in close proximity to surface waters. Episodic runoff with high nutrient concentrations generates large loads that can settle in pools of intermittent streams and remain bio-available through the growing season. Diversion and routing of confinement runoff to harvestable nutrient uptake areas outside of active water courses are effective controls.

In addition to the agricultural related BMPs, a reduction of sediment delivery from roads and eroding streambanks is another component of the nutrient reduction restoration plan. Additional sediment related BMPs are presented in **Section 9.3.1**.

In general, these are sustainable grazing and cropping practices that can reduce nutrient inputs while meeting production goals. The appropriate combination of BMPs will differ according to landowner preferences and equipment but are recommended as components of comprehensive plan for farm and ranch operators. Sound planning combined with effective conservation BMPs should be sought whenever possible and applied to croplands, pastures and livestock handling facilities. Assistance from resource professionals from various local, state, and federal agencies or non-profit groups is widely available in Montana. The local USDA Service Center and county conservation district offices are geared to offer both planning and implementation assistance.

9.3.3 Metals Restoration Strategy

The restoration strategy for metals focuses on regulatory mechanisms and/or programs applicable to the controllable source types present within the watershed; which, for the most part, are associated with historic mining and mining legacy issues. Potential metals loading sources associated with abandoned mines include discharging mine adits and mine waste materials on-site and in-channel. The goal of the metals restoration strategy is to limit the input of metals to stream channels from priority abandoned mine sites and other identified sources of metals impairments. For most of the mining-related sources, additional analysis will likely be required to identify site-specific metals delivery pathways and to develop mitigation plans.

Goals and objectives for future restoration work include the following:

- Prevent soluble metal contaminants or metals contaminated solid materials in the waste rock and tailings materials/sediments from migrating into adjacent surface waters to the extent practicable.
- Reduce or eliminate concentrated runoff and discharges that generate sediment and/or heavy metals contamination to adjacent surface waters and ground water to the extent practical.
- Identify, prioritize, and select response and restoration actions based on a comprehensive source assessment and streamlined risk analysis of areas affected by historical mining.

9.3.4 Pollution Restoration Strategy

Although TMDL development is not required for pollution listings, they are frequently linked to pollutants, and addressing pollution sources is an important component of TMDL implementation. Pollution listings within the Little Blackfoot TPA include alteration in stream-side or littoral vegetative covers, physical substrate habitat alterations, other anthropogenic substrate alterations, and low flow alterations. Typically, habitat impairments are addressed during implementation of associated pollutant TMDLs. Although flow alterations have the most direct link with temperature, adequate flow is also critical for downstream sediment transport and improving the assimilative capacity of streams for sediment, nutrient, and metals inputs. Therefore, if restoration goals within the Little Blackfoot TPA are not also addressing pollution impairments, additional pollution-related BMP implementation should be considered. Habitat and flow BMPs are discussed below in **Section 9.4**.

9.4 Restoration Approaches by Source Category

For each major source of human-caused pollutant loads in the Little Blackfoot TPA, general management recommendations are outlined below. The effect of different sources can change seasonally and be dependent on the magnitude of storm/high flow events. Therefore, restoration activities within the Little Blackfoot TPA should focus on all major sources for each pollutant category. Yet, restoration should begin with addressing significant sources where large load reductions can be obtained within

each source category. For each major source, BMPs will be most effective as part of a management strategy that focuses on critical areas within the watershed, which are those areas contributing the largest pollutant loads or are especially susceptible to disturbance. The source assessment results provided within **Appendices C - G** and summarized in **Section 5.7, 6.5, and 7.7** provide information that should be used to help determine priorities for each major source type in the watershed and for each of the general management recommendations discussed.

Applying BMPs for existing activities where they are currently needed is the core of TMDL implementation but only forms a part of the restoration strategy. Also important are efforts to avoid future load increases by ensuring that new activities within the watershed incorporate all appropriate BMPs, and ensuring continued implementation and maintenance of those BMPs currently in place or in practice. Restoration might also address other current pollution-causing uses and management practices. In some cases, efforts beyond implementing new BMPs may be required to address key pollutant sources. In these cases, BMPs are usually identified as a first effort followed by an adaptive management approach to determine if further restoration activities are necessary to achieve water quality standards. Monitoring is also an important part of the restoration process; recommendations are outlined in **Section 10.0**.

9.4.1 Grazing

Development of riparian grazing management plans should be a goal for landowners in the watershed who are not currently using a plan. Private land owners may be assisted by state, county federal, and local conservation groups to establish and implement appropriate grazing management plans. The goal of riparian grazing management is not to eliminate all grazing in these areas. Nevertheless, in some areas, a more restrictive management strategy may be necessary for a period in order to accelerate re-establishment of a riparian community with the most desirable species composition and structure. Grazing should be managed to provide filtering capacity via adequate groundcover, streambank stability via mature riparian vegetation communities, and shading from mature riparian climax communities.

Grazing management includes the timing and duration of grazing, the development of multi-pasture systems, including riparian pastures, and the development of off-site watering areas. The key strategy of the recommended grazing BMPs is to develop and maintain healthy riparian vegetation and minimize disturbance of the streambank and channel. The primary recommended BMPs for the Little Blackfoot TPA are providing off-site watering sources, limiting livestock access to streams, providing “water gaps” where livestock access to a stream is necessary, planting woody vegetation along streambanks, and establishing riparian buffers. Although passive restoration via new grazing plans or limited bank revegetation are a preferred BMPs, in some instances, bank stabilization may be necessary prior to planting vegetation. Other general grazing management recommendations and BMPs to address grazing sources of pollutants and pollution can be obtained in Appendix A of Montana’s NPS Management Plan (Montana Department of Environmental Quality, 2007).

9.4.2 Small Acreages

Small acreages are growing rapidly, and many small acreage owners own horses or cattle. Animals grazing on small acreages can lead to overgrazing and a shortage of grass cover, leaving the soil subject to erosion and runoff to surface waters. General BMP recommendations for small acreage lots with animals include creating drylots, developing a rotational grazing system, and maintaining healthy riparian buffers. Small acreage owners should collaborate with MSU Extension Service, NRCS, conservation districts and agriculture organizations to develop management plans for their lots. Further

information may be obtained from the Montana Nonpoint Source Management Plan (Montana Department of Environmental Quality, 2007) or the MSU extension website at: http://www.msuextension.org/ruralliving/Index.html.

9.4.3 Animal Feeding Operations

Animal feeding operations (AFOs) can pose a number of risks to water quality. To minimize water quality effects from AFOs, the USDA and EPA released the Unified National Strategy for AFOs in 1999 (U.S. Department of Agriculture and U.S. Environmental Protection Agency, 1999). This plan is a written document detailing manure storage and handling systems, surface runoff control measures, mortality management, chemical handling, manure application rates, schedules to meet crop nutrient needs, land management practices, and other options for manure disposal. An AFO that meets certain specified criteria is referred to as a Concentrated Animal Feeding Operation (CAFO), and in addition may be required to obtain a Montana Pollution Discharge Elimination System (MPDES) permit as a point source. Montana's AFO compliance strategy is based on federal law and has voluntary, as well as, regulatory components. If voluntary efforts can eliminate discharges to state waters, in some cases no direct regulation is necessary through a permit. Operators of AFOs may take advantage of effective, low cost practices to reduce potential runoff to state waters, which additionally increase property values and operation productivity. Properly installed vegetative filter strips, in conjunction with other practices to reduce wasteloads and runoff volume, are very effective at trapping and detaining sediment and reducing transport of nutrients and pathogens to surface waters, with removal rates approaching 90 percent (U.S. Department of Agriculture and U.S. Environmental Protection Agency, 1999). Other options may include clean water diversions, roof gutters, berms, sediment traps, fencing, structures for temporary manure storage, shaping, and grading. Animal health and productivity also benefit when clean, alternative water sources are installed to prevent contamination of surface water.

Opportunities for financial and technical assistance (including comprehensive nutrient management plan development) in achieving voluntary AFO and CAFO compliance are available from conservation districts and NRCS field offices. Voluntary participation may aide in preventing a more rigid regulatory program from being implemented for Montana livestock operators in the future.

Further information may be obtained from the DEQ website at: http://www.deq.mt.gov/wqinfo/mpdes/cafo.asp.

Montana's NPS pollution control strategies for addressing AFOs are summarized in the bullets below:

- Work with producers to prevent NPS pollution from AFOs.
- Promote use of State Revolving Fund for implementing AFO BMPs.
- Collaborate with MSU Extension Service, NRCS, and agriculture organizations in providing resources and training in whole farm planning to farmers, ranchers, conservation districts, watershed groups and other resource agencies.
- Encourage inspectors to refer farmers and ranchers with potential nonpoint source discharges to DEQ watershed protection staff for assistance with locating funding sources and grant opportunities for BMPs that meet their needs. (This is in addition to funds available through NRCS and the Farm Bill).
- Develop early intervention of education & outreach programs for small farms and ranches that have potential to discharge nonpoint source pollutants from animal management activities. This includes assistance from the DEQ Permitting Division, as well as external entities such as DNRC, local watershed groups, conservation districts, and MSU Extension.

9.4.4 Cropland

The primary strategy of the recommended cropland BMPs is to reduce sediment and nutrient inputs. The major factors involved in decreasing sediment loads are reducing the amount of erodible soil, reducing the rate of runoff, and intercepting eroding soil before it enters waterbodies. The main BMP recommendations for the Little Blackfoot TPA are vegetated filter strips (VFS) and riparian buffers. Both of these methods reduce the rate of runoff, promote infiltration of the soil (instead of delivering runoff directly to the stream), and intercept sediment. Effectiveness is typically about 70 percent for filter strips and 50 percent for buffers (Montana Department of Environmental Quality, 2007). Filter strips and buffers are most effective when used in conjunction with agricultural BMPs that reduce the availability of erodible soil such as conservation tillage, crop rotation, strip cropping, and precision farming. Filter strips along streams should be composed of natural vegetative communities which will also supply shade to reduce instream temperatures. Filter strips widths along streams should be at least double the average mature canopy height to assist in providing stream shade. Additional BMPs and details on the suggested BMPs can be obtained from NRCS and in Appendix A of Montana's NPS Management Plan (Montana Department of Environmental Quality, 2007).

9.4.5 Irrigation

Flow alteration and dewatering are commonly considered water quantity rather than water quality issues. However, changes to stream flow can have a profound effect on the ability of a stream to attenuate pollutants, especially nutrients, metals and heat. Flow reduction may increase water temperature, allow pollutants to accumulate in stream channels, reduce available habitat for fish and other aquatic life, and may cause the channel to respond by changing in size, morphology, meander pattern, rate of migration, bed elevation, bed material composition, floodplain morphology, and streamside vegetation if flood flows are reduced (Andrews and Nankervis, 1995; Schmidt and Potyondy, 2004). Local coordination and planning are especially important for flow management because State law indicates that legally obtained water rights cannot be divested, impaired, or diminished by Montana's water quality law (MCA 75-5-705).

The SWAT model indicated that improving irrigation efficiency will reduce nitrogen loading to streams in the Little Blackfoot River watershed. Improvements should focus on how to reduce the amount of stream water diverted during July and August, while still growing crops on traditional cropland. It may be desirable to investigate irrigation practices earlier in the year that promote groundwater return during July and August. Understanding irrigation water, groundwater and surface water interactions is an important part of understanding how irrigation practices will affect stream flow during specific seasons. Although additional investigation of inefficiencies in the irrigation network is needed to obtain the most improvement, potential changes are as follows:

- Install upgraded head gates for more exact control of water diversions and to minimize leakage when not in operation.
- Develop more efficient means to supply water to livestock.
- Determine necessary amounts of water to divert that would reduce over watering and improve forage quality and production.
- Redesign irrigation systems.
- Upgrade ditches (including possible lining) to increase ditch conveyance efficiency.

9.4.6 Riparian Areas and Floodplains

Riparian areas and floodplains are critical for wildlife habitat, groundwater recharge, reducing the severity of floods and upland and streambank erosion, and filtering pollutants from runoff. Therefore, enhancing and protecting riparian areas and floodplains within the watershed should be a priority of TMDL implementation in the Little Blackfoot TPA.

Initiatives to protect riparian areas and floodplains will help protect property, increase channel stability, and buffer waterbodies from pollutants. However, in areas with a much smaller buffer or where historical vegetation removal and development have shifted the riparian vegetation community and limited its functionality, a tiered approach for restoring stream channels and adjacent riparian vegetation should be considered that prioritizes areas for restoration based on the existing condition and potential for improvement. In non-conifer dominated areas, the restoration goals should focus on restoring natural shrub cover on streambanks to riparian vegetation target levels associated with the sediment and nutrient TMDLs. Passive riparian restoration is preferable, but in areas where stream channels are unnaturally stable or streambanks are eroding excessively, active restoration approaches, such as channel design, woody debris and log vanes, bank sloping, seeding, and shrub planting may be needed. Factors influencing appropriate riparian restoration would include the severity of degradation, site-potential for various species, and the availability of local sources as transplant materials. In general, riparian plantings would promote the establishment of functioning stands of native riparian species. Weed management should also be a dynamic component of managing riparian areas.

The use of riprap or other “hard” approaches is not recommended and is not consistent with water quality protection or implementation of this plan. Although they may be absolutely necessary in some instances, these “hard” approaches generally redirect channel energy and exacerbate erosion in other places. Bank armoring should be limited to areas with a demonstrated infrastructure threat. Where deemed necessary, apply bioengineered bank treatments to induce vegetative reinforcement of the upper bank, reduce stream scouring energy, and provide shading and cover habitat.

9.4.7 Unpaved Roads

The road sediment reductions in this document represent an estimation of the sediment load that would remain once appropriate road BMPs were applied at all locations. Achieving this reduction in sediment loading from roads may occur through a variety of methods at the discretion of local land managers and restoration specialists. Road BMPs can be found on the Montana DEQ or DNRC websites and within Montana’s Nonpoint Source Management Plan (Montana Department of Environmental Quality, 2007). Examples include:

- Providing adequate ditch relief up-grade of stream crossings.
- Constructing waterbars, where appropriate, and up-grade of stream crossings.
- Instead of cross pipes, using rolling dips on downhill grades with an embankment on one side to direct flow to the ditch. When installing rolling dips, ensure proper fillslope stability and sediment filtration between the road and nearby streams.
- Insloping roads along steep banks with the use of cross slopes and cross culverts.
- Outsloping low traffic roads on gently sloping terrain with the use of a cross slope.
- Using ditch turnouts and vegetative filter strips to decrease water velocity and sediment carrying capacity in ditches.
- For maintenance, grade materials to the center of the road and avoid removing the toe of the cutslope.
- Preventing disturbance to vulnerable slopes.

- Using topography to filter sediments; flat, vegetated areas are more effective sediment filters.
- Where possible, limit road access during wet periods when drainage features could be damaged.
- Limit new road stream crossings and the length of near-stream parallel segments to the extent practicable.

9.4.7.1 Culverts and Fish Passage

Although there are a lot of factors associated with culvert failure and it is difficult to estimate the true at-risk load, the culvert analysis found that approximately 79% of the culverts were designed to accommodate a 25-year storm event. The allocation strategy for culverts is no loading from culverts as a result of being undersized, improperly installed, or inadequately maintained. The culvert assessment included 15 culverts in the watershed, which is a small percentage of the total culverts, and it is recommended that the remaining culverts be assessed so that a priority list may be developed for culvert replacement. As culverts fail, they should be replaced by culverts that pass a 100 year flood on fish bearing streams and at least 25 year events on non fish bearing streams. Some road crossings may not pose a feasible situation for upgrades to these sizes because of road bed configuration; in those circumstances, the largest size culvert feasible should be used. If funding is available, culverts should be prioritized and replaced prior to failure.

Another consideration for culvert upgrades should be fish and aquatic organism passage. In a coarse assessment of fish passage, all culverts were determined to pose a significant passage risk to juvenile fish at all flows; this suggests that a large percentage of culverts in the watershed are barriers to fish passage. Each fish barrier should be assessed individually to determine if it functions as an invasive species and/or native species barrier. These two functions should be weighed against each other to determine if each culvert acting as a fish passage barrier should be mitigated. Montana FWP can aid in determining if a fish passage barrier should be mitigated, and, if so, can aid in culvert design.

9.4.7.2 Traction Sand

Severe winter weather and mountainous roads in the Little Blackfoot River watershed will require the continued use of relatively large quantities of traction sand. Nevertheless, closer evaluation of and adjustments to existing practices should be done to reduce traction sand loading to streams to the extent practicable. The necessary BMPs may vary throughout the watershed and particularly between state and private roads but may include the following:

- Utilize a snow blower to directionally place snow and traction sand on cut/fill slopes away from sensitive environments.
- Increase the use of chemical deicers and decrease the use of road sand, as long as doing so does not create a safety hazard or cause undue degradation to vegetation and water quality.
- Improve maintenance records to better estimate the use of road sand and chemicals, as well as to estimate the amount of sand recovered in sensitive areas.
- Continue to fund MDT research projects that will identify the best designs and procedures for minimizing road sand impacts to adjacent bodies of water and incorporate those findings into additional BMPs.
- Street sweeping and sand reclamation.
- Identify areas where the buffer could be improved or structural control measures may be needed.
- Improved maintenance of existing BMPs.
- Increase availability of traction sand BMP training to both permanent and seasonal MDT employees as well as private contractors.

9.4.8 Stormwater Construction Permitting and BMPs

Construction activities disturb the soil, and if not managed properly, they can be substantial sources of sediment. Construction activity disturbing one acre or greater is required to obtain permit coverage through DEQ under the Stormwater General Permit for Construction Activities. A Stormwater Pollution Prevention Plan (SWPPP) must be developed and submitted to obtain a permit. A SWPPP identifies pollutants of concern, which is most commonly sediment, construction related sources of those pollutants, any nearby waterbodies that could be affected by construction activities, and BMPs that will be implemented to minimize erosion and discharge of pollutants to waterbodies. The SWPPP must be implemented for the duration of the project, including final stabilization of disturbed areas, which is a vegetative cover of at least 70% of the pre-disturbance level or an equivalent permanent stabilization measure. Development and implementation of a thorough SWPPP should ensure WLAs within this document are met.

Land disturbance activities that are smaller than an acre (and exempt from permitting requirements) also have the potential to be substantial pollutant sources, and BMPs should be used to prevent and control erosion consistent with the upland erosion allocations. Potential BMPs for all construction activities include construction sequencing, permanent seeding with the aid of mulches or geotextiles, check dams, retaining walls, drain inlet protection, rock outlet protection, drainage swales, sediment basin/traps, earth dikes, erosion control structures, grassed waterways, infiltration basins, terraced slopes, tree/shrub planting, and vegetative buffer strips. An EPA support document for the construction permits has extensive information about construction related BMPs, including limitations, costs, and effectiveness (EPA 2009a).

9.4.9 Urban Area Stormwater BMPs

Even though Avon and Elliston do not have a large enough population to require a municipal stormwater permit, activities to reduce pollutant loading from new development or redevelopment should be pursued consistent with the upland erosion allocations and efforts to avoid future water quality problems. Any BMPs which promote onsite or after collection infiltration, evaporation, transpiration or reuse of the initial flush stormwater should be implemented as practicable on all new or redevelopment projects. EPA provides more comprehensive information about stormwater best management practices on their website at: http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm

9.4.10 Beaver Populations and Sediment Yields

Historic heavy trapping of beavers has likely had an effect on sediment yields in the watershed. Before the removal of beavers, many streams had a series of catchments that moderated flow, with smaller unincised multiple channels and frequent flooding. Now some stream segments have incised channels and are no longer connected to the floodplain. This results in more bank erosion because high flows scour streambanks to a greater extent instead of flowing onto the floodplain. Beaver ponds also capture and store sediment and there can be large reductions in total suspended solids (TSS) concentrations below a beaver impoundment in comparison to TSS concentrations above the beaver impoundment (Bason, 2004).

Management of headwaters areas should include consideration of beaver habitat. Long-term management could include maintenance of beaver habitat in headwaters protection areas and even allowing for increased beaver populations in areas currently lacking the beaver complexes that can trap

sediment, reduce peak flows, and increase summer low flows. Allowing for existing and even increased beaver habitat is considered consistent with the sediment TMDL water quality goals.

9.4.11 Forestry and Timber Harvest

Timber harvest activities should be conducted by all landowners according to Forestry BMPs for Montana (Montana State University, Extension Service, 2001) and the Montana Streamside Management Zone (SMZ) Law (77-5-301 through 307 MCA). The Montana Forestry BMPs cover timber harvesting and site preparation, road building including culvert design, harvest design, other harvesting activities, slash treatment and site preparation, winter logging, and hazardous substances. While the SMZ Law is intended to guide commercial timber harvesting activities in streamside areas (i.e., within 50 feet of a waterbody), the riparian protection principles behind the law should be applied to numerous land management activities (i.e., timber harvest for personal use, agriculture, development). Prior to harvesting on private land, landowners or operators are required to notify the Montana DNRC. DNRC is responsible for assisting landowners with BMPs and monitoring their effectiveness. The Montana Logging Association and DNRC offer regular Forestry BMP training sessions for private landowners. .

The SMZ Law protects against excessive erosion and therefore is appropriate for helping meet sediment load allocations. USFS INFISH Riparian Habitat Conservation Area guidelines provide significant sediment protection as well as protection from elevated thermal loading (i.e., elevated temperature) by providing adequate shade. This guidance improves upon Montana's SMZ law and includes an undisturbed 300 foot buffer on each side of fish bearing streams and 150 foot buffer on each side of non-fish bearing streams with limited exclusions and BMP guidance for timber harvest, roads, grazing, recreation and other human sources (U.S. Department of Agriculture, Forest Service, 1995).

In addition to the BMPs identified above, effects that timber harvest may have on yearly streamflow levels, such as peak flow, should be considered. Water yield and peak flow increases should be modeled in areas of continued timber harvest and potential effects should be evaluated. Furthermore, noxious weed control should be actively pursued in all harvest areas and along all forest roads.

9.4.12 Mining

Because restoration of metals sources that are not also associated with sediment and nutrients are typically implemented under state and federal programs, this section will discuss general restoration programs and funding mechanisms that may be applicable to the metals sources instead of specific BMPs. The need for further characterization of impairment conditions and loading sources is addressed through the framework monitoring plan in **Section 10.0**. A number of state and federal regulatory programs have been developed over the years to address water quality problems stemming from historic mines, associated disturbances, and metal refining impacts. Some regulatory programs and approaches considered most applicable to the Little Blackfoot River watershed include:

- The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA),
- The State of Montana Mine Waste Cleanup Bureau's Abandoned Mine Lands (AML) Reclamation Program,
- The Montana Comprehensive Environmental Cleanup and Responsibility Act (CECRA), which incorporates additional cleanup options under the Controlled Allocation of Liability Act (CALA) and the Voluntary Cleanup and Redevelopment Act (VCRA).

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
CERCLA, which is also common referred to as Superfund, is a Federal law that addresses cleanup on sites, such as historic mining areas, where there has been a hazardous substance release or threat of release. Sites are prioritized on the National Priority List (NPL) using a hazard ranking system with significant focus on human health. Under CERCLA, the potentially responsible party or parties must pay for all remediation efforts based upon a liability approach whereby any existing or historical land owner can be held liable for restoration costs. Where viable landowners are not available to fund cleanup, funding can be provided under Superfund authority. Federal agencies can be delegated Superfund authority, but cannot access funding from Superfund.

Cleanup actions under CERCLA must be based on professionally developed plans and can be categorized as either Removal or Remedial. Removal actions can be used to address the immediate need to stabilize or remove a threat where an emergency exists. Removal actions can also be non-time critical.

Once removal activities are completed, a site can then undergo Remedial Actions or may end up being scored low enough from a risk perspective that it no longer qualifies to be on the NPL for Remedial Action. Under these conditions the site is released back to the state for a "no further action" determination. At this point there may still be a need for additional cleanup since there may still be significant environmental threats or impacts, although the threats or impacts are not significant enough to justify Remedial Action under CERCLA. Any remaining threats or impacts would tend to be associated with wildlife, aquatic life, or aesthetic impacts to the environment or aesthetic impacts to drinking water supplies versus threats or impacts to human health. A site could, therefore, still be a concern from a water quality restoration perspective, even after CERCLA removal activities have been completed.

Remedial actions may or may not be associated with or subsequent to removal activities. A remedial action involves cleanup efforts whereby Applicable or Relevant and Appropriate Requirements and Standards (ARARS), which include state water quality standards, are satisfied. Once ARARS are satisfied, then a site can receive a "no further action" determination.

Montana Mine Waste Cleanup Bureau Abandoned Mine Reclamation Program (AML)
The Mine Waste Cleanup Bureau (MWCB), which is part of the DEQ Remediation Division, is responsible for reclamation of historical mining disturbances associated with abandoned mines in Montana.

The MWCB abandoned mine reclamation program is funded through the Surface Mining Control and Reclamation Act of 1977 (SMCRA) with SMCRA funds distributed to states by the federal government. In order to be eligible for SMCRA funding, a site must have been mined or affected by mining processes, and abandoned or inadequately reclaimed, prior to August 3, 1977 for private lands, August 28, 1974 for Forest Service administered lands, and prior to 1980 for lands administered by the U.S. Bureau of Reclamation. Furthermore, there must be no party (owner, operator, other) who may be responsible for reclamation requirements, and the site must not be located within an area designated for remedial action under the federal Superfund program or certain other programs. The DEQ reclamation priority number or responsible agency for the priority abandoned mines in the Little Blackfoot TPA are listed in **Table 9-1.**

Note: The USFS has removed some mine waste from Charter Oak, Golden Anchor, Hope, Hub Camp, Kimball, Mountain View, Ontario, Third Term and Viking Mines.

Table 9-1. Priority Abandoned Mine Sites Identified as Potential Sources of Metals Impairments.

Priority Abandoned Mine	Watershed	DEQ Priority # or Responsible Agency
Bald Butte Millsite*	Upper Dog Creek	#3
Lilly/Orphan Boy	Upper Telegraph Creek	#12
Sure Thing	Upper Telegraph Creek	#22
Julia	Upper Telegraph Creek	#42
Anna P./Hattie M.	Upper Telegraph Creek	#48
Golden Anchor	Upper Little Blackfoot	#63
Mountain View	Upper Little Blackfoot	#69
Kimball	Upper Little Blackfoot	#81
Monarch	Monarch Creek	#82
Hard Luck Mine	Ontario Creek	#100
Victory/Evening Star	Ophir Creek (Lower Little Blackfoot River)	#122
Telegraph	Sally Ann Creek	#123
Third Term	Upper Telegraph Creek	#131
Ontario Millsite	Un-named/Ontario Creek	Reclaimed by MWCB
Charter Oak	Upper Little Blackfoot	Reclaimed by USFS

*Currently undergoing reclamation activities

Montana Comprehensive Environmental Cleanup and Responsibility Act (CECRA)
Reclamation of historic mining-related disturbances administered by the State of Montana and not addressed under SMCRA, are typically addressed through the DEQ State Superfund or CECRA program. The CECRA program maintains a list of facilities potentially requiring response actions based on the confirmed release or substantial threat of a release of a hazardous or deleterious substance that may pose an imminent and substantial threat to public health, safety or welfare or the environment (ARM 17.55.108). Listed facilities are prioritized as maximum, high, medium, or low priority or in operation and maintenance status based on the potential threat posed. Currently, there are no active sites on the CECRA priority list in the Little Blackfoot River watershed.

CECRA also encourages the implementation of voluntary cleanup activities under the VCRA and CALA. It is possible that any historic mining-related metals loading sources identified in the watershed in the future could be added to the CECRA list and addressed through CECRA, with or without the VCRA and/or CALA process. A site can be added to the CECRA list at DEQ's initiative, or in response to a written request made by any person to the department containing the required information.

9.5 Potential Funding Sources

Funding and prioritization of restoration or water quality improvement project is integral to maintaining restoration activity and monitoring successes and failures. Several government agencies fund watershed or water quality improvement projects. Below is a brief summary of potential funding sources to assist with TMDL implementation.

9.5.1 Section 319 Nonpoint Source Grant Program

Section 319 grant funds are typically used to help identify, prioritize, and implement water quality protection projects with focus on TMDL development and implementation of nonpoint source projects. Individual contracts under the yearly grant typically range from $20,000 to $150,000, with a 25 percent

or more match requirement. 319 projects typically need to be administered through a non-profit or local government such as a conservation district, a watershed planning group, or a county.

9.5.2 Future Fisheries Improvement Program

The Future Fisheries grant program is administered by FWP and offers funding for on-the-ground projects that focus on habitat restoration to benefit wild and native fish. Anyone ranging from a landowner or community-based group to a state or local agency is eligible to apply. Applications are reviewed annually in December and June. Projects that may be applicable to the Little Blackfoot River watershed include restoring streambanks, improving fish passage, and restoring/protecting spawning habitats.

9.5.3 Watershed Planning and Assistance Grants

The MT DNRC administers Watershed Planning and Assistance Grants to watershed groups that are sponsored by a Conservation District. Funding is capped at $10,000 per project and the application cycle is quarterly. The grant focuses on locally developed watershed planning activities; eligible activities include developing a watershed plan, group coordination costs, data collection, and educational activities.

Numerous other funding opportunities exist for addressing nonpoint source pollution. Additional information regarding funding opportunities from state agencies is contained in Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, 2007) and information regarding additional funding opportunities can be found at http://www.epa.gov/nps/funding.html.

9.5.4 Environmental Quality Incentives Program

The Environmental Quality Incentives Program (EQIP) is administered by NRCS and offers financial (i.e., incentive payments and cost-share grants) and technical assistance to farmers and ranchers to help plan and implement conservation practices that improve soil, water, air and other natural resources on their land. The program is based on the concept of balancing agricultural production and forest management with environmental quality, and is also used to help producers meet environmental regulations. EQIP offers contracts with a minimum length of one year after project implementation to a maximum of 10 years. Each county receives an annual EQIP allocation and applications are accepted continually during the year; payments may not exceed $300,000 within a six-year period.

9.5.5 Resource Indemnity Trust/Reclamation and Development Grants Program

The Resource Indemnity Trust/Reclamation and Development Grants Program (RIT/RDG) is an annual program administered by MT DNRC that can provide up to $300,000 to address environmental related issues. This money can be applied to sites included on the AML priority list, but of low enough priority where cleanup under AML is uncertain. RIT/RDG program funds can also be used for conducting site assessment/ characterization activities such as identifying specific sources of water quality impairment. RIT/RDG projects typically need to be administered through a non-profit or local government such as a conservation district, a watershed planning group, or a county.

9.5.6 Upper Clark Fork River Basin Restoration Fund

The State of Montana has received monies through a series settlement agreements occurring between 1999 and 2008 with the Atlantic Richfield Company (ARCO) as a result of the release of mining-related waste that caused injuries to the natural resources within the Upper Clark Fork watershed. The Natural

Resource Damage Program (NRDP), which is part of the Montana Department of Justice, filed the suit on behalf of the State of Montana and currently manages the over-site of the funds.

Previously, a grants process was in place to disperse some of the settlement money from the 1999 Upper Clark Fork River Basin Restoration Fund. That process has been discontinued and a different process by which the remaining funds will be spent is currently being assessed as part of a long range plan. The main emphasis of the long range plan is to determine how the remaining funds will be distributed among aquatic, terrestrial, and groundwater resources. The plan will base funding of future projects on State's aquatic priority plan (Montana Department of Fish, Wildlife and Parks and Natural Resource Damage Program, 2011). The aquatic priorities indicate that some funding will likely be available for restoring and protecting fisheries habitat in the Little Blackfoot River watershed. The following waterbodies in the Little Blackfoot TPA were identified as priorities for fisheries habitat restoration and protection: the lower segment of the Little Blackfoot River (Priority 1), the upper segment of the Little Blackfoot River (Priority 2), both Dog Creek segments (Priority 2), part of Snowshoe Creek (Priority 2), and part of Spotted Dog Creek (Priority 2) (Montana Department of Fish, Wildlife and Parks and Natural Resource Damage Program, 2011). An outline describing how priority aquatic resource funding would occur is currently being evaluated and will likely be formalized by the end of 2011. And by the end of 2012, the formal process that will determine the funding of priority aquatic resource restoration will be finalized.

10.0 MONITORING STRATEGY

The monitoring framework discussed in this section is an important component of watershed restoration, a requirement of TMDL development under Montana's TMDL law, and the foundation of the adaptive management approach. While targets and allocations are calculated using the best available data, the data are only an estimate of a complex ecological system. The margin of safety is put in place to reflect some of this uncertainty, but other issues only become apparent when restoration strategies are underway. Having a monitoring strategy in place allows for feedback on the effectiveness of restoration activities (whether TMDL targets are being met), if all significant sources have been identified, and whether attainment of TMDL targets is feasible. Data from long-term monitoring programs also provide technical justifications to modify restoration strategies, targets, or allocations where appropriate.

The monitoring framework presented in this section provides a starting point for the development of more detailed and specific planning efforts regarding monitoring needs; it does not assign monitoring responsibility. Monitoring recommendations provided are intended to assist local land managers, stakeholder groups, and federal and state agencies in developing appropriate monitoring plans to meet aforementioned goals. Funding for future monitoring is uncertain and can vary with economic and political changes. Prioritizing monitoring activities depends on stakeholder priorities for restoration and funding opportunities.

The objectives for future monitoring in the Little Blackfoot TPA include: 1) tracking and monitoring restoration activities and evaluating the effectiveness of individual and cumulative restoration activities, 2) baseline and impairment status monitoring to assess attainment of water quality targets and identify long-term trends in water quality and 3) refining the source assessments. Each of these objectives is discussed below.

10.1 ADAPTIVE MANAGEMENT AND UNCERTAINTY

An adaptive management approach is used to manage resource commitments as well as achieve success in meeting the water quality standards and supporting all beneficial uses. This approach works in cooperation with the monitoring strategy and allows for adjustments to the restoration goals or pollutant targets, TMDLs, and/or allocations, as necessary. These adjustments would take into account new information as it arises.

The adaptive management approach is outlined below:

- TMDLs and Allocations: The analysis presented in this document assumes that the load reductions proposed for each of the listed streams will enable the streams to meet target conditions and that meeting target conditions will ensure full support of all beneficial uses. Much of the monitoring proposed in this section of the document is intended to validate this assumption. If it looks like greater reductions in loading or improved performance is necessary to meet targets, then updated TMDL and/or allocations will be developed based on achievable reductions via application of reasonable land, soil, and water conservations practices.
- Water Quality Status: As new stressors are added to the watershed and additional data are collected, new water quality targets may need to be developed or existing targets/allocations may need to be modified.

10.2 Tracking and Monitoring Restoration Activities and Effectiveness

Monitoring should be conducted prior to and after project implementation to help evaluate the effectiveness of specific practices or projects. This approach will help track the recovery of the system and the effects, or lack of effects, from ongoing management activities in the watershed. At a minimum, effectiveness monitoring should address the pollutants that are targeted for each project. Information about specific locations, spatial extent, designs, contact information, and any effectiveness evaluation should be compiled about each project. Information about all restoration projects along with tracking overall extent of BMP implementation should be compiled into one location for the entire watershed.

For nutrients and metals, loading reductions and BMP effectiveness can be evaluated with water quality samples and comparing them to the targets. For sediment, which has no numeric standard, loading reductions and BMP effectiveness may be estimated using the approaches used within this document. However, tracking BMP implementation and project-related measurements will likely be most practical for sediment. For instance, for road improvements, it is not anticipated that post-project sediment loads will be measured. Instead, documentation of the BMP, reduced contributing length, and before/after photos documenting the presence and effectiveness of the BMP will be most appropriate. For installation of riparian fencing, before/after photo documentation of riparian vegetation and streambank and a measurement such as greenline that documents the percentage of bare ground and shrub cover may be most appropriate. Evaluating instream parameters used for sediment targets will be one of the tools used to gage the success of implementation when DEQ conducts a formal assessment but may not be practical for most projects since the sediment effects within a stream represent cumulative effects from many watershed scale activities and because there is typically a lag time between project implementation and instream improvements (Meals, et al., 2010).

If sufficient implementation progress is made within a watershed, DEQ will conduct a TMDL Implementation Evaluation (TIE). During this process, recent data are compiled, monitoring is conducted (if necessary), data are compared to water quality targets (typically a subset for sediment), BMP implementation since TMDL development is summarized, and data are evaluated to determine if the TMDL is being achieved or if conditions are trending one way or another. If conditions indicate the TMDL is being achieved, the waterbody will be recommended for reassessment and may be delisted. If conditions indicate the TMDL is not being achieved, according to Montana State Law (75-5-703(9)), the evaluation must determine if:

- The implementation of a new or improved phase of voluntary reasonable land, soil, and water conservation practices is necessary,
- Water quality is improving, but more time is needed for compliance with water quality standards, or
- Revisions to the TMDL are necessary to achieve applicable water quality standards and full support of beneficial uses.

10.3 Baseline and Impairment Status Monitoring

In addition to effectiveness monitoring, watershed scale monitoring should be conducted to expand knowledge of existing conditions and to provide data that can be used during the TIE. Although DEQ is the lead agency for conducting impairment status monitoring, other agencies or entities may collect and provide compatible data. Wherever possible, it is recommended that the type of data and methodologies used to collect and analyze the information be consistent with DEQ methodology so as

to allow for comparison to TMDL targets and track progress toward meeting TMDL goals. The information in this section provides general guidance for future impairment status monitoring.

10.3.1 Sediment

Each of the sediment streams of interest was stratified into unique reaches based on physical characteristics and anthropogenic influence. The assessed sites represent only a percentage of the total number of stratified reaches. Sampling additional monitoring locations could provide additional data to assess existing conditions, and provide more specific information on a per stream basis as well as the TPA as a whole.

It is acknowledged that various agencies and entities have differing objectives, as well as time and resources available to achieve those objectives. However, when possible, it is recommended that at a minimum the following parameters be collected to allow for comparison to TMDL targets:

- Riffle pebble count (using Wolman Pebble Count methodology and/or 49-point grid tosses)
- Residual pool depth and pool frequency measurements
- Greenline assessment

Additional information will undoubtedly be useful and assist impairment status evaluations in the future and may include total suspended solids, identifying percentage of eroding banks, human sediment sources, areas with a high background sediment load, macroinvertebrate studies, McNeil core sediment samples, and fish population surveys and redd counts. The Helena National Forest has collected McNeil core data, which was not incorporated into this document, but as it is a direct sediment measurement, it may be useful as a target or implementation evaluation tool in the future.

An important part of impairment determination and adaptive management is determining when a stream has fully recovered from past management practices where recovery is still occurring from historical improvements in management but recent BMPs were not applied. Particularly within the Helena National Forest, ongoing PIBO monitoring can provide critical insight into the extent of recovery from past practices via comparisons between reference and managed sites.

10.3.2 Nutrients

Although extensive nutrient samples were collected to assist with TMDL development, less data were collected for both segments of Carpenter Creek and Threemile Creek because they were initially included to aid in the source assessment for the lower segment of the Little Blackfoot River. Therefore, when watershed scale monitoring is conducted to assist with future impairment determinations, particular attention should be given to collecting additional nutrient data on Carpenter and Threemile creeks. Future sampling should also include algal sampling for chlorophyll-*a* and AFDW. Additionally, macroinvertebrates are part of a second tier assessment if nutrient and/or algae concentrations do not clearly indicate impairment or non-impairment; macroinvertebrate data is currently sparse in the watershed and additional sampling is recommended on all waterbodies with TMDLs in this document.

10.3.3 Metals

Although extensive metals samples were collected to assist with TMDL development, for some metals, insufficient data were collected to fully verify the existing listing. For other metals that are not on the 2010 303(d) List, available data indicate they may be causing impairment but the sample size is too small to make a conclusion. Continued sampling at a subset of the recent sites displayed in **Table 10-1** is

recommended for consistency to characterize watershed conditions during future impairment determinations.

Table 10-1. Waterbody-Pollutant Combinations Where More Sampling is Needed

Stream Segment	Waterbody Segment ID	Pollutant
American Gulch Creek	MT76G004_079	Cadmium, Iron, Lead
Dog Creek (lower segment)	MT76G004_072	Cadmium
Dog Creek (upper segment)	MT76G004_071	Cyanide, Mercury
Little Blackfoot River (upper segment)	MT76G004_020	Cyanide
Monarch Creek	MT76G004_060	Mercury
O'Keefe Creek	MT76G004_054	Lead
Sally Ann Creek	MT76G004_055	Iron, Lead
Telegraph Creek (lower segment)	MT76G004_052	Mercury
Telegraph Creek (upper segment)	MT76G004_051	Beryllium
Un-named Creek	MT76G006_010	Mercury

10.4 Source Assessment Refinement

In many cases, the level of detail provided by the source assessments only provides broad source categories or areas that need to reduce pollutant loads and additional source inventory and load estimate work may be desirable. Strategies for strengthening source assessments for each of the pollutants may include more thorough sampling or field surveys of source categories and are described by pollutant in this section. Although additional suspended sediment and nutrient data at the USGS gage near Garrison may refine the SWAT model, most of the impairments are in tributaries, and thus resources could be used more efficiently by focusing on identifying the most significant source areas within each impaired stream's watershed to determine where implementation will be most effective. Recommendations for source assessment refinement are described below by pollutant.

10.4.1 Sediment

Sediment-related information that could help strengthen the source assessments is as follows:

- a refined bank erosion retreat rate for Little Blackfoot River watershed streams,
- a better understanding of bank erosion impacts from historical land management activities,
- improved modeling for upland erosion delivery in forested watersheds where riparian zones have recovered from SMZ law implementation,
- improved modeling for concentrated flow through riparian areas,
- evaluation of seasonal loading aspects for the major sources and potential implications regarding TMDL target parameters,
- a review of land management practices specific to subwatersheds of concern to determine where the greatest potential for improvement can occur for the major land use categories,
- additional sampling in streams with less data such as Dog, Spotted Dog, Telegraph, and Threemile creeks to get a better idea of the reductions needed and to identify source areas
- evaluation of "hot spots" that the model may not have adequately addressed, such as a confined animal operation adjacent to a stream, and
- additional field surveys of culverts, roads, and road crossings to help prioritize the road segments/crossings of most concern.

10.4.2 Nutrients

Nutrient-related information that could help strengthen the source assessment is as follows:

- more data to characterize background conditions, particularly in areas underlain by the Phosphoria Formation
- a better understanding of septic contributions,
- a better understanding of nutrient concentrations in groundwater and spatial variability
- a better understanding of the irrigation network and its effect on hydrology and nutrient concentrations
- a more detailed understanding of fertilization practices within the watershed
- a review of land management practices specific to subwatersheds of concern to determine where the greatest potential for improvement can occur for the major land use categories,
- evaluation of "hot spots" that the model may not have adequately addressed, such as a confined animal operation adjacent to a stream, and
- additional sampling in streams with less data such as Threemile and Carpenter creeks to get a better idea of the reductions needed and to identify source areas

10.4.3 Metals

Because of both limited data and the complexity of sources, many of the TMDL allocations to mining sources are clumped into composite allocations. In watersheds with composite WLAs to unpermitted point sources and in watersheds with composite LAs to diffuse mining-related sources that also include some abandoned mines or mining wastes, follow up monitoring should focus on defining the contribution from abandoned mines and other discrete mining sources. Although many of the mines in the DEQ and/or MBMG databases have been visited to determine the location and condition of abandoned mines, in most cases the contribution from individual abandoned mines is unknown. Additionally, there may be discrete abandoned mine sources that are contributing to exceedances of metals targets that are not identified in either of the State databases. As additional information becomes available regarding contributions from abandoned mines, TMDLs may be modified via adaptive management to split composite WLAs into separate WLAs and/or to develop WLAs for discrete mining sources in watersheds dominated by nonpoint source loading that currently have a composite LA.

Several of the priority abandoned mines were last assessed in the early 1990s, and conditions and source areas at those mines may have changed since then; additional monitoring is recommended to determine the nature of reclamation work required to meet TMDLs.

Metals-related information that could help strengthen the source assessments is as follows:

- Additional cyanide sampling around the Charter Oak Mine (upper Little Blackfoot basin) and Bald Butte Mine (upper Dog basin) where cyanide is known to have been used as part of historic mining processes
- Water quality data from sites nearer to historic mines to better identify and separate source areas, especially for O'Keefe, American Gulch and lower Dog Creeks
- High flow data from Un-named Creek to better recognize transmission pathways and investigate loading trends seasonally
- Additional sampling in stream segments with less data such as Sally Ann, O'Keefe, lower Telegraph, American Gulch, and lower Dog creeks to get a more specific idea of source areas

11.0 PUBLIC PARTICIPATION

Stakeholder and public involvement is a component of TMDL planning supported by EPA guidelines and required by Montana state law (MCA 75-5-703, 75-5-704) which directs DEQ to consult with watershed advisory groups and local conservation districts during the TMDL development process. Technical advisors, stakeholders and interested parties, state and federal agencies, interest groups, and the public were solicited to participate in differing capacities throughout the TMDL development process in the Little Blackfoot TMDL Planning Area (TPA).

11.1 PARTICIPANTS AND ROLES

Throughout completion of the Little Blackfoot TPA TMDLs, DEQ worked with stakeholders to keep them apprised of project status and solicited input from a TMDL advisory group. A description of the participants in the development of the TMDLs in the Little Blackfoot TPA and their roles is contained below.

Montana Department of Environmental Quality
Montana state law (MCA 75-5-703) directs DEQ to develop all necessary TMDLs. DEQ has provided resources toward completion of theses TMDLs in terms of staff, funding, internal planning, data collection, technical assessments, document development, and stakeholder communication and coordination. DEQ has worked with other state and federal agencies to gather data and conduct technical assessments. DEQ has also partnered with watershed organizations to collect data and coordinate local outreach activities for this project.

United States Environmental Protection Agency
EPA is the federal agency responsible for administering and coordinating requirements of the Clean Water Act (CWA). Section 303(d) of the CWA directs states to develop TMDLs (see **Section 1.1**), and EPA has developed guidance and programs to assist states in that regard. EPA has provided funding and technical assistance to Montana's overall TMDL program and is responsible for final TMDL approval. Project management was primarily provided by the EPA Regional Office in Helena, MT.

Conservation Districts
The majority of the Little Blackfoot TPA falls within Powell County; however a small portion in the northeastern section of the watershed is located in Lewis and Clark County. Therefore, DEQ provided both the Deer Lodge Valley Conservation District and the North Powell Conservation District with consultation opportunity during development of TMDLs. This included opportunities to provide comment during the various stages of TMDL development, and an opportunity for participation in the advisory group discussed below.

TMDL Advisory Group
The Little Blackfoot TMDL Advisory Group consisted of selected resource professionals who possess a familiarity with water quality issues and processes in the Little Blackfoot River watershed, and also representatives of applicable interest groups. All members were solicited to participate in an advisory capacity per Montana state law (75-5-703 and 704). DEQ requested participation from the interest groups defined in MCA 75-5-704 and included local city and county representatives, livestock-oriented and farming-oriented agriculture representatives, conservation groups, watershed groups, state and federal land management agencies, and representatives of recreation and tourism interests. The

advisory group also included additional stakeholders and landowners with an interest in maintaining and improving water quality and riparian resources.

Advisory group involvement was voluntary and the level of involvement was at the discretion of the individual members. Members had the opportunity to provide comment and review of technical TMDL assessments and reports and to attend meetings organized by DEQ for the purpose of soliciting feedback on project planning. Typically, draft documents were released to the advisory group for review under a limited timeframe, and their comments were then compiled and evaluated. Final technical decisions regarding document modifications resided with DEQ.

Communications with the group members was typically conducted through email and draft documents were made available through DEQ's wiki for TMDL projects (http://montanatmdlflathead.pbworks.com). Opportunities for review and comment were provided for participants at varying stages of TMDL development, including opportunity for review of the draft TMDL document prior to the public comment period.

Area Landowners
Since 56 percent of the planning area is in private ownership, local landowner cooperation in the TMDL process has been critical. Their contribution has included access for stream sampling and field assessments and personal descriptions of seasonal water quality and stream flow characteristics. The DEQ sincerely thanks the planning area landowners for their logistical support and informative participation in impromptu water resource and land management discussions with our field staff and consultants.

11.2 Response to Public Comments

Upon completion of the draft TMDL document, and prior to submittal to EPA, DEQ issues a press release and enters into a public comment period. During this timeframe, the draft TMDL document is made available for general public comment, and DEQ addresses and responds to all formal public comments.

The formal public comment period was initiated on November 22, 2011 and closed on December 21, 2011. Electronic copies of the draft document were made available at the Deer Lodge Valley Conservation District in Deer Lodge, MT and at the State Library in Helena, MT. A public informational meeting and open house was held in Avon, MT on December 7, 2011. EPA and DEQ provided an overview of the document, answered questions, and solicited public input and comment on the TMDLs. The announcement for the meeting was distributed to the Watershed Restoration Coalition (which now includes the Little Blackfoot Watershed Group), Deer Lodge Valley and North Powell conservation districts, the Little Blackfoot TMDL Advisory Group, the Statewide TMDL Advisory Group, and other identified interested parties via email. Notice of the meeting was posted on the DEQ webpage and DEQ wiki, at the Elliston Post Office, Elliston store, and Avon Café, and also advertised in the following newspapers: Independent Record (Helena) and Silver State Post (Deer Lodge/Powell County).

Numerous informal comments were made at the public meeting regarding the evaluation of nutrient loading from geology, wildlife, and agricultural sources during the growing season; although no formal comments of this nature were submitted during the public comment period, additional clarifying text was added to the nutrient source assessment discussion in **Section 6.5.2**. The comments received during the public comment period and DEQ responses to these comments are presented within **Appendix H**.

12.0 REFERENCES

British Columbia Ministry of Water, Land and Air Protection. 2001. British Columbia Approved Water Quality Guidelines (Criteria): 1998 Edition. Victoria, British Columbia: **British Columbia Ministry of Water, Land and Air Protection**. http://www.env.gov.bc.ca/wat/wq/BCguidelines/selenium/selenium.html. Accessed 11/17/11 A.D.

Alden, W. C. 1953. Physiography and Glacial Geology of Western Montana and Adjacent Areas. U.S. Geological Survey.

Andrews, E. D. and J. M. Nankervis. 1995. "Effective Discharge and the Design of Channel Maintenance Flows for Gravel-Bed Rivers: Natural and Anthropogenic Influences in Fluvial Geomorphology," in *Natural and Anthropogenic Influences in Fluvial Geomorphology: The Wolman Volume*, Costa, John E., Miller, Andrew J., Potter, Kenneth W., and Wilcock, Peter R. Geophysical Monograph Series, Ch. 10: American Geophysical Union): 151-164.

Asmussen, Loris, A. W. White, E. W. Hauser, and J. M. Sheridan. 1976. Reduction of 2, 4-D Load in Surface Runoff Down a Grassed Waterway. *Journal of Environmental Quality.* 6(2): 159-162.

Baigun, C. 2003. Characteristics of Deep Pools Used by Adult Summer Steelhead in Steamboat Creek, Oregon. *North American Journal of Fisheries Management.* 23(4): 1167-1174.

Bason, C. W. 2004. Effects of Beaver Impoundments on Stream Water Quality and Floodplain Vegetation in the Inner Coastal Plain of North Carolina. M.S.: East Carolina University, Greenville, NC.

Bauer, Stephen B. and Stephen C. Ralph. 1999. Aquatic Habitat Indicators and Their Application to Water Quality Objectives Within the Clean Water Act. Seattle, WA: US Environmental Protection Agency, Region 10. Report EPA 910-R-99-014.

Bengeyfield, P. 2004. Beaverhead-Deerlodge National Forest Stream Morphology Data. Unpublished.

Berkas, W. R., M. K. White, P. B. Ladd, F. A. Bailey, and Kent A. Dodge. 2005. Water Resources Data, Montana, Water Year 2005, V-2; Yellowstone and Upper Columbia River Basins and Ground-Water Levels. U.S. Geological Survey. Report U.S. Geological Water-Data Report MT-05-2.

Bilby, R. E. and J. W. Ward. 1989. Changes in Characteristics and Function of Woody Debris With Increasing Size of Stream in Western Washington. *Transactions of the American Fisheries Society.* 118: 368-378.

Bjorn, T. C. and D. W. Reiser. 1991. "Habitat Requirements of Salmonids in Streams," in *Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats*, Special Publication 19 ed., (Bethesda, MD: American Fisheries Society): 83-138.

Bonneau, J. L. and D. L. Scarnecchia. 1998. Seasonal and Diel Changes in Habitat Use by Juvenile Bull Trout (Salvelinus Confluentus) and Cutthroat Trout (Oncorhynchus Clarki) in a Mountain Stream. *Canadian Journal of Zoology.* 76: 783-790.

Bryce, S. A., G. A. Lomnicky, and Philip R. Kaufmann. 2010. Protecting Sediment-Sensitive Aquatic Species in Mountain Streams Through the Application of Biologically Based Streambed Sediment Criteria. *North American Benthological Society.* 29(2): 657-672.

Byron, E. 12/4/2008. Water Worries. *Helena Independent Record*

-----. 1/17/2009. DEQ Awaiting Results From Mine Blowout. *Helena Independent Record*

Cappiella, Karen, Tom Schueler, Julie Tasillo, and Tiffany Wright. 2006. Wetlands and Watersheds: Adapting Watershed Tools to Protect Wetlands. Ellicott City, Maryland: Center for Watershed Protection. Wetlands & Watersheds.

Carey, Jennifer Hunt. 1991. Phosphorus Sources in Gold Creek, A Tributary of the Clark Fork River in Western Montana. Master of Science. Missoula, MT: University of Montana.

Ciotti, D., S. M. Griffith, J. Kann, and J. Baham. 2010. Nutrient and Sediment Transport on Flood-Irrigated Pasture in the Klamath Basin, Oregon. Society for Range Management. Report 63(3). http://www.bioone.org/doi/full/10.2111/08-127.1.

Clark, P. 2010. Personal Communication. Peter Brumm, EPA.

Cover, Matthew R., Christina L. May, William E. Dietrich, and Vincent H. Resh. 2008. Quantitative Linkages Among Sediment Supply, Streambed Fine Sediment, and Bethic Macroinvertebrates in Northern California Streams. *Journal of the North American Benthological Society.* 27(1): 135-149.

Elliot, W. J. 2006. Soil Erosion and Sediment Redistribution in River Catchments: Measurement, Modelling and Management. P. N. Owens and A. J. Collins (Eds.), 1998 ed., Wallingford, United Kingdom: CABI Publishing.

Elliot.W.J. and Peter R. Robichaud. 2001. Comparing Erosion Risks From Forest Operations to Wildfire. In: The International Mountain Logging and 11th Pacific Northwest Skyline Symposium, 2001. 78-89.

Geosyntec Consultants and Wright Water Engineers, Inc. 2008. Overview of Performance by BMP Category and Common Pollutant Type (International Stormwater Best Management Practices Database [1999-2007]). Water Environment Research Foundation; American Society of Civil Engineers; U.S.E.P.A.; Federal Highway Administration; American Public Works Association. http://www.bmpdatabase.org/Docs/Performance%20Summary%20Cut%20Sheet%20June%202008.pdf.

Green, D. M. and J. B. Kauffman. 1989. "Nutrient Cycling at the Land-Water Interface: The Importance of the Riparian Zone," in *Practical Approaches to Riparian Resource Management: An Education Workshop*, Gresswell, R. E., Barton, B. A., and Kershner, J. L., (Billings, MT: U.S. Bureau of Land Management): 61-68.

Grumbles, B. 2006. Letter From Benjamin Grumbles, US EPA, to All EPA Regions Regarding Dail Load Development. U.S. Environmental Protection Agency.

Hall, J. K., N. L. Hartwig, and L. D. Hoffman. 1983. Application Mode and Altenative Cropping Effects on Atrazine Losses From a Hillside. *Journal of Environmental Quality.* 12(3): 336-340.

Han, J., J. S. Wu, and C. Allan. 2005. Suspended Sediment Removal by Vegetative Filter Strip Treating Highway Runoff. *Journal of Environmental Science and Health.* 40: 1637-1649.

Hargrave, P., T. B. Bowler, J. D. Lonn, J. P. Madison, J. J. Metesh, and R. Wintergerst. 1998. Abandoned-Inactive Mines of the Blackfoot-Little Blackfoot River Drainages, Helena National Forest, Montana Bureau of Mines and Geology. Report Open FIle Report 368.

Heckenberger, Brian. 2009. Personal Communication. Kusnierz, Lisa. Accessed 5/09.

Heitke, J. D., E. K. Archer, and B. B. Roper. 2010. 2010 Sampling Protocol for Stream Channel Attributes. Logan, UT: PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program STT Mutli-Federal Agency Monitoring Program, USFS.

Hydrosolutions Inc. 2009. Little Blackfoot TMDL Planning Area Chemistry and Chlorophyll Monitoring. 2008 Data Submittal and Quality Review Report. Helena, MT: Montana Department of Environmental Quality.

-----. 2010. Little Blackfoot TMDL Planning Area Chemistry and Chlorophyll Monitoring. 2009 Data Submittal and Quality Review Report. Helena, MT: Montana Department of Environmental Quality.

Ihle, Beth. 2008. Personal Communication. Lisa Kusnierz.

Irving, J. S. and T. C. Bjorn. 1984. Effects of Substrate Size Composition on Survival of Kokanee Salmon and Cutthroat Trout and Rainbow Trout Embryos. Moscow, ID: University of Idaho. Report Technical Report 84-6.

Kendy, Eloise and Ruth E. Tresch. 1996. Geographic, Geologic, and Hydrologic Summaries of Intermontane Basins of the Northern Rocky Mountains, Montana. Helena, MT: US Geological Survey. Report Water-Resources Investigations Report 96-4025.

Kershner, Jeffrey, Brett Roper, Nicolaas Bouwes, Richard Henderson, and Eric Archer. 2004. An Analysis of Stream Habitat Conditions in Reference and Managed Watersheds on Some Federal Lands

Within the Columbia River Basin. *North American Journal of Fisheries Management.* 24: 1363-1375.

Knighton, David. 1998. Fluvial Forms and Processes: A New Perspective, New York, New York: John Wiley and Sons Inc.

Knutson, K. L. and V. L. Naef. 1997. Management Recommendations for Washington's Priority Habitats: Riparian. Olympia, WA: Washington Department of Fish and Wildlife (WDFW).

Kramer, R. P., B. W. Riggers, and K. Furrow. 1993. Basinwide Methodolgoy. Stream Habitat Inventory Methodology. Missoula, MT: USDA Forest Service.

Kron, Darrin, Lisa Kusnierz, and Kyle Flynn. 2009. Middle and Lower Big Hole Planning Area TMDLs and Water Quality Improvement Plan. Helena, MT: Montana Dept. of Environmental Quality. Report M03-TMDL-02A.

Land & Water Consulting. 2002. Little Blackfoot River Physical Features Inventory and Riparian Assessment. Helena, MT: Land & Water Consulting, Inc. Report Project No. 110291.

Lewis, R. S. 1998. Geologic Map of the Butte 1 X 2 Quadrangle, Southwestern Montana. http://www.mbmg.mtech.edu/mbmgcat/public/ListCitation.asp?selectby=series&series_type=MBMG&series_number=363&series_sub=&.

Liermann, Brad W., Jason Lindstrom, and Ryan Kreiner. 2009. An Assessment of Fish Populations and Riparian Habitat in Tributaries of the Upper Clark Fork River Basin: Phase II. Montana Department of Fish, Wildlife and Park.

Lindstrom, Jason, Brad W. Liermann, and Ryan Kreiner. 2008. An Assessment of Fish Populations and Riparian Habitat in Tributaries of the Upper Clark Fork River Basin. Helena, MT: Montana Department of Fish, Wildlife and Parks.

MacDonald, Lee H., Alan W. Smart, and Robert C. Wissmar. 1991. Monitoring Guidelines to Evaluate Effects of Forestry on Streams in the Pacific Northwest and Alaska. Seattle, WA: U.S.Environmental Protection Agency. Report EPA 910/9-91-001.

May, Christine L. and Danny C. Lee. 2004. The Relationship Between In-Channel Sediment Storage, Pool Depth, and Summer Servival of Juvenile Salmonids in the Oregon Coast Range. *American Fisheries Society Journals.* 24(3): 761-774.

Mayer, Paul M., Steven K. Reynolds, Jr., Timothy J. Canfield, and Marshall D. McCutchen. 2005. Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness: A Review of Current Science and Regulations. Cincinnati, OH: National Risk Management Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency. Report EPA/600/R-15/118.

Meals, D. W., S. A. Dressing, and T. E. Davenport. 2010. Lag Time in Water Quality Response to Best Management Practices: A Reivew. *Journal of Environmental Quality.* 39: 85-96.

Mebane, C. A. 2001. Testing Bioassessment Metrics: Macroinvertebrate, Sculpin, and Salmonid Responses to Stream Habitat, Sediment, and Metals. *Environmental Monitoring and Assessment.* 67(3): 293-322.

Mickelson, S. K., J. L. Baker, and S. I. Ahmed. 2003. Vegetative Filter Strips for Reducing Atrazine and Sediment Runoff Transport. *Journal of Soil and Water Conservation.* 58(6): 359-367.

Milodragovich, E. L. 2003. Hydrogeochemistry of a Natural Wetland Receiving Acid Mine Drainage, Ontario Mine, Powell County, Montana.: Montana Tech of the University of Montana.

Moffitt, David. 2009. Documentation of Nitrogen and Phosphorus Loadings From Wildlife Populations. Natural Resources and Conservation Service. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_013181.pdf. Accessed 12/15/11 A.D.

Montana Bureau of Mines and Geology. 2008. Groundwater Information Center (GWIC). http://mbmggwic.mtech.edu/. Accessed 11/7/08.

Montana Department of Environmental Quality. 2009. Prospect Creek Watershed Sediment TMDLs and Framework for Water Quality Restoration. Helena, MT: Montana Department of Environmental Quality.

-----. 2011. Draft Water Quality Assessment Method. Helena, MT: Montana Department of Environmental Quality.

Montana Department of Environmental Quality, Water Quality Planning Bureau. 2006. Sample Collection, Sorting, and Taxonomic Identification of Benthic Macroinvertebrates Standard Operating Procedure. Helena, MT: Montana Department of Environmental Quality. Report WQPBWQM-009. http://deq.mt.gov/wqinfo/qaprogram/PDF/SOPs/WQPBWQM-009rev2_final_web.pdf. Accessed 7/8/11.

Montana Department of Environmental Quality. 2007. Montana Nonpoint Source Management Plan. Helena, MT: Montana Department of Environmental Quality.

-----. 2009. How to Perform a Nondegradation Analysis for Subsurface Wastewater Treatment Systems (SWTS) Under the Subdivision Review Process. Helena, MT: Montana Department of Environmental Quality.

-----. 2010a. Circular DEQ-7: Montana Numeric Water Quality Standards. Helena, MT: Montana Department of Environmental Quality. http://deq.mt.gov/wqinfo/Standards/PDF/DEQ-7.pdf. Accessed 6/9/11a.

-----. 2010b. Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments.

Montana Department of Fish, Wildlife and Parks. 2006. Fish Distribution Spatial Data.

Montana Department of Fish, Wildlife and Parks and Natural Resource Damage Program. 2011. Prioritization of Areas in the Upper Clark Fork River Basin for Fishery Enhancement: Proposed Final. http://www.doj.mt.gov/lands/docsnrdp/2011ucfrbprioritizationproposel.pdf.

Montana Department of Natural Resources and Conservation. 2008. Montana Natural Resources Information Interactive Map Website. Helena, MT: Montana Department of Natural Resources and Conservation. http://nris.state.mt.us/interactive.html. Accessed 7/25/11 A.D.

Montana State Library. 1992. Natural Resources Information System (NRIS): National Landcover Dataset, Montana. Montana State Library Natural Resource Information Service Website. http://nris.state.mt.us/nsdi/nris/nlcd/nlcdvector.html.

Montana State University, Extension Service. 2001. Water Quality BMPs for Montana Forests. Bozeman, MT: MSU Extension Publications.

Muhlfeld, Clint C. and David H. Bennett. 2001. Summer Habitat Use by Columbia River Redband Trout in the Kootenai River Drainage, Montana. *North American Journal of Fisheries Management.* 21(1): 223-235.

National Oceanic and Atmospheric Administration. 2008. Screening Quick Reference Table for Inorganics in Sediment. Archives of Environmental Contamination and Toxicology. Report 39. http://response.restoration.noaa.gov/book_shelf/122_NEW-SQuiRTs.pdf.

Natural Resource Conservation Service. 2011a. Montana Conservation Practice Standard: Filter Strips, Code 393. http://efotg.sc.egov.usda.gov/references/public/mt/393_standard_june_2011.pdf. Accessed 11/7/11 A.D.a.

-----. 2011b. Montana Conservation Practice Standard: Riparian Forest Buffer, Code 391. http://efotg.sc.egov.usda.gov/references/public/mt/391_standard_june_2011.pdf. Accessed 11/7/11 A.D.b.

Nielson, J. L., T. E. Lisel, and V. Ozaki. 1994. Thermally Stratified Pools and Their Use by Steelhead in Northern California Streams. *Transactions of the American Fisheries Society.* 123(4): 613-626.

Nordwick, S. 2008a. Final Report - An Integrated, Passive Biological Treatment System. U.S. Environmental Protection Agency. Report Mine Waste Technology Program, Activity III, Project 16.

-----. 2008b. Final Report- In Situ Source Control of Acid Generation Using Sulfate-Reducing Bacteria. U.S.Environmental Protection Agency. Report Mine Waste Technology Program, Activity III, Project 3.

Olsen, L. J. 2004. Plant-Metal Interactions in a Natural and Remediated High Elevation Metal-Contaminated Wetland. Masters Thesis.: Montana State University.

Olympus Technical Services, Inc. 2004. Expanded Engineering Evaluation/Cost Analysis for the Bald Butte Millsite and Devon/Sterlingand Albion Mine Sites. Helena, MT: Montana Department of Environmental Quality, Remediation Division, Mine Waste Cleanup Bureau.

Overton, C. Kerry, Sherry P. Wollrab, Bruce C. Roberts, and Michael A. Radko. 1997. R1/R4 (Northern/Intermountain Regions) Fish and Fish Habitat Standard Inventory Procedures Handbook. Ogden, UT: USDA Forest Service, Intermountain Research Station.

PBS&J. 2009. Little Blackfoot River Groundwater/Surface Water Interaction Study. Montana Water Trust.

Pioneer Technical Services, Inc. 1993. Abandoned Hardrock Mine Priority Sites Project Report, Park County (Emigrant District) Through Powell County (Ophir District).

Pringle, C. M. and F. J. Triska. 1991. Effects of Geothermal Groundwater on Nutrient Dynamics of a Lowland Costa Rican Stream. Report Ecology 72(3): 951-965.

Priscu, John C. 1987. Factors Regulating Nuisance and Potentially Toxic Blue-Green Algal Blooms in Canyon Ferry Reservoir. Bozeman, MT: Montana University System Water Resources Center, Montana State University. Report Report No. 159.

PRISM Group. 2004. Parameter-Elevation Regressions on Independent Slopes Model Climate Mapping System. http://www.ocs.orst.edu/prism/index.phtml. Accessed 11/8/11 A.D.

Relyea, C. B., G. W. Minshall, and R. J. Danehy. 2000. Stream Insects As Bioindicatores of Fine Sediment. In: Watershed 2000. Water Environment Federation Specialty Conference. Boise, ID: Idaho State University.

Rice, R. M., J. S. Rothacher, and W. F. Megahan. 1972. Erosional Consequences of Timber Harvesting: An Apprasial. In: National Symposium on Watersheds in Transition. Urbana, Illinois: American Water Resources Association.

Rosgen, David L. 1996. Applied River Morphology, Pagosa Springs, CO: Wildland Hydrology.

-----. 2004. River Assessment and Monitoring Field Guide, Lubrecht Forest, MT. Fort Collins, CO: Wildland Hydrology, Inc.

Rowe, Mike, Don Essig, and Benjamin Jessup. 2003. Guide to Selection of Sediment Targets for Use in Idaho TMDLs. Pocatello, ID: Idaho Department of Environmental Quality.

Ruppel, E. T. 1962. A Pleistoncene Ice Sheet in the Northern Boulder Mountains, Jefferson, Powell, and Lewis and Clark Counties, Montana. Report USGS Bulletin 1141-G.

Schmidt, Larry J. and John P. Potyondy. 2004. Quantifying Channel Maintenance Instream Flows: An Approach for Gravel-Bed Streams in the Western United States. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Report General Technical Report RMRS-GTR-128.

Schmidt, R. G., J. S. Loen, C. A. Wallace, and H. H. Mehnert. 1994. Geology of the Elliston Region, Powell and Lewis and Clark Counties, Montana. Report USGS Bulletin 1141-G.

Schwartz, G. E. and R. B. Alexander. 1995. Soils Data for the Conterminous United States Derived From the NRCS State Soil Geographic (STATSGO) Data Base. [Original Title: State Soil Geographic (STATSGO) Data Base for the Conterminous United States.]. USGS. Report USGS Open-File Report 95-449. http://water.usgs.gov/GIS/metadata/usgswrd/XML/ussoils.xml.

Shepard, B. B., Stephen A. Leathe, Thomas M. Weaver, and M. D. Enk. 1984. Monitoring Levels of Fine Sediment Within Tributaries of Flathead Lake, and Impacts of Fine Sediment on Bull Trout Recruitment. In: Wild Trout III Symposium; Yellowstone National Park, WY.

Staples, James Mark, Laura Gamradt, Otto Stein, and Xianming Shi. 2004. Recommendations for Winter Traction Materials Management on Roadways Adjacent to Bodies of Water. Helena, MT: Montana Department of Transportation.

Sullivan, S. M. P. and M. C. Watzin. 2010. Towards a Functional Understanding of the Effects of Sediment Aggradation on Stream Fish Conditions. *Rier Research and Applications.* 26(10): 1298-1314.

Suplee, M. and R. Sada de Suplee. 2011. Assessment Methodology for Determining Wadeable Stream Impairment Due to Excess Nitrogen and Phosphorus Levels. Helena, MT: Montana Department of Environmental Quality Water Quality Planning Bureau. Report WQPMASTR-01.

Suplee, Michael W., Vicki Watson, Mark E. Teply, and Heather McKee. 2009. How Green Is Too Green? Public Opinion of What Constitutes Undesirable Algae Levels in Streams. *Journal of the American Water Resources Association.* 45(1): 123-140.

Suplee, Michael W., Vicki Watson, Arun Varghese, and Joshua Cleland. 2008. Scientific and Technical Basis of the Numeric Nutrient Criteria for Montana's Wadeable Streams and Rivers. Helena, MT: Montana Department of Environmental Quality.

Suttle, K. B., M. E. Power, J. M. Levine, and C. McNeeley. 2004. How Fine Sediment in Riverbeds Impairs Growth and Survival of Juvenile Salmonids. *Ecological Applications.* 14(4): 969-974.

Swanson, Roger W. 1973. Geology of Permian Rocks in the Western Phosphate Field: Geology and Phosphate Deposits of the Permian Rocks in Central Western Montana. Washington, DC: U.S. Government Printing Office. Report Geological Survey Professional Paper 313-F.

Tetra Tech. 2006. Final Construction Report for the Ontario Mine and Millsite Reclamation Project. Helena, MT: Montana Department of Environmental Quality, Mine Waste Cleanup Bureau.

-----. 2009a. Reclamation Investigation for Teh Lilly/Orphan Boy Mine Site. Helena, MT: Montana Department of Environmental Quality Remediation Division, Mine Waste Cleanup Burea.

-----. 2009b. Reclamation Investigation for the Lilly/Orphan Boy Mine Site. Helena, MT: Montana Department of Environmental Quality Remediation Division, Mine Waste Cleanup Burea.

U.S. Department of Agriculture and U.S. Environmental Protection Agency. 1999. Unified National Strategy for Animal Feeding Operations. Report EPA Number 833R99900. http://www.epa.gov/npdes/pubs/finafost.pdf.

U.S. Department of Agriculture, Forest Service. 1995. Inland Native Fish Strategy: Interim Strategies for Managing Fish-Producing Watersheds in Eastern Oregon and Washington, Idaho, Western Montana and Portions of Nevada. Washington, D.C.: USDA Forest Service.

U.S. Environmental Protection Agency. 1999a. Protocol for Developing Nutrient TMDLs. Washington, D.C.: EPA Office of Water. Report EPA 841-B-99-007.

-----. 1999b. Protocol for Developing Sediment TMDLs. Washington, D.C.: U.S. Environmental Protection Agency. Report EPA 841-B-99-004.

-----. 2007. An Approach for Using Load Duration Curves in the Development of TMDLs. Washington, DC: Office of Wetlands, Oceans and Watersheds, US EPA. Report EPA 841-B-07-006. http://www.epa.gov/owow/tmdl/techsupp.html.

-----. 2009a. Development Document for Final Effluent Guidelines and Standards for the Contruction & Development Category. U.S. Environmental Protection Agency. http://water.epa.gov/scitech/wastetech/guide/construction/upload/2009_12_8_guide_construction_files_chapters.pdf.

-----. 2009b. Preliminary Data Summary of Urban Stormwater Best Management Practices. Report EPA-821-R-99-012.

-----. 2010. Using Stressor-Response Relationships to Derive Numeric Nutrient Criteria. Washington, DC: Office of Science and Technology, Office of Water, EPA. Report EPA-820-S-10-001.

United States Census Bureau. 2000. 2000 Census Data. http://factfinder.census.gov/home/saff/main.html?_lang=en.

University of Montana. 2002. Wildlife Spatial Analysis Lab, SILC – Satellite Imagery Land Cover Classification Projects for Idaho, Montana, and the Dakotas. http://www.wru.umt.edu/reports/gap.

USDA Forest Service. 2006. Effectiveness Monitoring for Streams and Riparian Areas Within the Pacific Northwest: Stream Channel Methods for Core Attributes. United States Department of Agriculture, Forest Service.

-----. 2007. Historic Mining on the Helena National Forest: A Brief Synopsis. Helena, MT: United States Forest Service. http://www.fs.fed.us/r1/helena/resources/heritage_resources/mining_history.shtml. Accessed 11/7/11 A.D.

Van Mullen, Joe. 2006. Upper Jefferson River Irrigation Delivery Improvement Project. Trout Unlimited and Jefferson River Watershed Council.

Water & Environmental Technologies, P.C. 2010. Road Sediment Assessment and Modeling: Little Blackfoot River TPA. Helena, MT: Montana Department of Environmental Quality.

Weaver, Thomas M. and J. J. Fraley. 1991. Fisheries Habitat and Fish Populations in Flathead Basin Forest Practices Water Quality and Fisheries Cooperative Program. Kalispell, MT: Flahead Basin Commission.

Wegner, Seth. 1999. A Review of the Scientific Literature on Riparian Buffers Width, Extent and Vegetation. Institute of Ecology, University of Georgia.

Wischmeier, W. H. and D. Smith. 1978. Predicting Rainfall Erosion Losses: A Guide to Conservation Planning. Washington, D.C.: United States Department of Agriculture. Report Agriculture Handbook No. 537. http://topsoil.nserl.purdue.edu/usle/AH_537.pdf.

Wolman, M. G. 1954. A Method of Sampling Coarse River-Bed Material. *Transactions of the American Geophysical Union.* 35(6): 951-956.

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

World Health Organization. 2003. Guidelines for Safe Recreational Water Environments, Volume 1: Coastal and Fresh Waters. Geneva, Switzerland: World Health Organization. http://www.who.int/water_sanitation_health/bathing/srwe1/en/.

Zweig, L. D. and C. F. Rabeni. 2001. Biomonitoring for Deposited Sediment Using Benthic Invertebrates: A Test on Four Missouri Streams. *Journal of the North American Benthological Society.* 20: 643-657.

APPENDIX A – FIGURES AND TABLES

LIST OF FIGURES

Figure A-1. Waterbodies in the Little Blackfoot TPA included on the 2010 303(d) List. A-2
Figure A-2. Level IV Ecoregions in the Little Blackfoot TPA. A-8
Figure A-3. Elevation data for the Little Blackfoot TPA..... A-9
Figure A-4. Geology of the Little Blackfoot TPA..... A-10
Figure A-5. Distribution of erosion susceptibility in the Little Blackfoot TPA..... A-11
Figure A-6. Soil slope values for the Little Blackfoot TPA. A-12
Figure A-7. Surface hydrography of the Little Blackfoot TPA at 1:24000 and the USGS gage..... A-13
Figure A-8. Location of wells and those with water quality data based on the GWIC database..... A-14
Figure A-9. Distribution of average annual precipitation within the Little Blackfoot TPA. A-15
Figure A-10. Land cover distribution within the Little Blackfoot TPA from University of Montana..... A-16
Figure A-11. NLCD land cover distribution within the Little Blackfoot TPA..... A-17
Figure A-12. Fish species distribution within the Little Blackfoot TPA. A-18
Figure A-13. Population density within the Little Blackfoot TPA..... A-19
Figure A-14. Public land ownership within the Little Blackfoot TPA. A-20
Figure A-15. Land ownership and agricultural land use distribution within the Little Blackfoot TPA.... A-21
Figure A-16. Abandoned mines, NPDES permit locations, and septic system density within the Little Blackfoot TPA..... A-22
Figure A-17. Distribution of the Phosphoria Formation in the Elliston Mining District (indicated in pink). Copied from (Swanson, 1973)..... A-23
Figure A-18. Distribution of the Phosphoria Formation in the Garrison Mining District (indicated in pink). Copied from (Swanson, 1973)..... A-24

LIST OF TABLES

Table A-1. 2010 IR Impaired Waterbodies, Impairment Causes, Impaired Uses, and Impairment Cause Status in the Little Blackfoot TPA..... A-3

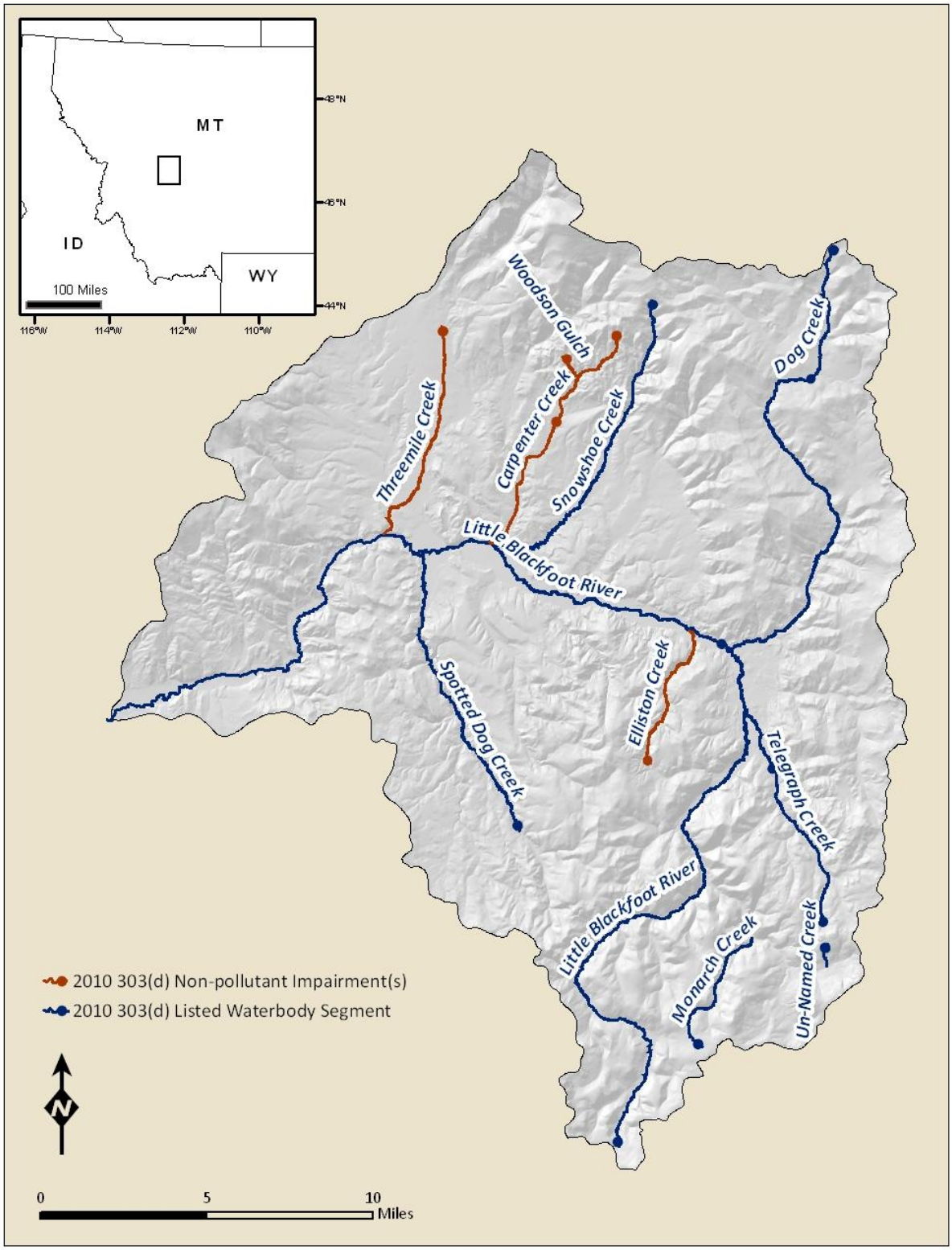


Figure A-1. Waterbodies in the Little Blackfoot TPA included on the 2010 303(d) List.

Table A-1. 2010 IR Impaired Waterbodies, Impairment Causes, Impaired Uses, and Impairment Cause Status in the Little Blackfoot TPA

Waterbody & Location Description	Waterbody ID	Impairment Cause	Pollutant Category	Impaired Use	Impairment Cause Status
CARPENTER CREEK, Basin Creek to mouth (Little Blackfoot River)	MT76G004_092	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed via restoration plan in this doc; not linked to a TMDL
		Other anthropogenic substrate alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed via restoration plan in this doc; not linked to a TMDL
		Physical substrate habitat alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed via restoration plan in this doc; not linked to a TMDL
CARPENTER CREEK, headwaters to Basin Creek	MT76G004_091	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed via restoration plan in this doc; not linked to a TMDL
		Other anthropogenic substrate alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed via restoration plan in this doc; not linked to a TMDL
		Physical substrate habitat alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Addressed via restoration plan in this doc; not linked to a TMDL
DOG CREEK, headwaters to Meadow Creek	MT76G004_071	Sedimentation/Siltation	Sediment	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Sediment TMDL contained in this document
		Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Addressed by sediment TMDL in this document
		Arsenic	Metals	Aquatic Life, Cold Water Fishery	Metals TMDL contained in this document
		Lead	Metals	Aquatic Life, Cold Water Fishery	Metals TMDL contained in this document
		Zinc	Metals	Aquatic Life, Cold Water Fishery	Metals TMDL contained in this document
DOG CREEK, Meadow Creek to mouth (Little Blackfoot River)	MT76G004_072	Sedimentation/Siltation	Sediment	Aquatic Life, Cold Water Fishery	Sediment TMDL contained in this document
		Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed by sediment and nutrient TMDLs in this document
		Nitrate/Nitrite	Nutrients	Aquatic Life, Cold Water Fishery	Not impaired based on updated assessment

Table A-1. 2010 IR Impaired Waterbodies, Impairment Causes, Impaired Uses, and Impairment Cause Status in the Little Blackfoot TPA

Waterbody & Location Description	Waterbody ID	Impairment Cause	Pollutant Category	Impaired Use	Impairment Cause Status
ELLISTON CREEK, headwaters to mouth (Little Blackfoot River)	MT76G004_040	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed by sediment and nutrient TMDLs in this document
LITTLE BLACKFOOT RIVER, Dog Creek to mouth (Clark Fork River)	MT76G004_010	Sedimentation/Siltation	Sediment	Aquatic Life, Cold Water Fishery	Sediment TMDL contained in this document
		Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed by sediment and nutrient TMDLs in this document
		Low flow alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Addressed via restoration plan in this doc; not linked to a TMDL
		Copper	Metals	Aquatic Life, Cold Water Fishery, Drinking Water	Not impaired based on updated assessment
		Lead	Metals	Aquatic Life, Cold Water Fishery, Drinking Water	Metals TMDL contained in this document
		Nitrate/Nitrite	Nutrients	Aquatic Life, Cold Water Fishery	Not impaired based on updated assessment
LITTLE BLACKFOOT RIVER, the headwaters to Dog Creek	MT76G004_020	Sedimentation/Siltation	Sediment	Aquatic Life, Cold Water Fishery	Sediment TMDL contained in this document
		Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed by sediment TMDL in this document
		Arsenic	Metals	Aquatic Life, Cold Water Fishery	Metals TMDL contained in this document
		Cyanide	Metals	Aquatic Life, Cold Water Fishery	Metals TMDL contained in this document

Table A-1. 2010 IR Impaired Waterbodies, Impairment Causes, Impaired Uses, and Impairment Cause Status in the Little Blackfoot TPA

Waterbody & Location Description	Waterbody ID	Impairment Cause	Pollutant Category	Impaired Use	Impairment Cause Status
MONARCH CREEK, headwaters to mouth (Ontario Creek)	MT76G004_060	Arsenic	Metals	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Not impaired based on updated assessment
		Copper	Metals	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Metals TMDL contained in this document
		Lead	Metals	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Metals TMDL contained in this document
		Mercury	Metals	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Metals TMDL contained in this document
		pH	Metals	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Addressed by metals TMDLs in this document (surrogate)
		Selenium	Metals	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Not impaired based on updated assessment
SNOWSHOE CREEK, headwaters to mouth (Little Blackfoot River)	MT76G004_080	Sedimentation/Siltation	Sediment	Aquatic Life, Cold Water Fishery	Sediment TMDL contained in this document
		Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed by sediment and nutrient TMDLs in this document
		Low flow alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Addressed via restoration plan in this doc; not linked to a TMDL
		Nitrate/Nitrite	Nutrients	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Nitrate/Nitrite TMDL contained in this document

Table A-1. 2010 IR Impaired Waterbodies, Impairment Causes, Impaired Uses, and Impairment Cause Status in the Little Blackfoot TPA

Waterbody & Location Description	Waterbody ID	Impairment Cause	Pollutant Category	Impaired Use	Impairment Cause Status
SPOTTED DOG CREEK, forest boundary to mouth (Little Blackfoot River)	MT76G004_032	Sedimentation/Siltation	Sediment	Aquatic Life, Cold Water Fishery	Sediment TMDL contained in this document
		Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed by sediment and nutrient TMDLs in this document
		Total Phosphorus	Nutrients	Aquatic Life, Cold Water Fishery	TP TMDL contained in this document
TELEGRAPH CREEK, Hahn Creek to mouth (Little Blackfoot River)	MT76G004_052	Lead	Metals	Drinking Water	Metals TMDL contained in this document
		Mercury	Metals	Drinking Water	Metals TMDL contained in this document
TELEGRAPH CREEK, headwaters to Hahn Creek	MT76G004_051	Sedimentation/Siltation	Sediment	Aquatic Life, Cold Water Fishery	Sediment TMDL contained in this document
		Alteration in stream-side or littoral vegetative covers		Aquatic Life, Cold Water Fishery	Addressed by sediment TMDL in this document
		Arsenic	Metals	Aquatic Life, Cold Water Fishery	Metals TMDL contained in this document
		Beryllium	Metals	Aquatic Life, Cold Water Fishery	Metals TMDL contained in this document
		Cadmium	Metals	Aquatic Life, Cold Water Fishery	Metals TMDL contained in this document
		Copper	Metals	Aquatic Life, Cold Water Fishery	Metals TMDL contained in this document
		Iron	Metals	Aquatic Life, Cold Water Fishery	Not impaired based on updated assessment
		Zinc	Metals	Aquatic Life, Cold Water Fishery	Metals TMDL contained in this document
THREEMILE CREEK, Quigley Ranch Reservoir to mouth (Little Blackfoot River)	MT76G004_112	Alteration in stream-side or littoral vegetative covers	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery	Addressed by sediment and nutrient TMDLs in this document
		Low flow alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Addressed via restoration plan in this doc; not linked to a TMDL

Table A-1. 2010 IR Impaired Waterbodies, Impairment Causes, Impaired Uses, and Impairment Cause Status in the Little Blackfoot TPA

Waterbody & Location Description	Waterbody ID	Impairment Cause	Pollutant Category	Impaired Use	Impairment Cause Status
UN-NAMED CREEK, headwaters to mouth (Ontario Creek), T8N R6W S27	MT76G006_010	Arsenic	Metals	Drinking Water	Metals TMDL contained in this document
		Cadmium	Metals	Aquatic Life, Cold Water Fishery	Metals TMDL contained in this document
		Copper	Metals	Aquatic Life, Cold Water Fishery	Metals TMDL contained in this document
		Lead	Metals	Aquatic Life, Cold Water Fishery	Metals TMDL contained in this document
		Mercury	Metals	Drinking Water	Metals TMDL contained in this document
		pH	Metals	Aquatic Life, Cold Water Fishery	Addressed by metals TMDLs in this document (surrogate)
		Zinc	Metals	Aquatic Life, Cold Water Fishery	Metals TMDL contained in this document
WOODSON GULCH, headwaters to mouth (Carpenter Creek)	MT76G004_100	Physical substrate habitat alterations	Not Applicable: Non-Pollutant	Aquatic Life, Cold Water Fishery, Primary Contact Recreation	Addressed via restoration plan in this doc; not linked to a TMDL

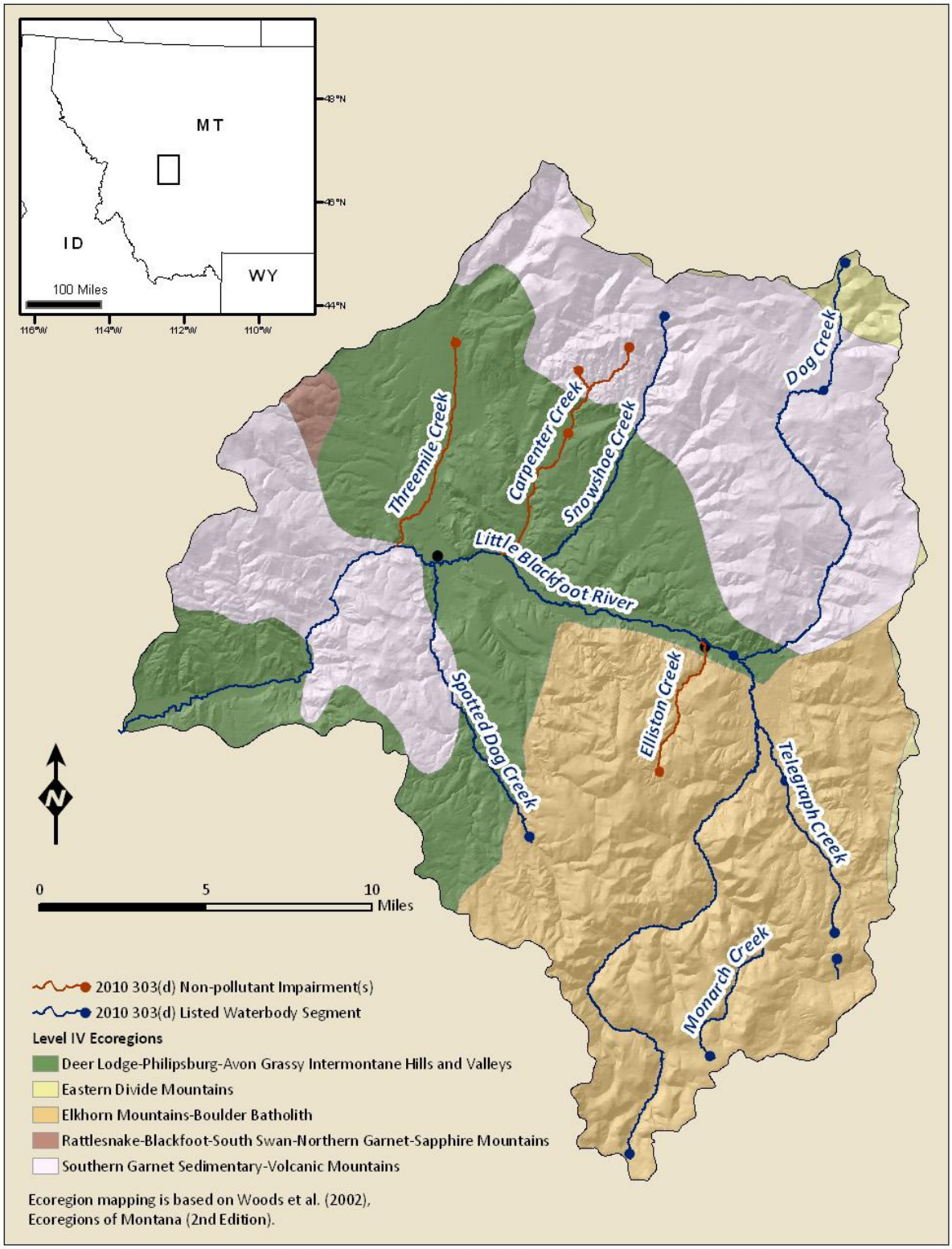


Figure A-2. Level IV Ecoregions in the Little Blackfoot TPA.

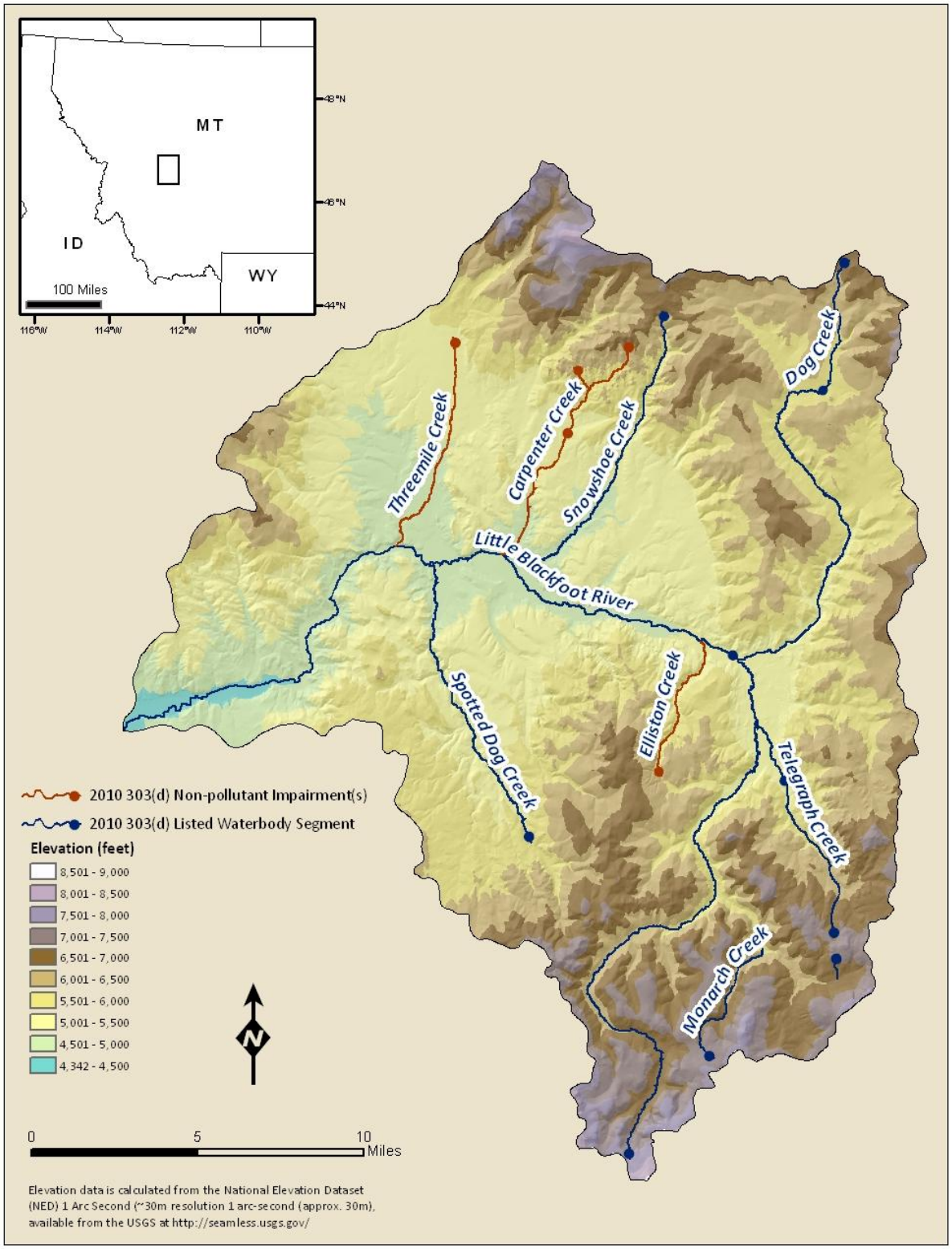


Figure A-3. Elevation data for the Little Blackfoot TPA.

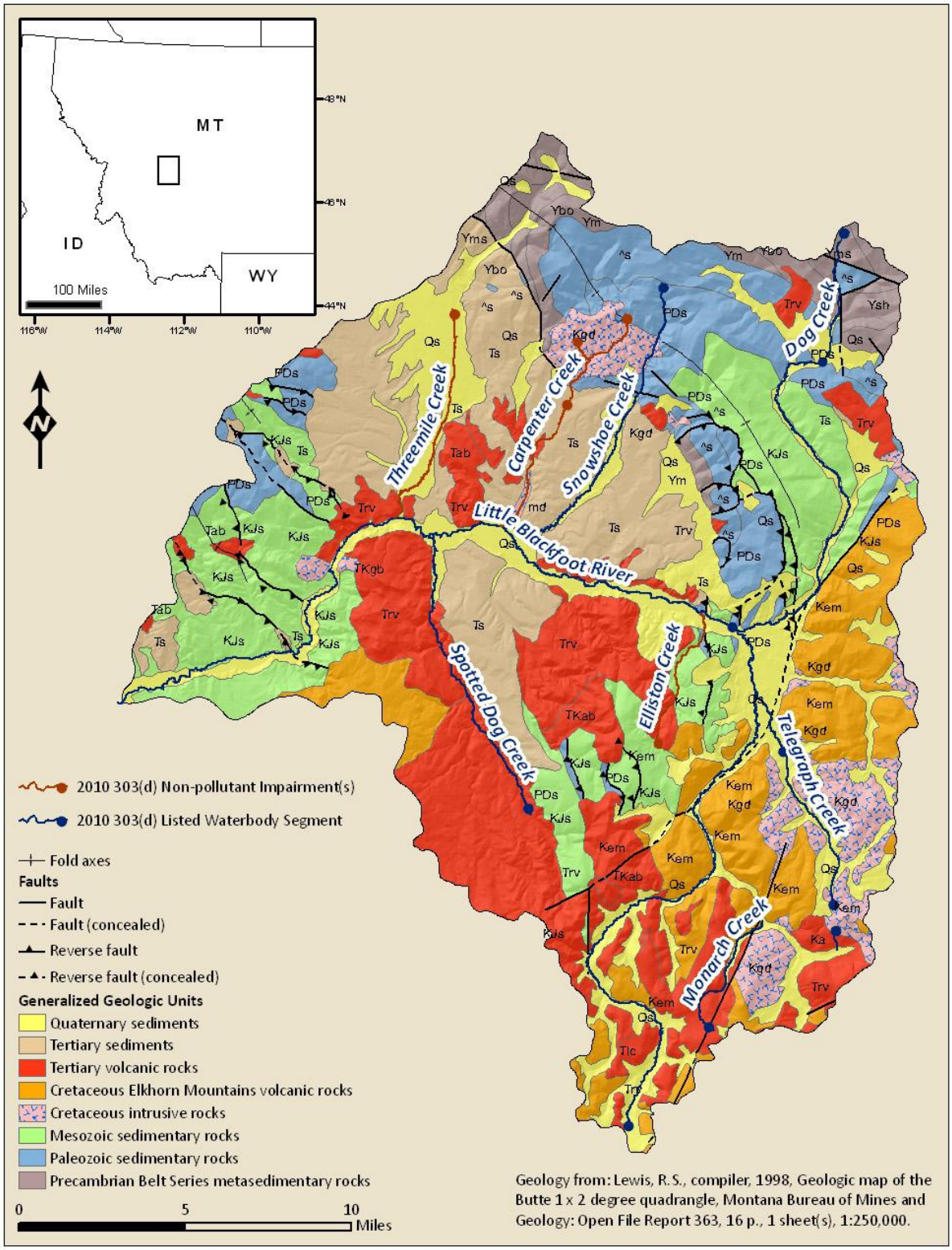


Figure A-4. Geology of the Little Blackfoot TPA.

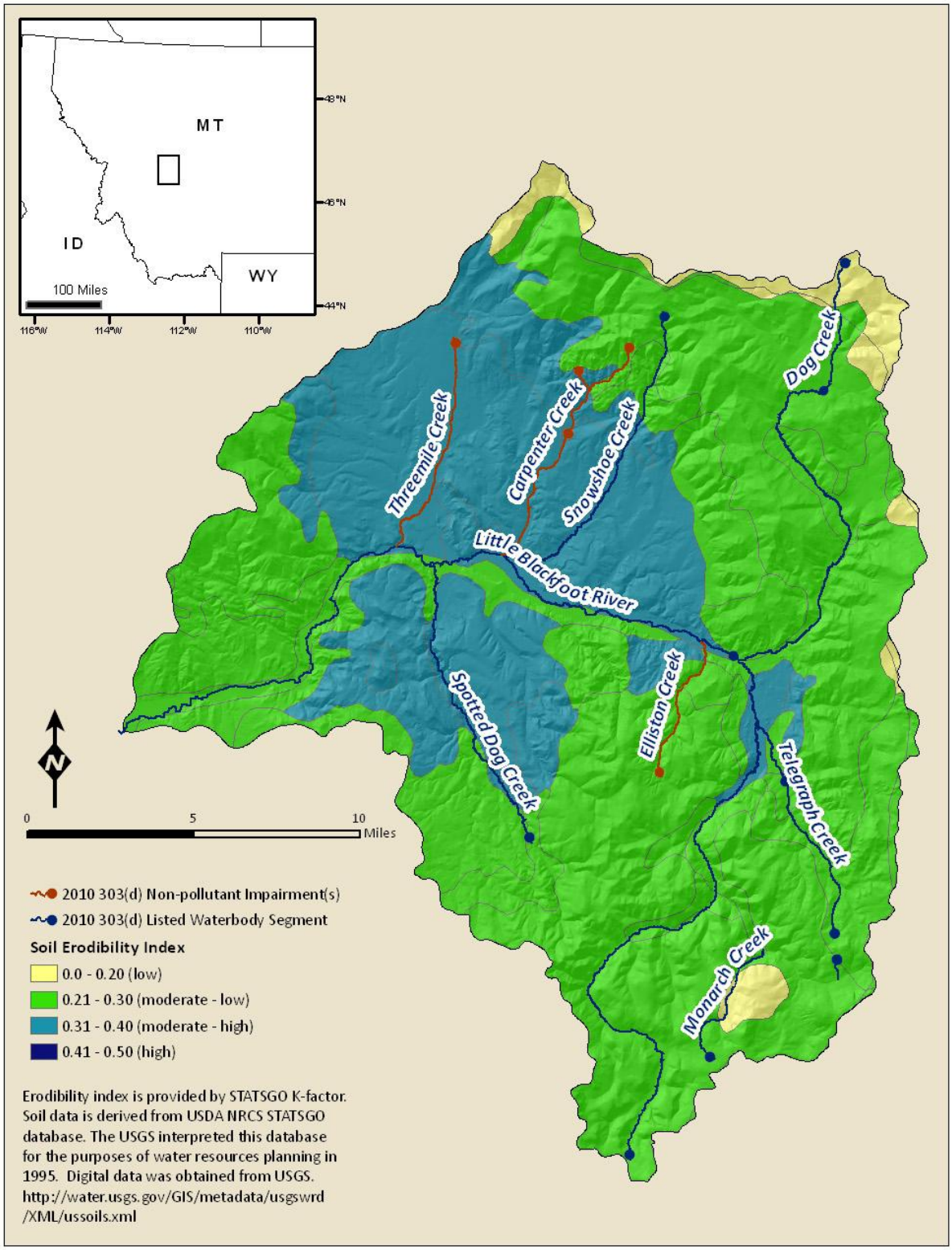


Figure A-5. Distribution of erosion susceptibility in the Little Blackfoot TPA.

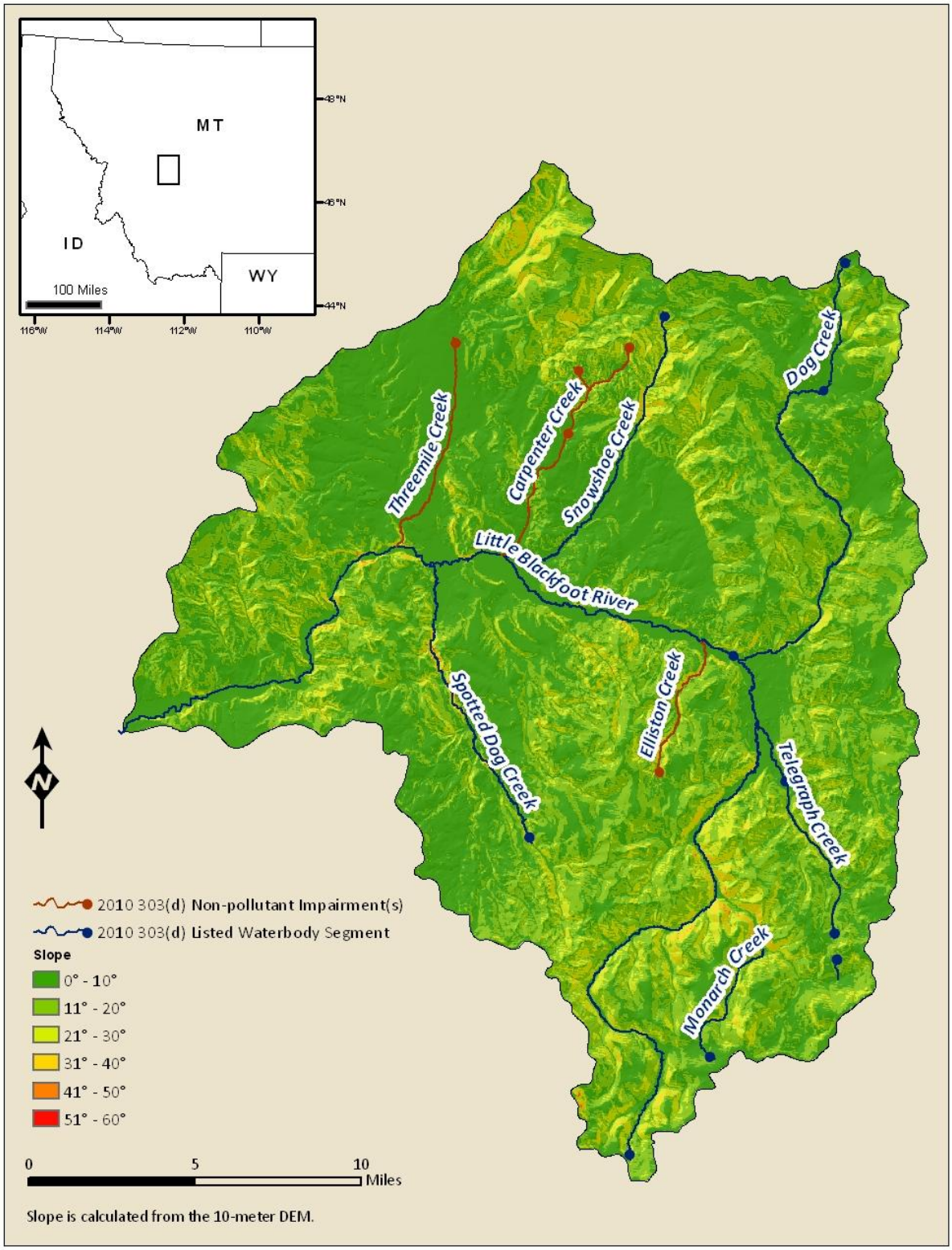


Figure A-6. Soil slope values for the Little Blackfoot TPA.

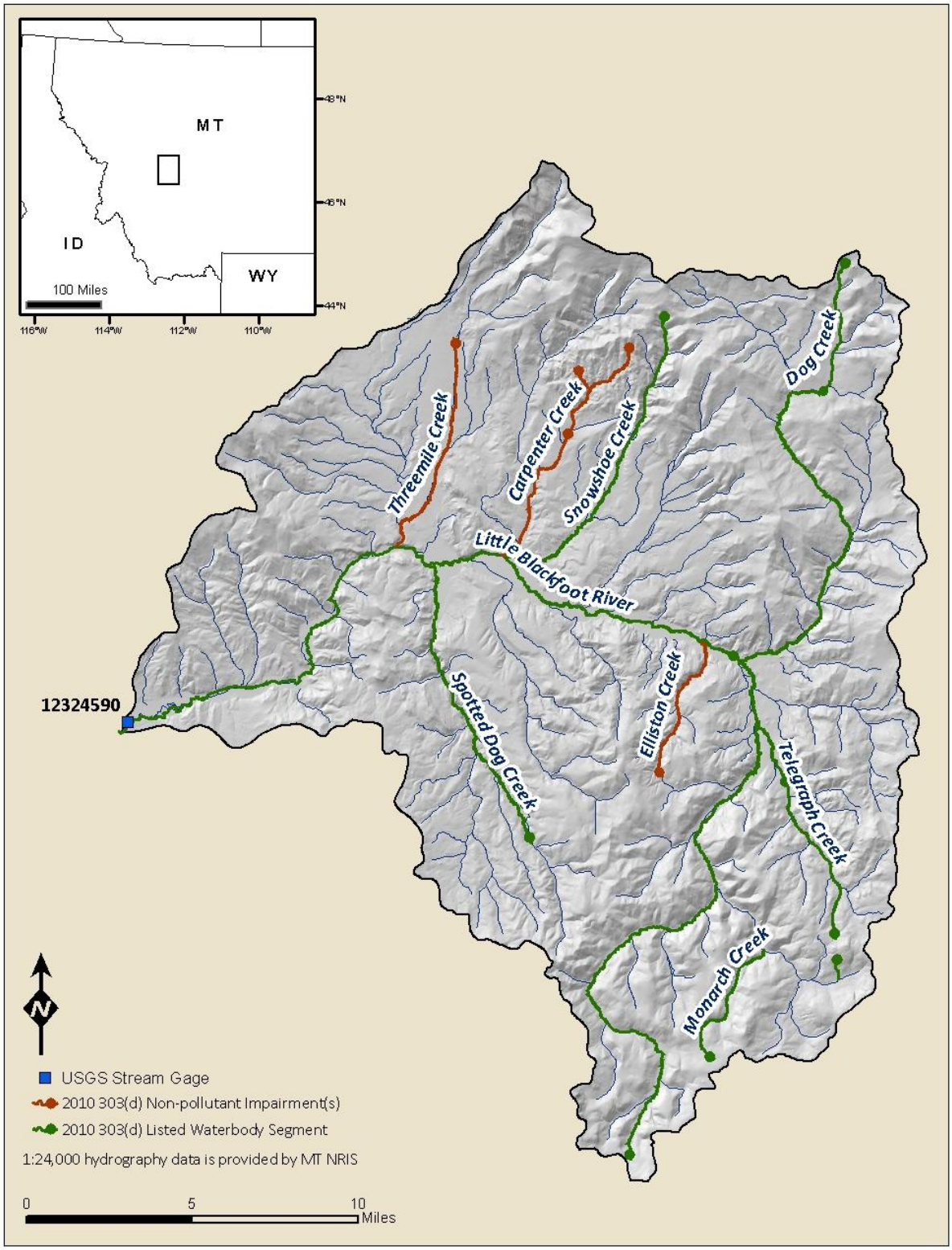


Figure A-7. Surface hydrography of the Little Blackfoot TPA at 1:24000 and the USGS gage.

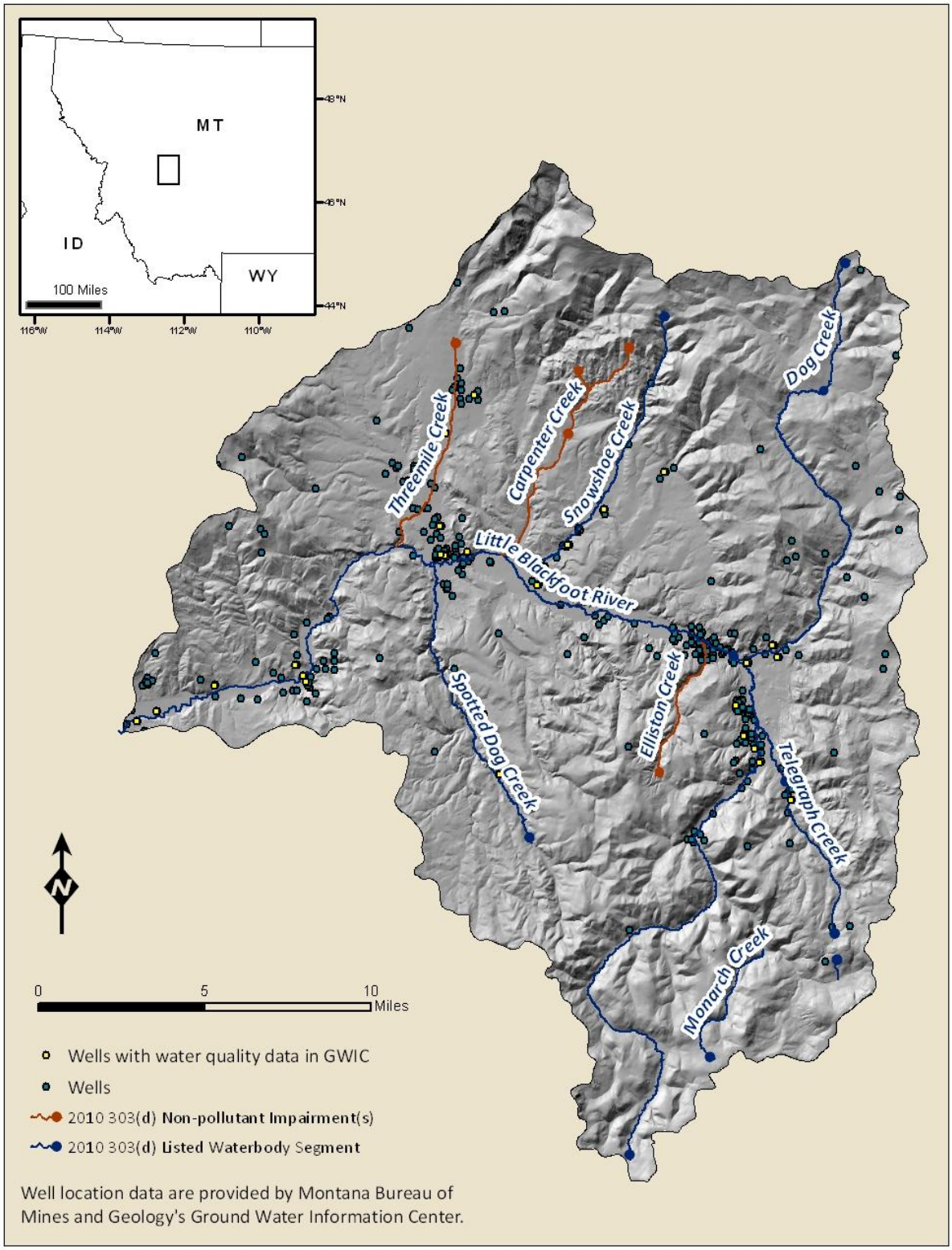


Figure A-8. Location of wells and those with water quality data based on the GWIC database.

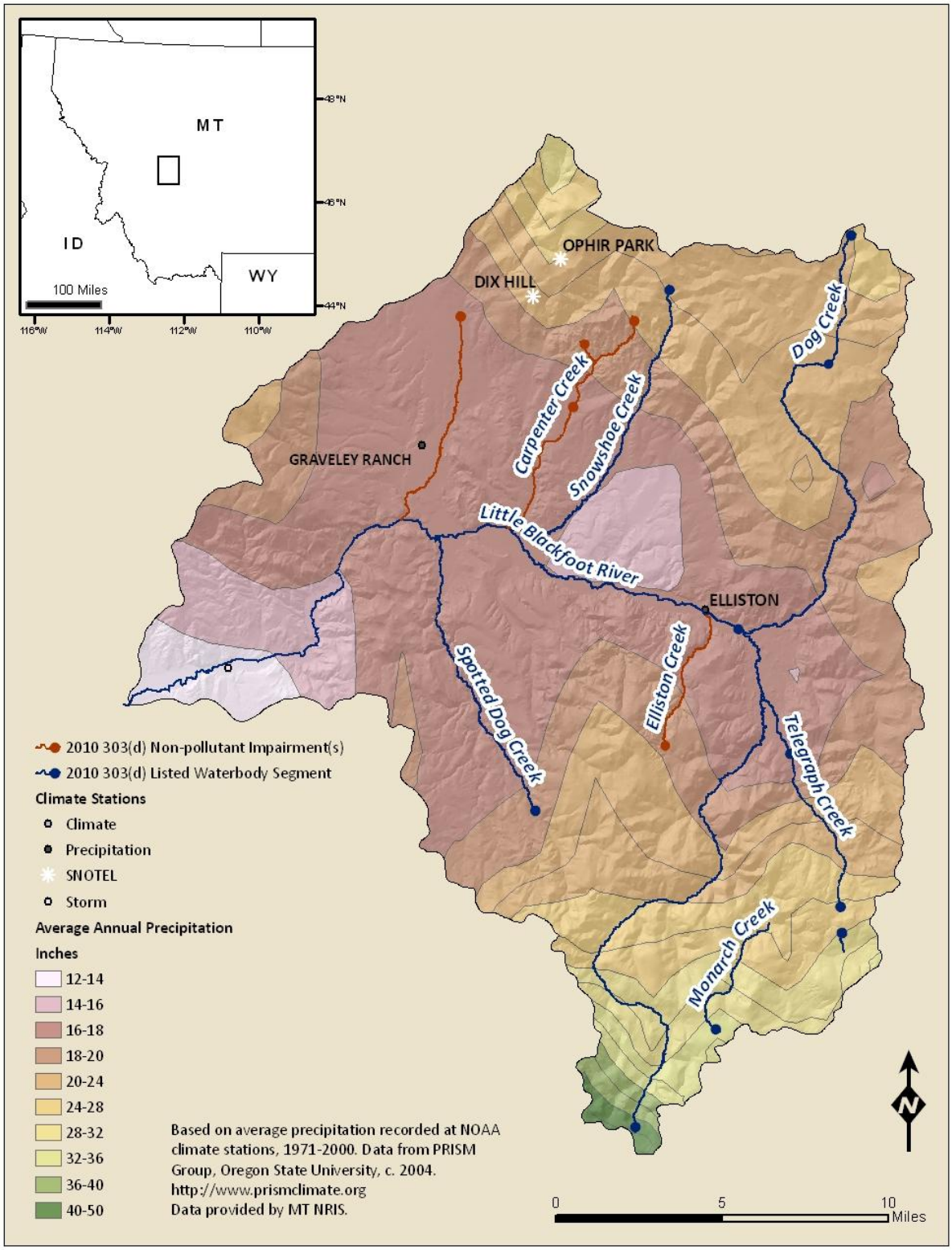


Figure A-9. Distribution of average annual precipitation within the Little Blackfoot TPA.

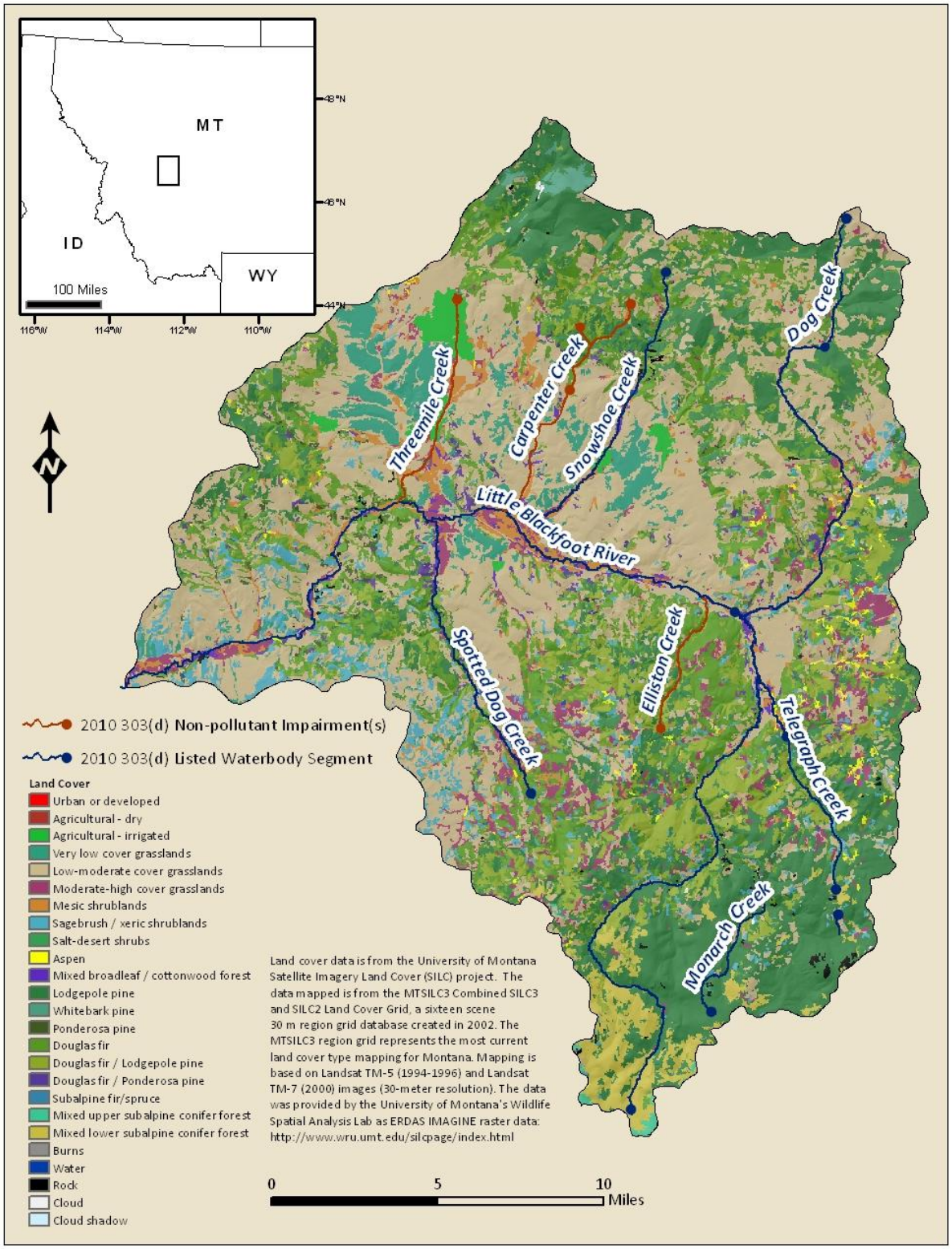


Figure A-10. Land cover distribution within the Little Blackfoot TPA from University of Montana.

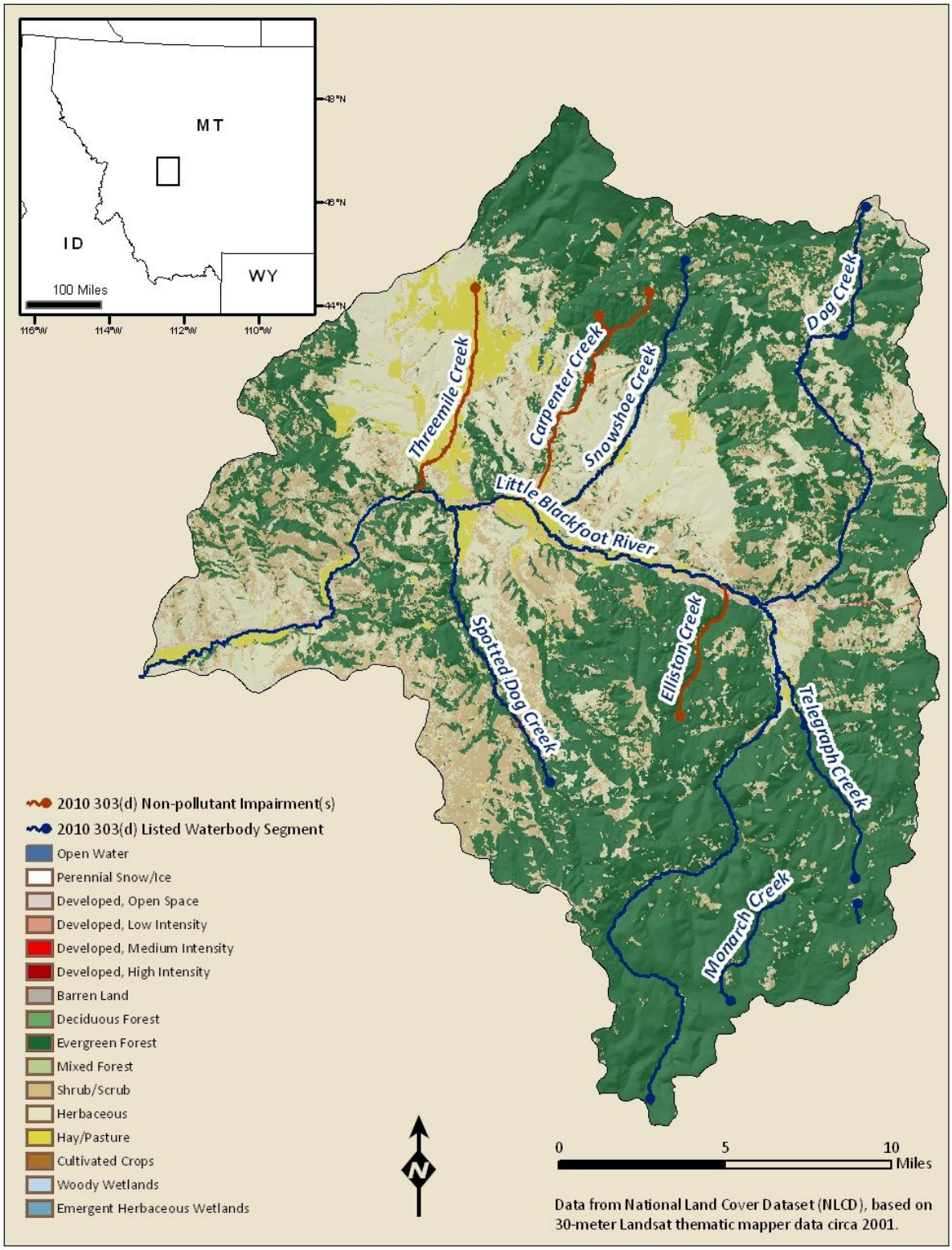


Figure A-11. NLCD land cover distribution within the Little Blackfoot TPA.

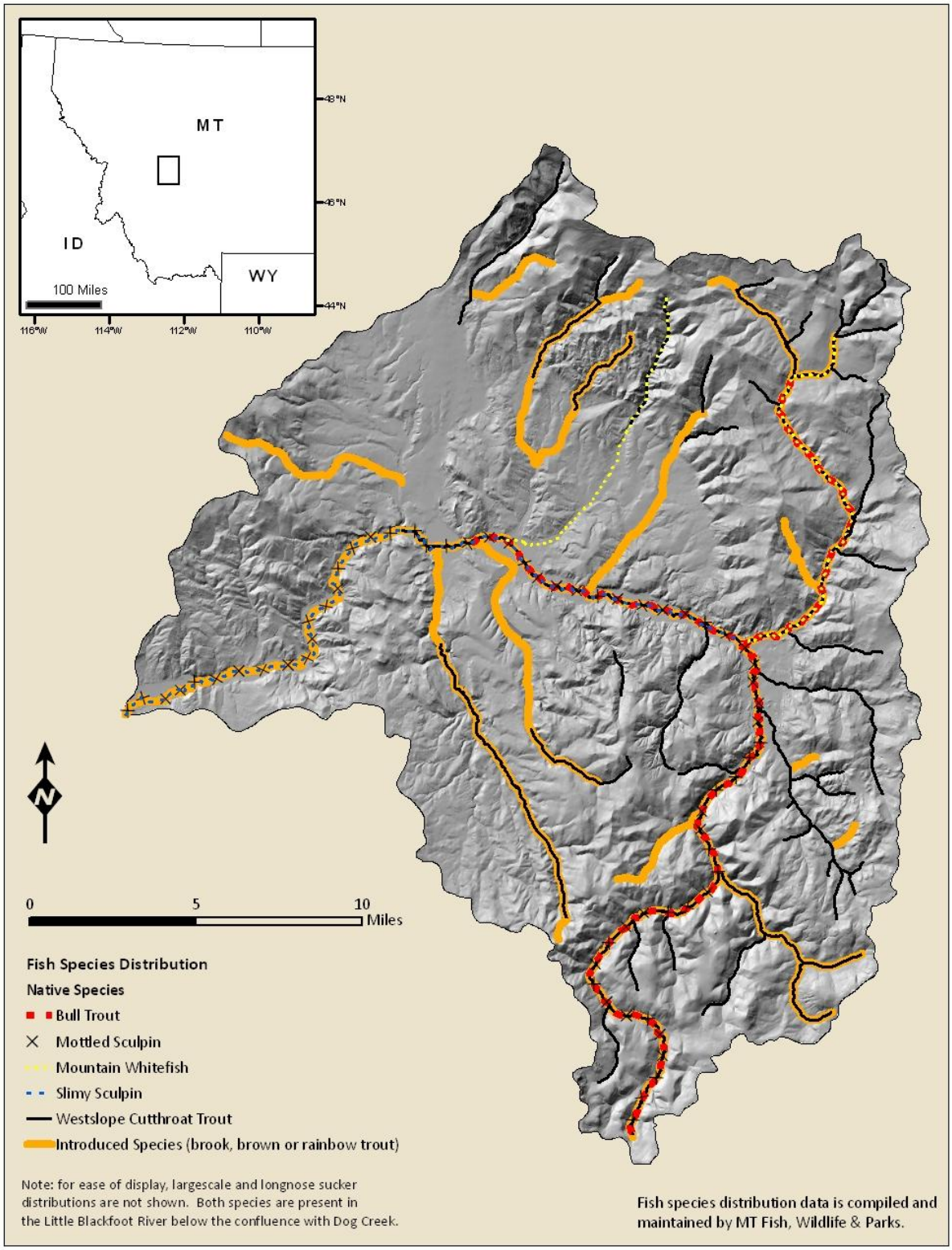


Figure A-12. Fish species distribution within the Little Blackfoot TPA.

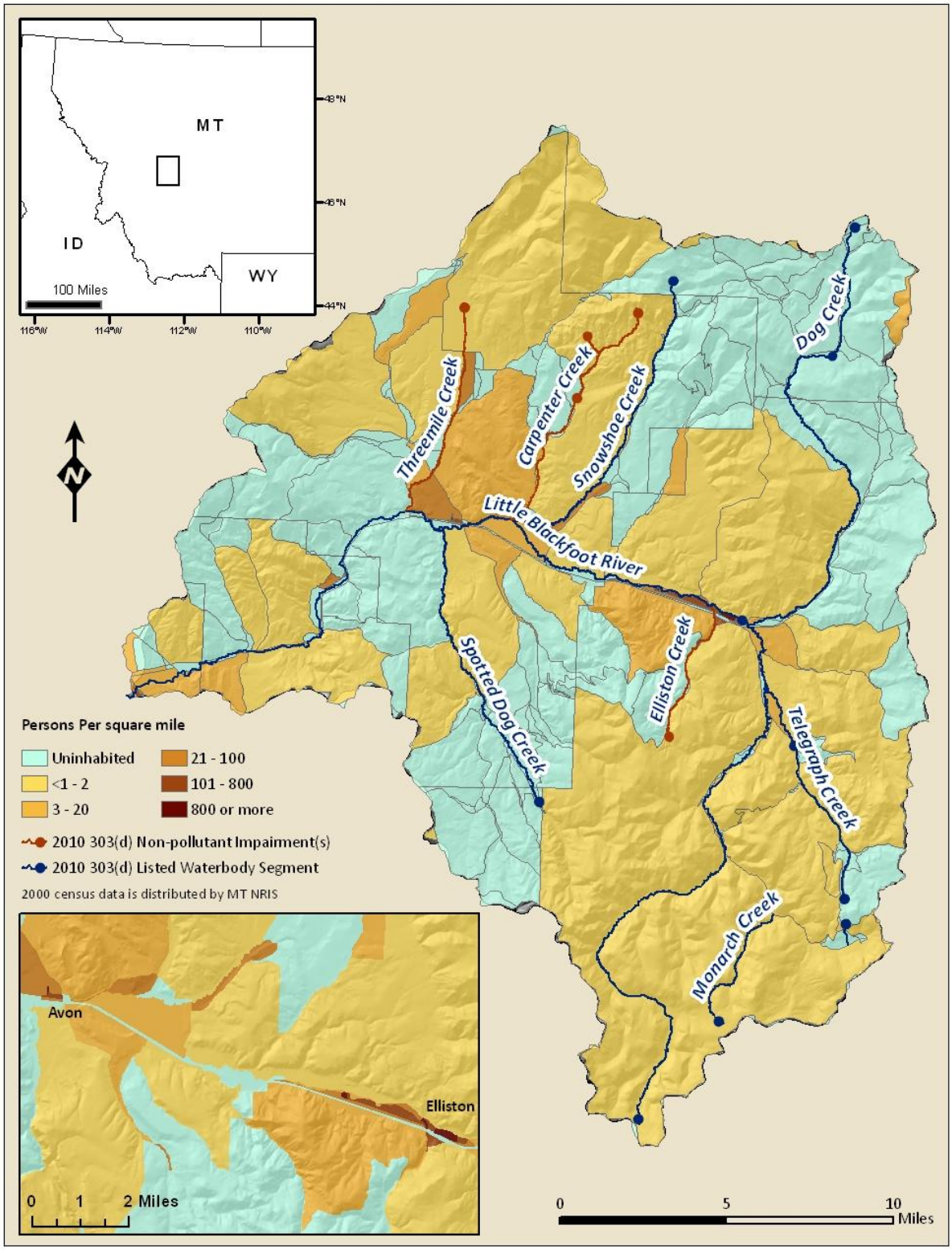


Figure A-13. Population density within the Little Blackfoot TPA.

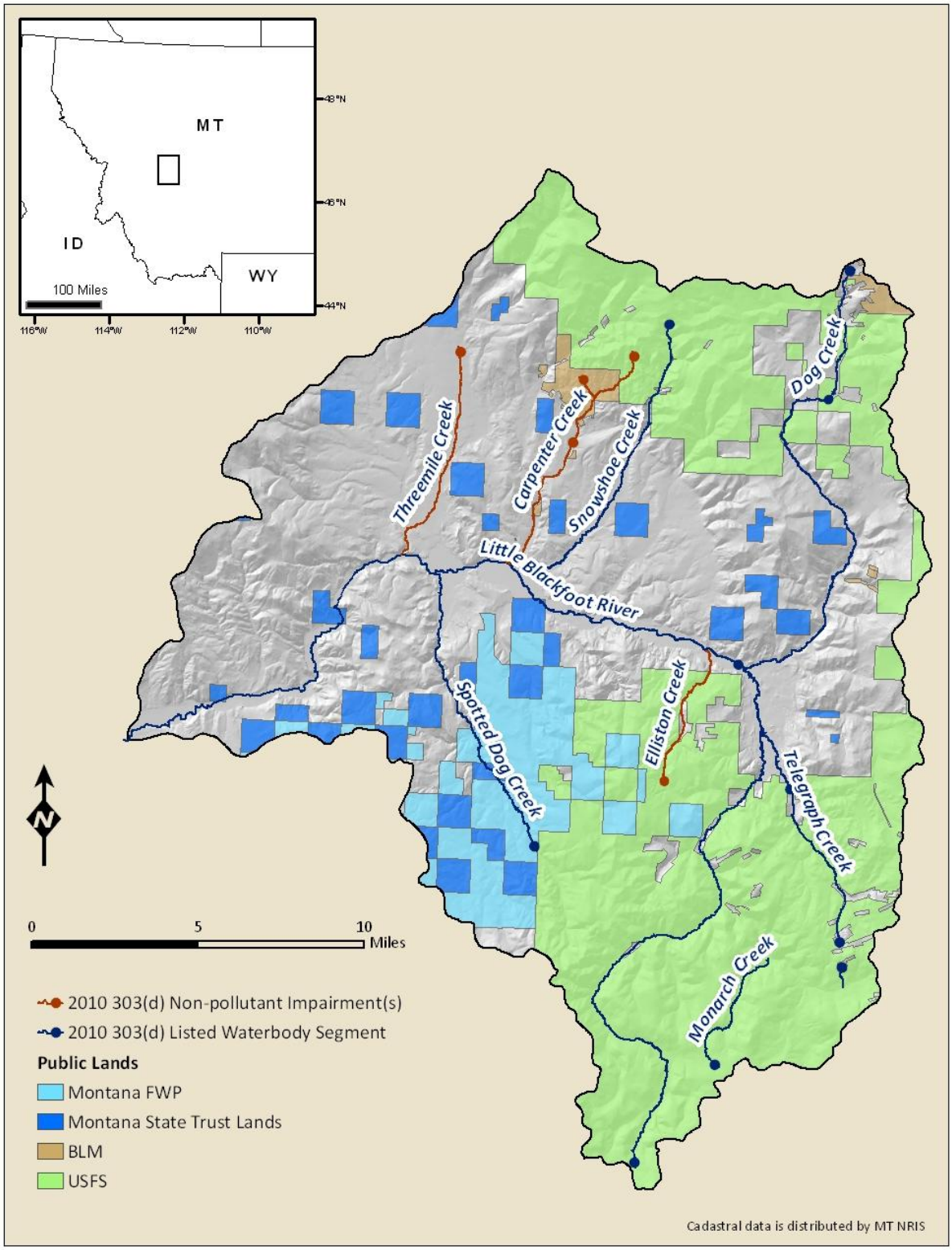


Figure A-14. Public land ownership within the Little Blackfoot TPA.

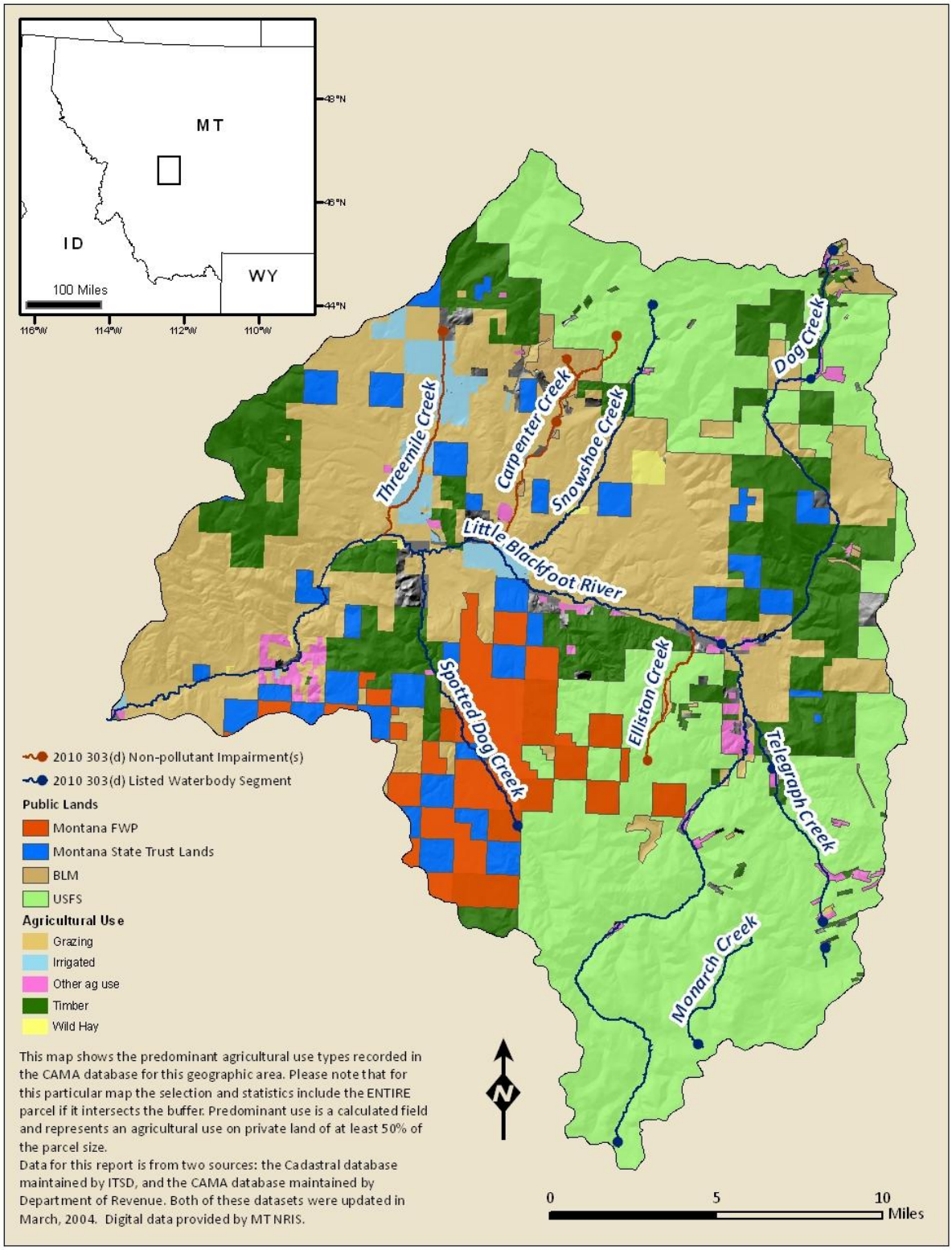


Figure A-15. Land ownership and agricultural land use distribution within the Little Blackfoot TPA.

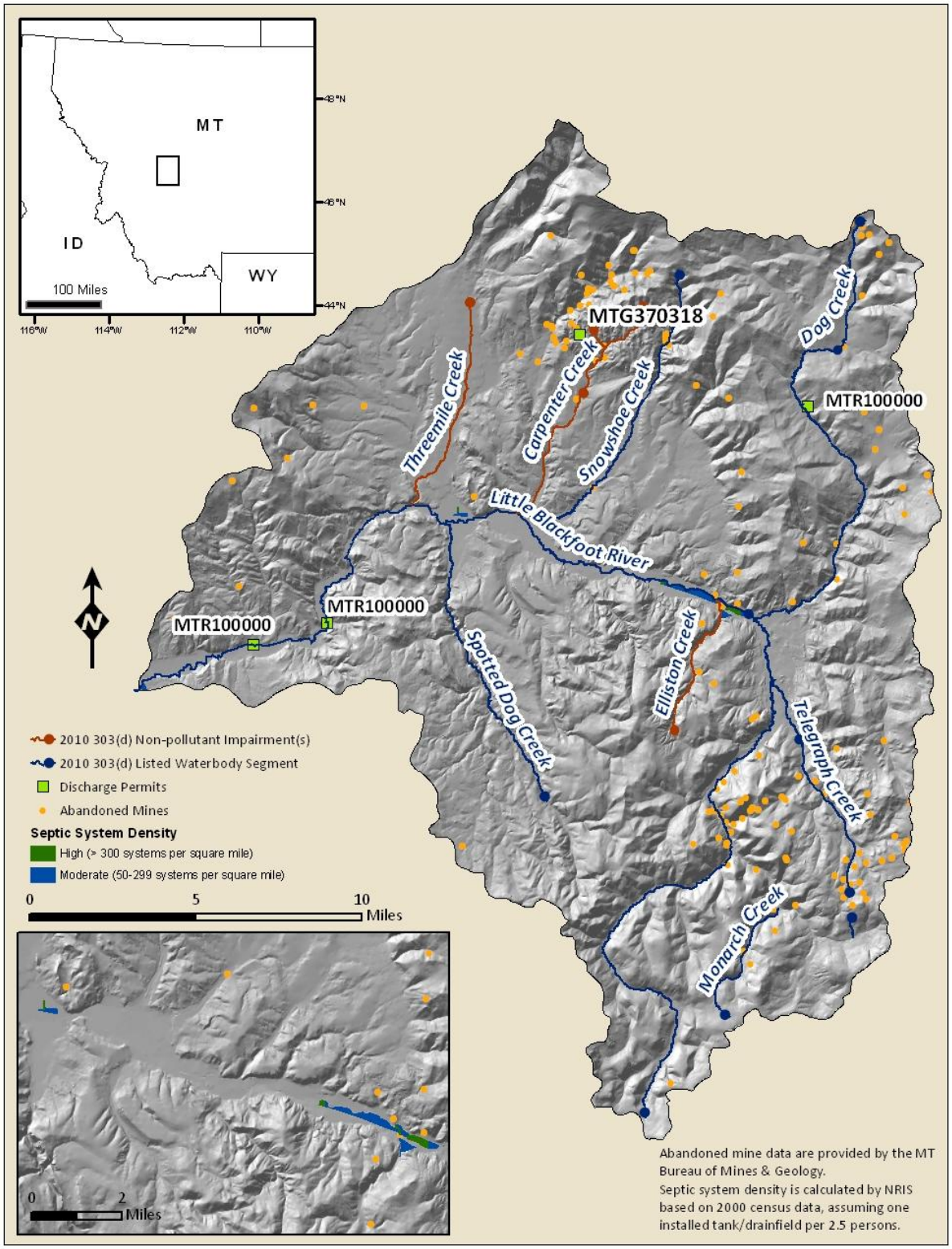


Figure A-16. Abandoned mines, NPDES permit locations, and septic system density within the Little Blackfoot TPA.

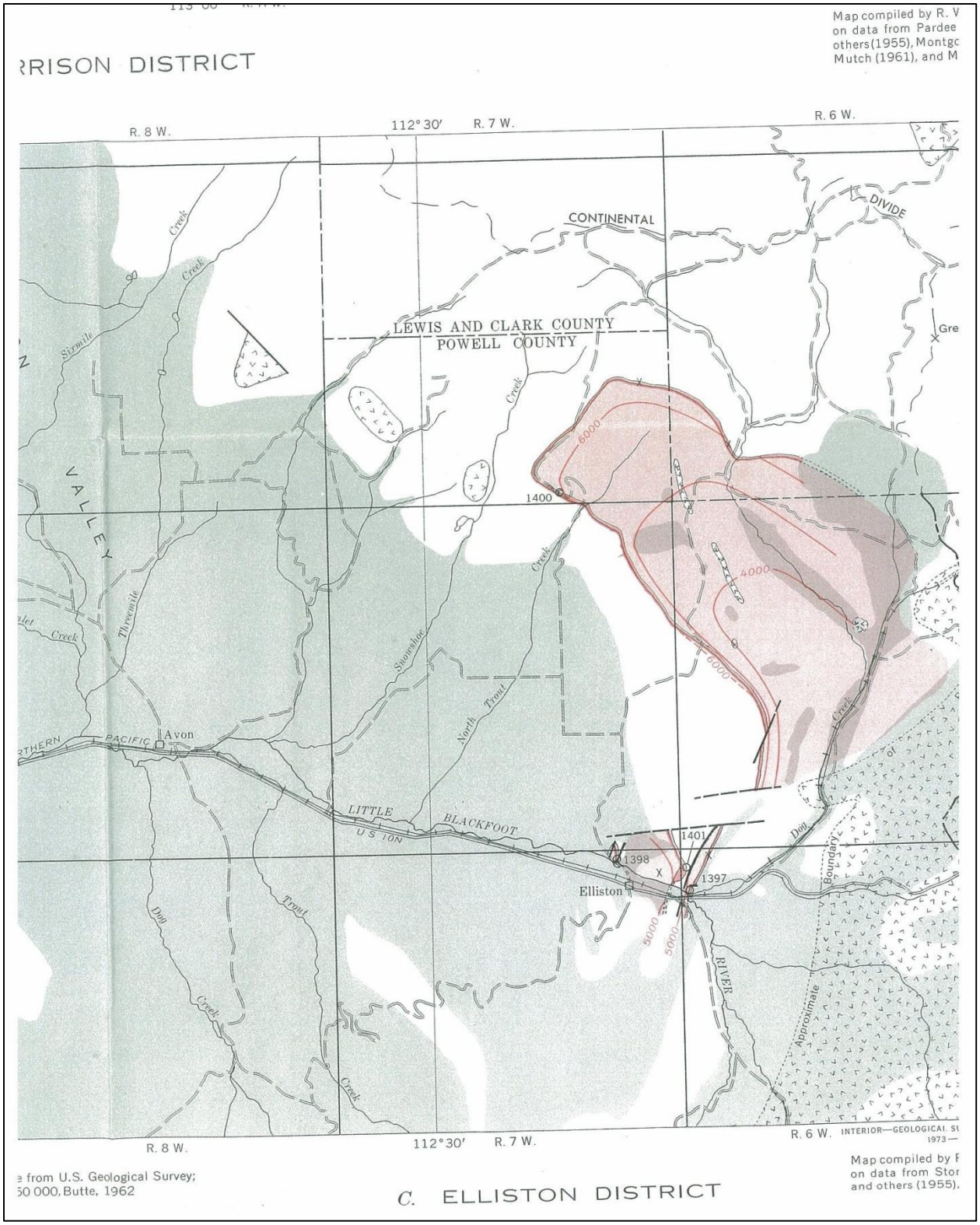


Figure A-17. Distribution of the Phosphoria Formation in the Elliston Mining District (indicated in pink). Copied from (Swanson, 1973).

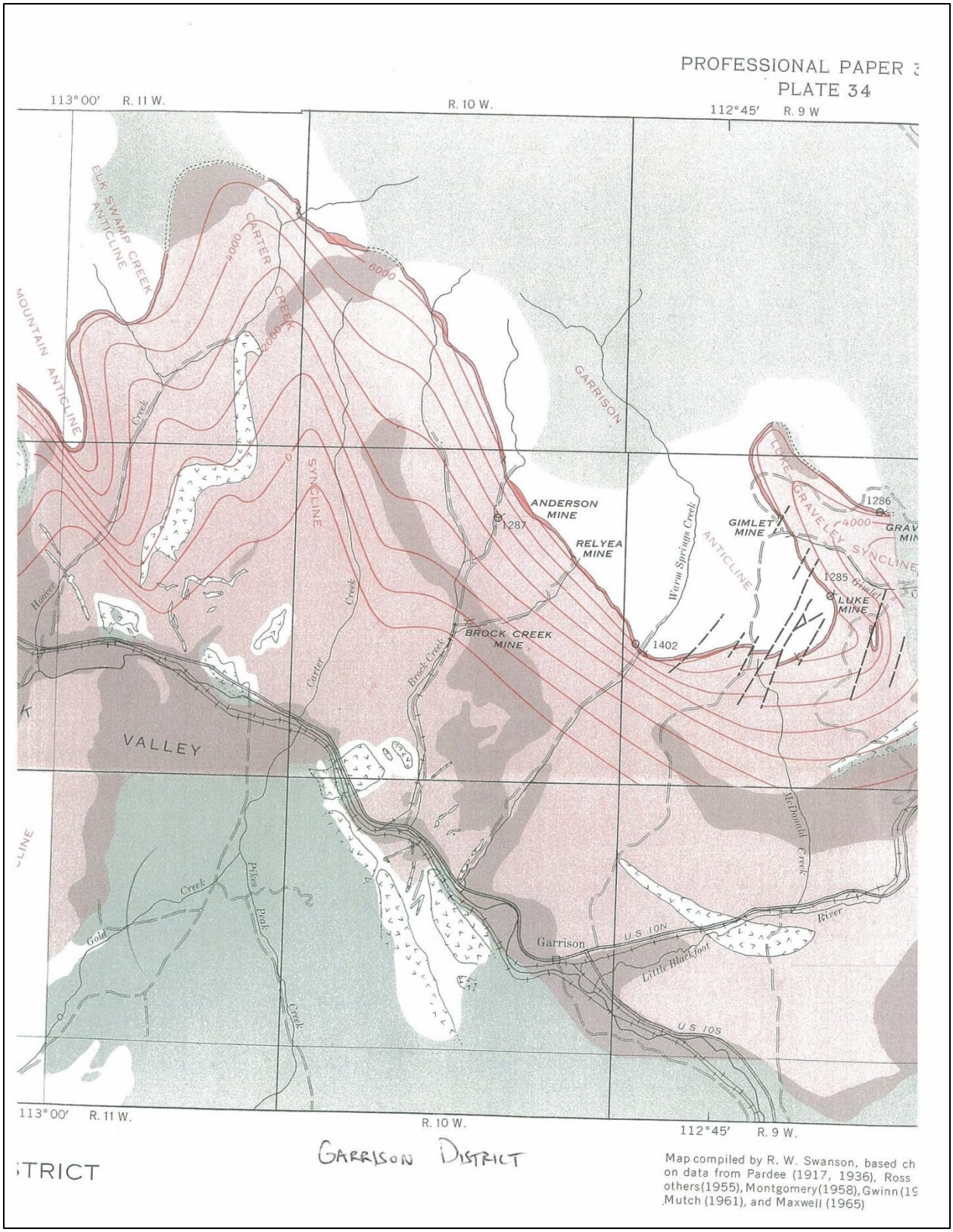


Figure A-18. Distribution of the Phosphoria Formation in the Garrison Mining District (indicated in pink). Copied from (Swanson, 1973).

APPENDIX B - REGULATORY FRAMEWORK AND REFERENCE CONDITION APPROACH

This appendix presents details about applicable Montana Water Quality Standards (WQS) and the general and statistical methods used for development of reference conditions.

TABLE OF CONTENTS

Acronyms B-2
B1.0 TMDL Development Requirements B-3
B2.0 Applicable Water Quality Standards B-4
B2.1 Classification and Beneficial Uses B-4
B2.2 Standards B-5
B.2.2.1 Sediment Standards B-6
B.2.2.2 Nutrient Standards B-7
B.2.2.3 Metals Standards B-8
B3.0 Reference Conditions B-9
B3.1 Reference Conditions as Defined in DEQ's Standard Operating Procedure for Water Quality Assessment (2006) B-9
B3.2 Use of Statistics for Developing Reference Values or Ranges B-11
References B-15

LIST OF TABLES

Table B2-1. Montana Surface Water Classifications and Designated Beneficial Uses B-5
Table B2-2. Applicable Rules for Sediment Related Pollutants B-6
Table B2-3. Numeric Nutrient and Benthic Algae Criteria for the Middle Rockies Ecoregion. B-7
Table B2-4. Human Health Standards for Nitrogen for the State of Montana. B-7
Table B2-5. Metals Numeric Water Quality Criteria for the Little Blackfoot TPA B-8
Table B2-6. Applicable Rules for Metals Concentrations in Sediment B-9

LIST OF FIGURES

Figure B3-1. Boxplot Example for Reference Data B-12
Figure B3-2. Boxplot example for the use of all data to set targets. B-14

ACRONYMS

Acronym	Definition
ARM	Administrative Rules of Montana
BER	Board of Environmental Review (Montana)
CFR	Code of Federal Regulations
CWA	Clean Water Act
DEQ	Department of Environmental Quality (Montana)
EPA	Environmental Protection Agency (US)
HHC	Human Health Criteria
MCA	Montana Codes Annotated
MCL	Maximum Contaminant Level
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TPA	TMDL Planning Area
TSS	Total Suspended Solids
UAA	Use Attainability Analysis
WQA	Water Quality Act
WQS	Water Quality Standards

B1.0 TMDL DEVELOPMENT REQUIREMENTS

Section 303(d) of the federal Clean Water Act (CWA) and the Montana Water Quality Act (WQA) (Section 75-5-703) requires development of TMDLs for impaired waterbodies that do not meet Montana WQS. Although waterbodies can become impaired from pollution (e.g. low flow alterations and habitat degradation) and pollutants (e.g. nutrients, sediment, metals, pathogens, and temperature), the CWA and Montana state law (75-5-703) require TMDL development only for impaired waters with pollutant causes. Section 303(d) also requires states to submit a list of impaired waterbodies to the U.S. Environmental Protection Agency (EPA) every two years. Prior to 2004, EPA and DEQ referred to this list simply as the 303(d) list.

Since 2004, EPA has requested that states combine the 303(d) list with the 305(b) report containing an assessment of Montana's water quality and its water quality programs. EPA refers to this new combined 303(d)/305(b) report as the Integrated Water Quality Report. The 303(d) list also includes identification of the probable cause(s) of the water quality impairment (e.g. pollutants such as metals, nutrients, sediment, pathogens or temperature), and the suspected source(s) of the pollutants of concern (e.g. various land use activities). State law (MCA 75-5-702) identifies that a sufficient credible data methodology for determining the impairment status of each waterbody is used for consistency. The impairment status determination methodology is identified in DEQ's Water Quality Assessment Process and Methods found in Appendix A of Montana's Water Quality Integrated Report (Montana Department of Environmental Quality, 2006).

Under Montana state law, an "impaired waterbody" is defined as a waterbody or stream segment for which sufficient credible data show that the waterbody or stream segment is failing to achieve compliance with applicable WQS (Montana Water Quality Act; Section 75-5-103(11)). A "threatened waterbody" is defined as a waterbody or stream segment for which sufficient credible data and calculated increases in loads show that the waterbody or stream segment is fully supporting its designated uses, but threatened for a particular designated use because of either (a) proposed sources that are not subject to pollution prevention or control actions required by a discharge permit, the nondegradation provisions, or reasonable land, soil, and water conservation practices or (b) documented adverse pollution trends (Montana WQA; Section 75-5-103(31)). State law and Section 303(d) of the CWA require states to develop all necessary TMDLs for impaired or threatened waterbodies. There are no threatened waterbodies within the Little Blackfoot TMDL Planning Area (TPA).

A TMDL is a pollutant budget for a waterbody identifying the maximum amount of the pollutant that a waterbody can assimilate without causing applicable WQS to be exceeded (violated). TMDLs are often expressed in terms of an amount, or load, of a particular pollutant (expressed in units of mass per time such as pounds per day). TMDLs must account for loads/impacts from point and nonpoint sources in addition to natural background sources and must incorporate a margin of safety and consider influences of seasonality on analysis and compliance with WQS. **Section 4.0** of the main document provides a description of the components of a TMDL.

To satisfy the federal CWA and Montana state law, TMDLs are developed for each waterbody-pollutant combination identified on Montana's 303(d) list of impaired or threatened waters, and are often presented within the context of a water quality restoration or protection plan. State law (Administrative Rules of Montana 75-5-703(8)) also directs Montana DEQ to "…support a voluntary program of

reasonable land, soil, and water conservation practices to achieve compliance with water quality standards for nonpoint source activities for waterbodies that are subject to a TMDL…" This is an important directive that is reflected in the overall TMDL development and implementation strategy within this plan. It is important to note that water quality protection measures are not considered voluntary where such measures are already a requirement under existing federal, state, or local regulations.

B2.0 APPLICABLE WATER QUALITY STANDARDS

WQS include the uses designated for a waterbody, the legally enforceable standards that ensure that the uses are supported, and a nondegradation policy that protects the high quality of a waterbody. The ultimate goal of this TMDL document, once implemented, is to ensure that all designated beneficial uses are fully supported and all water quality standards are met. Water quality standards form the basis for the targets described in **Sections B5.4**, **B6.4**, and **B7.4**. Pollutants addressed in this framework water quality improvement plan include sediment and temperature. This section provides a summary of the applicable water quality standards for these pollutants.

B2.1 CLASSIFICATION AND BENEFICIAL USES

Classification is the assignment (designation) of a single or group of uses to a waterbody based on the potential of the waterbody to support those uses. Designated uses or beneficial uses are simple narrative descriptions of water quality expectations or water quality goals. There are a variety of "uses" of state waters including growth and propagation of fish and associated aquatic life; drinking water; agriculture; industrial supply; and recreation and wildlife. The Montana WQA directs the Board of Environmental Review (BER) (i.e., the state) to establish a classification system for all waters of the state that includes their present (when the Act was originally written) and future most beneficial uses (ARM 17.30.607-616) and to adopt standards to protect those uses (ARM 17.30.620-670).

Montana, unlike many other states, uses a watershed-based classification system, with some specific exceptions. As a result, *all* waters of the state are classified and have designated uses and supporting standards. All classifications have multiple uses and in only one case (A-Closed) is a specific use (drinking water) given preference over the other designated uses. Some waters may not actually be used for a specific designated use, for example as a public drinking water supply; however, the quality of that waterbody must be maintained suitable for that designated use. When natural conditions limit or preclude a designated use, permitted point source discharges or nonpoint source activities or pollutant discharges must not make the natural conditions worse.

Modification of classifications or standards that would lower a water's classification or a standard (i.e., B-1 to a B-3), or removal of a designated use because of natural conditions, can only occur if the water was originally misclassified. All such modifications must be approved by the BER, and are undertaken via a Use Attainability Analysis (UAA) that must meet EPA requirements (40 CFR 131.10(g), (h) and (j)). The UAA and findings presented to the BER during rulemaking must prove that the modification is correct and all existing uses are supported. An existing use cannot be removed or made less stringent.

Descriptions of Montana's surface water classifications and designated beneficial uses are presented in **Table B2-1**. All waterbodies within the Little Blackfoot TPA are classified as B-1 (see **Section B3.1** and **Table B3-1** in the main document for individual stream classifications).

Table B2-1. Montana Surface Water Classifications and Designated Beneficial Uses

Classification	Designated Uses
A-CLOSED CLASSIFICATION:	Waters classified A-Closed are to be maintained suitable for drinking, culinary and food processing purposes after simple disinfection.
A-1 CLASSIFICATION:	Waters classified A-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment for removal of naturally present impurities.
B-1 CLASSIFICATION:	Waters classified B-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-2 CLASSIFICATION:	Waters classified B-2 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
B-3 CLASSIFICATION:	Waters classified B-3 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-1 CLASSIFICATION:	Waters classified C-1 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-2 CLASSIFICATION:	Waters classified C-2 are to be maintained suitable for bathing, swimming and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
C-3 CLASSIFICATION:	Waters classified C-3 are to be maintained suitable for bathing, swimming and recreation; growth and propagation of non-salmonid fishes and associated aquatic life, waterfowl and furbearers. The quality of these waters is naturally marginal for drinking, culinary and food processing purposes, agriculture and industrial water supply.
I CLASSIFICATION:	The goal of the State of Montana is to have these waters fully support the following uses: drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

B2.2 STANDARDS

In addition to the use classifications described above, Montana's WQS include numeric and narrative criteria as well as a nondegradation policy.

Numeric Standards

Numeric surface water quality standards have been developed for many parameters to protect human health and aquatic life. These standards are in the Department Circular DEQ-7 (Montana Department of Environmental Quality, 2010). The numeric human health standards have been developed for parameters determined to be toxic, carcinogenic, or harmful and have been established at levels to be protective of long-term (i.e., lifelong) exposures as well as through direct contact such as swimming.

The numeric aquatic life standards include chronic and acute values that are based on extensive laboratory studies including a wide variety of potentially affected species, a variety of life stages and durations of exposure. Chronic aquatic life standards are protective of long-term exposure to a

parameter. The protection afforded by the chronic standards includes detrimental effects to reproduction, early life stage survival and growth rates. In most cases the chronic standard is more stringent than the corresponding acute standard. Acute aquatic life standards are protective of short-term exposures to a parameter and are not to be exceeded.

High quality waters are afforded an additional level of protection by the nondegradation rules (ARM 17.30.701 et. seq.,) and in statute (75-5-303 MCA). Changes in water quality must be "non-significant", or an authorization to degrade must be granted by the DEQ. However, under no circumstance may standards be exceeded. It is important to note that waters that meet or are of better quality than a standard are high quality for that parameter, and nondegradation policies apply to new or increased discharges to that the waterbody.

Narrative Standards

Narrative standards have been developed for substances or conditions for which sufficient information does not exist to develop specific numeric standards. The term "Narrative Standards" commonly refers to the General Prohibitions in ARM 17.30.637 and other descriptive portions of the surface WQS. The General Prohibitions are also called the "free from" standards; that is, the surface waters of the state must be free from substances attributable to discharges, including thermal pollution, that impair the beneficial uses of a waterbody. Uses may be impaired by toxic or harmful conditions (from one or a combination of parameters) or conditions that produce undesirable aquatic life. Undesirable aquatic life includes bacteria, fungi, and algae.

The standards applicable to the list of pollutants addressed in the Little Blackfoot TPA are summarized below. In addition to the standards below, the beneficial use support standard for B-1 streams, as defined above, can apply to other conditions, often linked to pollution, limiting aquatic life. These other conditions can include effects from dewatering/flow alterations and effects from habitat modifications.

B.2.2.1 Sediment Standards

Sediment (i.e., coarse and fine bed sediment) and suspended sediment are addressed via the narrative criteria identified in **Table B2-2**. The relevant narrative criteria do not allow for harmful or other undesirable conditions related to increases above naturally occurring levels or from discharges to state surface waters. This is interpreted to mean that water quality goals should strive toward a condition in which any increases in sediment above naturally occurring levels are not harmful, detrimental or injurious to beneficial uses (see definitions in **Table B2-2**).

Table B2-2. Applicable Rules for Sediment Related Pollutants

Rule	Standard
17.30.623(2)	No person may violate the following specific water quality standards for waters classified B-1:
17.30.623(2)(d)	The maximum allowable increase above naturally occurring turbidity is 5 NTU for B-1 except as permitted in 75-5-318, MCA.
17.30.623(2)(f)	No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except a permitted in 75-5-318, MCA), settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.

Table B2-2. Applicable Rules for Sediment Related Pollutants

Rule	Standard
17.30.637(1)	State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will:
17.30.637(1)(a)	Settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines;
17.30.637(1)(d)	Create concentrations or combinations of materials that are toxic or harmful to human, animal, plant, or aquatic life.
17.30.602(19)	"Naturally occurring" means conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil, and water conservation practices have been applied.
17.30.602(25)	"Reasonable land, soil, and water conservation practices" means methods, measures, or practices that protect present and reasonably anticipated beneficial uses. These practices include but are not limited to structural and nonstructural controls and operation and maintenance procedures. Appropriate practices may be applied before, during, or after pollution-producing activities.

B.2.2.2 Nutrient Standards

The narrative standards applicable to nutrients in Montana are contained in the General Prohibitions of the surface water quality standards (ARM 17.30.637 et. Seq.,). The prohibition against the creation of "*conditions which produce undesirable aquatic life*" is generally the most relevant to nutrients. Undesirable aquatic life includes bacteria, fungi, and algae. Montana has recently developed draft nutrient criteria for nitrate+nitrite nitrogen (NO_2+NO_3), total nitrogen (TN), total phosphorus (TP), and chlorophyll-*a* based on the Level III ecoregion in which a stream is located (Suplee, et al., 2008). For the Middle Rockies Level III ecoregion, draft water quality criteria for NO_2+NO_3, TN, TP, and chlorophyll-*a* are presented in **Table B2-3**. These criteria are growing season, or summer, values applied from July 1st through September 30th. Additionally, numeric human health standards exist for nitrogen (**Table B2-4**), but the narrative standard is most applicable to nutrients as the concentration in most waterbodies in Montana is well below the human health standard and the nutrients contribute to undesirable aquatic life at much lower concentrations than the human health standard.

Table B2-3. Numeric Nutrient and Benthic Algae Criteria for the Middle Rockies Ecoregion.

Parameter	Criteria
Nitrate+Nitrite Nitrogen	≤ 0.100 mg/L
Total Nitrogen	≤ 0.300 mg/L
Total Phosphorus	≤ 0.030 mg/L
Benthic Algae	≤ 129 mg/m²

Table B2-4. Human Health Standards for Nitrogen for the State of Montana.

Parameter	Human Health Standard (µL)[1]
Nitrate as Nitrogen (NO_3-N)	10,000
Nitrite as Nitrogen (NO_2-N)	1,000
Nitrate plus Nitrite as N	10,000

[1]Maximum Allowable Concentration.

B.2.2.3 Metals Standards

Water quality standards that are applicable to metals impairments include both numeric water quality criteria given in DEQ-7 (**Table B2-5**) and general prohibitions (narrative criteria) given in **Table B2-6.** As water quality criteria for many metals is dependent upon water hardness, **Table B2-5** presents acute and chronic metals numeric water quality criteria at water harnesses of 25 mg/L and 100 mg/L for metals of concern in the Little Blackfoot TPA. Also presented in **Table B2-5** is the Human Health Criteria (HHC): note that for mercury and arsenic, the HHC is lower than applicable chronic criteria.

For iron, the human health standard (i.e., 300ug/L) is a secondary maximum contaminant level that is based on aesthetic water properties such as taste, odor, and the tendency of these metals to cause staining. Iron is not classified as a toxin or a carcinogen. Therefore, for the purposes of this TMDL document, the secondary MCL guidance values for iron is not applied or considered in the evaluation of water quality data. The chronic aquatic life standard of 1,000 µg/L for iron is used as the metals target for iron.

It should be noted that recent studies have indicated in some streams metals concentrations may vary through out the day because of diel pH and alkalinity changes. In some cases the variation can cross the standard threshold (both ways) for a metal. Montana water quality standards are not time of day dependent.

Table B2-5. Metals Numeric Water Quality Criteria for the Little Blackfoot TPA

Metal of Concern	Aquatic Life Criteria (ug/L) at 25 mg/L Hardness		Aquatic Life Criteria (ug/L) at 100 mg/L Hardness		HHC
	Acute	Chronic	Acute	Chronic	
Arsenic, TR	340	150	340	150	10
Beryllium	---	---	---	---	4
Cadmium, TR	0.52	0.10	2.13	0.27	5
Copper, TR	3.79	2.85	14.00	9.33	1,300
Cyanide, total	22	5.2	22	5.2	140
Iron, TR	---	1,000	---	1,000	*300
Lead, TR	13.98	0.54	81.65	3.18	15
Mercury, total	1.70	0.91	1.70	0.91	0.05
Zinc, TR	37.02	37.02	119.82	119.82	2,000

*HHC for iron is a secondary maximum contaminant level based on aesthetic properties

In addition to numeric criteria given in **Table B2-5**, narrative criteria also provides protection of beneficial uses. Toxic levels of metals in stream sediment are prohibited via ARM 17.30.637 (1)(d)). Metals concentrations in stream sediment are addressed via the suite of narrative criteria presented in **Table B2-6**. The relevant narrative criteria do not allow for 'concentrations or combinations of materials that are toxic or harmful to human, animal, plant, or aquatic life.' This is interpreted to mean that water quality goals should strive toward a condition in which any increases in metals concentration in sediment above naturally occurring levels are not harmful, detrimental or injurious to beneficial uses (see definitions in **Table B-3**). Evaluation of numeric and narrative criteria for specific metals impairments by stream segment is given in **Section B5.0**.

Table B2-6. Applicable Rules for Metals Concentrations in Sediment

Rule(s)	Criteria
17.30.623 (1) 17.30.624 (1)	Waters classified B-1 (B-2) are to be maintained suitable for drinking, culinary, and food processing purposes, after conventional treatment; bathing, swimming, and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.
17.30.623(2) 17.30.624(2)	No person may violate the following specific water quality standards for waters classified B-1 (B-2).
17.30.623 (2) (f) 17.30.624 (2) (f)	(f) No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except as permitted in 75-5-318, MCA), settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation,
17.30.623 (2) (h) 17.30.624 (2) (h)	(h) Concentrations of carcinogenic, bioconcentrating, toxic, radioactive, nutrient, or harmful parameters may not exceed the applicable standards set forth in department Circular DEQ-7.
17.30.637	General Prohibitions
17.30.637(1)	State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will.
17.30.637(1)(d)	Create concentrations or combinations of materials that are toxic or harmful to human, animal, plant, or aquatic life.

B.2.2.3.1 pH Standards

Waterbodies impaired by metals are also sometimes impaired by pH as a result of acid mine drainage. For human health, changes in pH are addressed by the general narrative criteria in ARM 17.30.601 et seq. and ARM 17.30.1001 et seq. For aquatic life, which can be sensitive to small pH changes, criteria are specified for each waterbody use classification. For B-1 waters, ARM 17.30.623 (2)(c) states “Induced variation of hydrogen ion concentration (pH) within the range of 6.5 to 8.5 must be less than 0.5 pH unit. Natural pH outside this range must be maintained without change. Natural pH above 7.0 must be maintained above 7.0.”

B3.0 Reference Conditions

B3.1 Reference Conditions as Defined in DEQ’s Standard Operating Procedure for Water Quality Assessment (2006)

DEQ uses the reference condition to evaluate compliance with many of the narrative WQS. The term “reference condition” is defined as the condition of a waterbody capable of supporting its present and future beneficial uses when all reasonable land, soil, and water conservation practices have been applied. In other words, reference condition reflects a waterbodies greatest potential for water quality given historic land use activities.

DEQ applies the reference condition approach for making beneficial use-support determinations for certain pollutants (such as sediment) that have specific narrative standards. All classes of waters are subject to the provision that there can be no increase above naturally occurring concentrations of sediment and settleable solids, oils, or floating solids sufficient to create a nuisance or render the water harmful, detrimental, or injurious. These levels depend on site-specific factors, so the reference conditions approach is used.

Also, Montana WQS do not contain specific provisions addressing nutrients (nitrogen and phosphorous), or detrimental modifications of habitat or flow. However, these factors are known to adversely affect beneficial uses under certain conditions or combination of conditions. The reference conditions approach is used to determine if beneficial uses are supported when nutrients, flow, or habitat modifications are present.

Waterbodies used to determine reference condition are not necessarily pristine or perfectly suited to giving the best possible support to all possible beneficial uses. Reference condition also does not reflect an effort to turn the clock back to conditions that may have existed before human settlement, but is intended to accommodate natural variations in biological communities, water chemistry, etc. due to climate, bedrock, soils, hydrology, and other natural physiochemical differences. The intention is to differentiate between natural conditions and widespread or significant alterations of biology, chemistry, or hydrogeomorphology due to human activity. Therefore, reference conditions should reflect minimum impacts from human activities. It attempts to identify the potential condition that could be attained (given historical land use) by the application of reasonable land, soil, and water conservation practices. DEQ realizes that presettlement water quality conditions usually are not attainable.

Comparison of conditions in a waterbody to reference waterbody conditions must be made during similar season and/or hydrologic conditions for both waters. For example, the Total Suspended Solids (TSS) of a stream at base flow during the summer should not be compared to the TSS of reference condition that would occur during a runoff event in the spring. In addition, a comparison should not be made to the lowest or highest TSS values of a reference site, which represent the outer boundaries of reference conditions.

The following methods may be used to determine reference conditions:

Primary Approach

- Comparing conditions in a waterbody to baseline data from minimally impaired waterbodies that are in a nearby watershed or in the same region having similar geology, hydrology, morphology, and/or riparian habitat.
- Evaluating historical data relating to condition of the waterbody in the past.
- Comparing conditions in a waterbody to conditions in another portion of the same waterbody, such as an unimpaired segment of the same stream.

Secondary Approach

- Reviewing literature (e.g. a review of studies of fish populations, etc., that were conducted on similar waterbodies that are least impaired.
- Seeking expert opinion (e.g. expert opinion from a regional fisheries biologist who has a good understanding of the waterbody's fisheries health or potential).

- Applying quantitative modeling (e.g. applying sediment transport models to determine how much sediment is entering a stream based on land use information, etc.).

DEQ uses the primary approach for determining reference condition if adequate regional reference data are available and uses the secondary approach to estimate reference condition when there is no regional data. DEQ often uses more than one approach to determine reference condition, especially when regional reference condition data are sparse or nonexistent.

B3.2 Use of Statistics for Developing Reference Values or Ranges

Reference value development must consider natural variability as well as variability that can occur as part of field measurement techniques. Statistical approaches are commonly used to help incorporate variability. One statistical approach is to compare stream conditions to the mean (average) value of a reference data set to see if the stream condition compares favorably to this value or falls within the range of one standard deviation around the reference mean. The use of these statistical values assumes a normal distribution; whereas, water resources data tend to have a non-normal distribution (Helsel and Hirsch, 1995). For this reason, another approach is to compare stream conditions to the median value of a reference data set to see if the stream condition compares favorably to this value or falls within the range defined by the 25th and 75th percentiles of the reference data. This is a more realistic approach than using one standard deviation since water quality data often include observations considerably higher or lower than most of the data. Very high and low observations can have a misleading impact on the statistical summaries if a normal distribution is incorrectly assumed, whereas statistics based on non-normal distributions are far less influenced by such observations.

Figure B3-1 is an example boxplot type presentation of the median, 25th and 75th percentiles, and minimum and maximum values of a reference data set. In this example, the reference stream results are stratified by two different stream types. Typical stratifications for reference stream data may include Rosgen stream types, stream size ranges, or geology. If the parameter being measured is one where low values are undesirable and can cause harm to aquatic life, then measured values in the potentially impaired stream that fall below the 25th percentile of reference data are not desirable and can be used to indicate impairment. If the parameter being measured is one where high values are undesirable, then measured values above the 75th percentile can be used to indicate impairment.

The use of a non-parametric statistical distribution for interpreting narrative WQS or developing numeric criteria is consistent with EPA guidance for determining nutrient criteria (Buck, et al., 2000). Furthermore, the selection of the applicable 25th or 75th percentile values from a reference data set is consistent with ongoing DEQ guidance development for interpreting narrative WQS where it is determined that there is “good” confidence in the quality of the reference sites and resulting information (Suplee, 2004). If it is determined that there is only a “fair” confidence in the quality of the reference sites, then the 50th percentile or median value should be used, and if it is determined that there is “very high” confidence, then the 90th percentile of the reference data set should be used. Most reference data sets available for water quality restoration planning and related TMDL development, particularly those dealing with sediment and habitat alterations, would tend to be “fair” to “good” quality. This is primarily due to a the limited number of available reference sites/data points available after applying all potentially applicable stratifications on the data, inherent variations in monitoring results among field crews, the potential for variations in field methodologies, and natural yearly variations in stream systems often not accounted for in the data set.

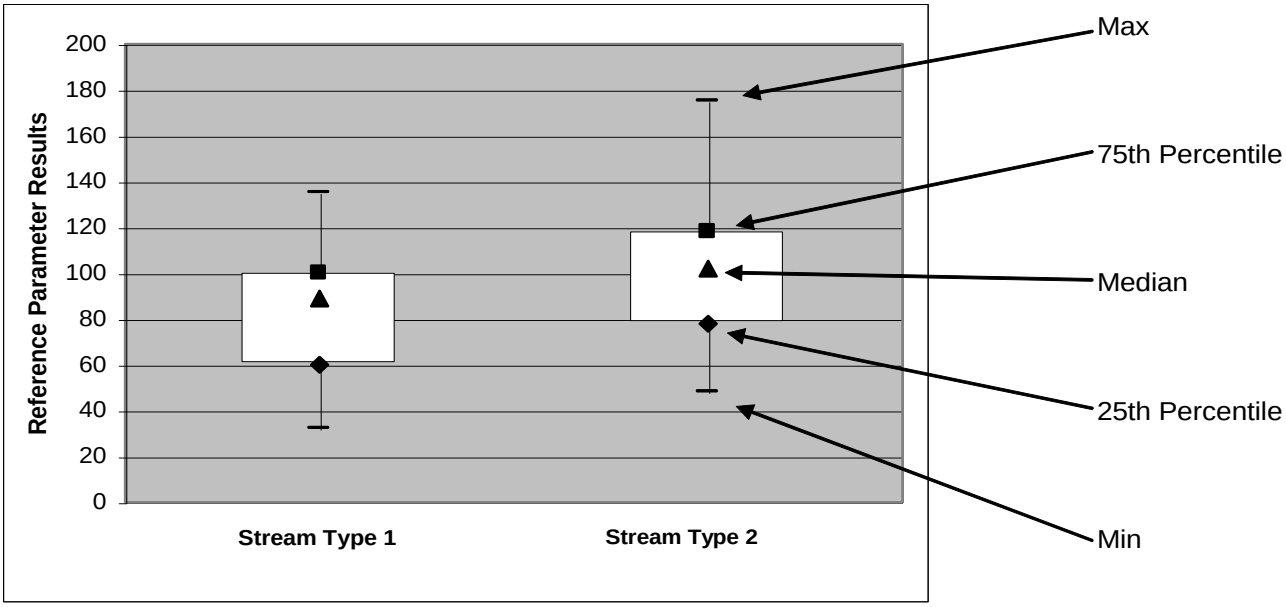


Figure B3-1. Boxplot Example for Reference Data.

The above 25th – 75th percentile statistical approach has several considerations:

1. It is a simple approach that is easy to apply and understand.
2. About 25 percent of all streams would naturally fall into the impairment range. Thus, it should not be applied unless there is some linkage to human activities that could lead to the observed conditions. Where applied, it must be noted that the stream's potential may prevent it from achieving the reference range as part of an adaptive management plan.
3. About 25 percent of all streams would naturally have a greater water quality potential than the minimum water quality bar represented by the 25th to 75th percentile range. This may represent a condition where the stream's potential has been significantly underestimated. Adaptive management can also account for these considerations.
4. Obtaining reference data that represents a naturally occurring condition can be difficult, particularly for larger waterbodies with multiple land uses within the drainage. This is because all reasonable land, soil, and water conservation practices may not be in place in many larger waterbodies across the region. Even if these practices are in place, the proposed reference stream may not have fully recovered from past activities, such as riparian harvest, where reasonable land, soil, and water conservation practices were not applied.
5. A stream should not be considered impaired unless there is a relationship between the parameter of concern and the beneficial use such that not meeting the reference range is likely to cause harm or other negative impacts to the beneficial use as described by the WQS in **Table B2-2**. In other words, if not meeting the reference range is not expected to negatively impact aquatic life, cold water fish, or other beneficial uses, then an impairment determination should not be made based on the particular parameter being evaluated. Relationships that show an impact to the beneficial use can be used to justify impairment based on the above statistical approach.

As identified in (2) and (3) above, there are two types of errors that can occur due to this or similar statistical approaches where a reference range or reference value is developed: (1) A stream could be considered impaired even though the naturally occurring condition for that stream parameter does not meet the desired reference range or (2) a stream could be considered not impaired for the parameter(s) of concern because the results for a given parameter fall just within the reference range, whereas the naturally occurring condition for that stream parameter represents much higher water quality and beneficial uses could still be negatively impacted. The implications of making either of these errors can be used to modify the above approach, although the approach used will need to be protective of water quality to be consistent with DEQ guidance and WQS (Suplee, 2004). Either way, adaptive management is applied to this water quality plan and associated TMDL development to help address the above considerations.

Where the data does suggest a normal distribution, or reference data is presented in a way that precludes use of non-normal statistics, the above approach can be modified to include the mean plus or minus one standard deviation to provide a similar reference range with all of the same considerations defined above.

Options When Regional Reference Data is Limited or Does Not Exist

In some cases, there is very limited reference data and applying a statistical approach like above is not possible. Under these conditions, the limited information can be used to develop a reference value or range, with the need to note the greater level of uncertainty and perhaps a greater level of future monitoring as part of the adaptive management approach. These conditions can also lead to more reliance on secondary type approaches for reference development.

Another approach would be to develop statistics for a given parameter from all streams within a watershed or region of interest (Buck, et al., 2000). The boxplot distribution of all the data for a given parameter can still be used to help determine potential target values knowing that most or all of the streams being evaluated are either impaired or otherwise have a reasonable probability of having significant water quality impacts. Under these conditions you would still use the median and the 25th or 75th percentiles as potential target values, but you would use the 25th and 75th percentiles in a way that is opposite from how you use the results from a regional reference distribution. This is because you are assuming that, for the parameter being evaluated, as many as 50 percent to 75 percent of the results from the whole data distribution represent questionable water quality. **Figure B3-2** is an example statistical distribution where higher values represent better water quality. In **Figure B3-2**, the median and 25th percentiles represent potential target values versus the median and 75th percentiles discussed above for regional reference distribution. Whether you use the median, the 25th percentile, or both should be based on an assessment of how impacted all the measured streams are in the watershed. Additional consideration of target achievability is important when using this approach. Also, there may be a need to also rely on secondary reference development methods to modify how you apply the target and/or to modify the final target value(s). Your certainty regarding indications of impairment or non-impairment may be lower using this approach, and you may need to rely more on adaptive management as part of TMDL implementation.

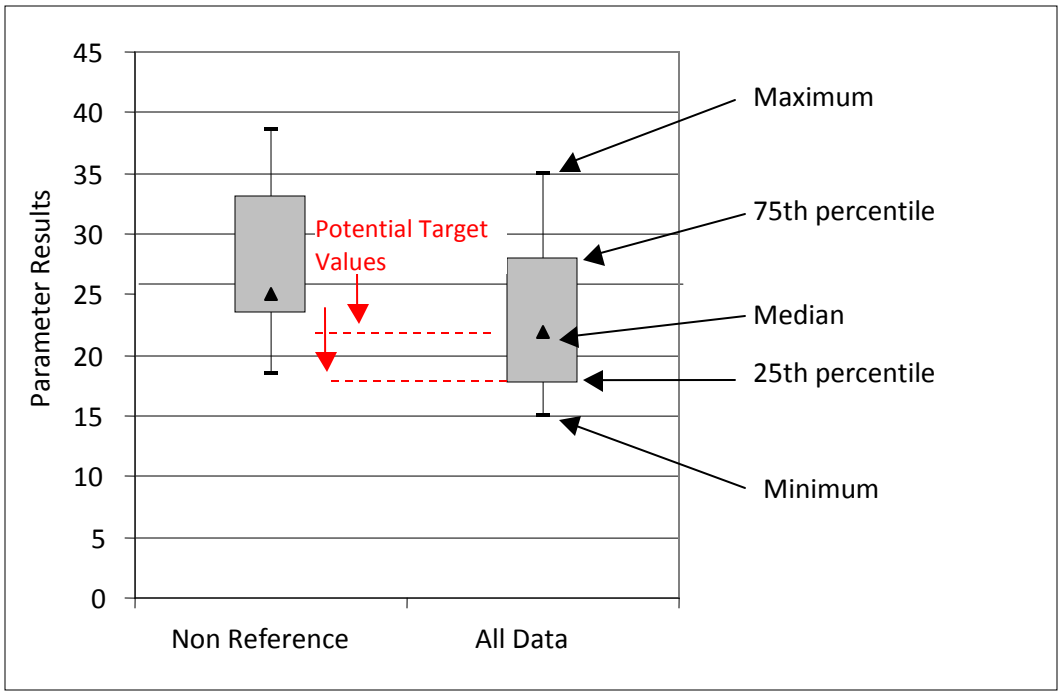


Figure B3-2. Boxplot example for the use of all data to set targets.

REFERENCES

Buck, Sharon, Walter K. Dodds, Jen Fisher, David A. Flemer, Debra Hart, Amanda K. Parker, Jan Stevenson, Vicki Watson, and Eugene B. Welch. 2000. Nutrient Criteria Technical Guidance Manual, Rivers and Streams. Washington, DC: United States Environmental Protection Agency. Report EPA-822-B00-002. http://www.epa.gov/waterscience/criteria/nutrient/guidance/rivers/index.html.

Helsel, Dennis R. and Robert M. Hirsch. 1995. Statistical Methods in Water Resources Studies in Environmental Science, Amsterdam, The Netherlands: Elsevier Science Publishers B.V.

Montana Department of Environmental Quality. 2006. Standard Operating Procedure, Water Quality Assessment Process and Methods (APPENDIX A to 303(d) 2000 - 2004). Helena, MT: Montana Department of Environmental Quality. Report WQPBWQM-001, Rev#: 02.

-----. 2010. Circular DEQ-7: Montana Numeric Water Quality Standards. Helena, MT: Montana Department of Environmental Quality. http://deq.mt.gov/wqinfo/Standards/PDF/DEQ-7.pdf. Accessed 6/9/11.

Suplee, Michael W. 2004. Wadeable Streams of Montana's Hi-Line Region: An Analysis of Their Nature and Condition With an Emphasis on Factors Affecting Aquatic Plant Communities and Recommendations to Prevent Nuisance Algae Conditions. Helena, MT: Montana Department of Environmental Quality, Water Quality Standards Section.

Suplee, Michael W., Vicki Watson, Arun Varghese, and Joshua Cleland. 2008. Scientific and Technical Basis of the Numeric Nutrient Criteria for Montana's Wadeable Streams and Rivers. Helena, MT: Montana Department of Environmental Quality.

APPENDIX C - 2009 SEDIMENT AND HABITAT ASSESSMENT

TABLE OF CONTENTS

C1.0 Introduction C-5
C2.0 Aerial Assessment Reach Stratification C-5
C2.1 Methods C-5
C2.1.1 Reach Types C-6
C2.2 Results C-6
C3.0 Sediment and Habitat Assessment C-7
C3.1 Methods C-7
C3.1.1 Channel Form and Stability Measurements C-11
C3.1.2 Fine Sediment Measurements C-11
C3.1.3 Instream Habitat Measurements C-12
C3.1.4 Riparian Health Measurements C-13
C3.2 Results C-13
C3.2.1 Reach Type Analysis C-13
C3.2.2 Monitoring Site Analysis C-26
C4.0 Streambank Erosion Assessment C-32
C4.1 Methods C-32
C4.1.1 Streambank Erosion Sediment Load Extrapolation C-33
C4.2 Results C-34
C4.2.1 Streambank Erosion Sediment Load Extrapolation C-34
C4.2.2 Streambank Composition C-36
C4.2.3 Streambank Erosion Sediment Load Reductions C-38
C5.0 Assumptions and Uncertainty C-41
C6.0 Summary C-41
C7.0 References C-42
Attachment CA - Sediment & Habitat Database, Little Blackfoot TMDL Planning Area C-45

LIST OF TABLES

Table C2-1. Reach Type Identifiers. C-6
Table C2-2. Aerial Assessment Stream Segments. C-7
Table C3-1. Reach Types and Monitoring Sites. C-8

Table C3-2. Width/Depth Ratio.....C-14
Table C3-3. Entrenchment Ratio.....C-16
Table C3-4. Riffle Pebble Count <2mm.....C-17
Table C3-5. Riffle Pebble Count <6mm.....C-18
Table C3-6. Riffle Grid Toss Fine Sediment <6mm.....C-19
Table C3-7. Pool Tail-out Grid Toss <6mm.....C-20
Table C3-8. Residual Pool Depth.....C-21
Table C3-9. Pools per 1000 feet.....C-22
Table C3-10. Pools per Mile.....C-22
Table C3-11. Large Woody Debris per 1000 Feet.....C-23
Table C3-12. Large Woody Debris per Mile.....C-23
Table C3-13. Greenline Understory Shrub Cover.....C-25
Table C3-14. Greenline Bare Ground.....C-26
Table C4-1. Annual Streambank Retreat Rates (Feet/Year), Lamar River, Yellowstone National Park (adapted from Rosgen 1996).....C-33
Table C4-2. Reach Type Streambank Erosion Sediment Loads by Reach Type Group.....C-34
Table C4-3. Monitoring Site Estimated Average Annual Sediment Loads due to Streambank Erosion.....C-35
Table C4-4. Sub-watershed Sediment Loads.....C-35
Table C4-5. Stream Segment Streambank Composition.....C-37
Table C4-6. Sub-watershed Sediment Loads due to Streambank Erosion for each Particle Size Class.....C-37
Table C4-7. Reach Type Streambank Sediment Load Reductions with BMPs.....C-39
Table C4-8. Sub-watershed Sediment Load Reductions with BMPs.....C-40
Table C4-9. Percentage of human-induced and natural streambank erosion per waterbody segment (only for those with TMDLs in Section 5.0).....C-41

LIST OF FIGURES

Figure C3-1. Aerial Assessment Reach Stratification.....C-9
Figure C3-2. Distribution of Reach Types.....C-10
Figure C3-3. Width/Depth Ratio.....C-14
Figure C3-4. Entrenchment Ratio.....C-15
Figure C3-5. Riffle Pebble Count <2mm.....C-16
Figure C3-6. Riffle Pebble Count <6mm.....C-17
Figure C3-7. Riffle Grid Toss Fine Sediment <6mm.....C-18
Figure C3-8. Pool Tail-out Grid Toss <6mm.....C-19
Figure C3-9. Residual Pool Depth.....C-20
Figure C3-10. Pools per 1000 Feet.....C-21
Figure C3-11. Large Woody Debris per 1000 Feet.....C-23
Figure C3-12. Greenline Understory Shrub Cover.....C-24
Figure C3-13. Greenline Bare Ground.....C-26
Figure C3-14. Width/Depth Ratio.....C-27
Figure C3-15. Entrenchment Ratio.....C-27
Figure C3-16. Riffle Pebble Count <2mm.....C-28
Figure C3-17. Riffle Pebble Count <6mm.....C-28
Figure C3-18. Riffle Grid Toss <6mm.....C-29

Figure C3-19. Pool Tail-out Grid Toss <6mm. C-30
Figure C3-20. Residual Pool Depth.....C-30
Figure C3-21. Pool and Large Woody Debris Frequency.....C-31
Figure C3-22. Greenline Understory Shrub Cover. C-31
Figure C3-23. Greenline Bare Ground.....C-32
Figure C4-1. Stream Segment and Sub-watershed Streambank Erosion Sources. C-36

ACRONYMS

Acronym	Definition
BEHI	Bank Erosion Hazard Index
BMP	Best Management Practices
DEQ	Department of Environmental Quality (Montana)
GIS	Geographic Information System
LWD	Large Woody Debris
MR	Middle Rockies
NAIP	National Agricultural Imagery Program
NBS	Near Bank Stress
NHD	National Hydrography Data(set)
RSI	Riffle Stability Index
SWAT	Soil & Water Assessment Tool
TMDL	Total Maximum Daily Load
TPA	Trading Partner Agreement
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WARSSS	Watershed Assessment of River Stability and Sediment Supply

C1.0 INTRODUCTION

This appendix is derived from a report prepared by Atkins (formerly PBS&J) (2010) for the Montana Department of Environmental Quality (DEQ). In 2009, DEQ initiated an effort to collect data to support the development of sediment TMDLs for streams within the Little Blackfoot TPA. The data collection effort involved assessing sediment and habitat conditions within the Little Blackfoot River watershed, as these conditions influence aquatic life beneficial uses. The data collection effort included stream stratification, sampling design, ground surveys, and sediment and habitat analyses, and is intended to assist DEQ in evaluating the impairment status of streams in the Little Blackfoot TPA and for developing TMDLs where necessary.

Within the Little Blackfoot TPA, Dog Creek, Telegraph Creek, Snowshoe Creek, Spotted Dog Creek and the Little Blackfoot River are listed as impaired due to sediment on the 2010 303(d) List. In addition, Elliston Creek and Threemile Creek are listed for alterations in stream-side or littoral vegetative covers, which is commonly a sediment-related impairment. Trout Creek is also included in this assessment based on stakeholder concerns and existing data indicating sediment impairments may be present.

A detailed sediment and habitat assessment of streams in the Little Blackfoot TPA was conducted to facilitate development of sediment TMDLs. During this assessment, streams were first analyzed in GIS using color aerial imagery and broken into similar reaches based on landscape characteristics. Following the aerial assessment reach stratification process, field data was collected at 19 monitoring sites during July of 2009. Field data collected during this effort was then used to quantify the existing condition of streams within the Little Blackfoot TPA and to estimate sediment loads from eroding streambanks to facilitate the development of sediment TMDLs. Although annual streambank load estimates are included in this assessment, only the percent reductions and percentage of natural versus human-induced erosion will be used for TMDL development in the Little Blackfoot TPA because actual load estimates are from the SWAT model (see **Appendix D**).

The three main components of this project are presented in the following sections: aerial assessment reach stratification, sediment and habitat assessment, and streambank erosion assessment.

C2.0 AERIAL ASSESSMENT REACH STRATIFICATION

C2.1 METHODS

An aerial assessment of streams in the Little Blackfoot TPA was conducted using National Agricultural Imagery Program (NAIP) color imagery from 2005 in GIS along with other relevant data layers, including the National Hydrography Dataset (NHD) 1:100,000 stream layer and United States Geological Survey 1:24,000 Topographic Quadrangle Digital Raster Graphics. GIS data layers were used to stratify streams into distinct reaches based on landscape and land-use factors following techniques described in *Watershed Stratification Methodology for TMDL Sediment and Habitat Investigations* (Montana Department of Environmental Quality, 2008).

The reach stratification methodology involves breaking a water body **stream segment** into **stream reaches** and **sub-reaches**. Montana DEQ tracks stream health by stream segment, which may encompass the entire stream or just a portion of the stream. Each of the stream segments in the Little

Blackfoot TPA was initially divided into distinct reaches based on four landscape factors: ecoregion, valley gradient, Strahler stream order, and valley confinement. Stream reaches classified by these four criteria were then further divided into sub-reaches based on the surrounding vegetation and land-use characteristics, including predominant vegetation type, adjacent land-use, riparian health, anthropogenic influences on streambank erosion, level of development, and the presence of anthropogenic (human) activity within 100 feet of the stream channel. This resulted in a series of stream reaches and sub-reaches delineated based on landscape and land-use factors which were compiled into an Aerial Assessment Database for the Little Blackfoot TPA.

C2.1.1 Reach Types

The aerial assessment reach stratification process involved dividing each stream segment into distinct reaches based on four landscape factors: ecoregion, valley gradient, Strahler stream order, and valley confinement. Each individual combination of the four landscape factors is referred to as a "**reach type**" in this report based on the following definition:

Reach Type -Unique combination of ecoregion, gradient, Strahler stream order and confinement

Reach types were described using the following naming convention based on the reach type identifiers presented in **Table C2-1**:

Level III Ecoregion – Valley Gradient – Strahler Stream Order – Confinement

Table C2-1. Reach Type Identifiers.

Landscape Factor	Stratification Category	Reach Type Identifier
Level III Ecoregion	Middle Rockies	MR
Valley Gradient	0-<2%	0
	2-<4%	2
	4-<10%	4
	>10%	10
Strahler Stream Order	first order	1
	second order	2
	third order	3
	fourth order	4
Confinement	unconfined	U
	confined	C

Thus, a stream reach identified as MR-0-3-U is a low gradient (0-<2%), 3rd order, unconfined stream in the Middle Rockies Level III ecoregion.

C2.2 RESULTS

A total of 129 reaches were delineated during the aerial assessment reach stratification process covering 121.6 miles of stream in the Little Blackfoot TPA (**Table C2-2**). Based on the level III ecoregion, there were a total of 19 distinct reach types delineated in the Little Blackfoot TPA and field data was collect in nine of these reach types (**Table C2-3**). A map of monitoring site locations is in **Figure 5-1** of the main document.

Table C2-2. Aerial Assessment Stream Segments.

Waterbody Segment	Number of Reaches	Number of Reaches and Sub-Reaches	Length (Miles)
Dog Creek	13	48	16.6
Elliston Creek	11	19	4.8
Little Blackfoot River, upstream of Dog Creek	25	50	21.5
Little Blackfoot River, downstream of Dog Creek	5	30	26.1
Snowshoe Creek	18	24	10.7
Spotted Dog Creek	12	23	11.1
Telegraph Creek	10	15	6.0
Threemile Creek	18	33	13.3
Trout Creek	17	38	11.5

C3.0 SEDIMENT AND HABITAT ASSESSMENT

C3.1 METHODS

Sediment and habitat data was collected following the approach described in *Longitudinal Field Methods for the Assessment of TMDL Sediment and Habitat Impairments* (Montana Department of Environmental Quality, 2007). Field monitoring sites were typically selected in relatively low-gradient portions of the study streams where sediment deposition is likely to occur. Other considerations in selecting field monitoring sites included representativeness of the reach to other reaches of the same slope, order, confinement and ecoregion, the extent of anthropogenic impacts relative to other reaches, and ease of access, as outlined in *Little Blackfoot River TMDL Planning Area Sediment Monitoring Sampling and Analysis Plan (Montana Department of Environmental Quality, 2009)*.

Sediment and habitat assessments were performed at 19 field monitoring sites, which were selected based on the aerial assessment in GIS and on-the-ground reconnaissance. Sediment and habitat data was collected within nine reach types (**Table C3-1**, **Figures C3-1** and **C3-2**). Monitoring sites were assessed progressing upstream and the length of the monitoring site was based on the bankfull channel width. A monitoring site length of 500 feet was used at four sites in which the bankfull width was less than 10 feet and a monitoring site length of 1,000 feet was used at 11 sites in which the bankfull width was between 10 feet and 50 feet. A monitoring site length of 2000 feet was used a four sites in which the bankfull width was greater than 50 feet. Each monitoring site was divided into five equally sized study cells in which a series of sediment and habitat measurements were performed. Study cells were numbered 1 through 5 progressing in an upstream direction. The following sections provide brief descriptions of the field methodologies employed during this assessment. A more in-depth description is available in *Longitudinal Field Methods for the Assessment of TMDL Sediment and Habitat Impairments* (Montana Department of Environmental Quality, 2007).

Table C3-1. Reach Types and Monitoring Sites.

Reach Type	Number of Reaches	Number of Monitoring Sites	Monitoring Sites
MR-0-1-U	1		
MR-0-2-C	2		
MR-0-2-U	28	2	SNOW18-05, TROU17-04
MR-0-3-C	4		
MR-0-3-U	33	4	DOG11-09, SPOT12-02, TELE10-02, THRE17-01
MR-0-4-U	34	3	DOG12-04, DOG13-03, LBR24-03
MR-0-5-U	30	3	LBR26-06, LBR27-06, LBR30-05
MR-10-1-C	7		
MR-10-1-U	14		
MR-2-1-U	5		
MR-2-2-C	8	2	ELLI08-01, ELLI08-02
MR-2-2-U	45	2	SPOT01-01, TROU15-01
MR-2-3-C	1		
MR-2-3-U	11	1	THRE16-01
MR-4-1-C	7		
MR-4-1-U	21	1	SNOW08-01
MR-4-2-C	9		
MR-4-2-U	10		
MR-4-3-U	5	1	TELE04-01

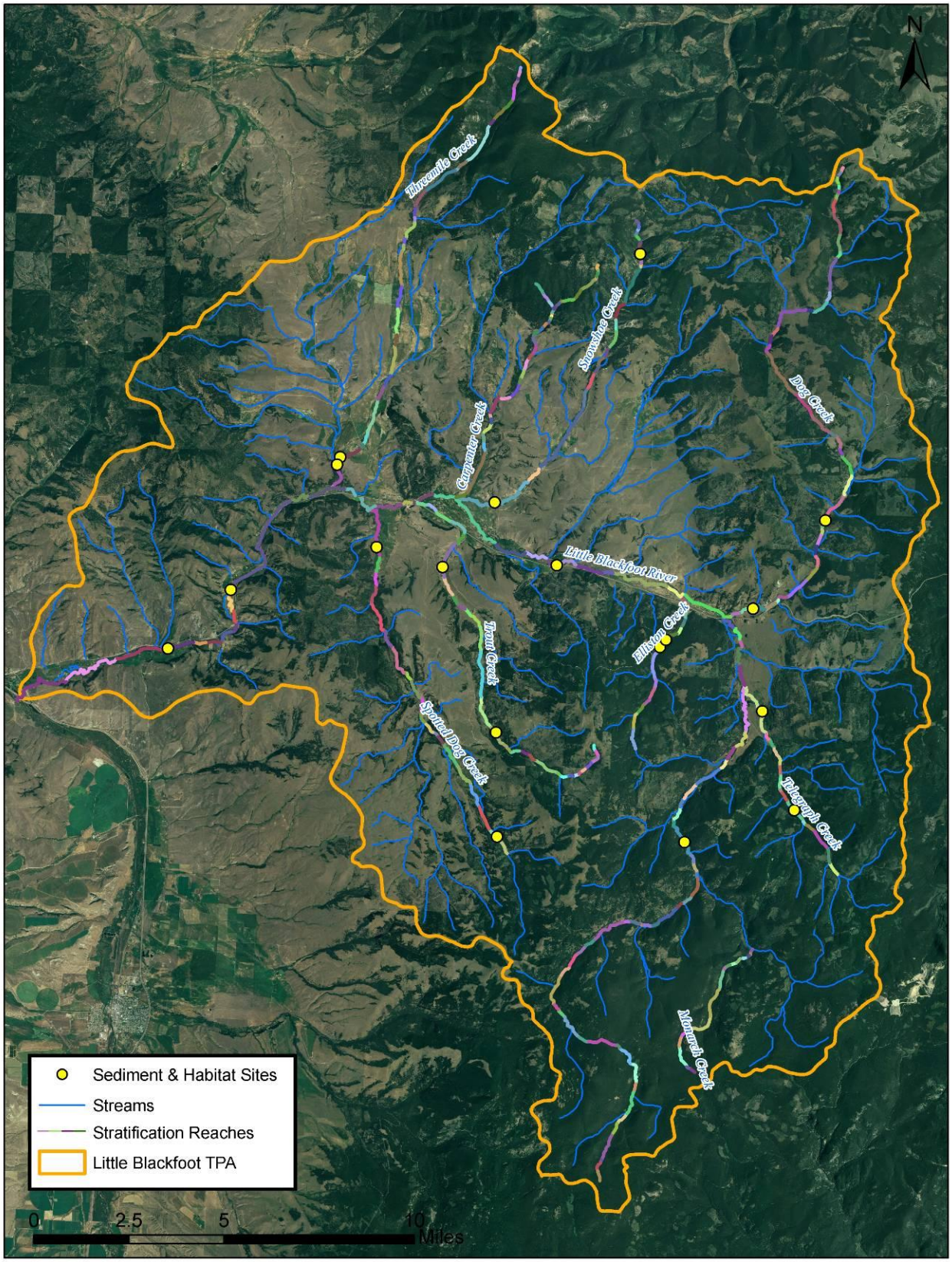


Figure C3-1. Aerial Assessment Reach Stratification.

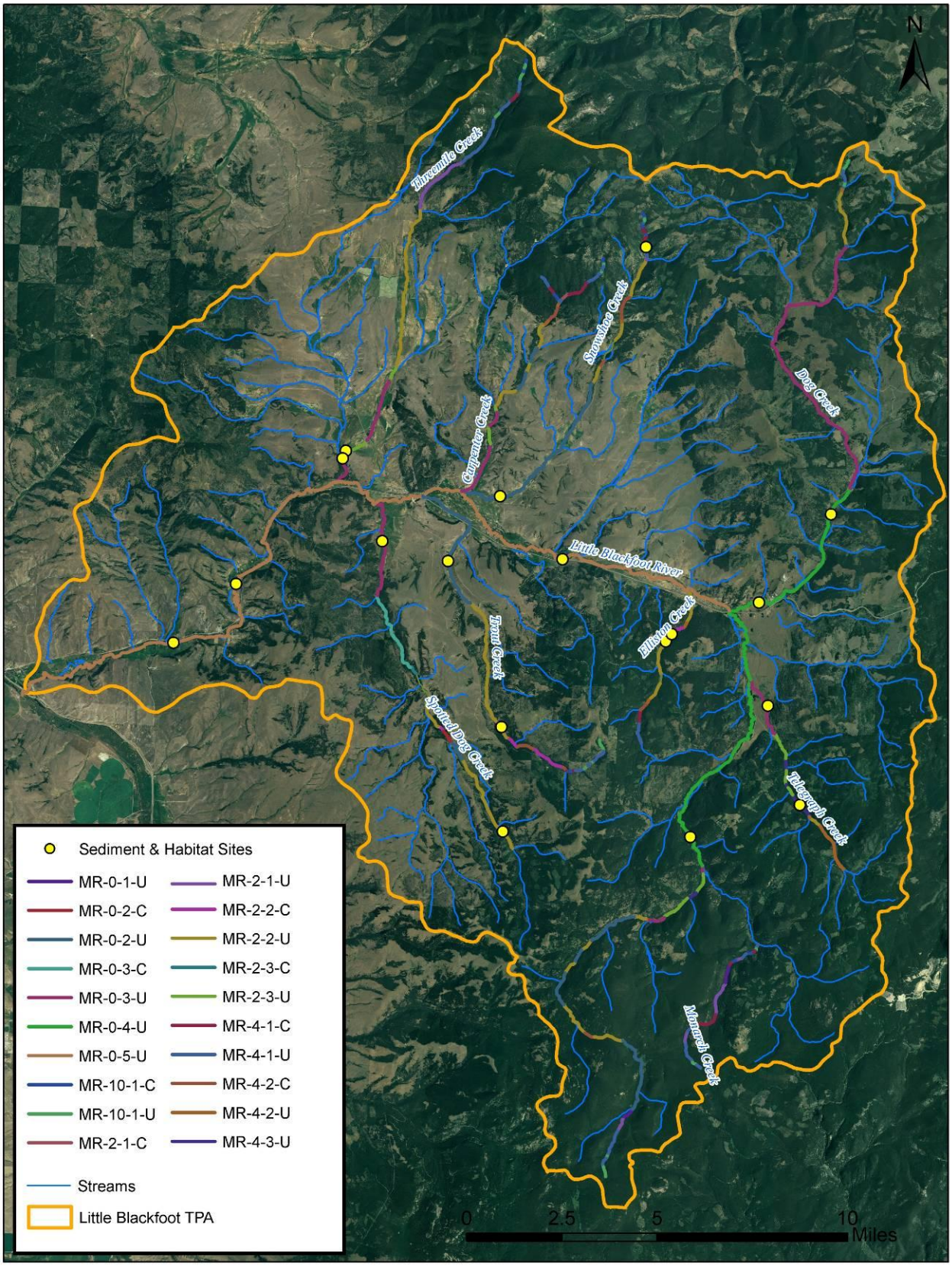


Figure C3-2. Distribution of Reach Types.

C3.1.1 Channel Form and Stability Measurements

Channel form and stability measurements include the field determination of bankfull, channel cross-sections, floodprone width, and surface water slope.

C3.1.1.1 Field Determination of Bankfull

The bankfull elevation was determined for each monitoring site. Bankfull is a concept used by hydrologists to define a regularly occurring channel-forming high flow. One of the first generally accepted definitions of bankfull was provided by Dunne and Leopold (1978):

> "The bankfull stage corresponds to the discharge at which channel maintenance is the most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels."

Indicators that were used to estimate the bankfull elevation included scour lines, changes in vegetation types, tops of point bars, changes in slope, changes in particle size and distribution, staining of rocks, and inundation features. Multiple locations and bankfull indicators were examined at each site to determine the bankfull elevation, which was then applied during channel cross-section measurements.

C3.1.1.2 Channel Cross-sections

Channel cross-section measurements were performed at the first riffle in each cell using a line level and a measuring rod. At each cross-section, depth measurements at bankfull were performed across the channel at regular intervals, which varied depending on channel width. The thalweg depth was recorded at the deepest point of the channel independent of the regularly spaced intervals.

C3.1.1.3 Floodprone Width Measurements

The floodprone elevation was determined by multiplying the maximum depth value by two (Rosgen, 1996). The floodprone width was then measured by stringing a tape from the bankfull channel margin on both the right and left banks until the tape (pulled tight and "flat") touched the ground at the floodprone elevation. When dense vegetation or other features prevented a direct line of tape from being strung, the floodprone width was estimated by pacing or making a visual estimate.

C3.1.1.4 Water Surface Slope

Water surface slope measurements were estimated using a clinometer. This measurement was used to evaluate the slope assigned in GIS based on the aerial assessment. The field measured slope was used when evaluating the Rosgen stream type at each monitoring site.

C3.1.2 Fine Sediment Measurements

Fine sediment measurements include the riffle pebble count, riffle grid toss, pool tail-out grid toss, and the riffle stability index.

C3.1.2.1 Riffle Pebble Count

One Wolman pebble count (Wolman, 1954) was performed at the first riffle encountered in cells 1, 3 and 5, providing a minimum of 300 particles measured within each assessment reach. Particle sizes were measured along their intermediate length axis (b-axis) and results were grouped into size categories. The pebble count was performed from bankfull to bankfull using the "heel to toe" method.

C3.1.2.2 Riffle Grid Toss

The riffle grid toss was performed at the same location as the pebble count measurement. The riffle grid toss measures fine sediment accumulation on the surface of the streambed. Grid tosses were performed prior to the pebble count to avoid disturbances to surface fine sediments.

C3.1.2.3 Pool Tail-out Grid Toss

A measurement of the percent of fine sediment in pool tail-outs was taken using the grid toss method at each pool in which potential spawning gravels were identified. Three measurements were taken in each pool with appropriate sized spawning gravels using a 49-point grid. The spawning potential was recorded as “Yes” (Y) or “Questionable” (Q). No grid toss measurements were made when the substrate was observed to be too large to support spawning. Grid toss measurements were performed when the substrate was observed to be too fine to support spawning since the goal of this assessment is to quantify fine sediment accumulation in spawning areas.

C3.1.2.4 Riffle Stability Index

In streams that had well-developed point bars, a Riffle Stability Index (RSI) evaluation was performed. For streams in which well-developed point bars were present, a total of three RSI measurements were conducted, which consisted of intermediate axis (b-axis) measurements of 15 particles determined to be among the largest size group of recently deposited particles that occur on over 10% of the point bar. During post-field data processing, the riffle stability index was determined by calculating the geometric mean of the dominant bar particle size measurements and comparing the result to the cumulative particle distribution from the riffle pebble count in an adjacent or nearby riffle.

C3.1.3 Instream Habitat Measurements

Instream habitat measurements include channel bed morphology, residual pool depth, pool habitat quality and woody debris quantification.

C3.1.3.1 Channel Bed Morphology

The length of each monitoring site occupied by pools and riffles was recorded progressing in an upstream direction. The upstream and downstream stations of “dominant” riffle and pool features were recorded. Features were considered “dominant” when occupying over 50% of the bankfull channel width.

C3.1.3.2 Residual Pool Depth

At each pool encountered, the maximum depth and the depth of the pool tail crest at its deepest point was measured. The difference between the maximum depth and the tail crest depth is considered the residual pool depth. No pool tail crest depth was recorded for dammed pools.

C3.1.3.3 Pool Habitat Quality

Qualitative assessments of each pool feature were undertaken, including pool type, size, formative feature, and cover type, along with the depth of any undercut banks associated with the pool. The total number of pools was also quantified.

C3.1.3.4 Woody Debris Quantification

The amount of large woody debris (LWD) within each monitoring site was recorded. Large pieces of woody debris located within the bankfull channel that were relatively stable so as to influence the channel form were counted as either single, aggregate or "willow bunch". A single piece of large woody debris was counted when it was greater than 9 feet long or spanned two-thirds of the wetted stream width, and 4 inches in diameter at the small end (Overton, et al., 1997).

C3.1.4 Riparian Health Measurements

Riparian health measurements include the riparian greenline assessment.

C3.1.4.1 Riparian Greenline Assessment

Along each monitoring site, an assessment of riparian vegetation cover was performed. Vegetation types were recorded at 10 to 20-foot intervals, depending on the bankfull channel width. The riparian greenline assessment described the general vegetation community type of the groundcover, understory and overstory on both banks. At 50-foot intervals, the riparian buffer width was estimated on either side of the channel. The riparian buffer width corresponds to the belt of vegetation buffering the stream from adjacent land uses.

C3.2 RESULTS

In the Little Blackfoot TPA, sediment and habitat parameters were assessed in July of 2009 at 19 monitoring sites. Out of the 19 reach types delineated in GIS, sediment and habitat assessments were performed in nine reach types, with a focus on low gradient reach types. A statistical analysis of the sediment and habitat data is presented by reach type and for individual monitoring sites in the following sections. The complete sediment and habitat dataset is presented in **Attachment A**.

C3.2.1 Reach Type Analysis

This section presents a statistical analysis of sediment and habitat base parameters for each of the reach types assessed in the Little Blackfoot TPA. For this assessment, stream reaches were grouped by stream order and bankfull channel width into the following groups:

- MR-0-2-U and MR-2-2-U
- MR-0-3-U and MR-2-3-U
- MR-0-4-U
- MR-0-5-U
- MR-2-2-C and MR-4-1-U
- MR-4-3-U

Reach type discussions are based on median values, while summary statistics for the minimum, 25th percentile, 75th percentile and maximum values are also provided since these may be more applicable for developing sediment TMDL criteria. Sediment and habitat base parameter analysis is provided by reach type for the following parameters:

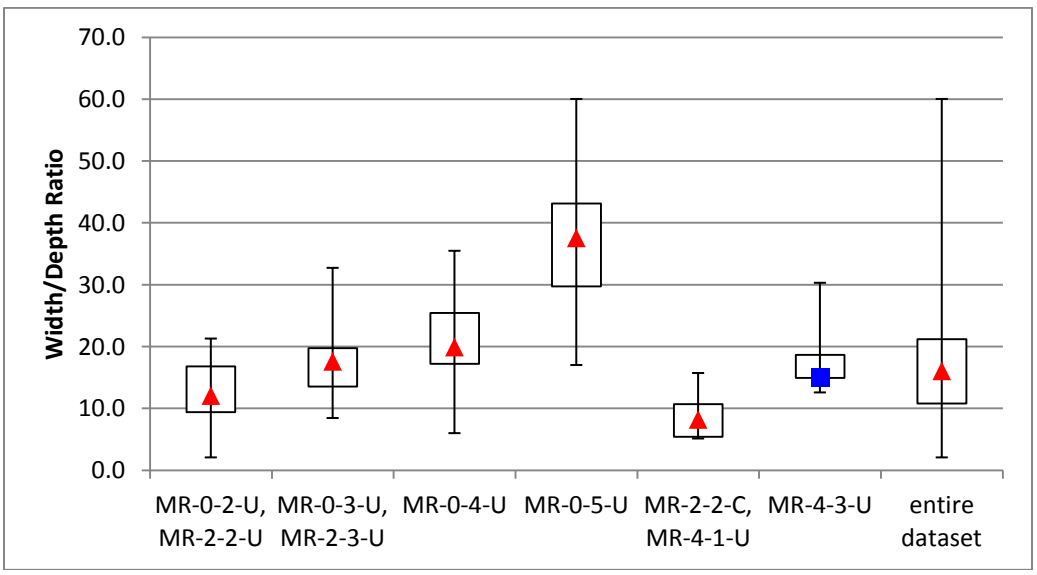
- width/depth ratio
- entrenchment ratio
- riffle pebble count <2mm
- riffle pebble count <6mm
- riffle grid-toss <6mm

- pool tail-out grid toss <6mm
- residual pool depth
- pool frequency
- LWD frequency
- greenline understory shrub cover
- greenline bare ground

C3.2.1.1 Width/Depth Ratio

The channel width/depth ratio is defined as the channel width at bankfull height divided by the mean bankfull depth (Rosgen, 1996). The channel width/depth ratio is one of several standard measurements used to classify stream channels, making it a useful variable for comparing conditions between reaches with the same stream type (Rosgen, 1996). A comparison of observed and expected width/depth ratios is also a useful indicator of channel over-widening and aggradation, which are often linked to excess streambank erosion and/or sediment inputs from sources upstream of the study reach. Channels that are over-widened are often associated with excess sediment deposition and streambank erosion, contain shallower and warmer water, and provide fewer deepwater habitat refugia for fish.

Median width/depth ratios for assessed reach types ranged from 8.2 in MR-2-2-C/MR-4-1-U to 37.6 in MR-0-5-U (**Figure C3-3, Table C3-2**). In the Little Blackfoot TPA, the width/depth ratio tends to increase as stream order increases.



Reach types with only one monitoring site denoted in blue square. Reach types with greater than one monitoring site denoted in red arrow.

Figure C3-3. Width/Depth Ratio.

Table C3-2. Width/Depth Ratio.

Statistical Parameter	Reach Type						
	MR-0-2-U, MR-2-2-U	MR-0-3-U, MR-2-3-U	MR-0-4-U	MR-0-5-U	MR-2-2-C, MR-4-1-U	MR-4-3-U	entire dataset
# of Monitoring Sites	4	5	3	3	3	1	19
Sample Size	15	18	15	11	13	5	77
Minimum	2.1	8.5	6.0	17.1	5.2	12.6	2.1

Table C3-2. Width/Depth Ratio.

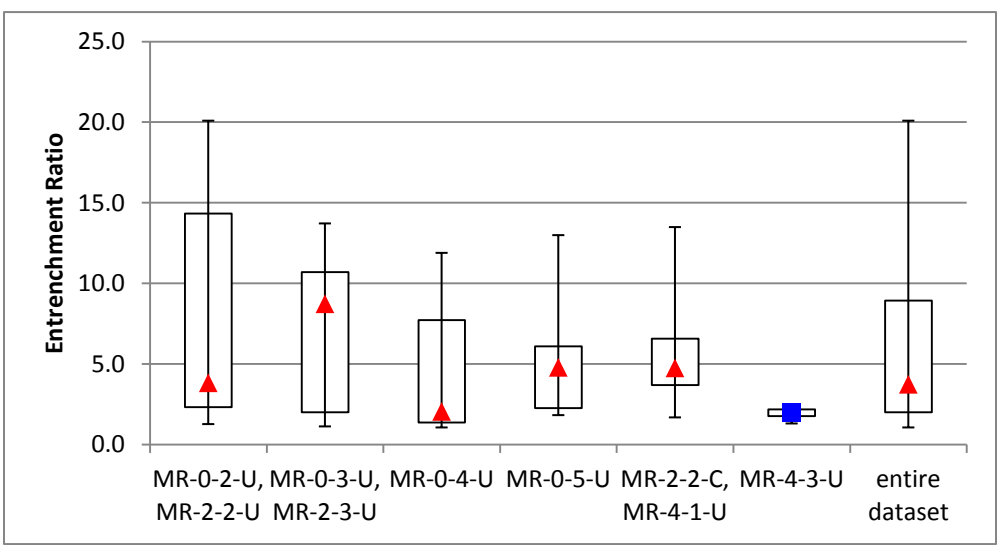
Statistical Parameter	Reach Type						
	MR-0-2-U, MR-2-2-U	MR-0-3-U, MR-2-3-U	MR-0-4-U	MR-0-5-U	MR-2-2-C, MR-4-1-U	MR-4-3-U	entire dataset
25th Percentile	9.4	13.6	17.2	29.8	5.4	15.0	10.8
Median	12.1	17.6	20.0	37.6	8.2	15.1	16.1
75th Percentile	16.8	19.7	25.4	43.1	10.7	18.6	21.2
Maximum	21.3	32.8	35.5	60.1	15.8	30.3	60.1
Monitoring Sites	SNOW18-05, TROU 15-01, TROU 17-04, SPOT01-01	DOG11-09, SPOT12-02, TELE10-02, THRE16-01, THRE17-01	DOG12-04, DOG13-03, LBR24-03	LBR26-06, LBR27-06, LBR30-05	ELLI08-01, ELLI08-02, SNOW08-01	TELE04-01	

Note: See **Table C2-1** for reach type descriptions.

C3.2.1.2 Entrenchment Ratio

A stream's entrenchment ratio is equal to the floodprone width divided by the bankfull width (Rosgen, 1996). The entrenchment ratio is used to help determine if a stream shows departure from its natural stream type and is an indicator of stream incision that describes how easily a stream can access its floodplain. Streams can become incised due to detrimental land management activities or may be naturally incised due to landscape characteristics. A stream that is overly entrenched generally is more prone to streambank erosion due to greater energy exerted on the banks during flood events. Greater scouring energy along incised channels results in higher sediment loads derived from eroding banks. If the stream is not actively degrading (down-cutting), the sources of human caused incision may be historical in nature, though sediment loading may continue to occur. The entrenchment ratio is an important measure of channel conditions since it relates to sediment loading and habitat condition.

The median entrenchment ratio for assessed reach types ranged from 2.0 in MR-4-3-U to 8.7 in MR-0-3-U/MR-2-3-U (**Figure C3-4, Table C3-3**).



Reach types with only one monitoring site denoted in blue square. Reach types with greater than one monitoring site denoted in red arrow.

Figure C3-4. Entrenchment Ratio.

Table C3-3. Entrenchment Ratio

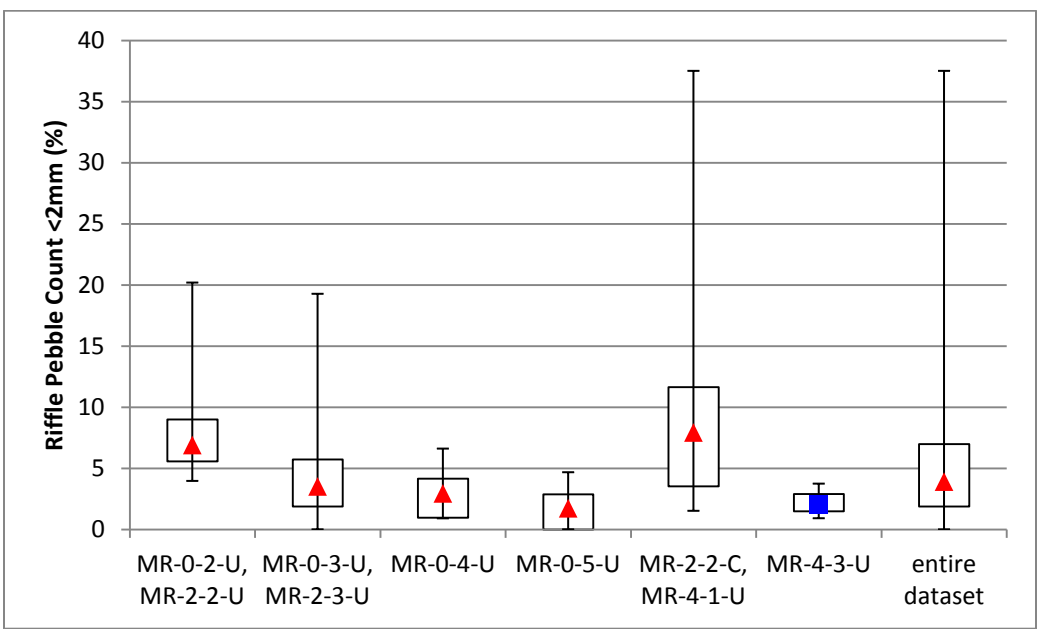
Statistical Parameter	Reach Type						
	MR-0-2-U, MR-2-2-U	MR-0-3-U, MR-2-3-U	MR-0-4-U	MR-0-5-U	MR-2-2-C, MR-4-1-U	MR-4-3-U	entire dataset
# of Monitoring Sites	4	5	3	3	3	1	19
Sample Size	15	18	15	11	13	5	77
Minimum	1.3	1.1	1.1	1.8	1.7	1.3	1.1
25th Percentile	2.3	2.0	1.4	2.3	3.7	1.8	2.0
Median	3.8	8.7	2.1	4.8	4.8	2.0	3.7
75th Percentile	14.3	10.7	7.7	6.1	6.6	2.2	8.9
Maximum	20.1	13.7	11.9	13.0	13.5	2.3	20.1
Monitoring Sites	SNOW18-05, TROU 15-01, TROU 17-04, SPOT01-01	DOG11-09, SPOT12-02, TELE10-02, THRE16-01, THRE17-01	DOG12-04, DOG13-03, LBR24-03	LBR26-06, LBR27-06, LBR30-05	ELLI08-01, ELLI08-02, SNOW08-01	TELE04-01	

Note: See **Table C2-1** for reach type descriptions.

C3.2.1.3 Riffle Pebble Count <2mm

Percent surface fine sediment provides a good measure of the siltation occurring in a river system. Surface fine sediment measured using the Wolman (1954) pebble count method is one indicator of aquatic habitat condition and can signify excessive sediment loading. The Wolman pebble count provides a survey of the particle distribution of the entire channel width, allowing investigators to calculate a percentage of the surface substrate (as frequency of occurrence) composed of fine sediment.

Median values for the percent of fine sediment <2mm based on riffle pebble counts ranged from 2% in MR-0-5-U and MR-4-3-U to 8% in MR-2-2-C/MR-4-1-U (**Figure C3-5**, **Table C3-4**).



Reach types with only one monitoring site denoted in blue squares. Reach types with greater than one monitoring site denoted in red arrows.

Figure C3-5. Riffle Pebble Count <2mm.

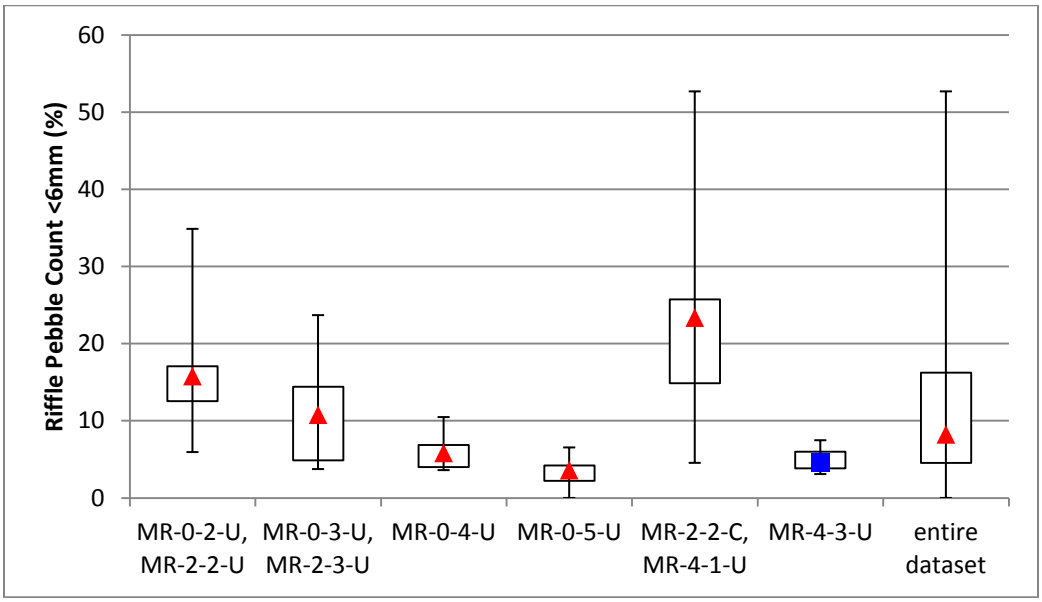
Table C3-4. Riffle Pebble Count <2mm.

Statistical Parameter	Reach Type						
	MR-0-2-U, MR-2-2-U	MR-0-3-U, MR-2-3-U	MR-0-4-U	MR-0-5-U	MR-2-2-C, MR-4-1-U	MR-4-3-U	entire dataset
# of Monitoring Sites	4	5	3	3	3	1	19
Sample Size	12	13	9	8	9	3	54
Minimum	4	0	1	0	2	1	0
25th Percentile	6	2	1	0	4	1	2
Median	7	4	3	2	8	2	4
75th Percentile	9	6	4	3	12	3	7
Maximum	20	19	7	5	38	4	38
Monitoring Sites	SNOW18-05, TROU 15-01, TROU 17-04, SPOT01-01	DOG11-09, SPOT12-02, TELE10-02, THRE16-01, THRE17-01	DOG12-04, DOG13-03, LBR24-03	LBR26-06, LBR27-06, LBR30-05	ELLI08-01, ELLI08-02, SNOW08-01	TELE04-01	

Note: See **Table C2-1** for reach type descriptions.

C3.2.1.4 Riffle Pebble Count <6mm

As with surface fine sediment <2mm, an accumulation of surface fine sediment <6mm may indicate excess sedimentation. Median values for the percent of fine sediment <6mm based on pebble counts conducted in riffles ranged from 4% in MR-0-5-U to 23% in MR-2-2-C/MR-4-1-U (**Figure C3-6, Table C3-5**). The percent of fine sediment <6mm followed the same general trend as the percent of fine sediment <2mm.



Reach types with only one monitoring site denoted in blue squares. Reach types with greater than one monitoring site denoted in red arrows.

Figure C3-6. Riffle Pebble Count <6mm.

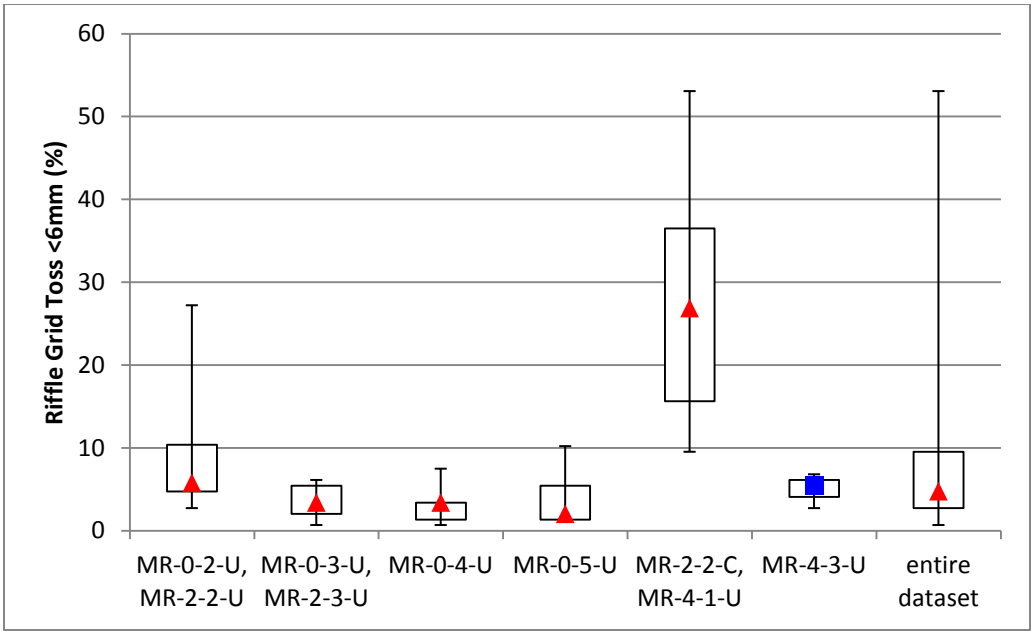
Table C3-5. Riffle Pebble Count <6mm.

Statistical Parameter	Reach Type						
	MR-0-2-U, MR-2-2-U	MR-0-3-U, MR-2-3-U	MR-0-4-U	MR-0-5-U	MR-2-2-C, MR-4-1-U	MR-4-3-U	entire dataset
# of Monitoring Sites	4	5	3	3	3	1	19
Sample Size	12	13	9	8	9	3	54
Minimum	6	4	4	0	5	3	0
25th Percentile	13	5	4	2	15	4	5
Median	16	11	6	4	23	5	8
75th Percentile	17	14	7	4	26	6	16
Maximum	35	24	10	7	53	7	53
Monitoring Sites	SNOW18-05, TROU 15-01, TROU 17-04, SPOT01-01	DOG11-09, SPOT12-02, TELE10-02, THRE16-01, THRE17-01	DOG12-04, DOG13-03, LBR24-03	LBR26-06, LBR27-06, LBR30-05	ELLI08-01, ELLI08-02, SNOW08-01	TELE04-01	

Note: See **Table C2-1** for reach type descriptions.

C3.2.1.5 Riffle Grid Toss <6mm

The riffle grid toss is a standard procedure frequently used in aquatic habitat assessment that provides complimentary information to the Wolman pebble count. Median values for riffle grid toss fine sediment <6mm in the Little Blackfoot TPA range from 2% in MR-0-5-U to 27% in MR-2-2-C/MR-4-1-U (**Figure C3-7, Table C3-6**).



Reach types with only one monitoring site denoted in blue squares. Reach types with greater than one monitoring site denoted in red arrows.

Figure C3-7. Riffle Grid Toss Fine Sediment <6mm.

Table C3-6. Riffle Grid Toss Fine Sediment <6mm.

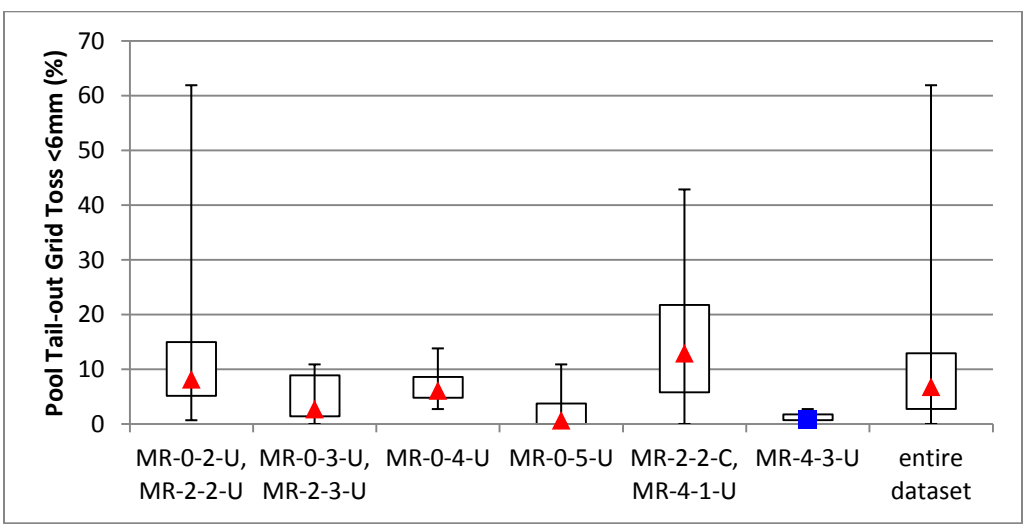
Statistical Parameter	Reach Type						
	MR-0-2-U, MR-2-2-U	MR-0-3-U, MR-2-3-U	MR-0-4-U	MR-0-5-U	MR-2-2-C, MR-4-1-U	MR-4-3-U	entire dataset
# of Monitoring Sites	4	5	3	3	3	1	19
Sample Size	12	9	9	7	8	3	48
Minimum	3	1	1	1	10	3	1
25th Percentile	5	2	1	1	16	4	3
Median	6	3	3	2	27	5	5
75th Percentile	10	5	3	5	36	6	10
Maximum	27	6	7	10	53	7	53
Monitoring Sites	SNOW18-05, TROU 15-01, TROU 17-04, SPOT01-01	DOG11-09, SPOT12-02, TELE10-02, THRE16-01, THRE17-01	DOG12-04, DOG13-03, LBR24-03	LBR26-06, LBR27-06, LBR30-05	ELLI08-01, ELLI08-02, SNOW08-01	TELE04-01	

Note: See **Table C2-1** for reach type descriptions.

C3.2.1.6 Pool Tail-out Grid Toss <6mm

Grid toss measurements in pool tail-outs provide a measure of fine sediment accumulation in potential spawning sites, which may have detrimental impacts on aquatic habitat by cementing spawning gravels, preventing flushing of toxins in egg beds, reducing oxygen and nutrient delivery to eggs and embryos, and impairing emergence of fry (Meehan, 1991). Weaver and Fraley (1991) observed a significant inverse relationship between the percentage of material less than 6.35mm and the emergence success of westslope cutthroat trout and bull trout.

Median values for pool tail-out grid toss fine sediment <6mm range from 1% in MR-0-5-U and MR-4-3-U to 13% in MR-2-2-C/MR-4-1-U (**Figure C3-8, Table C3-7**).



Reach types with only one monitoring site denoted in blue squares. Reach types with greater than one monitoring site denoted in red arrows.

Figure C3-8. Pool Tail-out Grid Toss <6mm.

Table C3-7. Pool Tail-out Grid Toss <6mm.

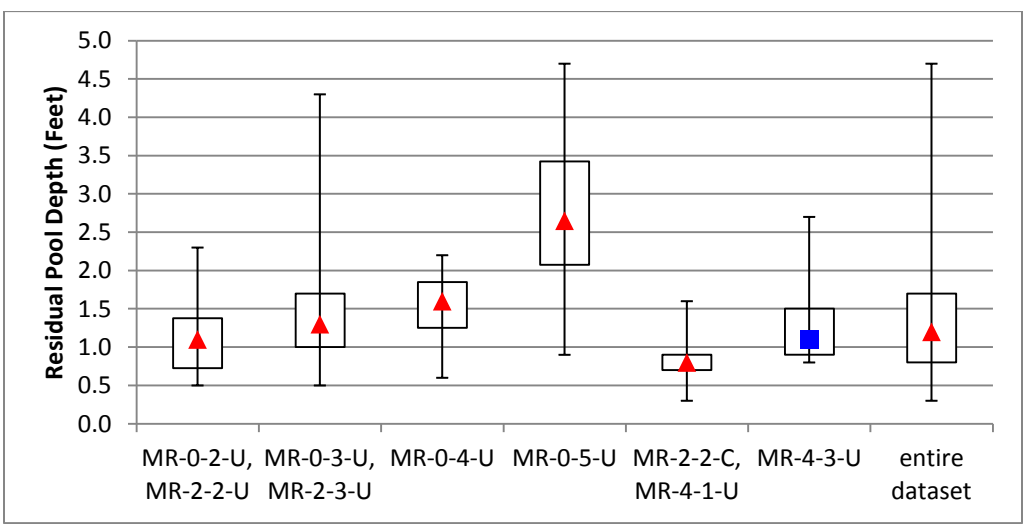
Statistical Parameter	Reach Type						
	MR-0-2-U, MR-2-2-U	MR-0-3-U, MR-2-3-U	MR-0-4-U	MR-0-5-U	MR-2-2-C, MR-4-1-U	MR-4-3-U	entire dataset
# of Monitoring Sites	4	5	3	3	3	1	19
Sample Size	39	13	4	11	23	3	93
Minimum	1	0	3	0	0	1	0
25th Percentile	5	1	5	0	6	1	3
Median	8	3	6	1	13	1	7
75th Percentile	15	9	9	4	22	2	13
Maximum	62	11	14	11	43	3	62
Monitoring Sites	SNOW18-05, TROU 15-01, TROU 17-04, SPOT01-01	DOG11-09, SPOT12-02, TELE10-02, THRE16-01, THRE17-01	DOG12-04, DOG13-03, LBR24-03	LBR26-06, LBR27-06, LBR30-05	ELLI08-01, ELLI08-02, SNOW08-01	TELE04-01	

Note: See **Table C2-1** for reach type descriptions.

C3.2.1.7 Residual Pool Depth

Residual pool depth, defined as the difference between the maximum depth and the tail crest depth, is a discharge-independent measure of pool depth and an indicator of the quality of pool habitat. Deep pools are important resting and hiding habitat for fish, and provide refugia during temperature extremes and high flow periods. Residual pool depth is also an indirect measurement of sediment inputs to streams since an increase in sediment loading would be expected to cause pools to fill, thus decreasing residual pool depth over time.

Median residual pool depths ranged from 0.8 feet in MR-2-2-C/MR-4-1-U to 2.7 feet in MR-0-5-U (**Figure C3-9, Table C3-8**). This analysis indicates that the deepest pools are found in the Little Blackfoot River downstream of the confluence with Dog Creek. In the Little Blackfoot TPA, residual pool depth tends to increase as stream order increases.



Reach types with only one monitoring site denoted in blue squares. Reach types with greater than one monitoring site denoted in red arrows.

Figure C3-9. Residual Pool Depth.

Table C3-8. Residual Pool Depth.

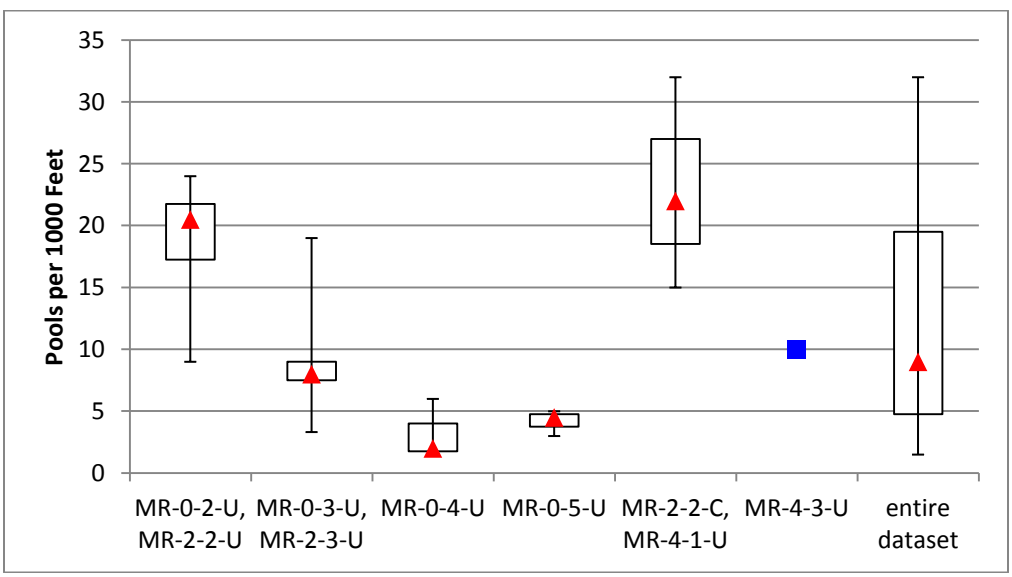
Statistical Parameter	Reach Type						
	MR-0-2-U, MR-2-2-U	MR-0-3-U, MR-2-3-U	MR-0-4-U	MR-0-5-U	MR-2-2-C, MR-4-1-U	MR-4-3-U	entire dataset
# of Monitoring Sites	4	5	3	3	3	1	19
Sample Size	58	41	11	24	30	9	173
Minimum	0.5	0.5	0.6	0.9	0.3	0.8	0.3
25th Percentile	0.7	1.0	1.3	2.1	0.7	0.9	0.8
Median	1.1	1.3	1.6	2.7	0.8	1.1	1.2
75th Percentile	1.4	1.7	1.9	3.4	0.9	1.5	1.7
Maximum	2.3	4.3	2.2	4.7	1.6	2.7	4.7
Monitoring Sites	SNOW18-05, TROU 15-01, TROU 17-04, SPOT01-01	DOG11-09, SPOT12-02, TELE10-02, THRE16-01, THRE17-01	DOG12-04, DOG13-03, LBR24-03	LBR26-06, LBR27-06, LBR30-05	ELLI08-01, ELLI08-02, SNOW08-01	TELE04-01	

Note: See **Table C2-1** for reach type descriptions.

C3.2.1.8 Pool Frequency

Pool frequency is a measure of the availability of pools to provide rearing habitat, cover, and refugia for salmonids. Pool frequency is related to channel complexity, availability of stable obstacles, and sediment supply. Excessive erosion and sediment deposition can reduce pool frequency by filling in smaller pools. Pool frequency can also be adversely affected by riparian habitat degradation resulting in a reduced supply of large woody debris or scouring from stable root masses in streambanks.

The median value for the number of pools per 1,000 feet ranged from two in MR-0-4-U to 22 in MR-2-2-C/MR-4-1-U (**Figure C3-10, Table C3-9**). Pool frequency tends to decrease as stream order increases in the Little Blackfoot TPA.



Reach types with only one monitoring site denoted in blue squares. Reach types with greater than one monitoring site denoted in red arrows.

Figure C3-10. Pools per 1000 Feet.

Table C3-9. Pools per 1000 feet.

Statistical Parameter	Reach Type						
	MR-0-2-U, MR-2-2-U	MR-0-3-U, MR-2-3-U	MR-0-4-U	MR-0-5-U	MR-2-2-C, MR-4-1-U	MR-4-3-U	entire dataset
# of Monitoring Sites	4	5	3	3	3	**1**	19
Sample Size	4	5	3	3	3	**1**	19
Minimum	9	3	2	3	15	**10**	2
25th Percentile	17	8	2	4	19	**10**	5
Median	21	8	2	5	22	**10**	9
75th Percentile	22	9	4	5	27	**10**	20
Maximum	24	19	6	5	32	**10**	32
Monitoring Sites	SNOW18-05, TROU 15-01, TROU 17-04, SPOT01-01	DOG11-09, SPOT12-02, TELE10-02, THRE16-01, THRE17-01	DOG12-04, DOG13-03, LBR24-03	LBR26-06, LBR27-06, LBR30-05	ELLI08-01, ELLI08-02, SNOW08-01	TELE04-01	

Note: See **Table C2-1** for reach type descriptions. Reach types with only one monitoring site denoted in **bold** italics.

Pool frequency data is also provided as pools per mile in **Table C3-10** for future TMDL applications.

Table C3-10. Pools per Mile.

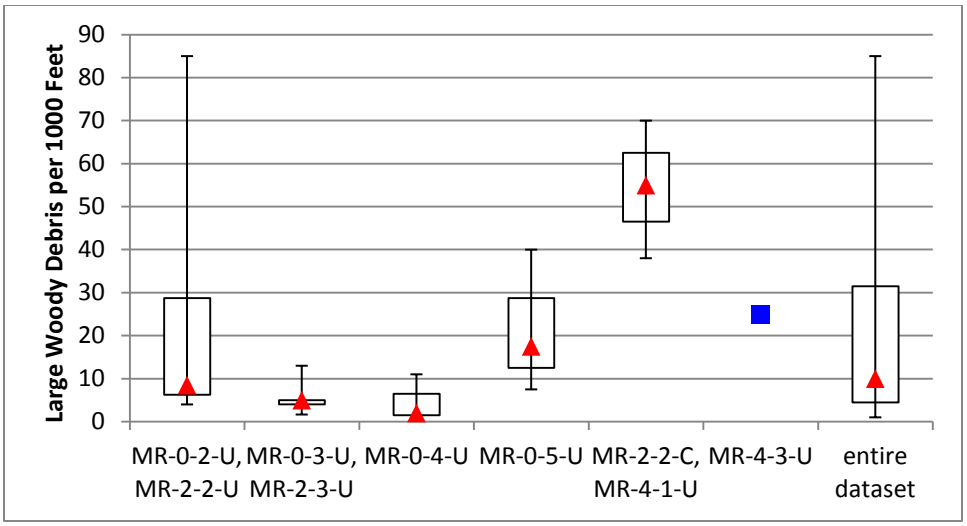
Statistical Parameter	Reach Type						
	MR-0-2-U, MR-2-2-U	MR-0-3-U, MR-2-3-U	MR-0-4-U	MR-0-5-U	MR-2-2-C, MR-4-1-U	MR-4-3-U	entire dataset
Minimum	48	18	8	16	79	**53**	8
25th Percentile	91	40	9	20	98	**53**	25
Median	108	42	11	24	116	**53**	48
75th Percentile	115	48	21	25	143	**53**	103
Maximum	127	100	32	26	169	**53**	169

Note: See **Table C2-1** for reach type descriptions. Reach types with only one monitoring site denoted in **bold** italics.

C3.2.1.9 Large Woody Debris Frequency

Large woody debris (LWD) is a critical component of high-quality salmonid habitat, providing habitat complexity, quality pool habitat, cover, and long-term nutrient inputs. LWD also constitutes a primary influence on stream function, including sediment and organic material transport, channel form, bar formation and stabilization, and flow dynamics (Bilby and Ward, 1989). LWD frequency can be measured and compared to reference reaches or literature values to determine if more or less LWD is present than would be expected under optimal conditions.

The median value for the amount of large woody debris (LWD) per 1,000 feet ranged from two in MR-0-4-U to 55 in MR-2-2-C/MR-4-1-U (**Figure C3-11, Table C3-11**). Note that “willow bunches” assigned in the field were tallied as large woody debris. Thus, this analysis makes no distinction as to the size of the woody material.



Reach types with only one monitoring site denoted in blue squares. Reach types with greater than one monitoring site denoted in red arrows.

Figure C3-11. Large Woody Debris per 1000 Feet.

Table C3-11. Large Woody Debris per 1000 Feet.

Statistical Parameter	Reach Type						
	MR-0-2-U, MR-2-2-U	MR-0-3-U, MR-2-3-U	MR-0-4-U	MR-0-5-U	MR-2-2-C, MR-4-1-U	MR-4-3-U	entire dataset
# of Monitoring Sites	4	5	3	3	3	**1**	19
Sample Size	4	5	3	3	3	**1**	19
Minimum	4	2	1	8	38	**25**	1
25th Percentile	6	4	2	13	47	**25**	5
Median	9	5	2	18	55	**25**	10
75th Percentile	29	5	7	29	63	**25**	32
Maximum	85	13	11	40	70	**25**	85
Monitoring Sites	SNOW18-05, TROU 15-01, TROU 17-04, SPOT01-01	DOG11-09, SPOT12-02, TELE10-02, THRE16-01, THRE17-01	DOG12-04, DOG13-03, LBR24-03	LBR26-06, LBR27-06, LBR30-05	ELLI08-01, ELLI08-02, SNOW08-01	TELE04-01	

Note: See **Table C2-1** for reach type descriptions. Reach types with only one monitoring site denoted in **bold** italics.

Data is also provided as large woody debris per mile in **Table C3-12** for future TMDL applications.

Table C3-12. Large Woody Debris per Mile.

Statistical Parameter	Reach Type						
	MR-0-2-U, MR-2-2-U	MR-0-3-U, MR-2-3-U	MR-0-4-U	MR-0-5-U	MR-2-2-C, MR-4-1-U	MR-4-3-U	entire dataset
Minimum	21	9	5	40	201	**132**	5
25th Percentile	33	21	8	66	246	**132**	24
Median	45	26	11	92	290	**132**	53
75th Percentile	152	26	34	152	330	**132**	166
Maximum	449	69	58	211	370	**132**	449

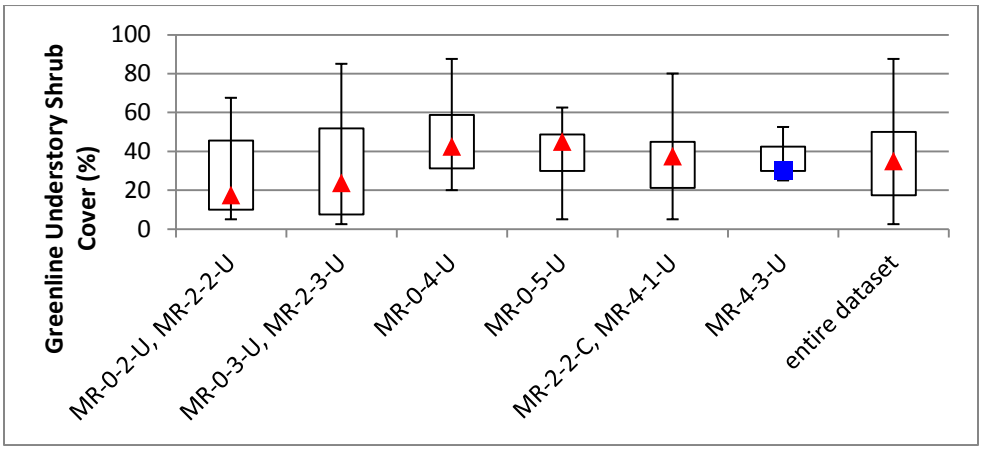
Note: See **Table C2-1** for reach type descriptions. Reach types with only one monitoring site denoted in **bold** italics.

C3.3.1.10 Greenline Understory Shrub Cover

Riparian shrub cover is one of the most important influences on streambank stability. Removal of riparian shrub cover can dramatically increase streambank erosion and increase channel width/depth ratios. Shrubs stabilize streambanks by holding soil and armoring lower banks with their roots, and reduce scouring energy of water by slowing flows with their branches.

Good riparian shrub cover is also important for fish habitat. Riparian shrubs provide shade, reducing solar inputs and increases in water temperature. The dense network of fibrous roots of riparian shrubs allows streambanks to remain intact while water scours the lowest portion of streambanks, creating important fish habitat in the form of overhanging banks and lateral scour pools. Overhanging branches of riparian shrubs provide important cover for aquatic species. In addition, riparian shrubs provide critical inputs of food for fish and their feed species. Terrestrial insects falling from riparian shrubs provide one of the main food sources for fish. Organic inputs from shrubs, such as leaves and small twigs, provide food for aquatic macroinvertebrates, which are also an important food source for fish.

The median value for greenline understory shrub cover ranged from 18% in MR-0-2-U/MR-2-2-U to 45% in MR-0-5-U (**Figure C3-12, Table C3-13**).



Reach types with only one monitoring site denoted in blue squares. Reach types with greater than one monitoring site denoted in red arrows.

Figure C3-12. Greenline Understory Shrub Cover.

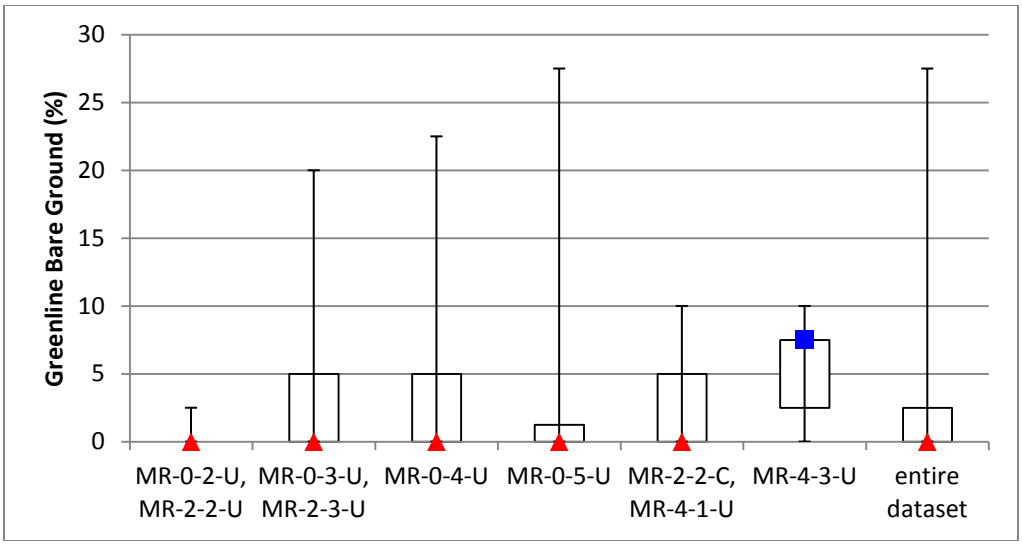
Table C3-13. Greenline Understory Shrub Cover.

Statistical Parameter	Reach Type						
	MR-0-2-U, MR-2-2-U	MR-0-3-U, MR-2-3-U	MR-0-4-U	MR-0-5-U	MR-2-2-C, MR-4-1-U	MR-4-3-U	entire dataset
# of Monitoring Sites	4	5	3	3	3	1	19
Sample Size	20	20	15	15	15	5	90
Minimum	5	3	20	5	5	25	3
25th Percentile	10	8	31	30	21	30	18
Median	18	24	43	45	38	30	35
75th Percentile	46	52	59	49	45	43	50
Maximum	68	85	88	63	80	53	88
Monitoring Sites	SNOW18-05, TROU 15-01, TROU 17-04, SPOT01-01	DOG11-09, SPOT12-02, TELE10-02, THRE16-01, THRE17-01	DOG12-04, DOG13-03, LBR24-03	LBR26-06, LBR27-06, LBR30-05	ELLI08-01, ELLI08-02, SNOW08-01	TELE04-01	

C3.2.1.11 Greenline Bare Ground

Percent bare ground is an important indicator of erosion potential, as well as an indicator of land management influences on riparian habitat. Bare ground was noted in the greenline inventory in cases where recent ground disturbance has resulted in exposed bare soil. Bare ground is often caused by trampling from livestock or wildlife, fallen trees, recent bank failure, new sediment deposits from overland or overbank flow, or severe disturbance in the riparian area, such as from past mining, road-building, or fire. Ground cover on streambanks is important to prevent sediment recruitment to stream channels since sediment can wash in from unprotected areas during snowmelt, storm runoff and flooding. Bare areas are also much more susceptible to erosion from hoof shear. Most stream reaches have a small amount of naturally-occurring bare ground. As conditions are highly variable, this measurement is most useful when compared to reference values from best available conditions within the study area or literature values.

The median value for greenline bare ground was 0% in all of the reach types except MR-4-3-U, which had a median value of 8% (**Figure C3-13, Table C3-14**).



Reach types with only one monitoring site denoted in blue squares. Reach types with greater than one monitoring site denoted in red arrows.

Figure C3-13. Greenline Bare Ground.

Table C3-14. Greenline Bare Ground.

Statistical Parameter	Reach Type						
	MR-0-2-U, MR-2-2-U	MR-0-3-U, MR-2-3-U	MR-0-4-U	MR-0-5-U	MR-2-2-C, MR-4-1-U	MR-4-3-U	entire dataset
# of Monitoring Sites	4	5	3	3	3	1	19
Sample Size	20	20	15	15	15	5	90
Minimum	0	0	0	0	0	0	0
25th Percentile	0	0	0	0	0	3	0
Median	0	0	0	0	0	8	0
75th Percentile	0	5	5	1	5	8	3
Maximum	3	20	23	28	10	10	28
Monitoring Sites	SNOW18-05, TROU 15-01, TROU 17-04, SPOT01-01	DOG11-09, SPOT12-02, TELE10-02, THRE16-01, THRE17-01	DOG12-04, DOG13-03, LBR24-03	LBR26-06, LBR27-06, LBR30-05	ELLI08-01, ELLI08-02, SNOW08-01	TELE04-01	

Note: See **Table C2-1** for reach type descriptions.

C3.2.2 Monitoring Site Analysis

Sediment and habitat data collected at each monitoring site was reviewed individually in the following sections. Monitoring site discussions are based on median values. Summary statistics for the minimum, 25th percentile, 75th percentile and maximum values are presented graphically, since these may be more applicable for developing sediment TMDL criteria.

C3.2.2.1 Width/Depth Ratio

The highest median width/depth ratio was observed in LBR27-06 (**Figure C3-14**). In the Little Blackfoot TPA, width/depth ratios generally increased in the downstream direction, which is the expected result as streams become larger.

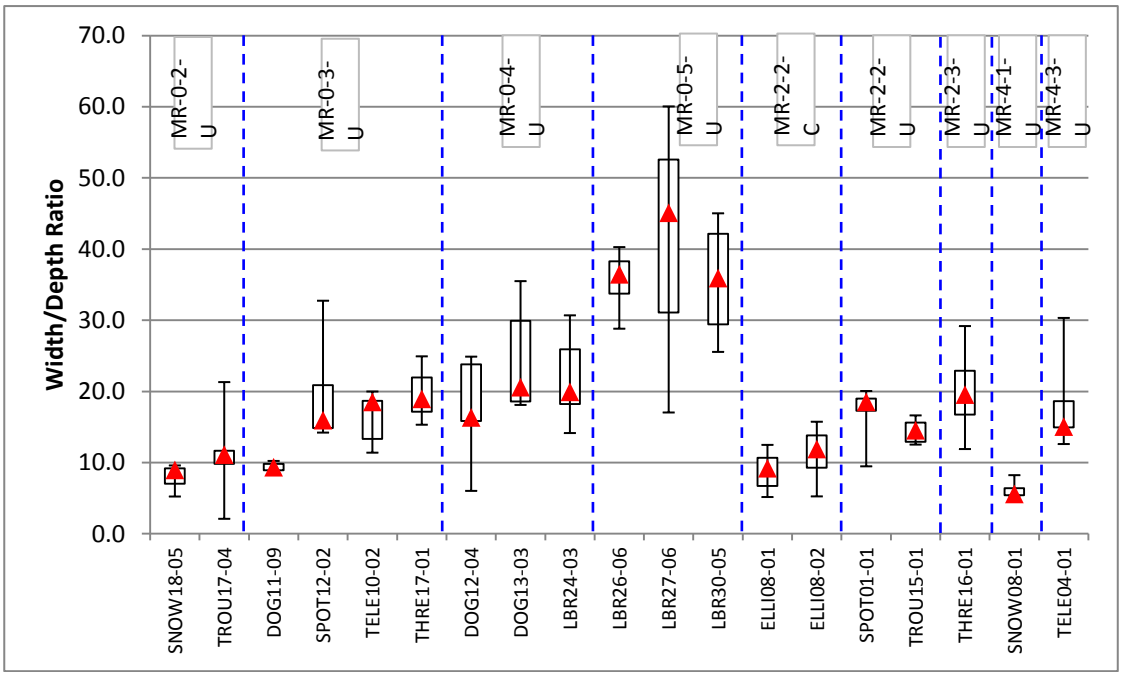


Figure C3-14. Width/Depth Ratio.

C3.2.2.2 Entrenchment Ratio

Entrenchment ratio data collected within the Little Blackfoot TPA indicates the following (**Figure C3-15**):

1. TROU17-04 has the greatest amount of floodplain access out of the sites assessed.
2. Entrenched conditions were documented in TELE10-02, DOG13-03, LBR30-05 and TELE04-01. Within the Little Blackfoot TPA, entrenched conditions are primarily the result of historic and ongoing agricultural practices and channelization due to railroad and road construction.

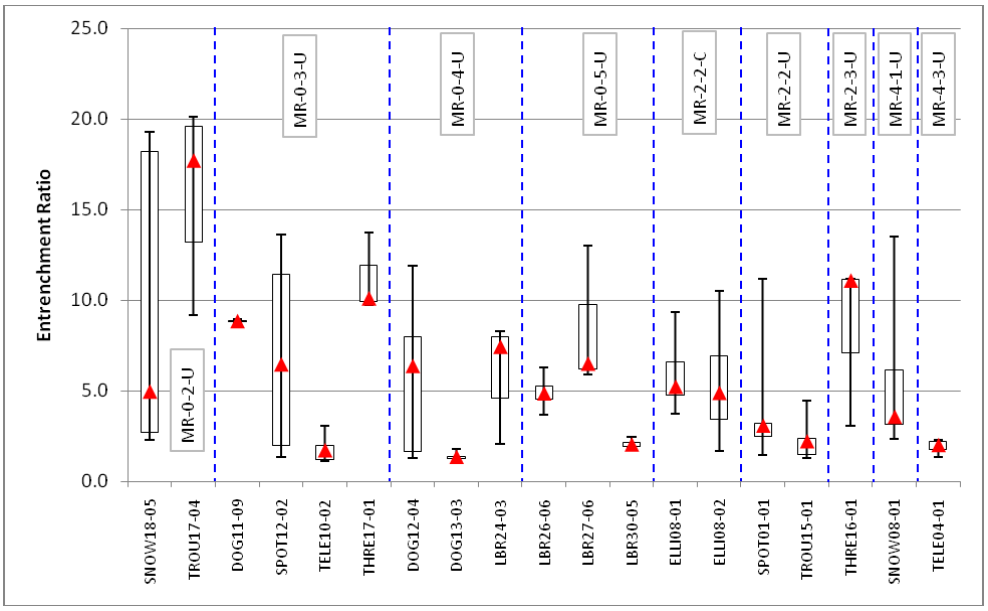


Figure C3-15. Entrenchment Ratio.

C3.2.2.3 Riffle Pebble Count <2mm

The median percent of fine sediment in riffles <2mm as measured by a pebble count was highest in ELLI08-01 and THRE16-01 (**Figure C3-16**).

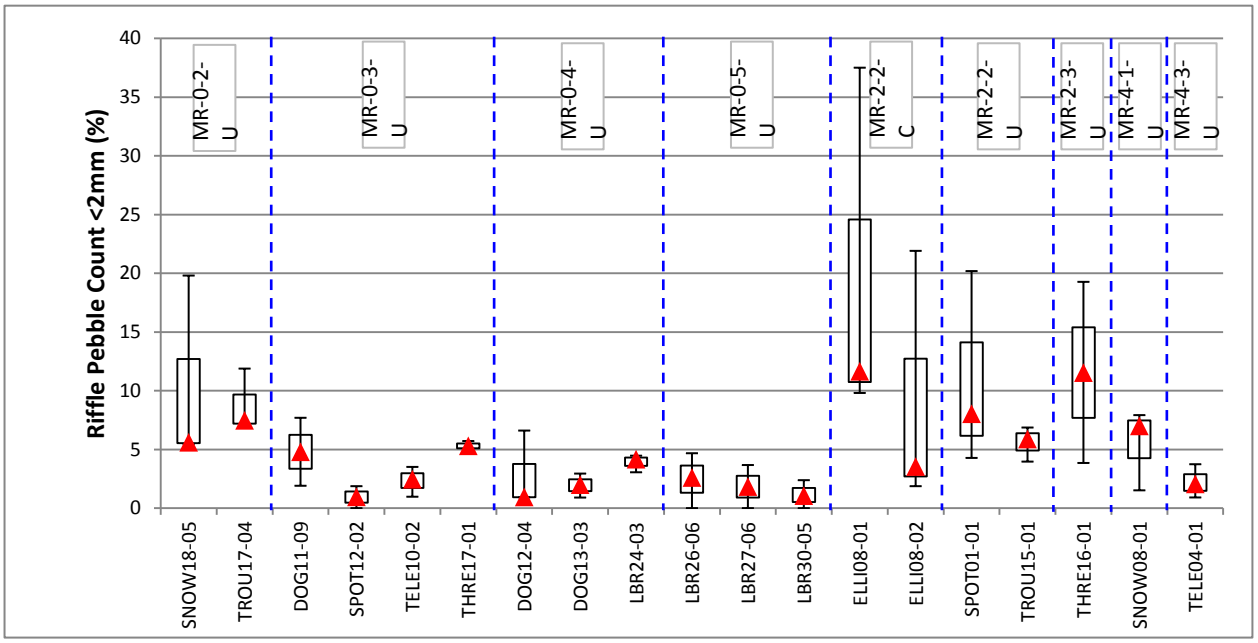


Figure C3-16. Riffle Pebble Count <2mm.

C3.2.2.4 Riffle Pebble Count <6mm

The percent of fine sediment in riffles <6mm as measured by a pebble count followed a similar trend as the percent of fine sediment <2mm, with the highest median values in ELLI08-01, ELLI08-02 and THRE16-01 (**Figure C3-17**).

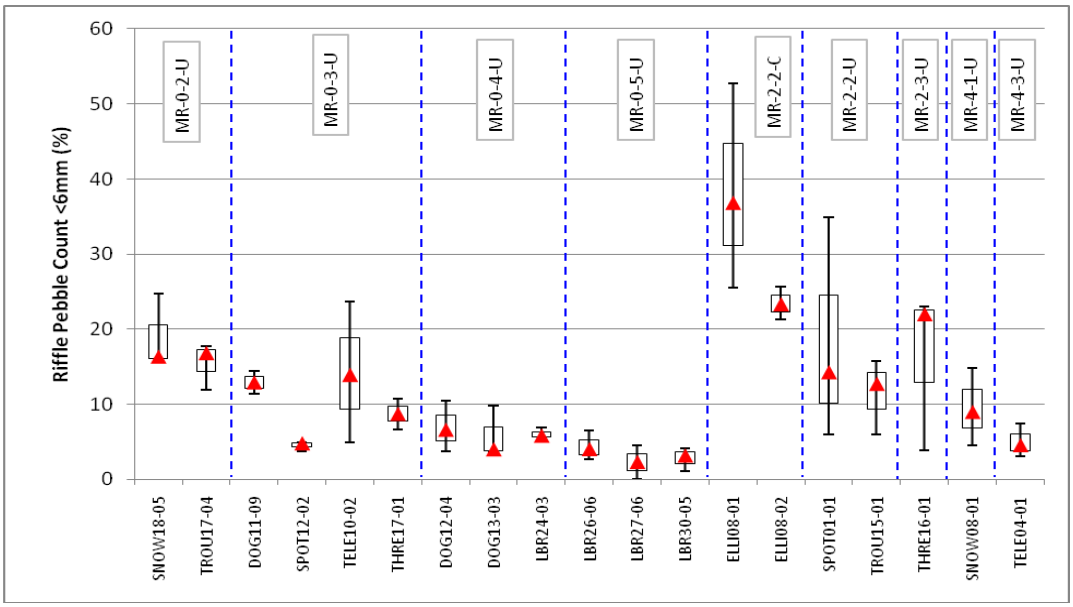


Figure C3-17. Riffle Pebble Count <6mm.

C3.2.2.5 Riffle Grid Toss <6mm

The median percent of fine sediment in riffles <6mm as measured by a grid toss was highest in ELLI08-01 and ELLI08-02 (**Figure C3-18**).

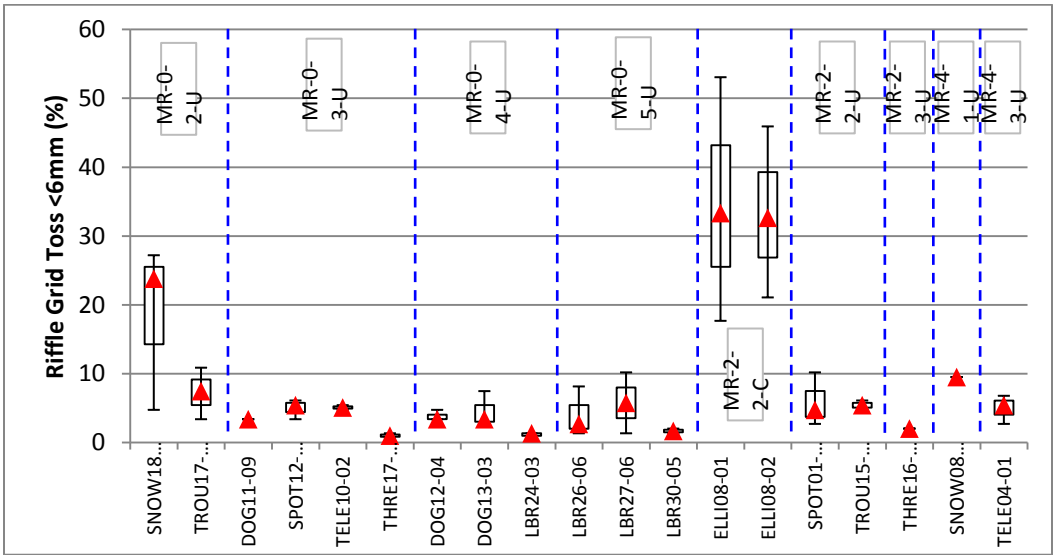


Figure C3-18. Riffle Grid Toss <6mm.

C3.2.2.6 Riffle Stability Index

The mobile percentile of particles on the riffle is termed "Riffle Stability Index" (RSI) and provides a useful estimate of the degree of increased sediment supply to riffles. The RSI addresses situations in which increases in gravel bedload from headwater activities is depositing material on riffles and filling pools, and it reflects qualitative differences between reference and managed watersheds. In the Little Blackfoot TPA, RSI evaluations were performed in ELLI08-01, SPOT12-02, LBR24-03, LBR26-06, LBR27-06, LBR30-05, and TROU17-04 (**Table C3-15**).

Table C3-15. Riffle Stability Index Summary.

Site	Mobile Particle Analysis		Pebble Count Analysis		RSI
	Cell	Geometric Mean	Cell	D50	
ELLI08-02	1	19	1	13	71
SPOT12-02	1	49	2	40	54
LBR24-03	2	104	1	68	87
LBR24-03	3	92	3	85	51
LBR26-06	1	87	1	84	51
LBR26-06	4	87	4	38	78
LBR26-06	5	79	5	78	51
LBR27-06	3	55	3	70	32
LBR27-06	4	47	4	50	44
LBR30-05	3	71	3	70	51
TROU17-04	5	45	5	31	68

C3.2.2.7 Pool Tail-out Grid Toss <6mm

The median percent of fine sediment in pool tail-outs as measured with the grid toss was highest in TROU17-04 and SNOW08-01 (**Figure C3-19**).

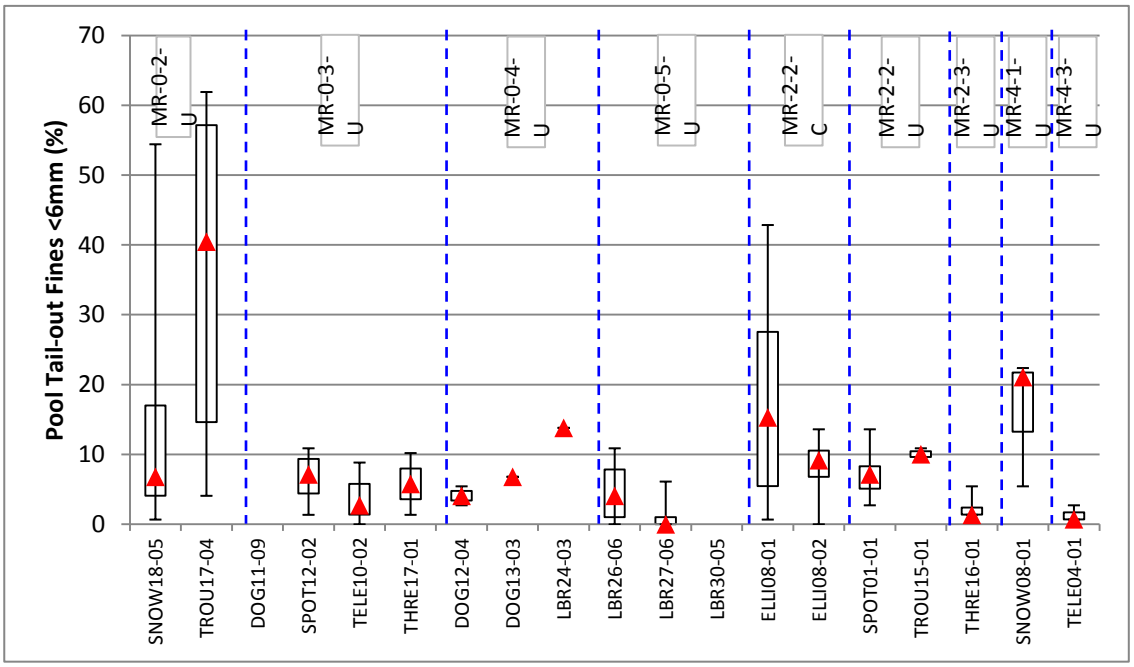


Figure C3-19. Pool Tail-out Grid Toss <6mm.

C3.2.2.8 Residual Pool Depth

The greatest median residual pool depth was measured in THRE17-01 and LBR27-06 (**Figure C3-20**). The lowest residual pool depth was found in SNOW08-01. In general, residual pool depths increase in the downstream direction within the assessed streams.

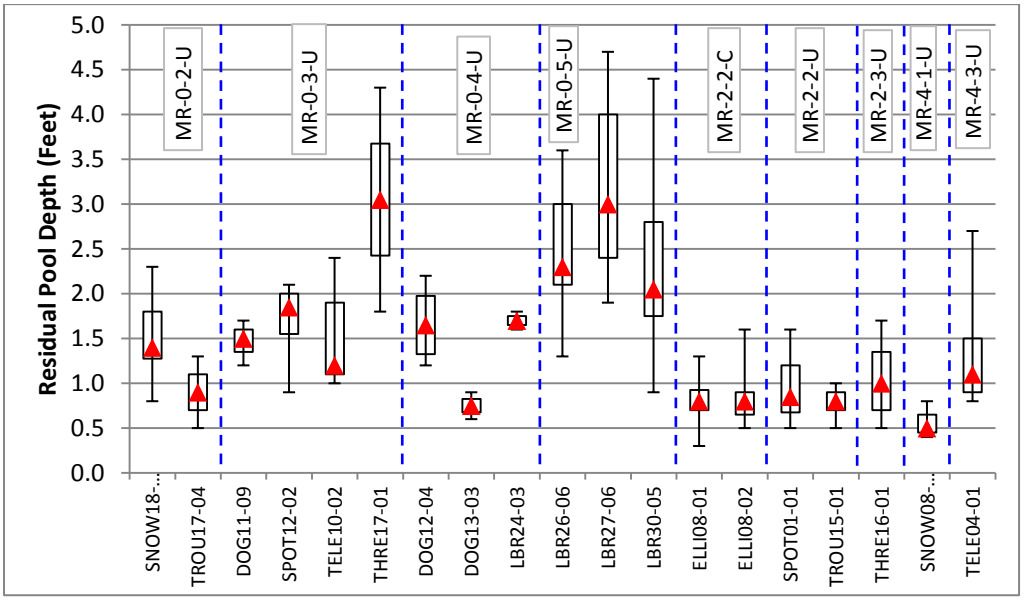


Figure C3-20. Residual Pool Depth.

C3.2.2.9 Pool Frequency

The greatest number of pools was found in ELLI08-01, while the fewest number of pools was found in LBR24-03 (**Figure C3-21**).

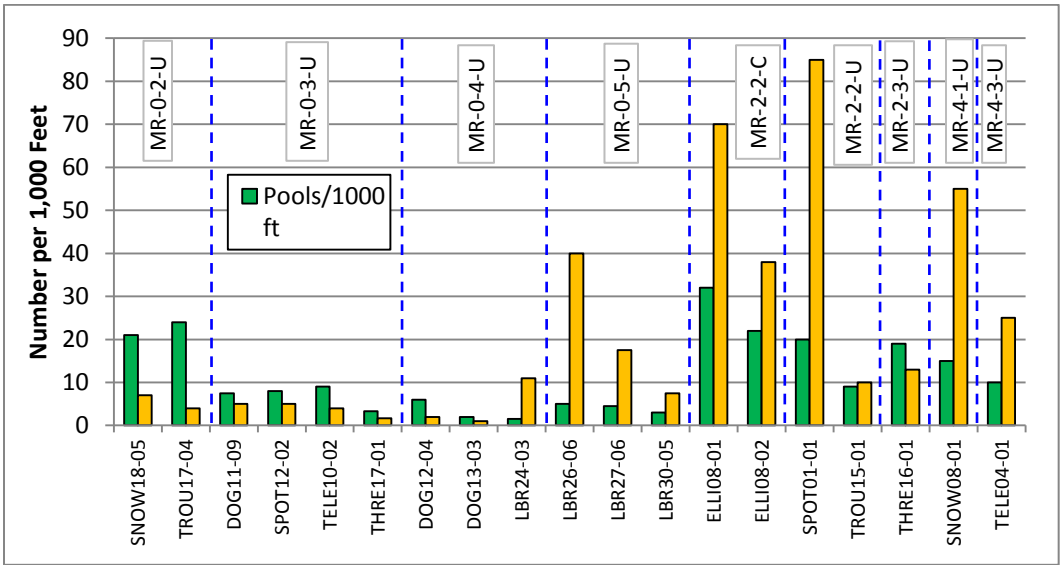


Figure C3-21. Pool and Large Woody Debris Frequency.

C3.2.2.10 Large Woody Debris Frequency

The greatest amount of large woody debris was found in SPOT01-01, while the least amount of large woody debris was found in DOG13-03 (**Figure C3-21**).

C3.2.2.11 Greenline Understory Shrub Cover

Median understory shrub cover exceeded 50% in TELE10-02, LBR24-03, LBR26-06, TROU15-01 and SNOW08-01 (**Figure C3-22**).

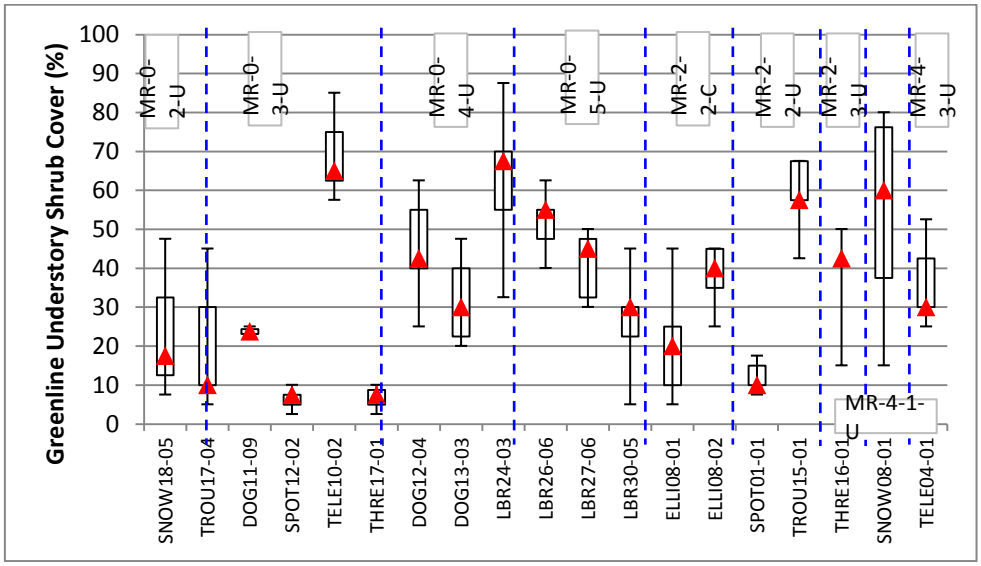


Figure C3-22. Greenline Understory Shrub Cover.

C3.2.2.12 Greenline Bare Ground

Median bare ground values ranged from 0% to 8%, with median values greater than 0% in DOG11-09, TELE10-02, LBR24-03, LBR30-05, ELLI08-01 and TELE04-01 (**Figure C3-23**).

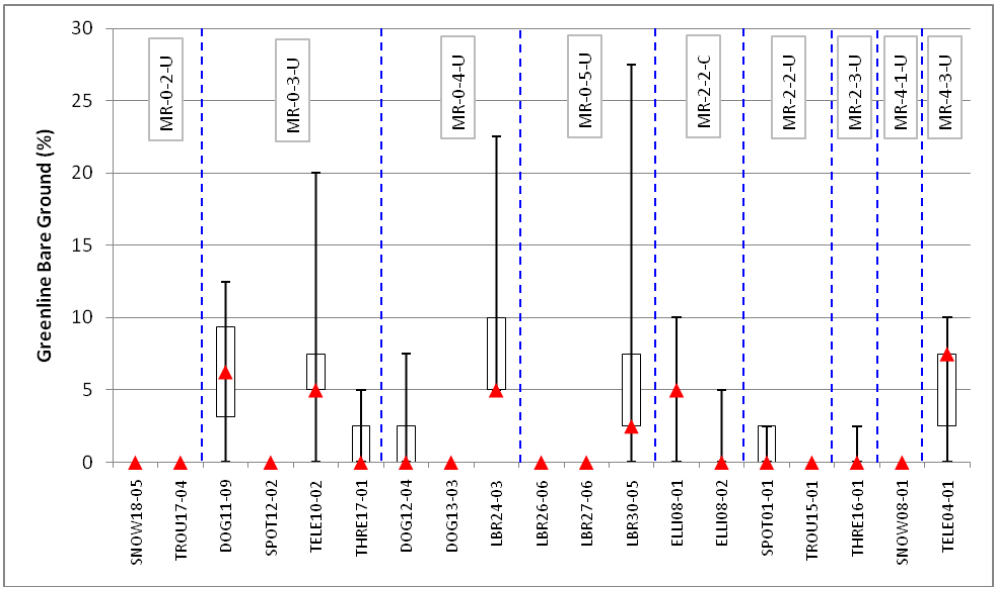


Figure C3-23. Greenline Bare Ground.

C4.0 STREAMBANK EROSION ASSESSMENT

C4.1 METHODS

Streambank erosion data was collected at 19 monitoring sites in the Little Blackfoot TPA. At each of the 19 monitoring sites, eroding streambanks were assessed for erosion severity and categorized as either "actively/visually eroding" or "slowly eroding/vegetated/undercut". At each eroding bank, **Bank Erosion Hazard Index (BEHI)** measurements were performed and the **Near Bank Stress (NBS)** was evaluated (Rosgen, 1996; 2004). Bank erosion severity was rated from "very low" to "extreme" based on the BEHI score, which was determined based on the following six parameters: bank height, bankfull height, root depth, root density, bank angle, and surface protection. Near Bank Stress was also rated from "very low" to "extreme" depending on the shape of the channel at the toe of the bank and the force of the water (i.e. "stream power") along the bank. In addition, the source, or underlying cause, of streambank erosion was evaluated based on observed anthropogenic disturbances within the riparian corridor, as well as current and historic land-use practices observed within the surrounding landscape. The source of streambank instability was identified based on the following near-stream source categories: transportation, riparian grazing, cropland, mining, silviculture, irrigation, natural, and "other". Naturally eroding streambanks were considered the result of "natural sources" while the "other" category was chosen when streambank erosion resulted from a source not described in the list, which included historic mining activities, irrigation infrastructure development, and willow removal in the Little Blackfoot TPA. If multiple sources were observed, then a percent was noted for each source.

Streambank erosion data collected at **monitoring sites** were extrapolated to the **stream reach**, **stream segment**, and **sub-watershed** scales based on similar reach type characteristics as identified in the Aerial Assessment Database. Sediment load calculations were performed for monitoring sites, stream reaches, stream segments, and sub-watersheds which are distinguished as follows:

Monitoring Site -	*A 500, 1000, or 2000 foot section of a stream reach where field monitoring was conducted*
Stream Reach -	*Subdivision of the stream segment based on ecoregion, stream order, gradient and confinement as evaluated in GIS*
Stream Segment -	*303(d) listed segment*
Sub-watershed -	*303(d) listed segment and tributary streams based on 1:100,000 NHD data layer*

For each eroding streambank, the average annual sediment load was estimated based on the streambank length, mean height, and the annual retreat rate. The length and mean height were measured in the field, while the annual retreat rate was determined based on the relationship between the BEHI and NBS ratings. Annual retreat rates were estimated based on retreat rates from the Lamar River in Yellowstone National Park (Rosgen, 1996) (**Table C4-1**). The annual sediment load in cubic feet was then calculated from the field data (annual retreat rate x mean bank height x bank length), converted into cubic yards, and finally converted into tons per year based on the bulk density of streambank material, which was assumed to average 1.3 tons/yard^3 as identified in *Watershed Assessment of River Stability and Sediment Supply* (WARSSS) (Rosgen, 2006a; 2006b). This process resulted in a sediment load for each eroding bank expressed in tons per year.

Table C4-1. Annual Streambank Retreat Rates (Feet/Year), Lamar River, Yellowstone National Park (adapted from (Rosgen, 1996)).

BEHI	Near Bank Stress					
	very low	low	moderate	high	very high	extreme
very Low	0.002	0.004	0.009	0.021	0.050	0.12
low	0.02	0.04	0.10	0.24	0.57	1.37
moderate	0.10	0.17	0.28	0.47	0.79	1.33
high - very high	0.37	0.53	0.76	1.09	1.57	2.26
extreme	0.98	1.21	1.49	1.83	2.25	2.76

C4.1.1 Streambank Erosion Sediment Load Extrapolation

Monitoring site sediment loads were extrapolated to the stream reach, stream segment and sub-watershed scales based on the aerial assessment reach type analysis. Streambank erosion data was extrapolated based on the following criteria:

1. Monitoring site sediment loads were extrapolated directly to the stream reach in which the monitoring site was located.

2. For un-assessed reaches, streambank erosion sediment loads were applied based on reach type averages. Field data was collected within nine individual reach types that were delineated by confinement, stream order and gradient. The nine reach types were consolidated into five reach type groups based on stream order and average bankfull width (**Table C4-2)**. Average sediment loads from the field assessed reach type groups were applied to the corresponding un-assessed reach types as presented in **Table C4-2**. The reach type load from SPOT12-02 (MR-0-3-U) was not included within the reach type group for 3rd order streams since this site was deemed to be unique within the Little Blackfoot TPA.

Table C4-2. Reach Type Streambank Erosion Sediment Loads by Reach Type Group.

Field Assessed Reach Type Group	Number of Monitoring Sites	Average Sediment Load per 1000 Feet (Tons/Year)	Un-Assessed Reach Types
MR-4-1-U	1	0.28	MR-0-1-U, MR-2-1-U, MR-4-1-C, MR-10-1-C, MR-10-1-U
MR-0-2-U, MR-2-2-U, MR-2-2-C	6	5.06	MR-0-2-C, MR-4-2-U, MR-4-2-C
MR-0-3-U, MR-2-3-U, MR-4-3-U	5	4.40	MR-0-3-C, MR-2-3-C
MR-0-4-U	3	19.99	none
MR-0-5-U	3	45.80	none

3. When streambank erosion sources exceeded 75% natural (as identified in the Aerial Assessment Database), erosion was assumed to be at the background rate per reach type grouping. The background erosion rate is based on an assessment of the five monitoring sites in the Little Blackfoot TPA (ELLI08-02, SNOW08-01, SPOT01-01, TELE04-01, and THRE17-01) in which streambank erosion sources were determined to be 100% natural. A background erosion rate based on 70% of the actively eroding banks and 30% of the slowly eroding streambanks was applied for each reach type group based on the field data from these five sites, which averaged 67% actively eroding streambanks and 33% slowly eroding streambanks. This approach was also used for calculating load reductions and is discussed in more detail in **Section C4.2.3**.

C4.2 RESULTS

C4.2.1 Streambank Erosion Sediment Load Extrapolation

A total average annual sediment load of 438.2 tons/year was attributed to the 92 assessed eroding streambanks within the 19 monitoring sites. Predominant sources of streambank erosion observed during the field assessment include cropland and riparian grazing. Average annual sediment loads for each monitoring site were normalized to a length of 1,000 feet for the purpose of comparison and extrapolation. Sediment loads due to streambank erosion for each monitoring site are presented in **Table C4-3**. Monitoring site sediment loads per 1,000 feet ranged from 0.28 tons/year at SNOW08-01 on Snowshoe Creek to 67.30 tons/year at LBR27-06 on the Little Blackfoot River.

Monitoring site sediment loads were extrapolated to the stream segment scale based on the reach type groups (**Table C4-2**). Stream segment sediment loads were estimated for all 128.1 miles of stream included in the Aerial Assessment Database. An average annual sediment load of 9,748 tons/year was attributed to eroding streambanks at the stream segment scale. In the Little Blackfoot TPA, streambank erosion sediment loads ranged from 89 tons/year in Elliston Creek to 7,711 tons/year in the lower Little Blackfoot River (**Table C4-4**). The lower Little Blackfoot River has the highest sediment load due to streambank erosion per mile of stream, followed by Spotted Dog Creek. Threemile Creek has the lowest streambank erosion sediment load per mile of stream. At the stream segment scale, this assessment indicates that irrigation, transportation and riparian grazing are the greatest anthropogenic contributors of sediment loads due to streambank erosion in the Little Blackfoot TPA (**Figure C4-1**). Sources assessed at the stream segment scale were also applied at the sub-watershed scale.

Average annual streambank erosion sediment loads at the sub-watershed scale were estimated for the assessed stream segments in the Little Blackfoot TPA based on the total length of stream within the sub-watershed. These sub-watershed sediment loads were estimated from the sum of the average annual streambank erosion sediment loads at the stream segment scale combined with an estimate of streambank erosion sediment loads from un-assessed streams. Based on a modified version of the

1:100,000 NHD stream layer in which ditches were removed, there are 523.1 miles of stream in the Little Blackfoot TPA (**Table C4-4**). Therefore, 395 miles of stream were not included within the Aerial Assessment Database and were not assessed. The majority of un-assessed streams were 1st and 2nd order tributaries. For the purposes of estimating an annual average sub-watershed streambank erosion sediment load, streambank erosion sediment inputs from un-assessed streams was assumed to be 12.52 tons per mile (2.37 tons/1000 feet) based on the 25th percentile of 1st and 2nd order streams assessed in the Little Blackfoot TPA. A total sediment load of 14,692 tons per year was derived for the Little Blackfoot TPA (**Table C4-4**).

Table C4-3. Monitoring Site Estimated Average Annual Sediment Loads due to Streambank Erosion.

Stream Segment	Reach ID	Reach Type	Length of Eroding Bank (Feet)	Monitoring Site Length (Feet)	Percent of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
Dog Creek	DOG11-09	MR-0-3-U	247	400	31	3.4	8.38
	DOG12-04	MR-0-4-U	254	1000	13	32.8	32.81
	DOG13-03	MR-0-4-U	301	1000	15	21.1	21.07
Elliston Creek	ELL08-01	MR-2-2-C	585	500	59	3.4	6.77
	ELLI08-02	MR-2-2-C	57	500	6	1.3	2.56
Little Blackfoot River	LBR24-03	MR-0-4-U	625	2000	16	12.1	6.07
	LBR26-06	MR-0-5-U	508	2000	13	103.2	51.62
	LBR27-06	MR-0-5-U	1145	2000	29	134.6	67.30
	LBR30-05	MR-0-5-U	1155	2000	29	37.0	18.48
Snowshoe Creek	SNOW08-01	MR-4-1-U	11	400	1	0.2	0.28
	SNOW18-05	MR-0-2-U	93	1000	5	2.2	2.18
Spotted Dog Creek	SPOT01-01	MR-2-2-U	88	1000	4	4.8	4.83
	SPOT12-02	MR-0-3-U	524	1000	26	63.6	63.62
Telegraph Creek	TELE04-01	MR-4-3-U	91	1000	5	2.1	2.10
	TELE10-02	MR-0-3-U	85	1000	4	1.7	1.70
Threemile Creek	THRE16-01	MR-2-3-U	35	1000	2	1.1	1.06
	THRE17-01	MR-0-3-U	88	600	7	5.3	8.78
Trout Creek	TROU15-01	MR-2-2-U	32	1000	2	2.8	2.76
	TROU17-04	MR-0-2-U	197	500	20	5.6	11.25

Table C4-4. Sub-watershed Sediment Loads.

Stream Segment	Stream Segment Length (Miles)	Stream Segment Sediment Load (Tons/Year)	Sub-watershed Stream Length (Miles)	Un-assessed Stream Length (Miles)	Sediment Load Applied to Un-assessed Stream Length (12.52 tons/year/mile)	Sub-watershed Sediment Load (Tons/Year)
Upper Little Blackfoot Sub-watershed						
Upper Dog Creek	4.3	78.8	26.8	22.5	281.7	360.5
Lower Dog Creek	17.9	838.1	76.1	58.2	728.4	1566.5
Upper Telegraph Creek	5.4	80.4	21.3	15.9	199.1	279.5
Lower Telegraph Creek	7.9	113.4	26.3	18.4	230.7	344.1
Little Blackfoot River, Upper	22.50	1085.3	195.7			
Upper Little Blackfoot Sub-watershed	**48.3**	**2,036.8**	**195.7**	**147.4**	**1,845.6**	**3,882.4**

Table C4-4. Sub-watershed Sediment Loads.

Stream Segment	Stream Segment Length (Miles)	Stream Segment Sediment Load (Tons/Year)	Sub-watershed Stream Length (Miles)	Un-assessed Stream Length (Miles)	Sediment Load Applied to Un-assessed Stream Length (12.52 tons/year/mile)	Sub-watershed Sediment Load (Tons/Year)
Lower Little Blackfoot Sub-watershed						
Elliston Creek	5.0	88.6	8.9	3.9	49.1	137.7
Snowshoe Creek	11.4	201.0	23.5	12.1	151.4	352.4
Spotted Dog Creek	11.6	753.5	54.4	42.8	536.0	1289.5
Threemile Creek	13.8	200.0	74.0	60.2	753.1	953.1
Trout Creek	11.5	296.3	25.6	14.1	176.0	472.3
Little Blackfoot River, Lower	26.50	6171.6	327.3			
Lower Little Blackfoot Sub-watershed	**79.8**	**7,711.0**	**327.3**	**247.5**	**3,098.8**	**10,809.8**
Little Blackfoot TPA						
Little Blackfoot Watershed	**128.1**	**9,747.8**	**523.1**	**394.9**	**4,944.3**	**14,692.2**

*Except for the Little Blackfoot River, the loads for any of the lower segments are cumulative for that watershed.

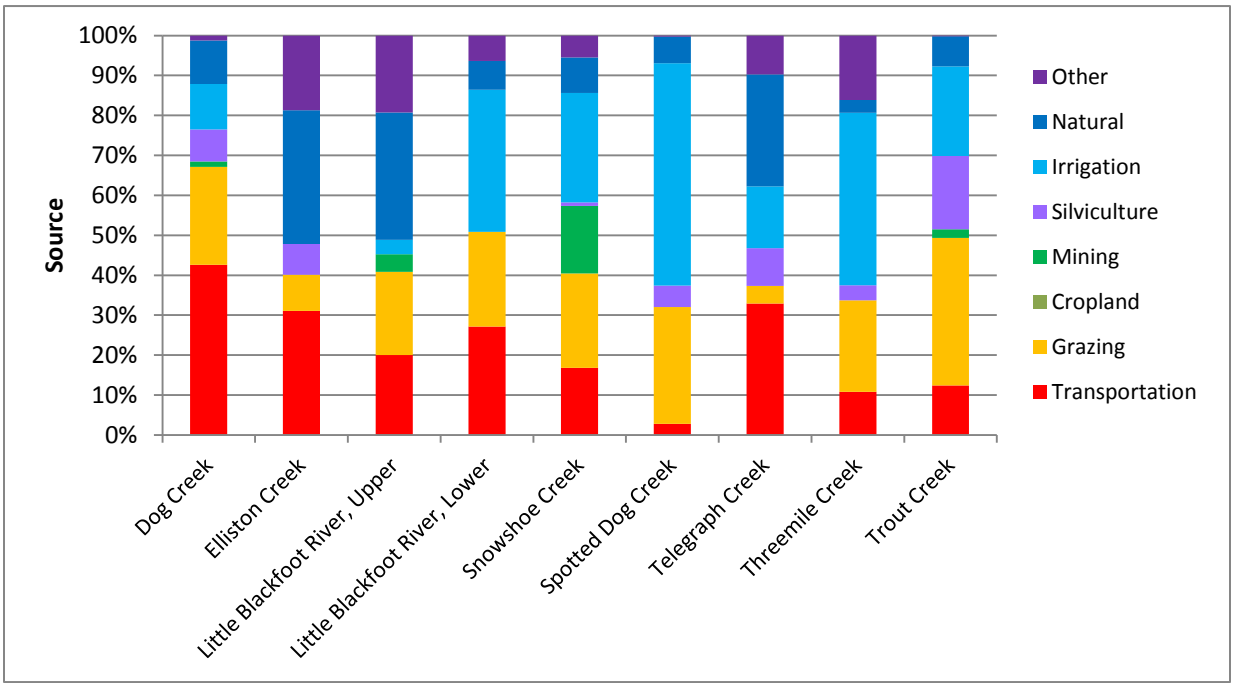


Figure C4-1. Stream Segment and Sub-watershed Streambank Erosion Sources.

C4.2.2 Streambank Composition

Streambank erosion sediment loads were evaluated based on streambank composition for the following particle size categories: coarse gravel, fine gravel and sand/silt. The percent of eroding streambank within each particle size category was evaluated for each monitoring site based on the sediment load from each eroding bank relative to the total sediment load for the monitoring site. Streambank composition data for each monitoring site was then used to evaluate streambank composition at the sub-watershed scale based on the sum of the monitoring site loads relative to the total sediment load

from the assessed monitoring sites within each individual stream segment (**Table C4-5**). Thus, it is assumed that streambank composition assessed at the field monitoring sites is representative of each streams sub-watershed. This analysis will help guide implementation activities geared toward reducing sediment loads for specific particle size categories. In the Little Blackfoot TPA, sand/silt generally comprised the greatest portion of the streambank sediment load, comprising greater than 55% of the sediment load in all of the assessed streams.

Table C4-5. Stream Segment Streambank Composition.

Stream Segment	Number of Monitoring Sites	Bank Composition Coarse Gravel >6mm (Percent)	Bank Composition Fine Gravel <6mm & >2mm (Percent)	Bank Composition Sand/Silt <2mm (Percent)
Dog Creek	3	31	10	59
Elliston Creek	2	6	2	92
Little Blackfoot River, Upper	1	48	9	43
Little Blackfoot River, Lower	3	28	6	67
Snowshoe Creek	2	9	9	82
Spotted Dog Creek	2	1	10	89
Telegraph Creek	2	16	6	78
Threemile Creek	2	8	8	85
Trout Creek	2	10	7	84

Streambank erosion sediment loads at the sub-watershed scale as presented in **Table C4-4** were analyzed based on the particle size distribution of the eroding streambanks. Sub-watershed sediment loads for each particle size class are presented in **Table C4-6**.

Table C4-6. Sub-watershed Sediment Loads due to Streambank Erosion for each Particle Size Class.

Stream Segment	Coarse Gravel >6mm Load (Tons/Year)	Fine Gravel <6mm & >2mm Load (Tons/Year)	Sand/Silt <2mm Load (Tons/Year)	Sub-watershed Sediment Load (Tons/Year)
Upper Little Blackfoot Sub-watershed				
Dog Creek	489.6	159.4	934.4	1583.3
Telegraph Creek	59.6	21.1	287.6	368.3
Little Blackfoot River, Upper				
Upper Little Blackfoot Sub-watershed	**1295.9**	**379.6**	**2260.0**	**3935.4**
Lower Little Blackfoot Sub-watershed				
Elliston Creek	8.5	2.7	129.5	140.6
Snowshoe Creek	32.8	32.8	295.7	361.3
Spotted Dog Creek	17.3	127.9	1150.3	1295.4
Threemile Creek	73.0	73.0	813.8	959.7
Trout Creek	45.5	31.1	395.8	472.3
Little Blackfoot River, Lower				
Lower Little Blackfoot Sub-watershed	**2325.8**	**697.8**	**7815.4**	**10838.9**
Little Blackfoot TPA				
Little Blackfoot Watershed	**3453.2**	**1030.2**	**10290.8**	**14774.2**

C4.2.3 Streambank Erosion Sediment Load Reductions

The narrative water quality standards that apply to sediment relate to the naturally occurring condition, which is typically associated with either reference conditions or those that occur if all reasonable land, soil, and water conservation practices are applied. Therefore, to assist with TMDL development, the streambank erosion assessment also includes an estimation of sediment loading reductions that could be achieved via the implementation of Best Management Practices (BMPs). Streambank erosion sediment load reductions were evaluated based on field collected data and streambank erosion sources identified in the Aerial Assessment Database through the following process:

1. Anthropogenic activities that remove streamside vegetation tend to de-stabilize streambanks and increase the amount of active streambank erosion. Through the implementation of riparian and streambank BMPs, streambanks can be stabilized and active erosion can be reduced. A reference site approach was used to identify an appropriate ratio of actively eroding streambanks compared to slowly eroding streambanks for streams in the Little Blackfoot TPA. Within the Little Blackfoot TPA, there were five monitoring sites (ELLI08-02, SNOW08-01, SPOT01-01, TELE04-01, and THRE17-01) in which streambank erosion sources were determined to be >75% natural. Streambank erosion data from these sites were used to approximate the effect of BMP implementation and to calculate load reductions. These five sites averaged 67% actively eroding streambanks and 33% slowly eroding streambanks. Based on these results, it is estimated that streams in the Little Blackfoot TPA would have approximately 70% actively eroding banks and 30% slowly eroding streambanks if all BMPs are applied. For the five reach type groups described in **Table C4-7**, streambank erosion sediment load reductions were derived using the average values for both actively eroding streambanks and slowly eroding streambanks. For each reach type group, the expected streambank erosion sediment load when BMPs were applied was calculated based on 70% of the actively eroding streambanks and 30% of the slowly eroding streambanks using the following equation:

   (0.70 x active) + (0.30 x slowly) = streambank erosion sediment load with BMPs

   For example, the reach type group for 2nd order streams, which includes the MR-0-2-U, MR-2-2-U, and MR-2-2-C reach types, averaged 4.23 tons/year from actively eroding streambanks and 1.00 tons/year from slowly eroding streambanks for 1,000 feet of stream, resulting in a reduced sediment load of 3.26 tons/year, as follows:

   (0.70 x 4.23) + (0.30 x 1.00) = 3.26

   In this analysis, the data from all actively eroding banks was utilized, including the two monitoring sites in which no active streambank erosion was observed. For the slowly eroding streambanks, the zero values were removed from the dataset since these monitoring sites tended to be dominated by anthropogenic disturbances. Streambank erosion sediment load reductions are presented for each reach type category in **Table C4-7**.

Table C4-7. Reach Type Streambank Sediment Load Reductions with BMPs.

Field Assessed Reach Type Group	Average Sediment Load per 1000 Feet	Reduced Sediment Load per 1000 Feet (Tons/Year)	Un-Assessed Reach Types
MR-4-1-U	0.28	0.08	MR-0-1-U, MR-2-1-U, MR-4-1-C, MR-10-1-C, MR-10-1-U
MR-0-2-U, MR-2-2-U, MR-2-2-C	5.06	3.26	MR-0-2-C, MR-4-2-U, MR-4-2-C
MR-0-3-U, MR-2-3-U, MR-4-3-U	4.40	2.85	MR-0-3-C, MR-2-3-C
MR-0-4-U	19.99	14.02	none
MR-0-5-U	45.80	32.36	none

2. For the reaches in which a monitoring site was located, the reach type category sediment load reduction was applied, except when this value exceeded the monitoring site value. In this case, the monitoring site sediment load was evaluated based on 70% of the actively eroding streambanks and 30% of the slowly eroding streambanks and this value was then applied to the entire reach in which the monitoring site was located.

3. Because they are assumed to be achieving the naturally occurring condition, no sediment load reductions were applied to reaches with >75% natural sources of erosion. In addition, no load reduction was applied to the natural load in reaches with <75% natural sources.

4. Because high gradient channels tend to be well armored and have a very low erosion rate, no sediment load reductions were applied to streams with slopes >10%.

5. Because little is known about the tributaries to the 303(d) listed stream segments and they are predominately 1st and 2nd order streams with a low streambank erosion load assigned during the extrapolation process, no sediment load reductions were applied to tributaries of the assessed 303(d) listed stream segments.

Based on the process described above, streambank erosion sediment load reductions for each sediment 303(d) listed sub-watershed in the Little Blackfoot TPA are provided in **Table C4-8**. Potential reductions in anthropogenic loading as a result of the application of BMPs range from 8% to 48%, with a 23% reduction identified to the entire Little Blackfoot watershed. The loading reductions listed in **Table C4-8** were calculated based on the achievable reductions in loading to the 303(d) listed water body segments, while additional reductions may also be possible from the tributaries to the listed water bodies. Because the actual loading estimates from this assessment will not be used for TMDL development, but the percentage of loading reductions and percentage of human-induced and natural erosion from this assessment will be used, **Table C4-9** includes the percentage by source for all waterbody segments with TMDLs in **Section 5.0** of the document.

Table C4-8. Sub-watershed Sediment Load Reductions with BMPs.

Stream Segment	Existing Sediment Load (Tons/Year)			Reduced Sediment Load through BMPs (Tons/Year)			Potential Reduction in Total Sediment Load (Total Existing-Total Reduced) (Tons/Year)	Percent Reduction in Total Sediment Load (Potential Reduction/Total Existing)	Potential Reduction in Anthropogenic Sediment Load (Anthropogenic Existing-Anthropogenic Reduced) (Tons/Year)	Percent Reduction in Anthropogenic Sediment Load (Potential Reduction/Anthropogenic Existing)
	Total Sediment Load (Tons/Year)	Anthropogenic Sediment Load (Tons/Year)	Natural Sediment Load (Tons/Year)	Total Sediment Load (Tons/Year)	Anthropogenic Sediment Load (Tons/Year)	Natural Sediment Load (Tons/Year)				
Upper Little Blackfoot										
Upper Dog Creek	360.5	310.0	50.5	336.6	286.1	50.5	23.9	7%	23.9	8%
Lower Dog Creek	1566.5	1395.8	170.8	1313.9	1143.2	170.8	252.6	16%	252.6	18%
Upper Telegraph Creek	279.5	198.4	81.0	257.8	176.7	81.0	21.7	8%	21.7	11%
Lower Telegraph Creek	344.1	247.6	96.5	313.6	217.2	96.5	30.5	9%	30.5	12%
Little Blackfoot River, Upper										
Upper Little Blackfoot Sub-watershed	3882.4	2987.1	895.3	3489.7	2594.4	895.3	392.7	10%	392.7	13%
Lower Little Blackfoot										
Elliston Creek	137.7	91.6	46.1	115.7	69.7	46.1	21.9	16%	21.9	24%
Snowshoe Creek	352.4	321.2	31.1	278.4	247.2	31.1	74.0	21%	74.0	23%
Spotted Dog Creek	1289.5	1203.4	86.1	709.1	623.0	86.1	580.4	45%	580.4	48%
Threemile Creek	953.1	922.5	30.6	880.3	849.6	30.6	72.8	8%	72.8	8%
Trout Creek	472.3	436.8	35.5	352.1	316.6	35.5	120.2	25%	120.2	28%
Little Blackfoot River, Lower										
Lower Little Blackfoot Sub-watershed	10809.8	10011.0	798.8	8221.6	7422.8	798.8	2588.2	24%	2588.2	26%
Little Blackfoot TPA										
Little Blackfoot Watershed	14692.2	13124.5	1567.7	11711.3	10143.7	1567.7	2980.8	20%	2980.8	23%

Table C4-9. Percentage of human-induced and natural streambank erosion per waterbody segment (only for those with TMDLs in Section 5.0).

Stream Segment	%Natural Load	% Human-Induced
Upper Little Blackfoot		
Upper Dog Creek	14%	86%
Lower Dog Creek	11%	89%
Upper Telegraph Creek	29%	71%
Lower Telegraph Creek	28%	72%
Upper Little Blackfoot Sub-watershed	23%	77%
Lower Little Blackfoot		
Elliston Creek	33%	67%
Snowshoe Creek	9%	91%
Spotted Dog Creek	7%	93%
Threemile Creek	3%	97%
Trout Creek	8%	92%
Lower Little Blackfoot Sub-watershed	7%	93%
Little Blackfoot Watershed	11%	89%

C5.0 ASSUMPTIONS AND UNCERTAINTY

This assessment assumes that different streams with similar reach type characteristics will have similar physical attributes and sediment loads due to streambank erosion. Since only a portion of the streams within the Little Blackfoot TPA were assessed in the field, a degree of uncertainty is unavoidable when extrapolating data from assessed sites to un-assessed sites. There is also some uncertainty in identifying streambank erosion sources from aerial imagery and a portion of the identified anthropogenic load is likely due to natural streambank erosion processes. Use of the USGS 1:100,000 NHD stream layer in GIS also creates uncertainty, since this layer was created from topographic maps and may not accurately represent conditions on the ground.

Sediment limitations in many streams in the Little Blackfoot TPA relate to the fine sediment fraction found on the stream bottom, while streambank erosion sediment modeling examined all sediment sizes. Since sediment source modeling may under-estimate or over-estimate sediment inputs due to selection of sediment monitoring sites and the extrapolation methods used, model results should not be taken as an absolutely accurate account of sediment production within each sub-watershed. Instead, the streambank erosion assessment model results should be considered an instrument for estimating sediment loads and making general comparisons of sediment loads from various sources.

C6.0 SUMMARY

The 2009 sediment and habitat assessment in the Little Blackfoot TPA provides a comprehensive analysis of existing sediment conditions within impaired stream segments and estimated streambank erosion sediment loads for use in TMDL development. A total of 129 reaches were delineated during the aerial assessment reach stratification process covering 128.1 miles of stream. Based on the level III ecoregion, there were a total of 19 distinct reach types and sediment and habitat parameters were assessed at 19 monitoring sites. Statistical analysis of the sediment and habitat data from the 19 monitoring sites will aid in developing sediment TMDL targets that are specific for the Little Blackfoot

TPA, while streambank erosion data will be utilized in the sediment TMDL. Within the 19 monitoring sites, an average annual sediment load of 438 tons/year was attributed to the 92 assessed eroding streambanks and average annual sediment load of 9,748 tons/year was estimated for the listed stream segments. Out of the 523.1 miles of stream within the Little Blackfoot TPA, a total sediment load of 14,692 tons per year was estimated. It is estimated that this sediment load can be reduced to 11,711 tons/year, which is a 23% reduction in sediment load from streambank erosion.

C7.0 REFERENCES

Bilby, R. E. and J. W. Ward. 1989. Changes in Characteristics and Function of Woody Debris With Increasing Size of Stream in Western Washington. *Transactions of the American Fisheries Society.* 118: 368-378.

Dunne, T. and Luna B. Leopold. 1978. Water in Environmental Planning, New York, NY: W.H. Freeman and Company.

Meehan, W. R. 1991. Influences of Forest and Rangeland Management on Salmonids Fishes and Their Habitats. American Fisheries Society. Report Special Publication 19.

Montana Department of Environmental Quality. 2007. Longitudinal Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments. Helena, MT: Montana Department of Environmental Quality.

-----. 2008. Watershed Stratification Methodology for TMDL Sediment and Habitat Investigations. Helena, MT: Montana Department of Environmental Quality.

-----. 2009. Little Blackfoot TMDL Planning Area Sediment and Habitat Investigations. Helena, MT: Montana Department of Environmental Quality.

Overton, C. Kerry, Sherry P. Wollrab, Bruce C. Roberts, and Michael A. Radko. 1997. R1/R4 (Northern/Intermountain Regions) Fish and Fish Habitat Standard Inventory Procedures Handbook. Ogden, UT: USDA Forest Service, Intermountain Research Station.

PBS&J. 2010. Sediment and Habitat Data and Bank Erosion Assessment: Little Blackfoot TMDL Planning Area. Helena, MT: Montana Department of Environmental Quality.

Rosgen, David L. 1996. Applied River Morphology, Pagosa Springs, CO: Wildland Hydrology.

-----. 2004. River Assessment and Monitoring Field Guide, Lubrecht Forest, MT. Fort Collins, CO: Wildland Hydrology, Inc.

-----. 2006a. Watershed Assessment of River Stability and Sediment Supply (WARSSS), Fort Collins, CO: Wildland Hydrology.

-----. 2006b. Watershed Assessment of River Stability and Sediment Supply (WARSSS), Version 1 ed., Fort Collins, CO: Wildland Hydrology. Accessed 3/1/8 A.D.b.

Weaver, Thomas M. and J. J. Fraley. 1991. Fisheries Habitat and Fish Populations in Flathead Basin Forest Practices Water Quality and Fisheries Cooperative Program. Kalispell, MT: Flahead Basin Commission.

Wolman, M. G. 1954. A Method of Sampling Coarse River-Bed Material. *Transactions of the American Geophysical Union.* 35(6): 951-956.

ATTACHMENT CA - SEDIMENT & HABITAT DATABASE, LITTLE BLACKFOOT TMDL PLANNING AREA

Reach ID	Site	Date	Cell	Reach Type	Existing Rosgen Stream Type	Potential Rosgen Stream Type	GIS Calculated Sinuosity	Field Slope (Percent)	Aerial Assessment Valley Gradient	Bankfull Channel Width	Cross-Sectional Area	Bankfull Mean Depth	Width / Depth Ratio	Maximum Depth	Floodprone Width	Entrenchment Ratio	Riffle Pebble Count D50	Riffle Pebble Count Percent <2mm	Riffle Pebble Count Percent <6mm	Riffle Grid Toss Percent <6mm	Riffle Stability Index	Number of Pools per 1000 Feet	Mean Residual Pool Depth	Number of Individual Pieces of LWD per 1000 Feet	Number of LWD Aggregates per 1000 Feet	Total Number of LWD per 1000 Feet	Percent Understory Shrub Cover	Percent Bare/Disturbed Ground	Percent Riprap	Percent Overstory Canopy Cover	Right Bank Mean Riparian Zone Width	Left Bank Mean Riparian Zone Width
DOG11-09	1	7/7/09	1	MR-0-3-U	E4	E4	1.26	1.0	<2%	15.5	23.5	1.51	10.2	2.3	135.5	8.7	44	2	11	3		8	1.5	3	0	5	25	0	0	0	140	>200
DOG11-09	1	7/7/09	2	MR-0-3-U	E4	E4	1.26	1.0	<2%	14.5	24.8	1.71	8.5	2.3	129.5	8.9	31	8	14								23	13	0	0	>200	>200
DOG12-04	1	7/7/09	1	MR-0-4-U	C4	E4	1.12	1.0	<2%	30.0	37.8	1.26	23.8	2.3	240.0	>8.0	38	1	10	3		6	1.7	1	0	2	25	0	0	0	23	13
DOG12-04	1	7/7/09	2	MR-0-4-U	C4	E4	1.12	1.0	<2%	22.9	32.1	1.40	16.4	2.5	272.9	>11.9											43	0	8	0	23	33
DOG12-04	1	7/7/09	3	MR-0-4-U	E4	E4	1.12	1.0	<2%	14.0	32.5	2.32	6.0	3.4	89.0	6.4	35	7	7	5							55	3	3	0	31	15
DOG12-04	1	7/7/09	4	MR-0-4-U	B4c	E4	1.12	1.0	<2%	31.0	38.6	1.25	24.9	2.0	51.0	1.6											40	8	0	0	26	0
DOG12-04	1	7/7/09	5	MR-0-4-U	F4	E4	1.12	1.0	<2%	19.0	22.8	1.20	15.8	2.3	24.0	1.3	58	1	4	3							63	0	28	0	19	0
DOG13-03	1	7/8/09	1	MR-0-4-U	B4	C4	1.01	3.6	<2%	25.7	32.0	1.25	20.6	1.7	45.7	1.8	53	2	4	3		2	0.8	1	0	1	40	0	0	8	0	0
DOG13-03	1	7/8/09	2	MR-0-4-U	B4	C4	1.01	3.6	<2%	24.0	31.8	1.33	18.1	2.1	33.5	1.4											23	0	3	0	0	0
DOG13-03	1	7/8/09	3	MR-0-4-U	F4b	C4	1.01	3.6	<2%	34.8	34.1	0.98	35.5	1.4	37.3	1.1	55	1	4	7							20	0	0	0	3	2
DOG13-03	1	7/8/09	4	MR-0-4-U	F4b	C4	1.01	3.6	<2%	25.3	34.4	1.36	18.6	1.9	31.3	1.2											30	0	5	0	0	4
DOG13-03	1	7/8/09	5	MR-0-4-U	F4b	C4	1.01	3.6	<2%	33.5	37.5	1.12	29.9	1.5	45.0	1.3	44	3	10	3							48	0	3	0	1	9
ELLI08-01	1	7/6/09	1	MR-2-2-C	E4	E4	1.21	1.1	2-<4%	9.5	8.5	0.89	10.7	1.4	35.6	3.7	5	38	53	53		32	0.8	62	2	70	10	10	0	45	0	0
ELLI08-01	1	7/6/09	2	MR-2-2-C	C4	E4	1.21	1.1	2-<4%	8.5	5.8	0.68	12.5	1.1	40.5	4.8											45	5	0	0	8	3
ELLI08-01	1	7/6/09	3	MR-2-2-C	E4	E4	1.21	1.1	2-<4%	7.0	7.3	1.04	6.7	1.3	46.0	6.6	13	12	37	33							5	5	0	0	0	0
ELLI08-01	1	7/6/09	4	MR-2-2-C	E4	E4	1.21	1.1	2-<4%	8.3	7.5	0.90	9.2	1.2	43.3	5.2											20	5	0	0	0	0
ELLI08-01	1	7/6/09	5	MR-2-2-C	E4	E4	1.21	1.1	2-<4%	6.0	7.0	1.16	5.2	1.4	56.0	9.3	17	10	25	18							25	0	0	10	3	3
ELLI08-02	1	7/6/09	1	MR-2-2-C	E4	E4	1.36	1.5	2-<4%	6.0	6.8	1.14	5.3	1.4	63.0	10.5	13	22	26	21	71	22	0.8	18	0	38	25	0	0	20	30	15
ELLI08-02	1	7/6/09	2	MR-2-2-C	C4	E4	1.36	1.5	2-<4%	9.5	6.8	0.72	13.2	1.2	54.5	5.7											45	5	0	30	20	35
ELLI08-02	1	7/6/09	3	MR-2-2-C	E4	E4	1.36	1.5	2-<4%	8.3	6.5	0.78	10.6	1.5	33.3	4.0	20	4	21	33							45	0	0	25	13	21
ELLI08-02	1	7/6/09	4	MR-2-2-C					2-<4%																		40	0	0	0	40	20
ELLI08-02	1	7/6/09	5	MR-2-2-C	B4c	E4	1.36	1.5	2-<4%	11.5	8.4	0.73	15.8	1.6	19.5	1.7	18	2	23	46							35	0	0	20	43	25
LBR24-03	1	7/10/09	1	MR-0-4-U	B3	C3b	1.11	3.2	<2%	47.0	85.2	1.81	25.9	2.3	97.0	2.1	68	4	6	1	87	2	1.7	9	1	11	70	5	0	10	>200	>200
LBR24-03	1	7/10/09	2	MR-0-4-U	C3b	C3b	1.11	3.2	<2%	35.8	64.2	1.79	20.0	2.4	265.8	7.4											68	5	0	3	>200	>180
LBR24-03	1	7/10/09	3	MR-0-4-U	C3b	C3b	1.11	3.2	<2%	48.2	75.7	1.57	30.7	2.6	383.2	>8.0	85	3	7	1	51						55	10	0	8	>200	>200
LBR24-03	1	7/10/09	4	MR-0-4-U	C3b	C3b	1.11	3.2	<2%	33.0	59.7	1.81	18.2	2.6	151.0	4.6											33	23	0	30	>200	>200
LBR24-03	1	7/10/09	5	MR-0-4-U	C3b	C3b	1.11	3.2	<2%	28.8	58.6	2.03	14.2	2.7	238.8	8.3	72	4	5	1							88	5	0	5	>200	>120
LBR26-06	1	7/8/09	1	MR-0-5-U	C3	C4	1.28	1.4	<2%	78.5	152.9	1.95	40.3	3.1	288.5	>3.7	84	3	3	3	51	5	2.5	8	5	40	55	0	0	3	>200	>200
LBR26-06	1	7/8/09	2	MR-0-5-U	C3/4	C4	1.28	1.4	<2%	71.4	135.6	1.90	37.6	2.7	346.4	>4.8											40	0	0	53	>200	>190
LBR26-06	1	7/8/09	3	MR-0-5-U					<2%																		48	0	0	5	>200	66
LBR26-06	1	7/8/09	4	MR-0-5-U	C4	C4	1.28	1.4	<2%	67.5	128.9	1.91	35.3	3.3	427.5	>6.3	38	5	7	8	78						55	0	0	15	>200	103
LBR26-06	1	7/8/09	5	MR-0-5-U	C3	C4	1.28	1.4	<2%	62.3	134.6	2.16	28.8	3.0	307.3	>4.9	78	0	4	1	51						63	0	0	8	>200	40
LBR27-06	1	7/9/09	1	MR-0-5-U	C3/4	C4	1.62	2.0	<2%	110.6	203.7	1.84	60.1	3.6	650.6	>5.9						5	3.2	9	2	18	30	0	0	15	60	14
LBR27-06	1	7/9/09	2	MR-0-5-U					<2%																		48	0	0	8	43	31
LBR27-06	1	7/9/09	3	MR-0-5-U	C3	C4	1.62	2.0	<2%	91.0	183.5	2.02	45.1	3.2	591.0	6.5	70	0	0	1	32						45	0	0	3	9	56
LBR27-06	1	7/9/09	4	MR-0-5-U	C4	C4	1.62	2.0	<2%	50.0	146.6	2.93	17.1	4.3	650.0	>13.0	50	4	5	10	44						50	0	0	15	29	11

Reach ID	Site	Date	Cell	Reach Type	Existing Rosgen Stream Type	Potential Rosgen Stream Type	GIS Calculated Sinuosity	Field Slope (Percent)	Aerial Assessment Valley Gradient	Bankfull Channel Width	Cross-Sectional Area	Bankfull Mean Depth	Width / Depth Ratio	Maximum Depth	Floodprone Width	Entrenchment Ratio	Riffle Pebble Count D50	Riffle Pebble Count Percent <2mm	Riffle Pebble Count Percent <6mm	Riffle Grid Toss Percent <6mm	Riffle Stability Index	Number of Pools per 1000 Feet	Mean Residual Pool Depth	Number of Individual Pieces of LWD per 1000 Feet	Number of LWD Aggregates per 1000 Feet	Total Number of LWD per 1000 Feet	Percent Understory Shrub Cover	Percent Bare/Disturbed Ground	Percent Riprap	Percent Overstory Canopy Cover	Right Bank Mean Riparian Zone Width	Left Bank Mean Riparian Zone Width
LBR27-06	1	7/9/09	5	MR-0-5-U					<2%																		33	0	0	10	19	20
LBR30-05	1	7/9/09	1	MR-0-5-U	B4c	C4	1.03	2.0	<2%	62.9	154.8	2.46	25.6	3.9	130.9	2.1	58	2	3	2		3	2.4	8	0	8	23	0	5	50	11	0
LBR30-05	1	7/9/09	2	MR-0-5-U	B3/4c	C4	1.03	2.0	<2%	79.0	203.4	2.58	30.7	3.3	156.0	2.0											30	28	50	48	4	0
LBR30-05	1	7/9/09	3	MR-0-5-U	C3	C4	1.03	2.0	<2%	79.2	139.3	1.76	45.0	3.2	195.2	2.5	70	0	4	1	51						45	3	30	60	8	0
LBR30-05	1	7/9/09	4	MR-0-5-U					<2%																		5	8	23	58	4	0
LBR30-05	1	7/9/09	5	MR-0-5-U	B3c	C4	1.03	2.0	<2%	83.7	170.0	2.03	41.2	3.0	153.7	1.8	72	1	1								30	3	20	30	33	0
SNOW08-01	1	7/14/09	1	MR-4-1-U	E4b	E4b	1.15	2-<4%	4-<10%	5.8	5.8	1.00	5.8	1.7	19.8	3.4	19	7	9	10		15	0.6	55	0	55	75	0	0	15	10	5
SNOW08-01	1	7/14/09	2	MR-4-1-U	E4b	E4b	1.15	2-<4%	4-<10%	5.9	6.4	1.09	5.4	1.4	13.9	2.4											80	0	0	55	0	0
SNOW08-01	1	7/14/09	3	MR-4-1-U	E4b	E4b	1.15	2-<4%	4-<10%	5.2	5.0	0.97	5.4	1.2	19.2	3.7	15	8	15	10							45	0	0	30	10	0
SNOW08-01	1	7/14/09	4	MR-4-1-U	E4b	E4b	1.15	2-<4%	4-<10%	8.0	7.8	0.97	8.2	1.4	108.0	13.5	20	2	5								15	0	0	15	0	5
SNOW18-05	1	7/9/09	1	MR-0-2-U	E4	E4	3.18	0.9	<2%	11.1	13.7	1.24	9.0	2.0	30.1	2.7	15	6	16	27		21	1.5	1	1	7	8	0	0	0	23	30
SNOW18-05	1	7/9/09	2	MR-0-2-U	E4	E4	3.18	0.9	<2%	8.0	12.2	1.53	5.2	1.8	39.6	5.0											48	0	0	20	20	38
SNOW18-05	1	7/9/09	3	MR-0-2-U	E4	E4	3.18	0.9	<2%	12.6	16.5	1.31	9.6	2.0	229.6	>18.2	11	20	25	24							33	0	0	5	23	40
SNOW18-05	1	7/9/09	4	MR-0-2-U	E4	E4	3.18	0.9	<2%	12.0	20.5	1.71	7.0	2.2	232.0	>19.3											13	0	0	0	28	20
SNOW18-05	1	7/9/09	5	MR-0-2-U	E4	E4	3.18	0.9	<2%	12.5	17.0	1.36	9.2	2.0	28.5	2.3	13	5	16	5							18	0	0	5	27	23
SPOT01-01	1	7/14/09	1	MR-2-2-U	C4	B4	1.08	1.8	2-<4%	17.3	16.1	0.93	18.5	1.3	42.5	2.5	53	4	6	10		20	1.0	53	7	85	10	0	0	65	>198	>200
SPOT01-01	1	7/14/09	2	MR-2-2-U	B4c	B4	1.08	1.8	2-<4%	16.1	13.6	0.85	19.0	1.2	23.3	1.4											8	0	0	30	193	>200
SPOT01-01	1	7/14/09	3	MR-2-2-U	C4	B4	1.08	1.8	2-<4%	15.6	14.1	0.90	17.3	1.4	174.6	11.2	12	20	35	3							10	0	0	28	153	>200
SPOT01-01	1	7/14/09	4	MR-2-2-U	C4	B4	1.08	1.8	2-<4%	17.9	16.0	0.89	20.1	1.3	54.9	3.1											18	3	0	40	105	>200
SPOT01-01	1	7/14/09	5	MR-2-2-U	E4	B4	1.08	1.8	2-<4%	11.7	14.4	1.23	9.5	1.9	37.7	3.2	31	8	14	5							15	3	0	50	108	>200
SPOT12-02	1	7/8/09	1	MR-0-3-U					<2%													8	1.7	0	0	5	3	0	0	0	>153	>200
SPOT12-02	1	7/8/09	2	MR-0-3-U	B4	E4	1.90	2.2	<2%	20.8	25.6	1.23	16.9	2.0	45.8	2.2	40	0	5	6	54						8	0	0	0	>200	>200
SPOT12-02	1	7/8/09	3	MR-0-3-U	B4	E4	1.90	2.2	<2%	30.3	28.0	0.93	32.8	2.3	41.3	1.4	53	2	4	5							8	0	0	5	>200	>200
SPOT12-02	1	7/8/09	4	MR-0-3-U	C4b	E4	1.90	2.2	<2%	17.0	20.3	1.20	14.2	1.7	232.0	>13.6											10	0	0	3	>200	>200
SPOT12-02	1	7/8/09	5	MR-0-3-U	C4b	E4	1.90	2.2	<2%	20.6	28.2	1.37	15.0	2.0	220.6	>10.7	43	1	5	3							5	0	0	0	>200	>200
TELE04-01	1	7/6/09	1	MR-4-3-U	B3	B3	1.07	3.0	4-<10%	19.5	25.4	1.30	15.0	2.1	42.5	2.2	64	4	7	7		10	1.4	11	3	25	53	8	0	20	>183	>200
TELE04-01	1	7/6/09	2	MR-4-3-U	B3	B3	1.07	3.0	4-<10%	20.0	31.7	1.59	12.6	2.1	40.0	2.0											43	8	0	45	>200	>200
TELE04-01	1	7/6/09	3	MR-4-3-U	F3b	B3	1.07	3.0	4-<10%	22.0	32.1	1.46	15.1	2.0	29.0	1.3	64	1	5	5							30	10	0	33	>188	>200
TELE04-01	1	7/6/09	4	MR-4-3-U	F3b	B3	1.07	3.0	4-<10%	22.0	26.0	1.18	18.6	1.8	39.0	1.8											30	3	0	35	>200	>200
TELE04-01	1	7/6/09	5	MR-4-3-U	B3	B3	1.07	3.0	4-<10%	27.0	24.0	0.89	30.3	1.9	62.0	2.3	121	2	3	3							25	0	0	30	>200	>200
TELE10-02	1	7/7/09	1	MR-0-3-U	B4c	E4	1.25	1.5	<2%	19.8	21.2	1.07	18.5	1.8	39.8	2.0	43	2	14	5		9	1.5	0	0	4	65	20	0	5	>200	>200
TELE10-02	1	7/7/09	2	MR-0-3-U	F4	E4	1.25	1.5	<2%	22.0	24.2	1.10	20.0	2.1	25.0	1.1											85	8	0	3	>200	>200
TELE10-02	1	7/7/09	3	MR-0-3-U	G4c	E4	1.25	1.5	<2%	17.7	27.5	1.55	11.4	2.1	21.7	1.2	29	4	24								63	0	0	13	>200	>200
TELE10-02	1	7/7/09	4	MR-0-3-U	B4	E4	1.25	1.5	<2%	21.0	23.6	1.12	18.7	1.9	36.0	1.7											75	5	0	13	>200	>200
TELE10-02	1	7/7/09	5	MR-0-3-U	C4	E4	1.25	1.5	<2%	17.0	21.7	1.28	13.3	1.7	52.0	3.1	62	1	5	5							58	5	0	10	>69	>158

Reach ID	Site	Date	Cell	Reach Type	Existing Rosgen Stream Type	Potential Rosgen Stream Type	GIS Calculated Sinuosity	Field Slope (Percent)	Aerial Assessment Valley Gradient	Bankfull Channel Width	Cross-Sectional Area	Bankfull Mean Depth	Width / Depth Ratio	Maximum Depth	Floodprone Width	Entrenchment Ratio	Riffle Pebble Count D50	Riffle Pebble Count Percent <2mm	Riffle Pebble Count Percent <6mm	Riffle Grid Toss Percent <6mm	Riffle Stability Index	Number of Pools per 1000 Feet	Mean Residual Pool Depth	Number of Individual Pieces of LWD per 1000 Feet	Number of LWD Aggregates per 1000 Feet	Total Number of LWD per 1000 Feet	Percent Understory Shrub Cover	Percent Bare/Disturbed Ground	Percent Riprap	Percent Overstory Canopy Cover	Right Bank Mean Riparian Zone Width	Left Bank Mean Riparian Zone Width
THRE16-01	1	7/15/09	1	MR-2-3-U	E4	E4	1.48	1.3	2-<4%	13.9	16.2	1.17	11.9	1.7	153.9	11.1	26	12	23	2		19	1.0	0	0	13	43	3	0	45	>200	>200
THRE16-01	1	7/15/09	2	MR-2-3-U					2-<4%																		50	0	0	20	>200	>200
THRE16-01	1	7/15/09	3	MR-2-3-U	C4	E4	1.48	1.3	2-<4%	20.0	13.7	0.69	29.2	1.2	223.0	>11.2	26	19	22								43	0	0	25	>200	>200
THRE16-01	1	7/15/09	4	MR-2-3-U	C4	E4	1.48	1.3	2-<4%	14.5	11.5	0.79	18.4	1.9	44.5	3.1											15	0	0	5	>200	>200
THRE16-01	1	7/15/09	5	MR-2-3-U		E4	1.48	1.3	2-<4%	16.0	12.3	0.77	20.8	1.5			57	4	4								43	0	0	0	>200	>200
THRE17-01	1	7/15/09	1	MR-0-3-U	C3	E4	1.23	1.8	<2%	27.5	30.3	1.10	24.9	1.9	377.5	13.7	87	5	11	1		3	3.1	0	0	2	10	0	0	5	158	>200
THRE17-01	1	7/15/09	2	MR-0-3-U	C3/4	E4	1.23	1.8	<2%	23.0	34.5	1.50	15.3	2.2	224.0	9.7											8	0	0	3	>200	>200
THRE17-01	1	7/15/09	3	MR-0-3-U	C4	E4	1.23	1.8	<2%	22.0	25.5	1.16	19.0	2.0	222.0	10.1	43	6	7	1							3	5	0	0	>200	>200
TROU15-01	1	7/14/09	1	MR-2-2-U	B4	B4	1.10	2.2	2-<4%	12.4	9.2	0.75	16.6	1.2	27.4	2.2	29	6	16	5		9	0.8	8	1	10	68	0	0	5	44	35
TROU15-01	1	7/14/09	2	MR-2-2-U	B4	B4	1.10	2.2	2-<4%	10.1	7.9	0.78	12.9	1.2	15.1	1.5											68	0	0	3	39	39
TROU15-01	1	7/14/09	3	MR-2-2-U	F4b	B4	1.10	2.2	2-<4%	12.5	10.0	0.80	15.6	1.4	16.0	1.3	48	4	6	6							58	0	0	18	22	13
TROU15-01	1	7/14/09	4	MR-2-2-U	C4b	B4	1.10	2.2	2-<4%	10.7	9.1	0.85	12.5	1.2	47.7	4.5											58	0	0	0	23	50
TROU15-01	1	7/14/09	5	MR-2-2-U	C4b	B4	1.10	2.2	2-<4%	12.3	10.4	0.85	14.6	1.4	28.9	2.3	48	7	13	5							43	0	0	0	38	36
TROU17-04	1	7/10/09	1	MR-0-2-U	E4	E4	1.40	1.5	<2%	3.3	5.2	1.56	2.1	1.7	30.3	9.2	19	12	17	11		24	0.9	2	0	4	10	0	0	0	10	50
TROU17-04	1	7/10/09	2	MR-0-2-U	E4	E4	1.40	1.5	<2%	11.4	13.3	1.16	9.8	1.8	223.4	>19.6											30	0	0	0	20	75
TROU17-04	1	7/10/09	3	MR-0-2-U	E4	E4	1.40	1.5	<2%	11.1	11.1	1.00	11.1	1.5	223.1	>20.1	12	7	18	7							45	0	0	0	0	20
TROU17-04	1	7/10/09	4	MR-0-2-U	E4	E4	1.40	1.5	<2%	12.1	12.5	1.04	11.7	1.7	213.6	>17.7											5	0	0	0	0	50
TROU17-04	1	7/10/09	5	MR-0-2-U	C4	E4	1.40	1.5	<2%	14.5	9.9	0.68	21.3	1.2	191.5	13.2	31	7	12	3	68						10	0	0	0	0	50

Reach ID	Reach Type	Pool	Residual Depth (Feet)	Spawning Gravels Identified	Pool Tail-out Fines (%)
DOG11-09	MR-0-3-U	1	1.2		
DOG11-09	MR-0-3-U	2	1.5		
DOG11-09	MR-0-3-U	3	1.7		
DOG12-04	MR-0-4-U	1	1.9		
DOG12-04	MR-0-4-U	2	2.2	Y	3
DOG12-04	MR-0-4-U	3	2.0		
DOG12-04	MR-0-4-U	4	1.2		
DOG12-04	MR-0-4-U	5	1.3		
DOG12-04	MR-0-4-U	6	1.4	Y	5
DOG13-03	MR-0-4-U	1	0.9		
DOG13-03	MR-0-4-U	2	0.6	Y	6.8
ELLI08-01	MR-2-2-C	1	0.7		
ELLI08-01	MR-2-2-C	2	0.7	Y	30
ELLI08-01	MR-2-2-C	3	0.7	Y	13
ELLI08-01	MR-2-2-C	4	1.1	Y	1
ELLI08-01	MR-2-2-C	5	1.0	Y	43
ELLI08-01	MR-2-2-C	6	0.9	Y	13
ELLI08-01	MR-2-2-C	7	0.8		
ELLI08-01	MR-2-2-C	8	0.7	Y	20
ELLI08-01	MR-2-2-C	9	0.9	Y	3
ELLI08-01	MR-2-2-C	10	0.3	Y	36
ELLI08-01	MR-2-2-C	11	0.7	Y	28
ELLI08-01	MR-2-2-C	12	0.8	Y	7
ELLI08-01	MR-2-2-C	13	1.1	Y	5
ELLI08-01	MR-2-2-C	14	1.3	Y	1
ELLI08-01	MR-2-2-C	15	0.7	Y	18
ELLI08-01	MR-2-2-C	16	0.9	Y	27
ELLI08-02	MR-2-2-C	1	0.7	Y	6
ELLI08-02	MR-2-2-C	2	0.5		
ELLI08-02	MR-2-2-C	3	0.6	Y	10
ELLI08-02	MR-2-2-C	4	0.5		
ELLI08-02	MR-2-2-C	5	1.1	Y	14
ELLI08-02	MR-2-2-C	6	0.8	Y	9
ELLI08-02	MR-2-2-C	7	1.6	Y	11
ELLI08-02	MR-2-2-C	8	0.7		
ELLI08-02	MR-2-2-C	9	0.8		
ELLI08-02	MR-2-2-C	10	0.8		
ELLI08-02	MR-2-2-C	11	1.0	Y	0
LBR24-03	MR-0-4-U	1	1.7		
LBR24-03	MR-0-4-U	2	1.6	Y	13.8
LBR24-03	MR-0-4-U	3	1.8		

Reach ID	Reach Type	Pool	Residual Depth (Feet)	Spawning Gravels Identified	Pool Tail-out Fines (%)
LBR26-06	MR-0-5-U	1	2.9	Y	11
LBR26-06	MR-0-5-U	2	2.3	Y	1
LBR26-06	MR-0-5-U	3	2.1		
LBR26-06	MR-0-5-U	4			
LBR26-06	MR-0-5-U	5	3.0		
LBR26-06	MR-0-5-U	6	2.1	Y	7
LBR26-06	MR-0-5-U	7	1.3		
LBR26-06	MR-0-5-U	8	3.6		
LBR26-06	MR-0-5-U	9	3.4	Y	0
LBR26-06	MR-0-5-U	10	2.0		
LBR27-06	MR-0-5-U	1	4.3	Y	1
LBR27-06	MR-0-5-U	2	3.5	not recorded	0
LBR27-06	MR-0-5-U	3	4.7	Y	0
LBR27-06	MR-0-5-U	4	2.9		
LBR27-06	MR-0-5-U	5	2.4	Y	0
LBR27-06	MR-0-5-U	6	3.0	not recorded	6
LBR27-06	MR-0-5-U	7	4.0	Y	1
LBR27-06	MR-0-5-U	8	2.2		
LBR27-06	MR-0-5-U	9	1.9	Y	0
LBR30-05	MR-0-5-U	1	0.9		
LBR30-05	MR-0-5-U	2	1.7		
LBR30-05	MR-0-5-U	3	2.2		
LBR30-05	MR-0-5-U	4	3.0		
LBR30-05	MR-0-5-U	5	4.4		
LBR30-05	MR-0-5-U	6	1.9		
SNOW08-01	MR-4-1-U	1			
SNOW08-01	MR-4-1-U	2			
SNOW08-01	MR-4-1-U	3			
SNOW08-01	MR-4-1-U	4	0.5	Y	5
SNOW08-01	MR-4-1-U	5	0.8	Y	21
SNOW08-01	MR-4-1-U	6	0.4	Y	22
SNOW18-05	MR-0-2-U	1	1.6	Y	16
SNOW18-05	MR-0-2-U	2	2.3	Y	10
SNOW18-05	MR-0-2-U	3	1.4	Y	5
SNOW18-05	MR-0-2-U	4	1.1	Y	2
SNOW18-05	MR-0-2-U	5	1.3		
SNOW18-05	MR-0-2-U	6	1.2	Y	1
SNOW18-05	MR-0-2-U	7			
SNOW18-05	MR-0-2-U	8	1.0		
SNOW18-05	MR-0-2-U	9	1.8	Y	29
SNOW18-05	MR-0-2-U	10	2.0		

Reach ID	Reach Type	Pool	Residual Depth (Feet)	Spawning Gravels Identified	Pool Tail-out Fines (%)
SNOW18-05	MR-0-2-U	11	1.5	Y	5
SNOW18-05	MR-0-2-U	12	0.8	N	52
SNOW18-05	MR-0-2-U	13	1.8	N	54
SNOW18-05	MR-0-2-U	14	1.1	Y	4
SNOW18-05	MR-0-2-U	15	1.4	Y	7
SNOW18-05	MR-0-2-U	16	1.4	Y	3
SNOW18-05	MR-0-2-U	17	1.8	Y	3
SNOW18-05	MR-0-2-U	18	1.3	Y	17
SNOW18-05	MR-0-2-U	19	1.6	Y	10
SNOW18-05	MR-0-2-U	20	1.4	Y	5
SNOW18-05	MR-0-2-U	21	2.1	Y	18
SPOT01-01	MR-2-2-U	1	1.2	Y	14
SPOT01-01	MR-2-2-U	2	0.6	Y	8
SPOT01-01	MR-2-2-U	3	0.8	Y	3
SPOT01-01	MR-2-2-U	4	0.6	Y	4
SPOT01-01	MR-2-2-U	5	1.2	Y	7
SPOT01-01	MR-2-2-U	6	1.1	Y	6
SPOT01-01	MR-2-2-U	7	1.6	Y	8
SPOT01-01	MR-2-2-U	8	0.7	Y	7
SPOT01-01	MR-2-2-U	9	0.6		
SPOT01-01	MR-2-2-U	10	0.5	Y	3
SPOT01-01	MR-2-2-U	11	1.2	Y	6
SPOT01-01	MR-2-2-U	12	1.1		
SPOT01-01	MR-2-2-U	13	0.6	Y	5
SPOT01-01	MR-2-2-U	14	0.9	Y	8
SPOT01-01	MR-2-2-U	15	0.7		
SPOT01-01	MR-2-2-U	16	0.8		
SPOT01-01	MR-2-2-U	17	0.8		
SPOT01-01	MR-2-2-U	18	1.3	Y	12
SPOT01-01	MR-2-2-U	19	1.5		
SPOT01-01	MR-2-2-U	20	1.2	Y	14
SPOT12-02	MR-0-3-U	1	2.1	Y	5
SPOT12-02	MR-0-3-U	2	1.9	Y	9
SPOT12-02	MR-0-3-U	3	1.8		
SPOT12-02	MR-0-3-U	4	2.0	Y	1
SPOT12-02	MR-0-3-U	5	2.0		
SPOT12-02	MR-0-3-U	6	0.9	Y	11
SPOT12-02	MR-0-3-U	7	1.6		
SPOT12-02	MR-0-3-U	8	1.4		
TELE04-01	MR-4-3-U	1	1.1		
TELE04-01	MR-4-3-U	2	0.8	Y	1
TELE04-01	MR-4-3-U	3	0.9		
TELE04-01	MR-4-3-U	4	0.9		

Reach ID	Reach Type	Pool	Residual Depth (Feet)	Spawning Gravels Identified	Pool Tail-out Fines (%)
TELE04-01	MR-4-3-U	5	2.2		
TELE04-01	MR-4-3-U	6	0.9	Y	3
TELE04-01	MR-4-3-U	7			
TELE04-01	MR-4-3-U	8	1.5		
TELE04-01	MR-4-3-U	9	1.3		
TELE04-01	MR-4-3-U	10	2.7	Y	1
TELE10-02	MR-0-3-U	1	2.4	Y	9
TELE10-02	MR-0-3-U	2	1.0		
TELE10-02	MR-0-3-U	3	1.2		
TELE10-02	MR-0-3-U	4	1.9	Y	3
TELE10-02	MR-0-3-U	5	1.1		
TELE10-02	MR-0-3-U	6	1.3		
TELE10-02	MR-0-3-U	7	2.2	Y	0
TELE10-02	MR-0-3-U	8	1.1		
TELE10-02	MR-0-3-U	9	1.0		
THRE16-01	MR-2-3-U	1	0.6		
THRE16-01	MR-2-3-U	2	1.7		
THRE16-01	MR-2-3-U	3	1.0		
THRE16-01	MR-2-3-U	4	0.5		
THRE16-01	MR-2-3-U	5	0.5		
THRE16-01	MR-2-3-U	6	1.1	Y	1
THRE16-01	MR-2-3-U	7	0.7		
THRE16-01	MR-2-3-U	8	1.3		
THRE16-01	MR-2-3-U	9	1.4	Y	1
THRE16-01	MR-2-3-U	10	1.4		
THRE16-01	MR-2-3-U	11	1.0	Y	5
THRE16-01	MR-2-3-U	12	0.5		
THRE16-01	MR-2-3-U	13	1.0		
THRE16-01	MR-2-3-U	14	0.7		
THRE16-01	MR-2-3-U	15	1.6		
THRE16-01	MR-2-3-U	16	1.3		
THRE16-01	MR-2-3-U	17	1.5	Y	1
THRE16-01	MR-2-3-U	18	1.2		
THRE16-01	MR-2-3-U	19	0.7		
THRE17-01	MR-0-3-U	1	4.3	Y	10
THRE17-01	MR-0-3-U	2	1.8	Y	1
TROU15-01	MR-2-2-U	1	0.5		
TROU15-01	MR-2-2-U	2	0.7	Y	9
TROU15-01	MR-2-2-U	3	0.9		
TROU15-01	MR-2-2-U	4	0.8		
TROU15-01	MR-2-2-U	5	0.7	Y	11
TROU15-01	MR-2-2-U	6	0.6		

Reach ID	Reach Type	Pool	Residual Depth (Feet)	Spawning Gravels Identified	Pool Tail-out Fines (%)
TROU15-01	MR-2-2-U	7	0.9		
TROU15-01	MR-2-2-U	8	1.0		
TROU15-01	MR-2-2-U	9	0.9		
TROU17-04	MR-0-2-U	1	0.5		
TROU17-04	MR-0-2-U	2			
TROU17-04	MR-0-2-U	3	1.3	Y	60
TROU17-04	MR-0-2-U	4	1.2	Y	32
TROU17-04	MR-0-2-U	5			
TROU17-04	MR-0-2-U	6	0.7	Y	62
TROU17-04	MR-0-2-U	7	1.1	Y	49
TROU17-04	MR-0-2-U	8	0.9	Y	4
TROU17-04	MR-0-2-U	9			
TROU17-04	MR-0-2-U	10	0.6	not recorded	9
TROU17-04	MR-0-2-U	11	0.7		
TROU17-04	MR-0-2-U	12	1.0		

Y = Spawning Gravels Present
N = Spawning Gravels Absent
Q = Questionable Spawning Gravels

APPENDIX D - LITTLE BLACKFOOT RIVER WATERSHED SEDIMENT AND NUTRIENT ASSESSMENT

TABLE OF CONTENTS

Acronyms D-5
D1.0 Introduction D-7
D1.1 Prior Studies D-9
D1.2 Report Units D-10
D2.0 Data Compilation and Assessment D-10
D2.1 Watershed Description D-10
D2.2 Climate D-10
D2.3 Streamflow Hydrology D-12
D2.3.1 Available Data D-13
D2.4 Land Use D-15
D2.5 Soils D-15
D2.6 Irrigation D-15
D3.0 Model Development D-16
D3.1 SWAT Model Description D-16
D3.2 Model Input D-17
D3.3 Simulation Period D-17
D3.4 Watershed Delineation D-18
D3.5 Hydrologic Response Units D-20
D3.6 Climatic Patterns D-21
D3.7 Routing Geometry D-22
D3.8 Evapotranspiration D-22
D3.9 Irrigation D-23
D3.10 Reservoirs D-23
D3.11 Wastewater Point Sources D-24
D3.12 Grazing D-25
D3.13 Roads D-26
D4.0 Model Calibration D-26
D4.1 Evaluation Criterion D-27
D4.2 Simulation Period and Boundary Conditions D-27

D4.3 Streamflow Calibration D-28
D4.4 Sediment Calibration D-34
D4.5 Nutrient Calibration D-36
D4.7 Model Validation/Confirmation D-40
D5.0 Scenario Analysis D-41
D5.1 Baseline Scenario D-42
D5.1.1 Baseline Scenario - Sediment D-43
D5.1.2 Baseline Scenario - Nutrients D-44
D5.2 Improved Roadways Scenario D-44
D5.2.1 Improved Roadways Scenario - Sediment D-44
D5.2.2 Improved Roadways Scenario - Nutrients D-45
D5.3 Stabilized Channel Scenario D-45
D5.3.1 Stabilized Channel Scenario - Sediment D-46
D5.3.2 Stabilized Channel Scenario - Nutrients D-46
D5.4 Improved Grazing Management Scenario D-46
D5.4.1 Improved Grazing Management Scenario - Sediment D-46
D5.4.2 Improved Grazing Management Scenario - Nutrients D-47
D5.5 Enhanced Riparian Health Scenario D-47
D5.5.1 Enhanced Riparian Health Scenario - Sediment D-47
D5.5.2 Enhanced Riparian Health Scenario - Nutrients D-48
D5.6 Improved Irrigation Scenario D-48
D5.7 Scenario Summary D-48
D6.0 Conclusion and Limitations D-51
D8.0 References D-52
Appendix DA - Modeling Scenario Results D-57
DA.1.0 Sediment D-57
DA.1.1 Overview D-57
DA.1.2 Tables D-57
DA.2.0 Nutrients D-62
DA.2.1 Overview D-62
DA.2.2 Tables D-63
Appendix DB - Sediment Total Maximum Daily Loads D-67
DB.1 Sediment D-67
DB.1.1 Overview D-67
DB.1.2 Approach D-67

Appendix DC – Model Input D-71
Appendix DD – Model Output D-73

LIST OF TABLES

Table D1-1. Water quality limited segments in the Little Blackfoot River watershed D-7
Table D2-1. Weather stations used in the Little Blackfoot River watershed model D-11
Table D2-2. Available data for calibration and validation of SWAT in the Little Blackfoot River D-14
Table D2-3. Land uses within the Little Blackfoot River watershed D-15
Table D3-1. Sub-basin summary, Little Blackfoot River watershed D-19
Table D3-2. Average USLE C factors D-20
Table D3-3. Data requirements for SWAT-available PET methods D-23
Table D4-1. Calibrated and adjusted parameters for the Little Blackfoot River SWAT model D-29
Table D4-2. Daily Calibration Metrics D-31
Table D4-3. Monthly Calibration Metrics D-32
Table D4-4. Average Annual Basin Values (from the SWAT output.std file) D-33
Table D4-5. Observed, best-fit, and simulated sediment concentrations, 2002-2005 ..... D-36
Table D4-6. Observed mean nutrient concentrations at Little Blackfoot River mouth (mg/L) D-38
Table D4-7. Daily validation metrics, 2006-2008 ..... D-41
Table D5-1. Sediment contributions, Little Blackfoot River D-43
Table D5-2 Total phosphorus contributions on the Little Blackfoot River during the growing season .. D-44
Table D5-3. Sediment loadings reductions from improved roadways by stream segment (DEQ, 2010) D-45
Table D5-4. Overall reductions in sediment loading by stream segment (on an annual basis) D-49
Table D5-5. Overall reductions in nutrient loading by stream segment on a seasonal (July – Oct) basis D-50
Table D5-6. Annual versus summer (July-September) nutrient reductions D-51
Table DA-1. Dog Creek Sediment Summary D-57
Table DA-2. Dog Creek (Above Meadow Creek) Sediment Summary D-58
Table DA-3. Elliston Creek Sediment Summary D-58
Table DA-4. Little Blackfoot River Sediment Summary D-59
Table DA-5. Little Blackfoot River (Above Dog Creek) Sediment Summary D-59
Table DA-6. Snowshoe Creek Sediment Summary D-60
Table DA-7. Spotted Dog Creek Sediment Summary D-60
Table DA-8. Telegraph Creek (Above Hahn Creek) Sediment Summary D-61
Table DA-9. Threemile Creek Sediment Summary D-61

Table DA-10. Trout Creek Sediment Summary D-62
Table DA-11. Carpenter Creek Phosphorus Summary D-63
Table DA-12. Dog Creek Phosphorus Summary D-63
Table DA-13. Little Blackfoot River Phosphorus Summary D-63
Table DA-14. Snowshoe Creek Nitrogen Summary D-64
Table DA-15. Spotted Dog Creek Phosphorus Summary D-64
Table DA-16. Threemile Creek Nitrogen Summary D-64
Table DA-17. Threemile Creek Phosphorus Summary D-65
Table DB-1. USGS Stream Gage 12324590 (Little Blackfoot River near Garrison) – Percent of Mean Annual Discharge Based on Mean of Daily Mean Discharge Values for each Day of Record (Calculation Period 1972-09-26 -> 2011-09-30) D-68
Table DB-2. TMDL expressed as an average annual load for each waterbody segment D-69

LIST OF FIGURES

Figure D1-1. The location of the Little Blackfoot River watershed within Montana D-8
Figure D1-2. The Little Blackfoot River watershed with 303(d) listed streams identified D-9
Figure D2-1. Location of weather stations used in the Little Blackfoot River watershed model D-12
Figure D2-2. Average annual hydrograph (1979-2009), Little Blackfoot River (USGS gage #12324590) D-13
Figure D2-3. Observed sediment and nutrient values used in calibration of model D-14
Figure D3-1. Sub-basins within the Little Blackfoot River watershed D-18
Figure D3-2. Elevation distribution by sub-basin within the Little Blackfoot River watershed D-20
Figure D3-3. Precipitation lapse rate used in the Little Blackfoot River watershed model D-21
Figure D3-4. Temperature lapse rate used in the Little Blackfoot River watershed model D-22
Figure D4-1. Hydrology for model run period D-28
Figure D4-2. Hydrology gage locations in the Little Blackfoot River watershed D-30
Figure D4-3. Simulated and Observed Daily Hydrology, 2002-2005 ..... D-31
Figure D4-4. Simulated and Observed Monthly Hydrology, 2002-2005 ..... D-32
Figure D4-5. Fraction of river discharge originating in the Little Blackfoot headwaters during the growing season (July-October, 2001-2010) D-33
Figure D4-6. Observed total suspended sediment concentrations versus discharge D-35
Figure D4-7. Best-Fit versus simulated sediment loading, 2002-2005 ..... D-36
Figure D4-8. Average monthly observed nitrogen concentrations (mg/L) D-37
Figure D4-9. Average monthly observed phosphorus concentrations (mg/L) D-38
Figure D4-10. Total nitrogen concentrations by month, 2002-2005 ..... D-39
Figure D4-11. Total phosphorus concentrations by month, 2002-2005 ..... D-39
Figure D4-12. Model validation, daily hydrology, 2006-2008 ..... D-41
Figure D5-1. Average annual hydrograph (simulated), 2002-2005 ..... D-43
Figure DB-1. Average daily sediment load for the lower segment of the Little Blackfoot River D-69

ACRONYMS

Acronym	Definition
AFO	Animal Feeding Operation
AMSL	Above Mean Sea Level
ArcSWAT	ArcView (GIS) Extension of SWAT
ARS	Agricultural Research Service
BMP	Best Management Practice
cfs	cubic feet per second (a unit of flow)
cms	cubic meters per second (a unit of flow)
DEQ	Department of Environmental Quality (Montana)
DNRC	Department of Natural Resources & Conservation
EPA	Environmental Protection Agency (US)
GIS	Geographical Information System
ha	Hectares (a unit of area)
HNF	Helena National Forest
HUC	Hydrologic Unit Code
MDOT	Montana Department of Transportation
MUSLE	Modified Universal Soil Loss Equation
NCDC	National Climatic Data Center
NED	National Elevation Dataset
NHD	National Hydrography Dataset
NLCD	National Land Cover Dataset
NO3	Nitrate/Nitrite
NRCS	Natural Resources Conservation Service
NSE	Nash-Sutcliffe Coefficient of Efficiency
QUAL2E	River and Stream Water Quality Model
RE	Relative Error
SCS	Soil Conservation Service
SNOTEL	NRCS Snowpack Telemetry
STATSGO	State Soil Geographic Database
SWAT	Soil and Water Assessment Tool (model)
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TPA	TMDL Planning Area
TSWQC	Tri-State Water Quality Council
UM	University of Montana
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey
USLE C	Universal Soil Loss Equation Cover Factor
WWTP	Wastewater Treatment Plant

D1.0 INTRODUCTION

The Little Blackfoot River watershed is located in western Montana within the Clark Fork River watershed (**Figure D1-1**). The Little Blackfoot River and eight tributaries are characterized as "water quality-limited" from sediment or nutrient impairment (**Table D1-1**). To satisfy Federal Clean Water Act requirements, Total Maximum Daily Loads (TMDLs) must be developed for these waterbodies such that they support beneficial uses. The Montana Department of Environmental Quality (DEQ) has determined that a modeling approach will be the most effective way to identify existing nonpoint source loads in the watershed, and complete equitable allocations between those sources as part of the TMDL. As such, a Soil and Water Assessment Tool (SWAT) watershed model has been prepared to account for watershed-scale loadings of sediment and nutrients, and to calculate associated fate and transport in the channel network.

The tool will be used for a number of TMDL planning purposes including (1) evaluating baseline conditions in the watershed, (2) partitioning between nonpoint sources, (3) allocating sediment and nutrients for TMDL development, (4) formulating water quality restoration plans, and (5) prescribing management and land use scenario changes within the Little Blackfoot River watershed to meet TMDL objectives.

A list of the reaches evaluated as part of this project is provided in **Table D1-1**, and these reaches are shown in **Figure D1-2**.

Table D1-1. Water quality limited segments in the Little Blackfoot River watershed

Waterbody Name	Reach Segment	TMDL Developed*
Carpenter Creek	MT76G004_092	TP
Dog Creek (upper)	MT76G004_071	Sediment
Dog Creek (lower)	MT76G004_072	Sediment/TP
Elliston Creek	MT76G004_040	Sediment
Little Blackfoot River (upper)	MT76G004_020	Sediment
Little Blackfoot River (lower)	MT76G004_010	Sediment/TP
Snowshoe Creek	MT76G004_080	Sediment/NO3-NO2
Spotted Dog Creek (lower)	MT76G004_032	Sediment/TP
Telegraph Creek (upper)	MT76G004_051	Sediment
Threemile Creek	MT76G004_112	Sediment/TN/TP
Trout Creek	MT76G004_120	Sediment

*TN: Total Nitrogen, TP: Total Phosphorus, NO3-NO2: Nitrate plus Nitrite

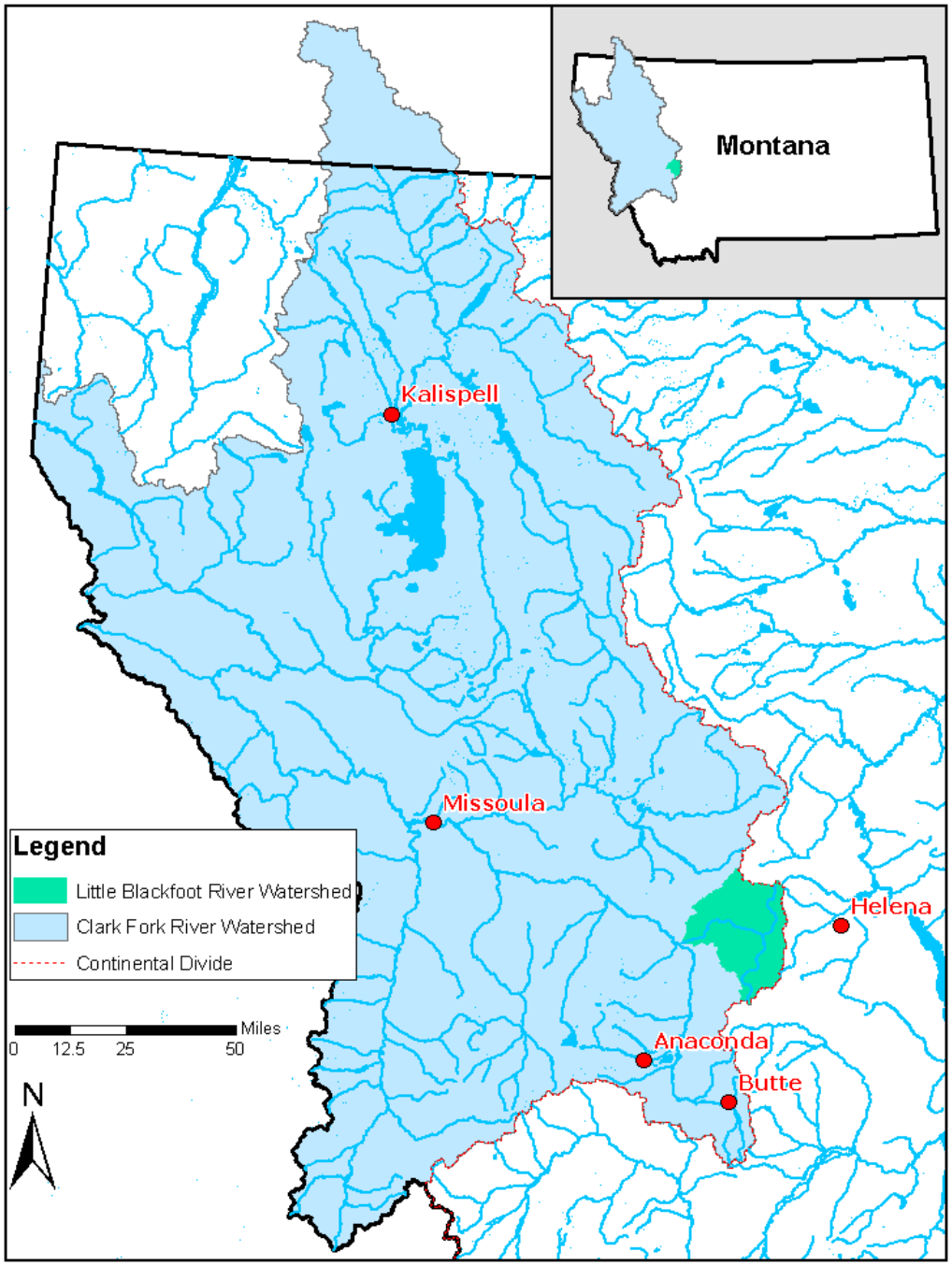


Figure D1-1. The location of the Little Blackfoot River watershed within Montana

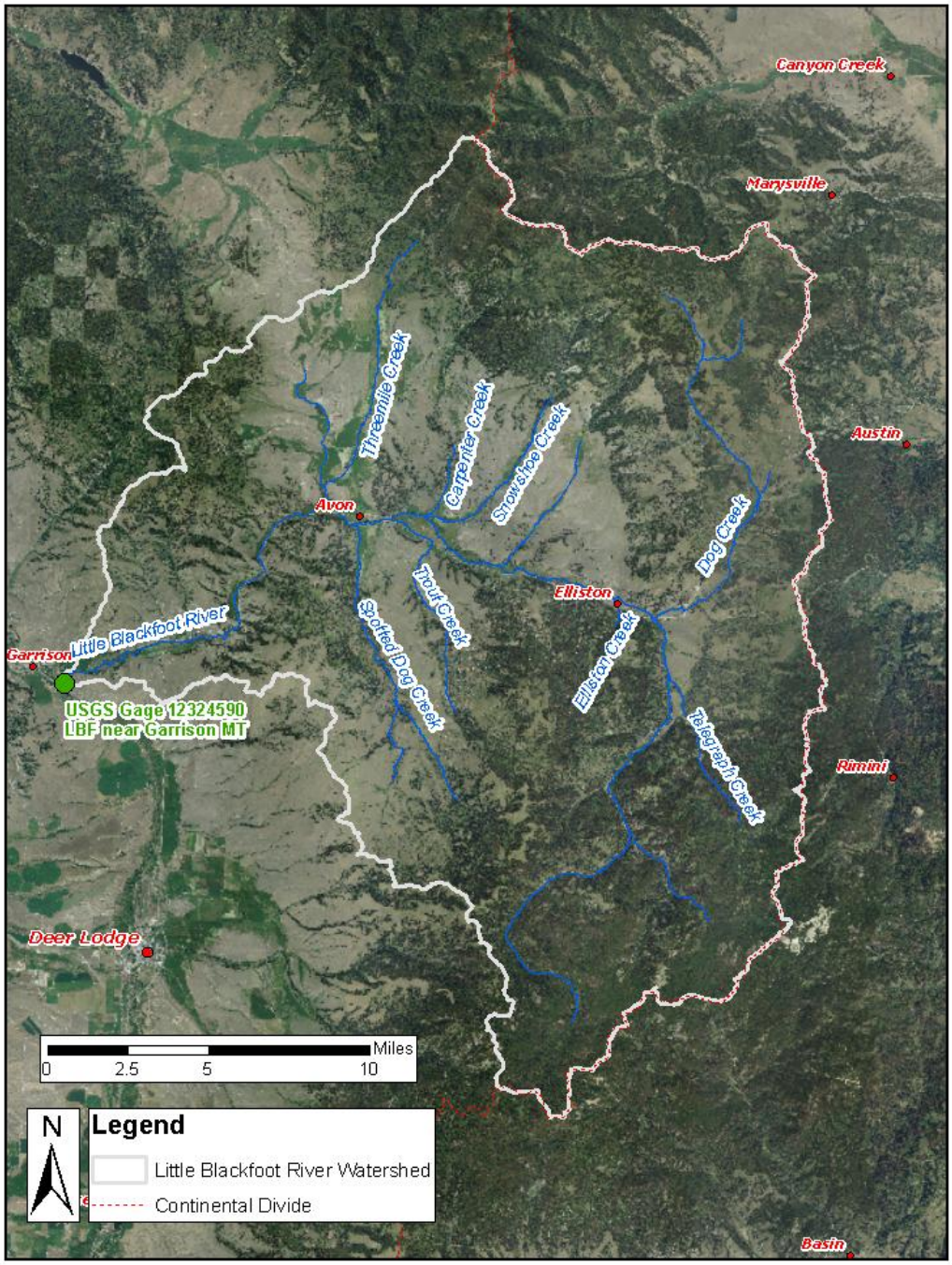


Figure D1-2. The Little Blackfoot River watershed with 303(d) listed streams identified

D1.1 Prior Studies

There have been several prior studies specific to the Little Blackfoot River watershed, all of which were reviewed for development of this model. These include:

- Flow Study on the Lower Little Blackfoot River (Barnes, 2008)
- Hydrogeochemistry of a Natural Wetland Receiving Acid Mine Drainage (Milodragovich, 2003a)
- Little Blackfoot River Groundwater/Surface Water Interaction Study (PBS&J, 2009)
- Plant-Metal Interactions in a Natural and Remediated High Elevation Metal-Contaminated Wetland (Olsen, 2004a).
- Road Sediment Assessment & Modeling Little Blackfoot River TPA (Water & Environmental Technologies, 2010)
- Sediment and Habitat Data and Bank Erosion Assessment (PBS&J, 2010)

D1.2 Report Units

Units used by SWAT (and reported here) are in the metric system. All units are clearly labeled in the report, but useful conversions are listed below. Many of the units were converted to English units in the actual TMDL report.

1 cubic meter per second (cms) = 35.3 cubic feet per second (cfs)
1,234.0 cubic meters = 1 acre-foot
1 degree Celsius (C) = 1.8 degrees Fahrenheit (F)
1 hectare (ha) = 2.47 acres (ac)
1 kilogram (kg) = 2.205 pounds (lbs)
1 metric ton (mT) = 1.102 short tons (tons)
25.4 millimeters (mm) = 1 inch (in)
2.59 square kilometers (sqkm) = 1 square mile (sqmi)

D2.0 Data Compilation and Assessment

A variety of different climatic, flow, water quality, and spatial geographic information system (GIS) data were reviewed and evaluated for use in SWAT model development. These details are briefly overviewed below.

D2.1 Watershed Description

The Little Blackfoot River is located in western Montana and flows west from the continental divide near Helena, Montana to Garrison, Montana, where it joins the Clark Fork River (**Figure D1-2**). The watershed is approximately 265,000 acres (107,000 hectares) in size, with 48 miles of mainstem river originating in the Boulder Mountains in the southeast. The continental divide runs along the southern, eastern, and northern borders of this watershed. Elevations in the watershed range from approximately 4,300 to 5,500 feet above mean sea level (AMSL) in the valley to mountain peaks over 8,500 feet AMSL. The average annual precipitation ranges from 10 to 20 inches in the valleys to approximately 30 to 50 inches in the mountains.

D2.2 Climate

Climate in the Little Blackfoot River watershed is inter-montane with distinct seasonality. Valleys tend to be moderately arid while mountainous regions are moderately wet. Annual average precipitation is estimated to be 22 inches basin-wide, with significant spatial variability. Snowfall in the surrounding

mountains is moderate, with snowpacks rarely exceeding 72 inches (six feet), although this varies significantly from year to year.

Climate data was obtained from seven weather stations in close proximity to the watershed (**Figure D2-1**). Daily precipitation, temperature, wind speed, solar radiation, and relative humidity were obtained from the Deer Lodge AgriMET Site (Coop ID DLRM), while daily precipitation and temperature were acquired from five of the remaining National Climatic Data Center (NCDC) and NRCS Snow Telemetry (SNOTEL) stations (**Table D2-1**). The MDOT Garrison weather station did not collect precipitation, and thus was used for temperature data only. Only one of the climate stations was located within the watershed (Elliston), with the rest being located in the surrounding area. Although there are other nearby stations, only these had a complete (or nearly complete) data set for the time frame included in the model. The modeling period (1999 through 2008) was chosen because it had the most climatic, hydrologic, and water-quality data available.

Table D2-1. Weather stations used in the Little Blackfoot River watershed model

Location	Station Type	Average Annual Precipitation (in)	Avg Annual Max Temp (F)	Avg Annual Min Temp (F)	Elevation (ft AMSL)	Avg. Max Snow Pack (in)
Austin	NCDC	16.2	52.7	30.0	4,999	-
Deer Lodge	NCDC	11.2	55.3	28.1	4,848	-
Elliston	NCDC	16.7	54.9	26.7	5,075	-
Frohner	SNOTEL	23.7	48.9	29.0	6,479	34.2
Nevada	SNOTEL	28.0	46.1	30.0	7,020	54.2
Rocker	SNOTEL	29.9	43.9	26.8	7,998	59.3
Garrison	MDOT	-	57.6	30.4	4,327	-

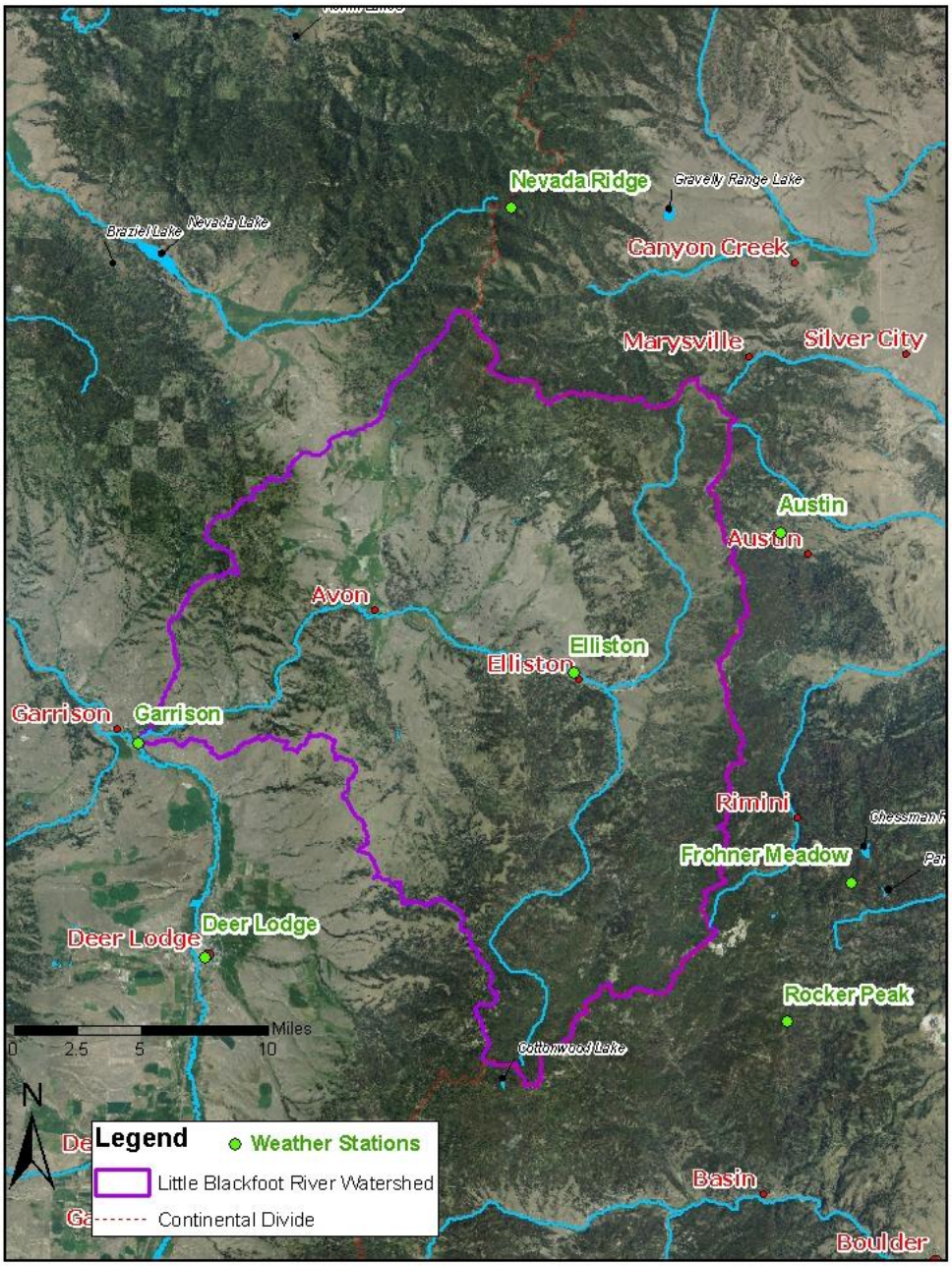


Figure D2-1. Location of weather stations used in the Little Blackfoot River watershed model

D2.3 STREAMFLOW HYDROLOGY

The hydrology of the Little Blackfoot River is a complex interconnection of tributaries from the surrounding mountains, groundwater recharge and discharge, wetlands, irrigation diversions, and other human withdrawals and discharges. Streamflow is monitored by the United States Geological Survey (USGS) at a single location at the outlet of the Little Blackfoot River (USGS #12324590 Little Blackfoot River near Garrison, MT). Based on nearly 40 years of available streamflow records for this gage (1972-2011), the average annual discharge for the river is approximately 155 cubic feet per second (cfs), ranging from a low of 6.5 cfs (8/23/1977) to a high of 6,280 cfs (5/22/1981). The onset of runoff

routinely begins in early April, reaching peak approximately the last week of May, and is typically back to baseflow conditions by August 1st (**Figure D2-2**).

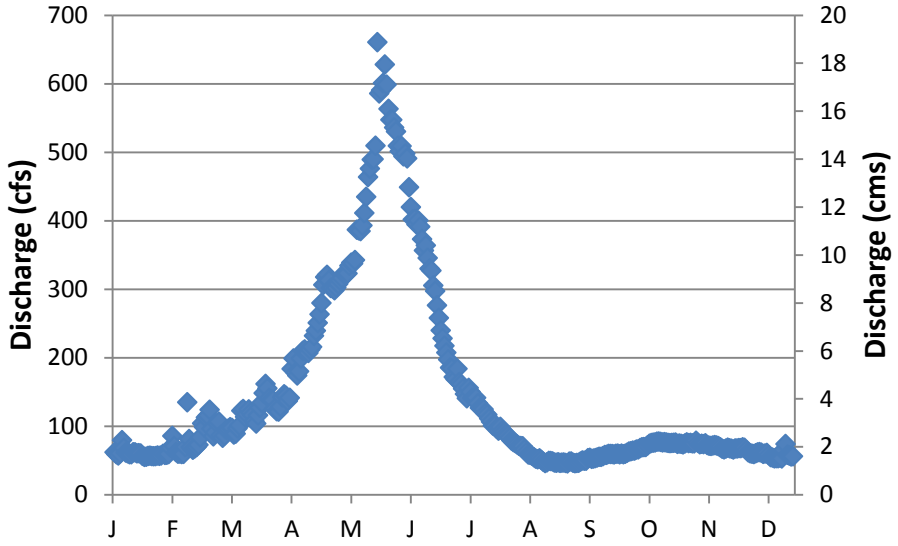


Figure D2-2. Average annual hydrograph (1979-2009), Little Blackfoot River (USGS gage #12324590)

There are approximately 1,500 – 2,000 active water rights within the Little Blackfoot River watershed, of which about half are for surface water (Montana Department of Natural Resources and Conservation, 2011). Numerous irrigation diversions are present and range from small one-field diversions on tributaries to larger mainstem diversions. The exact amount of water diverted from the Little Blackfoot River is difficult to determine because individual records are not kept, although if all water rights in the watershed were exercised to their fullest, they would exceed the typical summer flows in the Little Blackfoot River.

There are three reservoirs in the Little Blackfoot River watershed. These reservoirs are used primarily for irrigation. One reservoir is located on Snowshoe Creek, one is located on Spotted Dog Creek, and a third smaller one is located on Threemile Creek (Quigley Reservoir). Inflow to each reservoir depends on the amount of water accumulated in the mountain snowpack, temperatures during snowmelt, and spring precipitation. Reservoir releases are primarily based on satisfying downstream irrigation uses. These reservoirs are discussed further in **Section D3**.

D2.3.1 Available Data

Streamflow and water quality data are required components for sediment and nutrient model calibration. Those available to DEQ in 2010 were used in the modeling process. Data were reviewed with particular focus on recent data (1990 through 2009) for model construction and development. This data is considered most relevant as it is coincident with the landcover that will be used for the model (the 2001 National Land Cover Data [NLCD]). Key data included the following:

- Flow
- Sediment
- Nutrients
  - Total phosphorus (TP)
  - Soluble phosphorus or orthophosphate (OP)
  - Total nitrogen (TN)

- Nitrate/nitrite (NO_3/NO_2)

Data was acquired from several agencies including the USGS, United States Forest Service (USFS), Tri-State Water Quality Council (TSWQC), the University of Montana (UM), and the DEQ. Water quality data were collected by the USGS at the USGS station described in **Section D2.3**. A majority of the non-USGS data is for the period 1998 through 2005. USGS data collection ranges from the 1970s through the current period. All sampling was generally sporadic throughout the period.

Available data for calibration and validation of the Little Blackfoot SWAT model are identified in **Table D2-2.** This includes the location, overall period of record, and frequency of sampling for each data type (flow, sediment, and nutrients).

Table D2-2. Available data for calibration and validation of SWAT in the Little Blackfoot River

Location	Period of Record		Frequency of Sampling	
USGS 12324590 Little Blackfoot River near Garrison, MT	Flow Sediment Nutrients	1972-current 1978-2010 1978-2010	Flow Sediment Nutrients	Daily Intermittent Intermittent
Mouth of Little Blackfoot River	Sediment Nutrients	1990s-present 1990s-present	Sediment Nutrients	Intermittent Intermittent
Little Blackfoot River nr Telegraph Creek	Flow	2009-2010	Flow	Daily

Comparing the water quality sample dates with the flow data is valuable for assessing whether or not the water quality sampling was largely completed during low flow periods, or whether the data represent a range of flows from high to low. Flow data for the sediment and nutrient data used to calibrate the model are plotted by month (**Figure D2-3**). Sample data are spread out across the year, although a majority of the data are from the spring and summer. Data from the USGS gage and the mouth of the river are lumped together here (and throughout the document), as they are only a few hundred meters apart and have no known inflows between them.

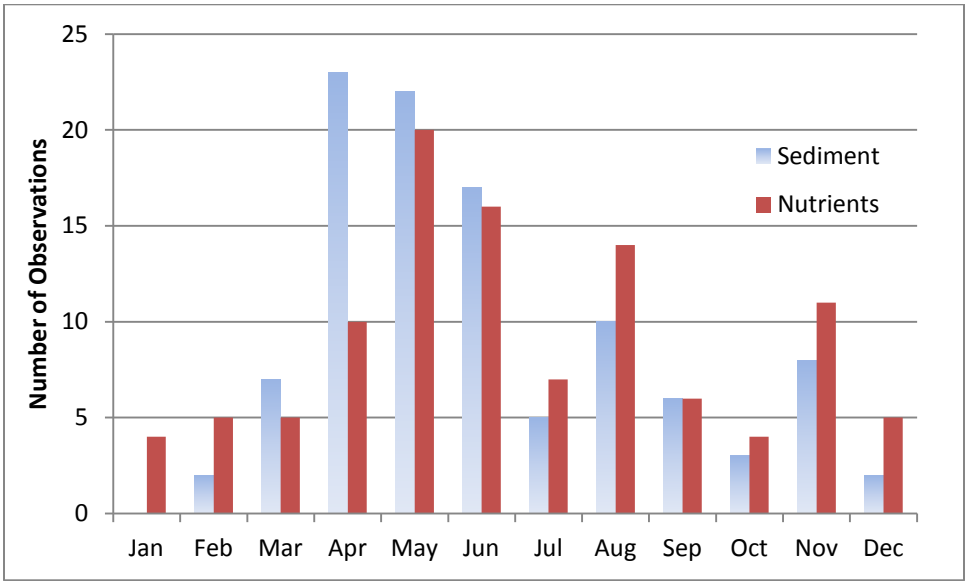


Figure D2-3. Observed sediment and nutrient values used in calibration of model

D2.4 LAND USE

Land uses in the model were based on the NLCD 2001 data set (**Table D2-3**). Nearly 95% of the watershed is categorized as either forest or rangeland. Land use activities in the Little Blackfoot River watershed consist primarily of activities associated with cattle production. Logging and associated activities such as road construction did occur in the 1970s and 1980s, and may occur again due to the recent pine-bark beetle epidemic; however, for the period of time during the model run (1998-2008), little known logging occurred (USFS, personal communication). Agriculture in the watershed consists primarily of irrigated hay. The NLCD labels about 300 acres of the watershed as "row crops", although field reconnaissance and personal communications with landowners suggest that there are almost no row crops grown in the Little Blackfoot River watershed. Therefore, in the model analysis, agricultural land was assumed to be pasture (and parameterized as such), and no further separation of the two was made. Stock owners often pasture their livestock on USFS Helena National Forest (HNF) range during the summer months and in irrigated hay fields during the winter. Urban residential development occurs in the communities of Elliston and Avon, as well as some other locations in the watershed, but overall only accounts for about 0.5% of the watershed. On-site septic systems in the watershed number approximately 301. There are no permitted wastewater treatment plant (WWTP) point source discharges in the watershed.

Table D2-3. Land uses within the Little Blackfoot River watershed

Land Use	SWAT Code	Area (hectares)	Area (acres)	Watershed Area (%)
Agricultural Land-Row Crops	AGRR	129.9	321.0	0.12%
Forest	FRSE	59,151.8	146,167.0	55.42%
Pasture	PAST	4,744.2	11,723.2	4.45%
Range	RNGB	41,556.5	102,688.2	38.94%
Urban-Residential	URBN	582.4	1,439.1	0.55%
Arid Range	SWRN	9.4	23.3	0.01%
Water	WATR	22.1	54.6	0.02%
Wetlands	WETF	535.2	1,322.6	0.50%
Totals	**-**	**106,732**	**263,739**	**100.0%**

D2.5 SOILS

Soils in the Little Blackfoot Watershed exhibit considerable spatial variability. A total of 17 soil associations occur in the watershed, as defined by the State Soil Geographic Database (STATSGO). Most soils on the bottom lands of the Little Blackfoot River are very shallow to barely moderately deep over loose sands and gravels. They consist of silt loams, loamy fine sands, and fine sandy loams. Deeper soils occur in the higher portions of the watershed. These soils are typically silt loams, loams, and cobbly loams.

D2.6 IRRIGATION

Approximately 4,900 hectares in this watershed are used to grow hay for cattle production. Streamflow on the Little Blackfoot River is heavily influenced by irrigation withdrawals for hay production in the late spring and summer. There are also three small reservoirs within the Little Blackfoot River watershed that are used for irrigation. Irrigation practices and reservoir management are discussed in more detail in **Section D3**.

D3.0 MODEL DEVELOPMENT

D3.1 SWAT MODEL DESCRIPTION

The Montana DEQ selected the SWAT model for modeling the Little Blackfoot River watershed. The SWAT model and its ArcView Extension (ArcSWAT) were developed and are actively supported by the U.S. Department of Agriculture (USDA) Agricultural Research Service (ARS). SWAT is a public domain watershed-scale hydrologic and water quality model developed to quantify the impact of land management practices in large, complex watersheds. It is a deterministic, distributed parameter continuous simulation basin-scale model. SWAT partitions a watershed into a number of subwatersheds that are homogeneous in terms of climate and topography, but are distributed in the context that they are linked with other subwatersheds through the channel network. Each subwatershed is further partitioned (i.e., discretized) into hydrologic response units (HRUs) that are lumped into unique soil, landcover, and slope combinations having no spatial context. These HRUs form the fundamental computational unit of the model.

The advantages of SWAT include:

- It is physically based and uses readily available inputs.
- It is computationally efficient in that modern computers are able to complete the simulation calculations within a reasonable amount of time.
- It incorporates comprehensive processes by using mathematical equations to represent flow, fate, and transport and other physical, chemical, and biological interactions.
- It can be used to study long-term affects and to simulate management scenarios.
- It has globally-validated model code, as both the model and its code are publicly available for free and widely used.

Pollutant yields, water balance, surface runoff, sediment yield, and management practices are computed at the HRU level, and then are aggregated for subsequent routing through the channel system. SWAT simulates both streamflow and sedimentation, and six general compartments are incorporated into the model to describe the flux of water through the landscape. These include: (1) snow accumulation and melt, (2) surface runoff, (3) unsaturated zone processes/evapotranspiration, (4) lateral flow, (5) shallow groundwater flow, and (6) deep aquifer flow. Hydrologic computations are completed using a modified version of the curve number (CN) (United States Department of Agriculture, 1986) where daily CN is adjusted according to the previous day's soil water content (Arnold, et al., 2011; Neitsch, et al., 2011). Sediment yield in SWAT is simulated using the Modified Universal Soil Loss Equation (MUSLE) (Williams and Berndt, 1977), where erosion and delivery are calculated as a function of peak runoff rate and volume, soil erodibility, slope steepness and length, cover factor, and supporting practice factor. In particular, the slope steepness and length (USLE LS factor), and the cover management factor (USLE C factor) are important because they are largely based on specific field-level conditions, and therefore the model has a harder time parameterizing them without user input. Channel sediment routing is based on the unique sediment transport characteristics of the individual routing reach and the upstream continuum of sediment from other subbasins and channel reaches. Sediment is routed through the stream channel considering deposition and degradation processes and using a simplified equation based on stream power as defined by Bagnold (1977). For each reach on each day, either deposition or degradation (e.g. bank erosion) occurs.

SWAT comprehensively models transfers and internal cycling of the major forms of nitrogen and phosphorus. The model monitors two pools of inorganic and three pools of organic forms of nitrogen. SWAT also monitors three pools of inorganic and three pools of organic forms of phosphorus. SWAT incorporates in-stream nutrient dynamics using kinetic routines from the in-stream water quality model referred to as QUAL2E (Brown and Barnwell, Jr., 1987). Other in-stream variables that may be simulated include temperature, dissolved oxygen, bacteria, and pesticides. Details regarding model development are described by Arnold et al. (1993). SWAT documentation consists of theoretical documentation, input and output documentation, and user's manual (Arnold, et al., 2011; Neitsch, et al., 2011; Winchell, et al.,2010).

D3.2 Model Input

ArcSWAT and SWAT Editor (both Version 2009.93.5) were used in this modeling effort. This is not the most current version of SWAT but it was the most recent version at the onset of the project, and compatibility problems did not allow the updating of the model version without significant structural modification. Fundamental input data for SWAT are topography, land use, soils, and climatic data. ArcSWAT (with its GIS interface) was used to perform the pre-processing, initial model setup and parameterization. Geographic data sources used for model setup are shown below:

- National Elevation Dataset (NED) – The USGS NED is a 1:24,000 scale high-resolution compilation of elevation data used for watershed delineation, flow accumulation processing, and slope determination (U.S. Geological Survey, 2010a).
- National Hydrography Dataset (NHD) – NHD is a 1:24,000 scale vector coverage of stream topology (U.S. Geological Survey, 2010b). It was used in definition of the stream and channel network.
- National Land Cover Dataset (NLCD) – The 2001 NLCD is a 21-category land cover classification (30-m grid) available for the conterminous U.S. Eight categories of land-use were used in this model (**Table D2-3**).
- STATSGO Soils – The STATSGO soil map (United States Department of Agriculture, Natural Resources Conservation Service, Soil Survey, 1994) is a 1:250,000 scale generalization of detailed soil survey data that was used to develop soil properties of landcover classes.

ArcSWAT was used as the initial model pre-processor. The raster based processing consists of a modular structure that contains a tool for optimizing the definition and segmentation of a watershed and network based on topography. It also consists of a tool for defining the HRUs over the watershed and an integrated user-friendly interface. The GIS interface not only allows users to segment a watershed, but to import and format the supporting data necessary for the specific application and calibration of the model.

D3.3 Simulation Period

The model simulation period was chosen to be coincident with the most recent landcover, available calibration data for flow, sediment, and nutrients, and climatic data sets with few or no missing values. The period of 1999 through 2008 was chosen to best meet these requirements. The dataset was partitioned into three subsets – 1999-2001 for a "warm-up" period, 2002-2005 for calibration, and 2006-2008 for validation. Land use did not change substantially in the watershed within this time period, so 2001 NLCD land-use data should adequately reflect the actual land use within the watershed.

This time period was generally within a drought period (i.e., low flows in the watershed). Low flow periods are generally more reactive to sediment and nutrient stresses than high flow periods. Since TMDLs must consider seasonality and the most critical time period for each pollutant, it is preferable for the model period to have low flows overall instead of high flows. This is further discussed in **Section D4.2**.

D3.4 WATERSHED DELINEATION

Subwatershed discretization was performed to capture 6th code hydrologic unit code (HUC) boundaries for the watershed, and also to capture specific 303(d) listed sub-watersheds within the model, all while keeping the model as simple as possible. This resulted in a delineation of 37 total subwatersheds (also referred to as sub-basins) for the Little Blackfoot River (**Figure D3-1**). Sub-basin sizes ranged from 56 hectares to almost 7,500 hectares (**Table D3-1**). Elevations within sub-basins also varied greatly, with well over 1,000 m (3,280 feet) of elevation differences between the headwaters and the watershed outlet (**Figure D3-2**).

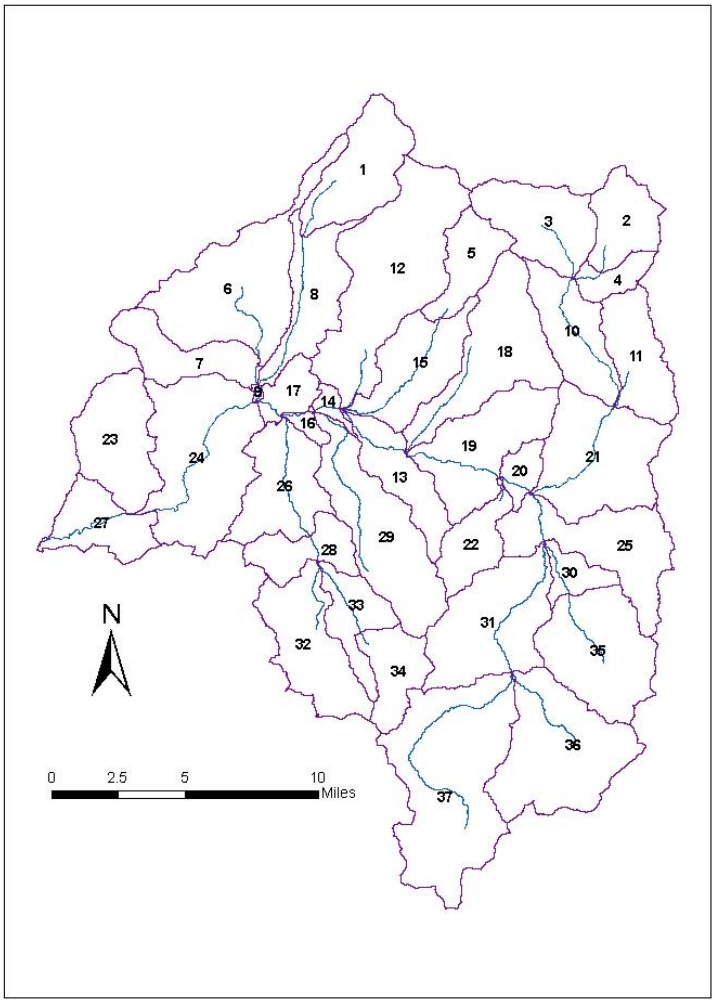


Figure D3-1. Sub-basins within the Little Blackfoot River watershed

Table D3-1. Sub-basin summary, Little Blackfoot River watershed

Sub-Basin	Area (square kilometers)	Area (hectares)	Area (acres)	% Watershed Area	Comment
1	30.2	3,021	7,464	2.8%	HW, Quigley Reservoir
2	18.9	1,892	4,674	1.8%	HW
3	29.2	2,915	7,203	2.7%	HW
4	8.2	823	2,032	0.8%	-
5	17.2	1,719	4,247	1.6%	HW, Snowshoe Reservoir
6	54.5	5,452	13,473	5.1%	HW
7	21.3	2,130	5,263	2.0%	
8	26.2	2,618	6,470	2.5%	
9	0.6	56	139	0.1%	
10	25.8	2,579	6,372	2.4%	
11	24.3	2,428	6,001	2.3%	HW
12	67.2	6,724	16,614	6.3%	HW
13	20.7	2,071	5,118	1.9%	LBR
14	3.2	316	780	0.3%	LBR
15	29.7	2,970	7,339	2.8%	
16	2.9	294	727	0.3%	LBR
17	9.5	954	2,358	0.9%	LBR
18	43.1	4,307	10,643	4.0%	HW
19	37.2	3,719	9,191	3.5%	LBR
20	7.0	704	1,739	0.7%	LBR
21	45.1	4,506	11,134	4.2%	
22	15.8	1,581	3,908	1.5%	HW
23	31.7	3,169	7,830	3.0%	
24	58.4	5,837	14,423	5.5%	LBR
25	38.0	3,804	9,401	3.6%	LBR
26	30.3	3,033	7,495	2.8%	
27	20.4	2,039	5,039	1.9%	Outlet, LBR
28	16.5	1,646	4,068	1.5%	Spotted Dog Reservoir
29	45.2	4,520	11,170	4.2%	HW
30	8.6	859	2,123	0.8%	
31	44.1	4,413	10,905	4.1%	LBR
32	33.7	3,374	8,336	3.2%	HW
33	17.1	1,706	4,216	1.6%	
34	17.4	1,741	4,302	1.6%	HW
35	41.7	4,168	10,298	3.9%	HW
36	51.5	5,150	12,727	4.8%	HW
37	74.9	7,493	18,515	7.0%	HW, LBR
Totals	**1,067.3**	**106,732**	**263,734**	**100.0%**	

HW: Headwaters sub-basin (no inflows), LBR: Little Blackfoot River sub-basin.

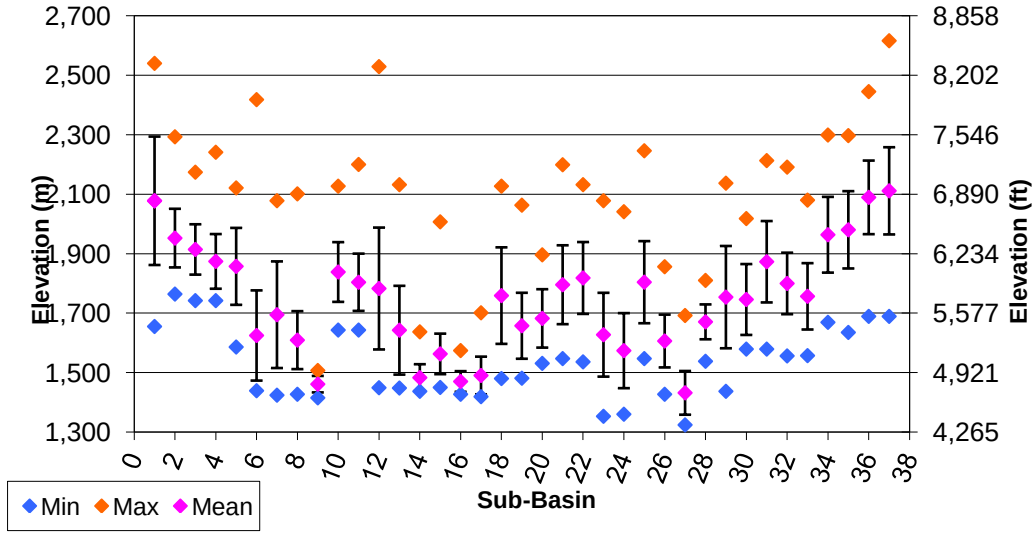


Figure D3-2. Elevation distribution by sub-basin within the Little Blackfoot River watershed

D3.5 Hydrologic Response Units

Subwatersheds were further subdivided into homogeneous landscape units, HRUs,having unique soil, land cover, and slope combinations. A minimum threshold percentage of two percent was specified, meaning that soil, land use, or slope categories totaling less than 2% of the sub-watershed would be excluded from the HRU definition process. This reduces the number of HRUs in the model and greatly reduces computational time without sacrificing accuracy. This process resulted in 1,387 HRUs delineated within the watershed. Management files for each HRU were written based on an understanding of activities that were occurring within the watershed which included: (1) cattle grazing on pasture, rangeland, and forests, (2) agricultural hay production, and (3) BMP implementations for future scenarios. Model runoff parameters were adjusted to calibrate water yield, and vegetation changes were simulated by modifying the minimum cover factor (USLE C) used in the sediment calculations. Riparian areas were simulated with filter strips.

USLE C factors are calculated by SWAT on a daily basis by modifying a user-specified minimum USLE C factor. Therefore, the USLE C factor is constantly changing from day to day based on plant growth, harvest, etc. However, average USLE C factors can be estimated based on the minimum USLE C factor. These average values are listed in **Table D3-2**. USLE C minimum factors were determined based on typical literature ranges for land use types, and were then adjusted based on the perceived condition (field visits, vegetation surveys, etc.) of these land uses within the watershed.

Table D3-2. Average USLE C factors

Land Use	USLE C factor
Forest	0.005
Pasture	0.013
Range	0.031
Arid Range	0.310
Urban	0.022
Wetland	0.008
Improved Pasture	0.008
Improved Range	0.028

D3.6 CLIMATIC PATTERNS

Climate data was obtained from a total of seven weather stations in close proximity to the watershed, as described in **Section D2.2**. Stations were assigned to representative subwatersheds in SWAT, based on proximity. Because precipitation and air temperature vary with elevation, especially in areas of large topographic relief, elevation bands were used in each subbasin to better describe orographic effects. Bands were generated from the SWAT topographic report and climatic information from the most proximal meteorological station was lapsed according to the elevation of the assigned climate station and each band. Lapse rates were determined based on the seven climate stations (**Figure D3-3** and **Figure D3-4**). Precipitation and temperature lapse rates were determined to be approximately 460 mm/km (r2=0.93) and -4.7 ˚C/km (r2=0.96) respectively, which is similar to that reported by Flynn and Van Liew (2010) in other watersheds in Montana. In order to define which precipitation station is assigned to a particular sub-basin, SWAT identifies the closest defined meteorological station by its proximity to the centroid of the sub-basin. Both temperature and precipitation information are then read from this station, and elevation bands are incorporated into the model to account for the orographic effects due to the large topographic variations in the watershed. These lapse rates were applied basin-wide.

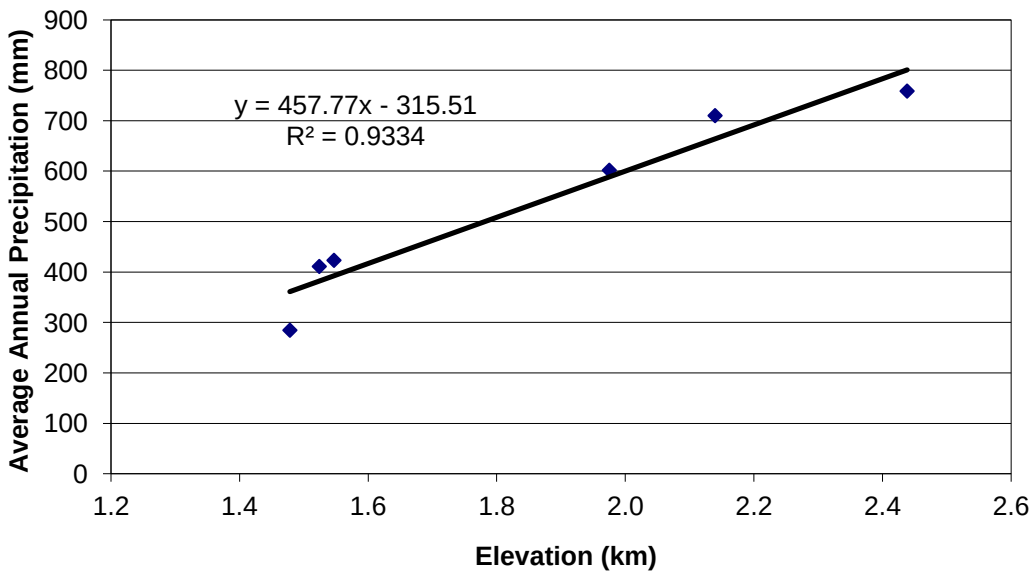


Figure D3-3. Precipitation lapse rate used in the Little Blackfoot River watershed model

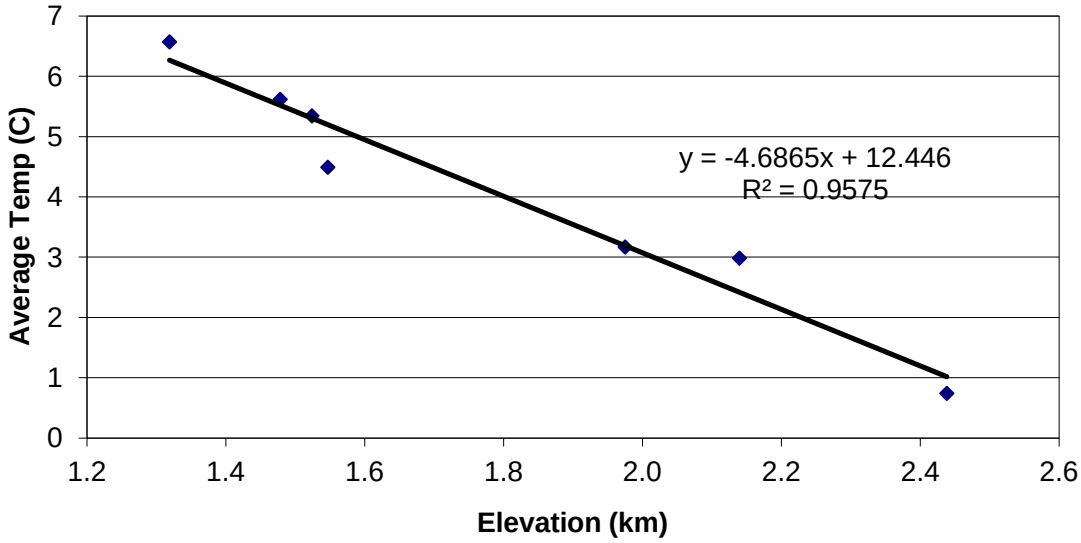


Figure D3-4. Temperature lapse rate used in the Little Blackfoot River watershed model

D3.7 ROUTING GEOMETRY

The SWAT model automatically calculates channel dimensions for the main channel and tributaries based on drainage area regression statistics. Flynn and Van Liew (2010) have shown that the SWAT regression is not valid for mountainous regions. Field channel measurements were taken by the DEQ for several reaches within the watershed (PBS&J, 2010), and when available these values were used to define the channel geometry. If these were not available, a USGS channel geometry-drainage area regression for western Montana (Lawlor, 2004) was used. Comparing the USGS regression and SWAT method with actual field data or aerial photos shows that SWAT consistently over-predicted the bankfull channel width and generally under-predicted the width-to-depth ratio.

The default main and tributary channel Manning's n values were low, and more representative of smooth channels or fallow agricultural lands. A Manning's n value more typical of natural stream systems was used. A slightly higher value was used for the tributaries than for the main channels. All routing coefficients can be found in **Appendix DC** (Model Input).

D3.8 EVAPOTRANSPIRATION

Evapotranspiration (ET) is the combined loss of water from ground surface evaporation and by transpiration from plants, while the potential evapotranspiration rate (PET) describes how fast water vapor would be lost from a densely vegetated plant-soil system if soil water content was continuously maintained at an optimal level. In SWAT, three options exist for estimating PET and subsequently ET: the Penman-Monteith method (Monteith, 1965), the Priestly-Taylor method (Priestly and Taylor, 1972), and the Hargreaves method (Hargreaves and Samani, 1985). Measured PET values can also be used if measurements are available. **Table D3-3** shows the data requirements of the three PET methods listed from the method requiring the most to least data for the calculation. The Penman-Monteith method was used in this model.

Table D3-3. Data requirements for SWAT-available PET methods

Method	Air Temperature	Wind Speed	Relative Humidity	Solar Radiation
Penman-Monteith	Input	Input	Input	Input
Priestly-Taylor	Input	not used	Input	Input
Hargreaves	Input	not used	not used	not used

D3.9 IRRIGATION

Streamflow on the Little Blackfoot River is heavily influenced by hay irrigation in the late spring and summer. There are also three small reservoirs within the Little Blackfoot River watershed that are used for irrigation. These include the Spotted Dog Reservoir, the Snowshoe Reservoir, and the Quigley Reservoir along Threemile Creek. These are discussed further in the next section. Hay in this watershed is grown for a single cutting in early August. Fields are irrigated after hay cutting to grow a smaller second crop for fall grazing.

Because the location of irrigation diversions cannot be depicted in SWAT, it was assumed in this study that water is diverted from river reaches that are nearest to the subbasin where irrigation occurs. If irrigated land was in a sub-basin that included a reservoir, the irrigation was assumed to come directly from the reservoir. Water applied to an HRU is used to fill the soil layers up to field capacity beginning with the soil surface layer and working downward until all the water applied is used up or the bottom of the profile is reached. If the amount of water specified in an irrigation operation exceeds the amount needed to fill the soil layers up to field capacity water content, the excess water is returned to the source. For pasture, irrigation was assumed to occur at a rate of three inches every two weeks, beginning in early June and ending in mid September. This value is similar to values used in models for other watersheds in western Montana (Montana Department of Environmental Quality, 2011).

D3.10 RESERVOIRS

SWAT models four different types of waterbodies: ponds, wetlands, depressions/potholes, and reservoirs. Reservoirs are located on the main channel network and receive water from all sub-basins upstream of the waterbody. As simulated in SWAT, no distinction is made between naturally-occurring and man-made structures. Daily calculations of surface area, precipitation, evaporation, and seepage are completed in SWAT based on user-provided information on the reservoir outflow or storage-operational curves. No ponds, wetlands, or depressions/potholes were modeled in the Little Blackfoot River watershed, but three reservoirs were modeled.

The three reservoirs include the Spotted Dog Reservoir, the Snowshoe Reservoir, and the Quigley Reservoir along Threemile Creek (at the outlets of sub-basins 1, 5, and 28 in **Figure D3-1**). All three reservoirs are believed to be used primarily for irrigation. There are no operation records or other statistics available for these reservoirs, so all reservoir data was estimated from GIS. The drainage areas above Quigley Reservoir, Snowshoe Reservoir, and Spotted Dog Reservoir are 3,021 ha, 1,719 ha, and 8,467 ha, respectively. Inflow to each reservoir depends on the amount of water accumulated in the mountain snowpack, temperatures during snowmelt, and spring precipitation. All three of these reservoirs are on tributaries rather than the mainstem, and do not have a great influence on the overall flows in the watershed.

Four different outflow options exist for modeling reservoirs within SWAT. These are: (1) measured daily outflow (from a USGS gage or other continuous streamflow source), (2) measured monthly outflow, (3)

average annual release rate for uncontrolled reservoir, and (4) target release for controlled reservoir. The operation of these facilities is uncertain, but the dam control structures are likely set to fill up near the end of the spring runoff season so as to have a full capacity for the summer irrigation season. In this model, the average annual release method was used. This means that an average daily (or monthly) release was specified, and any water after that was used to fill the reservoir. Once the reservoir is at capacity, then inflow is set equal to outflow. This is the most general reservoir management setting, and is appropriate when little or no management data is available. There was no data to set the average daily release to, so these values were determined through an iterative process. A value was chosen, and the modeled hydrology of the reservoir was observed. Then the average daily release was adjusted up or down until the reservoirs followed the known hydrology (e.g., reached full capacity near the end of the spring season).

D3.11 WASTEWATER POINT SOURCES

There are no permitted wastewater treatment plants or industrial sources within the Little Blackfoot River watershed. There are approximately 301 on-site septic systems located within the watershed (Regensburger, unpublished 2010). These on-site septic systems were treated as point sources in the model.

On-site septic systems were located based on residential land parcels within the Little Blackfoot River watershed as determined from the state's cadastral database. They were assigned to residential land parcels at the centroid of the parcel. Thus, each septic system was spatially located, and was then assigned to the appropriate sub-basin.

Nutrient loading estimates for each septic system were completed by estimating soil types (using GIS) at each drainfield and the nearby streams, and the distance of each drainfield to the nearest stream. Other parameters that were estimated were assumed to be of an "average" type (calcium carbonate concentrations in soil, nitrate and phosphorus reductions, etc.). Average reductions in the soil column were determined to be 52.5% for nitrate and 80.7% for phosphorus. Average annual loading rates for a single family home are 30.5 lbs/year of nitrate, and 6.44 lbs/year of phosphorus; with the estimated reductions of nitrate and phosphorus, the average loading to surface water is 14.5 lbs/year of nitrate and 1.24 lbs/year of phosphorus per single family septic system. Septic loading estimates for nutrients in the Little Blackfoot River watershed assumed that all septic systems are operating properly. The rationale for this assumption is discussed below.

The most likely type of failure to create a direct connection of untreated wastewater into an adjacent surface water is a septic system that is creating a surface expression of wastewater. This type of failure will commonly be repaired quickly (days or weeks at the most) by an owner as it is an obvious hazard and aesthetically unpleasant to anyone nearby. In addition, unless the failing systems is a short distance to a surface water the wastewater will likely seep into the ground prior to any direct surface water discharge. Short duration failures such as this do not provide significant additional loading of nutrients at the scale of time associated with the TMDL development, and therefore the accuracy of the model is not diminished by ignoring these types of failures. Other common types of failures are a septic tank with decreased volume due to excess sludge accumulation, and a reduction of the unsaturated zone beneath the drainfield due to groundwater mounding. To discuss these failures the treatment capabilities of conventional septic systems (septic tank and subsurface drainfield) must be reviewed first. A properly operating conventional septic system is not designed to remove significant amounts of nitrogen or phosphorus from the raw wastewater - its primary purpose is to remove solids and pathogens.

Therefore, a system that is failing through reduced septic tank settling or reduced unsaturated soil is not going to discharge a significantly larger load of either nitrogen or phosphorus to the environment. The septic loading analysis assumed that this small variation of nitrogen and phosphorus loading due to failing systems was well within the margin of error associated with septic systems that are documented (Environmental Research Laboratory-Duluth, 2002) to have a large range of flow rates (54 to 67 gallons per day per person), nitrogen concentrations (26-75 mg/L), and phosphorus concentrations (6-12 mg/L). Therefore, estimation of failure loading rates without any site specific data was deemed less accurate than the simpler assumption that all septic systems were operating properly.

An analysis of aerial photos indicated that there may be a livestock confinement on Threemile Creek, but field visits to this area did not verify that it should be modeled as such. Therefore, this was simply modeled as a grazed pasture. Future studies may want to re-consider this based on the best available data. The potential effect of livestock confinements on nutrient and sediment loading is significant. These facilities act as point sources discharging directly to streams, and can greatly contribute to nutrient and sediment loading. SWAT does not model direct excrement from cattle other than by using a user-specified point source. SWAT loads cattle manure into grazed fields, which then breaks down (or is carried into streams by runoff). Cattle manure and grazing are discussed further in the following section.

D3.12 GRAZING

The Little Blackfoot River watershed is heavily managed for cattle production. This includes agricultural growth of hay in the summer, and grazing on pasture, range, and forested lands in the winter and summer.

Irrigated hay fields are grazed throughout the fall, winter, and spring, and are then managed for hay production in the summer. During the summer, they are heavily irrigated, and area also fertilized on an infrequent basis. Much of the fertilization comes from cattle manure, although some ranches in the watershed do fertilize with chemical fertilizer on an annual basis. Hay is harvested in early August.

To estimate the effects of cattle production on the Little Blackfoot River watershed, the first step was to estimate the total number of cattle in the watershed throughout the year. This was done using two different methods. The first method was counting heads. During the winter months, several “windshield surveys” were done when cattle should be congregated in the pastures along the Little Blackfoot River. The cattle were simply counted, driving from Helena to Garrison, and then from Avon up to Nevada Creek. Both times, over 1,000 head of cattle were counted. While not scientific, this does set a lower bound (there are *at least* this many cattle in the watershed). The second method was the USFS Helena National Forest (HNF) grazing allotment data. The USFS has 12 active grazing allotments that overlap into the Little Blackfoot River watershed. These grazing allotments have a total area of approximately 36,800 hectares and 1,978 permitted cow-calf pairs. The spatial portion of each allotment within the watershed was prorated to determine the number of cattle in each watershed allotment. All allotments were assumed at 100% capacity every year. This is conservative, as several of the allotments are known to be less than full certain years. When the portions outside of the watershed are excluded, this leaves a proportionate area of approximately 25,700 hectares and about 1,431 cow-calf pairs. Although it is possible, or even likely, that some landowners summer their cattle on their own land, for this analysis we assumed that the watershed held approximately 1,431 cow-calf pairs. An extra 69 head were added to account for other stock animals, such as bulls, dairy cattle, horses, etc, and to make the estimate a round number which more appropriately reflects the precision (or lack thereof) of the estimate. Each

allotment was then overlaid by the sub-basins, and an area-weighted value was calculated for the number of grazed acres and head of cattle within each sub-basin.

The assumptions for the life cycle of cattle in the Little Blackfoot River watershed are as follows. From November to February, the cattle graze in the irrigated hay pasture without calves (the yearlings have been sold to feedlots outside of the watershed). It was assumed that 100% of the pasture in the watershed was grazed during the winter. From March through July, the cows are with calves. Around June 15th (this varied slightly in each grazing allotment), the cow-calf pairs are moved to summer pasture. From August through October, the cows are with grown calves. Around October 1st, the cattle move from summer pasture back down to the winter pasture, and the yearlings are sold (removed from the watershed) soon thereafter.

Each cow-calf pair consumes about 40 pounds of forage (dry weight) per day. A grazing value in kg/ha/day dry weight was obtained for each allotment based on this value. Daily trampling (kg/ha/day) was assumed to be approximately 95% of daily consumption. This is based on prior studies in western Montana, and a discussion with a local rancher who claims they trample “about as much as they eat”. Finally, each cow was assumed to produce about 63 pounds of manure (wet weight) per day, and calves anywhere from 26 lbs to 63 lbs per day depending on their age (Ohio State University, 1993). A cow-calf pair on average then produces approximately 100 lbs of manure per day. Manure is approximately 85% water weight, which means each cow-calf pair produces on average 15 lbs of manure (dry weight) each day. This ratio of daily manure production to daily food consumption is about 37% (15/40), which is similar to values of manure production used in modeling efforts on the Upper Clark Fork River and the Bitterroot River watersheds in western Montana (Montana Department of Environmental Quality, 2011). These assumptions were used to calculate the daily consumption, trampling, and manure production for cattle in the pasture areas and the summer range.

D3.13 Roads

The Little Blackfoot River watershed contains approximately 641 miles of roads, 92% of which are unpaved (PBS&J, 2010). Runoff from unpaved roadways carries excess sediment to the streams. Paved roadways (e.g. highways) are often treated with traction sand in the winter months, and this can also have an effect on sediment loading.

In this model, roadways were grouped by sub-basin and treated as point sources of sediment within that sub-basin based on the road assessment (PBS&J, 2010). The actual point source value for the model was taken from the assessment. Additionally, the assessment provided potential improvements in roadway sediment loading for each sub-basin. The point sources were input as average daily loadings, which means they are not tied to hydrology (i.e., the daily loading for April is the same as the daily loading for October, even though it rains more in April than in October). Overall, the roads were a minor source of sediment loading, and this is not expected to make a significant difference in the model results.

D4.0 Model Calibration

A deterministic modeling approach was employed by the DEQ to evaluate the cause-effect relationship between management activities and sediment and nutrients in the Little Blackfoot River watershed. Evaluation criteria are listed below.

D4.1 Evaluation Criterion

Two model performance statistics were used to assess monthly and daily predictions of the SWAT model. The first is relative error (RE), which is a measure of the average tendency of simulations to be larger or smaller than an observed value. RE is defined as the deviation between observed ($X_{i,obs}$) and simulated ($Y_{i,sim}$) values, where optimal RE is 0.0, and positive and negative values reflect bias toward under- or over-estimation. Van Liew et al. (2005) suggested RE values <±20% are "good", while more strict guidelines have been suggested elsewhere. For the purpose of this project, RE< ±10% was considered to be sufficient for model calibration. RE is calculated as:

$$RE\% = \frac{\sum_{i=1}^{n}(Y_{i,sim} - X_{i,obs})}{\sum_{i=1}^{n}(X_{i,obs})} \times 100 \qquad (1)$$

The second evaluation criterion was Nash-Sutcliffe coefficient of efficiency (NSE) (Nash and Sutcliffe, 1970). NSE expresses the fraction of the measured variance reproduced by the model and is defined as:

$$NSE = 1 - \frac{\sum_{i=1}^{n}(X_{i,obs} - Y_{i,sim})^2}{\sum_{i=1}^{n}(X_{i,obs} - \overline{X}_{i,obs})^2} \qquad (2)$$

By increasing NSE, error in the model is inherently decreased. Simulation results are considered to be good when NSE > 0.70, while NSE values between 0.36 and 0.70 are considered to be satisfactory (Motovilov, et al., 1999). The NSE is widely used and is considered one of the best objective functions for overall hydrograph fit (Moriasi, et al., 2007).

Criteria for seasonal and annual loading for water quality constituents (nitrogen, phosphorus, and sediment) were not established, although graphical comparisons of model performance were deemed suitable where time series plots are generally evaluated visually for agreement between the simulated and observed values.

D4.2 Simulation Period and Boundary Conditions

The simulation was performed for the time period 1999-2008. The 1999-2001 time period was used as a "warm-up" period to allow some of the initialized variables to reach a steady-state. This lowers the reliance on initial values and initial value estimation procedures, as these parameters have several years in which to reach a steady-state. The model was calibrated for the period 2002-2005, and validated for the period 2006-2008. Model calibration refers to the process of adjusting model parameters to obtain a fit to observed data. Once the model does a good job of reproducing observed values, it is then run with another data set (typically from an earlier or later time period) to test the performance of the model.

An overview of streamflow in the Little Blackfoot River shows that the modeled period was characterized by low overall flows (**Figure D4-1**). While it is always ideal to have a representative time

period, low flow periods are generally more reactive to sediment and nutrient stresses than high flow periods. Because TMDLs must consider seasonality and the most critical time period for each pollutant, it is acceptable for the model period to have low flows overall instead of high flows.

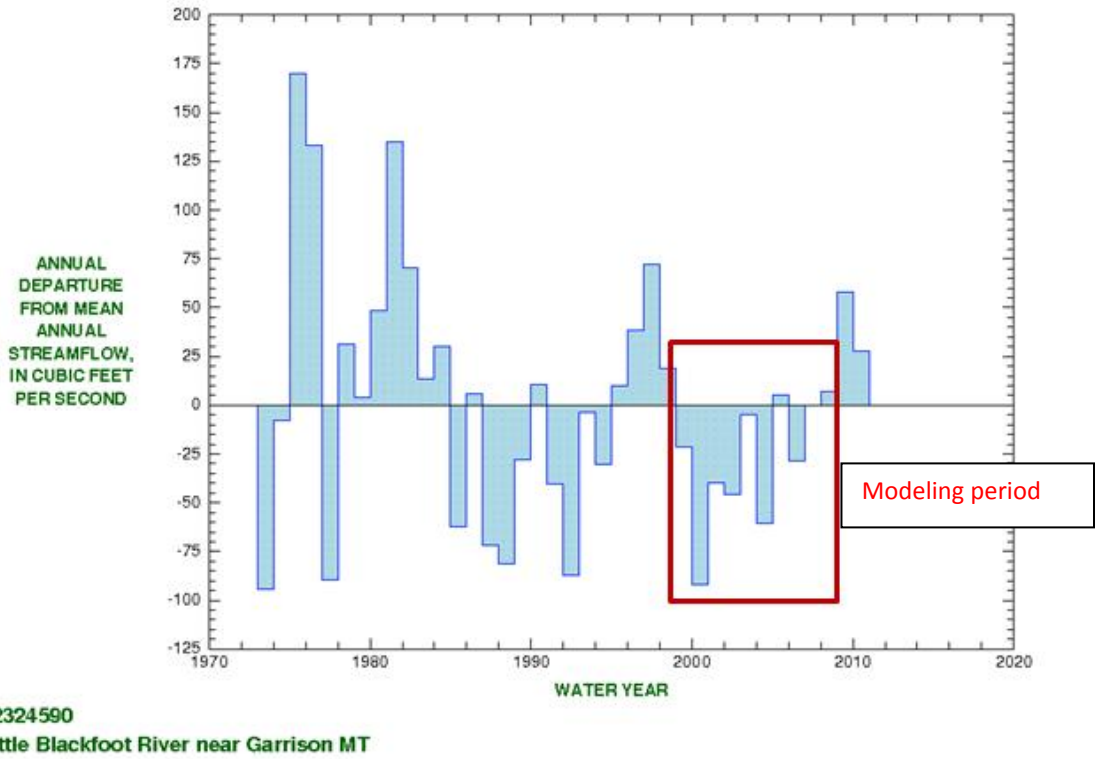


Figure D4-1. Hydrology for model run period

Boundary conditions are entirely geographic for this modeling effort. There are no inflows, as this watershed is one of the headwaters of the Clark Fork River. The only outflow is the mouth of the Little Blackfoot River near Garrison. There are no modeled inter-basin transfers in this watershed. Based on aerial photo interpretation, an inter-basin transfer may be occurring in the headwaters of Sixmile Creek (sub-basin 6), but this could not be verified and thus was not included in the modeling effort.

D4.3 Streamflow Calibration

Calibration of streamflow in SWAT was completed using a combined automated and manual approach. First, a sensitivity analysis was performed on various parameters to identify those that have a strong effect on the model. Then, a best-fit parameter set is first estimated using the automated shuffled complex evolution algorithm (SCE-UA) (Van Griensven and Bauwens, 2003) finally this was adjusted manually based on desired system response and watershed knowledge. Approximately 25 parameters that govern snow accumulation and melt, precipitation runoff, and subsurface flow were optimized, followed by manual calibration (**Table D4-1**).

Table D4-1. Calibrated and adjusted parameters for the Little Blackfoot River SWAT model

Component	Parameter	Description	Calibrated Value	Min	Max	Units
Basin (.bsn)	SFTMP	Snowfall temperature	2.0	-5	5	ºC
Basin (.bsn)	SMTMP	Snow melt base temperature	0.5	-5	5	ºC
Basin (.bsn)	SMFMX	Melt factor for snow on June 21	2.0	0	10	mm $ºC^{-1}$ day^{-1}
Basin (.bsn)	SMFMN	Melt factor for snow on December 21	0.1	0	10	mm $ºC^{-1}$ day^{-1}
Basin (.bsn)	SNOCOVMX	Minimum water that corresponds to 100% snow cover	50	0	500	mm
Basin (.bsn)	SNO50COV	Fraction of snow volume that corresponds to 50% cover	0.55	0	1	dimensionless
Basin (.bsn)	TIMP	Snowpack lag factor	0.1	0	1	dimensionless
Basin (.bsn)	SURLAG	Surface runoff lag time	4.0	1	24	days
Basin (.bsn)	SPCON	Linear parameter for sediment re-entrainment	0.0005	0.0001	0.01	dimensionless
Basin (.bsn)	SPEXP	Exponent parameter for sediment re-entrainment	2.0	1	2	dimensionless
Basin (.bsn)	ESCO	Soil evaporation compensation factor	0.95	0	1	dimensionless
Basin (.bsn)	EPCO	Plant water uptake compensation factor	0.96	0	1	dimensionless
HRU (.hru)	SLOPE	HRU slope steepness	0.0003-0.6	0	1	m/m
HRU (.hru)	SLSUBBSN	Average slope length	9-60	0	90	m
GW (.gw)	GW_DELAY	Delay time for aquifer recharge	205	0	500	days
GW (.gw)	ALPHA_BF	Baseflow recession constant	0.251-0.8	0	1	days
GW (.gw)	GW_REVAP	Revap coefficient	0.122	0.02	0.2	dimensionless
GW (.gw)	REVAPMN	Threshold depth for “revap” to occur	500	0	1000	mm
GW (.gw)	GWQMN	Threshold depth for return flow to occur	100	0	1000	mm
GW (.gw)	RCHRG_DP	Deep aquifer percolation fraction	0.05	0	1	fraction
Reach (.rte)	CH_K(2)	Effective hydraulic conductivity of main channel	171-500	0	1000	mm/hr
Reach (.rte)	CH_EROD	Channel erodibility factor	0.1	0	1	dimensionless
Reach (.rte)	CH_COV	Channel cover factor	0.8	0	1	dimensionless
Adjusted parameters						
Management (.mgt)	CN	Curve Number	Various			dimensionless
Crop (.crop)	USLE_C	cover management factor	See **Table D3-2**			dimensionless

The point of calibration was the USGS gage near Garrison, located approximately 700 meters upstream of the mouth of the Little Blackfoot River. For practical purposes, this was considered equivalent to the model outfall at the actual mouth. The last few hundred meters of the river channel have been channelized and leveed, and receive virtually no overland drainage. There is also a USFS gage that was used in for an ancillary calibration, discussed further below. These gages are shown in **Figure D4-2**.

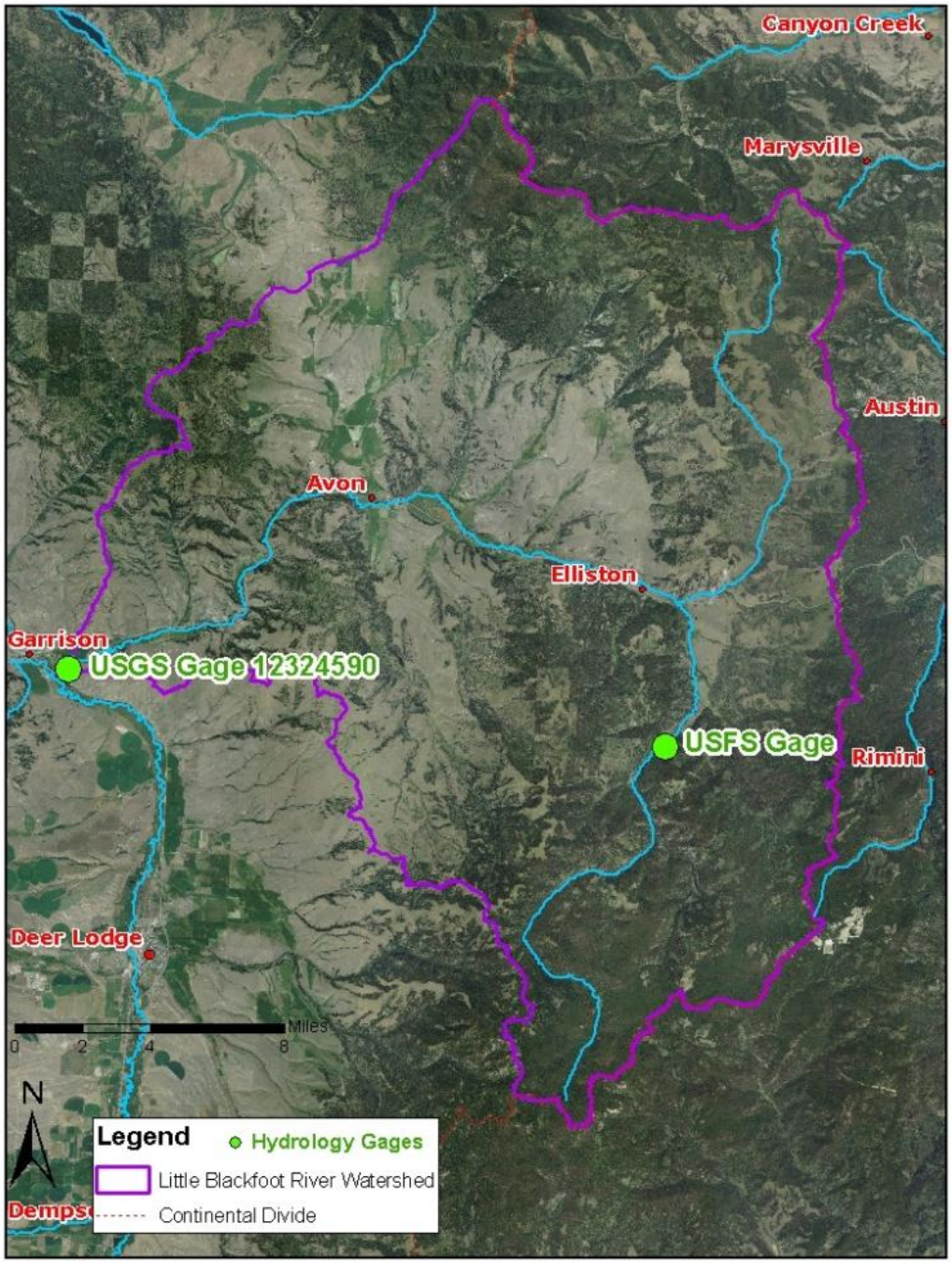


Figure D4-2. Hydrology gage locations in the Little Blackfoot River watershed

The calibrated daily flows from 2002-2005 are compared to the observed flows in **Figure D4-3**. The model does a good job of capturing the peak flows and the low flow periods in the summer. However, there are several peaks in the observed flows that are not seen in the simulated flows. This is typically due to localized precipitation events that the weather gage network does not capture due to large areas of the watershed with no weather stations present (**Figure D2-1**).

Overall water balance was good, with the difference between observed and simulated being less than 1% for the entire simulation period, with approximately 7% difference for the growing seasons (July-

September); the relative errors were -0.3 and 8.6%, respectively (**Table D4-2**). The Nash-Sutcliffe values were 0.71 for the entire simulation period, and 0.53 for the growing season. These values are within the specified bounds of model fit.

Summer growing season values were the most difficult to calibrate. Due to low summer flows, a small difference in simulated versus observed flows can make a large difference in the metrics used to analyze them. In particular, a delay in the spring discharge falling limb by even a week or so around July 1st made a large difference in the summer growing season fit. Additionally, the year to year variability of irrigation practices in the watershed make it a difficult effect to capture. In high runoff years, irrigators use more water, and in low years, they use less. This trend is difficult to capture in the management files because diversion volumes are not recorded by the users. Summer flow calibration involved manipulation of groundwater and lateral flow parameters to get the baseflow to correct conditions.

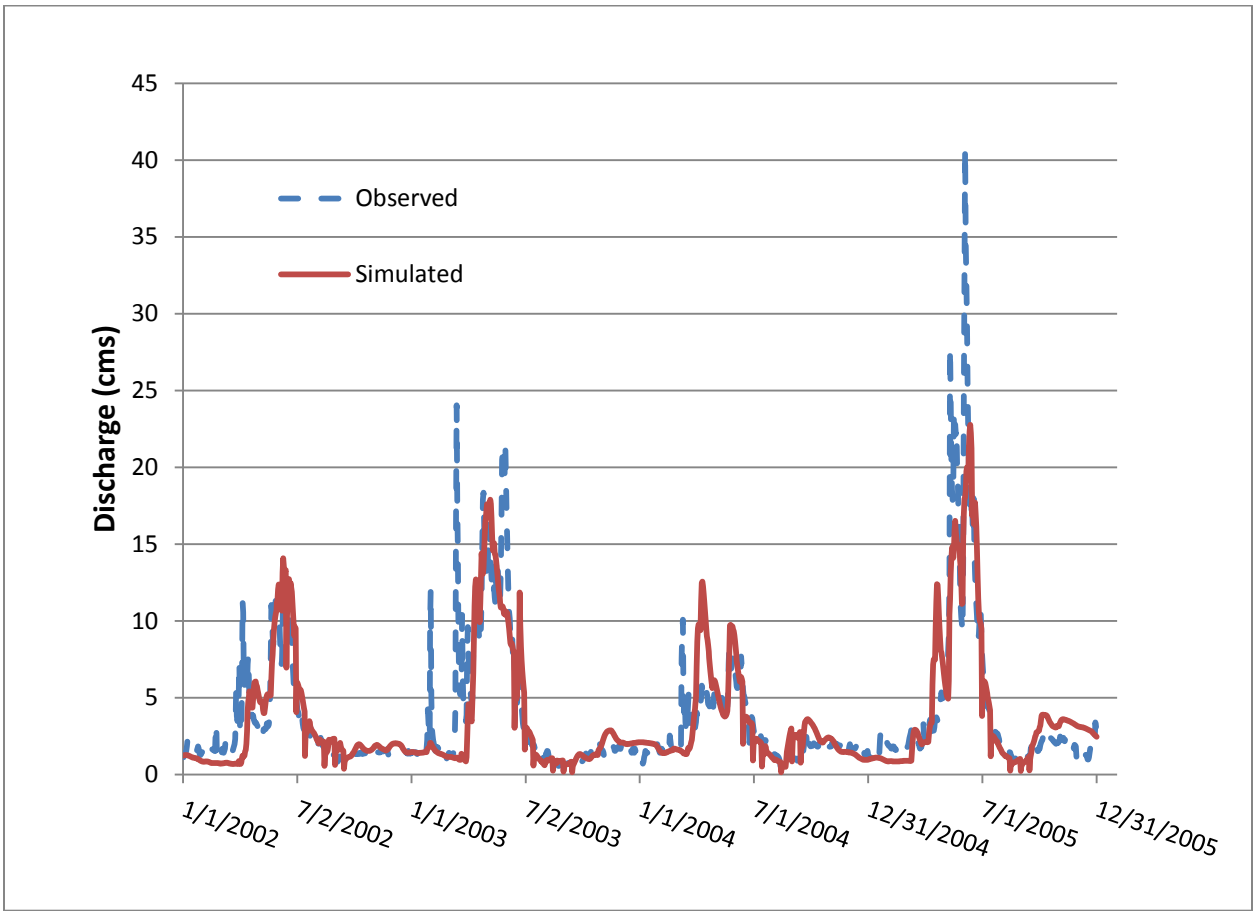


Figure D4-3. Simulated and Observed Daily Hydrology, 2002-2005

Table D4-2. Daily Calibration Metrics

	Observed Total Volume (acre-feet)	Simulated Total Volume (acre-feet)	Difference (%)	Relative Error (%)	Nash-Sutcliffe
Annual	367,857	366,679	-0.3	-0.3	0.71
Summer	44,120	47,213	7.0	8.6	0.53

The model was also analyzed on a monthly basis (**Figure D4-4**). The monthly values parallel the daily values, showing good match on relative error and Nash-Sutcliffe (**Table D4-3**). The Nash-Sutcliffe statistic

is based on the fluctuation between values, so the better match on monthly data is a function of the smaller variation between monthly totals versus daily totals.

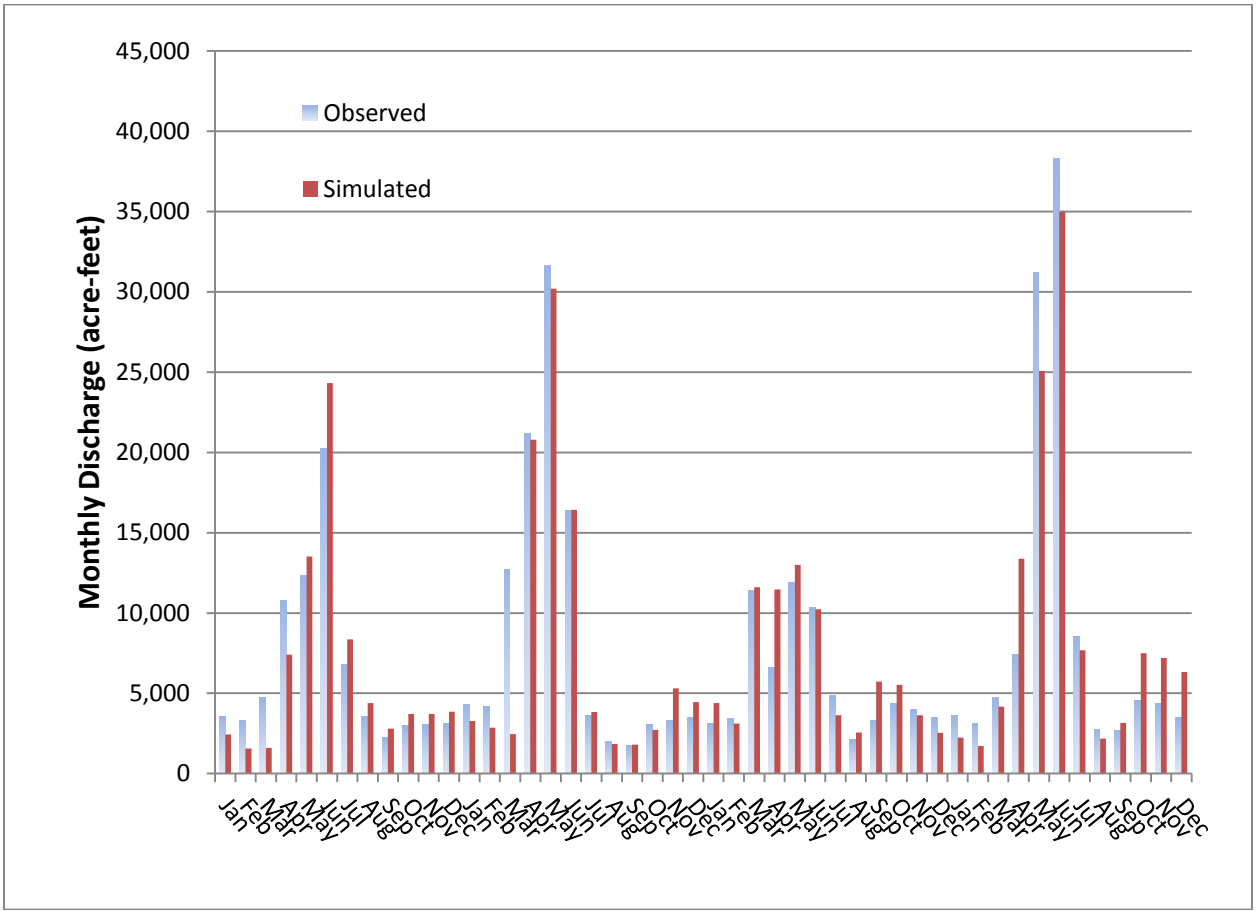


Figure D4-4. Simulated and Observed Monthly Hydrology, 2002-2005

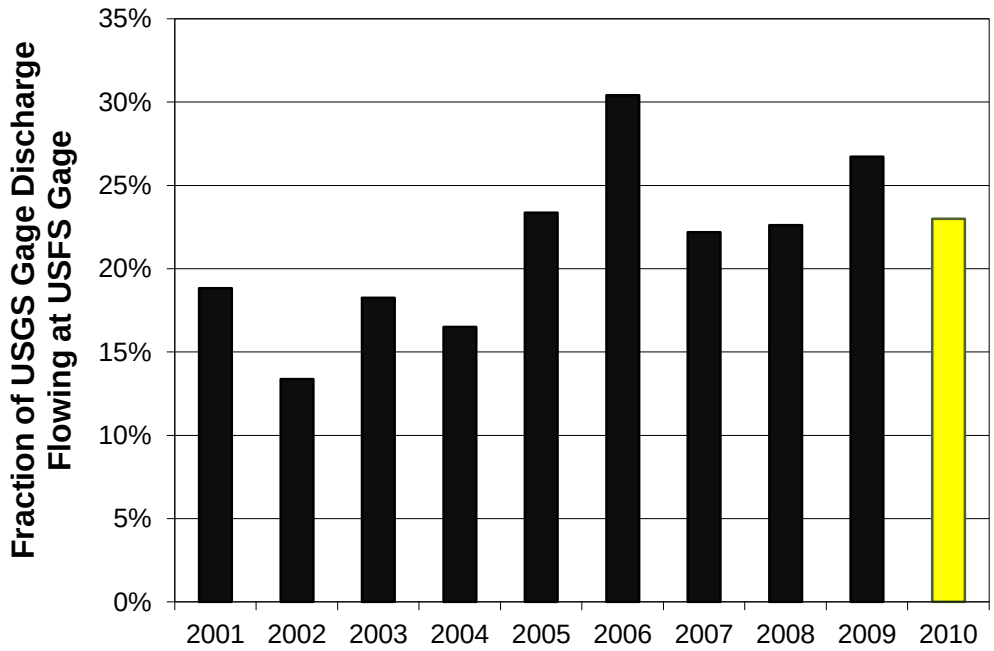
Table D4-3. Monthly Calibration Metrics

	Relative Error (%)	Nash-Sutcliffe
Annual	-0.3%	0.90
Summer	8.7%	0.74

These metrics show that the model calibration resulted in a good fit between simulated and observed data for hydrology at the outlet of the watershed. However, this does not necessarily reflect on how well the model might predict streamflows further upstream. To achieve a better calibration, it is useful to fit the results to more than one location if possible.

Although the USGS maintains no other gages on the watershed, the USFS HNF installed a gage on the upper Little Blackfoot River in 2009 (**Figure D4-2**), and began collecting data in the spring of 2010. Since the model was only run from 1999-2008, it does not overlap with the gage data of 2010, so no direct comparisons can be made between the two. However, the fraction of total flow volume of the Little Blackfoot River (from July through October, the only complete months that the USFS gage had data) that originates above this gage was compared to the simulated fraction to see if the fractions predicted by the model were similar to the observed values from 2010 (**Figure D4-5**). The climate files in the model included data for calendar year 2009, so even though this year was not used for the basic model run, the

model was run through 2009 and compared to the observed flow in 2010. The fraction of total river volume compared very favorably near the headwaters, further indicating that the hydrology calibration has resulted in a good fit.



* black values are simulated; the yellow value is observed

Figure D4-5. Fraction of river discharge originating in the Little Blackfoot headwaters during the growing season (July-October, 2001-2010)

Finally, the overall output water budget is shown in **Table D4-4**. This is from the standard output file in SWAT (output.std) and shows the annual average water budget for the modeling period. Although this data is not used for the calibration, it does provide a check on the overall water budget values. The ratio of surface runoff to precipitation and evapotranspiration to precipitation are similar to those observed in other modeling efforts in western Montana (Montana Department of Environmental Quality, 2011) and in other semi-arid climates (Tateishi and Ahn, 1996).

Table D4-4. Average Annual Basin Values (from the SWAT output.std file)

Parameter	Value (mm/year)	Percentage of Precipitation (%)
PRECIPITATION	550.5	-
SNOW FALL	213.69	38.8%
SNOW MELT	168.02	-
SUBLIMATION	37.19	-
SURFACE RUNOFF Q	19.41	3.5%
LATERAL SOIL Q	60.49	11.0%
GROUNDWATER (SHAL AQ) Q	36.71	6.7%
REVAP (SHAL AQ => SOIL/PLANTS)	39.71	-
DEEP AQ RECHARGE	4.43	-
TOTAL AQ RECHARGE	88.66	-
TOTAL WATER YLD	116.04	21.1%

Table D4-4. Average Annual Basin Values (from the SWAT output.std file)

Parameter	Value (mm/year)	Percentage of Precipitation (%)
PERCOLATION OUT OF SOIL	91.59	-
ET	374.5	68.0%
PET	623.2	113.2%
TRANSMISSION LOSSES	0.56	-

D4.4 SEDIMENT CALIBRATION

Sediment is delivered to the river mouth by two separate processes – sediment delivery and sediment routing. Sediment delivery is the process by which sediment is washed off of the land surface and carried into the river channel. This happens during runoff events, and is modeled by SWAT using the modified Universal Soil Loss Equation (MUSLE). Sediment routing within the river channel is a separate process, where sediment can either be deposited on the river channel, or sediment degradation can cause channel and bed erosion and pick up sediment on its way to the river outlet. Both delivery and routing are important to the sediment modeling process.

Calibration of the sediment model was difficult because the existing sediment data was not collected on a frequent or regular basis. There are 108 samples taken by various groups at the USGS gage over the course of approximately 30 years. Additionally, a handful of samples have been taken at various points along the Little Blackfoot River and its tributaries. Therefore, a daily calibration with Nash-Sutcliffe values was not possible. Furthermore, a direct comparison between the modeled data and the observed data (on a day when there is an observed data point) is not practical, as the sediment load is strongly correlated to discharge, and if the discharges were even a bit different, the comparison of sediment concentrations would not provide meaningful results. The model is not detailed enough to attempt a comparison of this nature. An alternative strategy had to be used to compare simulated sediment values to the few observed values.

To accomplish this, the 107 data points observed at the mouth of the Little Blackfoot River (one was discarded as an outlier) were plotted versus the observed daily discharge on the day the sample was taken. The data were then fit with a best-fit polynomial line (**Figure D4-6**). The r^2 value for this line was 0.68. The polynomial line was forced through zero. This polynomial fit was used to correlate observed daily discharges to a total suspended sediment value using the regression equation:

$$SED_{CONC} = 0.1797 \times Q^2 + 1.2077 \times Q \qquad (3)$$

Where SED_{CONC} is the sediment concentration of the water column in milligrams per liter (mg/L) and Q is the discharge in cubic meters per second (cms). The observed discharge on each day of the model run was used in this equation to come up with a corresponding sediment load for that day. This method was deemed the most appropriate based on the available data. It keeps the strong relationship between discharge and sediment load intact. However, this method does make some assumptions which introduce error into the process. First of all, the relationship has a non-zero y-intercept, so no matter how low the flow, there is always a minimum sediment load (1.2077 mg/L) present. More importantly, it ignores all temporal relationships. All months are treated the same regardless of season. Due to the small data set, data from the rising limb and falling limb of the hydrograph were not separated. The

rising limb often has much higher concentrations of sediment than the falling limb, and thus averaging these gives an average value which may under predict a rising limb. Finally, it may also underestimate total sediment, as there were no measured sediment values during peak discharges on the years measured (it is very hard to obtain a sample during peak discharge). The highest observed value for suspended sediment was approximately 280 mg/L. To compare, in a state-wide study of Montana streams, median suspended sediment concentrations ranged from 1 to over 25,000 mg/L (Lambing and Cleasby, 2006). Additionally, as can be seen in **Figure D4-6**, the best-fit line greatly underestimates some of the higher values. For example, the high point at point (25 cms, 250 mg/L) is almost twice as high as the best-fit line. Therefore, the sediment calibration was completed against a fabricated data set rather than a true observed data set. Thus, the calibration is designed to have the model respond to conditions similar to the 'best-fit observed', but keeping in mind that deviations of several times the 'best fit observed' value may not be a problem if other metrics indicate the fit is good.

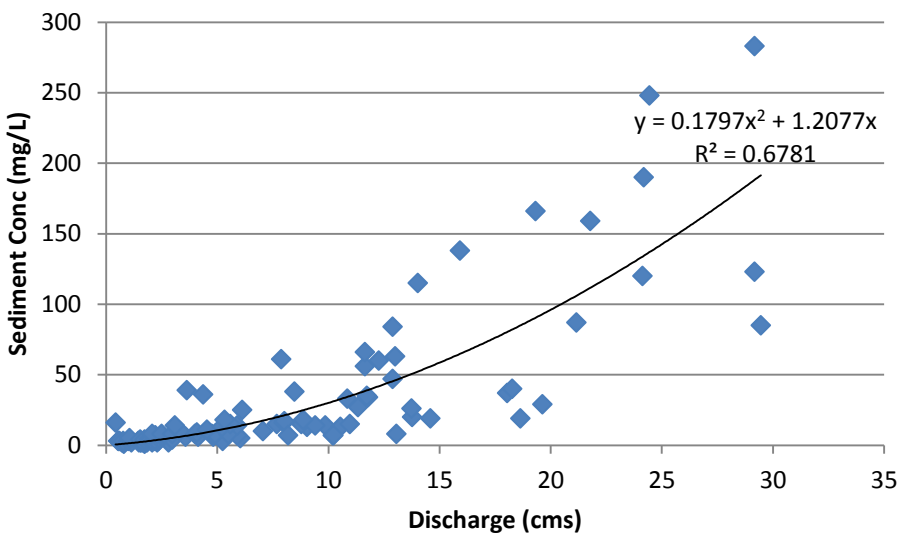


Figure D4-6. Observed total suspended sediment concentrations versus discharge

Best-fit sediment values are compared to simulated sediment values in **Figure D4-7** and **Table D4-5**. The simulated values are generally higher than the best-fit values, especially during times of peak runoff. However, a comparison of actual observed to best-fit observed to simulated shows how variable the sediment data is (**Table D4-5**).

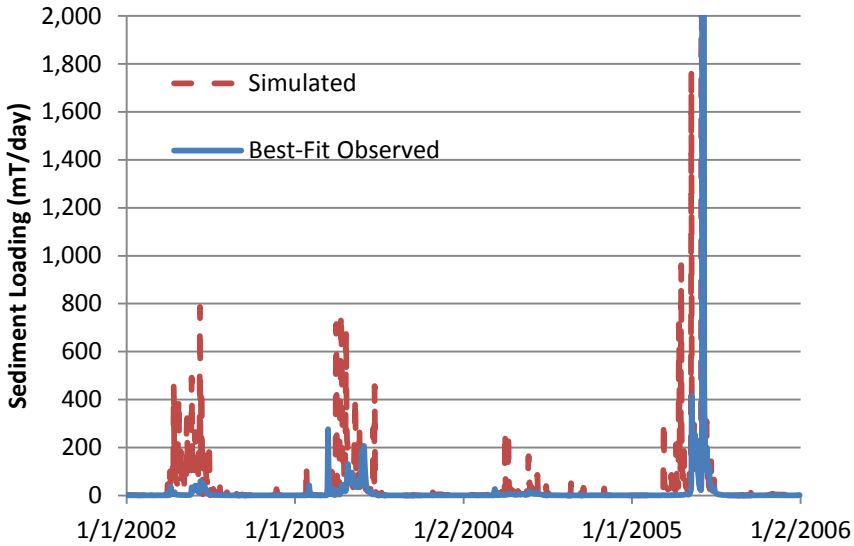


Figure D4-7. Best-Fit versus simulated sediment loading, 2002-2005

Table D4-5. Observed, best-fit, and simulated sediment concentrations, 2002-2005

		Observed (108 data points)	Best-Fit Line (based on 107 data points)	Simulated
TSS (mg/L)	**min**	1	0.60	0.72
	max	1,410	348	2,850
	mean	41.9	12.2	66.1
	median	8.5	2.8	19.5
Annual Loading (mT/year)		-	6,438	11,990

This is due to the issues associated with estimating the observed sediment values based on a trend line. Overall, the accuracy of the sediment values were determined to be sufficient for the purpose of conducting the sediment reduction scenarios.

D4.5 Nutrient Calibration

Nutrients of concern in this modeling effort are total nitrogen (TN), total phosphorus (TP), and nitrate/nitrites (NO_3/NO_2). Nutrients are similar to sediments in that they are delivered to the river mouth by several separate processes, but there is an additional process in the nutrient modeling – nutrient generation (along with delivery and routing). Nutrients are a dynamic parameter that are constantly being produced and consumed. Nutrient generation is the process by which plants, rain, soils, and management practices (fertilization, cattle) generate nitrogen and phosphorus in the upland areas. Delivery is the process by which nutrients are washed off of the land surface and carried into the river channel. This happens during runoff events, and is modeled by SWAT using equations to calculate surface runoff concentrations, movement through the soil, attachment to soil that is carried away in runoff events, and lateral and groundwater flows. Routing within the river channel is a separate process, where interactions with light, nutrients, algal growth and death, and oxygen levels can be simulated via a QUAL2E sub-routine.

As with the sediment data, the existing nutrient data was not collected on a daily basis. There are 105 samples taken by various groups at the USGS gage over the course of approximately 30 years.

Additionally, a handful of samples have been taken at various points along the Little Blackfoot River and its tributaries. The same problems present in the sediment calibration are present in the nutrient calibration, with the addition that nutrients are not only correlated to discharge, but are also strongly correlated to seasons. Soluble nutrient levels tend to drop in the summer when algal growth occurs, and rise as algae dies off in the fall. Therefore, not only was a daily calibration not possible, but a simple regression of all data points (regardless of season) would over-simplify the nutrient concentrations.

To overcome the calibration obstacles described, the 105 data points observed at the mouth of the Little Blackfoot River were separated by month and plotted (**Figures D4-8** and **D4-9**, **Table D4-6**). Each month was then assigned this mean value for each species - organic nitrogen, nitrate/nitrite, orthophosphate, and organic phosphorus. Observed daily discharges were then multiplied by the mean monthly concentrations to get best-fit observed daily nutrient loadings.

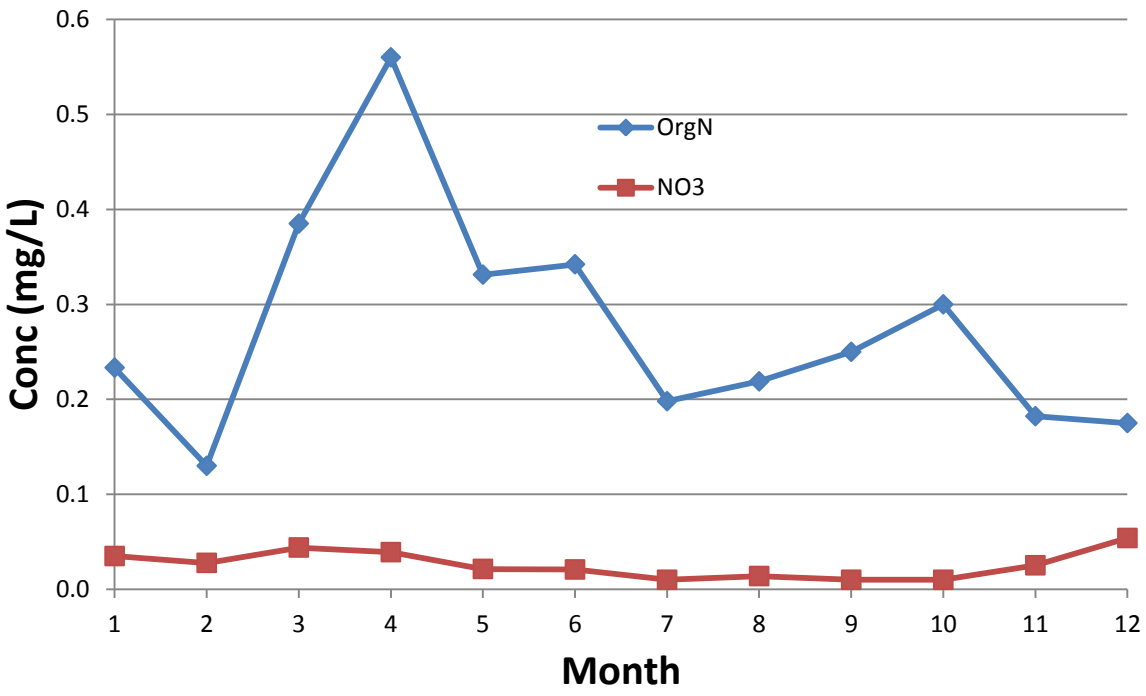


Figure D4-8. Average monthly observed nitrogen concentrations (mg/L)

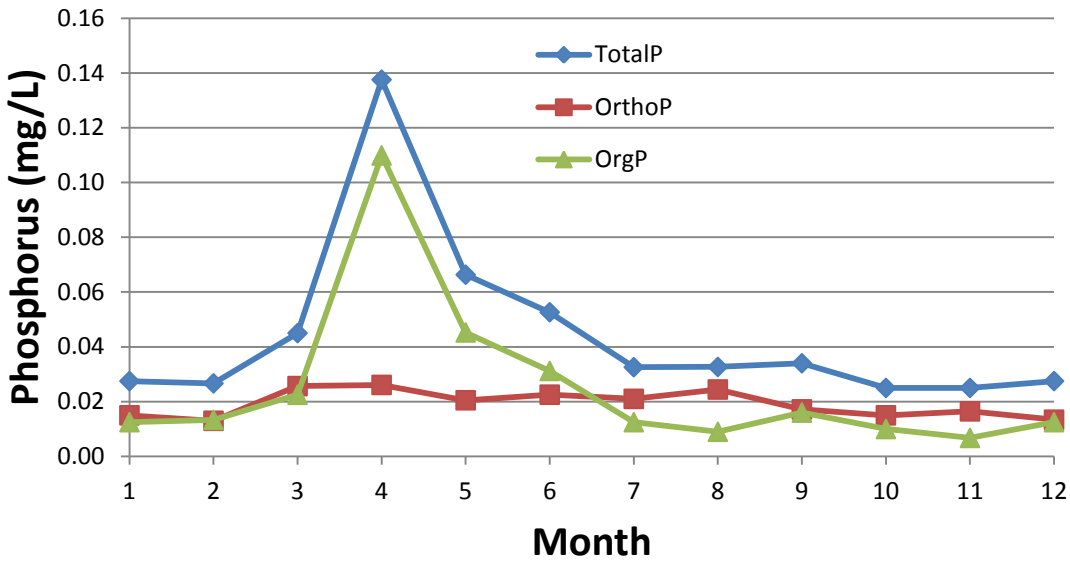


Figure D4-9. Average monthly observed phosphorus concentrations (mg/L)

Table D4-6. Observed mean nutrient concentrations at Little Blackfoot River mouth (mg/L)

Month	OrgN	NO3	TN	OrthoP	OrgP	TP
January	0.233	0.035	0.268	0.015	0.013	0.028
February	0.130	0.028	0.158	0.013	0.013	0.027
March	0.385	0.044	0.429	0.026	0.023	0.045
April	0.560	0.039	0.599	0.026	0.110	0.138
May	0.331	0.021	0.353	0.021	0.045	0.066
June	0.342	0.021	0.363	0.023	0.031	0.053
July	0.198	0.010	0.208	0.021	0.013	0.033
August	0.219	0.014	0.233	0.024	0.009	0.033
September	0.250	0.010	0.260	0.017	0.016	0.034
October	0.300	0.010	0.310	0.015	0.010	0.025
November	0.182	0.025	0.207	0.016	0.007	0.025
December	0.175	0.054	0.229	0.013	0.013	0.028

This method preserves the seasonal and hydrologic correlations with nutrient loadings. However, as in the sediment methodology, this method averages out singular events that may have led to some of the higher observed values. Since nutrient TMDLs apply only to the growing season (July through September), and most of the large singular events happen during the spring runoff, this method is less sensitive to these issues. Mean values during the growing season (**Table D4-6**) corroborate the TMDL listing for the Little Blackfoot River for total phosphorus (0.030 mg/L is the draft numeric criterion), and the lack of a listing in the Little Blackfoot River for total nitrogen (0.300 mg/L is the draft numeric criterion).

Results of the nutrient calibrations at the USGS gage are shown in **Figures D4-10** and **D4-11**. As can be seen, the overall balance of nutrients is good, although from month to month there is some variation. The overall nutrient total balance for the 2002-2005 growing seasons was within 15% for both nitrogen and phosphorus. Although nutrient loadings in the tributaries were not calibrated individually (due to

the small amount of data available within each tributary), model output was reviewed at each of these reaches, and the resulting concentrations were reasonable.

Nutrient speciation was also modeled. Although the total nitrogen and total phosphorus values were similar to observed, during the summer season the nitrogen speciation did not align with the observed data. Nitrate was present in the same or higher quantities than organic nitrogen, which is not in line with the observed data (**Figure D4-8**). We were unable to satisfactorily address this issue. However, only one of the developed nitrogen TMDLs was for nitrate/nitrite (Snowshoe Creek). This issue is discussed further in **Section D5.7**.

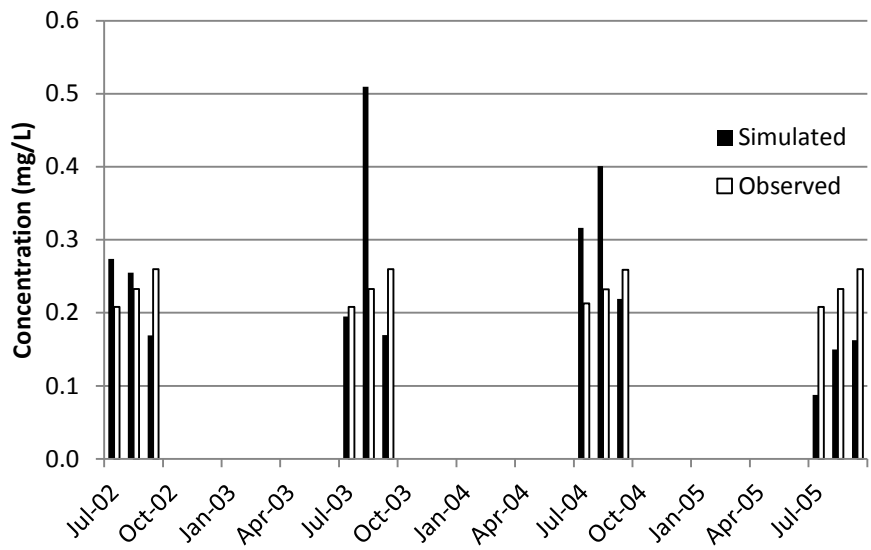


Figure D4-10. Total nitrogen concentrations by month, 2002-2005

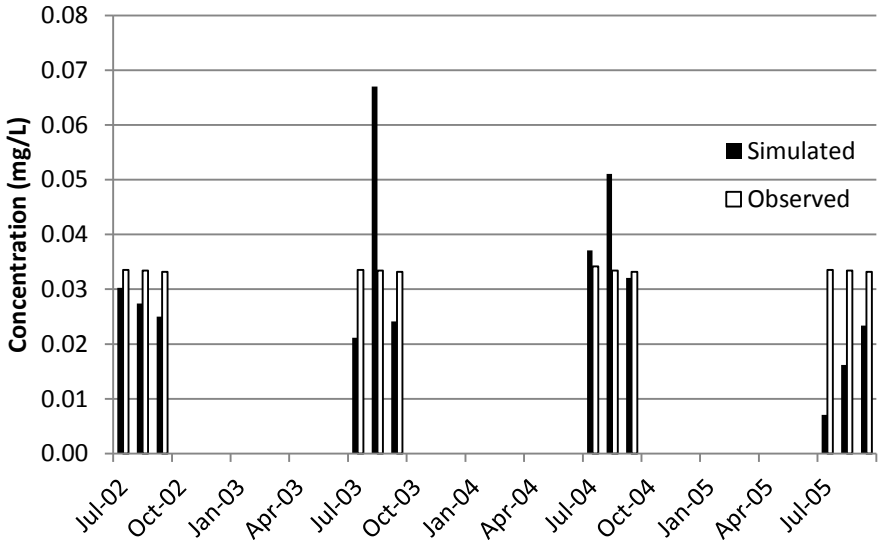


Figure D4-11. Total phosphorus concentrations by month, 2002-2005

D4.7 MODEL VALIDATION/CONFIRMATION

Model validation is the independent process by which a model is tested against "new" data, usually from a different time period than the calibration period. If the calibrated model predicts the validation period, it is considered to be "validated".

The calibrated model was run for the validation time period 1/1/2006 through 12/31/2008. There was a six month window of missing data from the USGS gage from November 2006 through April 2007. This missing time period was removed from the validation analysis. The validation results were similar to the calibration results (**Figure D4-12**). The model tended to under-predict high flow years (2005, 2008), while slightly over-predicting low-flow years (2004, 2006).

However, the relative error for the validation period was within the allowed range for the annual flow, and just outside of the accepted range for the summer flow (**Table D4-7**). The Nash-Sutcliffe efficiency values were acceptable for both time periods.

For both the calibration period and the validation period, the model accurately predicted flows on an annual basis. The validation period for summer flows trended towards under-predicting. Although the value was just outside the ideal range, this may have the effect of slightly under-predicting water-quality parameters associated with low-flow periods (i.e. nutrients).

There may also be several explanations for why the model slightly under-predicted summer flows in the validation period. Summer flows are difficult to predict due to the highly variable flows from year to year. Landowners tend to over-use water in wet years, and use just enough in dry years. This presents a problem for modeling, as the actual water use by ranchers cannot be accurately predicted from year to year. Additionally, in 2006 the Montana Water Trust purchased 2.52 cfs of water rights from May 1st to September 30th from a local land owner (PBS&J, 2009; Clark Fork Coalition, personal communication 2011) to enhance instream summer low-flows. The value of the water rights purchase was not determined until after the model was completed, so it was not included in the model. The water rights purchase does not affect the calibration period at all, and the small volume (2.52 cfs, or 0.07 cms, over four months) is unlikely to significantly affect the validation period results. However, if it does have a minor effect on the model, it would be to slightly under-predict summer flows in the validation period. Note that the Montana Water Trust was acquired by the Clark Fork Coalition in March 2010 and the water rights were transferred to the Clark Fork Coalition at that time.

In summary, all metrics were within the pre-determined allowed ranges with the exception of the relative error of the summer growing season validation period (and this was close to acceptable range). The model did a good job of predicting system trends, and since this is the overall goal, for this purpose the model was considered calibrated and validated.

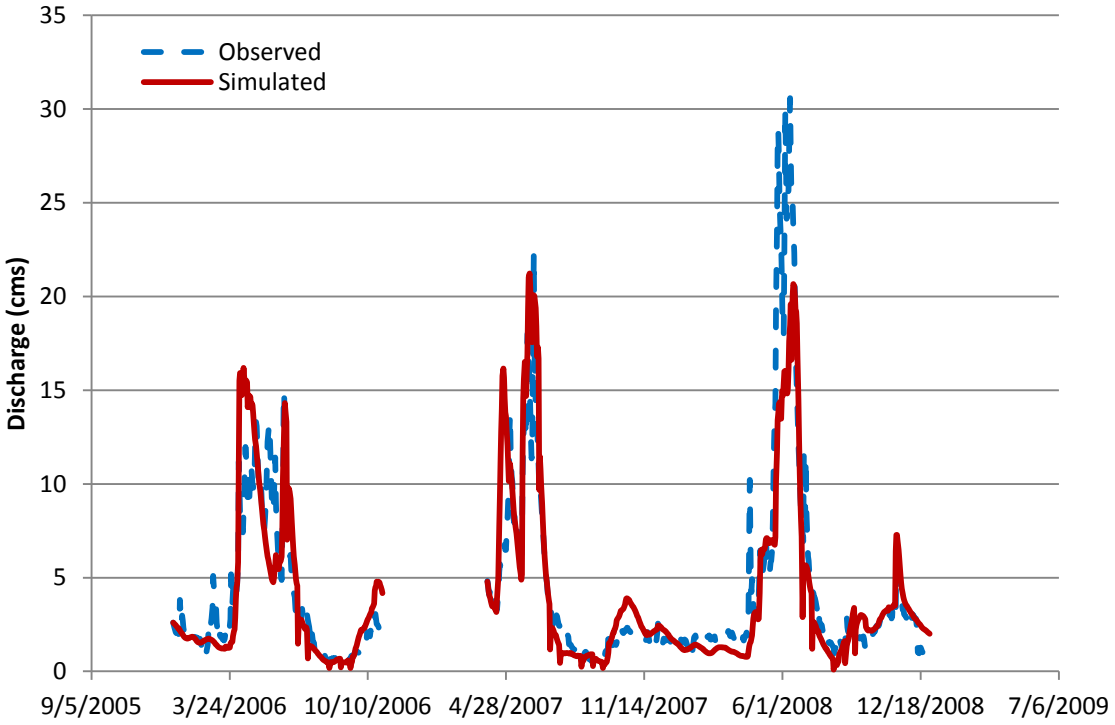


Figure D4-12. Model validation, daily hydrology, 2006-2008

Table D4-7. Daily validation metrics, 2006-2008

	Observed Total Volume (acre-feet)	Simulated Total Volume (acre-feet)	Difference (%)	Relative Error (%)	Nash-Sutcliffe
Annual	277,295	293,936	6.0%	6.0%	0.75
Summer	35,093	29,345	-16.4%	-16.6%	0.61

D5.0 SCENARIO ANALYSIS

Scenario development was accomplished using the calibrated and validated SWAT Little Blackfoot model. In addition to the baseline scenario (i.e. existing condition), several scenarios were modeled to estimate sediment and nutrient loading reductions associated with various best management practices (BMPs), and to identify the BMP combinations most likely to result in TMDL attainment. Scenarios were focused on sources that tend to be the most significant for sediment and nutrients, and included improvements in management practices that are commonly recommended and applicable to this watershed.

Scenarios modeled for this project include rotational grazing, channel protection, enhancement/protection of riparian areas, improvements to roadways, improved irrigation efficiency, and combinations thereof. These scenarios are further discussed (with results) below. An overall summary of reduction percentages by listed stream segment is given in **Section D5.7**, tables with the upland erosion reductions by source are provided for each watershed in **AppendixDA**. However, before discussing specific scenarios, the ability of SWAT to model BMPs is discussed.

With the exception of improved roads, all other scenarios are directly influenced by agricultural management practices. The scenarios are intended to simulate common BMPs but are not prescriptive. A literature search by Agouridis et al. (2005) provides a comprehensive literature review of common agricultural BMP implementation practices in the United States, and reports in general, that at least one aspect of stream water quality (e.g. chemical, physical, or biological) has improved in watersheds that received one or more of the following measures: livestock exclusion, offstream watering, alternate shade, rotational grazing, supplemental feeding, and buffer strips. As such, DEQ believes that one or more practices could be implemented cost-effectively (e.g. through cost-shares with NRCS) to improve water quality in the Little Blackfoot River watershed.

At the core of SWAT is the hydrologic response unit (HRU). This is SWAT's fundamental computational unit, and most parameter modifications affect SWAT at the HRU level. HRUs are portions of the same sub-basin that share similar land uses, soils, and slopes. An HRU can (and typically does) consist of multiple spatial areas that are located within the same sub-basin, but aren't adjacent to each other. However, these non-adjacent areas are lumped into one HRU as long as they share similar land use, soil, and slope. There is no spatial context to HRUs – every HRU is assumed to deliver its load directly to its reach and it is irrelevant to SWAT whether the HRU is adjacent to the stream, or at a distance from the stream – i.e., it treats all HRUs the same in that regard. Furthermore, most BMPs are applied to the HRU, not to the sub-basin or watershed, so applying a BMP to one stretch of river may require applying it to multiple HRUs (and their associated area), and may be somewhat limited by the breakdown of HRUs in each watershed.

One final point is that SWAT does not currently explicitly model riparian areas within reaches. Rather it allows for edge of HRU buffers which effectively are available to remove pollutants only at the edge of the HRU. It is important to reiterate that HRUs are not routed through each other, but only to the channel. A riparian feature is in the works for future versions of SWAT where HRUs can be routed through other HRUs (such as in the case of a riparian area). Currently, however, this is not an option in the model and therefore, any "improvements to riparian area" cannot directly be modeled without some assumptions about the extent of the riparian area that has an effect on a given HRU and its associated conditions.

D5.1 Baseline Scenario

The calibrated model was used to develop the baseline scenario. The baseline scenario represents the conditions that existed in the watershed in the 2002-2005 time period. The average hydrograph is shown in **Figure D5-1**. The downward spikes in the summer period represent the days when irrigation was turned on. Realistically, all fields and all ranches do not irrigate on the same day in the summer. However, to reduce model complexity, a simple irrigation schedule was used. While this has a minimal influence on an annual basis, it likely reduces the NSE and RE of the model fit for the summer growing season. Additionally, as mentioned in **Section D3.10**, any unused water in the irrigation scheme is returned to its source.

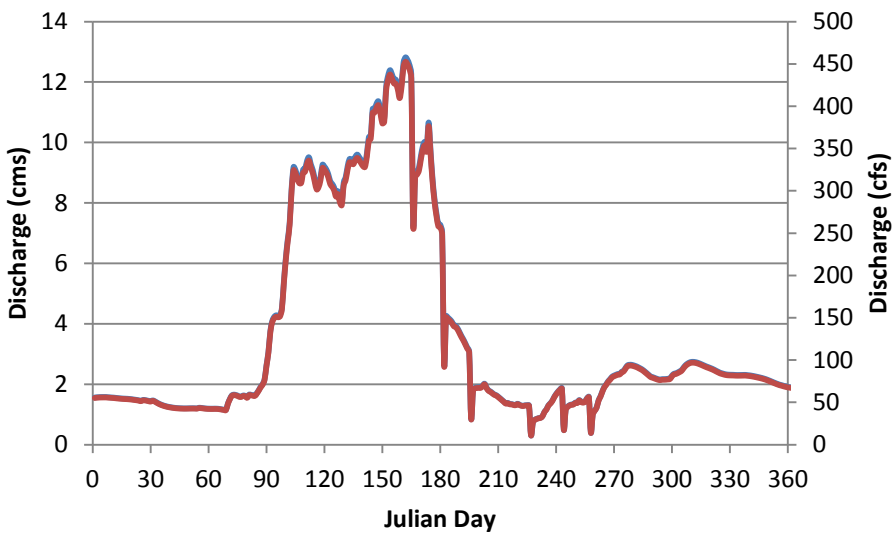


Figure D5-1. Average annual hydrograph (simulated), 2002-2005

D5.1.1 Baseline Scenario - Sediment

Sediment loading was calculated for each of the ten segments in need of sediment TMDLs. Each segment was broken down by the following potentially significant source categories: upland contributions by land use, roads, and streambank erosion. Streambank erosion was not specifically calculated as a source; rather, the difference between the sum of the loadings from all upland sources and roadways (considering any sediment loss in reservoirs if applicable) was determined, and then this value was subtracted from the actual load reaching the reach outlet. This difference was considered to be loading from streambank erosion. The breakdown for the entire watershed (Little Blackfoot River) is shown in **Table D5-1** as an example. The existing loads for the other listed streams, and all future scenario results (including the Little Blackfoot River), can be found in **Appendix DA**.

Table D5-1. Sediment contributions, Little Blackfoot River

Area (sqkm)	Area (ha)	Annual Load (metric tons/year)	Annual Load (%)	Category
592	59,169	1,664	12.4%	Forest
49	4,874	812	6.0%	Pasture
416	41,561	8,288	61.7%	Rangeland
6	582	185	1.4%	Urban
6	557	1	0.0%	Wetlands
-	-	69.5	0.5%	Roads
-	-	2,413	18.0%	Streambanks
1,067	*106,743*	*13,433*	*100.0%*	*Total**

*Total does not reflect actual delivered sediment load of 11,990 metric tons/year, as total includes 1,443 metric tons/year of sediment trapped in reservoirs.

In this watershed, rangeland is the highest contributor to sediment. Streambank erosion accounts for approximately 18% of the sediment loading. Urban and roadway loadings are minimal in this watershed. This trend remained fairly constant for the other listed streams. The sediment breakdowns for these watersheds can all be found in **Appendix DA** (Model Scenario Results).

D5.1.2 Baseline Scenario - Nutrients

A total phosphorus TMDL was developed for the Little Blackfoot River watershed and four tributaries. A total nitrogen TMDL was developed for one tributary (Threemile Creek), and a nitrate/nitrite TMDL was developed for one tributary (Snowshoe Creek). The existing phosphorus loads for the entire Little Blackfoot River watershed due to upland erosion and septic loads are shown in **Table D5-2** as an example. The existing loads for the other listed streams, and all future scenario results (including the Little Blackfoot River), can be found in **Appendix DA**.

Table D5-2 Total phosphorus contributions on the Little Blackfoot River during the growing season

Area (sqkm)	Area (ha)	Summer Load (kg/growing season)	Summer Load (%)	Category
592	59,169	78.2	20.8%	Forest
49	4,874	72.3	19.2%	Pasture
416	41,561	134.5	35.8%	Rangeland
6	582	47.3	12.6%	Urban
6	557	1.0	0.3%	Wetlands
-	-	42.4	11.3%	Septic
1,067	*106,743*	*375.7*	*100.0%*	*Total*

Phosphorus contributions are spread out across the land uses. Septic loads account for approximately 11% of the phosphorus loading in the watershed. The nutrient breakdowns for the other listed streams can be found in **Appendix DA** (Model Scenario Results). The existing results will be used in the next sections to compare to predicted loading for future management scenarios.

D5.2 IMPROVED ROADWAYS SCENARIO

Approximately 38% of the LBF watershed is managed by the USFS, and 55% is privately owned. Both the USFS land and private ranches are heavily traversed with roadways for access to grazing areas, logging areas, recreational areas, and other sites. Therefore, the watershed contains a large number of gravel and dirt roads, many of which are near or adjacent to streams. A 2010 road sediment assessment report categorized the road sediment loading throughout the watershed ((PBS&J, 2010); **TMDL Appendix E**). The report categorized the degree of impact based on several factors, and then estimated sediment loads based on these factors. Existing and future road conditions (after BMP implementation) and corresponding sediment loads were modeled to determine the amount of reduction that was feasible through road improvements.

The existing road conditions and sediment loadings calculated in the road assessment were introduced into the SWAT model through use of point sources. Since roads are not a separate land use in this model (i.e., they are not explicitly modeled), each sub-basin had a sediment point source added to simulate the road loadings. These loads are distributed evenly throughout the year. Note that the overall contribution from roadways is small in comparison to other upland sources (**Table D5-1**).

D5.2.1 Improved Roadways Scenario - Sediment

To apply future road improvements, the existing condition loadings were replaced by the future conditions loading results from the road sediment assessment report. Implementation of roadway BMPs would result in approximately a 55% drop in the sediment loadings from roadways (**Table D5-3**). Overall, roadways were a small fraction of the overall sediment loading (**Table D5-1**).

Table D5-3. Sediment loadings reductions from improved roadways by stream segment (PBS&J, 2010)

River Segment	Sub-Basin	Reduction (%) in Road Sediment Load
Threemile Creek	9	45%
Snowshoe Creek	15	74%
Spotted Dog Creek	26	79%
Little Blackfoot River - Mouth	27	54%
Little Blackfoot River - Headwaters	25	71%
Elliston Creek	22	56%
Trout Creek	29	37%
Telegraph Creek above Hahn Creek	35	71%
Dog Creek	21	71%
Dog Creek above Meadow Creek	2	70%

D5.2.2 Improved Roadways Scenario - Nutrients

Nutrient loadings were not affected by improvements in roadways. The overall loading from roadways is low, and only a small fraction of nutrient loading is tied to sediment. Therefore, this scenario was insignificant in reducing nutrient loadings.

D5.3 Stabilized Channel Scenario

Currently, many of the channels and reaches in the watershed are open to cattle grazing. This can result in trampled areas with little or no vegetation along the streams, and stream channel beds that become less stable. These processes increase sediment and nutrient loading to the river. Direct excretion of cattle manure into waterbodies adds relatively large loads of nutrients directly into the streams as well (although this aspect is not directly modeled by SWAT). Streambanks are a significant source of sediment in the watershed (**Table D5-1**).

The model at this time has no direct provision for modeling bank trample or increased erosion of streambanks from cattle. However, these processes can be roughly simulated via direct adjustment of the bank cover factors for a given stream reach. Bank cover factors account for the health of the bank by considering the amount of vegetation on the streambanks and channels and the status of the soils along the streambanks and channel beds.

To apply reductions in near-stream grazing and bank erosion, we increased the channel cover in areas that are heavily grazed. Since the Little Blackfoot River channel below Elliston is larger and has steeper and higher banks, and a significant portion of it is adjacent to the highway, it was assumed that cattle did not have easy access to this portion of the channel, and no improvements could be made. No changes were made to tributary areas that are not grazed.

The amount of increase in the channel cover factor was difficult to determine. We ended up using a fairly arbitrary reduction, reducing the channel cover factor from 0.8 (calibrated) to 0.2. This was difficult to justify, as there was no literature on the subject available. Because of the uncertainty in this calculation, we decided to use reductions from the bank erosion field assessment (**TMDL Appendix C**) (rather than from the SWAT model). The field-derived reductions were applied to the SWAT-modeled streambank load to calculate reductions for the final TMDL. These are the reductions listed in **Section D5.7**.

The modeled scenario did provide some benefit, as existing streambank loads and reductions from the model were compared to the field assessment, and the relative magnitude of contributions from each sub-basin was similar.

D5.3.1 Stabilized Channel Scenario - Sediment

Modeled improvements to channel protection and bank erosion have the potential to reduce streambank erosion in the Little Blackfoot River watershed by approximately one to five percent, depending on the sub-basin (**Table D5-4**). As mentioned above, this value was not used in the final TMDL, and relative reductions from the bank erosion field assessment were used.

D5.3.2 Stabilized Channel Scenario - Nutrients

Improvements in streambank erosion did not affect overall nutrient reductions. In reality, decreasing bank erosion will likely reduce phosphorus loading as well. However, because the overall reduction in sediment loading was small, and phosphorus attached to sediment is only a small portion of the overall phosphorus load, and the reduction happened in the actual reach where complex instream nutrient processes are happening (as compared to upland areas in the other scenarios), the model did not predict a phosphorus load reduction. Therefore, a phosphorus load reduction for this category was not used in the final TMDL (**Table D5-5**).

D5.4 Improved Grazing Management Scenario

The third scenario analyzed was an improvement in grazed land conditions. This includes both winter pasture and summer range. It has been well established that grazing decreases ground cover, which influences sedimentation processes. No specific practice was specified for this improvement, as ground cover can potentially be altered through a number of BMPs including alteration of cattle distribution on the landscape (e.g. water, shade), modification of the grazing time-frame and duration through different rotational practices, or reductions in stocking density. To reflect some combination of these changes, modifications were made to the USLE C factor in SWAT. Adjustment was made based on several studies in southwestern and central Montana which relate rangeland ground cover response to grazing practices. According to Evanko and Peterson (1955), bare ground was shown to be 14.9, 18.6, and 6.8 percent higher on the Beaverhead National Forest near Dillon, MT on sites that were heavily, moderately, and lightly grazed than those with no cattle on them. The comparison was made after a 15-18 year exclusion period. Similar results were found in an exclusion study on foothill sheep ranges in Meagher County near White Sulphur Springs, MT. Total cover (e.g. foliage and litter) was 16.7 percent higher between protected and grazed plots in that study after four years of exclusion (Vogel and Van Dyne, 1966). Thus it is apparent that a relationship between ground cover and grazing does exist, and a maximum difference between grazed and ungrazed lands is around 15-20 percent. Thus a conservative estimate of a 10% improvement for range USLE C factor, and a 15% improvement in pasture USLE C factor was used in this scenario (**Table D3-2**).

D5.4.1 Improved Grazing Management Scenario - Sediment

Improvements to grazing management have the potential to reduce overall upland loading of sediment to the listed watersheds by 2 to 22% (**Table D5-4**). The reductions are from loadings associated with grazed rangeland and pasture. Loading reductions by land use for this scenario are provided in **Appendix DA**.

D5.4.2 Improved Grazing Management Scenario - Nutrients

Improvements to grazing management have the potential to reduce overall upland loading of nitrogen and phosphorus to the listed watersheds by approximately 4 to 18% for nitrogen and 8% and 33% for phosphorus (**Table D5-5**), during the growing season (July through September). Loading reductions by land use for this scenario are provided in **Appendix DA**.

D5.5 ENHANCED RIPARIAN HEALTH SCENARIO

Riparian vegetation in the Little Blackfoot River watershed has been degraded by a variety of factors including historic vegetation removal, overgrazing and trampling, mining, silviculture, and residential development. Because riparian areas function as important filters for streamflow and overland runoff, a scenario was run to evaluate the effect of improved riparian health on sediment and nutrient loads.

A riparian habitat assessment was completed for the Little Blackfoot River watershed (PBS&J, 2010); described in **TMDL Appendix C**) to collect data on riparian area extent, health, and locations. Delineated reaches were given a riparian condition category of good, fair, or poor based on land use adjacent to the stream, riparian vegetation type and density, and the presence or absence of human related activities near the stream corridor. Based on this, the riparian areas along each stream investigated were given ratings (and corresponding percentages) of good, fair, or poor based on the results of the assessment.

Literature values were used to determine the buffering capacity potential for a given category. Sediment reduction potential improves by 25% when improving riparian condition from fair to good, and 50% when improved from poor to good (see **Section 5.7.1** of the TMDL for a discussion of this method). Sub-basins were analyzed for riparian health, and then riparian buffer areas (via field strips in the .hru file) were applied based on these results. Filter strips were applied at either a 30 foot, 50 foot, or 100 foot width depending on the health of the riparian area (see **Section 5.7.1** of the TMDL). Most improvements were either 30 feet or 50 feet. These buffer areas represent streambanks that have been removed from grazing and other management by fences or other means.

SWAT applies filter strips at the HRU level. Filter strips reduce the sediment and nutrient loads in both the overland flow and subsurface flow. The filter strip could be considered roughly analogous to a riparian area as they both filter nutrients and sediment from the computed HRU load prior to delivery to the channel for routing. In this scenario, filter strips were applied to areas that tend to be alongside streams (pasture), and areas that are heavily grazed (rangeland and forest). One important limitation (mentioned in **Section D5.0**) is since filter strips are applied to HRUs (and not at a watershed level), their application is somewhat restricted by the model-derived division of HRUs within each sub-basin. For example, if improved riparian areas were supposed to be applied to 50% of a sub-basin, but there were five HRUs each comprising 20% of the sub-basin, then we had to apply the filter strips to either 40% or 60% of the sub-basin (an HRU cannot be split up). We typically took the closer value if confronted with this issue. Therefore, some sub-basins may not be able to achieve the estimated reductions, while others will likely be able to achieve greater reductions.

D5.5.1 Enhanced Riparian Health Scenario - Sediment

Improvements to riparian areas have the potential to reduce overall upland loading of sediment to the listed watersheds by approximately 10 to 40% (**Table D5-4**). The reductions are from loadings associated with grazed rangeland, forest, and pasture. Loading reductions by land use for this scenario are provided in **Appendix DA**.

D5.5.2 Enhanced Riparian Health Scenario - Nutrients

Improvements to riparian areas have the potential to reduce overall upland loading of nitrogen and phosphorus to the listed watersheds by approximately 12 to 40% for nitrogen and 22 to 48% for phosphorus (**Table D5-5**), during the growing season (July through September). Loading reductions by land use for this scenario are provided in **Appendix DA**.

D5.6 Improved Irrigation Scenario

The LBF watershed contains approximately 4,900 hectares (12,500 acres) of irrigated pasture/hay. This land is typically flood irrigated starting in mid-spring when runoff is high, and then routinely irrigated throughout the summer. There is a short break in irrigation in August while hay is being harvested, and then irrigation resumes through the beginning of October.

Irrigation management is handled in SWAT by management files. These files contain detailed irrigation information. In irrigation management within SWAT, a date is specified, and on that date, the amount (mm/ha) of irrigation, irrigation efficiency, and fraction of surface runoff are specified.

In this scenario, it was assumed that the overall irrigation efficiency (either amount of water used, timing and duration of irrigation, delivery method, etc) could be improved by 5%. This value was chosen as being a reasonably attainable number.

Results of this scenario indicated that the overall sediment and phosphorus loading reductions (associated with overland runoff) were less than 1%. The nitrate/nitrite loading reductions (associated with subsurface flow) were higher, between 1 and 10%, depending on the watershed. However, since the only stream that is listed for nitrate/nitrite is Snowshoe Creek (**Table D1-1**), and this method did result in a small reduction in modeled crop yield, this option was not pursued further. This does not mean that an improvement in irrigation efficiency would not facilitate loading reductions, or enhance the overall health of the watershed, but rather that the model parameterization and BMP application need further refinement before this method could be used to make management recommendations.

D5.7 Scenario Summary

Sediment and nutrient reductions based on the different scenarios are shown in **Tables D5-4** and **D5-5**. More detailed breakdowns of upland erosion by land cover type can be found either in the corresponding section (for the entire Little Blackfoot River watershed), or in **Appendix DA**. Reported daily loads for sediment are required by the EPA. Although not analyzed in this report, daily sediment loads are included as **Appendix DB**.

Nutrients were reported on a seasonal basis (July – October) to determine reduction strategies for the growing season. However, they were modeled on an annual basis. In general, annual nutrient load reductions were greater than the summer growing season reductions (**Table D5-6**). Thus, it is likely that overall nutrient reductions will be greater than those reported.

One unaddressed issue is the nitrogen speciation problem, and the developed TMDL for nitrate/nitrite for Snowshoe Creek. The model was not able to accurately predict nitrogen speciation during the summer. However, since total nitrogen and nitrate/nitrite are closely related, the recommended BMPs for TN should also reduce NO3/NO2 by a similar amount.

The combination of improvements to roadways, improvements to grazing management, and improvements/enhancement of riparian health was the combination that achieved the highest total sediment and nutrient reductions of the modeled scenarios (**Table D5-4 and Table D5-5**). As discussed in **Section D5.4**, bank erosion reductions were calculated externally and applied to the results. Bank erosion reductions are also a part of the TMDL allocation.

Table D5-4. Overall reductions in sediment loading by stream segment (on an annual basis)

BMP Scenario	River Segment	Sub-Basin	Sediment Load Reductions (%)
Improved Roadways	Threemile Creek	9	0.5%
	Snowshoe Creek	15	1.2%
	Spotted Dog Creek	26	0.3%
	Little Blackfoot River - Mouth	27	0.3%
	Little Blackfoot River - Headwaters	25	0.2%
	Elliston Creek	22	0.0%
	Trout Creek	29	0.9%
	Telegraph Creek above Hahn Creek	35	1.7%
	Dog Creek	21	0.2%
	Dog Creek above Meadow Creek	2	0.7%
Improved Grazing Management	Threemile Creek	9	22.1%
	Snowshoe Creek	15	13.8%
	Spotted Dog Creek	26	8.1%
	Little Blackfoot River - Mouth	27	8.7%
	Little Blackfoot River - Headwaters	25	5.6%
	Elliston Creek	22	12.3%
	Trout Creek	29	8.2%
	Telegraph Creek above Hahn Creek	35	2.4%
	Dog Creek	21	6.4%
	Dog Creek above Meadow Creek	2	12.1%
Enhanced Riparian Health	Threemile Creek	9	40.4%
	Snowshoe Creek	15	12.9%
	Spotted Dog Creek	26	14.8%
	Little Blackfoot River - Mouth	27	12.0%
	Little Blackfoot River - Headwaters	25	7.0%
	Elliston Creek	22	22.3%
	Trout Creek	29	17.4%
	Telegraph Creek above Hahn Creek	35	13.9%
	Dog Creek	21	8.7%
	Dog Creek above Meadow Creek	2	14.8%
Stabilized Channels	Threemile Creek	9	0.3%
	Snowshoe Creek	15	1.9%
	Spotted Dog Creek	26	2.1%
	Little Blackfoot River - Mouth	27	3.6%
	Little Blackfoot River - Headwaters	25	0.6%
	Elliston Creek	22	0.4%
	Trout Creek	29	5.3%
	Telegraph Creek above Hahn Creek	35	1.2%
	Dog Creek	21	1.5%
	Dog Creek above Meadow Creek	2	0.0%
Enhanced Riparian	Threemile Creek	9	46.0%

Table D5-4. Overall reductions in sediment loading by stream segment (on an annual basis)

BMP Scenario	River Segment	Sub-Basin	Sediment Load Reductions (%)
Health plus Improved Roadways plus Improved Grazing Management	Snowshoe Creek	15	23.1%
	Spotted Dog Creek	26	21.7%
	Little Blackfoot River - Mouth	27	17.9%
	Little Blackfoot River - Headwaters	25	11.8%
	Elliston Creek	22	27.5%
	Trout Creek	29	23.1%
	Telegraph Creek above Hahn Creek	35	15.6%
	Dog Creek	21	14.1%
	Dog Creek above Meadow Creek	2	23.2%

Table D5-5. Overall reductions in nutrient loading by stream segment on a seasonal (July – Oct) basis

BMP Scenario	River Segment	Sub-Basin	Load Reductions (%)	
			TN	TP
Improved Roadways	Threemile Creek	9	0.0%	0.0%
	Carpenter Creek	12	0.0%	0.0%
	Snowshoe Creek	15	0.0%	0.0%
	Dog Creek	21	0.0%	0.0%
	Spotted Dog Creek	26	0.0%	0.0%
	Little Blackfoot River - Mouth	27	0.0%	0.0%
Improved Grazing Management	Threemile Creek	9	7.8%	8.5%
	Carpenter Creek	12	5.7%	10.0%
	Snowshoe Creek	15	18.0%	33.1%
	Dog Creek	21	3.6%	9.2%
	Spotted Dog Creek	26	15.0%	13.2%
	Little Blackfoot River - Mouth	27	8.4%	11.1%
Enhanced Riparian Health	Threemile Creek	9	39.2%	47.5%
	Carpenter Creek	12	17.4%	28.8%
	Snowshoe Creek	15	11.5%	22.1%
	Dog Creek	21	18.4%	28.1%
	Spotted Dog Creek	26	39.0%	45.6%
	Little Blackfoot River - Mouth	27	21.1%	29.6%
Stabilized Channels	Threemile Creek	9	0.0%	0.0%
	Carpenter Creek	12	0.0%	0.0%
	Snowshoe Creek	15	0.0%	0.0%
	Dog Creek	21	0.0%	0.0%
	Spotted Dog Creek	26	0.0%	0.0%
	Little Blackfoot River - Mouth	27	0.0%	0.0%
Enhanced Riparian Health plus Improved Roadways plus Improved Grazing Management	Threemile Creek	9	42.7%	49.2%
	Carpenter Creek	12	20.1%	33.6%
	Snowshoe Creek	15	25.3%	44.6%
	Dog Creek	21	18.5%	36.6%
	Spotted Dog Creek	26	42.5%	50.3%
	Little Blackfoot River - Mouth	27	25.3%	38.4%

Table D5-6. Annual versus summer (July-September) nutrient reductions

Management Scenario	Total Nitrogen Loading Reduction (%)		Total Phosphorus Loading Reduction (%)	
	Annual	Summer	Annual	Summer
Improved Grazing Management	8.1%	8.4%	14.9%	11.1%
Enhanced Riparian Health	24.6%	21.1%	36.1%	29.6%
Combined	29.9%	25.3%	41.3%	38.4%

D6.0 CONCLUSION AND LIMITATIONS

Hydrologic modeling was completed on the Little Blackfoot River watershed to identify the contribution of different source categories to sediment and nutrient pollution, and to assess potential land management scenarios that might address these problems. Several management scenarios were evaluated to identify the most effective means of reducing sediment and nutrient loads in the river. These included improved grazing management, preservation and enhancement of riparian areas, protection of streambanks from livestock, improvements in irrigation efficiency, and improvements in road management. Through scenario analysis, it was shown that livestock management was the most sensitive management option for controlling sediment and nutrient pollution. Thus, the key management implications from this study are that sediment and nutrient loading will most effectively be reduced by the protection and enhancement of riparian areas and streamside buffers in grazed and agricultural areas, and improved grazing management, which may include rotational grazing and/or limiting grazing access to streambanks and channels (see **Section D5.4**). The modeling effort suggests that this combination of management practices could potentially reduce sediment and nutrient yields by 15 – 50%.

A model is only as good as the input data, assumptions, and parameterization used to develop it. This model, like any other, has certain limitations based on these factors. Climatic data is always crucial, as precipitation and evapotranspiration (ET) are the two most important processes for determining hydrology in any watershed. This modeling effort had only one precipitation gage located within the physical watershed, and the only available ET data was located in Deer Lodge, which is outside of the watershed in a drier valley. Additionally, the lack of continuous sediment and nutrient data made it impossible to set up a rigorous, daily calibration for either of these constituents.

Many of the assumptions used in this model had to do with land management practices. The Little Blackfoot has a legacy of mining, and mining practices were largely ignored in this model due to lack of sediment and nutrient loadings information (Olsen, 2004b; Milodragovich, 2003b). Management practices for grazing, irrigation, and hay production were largely estimated from personal communication with only a small subset of land owners in the area or from sporadic field visits.

However, the calibrated and validated hydrologic model met nearly all of the pre-determined evaluation criterion metrics, and responded well to climatic inputs. Additionally, the sediment and nutrient calibrations were reasonable. This model is to be used as a relative gage of system response to various management changes, rather than an absolute indicator of sediment and nutrient loadings. And in this capacity, in spite of the limitations discussed above, the model met its objectives and is sufficient for the intended use.

D8.0 REFERENCES

Agourids, C. T., S. R. Workman, R. C. Warner, and G. D. Jennings. 2005. Livestock Grazing Management Impacts on Stream Water Quality: A Review. *Journal of American Water Resources Association.* 41(3): 591-606.

Arnold, J. G., P. M. Allen, and G. Bernhardt. 1993. A Comprehensive Surface-Groundwater Flow Model. *Journal of Hydrology.* 142: 47-69.

Arnold, J. G., J. R. Kiniry, J. R. Williams, E. B. Haney, and S. L. Neitsch. 2011. Soil and Waters Assessment Tool Input/Output File Documentation Version 2009. Report Texas Water Resources Institute Technical Paper No. 365.

Bagnold, R. A. 1977. Bedload Transport in Natural Rivers. *Water Resources Research.* 13(2): 303-312.

Barnes, Pat. 2008. Flow Study on the Lower Little Blackfoot River. Montana Trout Unlimited.

Brown, L. C. and Thomas O. Barnwell, Jr. 1987. The Enhanced Stream Water Quality Models QUAL2E and QUAL2E-UNCAS: Documentation and User Manual. Athens, GA: U.S. EPA Environmental Research Laboratory. Report EPA/600/3-87/007.

Clark Fork Coalition. 2011. Clark Fork Coalitions Comments on the Little Blackfoot River Draft TMDL. Montana Department of Environmental Quality.

Environmental Research Laboratory-Duluth. 2002. Onsite Wastewater Treatment Systems Manual. Cincinnati, OH: U.S. Environmental Protection Agency, Office of Water. Report EPA/625/R-00/008.

Evanko, Anthony B. and Roald A. Peterson. 1955. Comparisons of Protected and Grazed Mountain Rangelands in Southwestern Montana. *Ecology.* 36(1): 71-82.

Flynn, Kyle and M. W. Van Liew. 2010. Evaluation of SWAT for Sediment Prediction in a Mountainous Snowment-Dominated Catchment. *Transactions of the ASABE.* 54(1): 71-82.

Hargreaves, G. H. and Z. A. Samani. 1985. Reference Crop Evapotranspiration From Temperature. *Transaction of ASAE.* 1(2): 96-99.

Lambing, John H. and Thomas E. Cleasby. 2006. Water-Quality Characteristics of Montana Streams in a Statewide Monitoring Network, 1999-2003. Reston, VA: U.S. Geological Survey. Report Scientific Investigations Report 2006-5046.

Lawlor, Sean M. 2004. Determination of Channel-Morphology Characteristics, Bankfull Discharge, and Various Design-Peak Discharges in Western Montana. Reston, VA: U.S. Department of the Interior, U.S. Geological Survey. Report USGS Scientific Investigations Report 2004-5263.

Milodragovich, E. L. 2003a. Hydrogeochemistry of a Natural Wetland Receiving Acid Mine Drainage, Ontario Mine, Powell County, Montana.: Montana Tech of the University of Montana.

-----. 2003b. Hydrogeochemistry of a Natural Wetland Receiving Acid Mine Drainage, Ontario Mine, Powell County, Montana.: Montana Tech of the University of Montana.

Montana Department of Environmental Quality. 2011. Bitterroot Temperature and Tributary Sediment Total Maximum Daily Loads and Framework Water Quality Improvement Plan. Helena, MT: Montana Department of Environmental Quality.

Montana Department of Natural Resources and Conservation. 2011. Water Rights Query System. http://dnrc.mt.gov/wrd/water_rts/. Accessed 9/1/11 A.D.

Monteith, J. L. 1965. Evaporation and Environment: The s State and Movement of Water in Living Organisms. In: Symposium of the Society of Experimental Biology. Cambridge University Press; 205-234.

Moriasi, D. N., J. G. Arnold, M. W. Van Liew, R. L. Bingner, R. D. Harmel, and T. L. Veith. 2007. Model Evaluation Guidelines for Systematic Quantification of Accuracy in Watershed Simulations. *Transactions of the ASABE.* 50(3): 885-900.

Motovilov, Y. G., L. Gottschalk, K. Engeland, and A. Rodhe. 1999. Validation of Distributed Hydrological Model Against Spatial Observations. *Agricultural and Forest Meteorology.* 98: 257-277.

Nash, J. E. and J. V. Sutcliffe. 1970. River Flow Forecasting Through Conceptual Models, Part 1-A: Discussion of Principles. *Journal of Hydrology.* 10(3): 282-290.

Neitsch, S. L., J. G. Arnold, J. R. Kiniry, and J. R. Williams. 2011. Soil and Water Assessment Tool Theoretical Documentation Version 20092009. Grassland, Soil and Water Research Laboratory - Agricultural Research Service, Blackalnd Research Center - Texas AgriLife Research. http://swatmodel.tamu.edu/documentation.

Ohio State University. 1993. Ohio Livestock Manure Management Guide. Report The Ohio State University Extension Bulletin 604-06.

Olsen, L. J. 2004a. Plant-Metal Interactions in a Natural and Remediated High Elevation Metal-Contaminated Wetland. Masters Thesis.: Montana State University.

-----. 2004b. Plant-Metal Interactions in a Natural and Remediated High Elevation Metal-Contaminated Wetland. Masters Thesis.: Montana State University.

PBS&J. 2009. Little Blackfoot River Groundwater/Surface Water Interaction Study. Montana Water Trust.

-----. 2010. Sediment and Habitat Data and Bank Erosion Assessment: Little Blackfoot TMDL Planning Area. Helena, MT: Montana Department of Environmental Quality.

Priestly, C. H. B. and R. J. Taylor. 1972. On the Assessment of Surface Heat Flux and Evaporation Using Large-Scale Parameters. *Monthly Weather Review.* 100: 81-92.

Regensburger, Eric. 2010. Unpublished Method for Estimating Onsite Septic System Data. Unpublished work.

Tateishi, R. and C. H. Ahn. 1996. Mapping Evapotranspiration and Water Balance for Global Land Surfaces. *Journal of Photogrammetry and Remote Sensing.* 51(4): 209-215.

U.S. Geological Survey. 2010a. National Elevation Dataset (NED). http://ned.usgs.gov. Accessed 11/28/11 A.D.a.

-----. 2010b. National Hydrography Dataset (NHD). http://nhd.usgs.gov. Accessed 11/28/11 A.D.b.

United States Department of Agriculture. 1986. Urban Hydrology for Small Watersheds. Report Technical Release (TR) 55.

United States Department of Agriculture, Natural Resources Conservation Service, Soil Survey. 1994. Montana STATSGO Database. Natural Resources Conservation Service. http://soils.usda.gov/survey/geography/statsgo/.

Van Griensven, A. and W. Bauwens. 2003. Multiobjective Autocalbiration for Semidistributed Water Quality Models. *Water Resources Research.* 39(12): 1348.

Van Liew, M. W., Jeffrey G. Arnold, and D. D. Bosch. 2005. Problems and Potential of Autocalibrating a Hydrologic Model. *Trans.ASCE.* 48(3): 1025-1040.

Vogel, W. G. and G. M. Van Dyne. 1966. Vegetation Responses to Grazing Management on a Foothill Sheep Range. *Journal of Range Management.* 19: 80-85.

Water & Environmental Technologies. 2010. Road Sediment Assessment & Modeling: Little Blackfoot River TMDL Planning Area. Butte, MT: Water & Environmental Technologies. Report DEQ Contract 210129 or 206038.

Williams, J. R. and H. D. Berndt. 1977. Sediment Yield Prediction Based on Watershed Hydrology. *Transactions of the American Society of Agricultural Engineers.*: 1100-1104.

Winchell, M., R. Srinivasan, M. Di Luzio, and J. Arnold. 2010. ArcSWAT Interface for SWAT2009 User's Guide. Blackland Research Center.

APPENDIX DA - MODELING SCENARIO RESULTS

DA.1.0 SEDIMENT

DA.1.1 Overview

For each modeling scenario, the total loading was broken down into three categories. These categories include (1) upland erosion by land use - forest, rangeland (including arid rangeland), pasture (including agricultural area), wetlands, and developed areas, (2) roads, and (3) streambanks. For each of the 10 developed TMDLs, there is a table showing the loadings (metric tons/year) by land use for each scenario. These are **Tables DA-1** through **DA-10**. The final column in each table is the "recommended" scenario, where the improved grazing, enhanced riparian areas, streambank protection, and roadway improvement scenarios were combined. This is not necessarily an additive scenario, as the effects of one of these improvements may reduce the efficiency of another one (e.g., less sediment incoming from improved grazing means less sediment trapped by the riparian buffers).

The final reduction percentages may be slightly different than those listed in the TMDL (**Table D5-4**). This is because of the way the streambank erosion values are calculated in SWAT. The existing streambank erosion value was determined by SWAT from the calibrated model. Because SWAT bases its streambank erosion on how much sediment is in the water column, the various reduction scenarios resulted in less sediment in the water column, and therefore slightly affected the overall streambank erosion results. However, since the reduction percentages were applied with external data (from the sediment and bank erosion assessment), they were applied to the existing streambank erosion only, and the slight differences in the SWAT calculations were ignored in the developed TMDL. These differences are rarely more than 1%.

DA.1.2 TABLES

Tables are listed in alphabetical order of the stream segment name.

Table DA-1. Dog Creek Sediment Summary

Category	Area (ha)	Existing Annual Load (mT*/year)	Improved Roadways Annual Load (mT/year)	Stabilized Streambank Annual Load (mT/year)	Improved Grazing Annual Load (mT/year)	Enhanced Riparian Areas Annual Load (mT/year)	Combined** Annual Load (mT/year)
Forest	9,094	458	458	458	458	458	458
Pasture	152	28	28	28	16	7	4
Rangeland	5,774	1,436	1,436	1,436	1,322	1,284	1,181
Developed	90	62	62	62	62	62	62
Wetlands	36	0	0	0	0	0	0
Roads	-	4.68	1.38	4.68	4.68	4.68	1.38
Streambanks		212.7	212.7	178.7	212.7	212.7	178.7
Total	*15,147*	*2,202*	*2,198*	*2,168*	*2,075*	*2,029*	*1,885*
Total Reduction (%)		**-**	**0.1%**	**1.5%**	**5.7%**	**7.9%**	**14.4%**

* mT = metric tons = 1.102 short tons

** Combined scenario includes roadway improvements, improved grazing, and enhanced riparian areas

Table DA-2. Dog Creek (Above Meadow Creek) Sediment Summary

Category	Area (ha)	Existing Annual Load (mT*/year)	Improved Roadways Annual Load (mT/year)	Stabilized Streambank Annual Load (mT/year)	Improved Grazing Annual Load (mT/year)	Enhanced Riparian Health Annual Load (mT/year)	Combined** Annual Load (mT/year)
Forest	1,329	9	9	9	9	9	9
Pasture	1	0	0	0	0	0	0
Rangeland	562	109	109	109	95	92	82
Developed	0	0	0	0	0	0	0
Wetlands	0	0	0	0	0	0	0
Roads	-	1.22	0.4	1.22	1.22	1.22	0.4
Streambanks		0.84	0.84	0.78	0.84	0.84	0.78
Total	*1,892*	*120*	*119*	*120*	*106*	*103*	*92*
Total Reduction (%)		**-**	**0.7%**	**0.0%**	**11.9%**	**14.5%**	**23.5%**

* mT = metric tons = 1.102 short tons

** Combined scenario includes roadway improvements, improved grazing, and enhanced riparian areas

Table DA-3. Elliston Creek Sediment Summary

Category	Area (ha)	Existing Annual Load (mT*/year)	Improved Roadways Annual Load (mT/year)	Stabilized Streambank Annual Load (mT/year)	Improved Grazing Annual Load (mT/year)	Enhanced Riparian Health Annual Load (mT/year)	Combined** Annual Load (mT/year)
Forest	1,419	37	37	37	37	37	37
Pasture	21	23	23	23	14	8	4
Rangeland	140	45	45	45	41	37	34
Developed	4	2	2	2	2	2	2
Wetlands	0	0	0	0	0	0	0
Roads	-	0.83	0.83	0.83	0.83	0.83	0.83
Streambanks	-	3.0	3.0	2.5	3.0	3.0	2.5
Total	*1,585*	*110*	*110*	*109*	*97*	*86*	*80*
Total Reduction (%)		**-**	**0.0%**	**0.4%**	**11.9%**	**21.5%**	**27.0%**

* mT = metric tons = 1.102 short tons

** Combined scenario includes roadway improvements, improved grazing, and enhanced riparian areas

Table DA-4. Little Blackfoot River Sediment Summary

Category	Area (ha)	Existing Annual Load (mT*/year)	Improved Roadways Annual Load (mT/year)	Stabilized Streambank Annual Load (mT/year)	Improved Grazing Annual Load (mT/year)	Enhanced Riparian Health Annual Load (mT/year)	Combined** Annual Load (mT/year)
Forest	59,169	1,664	1,664	1,664	1,662	1,645	1,645
Pasture	4,874	812	812	812	473	239	142
Rangeland	41,561	8,288	8,288	8,288	7,678	7,567	7,019
Developed	582	185	185	185	185	185	185
Wetlands	557	0.9	0.9	0.9	0.9	0.9	0.9
Roads	-	69.5	32.8	69.5	69.5	69.5	32.8
Streambanks	-	2,413	2,413	1,930	2,413	2,413	1,930
*Total****	*106,743*	*13,433*	*13,397*	*12,951*	*12,481*	*12,119*	*10,955*
Total Reduction (%)		**-**	**0.3%**	**3.6%**	**7.1%**	**9.8%**	**18.4%**

* mT = metric tons = 1.102 short tons

** Combined scenario includes roadway improvements, improved grazing, and enhanced riparian areas*** Total does not reflect actual delivered sediment load, as it includes sediment trapped in reservoir.

Table DA-5. Little Blackfoot River (Above Dog Creek) Sediment Summary

Category	Area (ha)	Existing Annual Load (mT*/year)	Improved Roadways Annual Load (mT/year)	Stabilized Streambank Annual Load (mT/year)	Improved Grazing Annual Load (mT/year)	Enhanced Riparian Health Annual Load (mT/year)	Combined** Annual Load (mT/year)
Forest	22,734	779	779	779	777	760	760
Pasture	136	17	17	17	9	4	2
Rangeland	2,921	2,890	2,890	2,890	2,692	2,663	2,486
Developed	4	1	1	1	1	1	1
Wetlands	97	0.2	0.2	0.2	0.2	0.2	0.2
Roads	-	8.9	2.6	8.9	8.9	8.9	2.6
Streambanks	-	237	237	213	237	237	213
Total	*25,892*	*3,933*	*3,926*	*3,909*	*3,726*	*3,674*	*3,466*
Total Reduction (%)		**-**	**0.2%**	**0.6%**	**5.3%**	**6.6%**	**11.9%**

* mT = metric tons = 1.102 short tons

** Combined scenario includes roadway improvements, improved grazing, and enhanced riparian areas

Table DA-6. Snowshoe Creek Sediment Summary

Category	Area (ha)	Existing Annual Load (mT*/year)	Improved Roadways Annual Load (mT/year)	Stabilized Streambank Annual Load (mT/year)	Improved Grazing Annual Load (mT/year)	Enhanced Riparian Health Annual Load (mT/year)	Combined** Annual Load (mT/year)
Forest	1,400	24	24	24	24	24	24
Pasture	269	73	73	73	42	53	30
Rangeland	2,996	219	219	219	207	198	189
Developed	0	0	0	0	0	0	0
Wetlands	28	0	0	0	0.0	0.0	0.0
Roads		2.10	0.54	2.10	2.1	2.1	0.5
Streambanks		31	31	25	31	31	25
*Total****	*4,693*	*349*	*348*	*343*	*306*	*308*	*268*
Total Reduction (%)		**-**	**0.4%**	**1.9%**	**12.5%**	**11.8%**	**23.2%**

* mT = metric tons = 1.102 short tons

** Combined scenario includes roadway improvements, improved grazing, and enhanced riparian areas

Table DA-7. Spotted Dog Creek Sediment Summary

Category	Area (ha)	Existing Annual Load (mT*/year)	Improved Roadways Annual Load (mT/year)	Stabilized Streambank Annual Load (mT/year)	Improved Grazing Annual Load (mT/year)	Enhanced Riparian Health Annual Load (mT/year)	Combined** Annual Load (mT/year)
Forest	5,123	185	185	185	185	185	185
Pasture	342	80	80	80	44	24	14
Rangeland	6,023	1,268	1,268	1,268	1,180	1,097	1,017
Developed	0	0	0	0	0	0	0
Wetlands	12	0	0	0	0	0	0
Roads	-	3.63	0.75	3.63	3.63	3.63	0.75
Streambanks	-	76	76	42	76	76	42
*Total****	*11,500*	*1,612*	*1,609*	*1,578*	*1,488*	*1,385*	*1,257*
Total Reduction (%)		**-**	**0.2%**	**2.1%**	**7.7%**	**14.1%**	**22.0%**

* mT = metric tons = 1.102 short tons

** Combined scenario includes roadway improvements, improved grazing, and enhanced riparian areas*** Total does not reflect actual delivered sediment load, as it includes sediment trapped in reservoir.

Table DA-8. Telegraph Creek (Above Hahn Creek) Sediment Summary

Category	Area (ha)	Existing Annual Load (mT*/year)	Improved Roadways Annual Load (mT/year)	Stabilized Streambank Annual Load (mT/year)	Improved Grazing Annual Load (mT/year)	Enhanced Riparian Health Annual Load (mT/year)	Combined** Annual Load (mT/year)
Forest	3,890	103	103	103	103	86	86
Pasture	8	3	3	3	2	1	0
Rangeland	274	32	32	32	30	32	30
Developed	0	0	0	0	0	0	0
Wetlands	0	0	0	0	0	0	0
Roads	-	3.40	1.00	3.40	3.40	3.40	1.00
Streambanks	-	22.2	22.2	20.2	22.2	22.2	20.2
Total	*4,172*	*163*	*161*	*161*	*160*	*144*	*137*
Total Reduction (%)		**-**	**1.5%**	**1.2%**	**2.0%**	**11.7%**	**15.9%**

* mT = metric tons = 1.102 short tons

** Combined scenario includes roadway improvements, improved grazing, and enhanced riparian areas

Table DA-9. Threemile Creek Sediment Summary

Category	Area (ha)	Existing Annual Load (mT*/year)	Improved Roadways Annual Load (mT/year)	Stabilized Streambank Annual Load (mT/year)	Improved Grazing Annual Load (mT/year)	Enhanced Riparian Health Annual Load (mT/year)	Combined** Annual Load (mT/year)
Forest	5,086	41	41	41	41	40	40
Pasture	2,112	304	304	304	184	50	34
Rangeland	6,006	276	276	276	248	276	247
Developed	41	7	7	7	7	7	7
Wetlands	28	0.0	0.0	0.0	0.0	0.0	0.0
Roads	-	8.3	4.6	8.3	8.3	8.3	4.6
Streambanks	-	41	41	39	41	41	39
*Total****	*13,273*	*677*	*673*	*675*	*529*	*422*	*372*
Total Reduction (%)		**-**	**0.5%**	**0.3%**	**21.8%**	**37.7%**	**45.1%**

* mT = metric tons = 1.102 short tons

** Combined scenario includes roadway improvements, improved grazing, and enhanced riparian areas*** Total does not reflect actual delivered sediment load, as it includes sediment trapped in reservoir.

Table DA-10. Trout Creek Sediment Summary

Category	Area (ha)	Existing Annual Load (mT*/year)	Improved Roadways Annual Load (mT/year)	Stabilized Streambank Annual Load (mT/year)	Improved Grazing Annual Load (mT/year)	Enhanced Riparian Health Annual Load (mT/year)	Combined** Annual Load (mT/year)
Forest	2,454	42	42	42	42	42	42
Pasture	166	43	43	43	25	9	5
Rangeland	1,864	293	293	293	279	260	242
Developed	33	6	6	6	6	6	6
Wetlands	7	0	0	0	0	0	0
Roads	-	9.60	6.10	9.60	9.60	9.60	6.10
Streambanks	-	102.4	102.4	76.2	102.4	102.4	76.2
Total	*4,524*	*496*	*493*	*470*	*464*	*429*	*378*
Total Reduction (%)		**-**	**0.7%**	**5.3%**	**6.4%**	**13.5%**	**23.9%**

* mT = metric tons = 1.102 short tons

** Combined scenario includes roadway improvements, improved grazing, and enhanced riparian areas

DA.2.0 NUTRIENTS

DA.2.1 Overview

For each modeling scenario, the total nutrient load was broken down into two categories. These categories include (1) upland erosion by land use - forest, rangeland (including arid rangeland), pasture (including agricultural area), wetlands, and developed areas, and (2) septic systems. There is a table for each of the seven developed TMDLs (**Tables DA-11** through **DA-17**). The table loadings are for the summer only (kilograms/season) for each scenario. Since the roadway improvement and the channel streambank stabilization scenarios did not affect nutrients, they are not included in this breakdown. Total reductions of nitrogen and phosphorus values not part of a developed TMDL are listed in **Table D5-5** of the modeling report as totals only.

The final column in each table is the “recommended” scenario, where the improved grazing and enhanced riparian areas scenarios were combined. This is not necessarily an additive scenario, as the effects of one of these improvements may reduce the efficiency of another one (e.g., less nutrients incoming from improved grazing means less nutrients trapped by the riparian buffers).

DA.2.2 TABLES

Table DA-11. Carpenter Creek Phosphorus Summary

Category	Area (ha)	Existing Seasonal* Load (kg/season)	Improved Grazing Seasonal Load (kg/season)	Enhanced Riparian Health Seasonal Load (kg/season)	Combined** Seasonal Load (kg/season)
Forest	3,598	1	1	1	1
Pasture	185	4	3	2	1
Rangeland	2,909	11	10	9	8
Developed	0	0	0	0	0
Wetlands	32	0	0	0	0
Septic	-	0.42	0.42	0.42	0.42
Total	*6,724*	*16*	*15*	*12*	*11*
Total Reduction (%)		**-**	**10.0%**	**28.8%**	**33.6%**

* Seasonal load is the July through September loading on an annual basis.
** Combined scenario includes improved grazing and enhanced riparian health.

Table DA-12. Dog Creek Phosphorus Summary

Category	Area (ha)	Existing Seasonal* Load (kg/season)	Improved Grazing Seasonal Load (kg/season)	Enhanced Riparian Health Seasonal Load (kg/season)	Combined** Seasonal Load (kg/season)
Forest	9,094	35	35	22	22
Pasture	152	8	5	3	1
Rangeland	5,774	9	7	7	6
Developed	90	11	11	11	11
Wetlands	36	0	0	0	0
Septic	-	4.23	4.23	4.23	4.23
Total	*15,147*	*68*	*62*	*49*	*43*
Total Reduction (%)		**-**	**9.2%**	**28.1%**	**36.6%**

* Seasonal load is the July through September loading on an annual basis.
** Combined scenario includes improved grazing and enhanced riparian health.

Table DA-13. Little Blackfoot River Phosphorus Summary

Category	Area (ha)	Existing Seasonal* Load (kg/season)	Improved Grazing Seasonal Load (kg/season)	Enhanced Riparian Health Seasonal Load (kg/season)	Combined** Seasonal Load (kg/season)
Forest	59,152	78.2	78.2	63.6	63.6
Pasture	4,874	72.3	51.3	26.6	11.3
Rangeland	41,566	134.5	113.9	83.6	66.0
Developed	582	47.3	47.3	47.3	47.3
Wetlands	557	1.0	1.0	1.0	1.0
Septic	-	42.4	42.4	42.4	42.4
Total	*106,732*	*376*	*334*	*264*	*232*
Total Reduction (%)		**-**	**11.1%**	**29.6%**	**38.4%**

* Seasonal load is the July through September loading on an annual basis.
** Combined scenario includes improved grazing and enhanced riparian health.

Table DA-14. Snowshoe Creek Nitrogen Summary

Category	Area (ha)	Existing Seasonal* Load (kg/season)	Improved Grazing Seasonal Load (kg/season)	Enhanced Riparian Health Seasonal Load (kg/season)	Combined** Seasonal Load (kg/season)
Forest	1,400	8	8	8	8
Pasture	269	189	140	166	127
Rangeland	2,996	110	102	97	92
Developed	0	0	0	0	0
Wetlands	28	0	0	0	0
Septic		11.50	11.50	11.50	11.50
Total	*4,693*	*319*	*261*	*282*	*238*
Total Reduction (%)		**-**	**18.0%**	**11.5%**	**25.3%**

* Seasonal load is the July through September loading on an annual basis.
** Combined scenario includes improved grazing and enhanced riparian health.

Table DA-15. Spotted Dog Creek Phosphorus Summary

Category	Area (ha)	Existing Seasonal* Load (kg/season)	Improved Grazing Seasonal Load (kg/season)	Enhanced Riparian Health Seasonal Load (kg/season)	Combined** Seasonal Load (kg/season)
Forest	5,123	10	10	10	10
Pasture	342	19	14	5	3
Rangeland	6,023	24	22	14	13
Developed	0	0	0	0	0
Wetlands	12	0	0	0	0
Septic	-	0.28	0.28	0.28	0.28
Total	*11,500*	*53*	*46*	*29*	*26*
Total Reduction (%)		**-**	**13.2%**	**45.6%**	**50.3%**

* Seasonal load is the July through September loading on an annual basis.
** Combined scenario includes improved grazing and enhanced riparian health.

Table DA-16. Threemile Creek Nitrogen Summary

Category	Area (ha)	Existing Seasonal* Load (kg/season)	Improved Grazing Seasonal Load (kg/season)	Enhanced Riparian Health Seasonal Load (kg/season)	Combined** Seasonal Load (kg/season)
Forest	5,086	16	16	15	15
Pasture	2,112	247	225	31	28
Rangeland	6,006	281	258	270	253
Developed	41	9	9	9	9
Wetlands	28	1.0	1.0	1.0	1.0
Septic	-	27.9	27.9	27.9	27.9
Total	*13,273*	*581*	*536*	*353*	*333*
Total Reduction (%)		**-**	**7.8%**	**39.2%**	**42.7%**

* Seasonal load is the July through September loading on an annual basis.
** Combined scenario includes improved grazing and enhanced riparian health.

Table DA-17. Threemile Creek Phosphorus Summary

Category	Area (ha)	Existing Seasonal* Load (kg/season)	Improved Grazing Seasonal Load (kg/season)	Enhanced Riparian Areas Seasonal Load (kg/season)	Combined** Seasonal Load (kg/season)
Forest	5,086	0.4	0.4	0.4	0.4
Pasture	2,112	7	6	2	1
Rangeland	6,006	7	7	3	3
Developed	41	3	3	3	3
Wetlands	28	0	0	0	0
Septic	-	2.4	2.4	2.4	2.4
Total	*13,273*	*20*	*18*	*10*	*10*
Total Reduction (%)		**-**	**8.5%**	**47.5%**	**49.2%**

* Seasonal load is the July through September loading on an annual basis.

** Combined scenario includes improved grazing and enhanced riparian health.

APPENDIX DB - SEDIMENT TOTAL MAXIMUM DAILY LOADS

DB.1 SEDIMENT

DB.1.1 Overview

A percent reduction based on average yearly loading was used as the primary approach for expressing the sediment TMDLs within this document because there is uncertainty associated with the loads derived from the source assessment, and using the estimated sediment loads alone creates a rigid perception that the loads are absolutely conclusive. However, in this Appendix the TMDL is expressed using daily loads to satisfy an additional EPA required TMDL element. Daily loads should not be considered absolutely conclusive and may be refined in the future as part of the adaptive management process. It is not expected that daily loads will drive implementation activities.

DB.1.2 Approach

Since sediment loading in the Little Blackfoot River watershed is associated with nonpoint sources and stormwater-related point sources, the hydrograph is assumed to be a reasonable surrogate for sediment loading to streams in the watershed (i.e. peak contributions during periods of runoff and high flow). Therefore, mean daily discharge values from 40 years of record (1972 - 2011) at the gage near Garrison were used to calculate daily sediment values for TMDLs in the Little Blackfoot River watershed.

Using the mean of daily mean discharge values from the gage, a daily percentage relative to the mean annual discharge was calculated for each day (**Table DB-1**). For each TMDL, the daily percentages in **Table DB-1** can be multiplied by the total average annual load associated with the TMDL percent reductions in **Section D5** and shown in **Table DB-2** to calculate the daily load. For instance, the total allowable annual sediment load for the lower segment of the Little Blackfoot River is 12,068 (short) tons. To determine the TMDL for January 1, 12,068 tons is multiplied by 0.11% which provides a daily load for January 1st for the Little Blackfoot River of 13 tons. The annual daily load for the lower segment of the Little Blackfoot River is shown graphically in **Figure DB-1**. The daily loads are a composite of the allocations, but as allocations are not feasible on a daily basis, they are not contained within this Appendix. If desired, daily allocations may be obtained by applying allocations provided in **Section 5.8.3 (**of the TMDL) to the daily load.

Table DB-1. USGS Stream Gage 12324590 (Little Blackfoot River near Garrison) – Percent of Mean Annual Discharge Based on Mean of Daily Mean Discharge Values for each Day of Record (Calculation Period 1972-09-26 -> 2011-09-30)

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.11%	0.14%	0.15%	0.27%	0.56%	0.99%	0.35%	0.15%	0.09%	0.11%	0.14%	0.12%
2	0.10%	0.12%	0.16%	0.27%	0.56%	0.96%	0.34%	0.15%	0.09%	0.11%	0.14%	0.14%
3	0.10%	0.11%	0.16%	0.26%	0.57%	0.98%	0.32%	0.14%	0.09%	0.11%	0.14%	0.15%
4	0.11%	0.11%	0.17%	0.25%	0.60%	0.98%	0.35%	0.14%	0.09%	0.11%	0.14%	0.14%
5	0.13%	0.11%	0.17%	0.27%	0.61%	0.97%	0.33%	0.13%	0.09%	0.12%	0.14%	0.13%
6	0.12%	0.11%	0.15%	0.34%	0.62%	0.98%	0.31%	0.13%	0.09%	0.12%	0.14%	0.12%
7	0.11%	0.11%	0.16%	0.37%	0.65%	0.94%	0.29%	0.13%	0.09%	0.12%	0.14%	0.11%
8	0.11%	0.12%	0.18%	0.34%	0.65%	0.88%	0.28%	0.13%	0.09%	0.12%	0.14%	0.11%
9	0.10%	0.21%	0.18%	0.33%	0.65%	0.83%	0.26%	0.12%	0.09%	0.12%	0.14%	0.12%
10	0.10%	0.14%	0.21%	0.34%	0.70%	0.78%	0.28%	0.11%	0.09%	0.12%	0.13%	0.12%
11	0.11%	0.12%	0.20%	0.36%	0.76%	0.80%	0.27%	0.11%	0.10%	0.12%	0.13%	0.11%
12	0.11%	0.12%	0.19%	0.37%	0.77%	0.78%	0.25%	0.11%	0.10%	0.13%	0.13%	0.11%
13	0.11%	0.12%	0.20%	0.38%	0.76%	0.76%	0.26%	0.11%	0.10%	0.13%	0.14%	0.11%
14	0.11%	0.13%	0.21%	0.39%	0.79%	0.72%	0.25%	0.10%	0.10%	0.13%	0.13%	0.11%
15	0.14%	0.13%	0.20%	0.39%	0.84%	0.71%	0.24%	0.10%	0.10%	0.14%	0.13%	0.11%
16	0.15%	0.14%	0.20%	0.38%	0.88%	0.70%	0.23%	0.10%	0.10%	0.14%	0.13%	0.11%
17	0.13%	0.17%	0.21%	0.40%	0.91%	0.73%	0.23%	0.10%	0.10%	0.14%	0.13%	0.11%
18	0.12%	0.17%	0.22%	0.42%	0.95%	0.70%	0.23%	0.10%	0.10%	0.14%	0.13%	0.10%
19	0.11%	0.18%	0.23%	0.43%	0.98%	0.72%	0.22%	0.09%	0.11%	0.14%	0.13%	0.10%
20	0.11%	0.19%	0.23%	0.45%	0.97%	0.71%	0.21%	0.10%	0.11%	0.14%	0.13%	0.10%
21	0.11%	0.20%	0.24%	0.46%	0.98%	0.68%	0.20%	0.10%	0.11%	0.14%	0.13%	0.10%
22	0.11%	0.16%	0.26%	0.49%	1.19%	0.61%	0.19%	0.10%	0.11%	0.14%	0.12%	0.10%
23	0.11%	0.15%	0.28%	0.53%	1.10%	0.57%	0.19%	0.10%	0.11%	0.14%	0.12%	0.10%
24	0.11%	0.15%	0.28%	0.55%	1.12%	0.53%	0.18%	0.10%	0.11%	0.14%	0.12%	0.10%
25	0.11%	0.17%	0.25%	0.56%	1.16%	0.49%	0.17%	0.10%	0.11%	0.14%	0.12%	0.12%
26	0.11%	0.17%	0.25%	0.54%	1.12%	0.46%	0.17%	0.09%	0.11%	0.14%	0.12%	0.13%
27	0.11%	0.15%	0.26%	0.53%	1.07%	0.44%	0.17%	0.09%	0.11%	0.14%	0.12%	0.11%
28	0.11%	0.14%	0.24%	0.53%	1.03%	0.41%	0.17%	0.09%	0.11%	0.14%	0.12%	0.10%
29	0.11%	0.13%	0.23%	0.53%	1.02%	0.38%	0.16%	0.09%	0.11%	0.14%	0.12%	0.10%
30	0.11%		0.23%	0.54%	1.02%	0.36%	0.16%	0.09%	0.11%	0.14%	0.12%	0.10%
31	0.12%		0.26%		1.01%		0.16%	0.09%		0.14%		0.10%

Table DB-2. TMDL expressed as an average annual load for each waterbody segment

Stream Segment	Waterbody #	TMDL Expressed as Average Annual Load (short tons/year)	TMDL Expressed as Average Annual Load (metric tons/year)
DOG CREEK, headwaters to Meadow Creek	MT76G004_071	101	92
DOG CREEK, Meadow Creek to the mouth (Little Blackfoot River)	MT76G004_072	2,076	1,884
ELLISTON CREEK, headwaters to the mouth (Little Blackfoot River)	MT76G004_040	88	80
LITTLE BLACKFOOT RIVER, the headwaters to Dog Creek	MT76G004_020	3,813	3,460
LITTLE BLACKFOOT RIVER, Dog Creek to the mouth (Clark Fork River)	MT76G004_010	12,068	10,951
SNOWSHOE CREEK, headwaters to the mouth (Little Blackfoot River)	MT76G004_080	295	268
SPOTTED DOG CREEK, forest boundary to the mouth (Little Blackfoot River)	MT76G004_032	1,383	1,255
TELEGRAPH CREEK, headwaters to Hahn Creek	MT76G004_051	151	137
THREEMILE CREEK, Quigley Reservoir to the mouth (Little Blackfoot River)	MT76G004_112	418	379
TROUT CREEK, headwaters to the mouth (Little Blackfoot River)	MT76G004_120	416	377

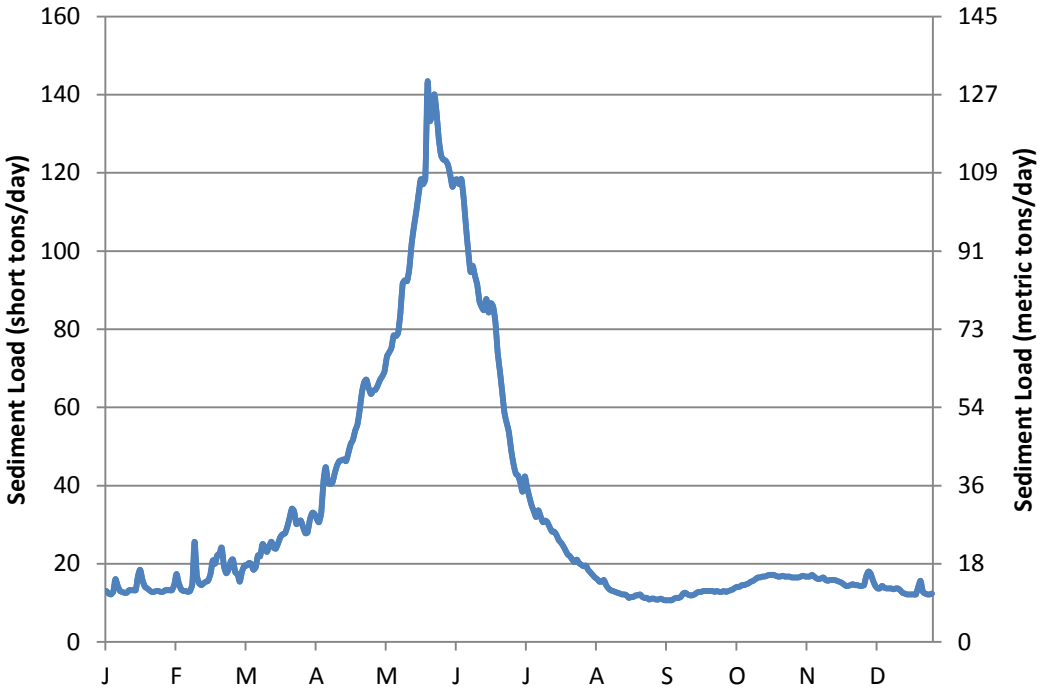


Figure DB-1. Average daily sediment load for the lower segment of the Little Blackfoot River

APPENDIX DC – MODEL INPUT

Will be furnished upon request

APPENDIX DD – MODEL OUTPUT

Will be furnished upon request.

APPENDIX E – ROAD SEDIMENT ASSESSMENT

TABLE OF CONTENTS

E1.0 Introduction E-4
E2.0 Data Collection E-4
E2.1 Spatial Analysis E-4
E2.2 Field Data Collection E-10
E2.3 Sediment Assessment Methodology E-10
E2.4 Mean Sediment Loads from Field Assessed Sites – Stream Crossings E-11
E2.5 Mean Sediment Loads from Field Assessed Sites – Parallel Segments E-12
E2.6 Traction Sand Analysis E-13
E3.0 Road Network Load Analysis E-14
E3.1 Unpaved Roads Loading Results E-14
E3.2 Culvert Assessment – Fish Passage E-15
E3.3 Culvert Assessment – Storm Event Failure Potential E-16
E4.0 Application of Best Management Practices E-17
E4.1 Contributing Road Length Reduction Scenario E-17
E4.2 Summary of Total Loads and Potential Reductions E-18
E4.3 Assessment of Existing BMPs E-18
E5.0 Quality Assurance / Quality Control Results E-19
E5.1 Representativeness E-19
E5.2 Comparability E-20
E5.3 Completeness E-20
E6.0 References E-20
Attachment EA - Attached Tables E-22
Attachment EB - WEPP: Road Model Adjustments and Custom Climate Parameters E-37
Attachment EC - WEPP: Road Modeling Results for Field Assessed Sites E-41
Attachment ED - WEPP: Road Modeling Results for Field Assessed Sites with Road Length Reductions E-44

LIST OF FIGURES

Figure E-1. Unpaved and Paved Crossings in the Little Blackfoot TPA. E-5
Figure E-2. Unpaved and Paved Crossings by Landscape Setting. E-6
Figure E-3. Unpaved and Paved Crossings by Land Ownership. E-7
Figure E-4. Unpaved and Paved Crossings by Soil Erosion Hazard Classification. E-8
Figure E-5. Parallel road segments within 100 and 200 feet of surface water and watershed elevation..... ..... E-9
Figure E-6. WEPP:Road Sediment Results for each BMP Category E-19

LIST OF TABLES

Table E2-1. Assessment Sites by Landscape Setting E-4
Table E2-2. Sediment Load Summary for Field Assessed Crossings by Landscape Type E-12
Table E2-3. Sediment Load Summary from Unpaved Field Assessed Parallel Sites E-13
Table E2-4. Traction Sand Quantity E-13
Table E3-1. Extrapolated Sediment Load Summary from Unpaved Road Crossings and Parallel Segments– Existing Conditions E-15
Table E3-2. Culvert Fish Passage Analysis Results E-15
Table E3-4. Percent of Culverts Passing Design Storm Events based on bankfull width E-16
Table E4-1. Extrapolated Sediment Load Summary from Unpaved Road Crossing– 200' Road Length Reduction E-18
Table E4-2. Percent Sediment Reduction per HUC: Road Length Reduction E-18
Table EA-1. Little Blackfoot River TPA Road Summary by 6th Code Subwatershed (USGS HUC 12) E-23
Table EA-2. Road Summary by Landscape Type, Land Ownership, and Soil Erosion Hazard Classification E-23
Table EA-3. Proposed Field Sites and Actual Field Assessed Sites E-24
Table EA-4. Traction Sand Contribution by HUC; Paved and Unpaved Roads within 100 feet of Surface Water E-25
Table EA-5. Unpaved Road Crossings by HUC/303(d) Subwatershed, Ownership and Landscape Type E-26
Table EA-6. Detailed Extrapolated Sediment Load From Unpaved Road Crossings by HUC/303(d) Subwatershed, Ownership and Landscape Type – Existing Conditions (tons/year) E-27
Table EA-7. Detailed Extrapolated Sediment Load From Parallel Segments by HUC/303(d) Subwatershed, Ownership and Landscape Type – Existing Conditions (tons/year) E-29
Table EA-8. Fish Passage Analysis for Selected Road Crossings Using Alaska Region Criteria E-30
Table EA-9. Peak Discharges Using Parrett and Johnson Equations (West Region) and Manning's Equation E-32
Table EA-10. Culvert Failure Load Potential Per 25% Probability and Per Storm Event (tons/year) E-33
Table EA-11. Total Annual Sediment Load from all Sources and Potential BMP Reduction E-34
Table EA-12. Comparability of Field Data to WEPP:Road Parameters E-36
Table EB-1. Model assumptions for the three traffic scenarios E-37
Table EB-2. Specific WEPP: Road Modeling Adjustments Per Crossing or Parallel Segment E-38
Table EB-3. Temperature and Precipitation for Elliston, MT E-38
Tables EB-4. Interpolated Climate Data for Elliston, MT E-39
Table EB-5. Temperature and Precipitation for Moulton, MT E-39

Table EB-6. Interpolated Climate Data for Moulton, MT E-39
Table EB-7. Temperature and Precipitation for 3Mile-V-2 PRISM E-40
Table EB-8. Interpolated Climate Data for 3Mile-V-2 PRISM E-40
Table EC-1. WEPP: Road Modeling Results for Field Assessed Crossings E-42
Table EC-2. WEPP: Road Modeling Results for Field Assessed Parallel Segments E-43
Table ED-1. WEPP: Road Modeling Results for Field Assessed Crossings: 200 feet maximum length E-45
Table ED-2. WEPP: Road Modeling Results for Field Assessed Parallel Segments: 400 feet maximum length E-46

ACRONYM LIST

Acronym	Definition
BMP	Best Management Practices
BMPS	Best Management Practices
CWAIC	Clean Water Act Information Center (DEQ)
DEQ	Department of Environmental Quality (Montana)
DNRC	Department of Natural Resources & Conservation
EA	Environmental Assessment
GIS	Geographic Information System
HNF	Helena National Forest
HUC	Hydrologic Unit Code
NRCS	National Resources Conservation Service
NRIS	Natural Resource Information System (Montana)
TMDL	Total Maximum Daily Load
TPA	TMDL Planning Area
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey

E1.0 INTRODUCTION

This appendix is derived from a roads assessment report prepared by Water and Environmental Technologies (2009a) for the Montana Department of Environmental Quality (DEQ). This report presents a sediment load analysis and culvert assessment of the road network within the Little Blackfoot River TMDL Planning Area (TPA) that was performed to assist with sediment TMDL development. Roads located near stream channels can impact stream function through degradation of riparian vegetation, channel encroachment, and sediment loading. The degree of impact is determined by a number of factors, including road type, construction specifications, drainage, soil type, topography, precipitation, and the use of Best Management Practices (BMPs). Through a combination of GIS analysis, field assessment, and computer modeling, estimated sediment loads were developed for unpaved road crossings and parallel segments. Existing road conditions were modeled and future road conditions were estimated after the application of sediment-reducing BMPs. Additionally, paved segments of road were evaluated for loading from traction sand and existing culverts were assessed for fish passage and potential loading during failure associated with runoff events.

E2.0 DATA COLLECTION

The Little Blackfoot road sediment assessment consisted of three primary tasks:

1) GIS Layer development and summary statistics,
2) Field assessment and sediment modeling, and
3) Sediment load calculations and load reduction allocations for sediment listed watersheds.

E2.1 SPATIAL ANALYSIS

Using road layers provided by the Helena National Forest (HNF) and from the Tiger 2000 Census Data, crossings and parallel segments in the road network were identified and classified relative to 6th code subwatershed, landscape setting, land ownership, and soil erosion hazard class (**Figures E1-E5**). Based on the GIS analysis, there are approximately 485 total unpaved crossings, 51 paved crossings, and 22.79 miles of parallel segments within 50 feet of surface water. A summary of road crossings by landscape setting in the Little Blackfoot TPA is shown in **Table E2-1**. Additional summary information is presented in **Tables EA-1, EA-2,** and **EA-5** of **Attachment EA**.

Table E2-1. Assessment Sites by Landscape Setting

Landscape Type	Total Road Crossings	% Total Road Crossings	Unpaved Road Crossings	% Unpaved Road Crossings	Number of Assessment Sites
Mountain	296	55.5	296	61.0	15
Mountain (USFS Roadless Area)	13	2.4	13	2.7	0
Foothill	156	29.3	139	28.7	5
Valley	68	12.8	37	7.7	2
Total	**533**	**100**	**485**	**100**	**22**

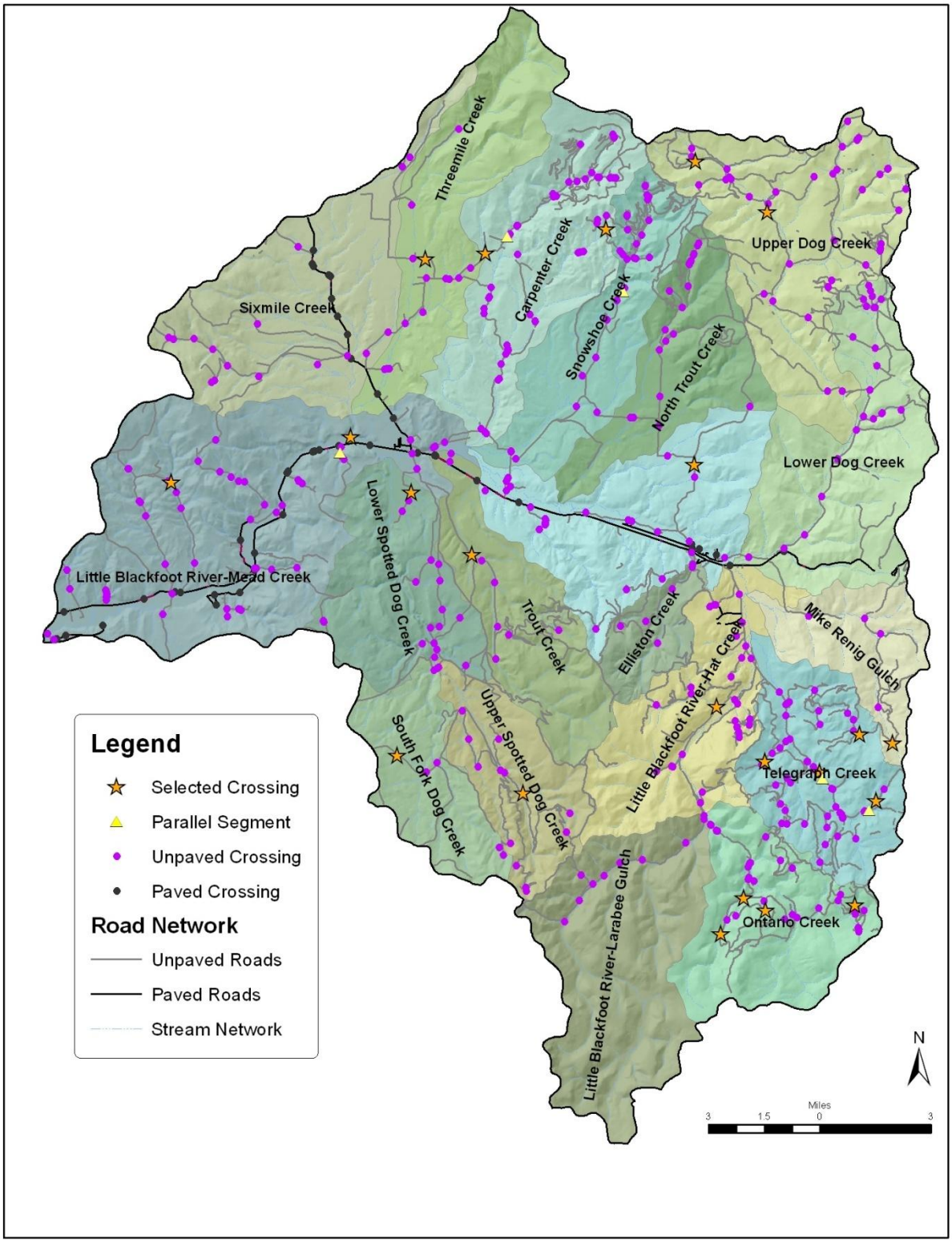


Figure E-1. Unpaved and Paved Crossings in the Little Blackfoot TPA.

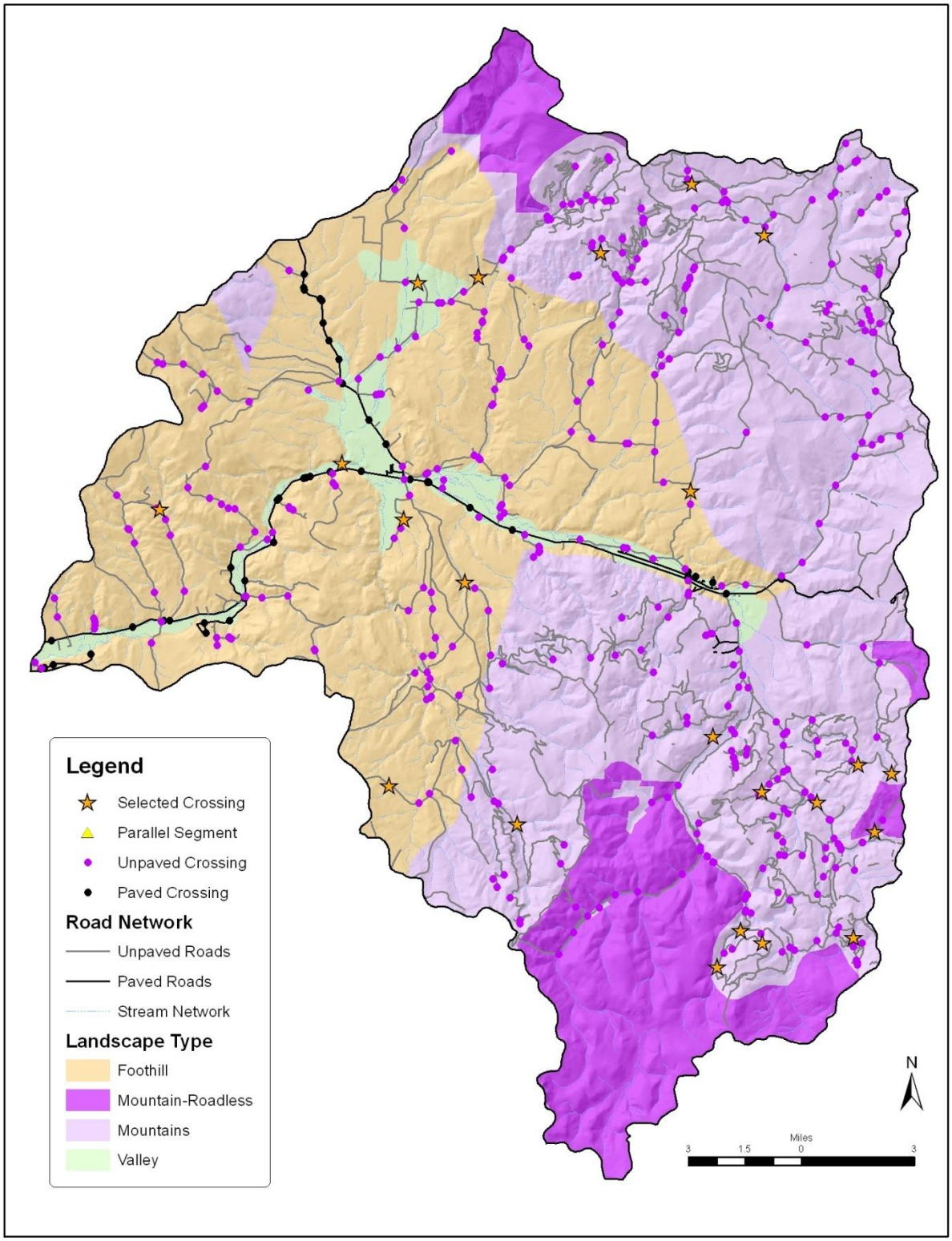


Figure E-2. Unpaved and Paved Crossings by Landscape Setting.

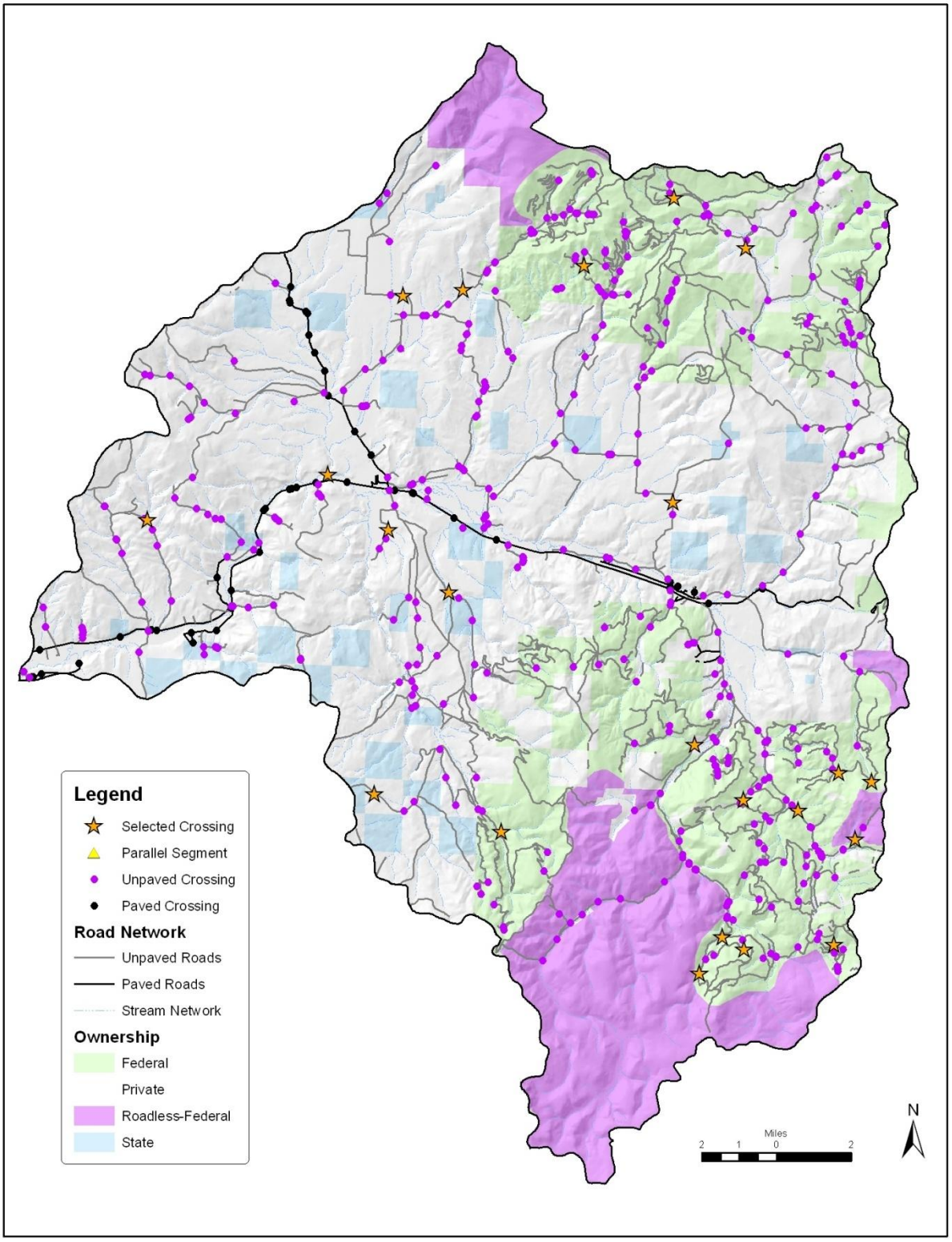


Figure E-3. Unpaved and Paved Crossings by Land Ownership.

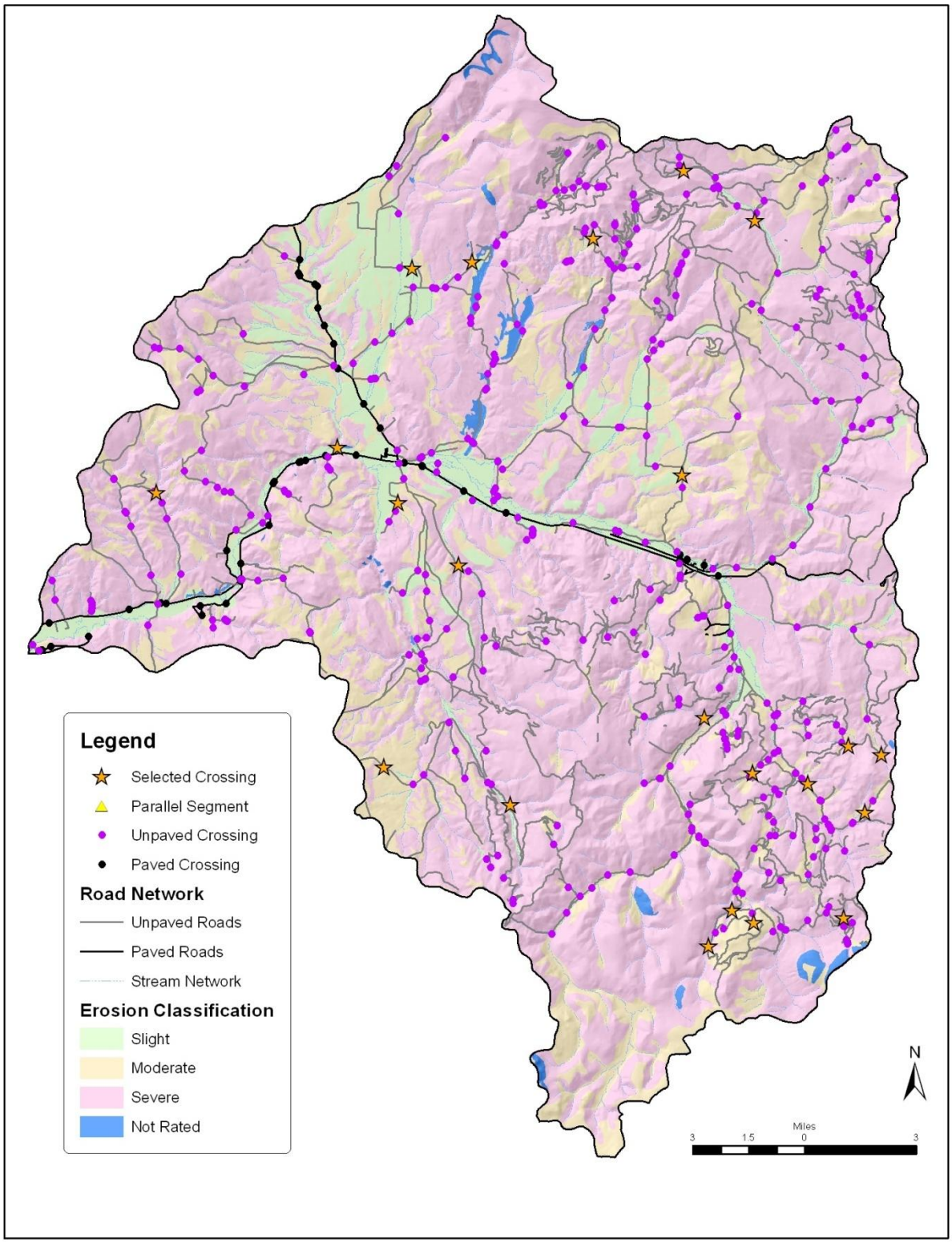


Figure E-4. Unpaved and Paved Crossings by Soil Erosion Hazard Classification.

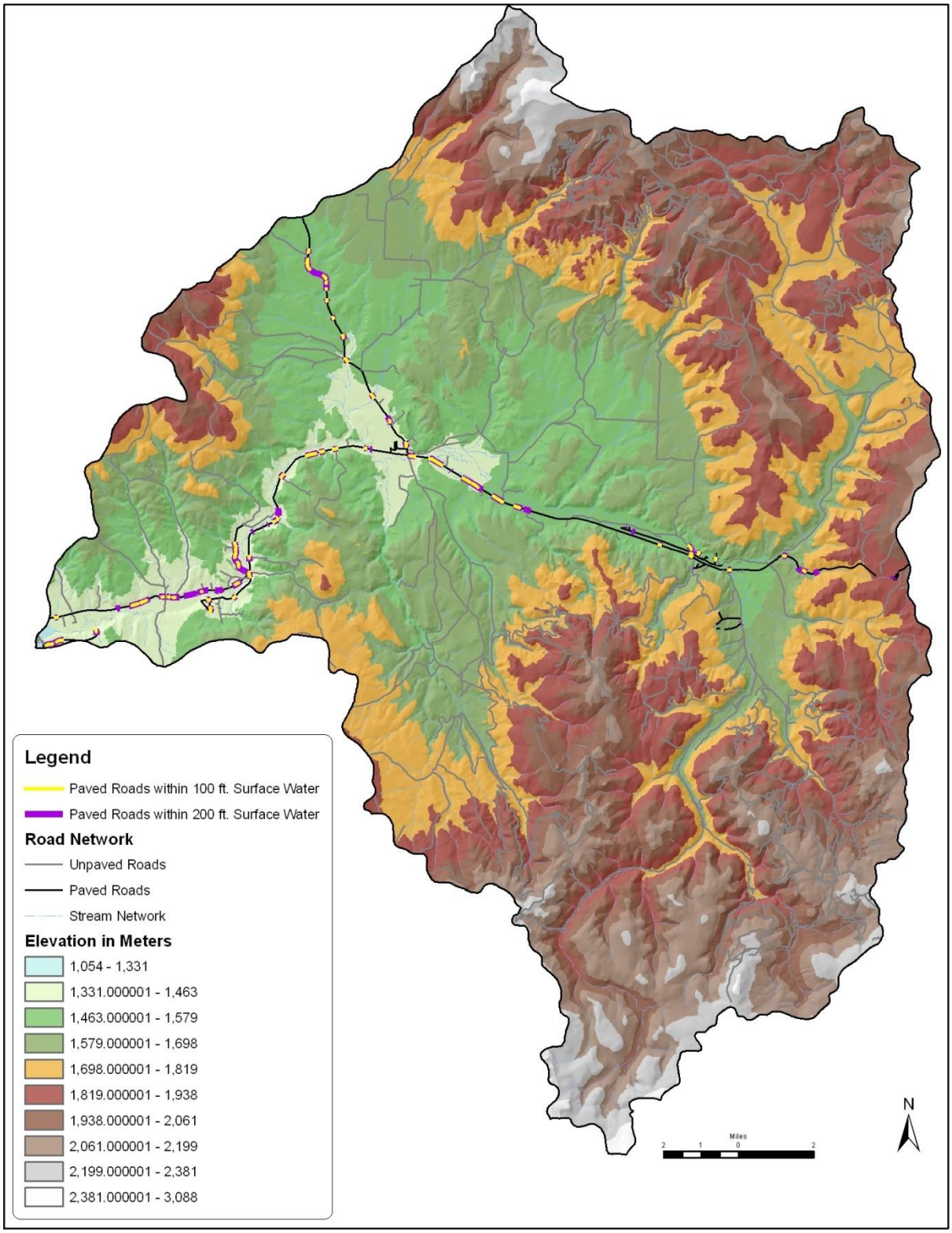


Figure E-5. Parallel road segments within 100 and 200 feet of surface water and watershed elevation.

E2.2 FIELD DATA COLLECTION

The goal of the field effort was to characterize approximately five percent of the road network. Using GIS, a random subset of 22 unpaved crossing sites were chosen for field assessment based on the proportion of total crossings within each landscape type. Parallel segment sites were selected in the field based on best professional judgment while traveling roads on which specific crossings were selected for evaluation. Although some site locations were relocated during the field effort due to ownership or vehicle access restrictions, a total of 22 unpaved crossings and 5 parallel segments were evaluated in the field (**Figure E1**).

Fifteen crossings were assessed in the mountain landscape, five crossings were assessed in the foothill landscape, and two crossings were assessed in the valley landscape type. Generally, the majority of parallel road segments are located in narrow stream valleys or canyons in foothill and mountain landscapes, where roads are constructed near streams. Four parallel segments were assessed in the mountain landscape type and one segment was assessed in the foothill landscape type. No parallel segments were assessed in the valley landscape type due to the small overall area of the valley landscape.

Crossing and parallel sites were named with the first three letters representing the 6th code HUC, the fourth letter represents the ownership category (Federal, Private or State), the fifth letter represents the landscape type (Mountain, Foothill or Valley) and the sixth letter represents the site type (crossing, X, or parallel segment, P). The last three numbers were automatically assigned through GIS software to ensure that each site is unique.

E2.3 SEDIMENT ASSESSMENT METHODOLOGY

The road sediment assessment was conducted following a Sampling and Analysis Plan (Water & Environmental Technologies, PC., 2009b), which was based on inputs needed for the WEPP:Road forest road erosion prediction model (http://forest.moscowfsl.wsu.edu/fswepp/). WEPP:Road is an interface to the Water Erosion Prediction Project (WEPP) model (Flanagan and Livingston, 1995), developed by the USDA Forest Service and other agencies, and is used to predict runoff, erosion, and sediment delivery from forest roads. The model predicts sediment yields based on specific soil, climate, ground cover, and topographic conditions. Specifically, the following model input data was collected in the field: soil type, percent rock, road surface, road design, traffic level, and specific road topographic values (road grade, road length, road width, fill grade, fill length, buffer grade, and buffer length). In addition, supplemental data was collected on vegetation condition of the buffer, evidence of erosion from the road system, the presence of road BMPs, and potential for fish passage and culvert failure.

Site specific climate profiles were created using data from the Western Regional Climate Center (http://www.wrcc.dri.edu). The Little Blackfoot River TPA encompasses a wide range of annual precipitation: Precipitation quantity ranges from 11 to 38 inches per year with an average value of 22 inches and a median value of 22 inches. The sites assessed in the field ranged in elevation from 4,462 to 6,562 feet. The only weather station located within the TMDL planning area is Elliston, Montana (#242738, 17.23 inches annual precipitation; 5080 feet elevation). However, several stations are located near the TPA: Moulton Reservoir, Boulder, Rimini, and two sites in Deer Lodge.

Climate stations were selected that exhibited similar conditions for each specific landscape type. The Moulton Reservoir, Montana station (245886: 6700 ft elevation, 21.53-inches annual precipitation) was

selected for mountain sites, and the Elliston, Montana station (242738: 5080-feet elevation, 17.23-inches annual precipitation) was selected to model the foothill sites (**Attachment EB**). The nearby climate stations did not appear to represent the precipitation quantity for the valley landscapes: Deer Lodge 3W, Montana station (10.77 inches), Deer Lodge COOP station (10.62 inches) and Boulder, Montana station (11.02 inches). The PRISM result for the TMC-P-V-X-442 site with 16.77 inches appeared to be the best conservative and representative climate station for the valley sites (**Attachment EB**).

The mean precipitation layer available on NRIS(Montana Department of Natural Resources and Conservation, 2008) predicted an average, area-weighted annual precipitation of 12.5 inches and 31.2 inches for the two valley landscape types (LBM-P-V-X-198 and TMC-P-V-X-442 respectively). The PRISM climate estimator based on specific latitude and longitude, as available on the WEPP:Road website, predicted 12.12 inches and 16.77 inches of annual precipitation respectively. These specific PRISM results from WEPP:Road are within the average values for the polygon layer on the NRIS GIS layer at the location of the culvert. Thus the custom climate station for valley landscapes was developed through PRISM software on the WEPP:Road website based on latitude and longitude of one site: TMC-P-V-X-442.

Per WEPP:Road documentation, 30 year simulations were run for unpaved road crossings and parallel segments in the mountain landscape since the quantity of precipitation exceeded 500 millimeters (19.69 inches). Fifty year simulations were run for crossings and parallel segments in the foothill and valley landscapes.

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

E2.4 Mean Sediment Loads from Field Assessed Sites – Stream Crossings

Field assessment data and WEPP:Road modeling results were used to develop existing sediment loads based on various watershed criteria. A standard statistical breakdown of loads from the unpaved road network within each sediment-listed watershed was generated using the applicable dataset of field assessed crossing and parallel sites. Mean load and contributing length, median load, maximum and minimum loads, and 25th and 75th percentile loads were calculated for unpaved road crossings within each landscape type that was the basis of the field assessment. Mean sediment loads from unpaved road crossings were estimated at 0.07 tons/year in mountain landscapes, 0.11 tons/year in the foothill landscapes, and 0.03 tons/year in the valley landscapes. A statistical summary of sediment loads for field assessed sites are included in **Table E2-2**.

Table E2-2. Sediment Load Summary for Field Assessed Crossings by Landscape Type

Statistical Parameter	Mountain	Foothill	Valley	Total of Field Assessed Crossings
Number of Sites (n)	15	5	2	22
Mean Contributing Length (ft)	450	394	588	
Mean Load (tons/year)	0.07	0.11	0.03	
Median Load (tons/year)	0.02	0.01	0.03	
Maximum Load (tons/year)	0.32	0.47	0.04	
Minimum Load (tons/year)	0.00	0.01	0.01	
25th Percentile (tons/year)	0.01	0.01	0.02	
75th Percentile (tons/year)	0.08	0.06	0.03	

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

For the purposes of estimating the sediment load from each road crossing in the Little Blackfoot River TPA, the average of all field sites by landscape type assumes that the random subset of crossings assessed as part of this study is representative of the road crossing conditions in the TPA.

The random selection of sites as described in **Section E2.2** selected one crossing in the USFS designated Roadless Area (Federal ownership). This crossing was not accessible during the field effort. Although would likely have a smaller average sediment load, because no data could be collected, the average sediment loads for Federal sites (0.06 tons/year) will be used for the thirteen crossings in the Federal – USFS Roadless Areas.

E2.5 Mean Sediment Loads from Field Assessed Sites – Parallel Segments

Mean sediment loads were calculated for parallel road segments, and loads were then normalized to a per-mile value to account for differences in contributing road length. Mean sediment loads from unpaved parallel road segments were estimated at 0.021 tons/year/mile in mountain landscapes and 0.003 tons/year/mile in foothill landscapes. No valley parallel segments were assessed in the field due to the small overall area of the valley landscape and the majority presence of paved roads or roads that did not parallel streams. As a result, the mean sediment loads from the mountain and foothill parallel segments were averaged together to obtain an estimated sediment load of 0.012 tons/year/mile for valley parallel segments (**Table E2-3**). A summary of modeling results from field assessed sites is located in **Attachment EC**.

Table E2-3. Sediment Load Summary from Unpaved Field Assessed Parallel Sites

Statistical Parameter	Mountain	Foothill	Valley (Average of Mountain/Foothill)
Number of Segments (n)	4	1	0
Mean Contributing Length (ft)	377	355	366
Mean Road Gradient (%)	6.3	8	N/A
Mean Buffer Length (ft)	22.3	49.5	N/A
Mean Buffer Gradient (%)A	8.7	27.5	N/A
Mean Load (tons/year/mile)	0.021	0.003	0.012
Median Load (tons/year/mile)	0.005	N/A	N/A
Maximum Load (tons/mile/ year)	0.075	N/A	N/A
Minimum Load (tons/year/mile)	0.001	N/A	N/A

[A]A minimum buffer gradient value of 0.3 % and a minimum buffer length of 1 foot was used for parallel sites that did not have a buffer.

For the purposes of estimating the sediment load from each parallel segment in the Little Blackfoot River TPA, the average of all field sites by landscape type assumes that the random subset of crossings assessed as part of this study is representative of the parallel segment conditions in the TPA.

E2.6 Traction Sand Analysis

As shown in **Figure E-5**, few of the parallel roads are paved. Per telephone conversations with the Powell County Road Department and Department of Transportation employees, estimates of traction sand are shown in **Table E2-4.**

Table E2-4. Traction Sand Quantity

Department	Number of Miles	Quantity of Traction Sand ($yards^3$)	Tons/mile/year
Powell County Road Department, District I ▪ Secondary Roads	60	50-300	6.25
Montana Department of Transportation ▪ Highway 12 (mile marker 0 to 12.5)	12.5	500	50
Montana Department of Transportation ▪ Highway 12 (Avon to Elliston)	11	845	96
Montana Department of Transportation ▪ Highway 141	19	885	58

[A] Conversions were calculated with an assumed bulk density of 1.25 tons per cubic yard.

The road assessments for the Blackfoot Headwaters (Montana Department of Environmental Quality, et al., 2004) and Bitterroot Headwater TPAs (Montana Department of Environmental Quality, 2005) assumed a traction sand delivery rate of 10% for roads within 100 feet and 5% for roads within 200 feet of surface water. BMP reductions were not developed with these reports. The TMDL for the St. Regis TPA (Montana Department of Environmental Quality, 2008) included an in-depth study of traction sand and quantified deposits at set distances from the road. Per best professional judgment and per the cumulative percent of mean deposit measured at set distances from the road, it was determined that sediment did not travel from distances greater than 112 feet to surface water. The St. Regis report did not quantify potential BMP reductions. The Prospect Creek TMDL report quantified sediment application based on buffer length and vegetative cover. Completed TMDL projects that included a BMP reduction for traction sand include:

- Upper Lolo Creek: 33% consistent with parallel and crossing reductions

- Prospect Creek TPA: 31% for all sites with a low buffer mitigation

In order to determine traction sand contributions per HUC for the Little Blackfoot River watershed, the GIS database was queried for paved parallel road lengths within 100 feet of streams. The distance to surface water was not further refined into smaller increments due to the inherent inaccuracies between the GIS road and stream layers. The Powell County Road Department applies traction sand to a few steep gravel roads; these contributions are not included in traction sand estimates.

The quantity of traction sand from parallel segments that may annually contribute to surface water was taken from the Prospect Creek report (Montana Department of Environmental Quality, 2009) assuming a buffer length of 50-100 feet and a vegetative cover of 50%. This equates to a 15% delivery rate for all parallel segments. The improvement of BMPs included a vegetative cover improvement from 50% to 60% for an overall delivery rate of 10%. All traction sand contributions and potential BMP reductions (33%) are shown in **Table EA-4 (Attachment EA)**.

E3.0 Road Network Load Analysis

E3.1 Unpaved Roads Loading Results

The annual mean sediment loads for unpaved road crossings and parallel segments from the three landscape types (mountain, foothill, and valley) were extrapolated to all sites in the Little Blackfoot TPA to determine total sediment load. Mean loads for unpaved crossings within mountain (0.07 tons/year), foothill (0.11 tons/year), and valley (0.03 tons/year) landscape types were applied to the total number of crossings within the TPA, and further classified by 6th code HUC and land ownership (**Attachment EA**, **EA-6** and **EA-7)**.

The total sediment load was 38.03 tons/year from 485 unpaved crossings and 0.35 tons/year from parallel road segments (**Table E3-1**). The majority of sediment load is generated from crossings on private land (21.2 tons/year), followed by Federal land (15.1 tons/year), and State land (1.8 tons/year). Per crossing, the load averaged 0.08 tons/year across all landscape settings; federal crossings (which were all in the mountain setting) contribute an average annual load of 0.06 tons/year, and private crossings (which are in all landscape settings) contribute an average annual load of 0.095 tons/year. The greatest load is likely produced from privately-owned road crossings due to the large quantity of private land in the foothill landscape.

Sediment load results were compared to the USDA NRCS Soil Hazard Classification as a possible tool to predict problem areas. The results from this study did not appear to correlate with hazard class, which is likely due to the greater sensitivity of the WEPP:road model to road length and road gradient for specific high-load crossings in the Little Blackfoot River TPA, rather than to the variables of the USDA NRCS rating system (soil erosion factor K, slope, and content of rock fragments).

Table E3-1. Extrapolated Sediment Load Summary from Unpaved Road Crossings and Parallel Segments– Existing Conditions

Road Feature	Landscape Type	Total Number of Crossings	Mean Sediment Load (Tons/year)	Total Sediment Load (Tons/year)
Crossing	Mountain	309	0.07	21.63
Crossing	Foothill	139	0.11	15.29
Crossing	Valley	37	0.03	1.11
Total:		**485**		**38.03**
Road Feature	**Landscape Type**	**Total Parallel Distance w/in 50-feet (Mi)**	**Mean Sediment Load (Tons/year/mile)**	**Total Sediment Load (Tons/year)**
Parallel	Mountain	14.5	0.021	0.30
Parallel	Foothill	6.5	0.003	0.02
Parallel	Valley	1.8	0.012	0.02
Total:		**22.8**		**0.35**
Total Little Blackfoot River TPA:				**38.38**

E3.2 CULVERT ASSESSMENT – FISH PASSAGE

Culverts were analyzed for their ability to allow for fish passage. Measurements were collected at each field assessed crossing site, and these values were used to determine if culverts represented fish passage barriers at various flow conditions. Of the 22 field assessed road crossing sites, field sites with bridges, along with any sites where any of the required screening data could not be accurately collected, were removed from the dataset. After removing these sites from the dataset, fifteen culverts were determined to be suitable for fish passage assessment.

The fish passage evaluation was completed using the criteria in *A Summary of Technical Considerations to Minimize the Blockage of Fish at Culverts on National Forests in Alaska* (U.S. Department of Agriculture, Forest Service, Alaska Region, 2002). The analysis uses site-specific information to classify culverts as green (passing all lifestages of salmonids), red (partial or total barrier to salmonids), or grey (needs additional analysis). Indicators used in the classification are the ratio of the culvert width to bankfull width (constriction ratio), culvert slope, and outlet drop, with large (>48-inches) and small (<48-inches) culvert groups evaluated differently. Failure of any one of the three indicators results in a red classification. Using the Alaska fish passage analysis, 12 of 15 culverts (80%) were classified as partial or total fish barriers (red), and 3 of 15 (20%) were classified as needing additional evaluation (grey). None of the field assessed culverts were classified as capable of passing fish at all flows and life stages (**Table E3-2, Table EA-8**). The predominant cause for preventing fish passage was steep culvert gradient.

Table E3-2. Culvert Fish Passage Analysis Results

Culvert Classification	Definition of Indicator	Number of Culverts	Percentage of Total Culverts Assessed
Red[1]	High certainty of not providing juvenile fish passage at all desired stream flows	12	80%
Green[2]	High certainty of meeting juvenile fish passage at all flows	0	0%
Grey[3]	Additional and more detailed analysis is required to determine juvenile fish passage ability	3	20%

The seven crossings that could not be assessed for fish passage were due to: the lack of a culvert (4 ford crossings), the culvert slope could not be determined (culvert plugged, 2 crossings), or the bankfull

width was not well defined in a dry channel (1 culvert). Eighteen of the 22 culverts had visual stream flow during the visit; all of the crossings that were assessed for fish passage had visual flow. Flow was visually estimated and ranged from 1 cfs to 16 cfs.

E3.3 CULVERT ASSESSMENT – STORM EVENT FAILURE POTENTIAL

Each culvert with a field measured bankfull width was evaluated using USGS regression equations developed by Parrett and Johnson (Parrett and Johnson, 2004). Previous studies by Chuck Parrett of the USGS (DNRC, Montana floodplain) have indicated that regression equations based on bankfull width may be more reliable if the basin characteristic and climate are not unique to the specific crossing. Regardless of the method, as peak discharge increases, so does the percentage of culverts incapable of passing the greater flows. Based on the peak flow analysis with bankfull width as the independent variable, it appears that most culverts were designed to pass the Q25 flow, as the majority of culverts (79%) passed this flow (**Table E3-4** and **Attachment EA, Table EA-9)**.

Table E3-4. Percent of Culverts Passing Design Storm Events based on bankfull width

Design Storm Event	Number of Culverts Passing	Number of Culverts Failing Design Flow	Cumulative Percent Passing
Total Culverts	14[A]		100%
Q2	14	14	100%
Q5	11	3	79%
Q10	11	3	79%
Q25	11	3	79%
Q50	8	6	53%
Q100	6	8	43%

[A] NTC-P-F-X-348 bankfull width could not be determined due to the heavily vegetated swale, thus only 14 culverts were assessed with this method.

Potential road fill volume at risk for delivery in the event of a culvert failure was calculated using field measurements of the road prism over the culvert. The volumes calculated are conservative, assuming that the entire road prism above the culvert fails to bankfull width and is delivered to the stream, which will likely not always be the case. One crossing did not have bankfull width and twice the culvert width was used for fill at risk calculations. Bulk density was assumed to be 0.969 tons/yd^3 (1.15 Mg/m^3) for all sites. In some instances, only part of the road fill may be delivered, and in other cases, water may overtop the road but the culvert will stay intact.

It is difficult to develop a specific road crossing allocation for sediment delivered in the event of a culvert failure, as there are several factors that may impact the accuracy of the data. First, peak flows generated using the USGS regression equations are subject to large standard errors that may substantially over or underestimate peak discharge. In addition, peak flows generated using Manning's equation rely heavily on culvert slope. Slope values measured during field activities were estimated using a handheld inclinometer, where accessible, and visual estimates were recorded where access or use of an inclinometer was not possible. Different slope estimates may lead to variations in peak flow calculations. Second, the culvert assessment was conducted on a small subset of culverts, which may or may not be representative of the entire Little Blackfoot River TPA. Third, it is difficult to estimate which culverts will fail in any given year, and what percentage of at-risk fill material will be delivered to the stream.

Despite these difficulties, the potential load associated with culvert failure was estimated. A conservative failure probability of 25% was used to estimate the annual potential sediment delivery

using the average fill at risk multiplied by the number of crossings estimated to not be able to pass a 25-year storm event. Given a 25% annual probability of failure for culverts that are not sized for a Q25 event, it is estimated that 196 tons of sediment are at-risk for the Little Blackfoot TPA (**Attachment EA**, **Table EA-10**).

E4.0 Application of Best Management Practices

Sediment impacts are widespread throughout the Little Blackfoot TPA, and sediment loading from the unpaved road network is one of several sources within the watershed. Application of BMPs on the unpaved road network will result in a decrease in sediment loading to streams. BMP sediment reduction was evaluated based on a reduction in contributing road length.

E4.1 Contributing Road Length Reduction Scenario

A contributing road length reduction scenario for road crossings was selected assuming a total road length reduction to 200 feet (100-feet on each road for a crossing with two contributing road segments or 200 feet on crossings with one contributing segment). On crossing locations in excess of this length reduction scenario, road lengths were reduced to the corresponding post-BMP scenario of 200-feet. No changes were made to crossing locations where the contributing road length was less than the 200-foot BMP reduction scenario. The 200-foot BMP scenario was evaluated using the WEPP:Road model, so potential sediment load reductions could be estimated. The results for each field site are included in **Attachment ED**.

Due to the overall minimal contribution from parallel segments (i.e., <1%), BMP reduction scenarios were not developed for parallel road segments. There were culvert drains installed on parallel roads within the Snowshoe Creek, Telegraph Creek and Elliston Creek watersheds that were well maintained. The minimized contributing road length is evident in the overall annual average sediment load per mile, which ranged from 0.003 to 0.012 tons/year.

For the 200-foot BMP scenario, mean sediment loads would be reduced from 0.07 tons/year to 0.02 tons/year for mountain crossings, from 0.11 tons/year to 0.02 tons/year for foothill crossings, and from 0.03 tons/year to 0.01 tons/year for valley crossings. The most significant reduction in sediment load occurs in the foothill landscape type (0.11 tons/year average annual sediment to 0.02 tons/year). This reduction is likely due to the large change in the average road length from existing conditions (394 feet) to the reduced road length conditions (182 feet). Under the BMP scenario, total sediment load from road crossings would be reduced from 38.03 tons/year to 9.33 tons/year (75.5% reduction). Estimated summary load reductions are shown by landscape setting in **Table E4-1** and by 6th code HUC/303(d) watershed in **Table E4-2.**

Due to the extent of the unpaved road network and the resulting inability to assess it in its entirety, generalized assumptions are necessary for modeling the effects of BMPs. Restoration efforts would need to consider site-specific BMPs that, on average, would likely be represented by the modeling assumptions. Other management issues that will impact BMP scenarios are the ability to perform restoration work within the different land ownership categories.

Table E4-1. Extrapolated Sediment Load Summary from Unpaved Road Crossing– 200' Road Length Reduction

Landscape Type	Total Number of Sites	Mean Sediment Load (Tons/year)	Total Sediment Load (Tons/year)	Load Reduction %
Mountain	309	0.02	6.18	71.4%
Foothill	139	0.02	2.78	81.8%
Valley	37	0.01	0.37	66.7%
Total:	**485**		**9.33**	**75.5%**

Table E4-2. Percent Sediment Reduction per HUC: Road Length Reduction

HUC	Annual Sediment Load (tons/year)	Road Length Reduction Annual Sediment Load (tons/year)	Load Reduction %
Little Blackfoot River-Hat Creek	2.13	0.61	71.4%
Little Blackfoot River-Larabee Gulch	0.7	0.2	71.4%
Little Blackfoot River-Mead Creek	5.5	1.05	80.9%
Little Blackfoot River (Previously Elliston Creek)	1.74	0.42	75.9%
Elliston Creek	0.45	0.13	71.1%
Upper Upper Dog Creek	1.33	0.38	71.4%
Lower Dog Creek	1.65	0.46	72.1%
Lower Upper Dog Creek	2.1	0.6	71.4%
Snowshoe Creek	2.28	0.56	75.4%
Lower Spotted Dog Creek	2.2	0.4	81.8%
Lower Upper Spotted Dog Creek	0.54	0.12	77.8%
South Fork Dog Creek	0.69	0.14	79.7%
Upper Telegraph Creek	3.71	1.06	71.4%
Lower Threemile Creek	0.63	0.16	74.6%
Lower Carpenter Creek	3.96	0.88	77.8%
Upper Carpenter Creek	0.56	0.16	71.4%
Lower Telegraph Creek	0.35	0.1	71.4%
Mike Renig Gulch	0.35	0.1	71.4%
North Trout Creek	1.81	0.46	74.6%
Ontario Creek	2.45	0.7	71.4%
Sixmile Creek	1.45	0.28	80.7%
Trout Creek	0.78	0.18	76.9%
Upper Upper Spotted Dog Creek	0.56	0.16	71.4%
Upper Threemile Creek	0.11	0.02	81.8%
	38.03	**9.33**	**75.5%**

E4.2 Summary of Total Loads and Potential Reductions

Sediment loading from unpaved crossings, parallel segments, culvert failure, and traction sand application are summarized in **Attachment EA**, **Table EA-11**.

E4.3 Assessment of Existing BMPs

Besides reducing the contributing road length, other potential BMPs are available that would reduce sediment loading from the unpaved road network. Road sediment reduction strategies such as the installation of full structural BMPs at existing road crossings (drive through dips, culvert drains, settling

basins, silt fence, etc), road surface improvement, reduction in road traffic levels (seasonal or permanent road closures), and timely road maintenance to reduce surface rutting are all BMPs that will reduce sediment loading from the road network. The presence of BMPs was noted for each of the field-assessed stream crossing sites. Of the 22 sites, 12 had at least one of the following BMPs: graveled surface, water bar, culvert drain, or drive through dip (**Figure E-6**).

The sediment yield for each crossing was impacted by the road surface (gravel or native) and the traffic level (high, low or none) in the WEPP model. Conclusions from **Figure E-6** are preliminary due to the small sample sizes; however, it appears that the minimized traffic may reduce sediment yield regardless of the presence of BMPs. The presence of gravel did not appear to decrease sediment yield; however this may be due to traffic level rather than to the presence of gravel, as noted in the comparison of the following category one and two (no BMPS and gravel only BMP). Based on the small sample sizes, drive-through dips, culvert drains and water bars appeared to be equally effective for the Little Blackfoot River assessed crossings. WEPP software does not allow for specific modeling of BMPs and the results may not completely indicate effectiveness.

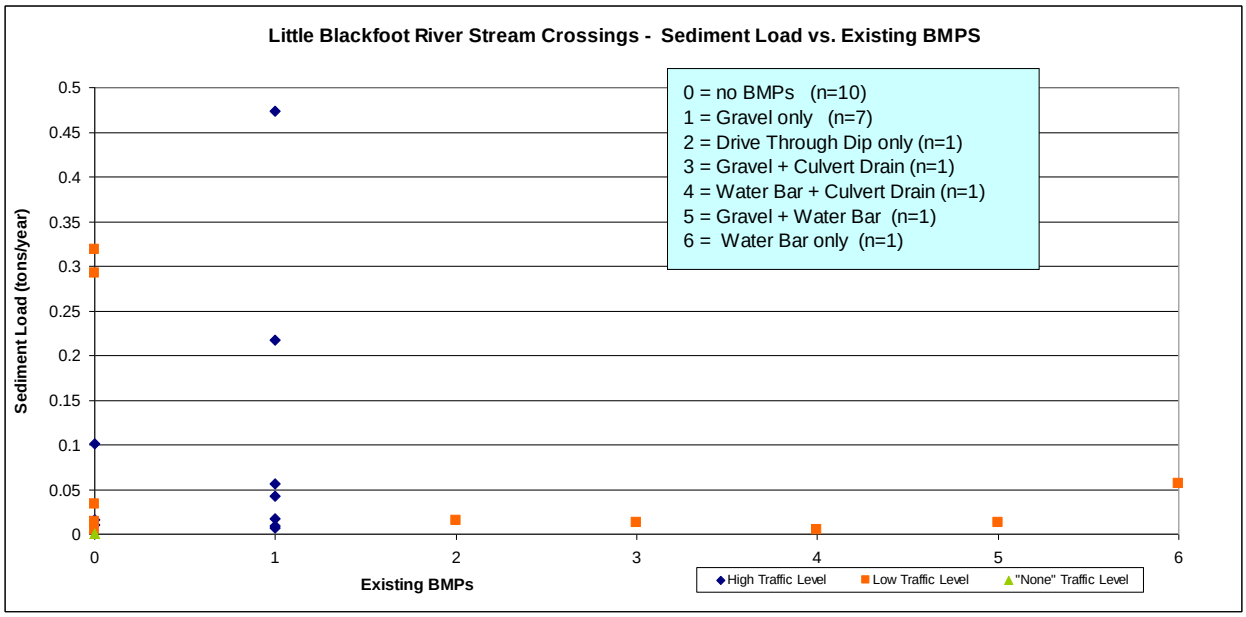


Figure E-6. WEPP:Road Sediment Results for each BMP Category

E5.0 Quality Assurance / Quality Control Results

E5.1 Representativeness

Representativeness refers to the extent to which measurements represent an environmental condition in time and space. Twenty two sites were randomly selected through GIS based on watershed and ownership categories with the intent that at least twenty sites would be assessed. A total of 22 road crossings were assessed in the field. Spatial representation is shown in **Attachment EA**, **Table EA-3**. Temporal variations were not accounted for in this study, as the field data collected at road crossing locations does not change during the year.

E5.2 COMPARABILITY

Comparability is the applicability of the project's data to the WEPP:Road model input data. The WEPP:Road model includes a high and low data value for each input parameter. Field data was compared to the model input range and sites with data outside these ranges were flagged for additional evaluation through the review of photographs, field comments, personal communication and other field data. No sites were determined to have unacceptable field data for the WEPP:Road model.

E5.3 COMPLETENESS

Completeness is a measure of the amount of data prescribed for assessment activities and the usable data actually collected, expressed as a percentage.

Completeness as % = (No. Valid Data Points or Samples / Total # Data Points or Samples) x 100
The overall project goal was 90% completeness. A total of 27 sites were assessed in the field. As documented in **Attachment EB,** all sites were deemed valid through data adjustments based on comments, conversations with the field crew and through analysis of photographs for input into the WEPP:model. This equates to a completeness of 100%. Incomplete field notes that were altered through the use of photographs were fill gradient for NTC-P-M-X-387, and road gradient for CPC-P-M-P-465. The road design for TGC-F-M-X-74 was difficult to determine with the recent snow and the road was determined as rutted through best professional judgment. The rock content in the prism material for TGC-F-M-X-48 was adjusted downward from 80% to 50% per WEPP guidance. The field notes were erroneous for the road length of LBM-P-F-X-185: the length was recorded as 100 feet and was actually 1000 feet. The modeled output (**Attachment ED**) includes these five updates.

E6.0 REFERENCES

Flanagan, D. C. and S. J. Livingston. 1995. WEPP User Summary. West Lafayette, IN: USDA-ARS National Soil Erosion Research Laboratory. Report NSERL Report 11.

Montana Department of Environmental Quality. 2005. Water Quality Restoration Plan and Total Maximum Daily Loads for the Bitterroot Headwaters Planning Area Version 1.0. Helena, MT: Montana Department of Environmental Quality.

-----. 2009. Prospect Creek Watershed Sediment TMDLs and Framework for Water Quality Restoration. Helena, MT: Montana Department of Environmental Quality.

Montana Department of Environmental Quality. 2008. St. Regis Watershed Total Maximum Daily Loads and Framework Water Quality Restoration Assessment - Sediment and Temperature TMDLs. Helena, MT: Montana Department of Environmental Quality.

Montana Department of Environmental Quality, DTM Consulting, Applied Geomorphology Inc., Blackfoot Challenge, and Confluence Consulting Inc. 2004. Blackfoot Headwaters Planning Area Water Quality and Habitat Restoration Plan and TMDL for Sediment. Helena, MT: Montana Department of Environmental Quality.

Montana Department of Natural Resources and Conservation. 2008. Montana Natural Resources Information Interactive Map Website. Helena, MT: Montana Department of Natural Resources and Conservation. http://nris.state.mt.us/interactive.html. Accessed 7/25/11 A.D.

Parrett, Charles and D. R. Johnson. 2004. Methods for Estimating Flood Frequency in Montana Based on Data Through Water Year 1998. Report U.S. Giological Survey Water -Resources Investigations Report 03-4308.

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

Wanielista, M. P., R. Kersten, and R. Eaglin. 1997. Hydrology and Water Quality Control, 2nd ed., New York, New York: John Wiley & Sons, Inc.

Water & Environmental Technologies, PC. 2009a. Task 1: Road GIS & Summary Statistics, Little Blackfoot River TPA. Helena, MT: Montana Department of Environmental Quality, Water Quality Planning Bureau.

-----. 2009b. Task 2: Sampling and Analysis Plan, Little Blackfoot River TPA. Helena, MT: Montana Department of Environmental Quality, Water Quality Planning Bureau.

ATTACHMENT EA - ATTACHED TABLES

Table EA-1. Little Blackfoot River TPA Road Summary by 6th Code Subwatershed (USGS HUC 12)

2008 303(d) Listed Segments	6th Code Subwatershed (USGS HUC 12)	Area (Mi^2)	Stream Miles (Mi)	Unpaved Crossings	Unpaved Crossing Density (Crossing / Mi^2)	Paved Crossings	Total Crossings	Total Road Length (Mi)	Total Road Density (Mi/Mi^2)	% of Total Roads which are unpaved	Total Unpaved Road Length w/in 50 ft Streams (Mi)	Total Unpaved Road Density w/in 50 ft of Streams (Mi/Mi^2)
Upper Little Blackfoot River	**Little Blackfoot River-Hat Creek**	21.12	34.56	31	1.47	1	32	44.32	2.10	94.7%	1.15	5.5%
	Little Blackfoot River-Larabee Gulch	28.43	44.15	10	0.35	0	10	10.23	0.36	100.0%	0.31	1.1%
Lower Little Blackfoot River	**Little Blackfoot River-Mead Creek**	49.02	99.09	58	1.18	27	85	65.80	1.34	68.1%	2.93	6.0%
	Little Blackfoot River (Previously Elliston Creek)	25.44	44.62	26	1.02	4	30	32.04	1.26	65.9%	1.33	5.2%
Elliston Creek	**Elliston Creek**	6.09	9.23	7	1.15	3	10	15.34	2.52	94.4%	0.42	6.9%
Upper Dog Creek	**Upper Dog Creek – Listed Waterbody MT76G004_071**	9.14	16.25	19	2.08	0	19	21.72	2.38	100.0%	1.00	11.0%
Lower Dog Creek	**Lower Dog Creek - Listed Waterbody MT76G004_072**	25.84	34.00	23	0.89	1	24	40.62	1.57	88.5%	1.10	4.3%
	Upper Dog Creek – Listed Waterbody MT76G004_072	22.58	30.92	30	1.33	0	30	46.37	2.05	100.0%	1.67	7.4%
Snowshoe Creek	**Snowshoe Creek**	18.13	33.88	28	1.54	0	28	40.74	2.25	100.0%	1.83	10.1%
Lower Spotted Dog Creek	**Lower Spotted Dog Creek**	18.18	32.92	20	1.10	0	20	21.51	1.18	100.0%	1.11	6.1%
	Upper Spotted Dog Creek - Listed	6.57	12.09	6	0.91	0	6	14.78	2.25	100.0%	0.17	2.6%
	South Fork Dog Creek	13.10	25.07	7	0.53	0	7	14.88	1.14	100.0%	0.24	1.8%
Upper Telegraph Creek	**Telegraph Creek - Listed**	16.03	31.02	53	3.31	0	53	44.43	2.77	100.0%	1.77	11.1%
Lower Threemile Creek	**Threemile Creek - Listed**	15.41	26.46	13	0.84	1	14	10.86	0.70	90.1%	0.43	2.8%
Not Listed for Sediment	Lower Carpenter Creek	21.33	31.74	44	2.06	0	44	42.76	2.00	100.0%	2.46	11.5%
Not Listed for Sediment	Upper Carpenter Creek	4.92	10.78	8	1.63	0	8	3.93	0.80	100.0%	0.37	7.5%
Not Listed for Sediment	Telegraph Creek – Not Listed	3.05	4.21	5	1.64	0	5	8.51	2.79	100.0%	0.15	4.8%
Not Listed for Sediment	Mike Renig Gulch	11.43	16.57	5	0.44	0	5	13.05	1.14	100.0%	0.52	4.6%
Not Listed for Sediment	North Trout Creek	16.44	22.74	23	1.40	0	23	26.24	1.60	100.0%	1.26	7.7%
Not Listed for Sediment	Ontario Creek	20.00	33.70	35	1.75	0	35	36.24	1.81	100.0%	0.95	4.7%
Not Listed for Sediment	Sixmile Creek	29.52	64.35	15	0.51	10	25	35.16	1.19	86.1%	0.91	3.1%
Not Listed for Sediment	Trout Creek	17.18	33.36	10	0.58	4	14	29.77	1.73	94.8%	0.39	2.3%
Not Listed for Sediment	Upper Spotted Dog Creek – Not Listed	7.05	11.19	8	1.13	0	8	19.71	2.80	100.0%	0.27	3.9%
Not Listed for Sediment	Threemile Creek – Not Listed	6.70	8.90	1	0.15	0	1	1.50	0.22	100.0%	0.03	0.5%
	Total	**412.6**	**711.8**	**485**	**1.18**	**51**	**536**	**640.5**	**1.5**	**92.6%**	**22.8**	**5.5%**

Note: USGS HUC 12 boundaries were further divided based on CWAIC 303(d) listings. These are denoted with a "Listed or Not-Listed suffix.

[A]USGS HUC 12 combines Little Blackfoot River with Elliston Creek. Elliston Creek is 303(d) Listed and was separated from the HUC 12 classification. The second row, Little Blackfoot River does not include Elliston Creek information.

Bold text indicates that segment is 303(d) listed for sediment impairment

Table EA-2. Road Summary by Landscape Type, Land Ownership, and Soil Erosion Hazard Classification

Landscape Type	Area (Mi^2)	Stream Miles (Mi)	Unpaved Crossings	Unpaved Crossing Density (Crossing/Mi^2)	Paved Crossings	Total Crossings	Total Road Length (Mi)	Total Road Density (Mi/Mi^2)	% of Total Roads which are unpaved	Total Unpaved Road Length w/in 50 ft Streams (Mi)	Total Unpaved Road Density w/in 50 ft of Streams (Mi/Mi^2)
Valley	18.27	75.72	37	2.03	31	68	48.90	2.68	43.31%	1.751	9.58%
Foothill	151.78	275.60	139	0.92	20	156	166.18	1.09	91.22%	6.538	4.31%
Mountain	187.44	284.75	296	1.58	0	296	409.12	2.18	98.78%	13.94	7.44%
Mountain (USFS Roadless Area)	55.20	75.74	13	0.24	0	13	16.31	0.30	100.00%	0.563	1.02%
Total	***412.6***	***711.8***	***485***	***1.18***	***51***	***533***	***640.5***	***1.5***	***92.6%***	***22.8***	***5.5%***

Table EA-2. Road Summary by Landscape Type, Land Ownership, and Soil Erosion Hazard Classification

Land Ownership	Area (Mi^2)	Stream Miles (Mi)	Unpaved Crossings	Unpaved Crossing Density (Crossing/Mi^2)	Paved Crossings	Total Crossings	Total Road Length (Mi)	Total Road Density (Mi/Mi^2)	% of Total Roads which are unpaved	Total Unpaved Road Length w/in 50 ft Streams (Mi)	Total Unpaved Road Density w/in 50 ft of Streams (Mi/Mi^2)
Federal Land	102.37	145.90	202	1.97	0	202	308.87	3.02	99.72%	9.532	9.31%
Private	231.51	451.95	250	1.08	49	296	298.30	1.29	85.15%	11.889	5.14%
State Land	23.50	38.22	20	0.85	2	22	17.03	0.72	87.55%	0.809	3.44%
Federal (USFS Roadless)	55.20	75.74	13	0.24	0	13	16.31	0.30	100.00%	0.563	1.02%
Total	***412.6***	***711.8***	***485***	***1.18***	***51***	***533***	***640.5***	***1.5***	***92.6%***	***22.8***	***5.5%***
Soil Erosion Hazard Classification	**Area (Mi^2)**	**Stream Miles (Mi)**	**Unpaved Crossings**	**Unpaved Crossing Density (Crossing/Mi^2)**	**Paved Crossings**	**Total Crossings**	**Total Road Length (Mi)**	**Total Road Density (Mi/Mi^2)**	**% of Total Roads which are unpaved**	**Total Unpaved Road Length w/in 50 ft Streams (Mi)**	**Total Unpaved Road Density w/in 50 ft of Streams (Mi/Mi^2)**
Moderate	83.72	149.59	142	1.70	6	148	150.44	1.80	94.56%	5.41	6.47%
NR	3.62	13.27	10	2.76	0	10	4.11	1.14	99.17%	0.55	15.23%
Severe	292.06	394.07	248	0.85	14	259	410.82	1.41	96.71%	13.33	4.56%
Slight	32.91	154.88	85	2.58	31	116	75.14	2.28	65.99%	3.50	10.63%
Total	***412.6***	***711.8***	***485***	***1.17***	***51***	***533***	***640.5***	***1.5***	***92.6%***	***22.8***	***5.5%***

Table EA-3. Proposed Field Sites and Actual Field Assessed Sites

6th Code Subwatershed (USGS HUC 12)	Number of Sites Randomly Selected with GIS	Number of Actual Field Assessed Sites (Crossing / Parallel)	Landscape Type	Number of Sites Randomly Selected with GIS	Number of Actual Field Assessed Sites (Crossing/Parallel)
Carpenter Creek	2	1 / 1	Valley	2	2/ 0
Little Blackfoot River[A]			Foothill	6	5 / 1
Elliston Creek[A]	1		Mountain	13	15 / 4
Little Blackfoot River-Hat Creek	1	1 / 0	Mountain (USFS Roadless Area)	1	0 / 0
Little Blackfoot River-Larabee Gulch			**Land Ownership**	**Number of Field Sites Randomly Selected**	**Number of Assessed Sites (Crossing/Parallel)**
Little Blackfoot River-Mead Creek	2	3 / 1	Federal Land	11	11 / 1
Lower Dog Creek			Private	10	10 / 4
Lower Spotted Dog Creek	1		State Land	0	1 / 0
Mike Renig Gulch	1		Federal (USFS Roadless)	1	0 / 0
North Trout Creek		2 / 0	**Soil Erosion Hazard Classification**	**Number of Field Sites Randomly Selected**	**Number of Assessed Sites (Crossing/Parallel)**
Ontario Creek	4		Moderate	10	3 / 1
Sixmile Creek			NR	1	0 / 1
Snowshoe Creek		2 / 1	Severe	10	15 / 3
South Fork Dog Creek	1		Slight	1	4 / 0
Telegraph Creek	4	6 / 2			
Threemile Creek	1	1 / 0			
Trout Creek	1	3 / 0			
Upper Dog Creek	2	1 / 0			
Upper Spotted Dog Creek	1	2 / 0			

[A]USGS HUC 12 combines Little Blackfoot River with Elliston Creek. Elliston Creek is 303(d) Listed and was separated from the HUC 12 classification. The second row, Little Blackfoot River does not include Elliston Creek information.

Table EA-4. Traction Sand Contribution by HUC; Paved and Unpaved Roads within 100 feet of Surface Water

Department	HUCs	Miles within 100 feet of surface water	Application Rate Tons/mile/year	Tons /year 15% delivery	BMP Application Total Sediment Load (t/y) 10% delivery	Total Reduction
Powell County Road Department, District I Secondary Roads*	Little Blackfoot River – Mead Creek	1.21	6.25	1.13	0.76	33%
	Little Blackfoot River (previously Elliston Creek)	0.11	6.25	0.10	0.07	33%
Highway 12 (mile marker 0 to 12.5)	Little Blackfoot River – Mead Creek	1.52	50	11.40	7.60	33%
Highway 12 (Avon to Elliston)	Trout Creek	0.68	96	9.79	6.53	33%
	Elliston Creek	0.03	96	0.43	0.29	33%
	Little Blackfoot River (previously Elliston Creek)	0.55	96	7.92	5.28	33%
Highway 141	Little Blackfoot River – Mead Creek	0.15	58	1.31	0.87	33%
	Lower Threemile Creek	0.11	58	0.96	0.64	33%
	Sixmile Creek	0.69	58	6.00	4.00	33%

Secondary roads were calculated as all paved roads within the HUC not including Highway 141 or Highway 12. Traction sand contributions from unpaved secondary roads are not included in these calculations

.

Table EA-5. Unpaved Road Crossings by HUC/303(d) Subwatershed, Ownership and Landscape Type

Ownership	Private			Federal Land			Federal (USFS Roadless Designation)			State			Total
6th Code/303(d) Subwatershed	Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	Crossings
Little Blackfoot River-Hat Creek	1	-	13	-	-	14	-	-	3	-	-	-	31
Little Blackfoot River-Larabee Gulch	-	-	1	-	-	1	-	-	8	-	-	-	10
Little Blackfoot River-Mead Creek	9	41	-	-	-	-	-	-	-	2	6	-	58
Little Blackfoot River (Previously Elliston Creek)	8	8	5	-	-	3	-	-	-	2	-	-	26
Elliston Creek	1	-	3	-	-	3	-	-	-	-	-	-	7
Upper Dog Creek – Listed Waterbody MT76G004_071	-	-	7	-	-	12	-	-	-	-	-	-	19
Lower Dog Creek - Listed Waterbody MT76G004_072	-	1	14	-	-	8	-	-	-	-	-	-	23
Upper Dog Creek – Listed Waterbody MT76G004_072	-	-	9	-	-	21	-	-	-	-	-	-	30
Snowshoe Creek	-	7	2	-	-	18	-	-	-	-	1	-	28
Lower Spotted Dog Creek	-	18	-	-	-	-	-	-	-	-	2	-	20
Upper Spotted Dog Creek - Listed	-	3	2	-	-	1	-	-	-	-	-	-	6
South Fork Dog Creek	-	4	-	-	-	2	-	-	-	-	1	-	7
Upper Telegraph Creek - Listed	-	-	11	-	-	40	-	-	2	-	-	-	53
Threemile Creek - Listed	10	3	-	-	-	-	-	-	-	-	-	-	13
Lower Carpenter Creek	-	22	8	-	-	14	-	-	-	-	-	-	44
Upper Carpenter Creek	-	-	3	-	-	5	-	-	-	-	-	-	8
Telegraph Creek – Not Listed	-	-	2	-	-	3	-	-	-	-	-	-	5
Mike Renig Gulch	-	-	2	-	-	2	-	-	-	-	-	1	5
North Trout Creek	-	5	1	-	-	16	-	-	-	-	-	1	23
Ontario Creek	-	-	5	-	-	30	-	-	-	-	-	-	35
Sixmile Creek	2	10	1	-	-	-	-	-	-	-	2	-	15
Trout Creek	2	2	3	-	-	1	-	-	-	-	2	-	10

Table EA-5. Unpaved Road Crossings by HUC/303(d) Subwatershed, Ownership and Landscape Type

Ownership	Private			Federal Land			Federal (USFS Roadless Designation)			State			Total
6th Code/303(d) Subwatershed	Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	Crossings
Upper Spotted Dog Creek – Not Listed	-	-	-	-	-	8	-	-	-	-	-	-	8
Threemile Creek – Not Listed	-	1	-	-	-	-	-	-	-	-	-	-	1
Total	***33***	***125***	***92***	***0***	***0***	***202***	***0***	***0***	***13***	***4***	***14***	***2***	***485***

Bold text indicates that segment is 303(d) listed for sediment impairment.

Table EA-6. Detailed Extrapolated Sediment Load From Unpaved Road Crossings by HUC/303(d) Subwatershed, Ownership and Landscape Type – Existing Conditions (tons/year)

Ownership	Private			Federal Land			Federal (USFS Roadless Designation)			State			Total Annual Sediment Load (tons/year)
6th Code/303(d) Subwatershed	Valley	Foothill	Mountain	Valley	Total Annual Sediment Load	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	
Little Blackfoot River-Hat Creek	0.03	0.00	0.91	0.00	0.00	0.98	0.00	0.00	0.21	0.00	0.00	0.00	2.13
Little Blackfoot River-Larabee Gulch	0.00	0.00	0.07	0.00	0.00	0.07	0.00	0.00	0.56	0.00	0.00	0.00	0.70
Little Blackfoot River-Mead Creek	0.27	4.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.66	0.00	5.50
Little Blackfoot River (Previously Elliston Creek)	0.24	0.88	0.35	0.00	0.00	0.21	0.00	0.00	0.00	0.06	0.00	0.00	1.74
Elliston Creek	0.03	0.00	0.21	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.45
Upper Dog Creek – Listed Waterbody MT76G004_071	0.00	0.00	0.49	0.00	0.00	0.84	0.00	0.00	0.00	0.00	0.00	0.00	1.33
Lower Dog Creek - Listed Waterbody MT76G004_072	0.00	0.11	0.98	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	1.65

Table EA-6. Detailed Extrapolated Sediment Load From Unpaved Road Crossings by HUC/303(d) Subwatershed, Ownership and Landscape Type – Existing Conditions (tons/year)

Ownership	Private			Federal Land			Federal (USFS Roadless Designation)			State			Total Annual Sediment Load (tons/year)
6th Code/303(d) Subwatershed	Valley	Foothill	Mountain	Valley	Total Annual Sediment Load	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	
Upper Dog Creek – Listed Waterbody MT76G004_072	0.00	0.00	0.63	0.00	0.00	1.47	0.00	0.00	0.00	0.00	0.00	0.00	2.10
Snowshoe Creek	0.00	0.77	0.14	0.00	0.00	1.26	0.00	0.00	0.00	0.00	0.11	0.00	2.28
Lower Spotted Dog Creek	0.00	1.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	2.20
Upper Spotted Dog Creek - Listed	0.00	0.33	0.14	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.54
South Fork Dog Creek	0.00	0.44	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.11	0.00	0.69
Upper Telegraph Creek - Listed	0.00	0.00	0.77	0.00	0.00	2.80	0.00	0.00	0.14	0.00	0.00	0.00	3.71
Threemile Creek - Listed	0.30	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63
Lower Carpenter Creek	0.00	2.42	0.56	0.00	0.00	0.98	0.00	0.00	0.00	0.00	0.00	0.00	3.96
Upper Carpenter Creek	0.00	0.00	0.21	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.56
Telegraph Creek – Not Listed	0.00	0.00	0.14	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Mike Renig Gulch	0.00	0.00	0.14	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.07	0.35
North Trout Creek	0.00	0.55	0.07	0.00	0.00	1.12	0.00	0.00	0.00	0.00	0.00	0.07	1.81
Ontario Creek	0.00	0.00	0.35	0.00	0.00	2.10	0.00	0.00	0.00	0.00	0.00	0.00	2.45
Sixmile Creek	0.06	1.10	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	1.45
Trout Creek	0.06	0.22	0.21	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.22	0.00	0.78
Upper Spotted Dog Creek – Not Listed	0.00	0.00	0.00	0.00	0.00	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.56
Threemile Creek – Not Listed	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Total	***0.99***	***13.75***	***6.44***	***0.00***	***0.00***	***14.14***	***0.00***	***0.00***	***0.91***	***0.12***	***1.54***	***0.14***	***38.03***

Bold text indicates that segment is 303(d) listed for sediment impairment

Table EA-7. Detailed Extrapolated Sediment Load From Parallel Segments by HUC/303(d) Subwatershed, Ownership and Landscape Type – Existing Conditions (tons/year)

Ownership	Private			Federal Land			Federal (USFS Roadless Designation)			State			Total Annual Sediment Load (tons/year)
6th Code/303(d) Subwatershed	Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	
Little Blackfoot River-Hat Creek	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Little Blackfoot River-Larabee Gulch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Little Blackfoot River-Mead Creek	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Little Blackfoot River (Previously Elliston Creek)	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Elliston Creek	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Upper Dog Creek – Listed Waterbody MT76G004_071	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Lower Dog Creek - Listed Waterbody MT76G004_072	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Upper Dog Creek – Listed Waterbody MT76G004_072	0.00	0.00	0.01	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Snowshoe Creek	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Lower Spotted Dog Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Spotted Dog Creek - Listed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
South Fork Dog Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Upper Telegraph Creek - Listed	0.00	0.00	0.01	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Threemile Creek - Listed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table EA-7. Detailed Extrapolated Sediment Load From Parallel Segments by HUC/303(d) Subwatershed, Ownership and Landscape Type – Existing Conditions (tons/year)

Ownership	Private			Federal Land			Federal (USFS Roadless Designation)			State			Total Annual Sediment Load (tons/year)
6th Code/303(d) Subwatershed	Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	Valley	Foothill	Mountain	
Lower Carpenter Creek	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.03
Upper Carpenter Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Telegraph Creek – Not Listed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mike Renig Gulch	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
North Trout Creek	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Ontario Creek	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Sixmile Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trout Creek	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Upper Spotted Dog Creek – Not Listed	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Threemile Creek – Not Listed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	***0.02***	***0.02***	***0.09***	***0.00***	***0.00***	***0.20***	***0.00***	***0.00***	***0.01***	***0.00***	***0.00***	***0.00***	***0.35***

Bold text indicates that segment is 303(d) listed for sediment impairment.

Table EA-8. Fish Passage Analysis for Selected Road Crossings Using Alaska Region Criteria

Location ID	Structure Type	Structure Diameter or Dimensions (in)	Width (ft)	Culvert Slope (%)	Bf in Riffle Above Culvert (ft)[A]	Culvert /BF ratio	Perch (in)	Streambed Materials in Culvert	Final Classification	Notes/Comments
Fish passage evaluation criteria: Circular CMP 48" span and smaller										
TGC-F-M-X-115	CMP / WOOD	12 OR 24	1	2.0[1]	3.5	0.29[1]	13.0[1]	N/A	[1]RED	Downstream end wood; damaged upstream end - crushed and sunken; closed road - bridge "temporarily out", road non-existant
LBM-S-F-X-270	CMP	24	2	6.0[1]	3	0.67[3]	0.0[2]	Yes	[1]RED	

Table EA-8. Fish Passage Analysis for Selected Road Crossings Using Alaska Region Criteria

Location ID	Structure Type	Structure Diameter or Dimensions (in)	Width (ft)	Culvert Slope (%)	Bf in Riffle Above Culvert (ft)[A]	Culvert /BF ratio	Perch (in)	Streambed Materials in Culvert	Final Classification	Notes/Comments
TGC-F-M-X-127	CMP	24	2	3.0[1]	3.5	0.57[3]	4.0[3]	No	[1]RED	Lip on culvert upstream
TGC-F-M-X-130	CMP	24	2	2.5[1]	3	0.67[3]	4.0[3]	No	[1]RED	newly constructed road
TRC-F-M-X-168	CMP	24	2	5.0[1]	4.5	0.44[1]	6.0[1]	No	[1]RED	Cattle impact, dam above u/s end
LBM-P-V-X-198	CMP	30	2.5	1.5[1]	8	0.31[1]	0.0[2]	No	[1]RED	Recently installed, erosion present on upstream end
USD-P-M-X-116	CMP	30	2.5	2.5[1]	3	0.83[2]	24.0[1]	No	[1]RED	
NTC-P-M-X-387	CMP	36	3	4.5[1]	4	0.75[3]	3.3[3]	No	[1]RED	approx 3-4 cfs
TGC-F-M-X-48	CMP	36	3	1.5[1]	4.5	0.67[3]	11.0[1]	No	[1]RED	culvert ponded w/s end, perched d/s end
SSC-F-M-X-462	CMP	36	3	3.0[1]	3	1.00[2]	15.0[1]	No	[1]RED	Mountain drainage, ~ 1-2 cfs
TMC-P-V-X-442	squash CMP	30 x 42	3.5	1.5[1]	7	0.50[3]	0.0[2]	No	[1]RED	culvert & stream parallel to three mile creek, fed from private pond, 2-3 cfs; landowner said culvert installed 4 years ago.
SSC-P-F-X-347	CMP	45	3.75	0.0[2]	6	0.63[3]	0.0[2]	No	[3]GREY	Slough / Pond at d/s end
Fish passage evaluation criteria: Circular CMP greater than 48" and less than 100% substrate cover										
LBH-P-M-X-134	ARCH CMP	52	4.3	1.0[3]	6	0.72[3]	0.0[2]	Yes	[3]GREY	Model culvert (arch), streambed material well placed
TGC-F-M-X-74	squash CMP	36 X 55	4.6	2.0[3]	6.5	0.71[3]	0.0[2]	No	[3]GREY	Well constructed culvert in stream
USD-F-M-X-96	squash CMP	45 x 57	4.75	2.5[1]	8	0.59[3]	0.0[2]	No	[1]RED	

Legend: [1]High certainty of not providing juvenile fish passage [2]High certainty of providing juvenile fish passage [3]Additional and more detailed analysis is required
[A]Flowing water was noted at all 15 crossing locations.

Table EA-9. Peak Discharges Using Parrett and Johnson Equations (West Region) and Manning's Equation

Site Information					Peak Discharges Using Parrett and Johnson Equations (West Region)						Peak Discharges Using Manning's Equation, pipes flowing full					
Site ID	**Structure**	**Bankfull Width (ft)**	**CMP Diameter or Height (ft)**	**X-sect Area (ft2)**	**Q2 (cfs)**	**Q5 (cfs)**	**Q10 (cfs)**	**Q25 (cfs)**	**Q50 (cfs)**	**Q100 (cfs)**	**Streambed Materials in Culvert**	**n[A]**	**Slope %**	**Velocity (ft/sec)**	**Peak Flow (cfs)**	**Max. Conveyance Manning's > Omang**
TMC-P-V-X-442	Squashed CMP	7.00	2.5	4.91	13.24	25.30	35.17	49.73	62.72	75.60	No	0.027	1.5	4.93	24.2	**Q2**
LBM-P-V-X-198	CMP	8.00	2.5	4.91	17.25	32.43	44.66	62.57	78.60	94.36	No	0.027	1.5	4.93	24.2	**Q2**
SSC-P-F-X-347	CMP	6.00	3.8	11.04	9.76	18.99	26.69	38.15	48.34	58.53	No	0.027	0.1	1.67	18.4	**Q2***
TGC-F-M-X-127	CMP	3.50	2.0	3.14	3.36	6.97	10.17	15.10	19.44	23.92	No	0.027	3.0	6.01	18.9	**Q25**
TRC-F-M-X-168	CMP	4.50	2.0	3.14	5.52	11.12	15.95	23.26	29.73	36.31	No	0.027	5.0	7.75	24.4	**Q25**
TGC-F-M-X-74	Squashed CMP	6.50	3.0	7.07	11.44	22.04	30.80	43.78	55.34	66.85	No	0.027	2.0	6.43	45.4	**Q25**
TGC-F-M-X-130	CMP	3.00	2.0	3.14	2.47	5.23	7.72	11.58	14.98	18.52	No	0.027	2.5	5.48	17.2	**Q50**
USD-F-M-X-96	Squashed CMP	8.00	3.8	11.04	17.25	32.43	44.66	62.57	78.60	94.36	No	0.027	2.5	8.34	92.1	**Q50**
LBM-S-F-X-270	CMP	3.00	2.0	3.14	2.47	5.23	7.72	11.58	14.98	18.52	Yes	0.027	6.0	8.49	26.7	**Q100**
USD-P-M-X-116	CMP	3.00	2.5	4.91	2.47	5.23	7.72	11.58	14.98	18.52	No	0.027	2.5	6.36	31.2	**Q100**
NTC-P-M-X-387	CMP	4.00	3.0	7.07	4.37	8.93	12.92	18.99	24.36	29.86	No	0.027	4.5	9.64	68.1	**Q100**
TGC-F-M-X-48	CMP	4.50	3.0	7.07	5.52	11.12	15.95	23.26	29.73	36.31	No	0.027	1.5	5.56	39.3	**Q100**
SSC-F-M-X-462	CMP	3.00	3.0	7.07	2.47	5.23	7.72	11.58	14.98	18.52	No	0.027	3.0	7.87	55.6	**Q100**
LBH-P-M-X-134	Arch CMP	6.00	4.3	14.75	9.76	18.99	26.69	38.15	48.34	58.53	Yes	0.027	1.0	5.81	85.6	**Q100**
TGC-F-M-X-115	CMP/Wood	3.50	1.0	0.79	3.36	6.97	10.17	15.10	19.44	23.92	N/A	0.02	N/A	N/A	N/A	**N/A**
TGC-F-M-X-94	CMP	2.00	1.3	1.23	1.11	2.46	3.73	5.77	7.55	9.45	Yes	0.027	N/A	N/A	N/A	**N/A**
NTC-P-F-X-348	CMP	N/A	2.0	3.14	N/A	N/A	N/A	N/A	N/A	N/A	No	0.027	1.5	4.25	13.3	**N/A**
LBM-P-F-X-185	CMP / Concrete	3.00	3.0	7.07	2.47	5.23	7.72	11.58	14.98	18.52	N/A	0.02	N/A	N/A	N/A	**N/A**
CPC-F-M-X-502	Ford crossing	Ford crossing	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
UDC-F-M-X-411	Ford crossing	Ford crossing	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
TRC-P-F-X-237	Ford crossing	Ford crossing	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**
TRC-P-M-X-232	Ford crossing	Ford crossing	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**

The slope of SSC-P-F-X-347 was changed from 0 to 0.1 percent in order to complete Manning's equation calculations. *** Assumed 0.1% slope**

[A]n, Manning's Equation Roughness Coefficient Reference: (Wanielista, et al., 1997)

Table EA-10. Culvert Failure Load Potential Per 25% Probability and Per Storm Event (tons/year)

6th Code Subwatershed (USGS HUC 12)	Q2	Q5, Q10 & Q25	Q50	Q100
Percent of Culverts Passing Storm Event	**0%**	**21%**	**47%**	**57%**
Little Blackfoot River-Hat Creek	0.0	12.5	28.0	34.0
Little Blackfoot River-Larabee Gulch	0.0	4.0	9.0	11.0
Little Blackfoot River-Mead Creek	0.0	23.4	52.5	63.6
Little Blackfoot River (Previously Elliston Creek)	0.0	10.5	23.5	28.5
Elliston Creek	0.0	2.8	6.3	7.7
Upper Dog Creek – Listed Waterbody MT76G004_071	0.0	7.7	17.2	20.8
Lower Dog Creek - Listed Waterbody MT76G004_072	0.0	9.3	20.8	25.2
Upper Dog Creek – Listed Waterbody MT76G004_072	0.0	12.1	27.1	32.9
Snowshoe Creek	0.0	11.3	25.3	30.7
Lower Spotted Dog Creek	0.0	8.1	18.1	21.9
Upper Spotted Dog Creek - Listed	0.0	2.4	5.4	6.6
South Fork Dog Creek	0.0	2.8	6.3	7.7
Telegraph Creek - Listed	0.0	21.4	48.0	58.2
Threemile Creek - Listed	0.0	5.3	11.8	14.3
Lower Carpenter Creek	0.0	17.8	39.8	48.3
Upper Carpenter Creek	0.0	3.2	7.2	8.8
Telegraph Creek – Not Listed	0.0	2.0	4.5	5.5
Mike Renig Gulch	0.0	2.0	4.5	5.5
North Trout Creek	0.0	9.3	20.8	25.2
Ontario Creek	0.0	14.1	31.7	38.4
Sixmile Creek	0.0	6.1	13.6	16.5
Trout Creek	0.0	4.0	9.0	11.0
Upper Spotted Dog Creek – Not Listed	0.0	3.2	7.2	8.8
Threemile Creek – Not Listed	0.0	0.4	0.9	1.1
Total	***0.0***	***195.7***	***437.9***	***532.2***

Sample calculation: Little Blackfoot River – Hat Creek , Q5 Storm Event

$$Load = (probability) \times (percent_passing) \times (\#crossings) \times (average_fill_at_risk_TableA\text{–}10)$$

$$Load = (0.25) \times (0.21) \times (31 crossings) \times (7.7 tons) = 12.5 \frac{tons}{year}$$

Table EA-11. Total Annual Sediment Load from all Sources and Potential BMP Reduction

6th Code Subwatershed (USGS HUC 12)	Total Annual Sediment Load Crossings (t/y)	Total Annual Sediment Load Parallel Segments (t/y)	Total Annual Sediment Load – Traction Sand (t/y)	Culvert Failure-Q2 Storm Event	Culvert Failure-Q5, Q10 and Q25 Storm Events	Culvert Failure-Q50 Storm Event	Culvert Failure-Q100 Storm Event	Sum [A] (Crossings, Parallel Segments, &Traction Sand)	Sum with All Available Sediment Reductions[B] (t/y)	Percent Reduction[C] %
	1	2	3	4	5	6	7	8	9	10
Little Blackfoot River-Hat Creek	2.13	0.02	-	0.0	12.5	28.0	34.0	2.15	0.63	70.7%
Little Blackfoot River-Larabee Gulch	0.70	0.01	-	0.0	4.0	9.0	11.0	0.71	0.21	70.4%
Telegraph Creek - Listed	3.71	0.04	-	0.0	21.4	48.0	58.2	3.75	1.1	70.7%
Telegraph Creek – Not Listed	0.35	0.00	-	0.0	2.0	4.5	5.5	0.35	0.1	71.4%
Ontario Creek	2.45	0.02	-	0.0	14.1	31.7	38.4	2.47	0.72	70.9%
Mike Renig Gulch	0.35	0.01	-	0.0	2.0	4.5	5.5	0.36	0.11	69.4%
Upper Little Blackfoot River Total	***9.69***	***0.10***			***56.0***	***125.7***	***152.6***	***9.79***	***2.87***	***70.7%***
Little Blackfoot River-Mead Creek	5.50	0.01	13.85	0.0	23.4	52.5	63.6	19.36	10.29	46.8%
Little Blackfoot River (Previously Elliston Creek)	1.74	0.02	7.24	0.0	10.5	23.5	28.5	9.78	5.79	40.8%
Elliston Creek	0.45	0.01	0.45	0.0	2.8	6.3	7.7	0.89	0.43	51.7%
Upper Dog Creek – Listed Waterbody MT76G004_071	1.33	0.02	-	0.0	7.7	17.2	20.8	1.35	0.4	70.4%
Lower Dog Creek - Listed Waterbody MT76G004_072	1.65	0.02	-	0.0	9.3	20.8	25.2	1.67	0.48	71.3%
Upper Dog Creek – Listed Waterbody MT76G004_072	2.10	0.04	-	0.0	12.1	27.1	32.9	2.14	0.64	70.1%
Snowshoe Creek	2.28	0.03	-	0.0	11.3	25.3	30.7	2.31	0.59	74.5%
Lower Spotted Dog Creek	2.20	0.00	-	0.0	8.1	18.1	21.9	2.2	0.4	81.8%

Table EA-11. Total Annual Sediment Load from all Sources and Potential BMP Reduction

6th Code Subwatershed (USGS HUC 12)	Total Annual Sediment Load Crossings (t/y)	Total Annual Sediment Load Parallel Segments (t/y)	Total Annual Sediment Load – Traction Sand (t/y)	Culvert Failure-Q2 Storm Event	Culvert Failure-Q5, Q10 and Q25 Storm Events	Culvert Failure-Q50 Storm Event	Culvert Failure-Q100 Storm Event	Sum [A] (Crossings, Parallel Segments, &Traction Sand)	Sum with All Available Sediment Reductions[B] (t/y)	Percent Reduction[C] %
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Upper Spotted Dog Creek - Listed	0.54	0.00	-	0.0	2.4	5.4	6.6	0.54	0.12	77.8%
South Fork Dog Creek	0.69	0.00	-	0.0	2.8	6.3	7.7	0.69	0.14	79.7%
Threemile Creek - Listed	0.63	0.00	0.96	0.0	5.3	11.8	14.3	1.59	0.8	49.7%
Lower Carpenter Creek	3.96	0.03	-	0.0	17.8	39.8	48.3	3.99	0.91	77.2%
Upper Carpenter Creek	0.56	0.01	-	0.0	3.2	7.2	8.8	0.57	0.17	70.2%
North Trout Creek	1.81	0.02	-	0.0	9.3	20.8	25.2	1.83	0.48	73.8%
Sixmile Creek	1.45	0.00	6.00	0.0	6.1	13.6	16.5	7.45	4.28	42.6%
Trout Creek	0.78	0.01	9.79	0.0	4.0	9.0	11.0	10.58	6.72	36.5%
Upper Spotted Dog Creek – Not Listed	0.56	0.01	-	0.0	3.2	7.2	8.8	0.57	0.17	70.2%
Threemile Creek – Not Listed	0.11	0.00	-	0.0	0.4	0.9	1.1	0.11	0.02	81.8%
Lower Little Blackfoot River Total	***38.03***	***0.35***	***39.04***	***0.0***	***195.7***	***437.9***	***532.2***	***76.65***	***35.7***	***53.4%***

Bold text indicates that segment is 303(d) listed for sediment impairment

[A]Sum = Column 1+2+3

[B]Sum = Sediment load per crossing (**Table EA-13** Total Load) + Column 2 + Sediment Load per Traction Sand BMPs (**Table EA-4**)

[C]Percent Reduction = (Column 8-Column 9) / Column 8

.

Table EA-12. Comparability of Field Data to WEPP:Road Parameters

WEPP:Road Variable	Road gradient (%)	Road length (ft)	Road width (ft)	Fill gradient (%)	Fill length (ft)	Buff gradient (%)	Buff length (ft)	Rock content (%)
Minimum Value	0.3%	3 ft	1 ft	0.3%	1 ft	0.3%	1 ft	0%
Maximum Value	40%	1000 ft	300 ft	150%	1000 ft	100%	1000 ft	100%
Measured Range from the Field Data	0.5 - 13%	35 – 1000 feet	8 – 33 ft	0.3 – 145 %	1 – 37 ft	0.3 – 27.5%	1 – 60 ft	5 – 50%
Non-compliant values	CPC-P-M-P-465 (Not recorded)	TMC-P-V-X-442 (1147 feet)	None.	Multiple entries (-)	Multiple entries (-)	Multiple entries (-)	Multiple entries (-)	TGC-F-M-X-48 (80%)
Action Taken	Assumptions listed in **Attachment EC**.	Assumptions listed in **Attachment EC**.	None.	Minimum values entered for (-) entries.	Minimum values entered for (-) entries.	Minimum values entered for (-) entries.	Minimum values entered for (-) entries.	50% entered per WEPP guidance.

ATTACHMENT EB - WEPP: ROAD MODEL ADJUSTMENTS AND CUSTOM CLIMATE PARAMETERS

WEPP: ROAD MODEL ADJUSTMENTS

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

There are three traffic scenarios available in the model. For roads where vegetation has grown up on the edges, the no traffic scenario is most appropriate as this scenario grows a limited amount of vegetation on the road. It uses the same plant growth for the road that the high traffic used for the fillslope. **Table EB-1** explains the model assumptions for the three traffic scenarios.

Table EB-1. Model assumptions for the three traffic scenarios

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

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

PARALLEL ROAD ADJUSTMENTS

The WEPP:Road model has a maximum contributing road length of 1000-feet. According to Dr. Elliott, it is rare that the contributing road length ever exceeds this distance. As a result, any field assessed parallel road segment in excess of this distance was reduced to 1000-feet for modeling purposes. **Table EB-2** explains the model adjustments.

ROAD CROSSING MODEL ADJUSTMENTS

Some road crossing locations had contributing road length on each side of the crossing, and road conditions were significantly different on each side. In these situations, each road segment was modeled separately and the two segments were then summed to get the total sediment load for the crossing. Also, some crossing locations were located at the convergence of two or more roads, with all roads contributing to sediment load at the crossing. In these cases, road segments were modeled separately and then summed to get the total sediment load for the crossing. **Table EB-2** explains the model adjustments..

Table EB-2. Specific WEPP: Road Modeling Adjustments Per Crossing or Parallel Segment

Site Name	Road Design	Model Adjustments
LBM-P-F-P-316	OR	Insloped, Rutted road - modeled as OR per WEPP guidance
TMC-P-V-X-442	IV & OU	Crowned Road. Modeled as IV and OU with half the width of road for each road type per WEPP Draft Guidance, Reduced road length from 1147 feet to 1000 feet per WEPP:road author guidance.
CPC-P-M-P-465	OR	Crowned Road. Modeled as OR with width of road only per WEPP Draft Guidance, Added Road gradient from photographs.
UDC-F-M-X-411	OR	Insloped, Rutted road - modeled as OR per WEPP guidance
NTC-P-M-X-387	OR	Insloped, Rutted road - modeled as OR per WEPP guidance. Added fill gradient from photographs.
LBM-P-F-X-185	IB	Crowned Road. Modeled as IB with width of road + ditches per WEPP Draft Guidance. Field sheets erroneous with Road Length. Modeled as 1000 ft.
LBM-P-V-X-198	IB	Crowned Road. Modeled as IB with width of road + ditch per WEPP Draft Guidance
LBH-P-M-X-134	IV	Crowned Road. Modeled as IB with width of road + ditch per WEPP Draft Guidance
TGC-F-M-X-130	OR	Insloped, Rutted road - modeled as OR per WEPP guidance
TGC-F-M-X-130	OR	
TGC-F-M-X-74	OR	Difficult to determine if the road was rutted due to snow. Assumed rutted and modeled as OR with veg. ditch (width of road only in claculation) per WEPP guidance.
TGC-F-M-X-48	IB	Crowned Road. Modeled as IB with width of road only per WEPP Draft Guidance. Rock content 50%.

Road crossings and parallel segments that are not listed above were not altered from the field worksheets when entered into the WEPP model.
Road Design options: OU = Outslope unrutted road, OR = Outslope rutted road, IV = Inslope road with vegetated or rocked ditch, IB = Inslope road with bare ditch

Elliston, MT (46.40°N 112.80°W; 5080 feet elevation) information for the last 34 years of record see **Table EB-3** and **EB-4**.

Table EB-3. Temperature and Precipitation for Elliston, MT

Month	Mean Maximum Temperature (°F)	Mean Minimum Temperature (°F)	Mean Precipitation (in)	Number of wet days
January	30.2	9.0	1.10	10.0
February	35.4	12.8	0.71	7.8
March	40.1	16.2	1.00	10.0
April	50.5	25.4	1.54	9.1
May	61.1	33.4	2.21	11.1
June	69.0	39.8	2.97	11.0
July	81.5	44.4	1.27	7.1
August	78.9	41.8	1.35	5.9
September	67.5	34.1	1.69	7.1
October	55.6	26.6	1.31	6.9
November	40.5	17.8	1.05	8.1
December	32.3	11.6	0.99	9.0
Annual			17.21	103.1

Tables EB-4. Interpolated Climate Data for Elliston, MT

Station	Weighting	Station	Weighting
Wind Stations		**Solar Radiation and Max .5 P Stations**	
DRUMMOND MT	43.4 %	HELENA, MONTANA	69.4 %
BUTTE MT	30.7 %	KALISPELL, MONTANA	18.9 %
HELENA MT	26 %	POCATELLO, IDAHO	11.7 %
Dewpoint Stations		**Time-to-Peak Stations**	
BUTTE MT	42 %	BOULDER ST SCHOOL M	36.5 %
HELENA MT	37.6 %	BUTTE 8 S MT	35.3 %
MISSOULA MT	20.4 %	OVANDO 1 SW MT	28.2 %

Modified by Rock:Clime on November 18, 2009 from DEER LODGE 3W MT 242275 0

Moulton, MT **(**46.40°N 112.80°W; 6700 feet elevation) information for the 34 years of record see **Table EB-5** and **EB-6**.

Table EB-5. Temperature and Precipitation for Moulton, MT

Month	Mean Maximum Temperature (°F)	Mean Minimum Temperature (°F)	Mean Precipitation (in)	Number of wet days
January	31.8	3.9	1.24	8.9
February	33.8	5.3	1.70	8.9
March	39.1	12.9	2.10	9.1
April	44.8	18.3	1.86	8.1
May	52.8	26.8	2.87	9.9
June	62.6	32.7	2.74	10.1
July	72.3	37.6	1.61	8.1
August	72.5	37.4	1.23	6.8
September	60.3	28.2	2.02	9.2
October	47.3	20.1	1.65	6.9
November	34.1	9.1	1.28	7.1
December	29.2	2.6	1.38	9.9
Annual			21.68	103.0

Table EB-6. Interpolated Climate Data for Moulton, MT

Station	Weighting	Station	Weighting
Wind Stations		**Solar Radiation and Max .5 P Stations**	
DRUMMOND MT	43.4 %	HELENA, MONTANA	69.4 %
BUTTE MT	30.7 %	KALISPELL, MONTANA	18.9 %
HELENA MT	26 %	POCATELLO, IDAHO	11.7 %
Dewpoint Stations		**Time-to-Peak Stations**	
BUTTE MT	42 %	BOULDER ST SCHOOL M	36.5 %
HELENA MT	37.6 %	BUTTE 8 S MT	35.3 %
MISSOULA MT	20.4 %	OVANDO 1 SW MT	28.2 %
Modified by Rock:Clime on November 18, 2009 from DEER LODGE 3W MT 242275 0			

3Mile-V-2 PRISM (46.67°N 112.60°E; 5248 feet elevation) information for the last 34 years of record see **Table EB-7** and **EB-8**.

Table EB-7. Temperature and Precipitation for 3Mile-V-2 PRISM

Month	Mean Maximum Temperature (°F)	Mean Minimum Temperature (°F)	Mean Precipitation (in)	Number of wet days
January	31.8	10.1	1.31	6.0
February	38.4	15.9	0.94	4.3
March	44.4	19.4	1.13	5.6
April	54.8	25.8	1.38	7.7
May	63.0	32.8	2.32	11.1
June	71.9	40.0	1.95	10.8
July	80.7	43.1	1.32	6.6
August	80.1	41.8	1.47	7.3
September	69.2	34.0	1.43	7.2
October	58.4	26.2	1.01	5.3
November	42.1	18.1	1.12	5.6
December	33.0	11.9	1.37	6.8
Annual			16.76	84.4

Table EB-8. Interpolated Climate Data for 3Mile-V-2 PRISM

Station	Weighting	Station	Weighting
Wind Stations		**Solar Radiation and Max .5 P Stations**	
DRUMMOND MT	43.4 %	HELENA, MONTANA	69.4 %
BUTTE MT	30.7 %	KALISPELL, MONTANA	18.9 %
HELENA MT	26 %	POCATELLO, IDAHO	11.7 %
Dewpoint Stations		**Time-to-Peak Stations**	
BUTTE MT	42 %	BOULDER ST SCHOOL M	36.5 %
HELENA MT	37.6 %	BUTTE 8 S MT	35.3 %
MISSOULA MT	20.4 %	OVANDO 1 SW MT	28.2 %

Modified by Rock:Clime on November 24, 2009 from DEER LODGE 3W MT 242275 0

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

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

Comment	Elevation	Soil	Years	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual rain runoff (in)	Average annual snow runoff (in)	Average annual sediment leaving road (lb/yr)	Average annual sediment leaving buffer (lb/yr)
Valley Landscape																	
LBM-P-V-X-198	3MILE PRISM	Sandy Loam	50	Insloped, bare ditch	graveled high	0.5	176	18	27	7	0.3	1	25	0.2	0	21	19
TMC-P-V-X-442	3MILE PRISM	Silty Loam	50	Insloped, vegetated or rocked ditch	graveled high	1	1000	10	100	5	0.3	1	10	0.2	0	49	85
TMC-P-V-X-442	3MILE PRISM	Silty Loam	50	Outsloped, unrutted	graveled high	1	1000	10	145	5	0.3	1	10	0	0	217	Summed
Valley Landscape (tons/year)							**588**									**Mean**	**0.03**
														25th	**0.018**	**Median**	**0.03**
														75th	**0.03**	**Maximum**	**0.04**
																Minimum	**0.01**
Foothill Landscape																	
LBM-P-F-X-185	Elliston	Sand Loam	50	Insloped, bare ditch	graveled high	4	1000	26	0.3	1	0.3	1	10	0.4	0	1,032	947
TRC-P-F-X-237	Elliston	Sand Loam	50	Insloped, vegetated or rocked ditch	native low	3	305	9	9.5	8	0.3	1	15	0.2	0	9	10
TRC-P-F-X-237	Elliston	Sand Loam	50	Insloped, vegetated or rocked ditch	native low	5	45	9	5	8	0.3	1	15	0.1	0	2	Summed
SSC-P-F-X-347	Elliston	Sand Loam	50	Insloped, vegetated or rocked ditch	graveled high	5	310	14	100	7	0.3	1	35	0.3	0	95	113
LBM-S-F-X-270	Elliston	Sand Loam	50	Outsloped, rutted	graveled low	3	64.5	10.5	23	14	0.3	1	30	0.2	0	4	26
LBM-S-F-X-270	Elliston	Sand Loam	50	Outsloped, rutted	graveled low	13	110	10.5	23	14	0.3	1	30	0.3	0	33	Summed
NTC-P-F-X-348	Elliston	Sand Loam	50	Outsloped, unrutted	graveled high	0.5	135	16	35	11	0.3	1	50	0.1	0	26	13
Foothill Landscape (tons/year)							**394**									**Mean**	**0.11**
														25th	**0.007**	**Median**	**0.01**
														75th	**0.06**	**Maximum**	**0.47**
																Minimum	**0.01**
Mountain Landscape																	
LBH-P-M-X-134	Moulton	Clay Loam	30	Insloped, vegetated or rocked ditch	native high	1	100	26	23	4.75	0.3	1	45	1	1.9	33	20
TGC-F-M-X-74	Moulton	Clay Loam	30	Outsloped, rutted	native low	2	137	16	36	5	0.3	1	30	0.9	2	14	9
TGC-F-M-X-48	Moulton	Loam	30	Insloped, bare ditch	graveled low	3	144	9	70	12	0.3	1	50	0.2	0	12	26
TGC-F-M-X-48	Moulton	Loam	30	Insloped, bare ditch	graveled low	5	156	9	70	12	0.3	1	50	0.2	0	17	Summed
TGC-F-M-X-130	Moulton	Sand Loam	30	Outsloped, rutted	native low	8	123	15	46	10	0.3	1	30	0.2	0	22	30
TGC-F-M-X-130	Moulton	Sand Loam	30	Outsloped, rutted	native low	5	120	8	46	13	0.3	1	30	0.2	0	8	Summed
TGC-F-M-X-94	Moulton	Sand Loam	30	Insloped, vegetated or rocked ditch	native low	4	860	17	26	3	0.3	1	20	0.2	0.1	69	66
TRC-P-M-X-232	Moulton	Sand Loam	30	Insloped, vegetated or rocked ditch	native low	2.5	628	9	0.3	1	0.3	1	35	0.2	0.1	20	28
TRC-P-M-X-232	Moulton	Sand Loam	30	Insloped, vegetated or rocked ditch	native low	6	200	9	0.3	1	0.3	1	35	0.2	0.1	11	Summed
USD-F-M-X-96	Moulton	Sand Loam	30	Insloped, vegetated or rocked ditch	graveled high	1	67	13	26	37	0.3	1	10	0.1	0	6	35
USD-F-M-X-96	Moulton	Sand Loam	30	Insloped, vegetated or rocked ditch	graveled low	6	180	13	26	37	0.3	1	10	0.2	0	33	Summed
USD-P-M-X-116	Moulton	Sand Loam	30	Insloped, vegetated or rocked ditch	native high	4	416	22	58	13	0.3	1	25	0.2	0.1	164	202
USD-P-M-X-116	Moulton	Sand Loam	30	Insloped, vegetated or rocked ditch	native high	2	286	13	58	13	0.3	1	25	0.2	0	37	Summed
USD-P-M-X-116	Moulton	Sand Loam	30	Outsloped, rutted	native high	3	96	13	58	13	0.3	1	25	0.2	0	13	Summed
TGC-F-M-X-127	Moulton	Sand Loam	30	Outsloped, rutted	native low	6	275.5	11	85	14	0.3	1	45	0.4	0.1	81	112
TGC-F-M-X-127	Moulton	Sand Loam	30	Outsloped, rutted	native low	9	152	11	85	14	0.3	1	45	0.3	0.1	46	Summed
TRC-F-M-X-168	Moulton	Sand Loam	30	Outsloped, rutted	graveled high	4	276	15	58	17	0.3	1	35	0.2	0	94	434
TRC-F-M-X-168	Moulton	Sand Loam	30	Outsloped, rutted	graveled high	5	599	15	58	17	0.3	1	35	0.2	0	322	Summed
SSC-F-M-X-462	Moulton	Sand Loam	30	Outsloped, unrutted	native high	2	550	15	17	26	0.3	1	30	0	0	78	32
UDC-F-M-X-411	Moulton	Silt Loam	30	Outsloped, rutted	native low	7.5	700	10	0.3	1	0.3	1	30	1	1.8	760	585
NTC-P-M-X-387	Moulton	Silt Loam	30	Outsloped, rutted	native low	10.5	300	33	100	7	0.3	1	25	0.7	1.2	862	636
CPC-F-M-X-502	Moulton	Silt Loam	30	Outsloped, unrutted	native none	1	35	8	56	3	0.3	1	25	0.1	0	2	0
TGC-F-M-X-115	Moulton	Silt Loam	30	Outsloped, unrutted	native none	5	55	10	21	4	0.3	1	0	0.1	0	4	1

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

Comment	Elevation	Soil	Years	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual rain runoff (in)	Average annual snow runoff (in)	Average annual sediment leaving road (lb/yr)	Average annual sediment leaving buffer (lb/yr)
Mountain Landscape (tons/year)							**450**									**Mean**	**0.07**
														25th	**0.012**	**Median**	**0.02**
														75th	**0.08**	**Maximum**	**0.32**
																Minimum	**0.00**

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

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

Comment	Elevation	Soil	Years	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual rain runoff (in)	Average annual snow runoff (in)	Average annual sediment leaving road (lb/yr)	Average annual sediment leaving buffer (lb/yr)
Fooothill Parallel Segments																	
LBM-P-F-P-316	Elliston	Silt Loam	50	Outsloped, rutted	native low	8	355	15	78	5	27.5	49.5	7.5	0.1	0	435	82
Mountain Parallel Segments																	
SSC-P-M-P-412	Moulton	Sand Loam	30	Insloped, vegetated or rocked ditch	native low	9	200	22	85	6	0.3	1	40	0.3	0.1	73	65
SSC-P-M-P-412	Moulton	Sand Loam	30	Outsloped, rutted	native high	7	304	10	42	6	20	60	15	0	0	117	24
CPC-P-M-P-465	Moulton	Silt Loam	30	Outsloped, rutted	native high	5	528	15	119	3	0.3	1	50	1.6	3.1	2,541	2,098
SSC-P-M-P-412	Moulton	Silt Loam	30	Insloped, vegetated or rocked ditch	graveled high	4	475	22	70	12	14	27	15	0.1	0	290	203
Mountain Landscape Parallel Segments Results (tons/year/mile)											Mean	22.3				**Mean**	**0.021**
											Median	14		**25th**	**0.002**	**Median**	**0.005**
														75th	**0.024**	**Maximum**	**0.075**
																Minimum	**0.001**

ATTACHMENT ED - WEPP: ROAD MODELING RESULTS FOR FIELD ASSESSED SITES WITH ROAD LENGTH REDUCTIONS

Table ED-1. WEPP: Road Modeling Results for Field Assessed Crossings: 200 feet maximum length

Comment	Elevation	Soil	Years	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual rain runoff (in)	Average annual snow runoff (in)	Average annual sediment leaving road (lb/yr)	Average annual sediment leaving buffer (lb/yr)
Valley Landscape																	
LBM-P-V-X-198	3MILE PRISM	Sandy Loam	50	Insloped, bare ditch	graveled high	0.5	176	18	27	7	0.3	1	25	0.2	0	21	19
TMC-P-V-X-442	3MILE PRISM	Silty Loam	50	Insloped, vegetated or rocked ditch	graveled high	1	200	10	100	5	0.3	1	10	0.2	0	23	29
TMC-P-V-X-442	3MILE PRISM	Silty Loam	50	Outsloped, unrutted	graveled high	1	200	10	145	5	0.3	1	10	0	0	43	Summed
Valley Landscape (tons/year)							**188**									**Mean**	**0.01**
														25th	**0.011**	**Median**	**0.01**
														75th	**0.01**	**Maximum**	**0.01**
																Minimum	**0.01**
Foothill Landscape																	
LBM-P-F-X-185	Elliston	Sand Loam	50	Insloped, bare ditch	graveled high	4	200	26	0.3	1	0.3	1	10	0.4	0	168	133
TRC-P-F-X-237	Elliston	Sand Loam	50	Insloped, vegetated or rocked ditch	native low	3	155	9	9.5	8	0.3	1	15	0.2	0	5	5
TRC-P-F-X-237	Elliston	Sand Loam	50	Insloped, vegetated or rocked ditch	native low	5	45	9	5	8	0.3	1	15	0.1	0	2	Summed
SSC-P-F-X-347	Elliston	Sand Loam	50	Insloped, vegetated or rocked ditch	graveled high	5	200	14	100	7	0.3	1	35	0.3	0	74	65
LBM-S-F-X-270	Elliston	Sand Loam	50	Outsloped, rutted	graveled low	3	64.5	10.5	23	14	0.3	1	30	0.2	0	4	26
LBM-S-F-X-270	Elliston	Sand Loam	50	Outsloped, rutted	graveled low	13	110	10.5	23	14	0.3	1	30	0.3	0	33	Summed
NTC-P-F-X-348	Elliston	Sand Loam	50	Outsloped, unrutted	graveled high	0.5	135	16	35	11	0.3	1	50	0.1	0	26	13
Foothill Landscape (tons/year)							**182**									**Mean**	**0.02**
														25th	**0.007**	**Median**	**0.01**
														75th	**0.03**	**Maximum**	**0.07**
																Minimum	**0.00**
Mountain Landscape																	
LBH-P-M-X-134	Moulton	Clay Loam	30	Insloped, vegetated or rocked ditch	native high	1	100	26	23	4.75	0.3	1	45	1	1.9	33	20
TGC-F-M-X-74	Moulton	Clay Loam	30	Outsloped, rutted	native low	2	137	16	36	5	0.3	1	30	0.9	2	14	9
TGC-F-M-X-48	Moulton	Loam	30	Insloped, bare ditch	graveled low	3	100	9	70	12	0.3	1	50	0.2	0	8	15
TGC-F-M-X-48	Moulton	Loam	30	Insloped, bare ditch	graveled low	5	100	9	70	12	0.3	1	50	0.2	0	10	Summed
TGC-F-M-X-130	Moulton	Sand Loam	30	Outsloped, rutted	native low	8	100	15	46	10	0.3	1	30	0.2	0	16	22
TGC-F-M-X-130	Moulton	Sand Loam	30	Outsloped, rutted	native low	5	100	8	46	13	0.3	1	30	0.2	0	6	
TGC-F-M-X-94	Moulton	Sand Loam	30	Insloped, vegetated or rocked ditch	native low	4	200	17	26	3	0.3	1	20	0.2	0	13	11
TRC-P-M-X-232	Moulton	Sand Loam	30	Insloped, vegetated or rocked ditch	native low	2.5	100	9	0.3	1	0.3	1	35	0.2	0.1	3	5
TRC-P-M-X-232	Moulton	Sand Loam	30	Insloped, vegetated or rocked ditch	native low	6	100	9	0.3	1	0.3	1	35	0.2	0.1	5	Summed
USD-F-M-X-96	Moulton	Sand Loam	30	Insloped, vegetated or rocked ditch	graveled high	1	67	13	26	37	0.3	1	10	0.1	0	6	24
USD-F-M-X-96	Moulton	Sand Loam	30	Insloped, vegetated or rocked ditch	graveled low	6	133	13	26	37	0.3	1	10	0.2	0	15	Summed
USD-P-M-X-116	Moulton	Sand Loam	30	Insloped, vegetated or rocked ditch	native high	4	104	22	58	13	0.3	1	25	0.2	0	26	40
USD-P-M-X-116	Moulton	Sand Loam	30	Outsloped, rutted	native high	3	96	13	58	13	0.3	1	25	0.2	0	13	Summed
USD-P-M-X-116	Moulton	Sand Loam	30	Outsloped, rutted	native high	SEGMENT NOT INCLUDED WITH BMP ROAD LENGTH REDUCTION											
TGC-F-M-X-127	Moulton	Sand Loam	30	Outsloped, rutted	native low	6	100	11	85	14	0.3	1	45	0.3	0.1	20	38
TGC-F-M-X-127	Moulton	Sand Loam	30	Outsloped, rutted	native low	9	100	11	85	14	0.3	1	45	0.3	0.1	19	Summed
TRC-F-M-X-168	Moulton	Sand Loam	30	Outsloped, rutted	graveled high	4	100	15	58	17	0.3	1	35	0.2	0	22	53
TRC-F-M-X-168	Moulton	Sand Loam	30	Outsloped, rutted	graveled high	5	100	15	58	17	0.3	1	35	0.2	0	27	Summed
SSC-F-M-X-462	Moulton	Sand Loam	30	Outsloped, unrutted	native high	2	200	15	17	26	0.3	1	30	0	0	28	12
UDC-F-M-X-411	Moulton	Silt Loam	30	Outsloped, rutted	native low	7.5	200	10	0.3	1	0.3	1	30	0.8	1.5	55	37
NTC-P-M-X-387	Moulton	Silt Loam	30	Outsloped, rutted	native low	10.5	200	33	100	7	0.3	1	25	0.6	0.9	386	272
CPC-F-M-X-502	Moulton	Silt Loam	30	Outsloped, unrutted	native none	1	35	8	56	3	0.3	1	25	0.1	0	2	0
TGC-F-M-X-115	Moulton	Silt Loam	30	Outsloped, unrutted	native none	5	55	10	21	4	0.3	1	0	0.1	0	4	1

Table ED-1. WEPP: Road Modeling Results for Field Assessed Crossings: 200 feet maximum length

Comment	Elevation	Soil	Years	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual rain runoff (in)	Average annual snow runoff (in)	Average annual sediment leaving road (lb/yr)	Average annual sediment leaving buffer (lb/yr)
Mountain Landscape (tons/year)							**177**									**Mean**	**0.02**
														25th	**0.005**	**Median**	**0.01**
														75th	**0.02**	**Maximum**	**0.14**
																Minimum	**0.00**

Table ED-2. WEPP: Road Modeling Results for Field Assessed Parallel Segments: 400 feet maximum length

Comment	Elevation	Soil	Years	Design	Surface, traffic	Road grad (%)	Road length (ft)	Road width (ft)	Fill grad (%)	Fill length (ft)	Buff grad (%)	Buff length (ft)	Rock cont (%)	Average annual rain runoff (in)	Average annual snow runoff (in)	Average annual sediment leaving road (lb/yr)	Average annual sediment leaving buffer (lb/yr)
Fooothill Parallel Segments																	
LBM-P-F-P-316	Elliston	Silt Loam	50	Outsloped, rutted	native low	8	355	15	78	5	27.5	49.5	7.5	0.1	0	435	82
Mountain Parallel Segments																	
SSC-P-M-P-412	Moulton	Sand Loam	30	Insloped, vegetated or rocked ditch	native low	9	200	22	85	6	0.3	1	40	0.3	0.1	73	65
SSC-P-M-P-412	Moulton	Sand Loam	30	Outsloped, rutted	native high	7	304	10	42	6	20	60	15	0	0	117	24
CPC-P-M-P-465	Moulton	Silt Loam	30	Outsloped, rutted	native high	5	400	15	119	3	0.3	1	50	1.5	2.9	1,365	1,111
SSC-P-M-P-412	Moulton	Silt Loam	30	Insloped, vegetated or rocked ditch	graveled high	4	400	22	70	12	14	27	15	0.1	0	225	146
Mountain Landscape Parallel Segments Results (tons/year/mile)											Mean	22.3				**Mean**	**0.010**
											Median	14		**25th**	**0.002**	**Median**	**0.003**
														75th	**0.012**	**Maximum**	**0.075**
																Minimum	**0.001**

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

APPENDIX F - DETAILED SOURCE ASSESSMENT AND DATA REVIEW

TABLE OF CONTENTS

F.1 Un-named Creek (MT76G006_010*) F-3
Detailed Mining History F-3
Ontario Mine F-3
Data Review by Pollutant F-3
F.2 Monarch Creek (MT76G004_060) F-5
Detailed Mining History F-5
Monarch Mine F-5
Data Review by Pollutant F-5
F.3 Ontario Creek (MT76G004_130) F-7
Detailed Mining History F-7
Hard Luck Mine F-7
Data Review by Pollutant F-7
F.4 Sally Ann Creek (MT76G004_055) F-8
Detailed Mining History F-8
Telegraph Mine F-8
Data Review by Pollutant F-8
F.5 O'Keefe Creek (MT76G004_054) F-9
Detailed Mining History F-9
Sure Thing Mine F-9
Data Review by Pollutant F-9
F.6 Telegraph Creek, Upper Segment (MT76G004_051) F-10
Detailed Mining History F-10
Lilly/Orphan Boy Mine F-10
Third Term Mine F-10
Julia Mine F-11
Anna R/Hattie M Mine F-11
Hub Camp Mine F-11
Viking Mine F-11
Unnamed Mine 8N6W6ABDB F-11
Data Review by Pollutant F-12
F.7 Telegraph Creek, Lower Segment (MT76G004_052) F-13

Detailed Mining History F-13
Data Review by Pollutant F-13
F.8 American Gulch Creek (MT76G004_079) F-14
Detailed Mining History F-14
Data Review by Pollutant F-14
F.9 Dog Creek, Upper Segment (MT76G004_071) F-15
Detailed Mining History F-15
Bald Butte Mine F-15
Devon/Sterling and Albion Mine F-15
Data Review by Pollutant F-15
F.10 Lower Dog Creek (MT76G004_072) F-16
Detailed Mining History F-16
Data Review by Pollutant F-16
F.11 Little Blackfoot River, Upper Segment (MT76G004_020) F-17
Detailed Mining History F-17
Charter Oak Mine F-17
Kimball Mine F-17
Golden Anchor Mine F-18
Mountain View Mine F-18
Data Review by Pollutant F-18
F.12 Little Blackfoot River, Lower Segment (MT76G004_010) F-20
Detailed Mining History F-20
Victory/Evening Star Mine F-20
Data Review by Pollutant F-20

F.1 UN-NAMED CREEK (MT76G006_010*)

DETAILED MINING HISTORY

Ontario Mine

The Ontario Mine is located mostly on private land with a small portion on the Helena National Forest and was one of the most prolific mines in the Elliston District. The mine worked a vein deposit that contained pyrite (a mineral known to promote the formation of acid mine drainage) producing lead, silver, gold and copper from 1890-1940 (Olsen, 2004). Until recently, the site consisted of ruined buildings, a discharging adit and a waste rock pile on private property and another discharging adit and lesser amounts of waste rock on National Forest lands. A key feature on both sides of the property line was a 150 feet wide tailings pile that extended 3,400 feet from the mill to Ontario Creek, with a major deposit at the confluence (Pioneer Technical Services, Inc., 1993). Tailings in the creek were additionally deposited at least another 1,500 feet downstream and were over 10 feet thick in some places (Hargrave, et al., 1998). The source of Un-named Creek is the upper discharging adit (Pioneer Technical Services, Inc., 1993). No high flow data is available for Un-named Creek but since the adit discharge supplies a substantial portion of the streamflow, conditions are assumed to be relatively constant throughout the year. In 2003, the USFS reclaimed mine-impacted land on Forest Service property (Tetra Tech, 2006). Two years later the DEQ AML program addressed the affected private property. The 2005 operation removed bare tailings piles and rock-lined the adit drainage channel; but DEQ AML did not treat or stop the adit discharge and the tailings that had naturally revegetated were left in place (Olsen, 2004). Efforts to reclaim Ontario Mine have not convincingly reduced metals concentrations in the creek; the highest cadmium concentration in the last 16 years was collected in 2008, after reclamation.

DATA REVIEW BY POLLUTANT

<u>Arsenic</u>

Un-named Creek is listed as impaired by arsenic on the 2010 303(d) List. Out of nine recent surface water samples, seven exceeded the human health standard and two samples exceeded the chronic aquatic life standard (22%). Because more than 10% of the samples exceeded the chronic aquatic life standard and the human health standard was exceeded, arsenic water quality targets were not met. Additionally, a sediment sample collected by DEQ in 2008 identified arsenic concentrations at levels nearly 350 times the supplemental indicator value. Based on target and supplemental indicator value exceedances, an arsenic TMDL was developed for Un-named Creek.

<u>Cadmium</u>

Un-named Creek is listed as impaired by cadmium on the 2010 303(d) List. Out of nine recent surface water samples, three exceeded the human health standard and all nine (100%) exceeded both standards of aquatic life. Because more than 10% of the samples exceeded the chronic aquatic life standard, concentrations were more than two times the acute aquatic life standard and the human health standard was exceeded, cadmium water quality targets were not met. Stream sediments collected in 2008 tested below the supplementary indicator value. Based on target exceedances, a cadmium TMDL was developed for Un-named Creek.

<u>Copper</u>

Un-named Creek is listed as impaired by copper on the 2010 303(d) List. Out of nine recent surface water samples, all nine (100%) greatly exceeded both standards of aquatic life. The highest recorded

copper concentration was 36 times more elevated than the acute aquatic life standard value. Because more than 10% of the samples exceeded the chronic aquatic life standard and concentrations were more than two times the acute aquatic life standard, copper water quality targets were not met. Stream sediments collected in 2008 tested below the supplementary indicator value. Based on target exceedances, a copper TMDL was developed for Un-named Creek.

Iron

Un-named Creek is not listed as impaired by iron on the 2010 303(d) List, however recent data provide evidence of iron as a cause of water quality impairment. Out of nine recent surface water samples, four (44%) exceeded the chronic aquatic life standard. Widespread iron deposits were observed in the rock-lined channel substrate during recent DEQ sampling. Because more than 10% of the samples exceeded the chronic aquatic life standard, iron water quality targets were not met. Additionally, although iron PELs also have not been established, a stream sediment sample collected in 2008 contained a staggering 242,000 µg/g of iron, which is nearly five times greater than the maximum value measured in other sediment samples throughout the Little Blackfoot watershed. Based on target exceedances, an iron TMDL was developed for Un-named Creek.

Lead

Un-named Creek is listed as impaired by lead on the 2010 303(d) List. Out of nine recent surface water samples, eight exceeded the chronic aquatic life standard (89%) and seven exceeded the human health standard. Because more than 10% of the samples exceeded the chronic aquatic life standard, concentrations were more than two times the acute aquatic life standard and the human health standard was exceeded, lead water quality targets were not met. Additionally, a sediment sample collected by DEQ in 2008 identified arsenic concentrations at levels more than three times the supplemental indicator value. Based on target and supplemental indicator value exceedances, a lead TMDL was developed for Un-named Creek.

Mercury

Un-named Creek is listed as impaired by mercury on the 2010 303(d) List. Out of five recent surface water samples, all five tested below the detection limit for mercury. However, only one of these samples can be used for TMDL development determinations because the other four had detection limits equal to the human health standard (0.05 µg/L) and unless detection limits are below the water quality standard, exceedances cannot be determined. Mercury was found to be below detection in the single sample with an acceptable detection limit (0.005 µg/L). Even though recent data depicts Un-named Creek as potentially attaining mercury water quality targets, because there is only one acceptable surface water sample and because human-related metals sources are present in the watershed, a mercury TMDL was developed. Additional monitoring for mercury is recommended.

pH

Un-named Creek is listed as impaired by pH on the 2010 303(d) List. All eight samples of Un-named Creek displayed severely acidic pH values. The lowest recorded pH value was 3.1, the highest was 5.4 and the median was 3.9. Other streams in the Little Blackfoot River TPA sampled in the watershed upstream of most mining influences exhibited more neutral pH levels. Additionally, the Ontario Mine worked a vein deposit containing pyrite, a mineral known to promote acid mine drainage (Olsen, 2004). It is therefore assumed that Un-named Creek's pH is depressed from natural background levels due to acid mine drainage associated with the Ontario Mine but because setting a daily load for pH is not practical and the reclamation activities needed to meet metals TMDLs should also address the sources causing pH impairment, metals TMDLs will act as a surrogate for a pH TMDL.

Zinc

Un-named Creek is listed as impaired by zinc on the 2010 303(d) List. Out of nine recent surface water samples, all nine (100%) exceeded both standards of aquatic life and one sample exceeded the human health standard. Even the lowest zinc concentration exceeded the acute aquatic life standard by a factor of six. Because more than 10% of the samples exceeded the chronic aquatic life standard, concentrations were more than two times the acute aquatic life standard and the human health standard was exceeded, zinc water quality targets were not met. Stream sediments collected in 2008 tested slightly below the secondary indicatory value (245 µg/g vs. 315 µg/g). Based on target exceedances, a zinc TMDL was developed for Un-named Creek.

F.2 Monarch Creek (MT76G004_060)

Detailed Mining History

Monarch Mine

The Monarch Mine is an inactive lode mine on DEQ's priority abandoned mines list located in the Helena National Forest on the northeast aspect of Bison Mountain. Monarch Mine was one of the most productive mines in the area operating from 1894 to 1909, with subsequent sporadic activity as recent as 1995 (Hargrave, et al., 1998). The site consists of a collapsed mill building, an open but locked adit, another adit that is caved-in but discharging and approximately 0.75 acres of well-vegetated tailings noticeable only by the presence of ferric-hydroxide-stained pools between the mill and creek (Hargrave, et al., 1998). A 1989 DEQ visual assessment observed "yellow boy" but the phenomenon has not been noted since (Montana Department of Environmental Quality, 2010). The discharging adit and a spring emerging out of a tailings pile exceed metals standards when tested by MBMG in 1995. At that time, Monarch Creek had no exceedances, although concentrations were higher in the sample downstream of the mine (Hargrave, et al., 1998). The MBMG report also found pyrite, a mineral known to promote the formation of acid mine drainage, present in the veins of Monarch Mine (Hargrave, et al., 1998).

Data Review by Pollutant

Arsenic

Monarch Creek is listed as impaired by arsenic on the 2010 303(d) List. Out of eight recent surface water samples, none exceeded water quality standards. Instead, all samples tested below the 3 µg/L detection limit. A DEQ 2004 formal reassessment of Monarch Creek found arsenic in stream sediment to be slightly elevated (23.6 µg/g vs. 17 µg/g PEL) but did not observe any effects to the benthic fauna (Montana Department of Environmental Quality, 2010). The reassessment concluded that although no surface water targets were exceeded, potential metals sources existed, and the steam remained listed for metals until more data could be collected to prove otherwise. When DEQ sampled Monarch Creek in 2008 and 2009, the findings were similar to the 2004 assessment; no surface water exceedances for arsenic but both sediment samples (19 µg/g and 22 µg/g) exceeded the supplemental indicator value. Because no recent samples exceeded arsenic water quality targets, no TMLD was developed and the 303(d) listing status for arsenic will be formally reevaluated by DEQ in the future.

Copper

Monarch Creek is listed as impaired by copper on the 2010 303(d) List. Out of eight recent surface water samples, two (25%) exceeded the chronic aquatic life standard. All copper samples collected during low

flow time periods were below detection. Because more than 10% of the samples exceeded the chronic aquatic life standard, copper water quality targets were not met. Stream sediments collected in 2004, 2008 and 2009 tested below the supplementary indicator value. Based on target exceedances, a copper TMDL was developed for Monarch Creek.

Lead

Monarch Creek is listed as impaired by lead on the 2010 303(d) List. Out of eight recent surface water samples, two (25%) exceeded the chronic aquatic life standard and both occurred during high flow conditions. All lead samples collected during low flow time periods were below detection. Because more than 10% of the samples exceeded the chronic aquatic life standard, lead water quality targets were not met. Additionally, two out of three sediment samples identified lead concentrations at levels exceeding the supplemental indicator value. Based on target and supplemental indicator value exceedances, a lead TMDL was developed for Monarch Creek.

Mercury

Monarch Creek is listed as impaired by mercury on the 2010 303(d) List. Out of six recent surface water samples, all six tested below the detection limit for mercury However, only one of these samples can be used for TMDL development determinations because the other five had detection limits equal to the human health standard (0.05 µg/L) and unless detection limits are below the water quality standard, exceedances cannot be determined. Mercury was found to be below detection in the single sample with an acceptable detection limit (0.005 µg/L). Even though recent data depicts Monarch Creek as potentially attaining mercury water quality targets, because there is only one acceptable surface water sample and because human-related metals sources are present in the watershed, a mercury TMDL was developed. Additional monitoring for mercury is recommended.

pH

Monarch Creek is listed as impaired by pH on the 2010 303(d) List. All eight samples of Monarch Creek displayed acidic pH values. The lowest recorded pH value was 4.96, the highest was 7.45 and the median was 5.92. There was no noticeable pattern in the pH data in regard to seasonality or flow conditions. Other streams in the Little Blackfoot River TPA sampled in the watershed upstream of most mining influences exhibited more neutral pH levels. DEQ's 2004 reassessment of Monarch Creek found small concentrations of common constituents present in the stream resulting in a low buffering capacity (Montana Department of Environmental Quality, 2010). Additionally, the Monarch Mine worked a vein deposit containing pyrite, a mineral known to promote acid mine drainage (Olsen, 2004). It is therefore assumed that Monarch Creek's pH is depressed from natural background levels due to acid mine drainage associated with the Monarch Mine but because setting a daily load for pH is not practical and the reclamation activities needed to meet metals TMDLs should also address the sources causing pH impairment, metals TMDLs will act as a surrogate for a pH TMDL.

Selenium

Monarch Creek is listed as impaired by selenium on the 2010 303(d) List. Out of eight recent surface water samples, none exceeded water quality targets. Instead, seven samples (88%) tested below detection and the remaining sample had a minimally detectable selenium concentration of 1 µg/L. Concentrations were low during both flow conditions. While there were no surface water target exceedances, one of the three sediment samples did exceed the supplemental indicator value. Because no recent samples exceeded selenium water quality targets, no TMLD was developed and the 303(d) listing status for selenium will be formally reevaluated by DEQ in the future.

F.3 ONTARIO CREEK (MT76G004_130)

DETAILED MINING HISTORY

Hard Luck Mine

The Hard Luck Mine is an inactive lode mine on DEQ's priority abandoned mines list located in the Helena National Forest. The disturbed 0.3 acre site is situated 1,000 feet from Ontario Creek upstream of the confluence with Monarch Creek (Pioneer Technical Services, Inc., 1993). Operation dates and production records for Hard Luck Mine could not be found. A 1993 visit by Pioneer Technical Services identified three waste rock two adits and one building on site but did not collect any samples. At that time, the discharge from one adit was being piped around the waste rock dump but investigators noted the diversion system could be improved. The Hard Luck Mine was visited a few years later by MBMG which found the site to be dry (Hargrave, et al., 1998).

DATA REVIEW BY POLLUTANT

Cadmium

Ontario Creek is not listed as impaired by cadmium on the 2010 303(d) List, however recent data provide evidence of cadmium as a cause of water quality impairment. Out of nine recent surface water samples, two (22%) exceeded the chronic aquatic life standard. Both exceedances occurred during high flow conditions. Because more than 10% of the samples exceeded the chronic aquatic life standard and one sample was more than two times the acute aquatic life standard, cadmium water quality targets were not met. Additionally, two out of three sediment samples identified cadmium concentrations at levels exceeding the supplemental indicator value. Based on target and supplemental indicator value exceedances, a cadmium TMDL was developed for Ontario Creek.

Copper

Ontario Creek is not listed as impaired by copper on the 2010 303(d) List, however recent data provide evidence of copper as a cause of water quality impairment. Out of nine recent surface water samples, three (33%) exceeded the chronic aquatic life standard. All exceedances occurred during high flow conditions. Because more than 10% of the samples exceeded the chronic aquatic life standard, copper water quality targets were not met. Stream sediments collected in 2008 and 2009 tested below the supplementary indicator value. Based on target exceedances, a copper TMDL was developed for Ontario Creek.

Lead

Ontario Creek is not listed as impaired by lead on the 2010 303(d) List, however recent data provide evidence of lead as a cause of water quality impairment. Out of nine recent surface water samples, three (33%) exceeded the chronic aquatic life standard. All lead samples collected during low flow time periods were below detection. Because more than 10% of the samples exceeded the chronic aquatic life standard, lead water quality targets were not met. Additionally, two out of three sediment samples identified lead concentrations at levels exceeding the supplemental indicator value. Based on target and supplemental indicator value exceedances, a lead TMDL was developed for Ontario Creek.

F.4 Sally Ann Creek (MT76G004_055)

Detailed Mining History

Telegraph Mine

The Telegraph Mine is an inactive lode mine on DEQ's priority abandoned mines list located in the Helena National Forest. Historic placer mining is also evident. The disturbed half acre site is located directly adjacent to Tenmile-Telegraph Creek Road and near Bryan Creek, a seasonally flowing tributary to Sally Ann Creek (Pioneer Technical Services, Inc., 1993). An investigation into the site history by MBMG found the mine and mill active from 1927 to 1934, producing 30 tons of ore. The site consists of a collapsed, discharging adit on the north side of the road and a stamp mill, small cabin and tailings on the south side. An unnamed spring emerges near the mill and flows through a mixture of waste rock, tailings and native material before flowing into Bryan Creek. The unnamed tributary and the adit discharge tested very acidic and had high concentrations of metals when the MBMG collected samples in 1995 (Hargrave, et al., 1998). No samples were collected on Bryan Creek at that time because it was dry. In 2005, the USFS removed waste material from the site (Ihle, Beth, personal communication 2008).

Data Review by Pollutant

Cadmium

Sally Ann Creek is not listed as impaired by cadmium on the 2010 303(d) List, however recent data provide evidence of cadmium as a cause of water quality impairment. Out of six recent surface water samples, two (33%) exceeded the chronic aquatic life standard. Both exceedances occurred during high flow conditions. Because more than 10% of the samples exceeded the chronic aquatic life standard and two samples were more than two times the acute aquatic life standard, cadmium water quality targets were not met. Additionally, one out of two sediment samples identified cadmium concentrations at levels exceeding the supplemental indicator value. Based on target and supplemental indicator value exceedances, a cadmium TMDL was developed for Sally Ann Creek.

Copper

Sally Ann Creek is not listed as impaired by copper on the 2010 303(d) List, however recent data provide evidence of copper as a cause of water quality impairment. Out of six recent surface water samples, three (50%) exceeded the chronic aquatic life standard. All exceedances occurred during high flow conditions. Because more than 10% of the samples exceeded the chronic aquatic life standard, copper water quality targets were not met. Stream sediments collected in 2008 and 2009 tested below the supplementary indicator value. Based on target exceedances, a copper TMDL was developed for Sally Ann Creek.

Zinc

Sally Ann Creek is not listed as impaired by zinc on the 2010 303(d) List, however recent data provide evidence of zinc as a cause of water quality impairment. Out of six recent surface water samples, two (33%) exceeded both standards of aquatic life. Both exceedances occurred during high flow conditions. Because more than 10% of the samples exceeded the chronic aquatic life standard, zinc water quality targets were not met. Additionally, one out of two sediment samples identified zinc concentrations at levels exceeding the supplemental indicator value. Based on target and supplemental indicator value exceedances, a zinc TMDL was developed for Sally Ann Creek.

F.5 O'Keefe Creek (MT76G004_054)

Detailed Mining History

Sure Thing Mine

The Sure Thing Mine is an inactive lode mine on DEQ's priority abandoned mines list located on mixed private/public ownership. The Sure Thing Mine is situated on the northeast aspect of O'Keefe Mountain and roughly 1,700 feet from O'Keefe Creek. While it was mostly an exploratory mine, records show that gold, silver and lead were produced from 1902 to 1947 (Pioneer Technical Services, Inc., 1993). The site consists of numerous highly acidic seeps and a discharging adit flows through a pile of tailings and waste rock (Pioneer Technical Services, Inc., 1993). Starting in 2001 the Sure Thing Mine was the site of a four year field demonstration investigating the effectiveness of using sulfate-reducing bacteria to mitigate the impacts of acid mine drainage. The study found metals concentrations in the adit discharge were reduced and pH increased, but after the study period the treatment system was removed (Nordwick, 2008a).

O'Keefe Creek/Copper King Mine

The O'Keefe Creek/Copper King Mine is an inactive lode mine adjacent to O'Keefe Creek located on private property surrounded by the Helena National Forest. MBMG visited the area in 1995 and noted no evidence of stressed vegetation but the mine was not inspected due to its location on private property. At that time the mine was still active and water samples collected from O'Keefe Creek exhibited acceptable water quality despite noticing mine wastes in contact with the stream and several impoundments (Hargrave, et al., 1998).

Data Review by Pollutant

Cadmium

O'Keefe Creek is not listed as impaired by cadmium on the 2010 303(d) List, however recent data provide evidence of cadmium as a cause of water quality impairment. Out of four recent surface water samples, two (50%) exceeded the chronic aquatic life standard and one exceeded the acute aquatic life standard. All exceedances occurred during high flow conditions. Because more than 10% of the samples exceeded the chronic aquatic life standard and one sample was more than two times the acute aquatic life standard, cadmium water quality targets were not met. Additionally, a sediment sample collected by DEQ in 2008 identified cadmium concentrations at levels eight times the supplemental indicator value. Based on target and supplemental indicator value exceedances, a cadmium TMDL was developed for O'Keefe Creek.

Copper

O'Keefe Creek is not listed as impaired by copper on the 2010 303(d) List, however recent data provide evidence of copper as a cause of water quality impairment. Out of four recent surface water samples, two (50%) exceeded both standards of aquatic life. Both exceedances occurred during high flow conditions. Because more than 10% of the samples exceeded the chronic aquatic life standard, copper water quality targets were not met. Stream sediments collected in 2008 tested below the supplementary indicator value. Based on target exceedances, a copper TMDL was developed for O'Keefe Creek.

Zinc

O'Keefe Creek is not listed as impaired by zinc on the 2010 303(d) List, however recent data provide evidence of zinc as a cause of water quality impairment. Out of four recent surface water samples, three (75%) exceeded both standards of aquatic life. Exceedances occurred during both flow conditions. Because more than 10% of the samples exceeded the chronic aquatic life standard, zinc water quality targets were not met. Additionally, a stream sediment sample collected by DEQ in 2008 identified zinc concentrations at levels eight times the supplemental indicator value. Based on target and supplemental indicator value exceedances, a zinc TMDL was developed for O'Keefe Creek.

F.6 Telegraph Creek, Upper Segment (MT76G004_051)

Detailed Mining History

Lilly/Orphan Boy Mine

The Lilly/Orphan Boy Mine is an inactive lode mine on DEQ's priority abandoned mines list located on private property surrounded by the Helena National Forest. The mine was active intermittently from 1934 to 1968. Over those years 1,228 tons of ore were produced yielding mostly lead and zinc (Hargrave, et al., 1998). The 1½ acre site is comprised of a 250-foot shaft, three adits and three waste rock piles containing approximately 2,430 yd^3 of waste rock (Tetra Tech, 2009). These features parallel Telegraph Creek with one waste rock pile spanning the creek bottom. Starting in 1994 the Lily/Orphan Boy Mine was the site of a ten year field demonstration investigating the effectiveness of using sulfate-reducing bacteria to mitigate the impacts of acid mine drainage. The study found metals concentrations in the adit discharge were reduced and pH increased, but after the study period the treatment system was removed (Nordwick, 2008b). DEQ's AML Program recently completed a reclamation investigation assessing conditions and detailing the site's potential for reclamation (Tetra Tech, 2009). Phase II of the report, in which a detailed engineering and cost analysis is performed, is forthcoming (Clark, P., personal communication 2010). While inventorying abandoned mines in 1995, the MBMG collected water samples that had numerous exceedances and revealed noticeable increases of metals concentrations downstream of the disturbed site (Hargrave, et al., 1998).

Third Term Mine

The Third Term Mine is an inactive lode mine on DEQ's priority abandoned mines list located in the Helena National Forest. The mine site lies adjacent to Little Flume Gulch, which flows into Flume Gulch and eventually Telegraph Creek. According to production records, the mine was active in the 1950's and worked a vein deposit that contained pyrite (a mineral known to promote the formation of acid mine drainage) producing 50 tons of ore (Hargrave, et al., 1998; Pioneer Technical Services, Inc., 1993). In 1993 the adit tunnel was backfilled and the surrounding slope was regarded by DEQ AML (Clark, P., personal communication 2010). However, two years later the adit had subsided (Hargrave, et al., 1998). At that time MBMG observed the reclaimed area was lacking soils or vegetation but described the waste rock as resistant to erosion; also, the stream vicinity appeared clear of waste material and supported vegetation (Hargrave, et al., 1998). In an attempt to explain the numerous surface water exceedances observed, the MBMG report stated that the adit, despite lacking surface flow, was likely discharging subterraneously through coarse material into Little Flume Gulch. Mercury concentrations in Little Flume Gulch exceeded the human health standard in 1993 (0.24 µg/L vs. 0.05 µg/L) but were below detection in 1995; but since the 1995 detection limit (0.1 µg/L) was above the standard, exceedances at that time

cannot be determined (Hargrave, et al., 1998; Pioneer Technical Services, Inc., 1993). In 2005, the USFS removed waste material from the site (Ihle, Beth, personal communication 2008). Third Term Mine is a potential source for lower Telegraph Creek's mercury listing and because the lowest sample site on upper Telegraph Creek did not capture inputs from Flume Gulch, additional monitoring is recommended.

Julia Mine

The Julia Mine is an inactive load mine on DEQ's priority abandoned mines list located in the Helena National Forest on the ridge above Booth Gulch. The disturbed 0.5 acre site lies roughly 1.5 miles southwest of Telegraph Creek. Initial operations started in 1905 but the facility was heavily developed in 1911 to house numerous buildings and include two adits and one mine shaft (Pardee and Schrader, 1933). An estimated 10,700 yards of waste rock sit at the site (Pioneer Technical Services, Inc., 1993).

Anna R/Hattie M Mine

The Anna R/Hattie M Mine is an inactive load mine on DEQ's priority abandoned mine list located ½ mile downstream from the Lily/Orphan Boy Mine site and 500 feet from Telegraph Creek. The disturbed 0.17 acre site consists of a mine shaft, 2,200 cubic yards of waste rock and two caved adits; one of which had flow that was highly acidic and had elevated cadmium concentrations when sampled in 1993 (Pioneer Technical Services, Inc., 1993). A small mill structure is also present although all tailings appear to have been removed from the site (Pioneer Technical Services, Inc., 1993).

Hub Camp Mine

The Hub Camp Mine is an inactive load mine which has been investigated for its environmental impacts but is not on DEQ's priority abandoned mine list. It is located several hundred feet north of Telegraph Creek on Helena National Forest property. The Hub Camp Mine operated from around 1937 to 1948 and yielded 52 tons of ore (Hargrave, et al., 1998). When the site was visited by MBMG in 1995, it consisted of two caved-in adits, numerous waste rock piles and several dilapidated structures; water flowed from one adit, over a pile of waste material and eventually disappeared into the ground before reaching Telegraph Creek. The waste rock was well vegetated and samples from the adit discharge met all applicable standards (Hargrave, et al., 1998). In 2005, the USFS removed waste material from the site (Ihle, Beth, personal communication 2008).

Viking Mine

The Viking Mine is an inactive load mine which has been investigated for its environmental impacts but is not on DEQ's priority abandoned mine list. It is located on Forest Service property near Moose Gulch. A caved adit, a dilapidated metal building, an ore bin and multiple waste rock piles were observed at the site in 1995 by MBMG. The adit discharge, which reentered the waste dump, was fairly acidic and exceeded standards for six metals. The dumps appeared stable and soils below the affected area showed no visible mining impacts (Hargrave, et al., 1998). In 2005, the USFS removed waste material from the site (Ihle, Beth, personal communication 2008).

Unnamed Mine 8N6W6ABDB

Unnamed Mine 8N6W6ABDB is an inactive load mine which has been investigated for its environmental impacts but is not on DEQ's priority abandoned mine list. It is located in the same drainage as the Viking Mine on patented land surrounded by the Helena National Forest. The site has a waste rock dump and

one caved adit discharging into a small pond and then flowing into Moose Gulch. Samples collected by MBMG in 1995 showed no visible impact to soils, and the water quality of the stream into which the adit was discharging met all applicable standards (Hargrave, et al., 1998).

DATA REVIEW BY POLLUTANT

Arsenic

Upper Telegraph Creek is listed as impaired by arsenic on the 2010 303(d) List. Out of eight recent surface water samples, one exceeded the human health standard. The exceedance occurred during low flow, directly below the Lily/Orphan Boy waste rock pile. Because the human health standard was exceeded, arsenic water quality targets were not met. Additionally, sediment samples collected by DEQ in 2008 and 2009 identified arsenic concentrations at levels 28 times the supplemental indicator value. Based on target and supplemental indicator value exceedances, an arsenic TMDL was developed for the upper segment of Telegraph Creek.

Beryllium

Upper Telegraph Creek is listed as impaired by beryllium on the 2010 303(d) List. Out of four recent surface water samples, all four tested below the detection limit for beryllium. Concentrations were low regardless of flow condition. Even though recent data depicts upper Telegraph Creek as potentially attaining beryllium water quality targets, because there is only four surface water samples and because human-related metals sources are present in the watershed, a beryllium TMDL was developed.

Cadmium

Upper Telegraph Creek is listed as impaired by cadmium on the 2010 303(d) List. Out of eight recent surface water samples, five (63%) exceeded the chronic aquatic life standard and one exceeded the acute aquatic life standard by a factor of six. Because more than 10% of the samples exceeded the chronic aquatic life standard and one sample was more than two times the acute aquatic life standard, cadmium water quality targets were not met. Additionally, sediment samples collected by DEQ in 2008 and 2009 identified cadmium concentrations at levels 20 times the supplemental indicator value. Based on target and supplemental indicator value exceedances, a cadmium TMDL was developed for upper Telegraph Creek.

Copper

Upper Telegraph Creek is listed as impaired by copper on the 2010 303(d) List. Out of eight recent surface water samples, three (38%) exceeded both standards of aquatic life. All exceedances occurred during high flow conditions. Because more than 10% of the samples exceeded the chronic aquatic life standard, copper water quality targets were not met. Stream sediments collected in 2008 and 2009 tested slightly below the secondary indicatory value (188 µg/g vs. 197 µg/g). Based on target exceedances, a copper TMDL was developed for upper Telegraph Creek.

Iron

Upper Telegraph Creek is listed as impaired by iron on the 2010 303(d) List. Out of eight recent surface water samples, none exceeded water quality targets. Samples were collected over a two year period, over both flow conditions at four different sites. Because no recent samples exceeded iron water quality targets, no TMLD was developed and the 303(d) listing status for iron will be formally reevaluated by DEQ in the future.

Lead
Upper Telegraph Creek is not listed as impaired by lead on the 2010 303(d) List, however recent data provide evidence that lead is a cause of water quality impairment. Out of six recent surface water samples, three (50%) exceeded the chronic aquatic life standard. All samples collected during high flow conditions exceeded standards while all samples collected during low flow were below detection for lead. Because more than 10% of the samples exceeded the chronic aquatic life standard, lead water quality targets were not met. Additionally, one of three sediment samples collected by DEQ in 2008 and 2009 exceeded the supplemental indicator value. Based on target and supplemental indicator value exceedances, a lead TMDL was developed for the upper segment of Telegraph Creek.

Zinc
Upper Telegraph Creek is listed as impaired by zinc on the 2010 303(d) List. Out of eight recent surface water samples, five (63%) exceeded both aquatic life standards and one exceeded the acute aquatic life standard by a factor of 16. Because more than 10% of the samples exceeded the chronic aquatic life standard and one sample was more than two times the acute aquatic life standard, zinc water quality targets were not met. Additionally, all three sediment samples collected by DEQ in 2008 and 2009 exceeded the secondary indicator value by more than double. Based on target and supplemental indicator value exceedances, a zinc TMDL was developed for the upper segment of Telegraph Creek.

F.7 Telegraph Creek, Lower Segment (MT76G004_052)

Detailed Mining History

No known mining occurred in the lower Telegraph Creek basin.

Data Review by Pollutant

Cadmium
Lower Telegraph Creek is not listed as impaired by cadmium on the 2010 303(d) List, however recent data provide evidence that cadmium is a cause of water quality impairment. Out of four recent surface water samples, two (50%) exceeded the chronic aquatic life standard. All samples collected during high flow conditions exceeded standards while all samples collected during low flow were at or below the detection limit. Because more than 10% of the samples exceeded the chronic aquatic life standard, cadmium water quality targets were not met. Additionally, stream sediments collected in 2008 exceeded the supplementary indicator value. Based on target and supplemental indicator value exceedances, a cadmium TMDL was developed for the lower segment of Telegraph Creek.

Copper
Lower Telegraph Creek is not listed as impaired by copper on the 2010 303(d) List, however recent data provide evidence that copper is a cause of water quality impairment. Out of four recent surface water samples, two (50%) exceeded both aquatic life standards. All exceedances occurred during high flow conditions. Because more than 10% of the samples exceeded the chronic aquatic life standard, copper water quality targets were not met. Stream sediments collected in 2008 tested below the supplementary indicator value. Based on target exceedances, a copper TMDL was developed for the lower segment of Telegraph Creek.

Lead
Lower Telegraph Creek is listed as impaired by lead on the 2010 303(d) List. Out of four recent surface water samples, two (50%) exceeded the chronic aquatic life standards. All samples collected during high flow conditions exceeded standards while all samples collected during low flow were below the detection limit. Because more than 10% of the samples exceeded the chronic aquatic life standard, lead water quality targets were not met. Stream sediments collected in 2008 tested slightly below the secondary indicatory value (88 µg/g vs. 91.3 µg/g). Based on target exceedances, a lead TMDL was developed for the lower segment of Telegraph Creek.

Mercury
Lower Telegraph Creek is listed as impaired by mercury on the 2010 303(d) List. Out of four recent surface water samples, all four tested below the detection limit for mercury However, only one of these samples can be used for TMDL development determinations because the other three had detection limits equal to the human health standard (0.05 µg/L) and unless detection limits are below the water quality standard, exceedances cannot be determined. Mercury was found to be below detection in the single sample with an acceptable detection limit (0.005 µg/L). Even though recent data depicts Monarch Creek as potentially attaining mercury water quality targets, because there is only one acceptable surface water sample and because human-related metals sources are present in the watershed, a mercury TMDL was developed. Additional monitoring for mercury is recommended.

Zinc
Lower Telegraph Creek is not listed as impaired by zinc on the 2010 303(d) List, however recent data provide evidence that zinc is a cause of water quality impairment. Out of four recent surface water samples, two (50%) exceeded both standards of aquatic life. All exceedances occurred during high flow conditions. Because more than 10% of the samples exceeded the chronic aquatic life standard, zinc water quality targets were not met. Additionally, stream sediments collected in 2008 exceeded the supplementary indicator value. Based on target and supplemental indicator value exceedances, a zinc TMDL was developed for the lower segment of Telegraph Creek.

F.8 American Gulch Creek (MT76G004_079)

Detailed Mining History

While abandoned mine databases lack detailed descriptions of mines in the American Gulch Creek basin, at least five are known to exist: Carbonate Marysville, Neenan, NE SE Section 10, Pine Ridge and Un-named 11N06W10CADD. Additional monitoring is recommended to better characterize influences from these mine, especially because most mines are located in the headwaters but the only sample site established on American Gulch Creek was near the mouth.

Data Review by Pollutant

Arsenic
American Gulch Creek is not listed as impaired by arsenic on the 2010 303(d) List, however recent data provide evidence that arsenic is a cause of water quality impairment. Out of four recent surface water samples, all four exceed the human health standard. Exceedances occurred during both flow conditions. Because the human health standard was exceeded, arsenic water quality targets were not met. Additionally, stream sediments samples collected in 2008 identified arsenic concentrations at levels

nearly four times the supplemental indicator value. Based on target and supplemental indicator value exceedances, an arsenic TMDL was developed for the American Gulch Creek.

F.9 Dog Creek, Upper Segment (MT76G004_071)

Detailed Mining History

Bald Butte Mine

The Bald Butte Mine is an inactive lode mine on DEQ's priority abandoned mines list located on land managed by the BLM and USFS. The mine produced gold, silver, zinc, and lead from 1902 until 1943. In 2010, DEQ started a three year reclamation project on the Bald Butte Mine aimed at limiting the mobility of contaminants. Prior to reclamation, the Bald Butte Mine site consisted of four waste rock piles, a mill foundation, a fenced shaft, and six tailings piles; all of which were located within the Dog Creek floodplain. At the height of operations, the site also included a 200-ton cyanide plant and a 40-stamp mill (Olympus Technical Services, Inc., 2004). Reclamation plans call for transporting 140,300 cubic yards of mine waste from the two sites to a nearby repository on BLM land to prevent further erosion and migration of the contaminants. In 2010, the first year of project operations, roughly 40,000 cubic yards of material was removed (Opp, Steve, personal communication 2011). A site investigation performed as part of the reclamation plan extensively sampled stream sediments for metals and consistently found arsenic, cadmium, copper, lead, mercury and zinc more than double the supplemental indicator value (Olympus Technical Services, Inc., 2004).

Devon/Sterling and Albion Mine

The Devon/Sterling and Albion Mine is a cluster of inactive mines which are part of the Bald Butte reclamation planning area. Located just upstream of the Bald Butte Mine along an unnamed tributary to Dog Creek, the site had two adits, one of which was discharging on a site visit in the fall of 2003 (Olympus Technical Services, Inc., 2004). Additionally, a perennial stream ran through one waste rock pile and flowed past the toe of two other piles. The amount mine waste to be removed from the Devon/Sterling and Albion Mine is included in the estimate for Bald Butte and will be transported to the same repository.

Data Review by Pollutant

<u>Arsenic</u>

Upper Dog Creek is listed as impaired by arsenic on the 2010 303(d) List. Out of 12 recent surface water samples, eight (67%) exceeded the human health standard. All of the non-exceedance samples were collected upstream of the Bald Butte Millsite. Because the human health standard was exceeded, arsenic water quality targets were not met. Additionally, sediment samples identified arsenic concentrations as much as 57 times the supplemental indicator value. Based on target and supplemental indicator value exceedances, an arsenic TMDL was developed for the upper segment of Dog Creek.

<u>Cadmium</u>

Upper Dog Creek is not listed as impaired by cadmium on the 2010 303(d) List, however recent data provide evidence that cadmium is a cause of water quality impairment. Out of 12 recent surface water samples, eight (67%) exceeded the chronic aquatic life standard. Because more than 10% of the samples exceeded the chronic aquatic life standard, cadmium water quality targets were not met. Additionally,

sediment samples identified cadmium concentrations as much as eight times the supplemental indicator value. Based on target and supplemental indicator value exceedances, a cadmium TMDL was developed for the upper segment of Dog Creek.

Copper

Upper Dog Creek is not listed as impaired by copper on the 2010 303(d) List, however recent data provide evidence that copper is a cause of water quality impairment. Out of nine recent surface water samples, three (33%) exceeded the chronic aquatic life standard. All exceedances occurred during high flow conditions. Because more than 10% of the samples exceeded the chronic aquatic life standard, copper water quality targets were not met. Additionally, sediment samples identified copper concentrations as much as five times the supplemental indicator value. Based on target and supplemental indicator value exceedances, a copper TMDL was developed for the upper segment of Dog Creek.

Lead

Upper Dog Creek is listed as impaired by lead on the 2010 303(d) List. Out of 12 recent surface water samples, 11 (92%) exceeded the chronic aquatic life standard and one sample exceeded the human health standard. Exceedances were observed during both flow conditions. Because more than 10% of the samples exceeded the chronic aquatic life standard and the human health standard was exceeded, lead water quality targets were not met. Additionally, sediment samples identified lead concentrations as much as 30 times the supplemental indicator value. Based on target and supplemental indicator value exceedances, a lead TMDL was developed for the upper segment of Dog Creek.

Zinc

Upper Dog Creek is listed as impaired by zinc on the 2010 303(d) List. Out of 12 recent surface water samples, two (17%) exceeded both standards of aquatic life. Both exceedances occurred during high flow conditions. Because more than 10% of the samples exceeded the chronic aquatic life standard and a sample was more than two times the acute aquatic life standard, zinc water quality targets were not met. Additionally, sediment samples identified lead concentrations as much as 12 times the supplemental indicator value. Based on target and supplemental indicator value exceedances, a zinc TMDL was developed for the upper segment of Dog Creek.

F.10 Lower Dog Creek (MT76G004_072)

Detailed Mining History

While abandoned mine databases lack detailed descriptions of mines unique to the lower Dog Creek basin, an estimated 15 are known to exist. Information on historic mining in the upper Dog Creek basin is provided in **Section F.9**. Additional monitoring is recommended to better characterize influences from specific mines.

Data Review by Pollutant

Copper

Lower Dog Creek is not listed as impaired by copper on the 2010 303(d) List, however recent data provide evidence that copper is a cause of water quality impairment. Out of four recent surface water samples, two (50%) exceeded the chronic aquatic life standard. Both exceedances occurred during high

flow conditions. Because more than 10% of the samples exceeded the chronic aquatic life standard, copper water quality targets were not met. Stream sediments collected in 2008 tested below the supplementary indicator value. Based on target exceedances, a copper TMDL was developed for lower Dog Creek.

Lead

Lower Dog Creek is not listed as impaired by lead on the 2010 303(d) List, however recent data provide evidence that lead is a cause of water quality impairment. Out of four recent surface water samples, two (50%) exceeded the chronic aquatic life standard. Both exceedances occurred during high flow conditions. Because more than 10% of the samples exceeded the chronic aquatic life standard, copper water quality targets were not met. Additionally, stream sediments collected in 2008 exceeded the supplementary indicator value. Based on target and supplemental indicator value exceedances, a lead TMDL was developed for lower Dog Creek.

F.11 Little Blackfoot River, Upper Segment (MT76G004_020)

Detailed Mining History

Charter Oak Mine

The Charter Oak Mine is an inactive load mine on DEQ's priority abandoned mines list located in the Helena National Forest adjacent to the Little Blackfoot River. Around 9,000 tons of ore was processed at Charter Oak from 1916 to 1966 (Hargrave, et al., 1998; Pioneer Technical Services, Inc., 1993). Productivity peaked during World War II to the extent that the federal government designated Charter Oak a strategic metals mine (USDA Forest Service, 2007). For years after mining ceased, the site consisted six or more adits, extensive mill tailings, numerous barrels of waste oil and acid, and several small buildings surrounding a mill (Pioneer Technical Services, Inc., 1993). During site visits in the early 1990's by Pioneer Technical Services, USFS and MBMG, it was noted that two of the adits were discharging towards the Little Blackfoot River and one adit had an extremely low pH discharge with several metal standard exceedances (Hargrave, et al., 1998; Pioneer Technical Services, Inc., 1993). In 1993, DEQ AML found numerous barrels of chemicals/solvents, including empty sodium cyanide (NaCN) barrels, and sprayer equipment most likely used for CN^- application at the site (Pioneer Technical Services, Inc., 1993). While the Charter Oak Mine is the most likely cause of cyanide impairment for the upper Little Blackfoot River, USFS samples collected in the spring of 2010 from a beaver pond near the base of the mill area and from one of the discharging adits detected no trace of cyanide (Oaks, Hans, personal communication 2011). Despite the poor water quality of the adits and a portion of the tailings being submerged by the river, the Little Blackfoot River below the Charter Oak Mine did not exceed metals standards when sampled in 1995 (Hargrave, et al., 1998). From 1996 through 1998, the USFS removed hazardous substances, placed waste rock and tailings in an onsite repository work, performed adit work and stabilized buildings (USDA Forest Service, 2007; Ihle, Beth, personal communication 2008). In 2001 the Charter Oak Mine was listed on the National Register of Historic Places and it is currently open to the public for interpretative tours on select summer weekends Water quality samples collected after reclamtion still had many metals exceedances.

Kimball Mine

The Kimball Mine is an inactive load mine on DEQ's priority abandoned mines list located in the Helena National Forest adjacent to the Little Blackfoot River. The site lies on a hillside, separated from the river

by a ¼ mile wide, well vegetated floodplain (Pioneer Technical Services, Inc., 1993). Operation dates and production records could not be found for the Kimball Mine, however until recently the area contained two caved adits and several large coalescing waste rock dumps that extend into the floodplain (Hargrave, et al., 1998). In 2006, the USFS removed waste material from the site (Ihle, Beth, personal communication 2008). The MBMG did not collect any water samples when they visited in 1995, because there was no surface water at the site and it appeared the adits never discharge. Sediment samples were collected, and showed the waste rock contained high concentrations of arsenic, lead and pyrite, a mineral known to promote the formation of acid mine drainage (Hargrave, et al., 1998). MBMG also witnessed evidence of erosion occuring in the fine-grained waste rock pile in the floodplain.

Golden Anchor Mine

The Golden Anchor Mine is an inactive load mine on DEQ's priority abandoned mines list located in the Helena National Forest near an un-named tributary to the Little Blackfoot River and only 1,500 feet from the Kimball Mine. Alternative reports refer to the Golden Anchor Millsite as the Big Dick Mill. The mill was active intermittently from 1902 to 1954 processing 16,200 tons of ore that contained lead, silver, gold, copper and zinc (Hargrave, et al., 1998). A large mill building, several smaller cabins and a large bunkhouse remain at the site. Before the USFS removed waste material from the site in 2006, waste rock and tailings extended along the stream for over 450 feet (Hargrave, et al., 1998; Ihle, Beth, personal communication 2008). Samples collected in 1995 by MBMG, of the un-named stream above and below the mill actually showed that concentrations of most metals constituents were lower in the downstream sample indicating the tailings have little impact on water quality (Hargrave, et al., 1998). After the Golden Anchor mine closed, it was plugged with an earthen core and water backed up behind the plug for years until it eventually blew out in November 2008. The bright orange-colored water carved a waist-deep channel, stained trees almost five feet off the ground and discolored water that could be seen three miles downstream in the Little Blackfoot River (Byron, 11/28/2008; Byron, 12/4/2008). The blow out flushed high concentrations of metals downstream, but water samples collected by USFS and DEQ showed the spike was temporary (Byron, 1/17/2009). There was a concern for bull trout, but no fish-kills were observed.

Mountain View Mine

The Mountain View Mine is an inactive load mine on DEQ's priority abandoned mines list located in the same un-named tributary drainage to the Little Blackfoot River as the Golden Anchor Mill. No historical operation dates or production details could be found for the site. The Mountain View Mine consisted of one open adit, two caved adits and two waste rock piles when DEQ AML investigated the site in 1993. At that time, the stream was dry upstream of the mine site and the discharging adit, which flowed under waste rock, was the source of the un-named tributary (Pioneer Technical Services, Inc., 1993). The Forest Service collected surface water data in 1995 just below the waste rock pile that exceeded numerous metals standards. In 2006, the USFS removed waste material from the site (Ihle, Beth, personal communication 2008).

DATA REVIEW BY POLLUTANT

<u>Arsenic</u>

The upper segment of the Little Blackfoot River is listed as impaired by arsenic on the 2010 303(d) List. Out of 20 recent surface water samples, five (25%) exceeded the human health standard. All of the samples collected upstream of the Ontario Creek confluence were below detection. Because the human health standard was exceeded, arsenic water quality targets were not met. Additionally, sediment

samples identified arsenic concentrations as much as 11 times the supplemental indicator value. Based on target and supplemental indicator value exceedances, an arsenic TMDL was developed for the upper segment of the Little Blackfoot River.

Cadmium

The upper segment of the Little Blackfoot River is not listed as impaired by cadmium on the 2010 303(d) List, however recent data provide evidence that cadmium is a cause of water quality impairment. Out of 20 recent surface water samples, four exceeded the chronic aquatic life standard and one sample was nearly 2.5 times the acute aquatic life standard. All exceedances occurred during high flow conditions and every sample that that did not exceed standards did not detect cadmium. Because more than 10% of the samples exceeded the chronic aquatic life standard and one sample was more than two times the acute aquatic life standard, cadmium water quality targets were not met. Stream sediments collected in 2008 tested below the supplementary indicator value. Based on target exceedances, a cadmium TMDL was developed the upper segment of the Little Blackfoot River.

Copper

The upper segment of the Little Blackfoot River is not listed as impaired by copper on the 2010 303(d) List, however recent data provide evidence that copper is a cause of water quality impairment. Of the 20 recent surface water samples, three (12%) exceeded both standards of aquatic life. All exceedances occurred during high flow conditions. Because more than 10% of the samples exceeded the chronic aquatic life standard, copper water quality targets were not met. Stream sediments collected in 2008 tested below the supplementary indicator value. Based on target exceedances, a copper TMDL was developed the upper segment of the Little Blackfoot River.

Cyanide

The upper segment of the Little Blackfoot River is listed as impaired by cyanide on the 2010 303(d) List. Out of eight recent surface water samples, one (13%) exceeded both standards of aquatic life. All samples tested below detection except a field replicate whose paired sample was did not detect cadmium. However, because the analysis method for detecting cyanide sometimes biases lower than actual readings, the replicate sample will replace the original in this instance to be conservative. Because more than 10% of the samples exceeded the chronic aquatic life standard, cyanide water quality targets were not met. Based on target exceedances, a cyanide TMDL was developed for the upper segment of the Little Blackfoot River.

Lead

The upper segment of the Little Blackfoot River is not listed as impaired by lead on the 2010 303(d) List, however recent data provide evidence that lead is a cause of water quality impairment. Out of 20 recent surface water samples, six (30%) exceeded the chronic aquatic life standard and one exceeded the human health standard. All exceedances occurred during high flow conditions. Because more than 10% of the samples exceeded the chronic aquatic life standard and one sample exceeded the human health standard, lead water quality targets were not met. Additionally, stream sediments collected in 2008 exceeded the supplementary indicator value. Based on target and supplemental indicator value exceedances, a lead TMDL was developed for the upper segment of the Little Blackfoot River.

F.12 Little Blackfoot River, Lower Segment (MT76G004_010)

Detailed Mining History

Victory/Evening Star Mine

The Victory/Evening Star Mine is an inactive load mine on DEQ's priority abandoned mines list located near Ophir Creek, a tributary to the Little Blackfoot River's lower segment. The mill building is on patented land but tailings have been deposited along the floodplain of Ophir Creek extending into Forest Service property. Most mine workings are well away from the floodplain and those that were near the creek did not appear to be actively eroding when MBMG visited the site in 1995 (Hargrave, et al., 1998). At that time none of the adits were discharging and surface water samples of Ophir Creek could not be collected upstream of the mine site because flow was subterraneous. The water re-surfaced in a pond near the mine site and a sample was collected just downstream that had no metal exceedances (Hargrave, et al., 1998). The MBMG assessment also noted that recreation is somewhat popular in the area, and although most of the buildings are not a liability because they have already collapsed, there is an open mine shaft on site (Hargrave, et al., 1998).

Data Review by Pollutant

Arsenic

The lower segment of the Little Blackfoot River is not listed as impaired by arsenic on the 2010 303(d) List, however recent data provide evidence that arsenic is a cause of water quality impairment. Out of 34 recent surface water samples, three exceeded the human health standard. All exceedances occurred during high flow conditions. Because the human health standard was exceeded, arsenic water quality targets were not met. Additionally, sediment samples identified arsenic concentrations as much as four times the supplemental indicator value. Based on target and supplemental indicator value exceedances, an arsenic TMDL was developed for the lower segment of the Little Blackfoot River.

Copper

The lower segment of the Little Blackfoot River is listed as impaired by copper on the 2010 303(d) List. Out of 34 recent surface water samples, three (9%) exceeded the chronic aquatic life standard and two exceeded the acute aquatic life standard. However none of the acute exceedances were more than twice the standard. Because less than 10% of the samples exceeded the chronic aquatic life standard, and no samples exceeded twice the acute aquatic life standard or the human health standard, all copper water quality targets were met. Additionally, all four stream sediment samples tested below the supplementary indicator value. Because no recent samples exceeded copper water quality targets, no TMLD was developed and the 303(d) listing status for copper will be formally reevaluated by DEQ in the future.

Lead

The lower segment of the Little Blackfoot River is listed as impaired by lead on the 2010 303(d) List. Out of 34 recent surface water samples, six (18%) exceeded the chronic aquatic life standard. Five of the six exceedances were collected during high flow conditions. Because more than 10% of the samples exceeded the chronic aquatic life standard, lead water quality targets were not met. One of three stream sediment samples exceeded the supplementary indicator value. Based on target and supplemental indicator value exceedances, a copper TMDL was developed for the lower segment of the Little Blackfoot River.

F.13 REFERENCES

Byron, E. 11/28/2008. Biologists Checking Fish Following Mine Blowout. *Helena Independent Record*

-----. 12/4/2008. Water Worries. *Helena Independent Record*

-----. 1/17/2009. DEQ Awaiting Results From Mine Blowout. *Helena Independent Record*

Clark, P. 2010. Personal Communication. Peter Brumm, EPA.

Hargrave, P., T. B. Bowler, J. D. Lonn, J. P. Madison, J. J. Metesh, and R. Wintergerst. 1998. Abandoned-Inactive Mines of the Blackfoot-Little Blackfoot River Drainages, Helena National Forest, Montana Bureau of Mines and Geology. Report Open FIle Report 368.

Ihle, Beth. 2008. Personal Communication. Lisa Kusnierz.

Montana Department of Environmental Quality. 2010. Integrated 305(b)/303(d) Water Quality Report. http://www.deq.mt.gov/CWAIC/wq_reps.aspx?yr=2010qryld=10815.

Nordwick, S. 2008a. Final Report - An Integrated, Passive Biological Treatment System. U.S. Environmental Protection Agency. Report Mine Waste Technology Program, Activity III, Project 16.

-----. 2008b. Final Report- In Situ Source Control of Acid Generation Using Sulfate-Reducing Bacteria. U.S.Environmental Protection Agency. Report Mine Waste Technology Program, Activity III, Project 3.

Oaks, Hans. 2011. Personal Communication. Peter Brumm.

Olsen, L. J. 2004. Plant-Metal Interactions in a Natural and Remediated High Elevation Metal-Contaminated Wetland. Masters Thesis.: Montana State University.

Olympus Technical Services, Inc. 2004. Expanded Engineering Evaluation/Cost Analysis for the Bald Butte Millsite and Devon/Sterlingand Albion Mine Sites. Helena, MT: Montana Department of Environmental Quality, Remediation Division, Mine Waste Cleanup Bureau.

Opp, Steve. 2011. Personal Communication. Peter Brumm.

Pardee, J. T. and F. C. Schrader. 1933. Metalliferous Deposits of the Greater Helena Mining Region, Montana. http://www.deq.mt.gov/abandonedmines/linkdocs/157tech.mcpx. Accessed 11/8/11 A.D.

Pioneer Technical Services, Inc. 1993. Abandoned Hardrock Mine Priority Sites Project Report, Park County (Emigrant District) Through Powell County (Ophir District).

Tetra Tech. 2006. Final Construction Report for the Ontario Mine and Millsite Reclamation Project. Helena, MT: Montana Department of Environmental Quality, Mine Waste Cleanup Bureau.

-----. 2009. Reclamation Investigation for the Lilly/Orphan Boy Mine Site. Helena, MT: Montana Department of Environmental Quality Remediation Division, Mine Waste Cleanup Burea.

USDA Forest Service. 2007. Historic Mining on the Helena National Forest: A Brief Synopsis. Helena, MT: United States Forest Service. http://www.fs.fed.us/r1/helena/resources/heritage_resources/mining_history.shtml. Accessed 11/7/11 A.D.

APPENDIX G – METALS AND NUTRIENT WATER QUALITY DATA

Table G-1. Recent Surface Water Metals Data for the Little Blackfoot River TPA

Waterbody Segment	Site ID	Sample Date	Organization	Hardness (mg/L)	Flow (cfs)	pH	Al (µg/L) D	As (µg/L) TR	Be (µg/L) TR	Cd (µg/L) TR	Cu (µg/L) TR	CN (µg/L) T	Fe (µg/L) TR	Pb (µg/L) TR	Hg (µg/L) TR	Se (µg/L) TR	Zn (µg/L) TR
American Gulch Creek	DOG3	8/25/09	DEQ	149	0.85	7.64	< 30	16	-	< .08	< 1	-	-	< .5	-	-	< 10
American Gulch Creek	DOG3	7/24/08	DEQ	163	0.76	8.15	< 30	14	-	< .08	< 1	-	290	< .5	-	< 1	< 10
American Gulch Creek	DOG3	5/22/09	DEQ	99	13.37	7.64	< 30	13	-	0.55	7	-	-	6.4	-	-	70
American Gulch Creek	DOG3	5/28/08	DEQ	85	16.2	7.81	70	14	-	< .08	2	-	1040	1.8	-	< 1	10
Carpenter Creek	CAR1	5/19/09	DEQ	146	29.09	8.26	< 30	4	-	0.41	2	-	70	< .5	-	-	< 10
Carpenter Creek	CAR1	8/31/09	DEQ	187	3.58	8.29	< 30	5	-	< .08	1	-	-	< .5	-	-	< 10
Carpenter Creek	CAR1	7/25/08	DEQ	222	3.69	8.45	< 30	4	-	< .08	< 1	-	160	< .5	-	< 1	< 10
Carpenter Creek	CAR1	5/29/08	DEQ	157	33.68	8.17	< 30	4	-	< .08	2	-	< 10	< .5	-	< 1	< 10
Lower Dog Creek	DOG8	8/26/09	DEQ	134	12.17	7.97	< 30	8	-	< .08	3	-	-	1.7	-	-	< 10
Lower Dog Creek	DOG8	7/22/08	DEQ	121	17.35	8.22	30	6	-	< .08	2	-	360	2.3	-	< 1	< 10
Lower Dog Creek	DOG8	5/19/09	DEQ	49	247.6	6.71	130	5	-	1.21	7	-	-	6.4	-	-	20
Lower Dog Creek	DOG8	5/29/08	DEQ	53	119.17	7.86	350	4	-	< .08	6	-	790	4.4	-	< 1	20
Lower Little Blackfoot River	12324590/LBF10	8/27/03	USGS	172	25	8	-	5	-	< .04	1.1	-	64	0.06	-	-	< 2
Lower Little Blackfoot River	12324590/LBF10	8/20/04	USGS	161	20	8.6	-	6	-	< .04	1.6	-	76	0.08	-	-	< 2
Lower Little Blackfoot River	12324590/LBF10	7/19/04	USGS	130	73	8.7	-	7	-	< .04	1.2	-	61	0.08	-	-	< 2
Lower Little Blackfoot River	LBF10	5/20/09	DEQ	67	1555.5	7.6	< 30	14	-	0.2	11	-	-	9.2	-	-	< 10
Lower Little Blackfoot River	LBF10	9/1/09	DEQ	138	58.2	8.04	< 30	5	-	< .08	1	-	-	< .5	-	-	< 10
Lower Little Blackfoot River	LBF9	9/1/09	DEQ	125	63.33	8.09	< 30	6	-	< .08	1	-	-	< .5	-	-	< 10
Lower Little Blackfoot River	LBF7	5/29/08	DEQ	40	1192.6	7.76	170	6	-	< .08	4	-	570	2.3	-	< 1	< 10
Lower Little Blackfoot River	LBF7	7/25/08	DEQ	85	79.57	7.83	< 30	6	-	< .08	< 1	-	110	3.3	-	< 1	< 10
Lower Little Blackfoot River	LBF10	7/26/08	DEQ	138	100.63	8.21	< 30	6	-	< .08	< 1	-	90	< .5	-	< 1	< 10
Lower Little Blackfoot River	12324590/LBF10	9/4/01	USGS	142	19	8.4	-	6	-	< 0.1	1.3	-	42	< 1	-	-	< 1
Lower Little Blackfoot River	12324590/LBF10	9/22/03	USGS	152	40	8.2	-	5	-	< .04	2.3	-	51	0.07	-	-	-
Lower Little Blackfoot River	12324590/LBF10	11/19/03	USGS	136	61	8.2	-	4	-	< .04	1.1	-	124	0.2	-	-	-
Lower Little Blackfoot River	LBF10	5/29/08	DEQ	75	1317	7.73	110	6	-	< .08	4	-	1110	1.8	-	< 1	40
Lower Little Blackfoot River	LBF7	5/20/09	DEQ	37	1009.6	6.65	60	15	-	0.16	7	-	-	12.1	-	-	30
Lower Little Blackfoot River	LBF7	9/1/09	DEQ	84	51.1	8.13	< 30	6	< 1	< .08	1	-	80	< .5	-	< 1	30
Lower Little Blackfoot River	LBF9	7/26/08	DEQ	122	105.13	8.22	< 30	6	-	< .08	< 1	-	90	< .5	-	< 1	20
Lower Little Blackfoot River	12324590/LBF10	5/27/03	USGS	68.2	747	7.9	-	8	-	0.1	4.9	-	-	4.38	-	-	15
Lower Little Blackfoot River	LBF9	5/20/09	DEQ	60	1452.3	7.59	< 30	13	-	0.1	8	-	-	8.1	-	-	10
Lower Little Blackfoot River	LBF9	5/29/08	DEQ	71	846	-	140	6	-	< .08	4	-	960	1.8	-	< 1	10
Lower Little Blackfoot River	12324590/LBF10	3/21/01	USGS	103	128	8	-	8	-	< 0.1	4.2	-	690	1.01	-	-	8
Lower Little Blackfoot River	12324590/LBF10	6/5/01	USGS	119	455	8.1	-	7	-	0.1	2.7	-	428	1.17	-	-	6
Lower Little Blackfoot River	12324590/LBF10	5/29/02	USGS	80.2	414	8.2	-	6	-	0.04	2.9	-	591	1.41	-	-	6
Lower Little Blackfoot River	12324590/LBF10	5/3/01	USGS	79.1	383	8	-	6	-	< 0.1	3	-	701	1.79	-	-	6
Lower Little Blackfoot River	12324590/LBF10	6/4/02	USGS	85.6	372	8.1	-	6	-	0.03	2	-	279	< 1	-	-	4
Lower Little Blackfoot River	12324590/LBF10	6/1/04	USGS	105	249	8.3	-	5	-	0.03	1.7	-	215	0.46	-	-	3
Lower Little Blackfoot River	12324590/LBF10	4/20/04	USGS	95.6	168	8.3	-	5	-	< .04	1.9	-	237	0.56	-	-	3

Table G-1. Recent Surface Water Metals Data for the Little Blackfoot River TPA

Waterbody Segment	Site ID	Sample Date	Organization	Hardness (mg/L)	Flow (cfs)	pH	Al (µg/L) D	As (µg/L) TR	Be (µg/L) TR	Cd (µg/L) TR	Cu (µg/L) TR	CN (µg/L) T	Fe (µg/L) TR	Pb (µg/L) TR	Hg (µg/L) TR	Se (µg/L) TR	Zn (µg/L) TR
Lower Little Blackfoot River	12324590/LBF10	5/22/01	USGS	83.4	319	8.2	-	5	-	< 0.1	1.8	-	269	< 1	-	-	3
Lower Little Blackfoot River	12324590/LBF10	4/9/02	USGS	88	197	8.1	-	6	-	< 0.1	2.5	-	383	< 1	-	-	3
Lower Little Blackfoot River	12324590/LBF10	5/17/04	USGS	114	141	8.4	-	5	-	< .04	1.6	-	199	0.43	-	-	2
Lower Little Blackfoot River	12324590/LBF10	6/24/02	USGS	102	289	8.4	-	6	-	0.02	1.6	-	157	< 1	-	-	2
Lower Little Blackfoot River	C01LTBLR01/LBF10	6/30/04	DEQ	140.37	120	7.58	-	6	-	< 0.1	1	-	100	1	-	-	1
Lower Little Blackfoot River	C01LTBLR01/LBF10	7/21/05	DEQ	130	105	7.43	-	6	-	< .08	1	-	70	< .5	-	-	1
Lower Little Blackfoot River	12324590/LBF10	11/8/01	USGS	130	63	8.1	-	5	-	< 0.1	0.9	-	38	< 1	-	-	1
Lower Little Blackfoot River	12324590/LBF10	8/21/02	USGS	121	51	8.6	-	6	-	0.02	1	-	73	< 1	-	-	1
Lower Telegraph Creek	TGH4	5/21/09	DEQ	16	98.38	6.2	160	4	< 1	0.87	5	-	650	1.4	< .05	-	50
Lower Telegraph Creek	TGH4	5/30/08	DEQ	15	72.4	7.1	300	< 3	-	0.11	5	-	390	1.1	< .05	< 1	40
Lower Telegraph Creek	TGH4	7/25/08	DEQ	38	3.2	7.72	< 30	< 3	-	< .08	2	-	60	< .5	< .05	< 1	30
Lower Telegraph Creek	TGH4	8/27/09	DEQ	42	1.62	6.1	< 30	< 3	< 1	0.08	2	-	140	< .5	< .005	-	20
Monarch Creek	MCH1	5/27/08	DEQ	6	22.82	5.87	70	< 3	-	< .08	1	-	100	< .5	< .05	< 1	< 10
Monarch Creek	MCH1	7/23/08	DEQ	9	1.14	7.45	< 30	< 3	-	< .08	< 1	-	< 50	< .5	< .05	< 1	< 10
Monarch Creek	MCH3	5/21/09	DEQ	10	38.1	5.96	90	< 3	-	< .08	3	-	570	3.5	< .05	1	-
Monarch Creek	MCH2	5/27/08	DEQ	9.2	13.79	6.35	130	< 3	-	< .08	3	-	190	0.8	< .05	< 1	-
Monarch Creek	MCH2	7/23/08	DEQ	15	1.49	7.24	40	< 3	-	< .08	< 1	-	150	< .5	< .05	< 1	-
Monarch Creek	MCH2	8/27/09	DEQ	15	0.99	4.96	< 30	< 3	-	< .08	< 1	-	30	< .5	< .005	< 1	-
Monarch Creek	MCH1	8/27/09	DEQ	9	0.93	5.08	< 30	< 3	-	< .08	< 1	-	< 30	< .5	-	< 1	-
Monarch Creek	C01MONRC10/MCH2	8/17/04	DEQ	16	1	5.86	< 100	< 3	-	< 0.1	< 1	-	20	< .5	-	< 1	-
O'Keefe Creek	TGH2	5/28/08	DEQ	11	45.71	6.6	190	< 3	-	0.25	4	-	250	0.5	< .05	-	70
O'Keefe Creek	TGH2	5/20/09	DEQ	10	40.21	5.96	70	3	< 1	1.92	5	-	420	1.7	-	-	70
O'Keefe Creek	TGH2	7/24/08	DEQ	27	3.87	6.47	40	< 3	-	0.1	2	-	250	< .5	< .05	-	50
O'Keefe Creek	TGH2	8/28/09	DEQ	28	0.8	5.98	< 30	< 3	< 1	0.1	1	-	260	< .5	-	-	30
Ontario Creek	ONT0	8/27/09	DEQ	7	0.07	4.29	40	< 3	-	< .08	2	-	140	< .5	-	-	< 10
Ontario Creek	LBF0044	10/7/08	USFS	17	-	6.3	100	9	-	< .08	< 1	-	110	< .5	-	-	130
Ontario Creek	LBF0044	7/20/10	USFS	-	-	6.8	-	6	-	< .08	< 1	-	180	< .5	-	-	110
Ontario Creek	ONT2A	5/21/09	DEQ	9	112.89	6	150	7	-	1.4	4	-	-	3.3	-	-	20
Ontario Creek	ONT2	5/21/09	DEQ	9	238.09	5.8	130	10	-	0.22	4	-	600	4.9	-	-	20
Ontario Creek	ONT2A	8/27/09	DEQ	11	3.19	4.96	< 30	9	-	0.1	2	-	-	< .5	-	-	20
Ontario Creek	ONT2	5/27/08	DEQ	9.2	134.96	6.03	180	8	-	0.09	3	-	320	2.1	< .05	< 1	20
Ontario Creek	ONT2	8/26/09	DEQ	15	5.39	5.54	< 30	10	-	< .08	1	-	40	< .5	-	-	10
Ontario Creek	ONT2	7/23/08	DEQ	14	8.96	7.13	60	9	-	< .08	1	-	70	< .5	< .05	< 1	10
Ophir Creek	OPH1	8/31/09	DEQ	191	1.91	8.37	< 30	5	-	< .08	1	-	-	< .5	-	-	< 10
Ophir Creek	OPH1	5/19/09	DEQ	148	21.79	8.31	< 30	4	-	1.08	2	-	-	< .5	-	-	< 10
Sally Ann Creek	TGH0	5/20/09	DEQ	11	10.94	6.2	< 30	< 3	< 1	1.4	3	-	420	< .5	-	-	< 10
Sally Ann Creek	TGH0	8/28/09	DEQ	-	0.22	6.23	< 30	< 3	< 1	< .08	2	-	1170	< .5	-	-	< 10
Sally Ann Creek	TGH1	5/28/08	DEQ	11	6.97	6.23	180	< 3	-	0.08	4	-	330	0.5	< .05	< 1	60
Sally Ann Creek	TGH1	5/20/09	DEQ	10	33.43	6.37	70	< 3	< 1	1.35	4	-	500	1.5	-	-	50
Sally Ann Creek	TGH1	7/23/08	DEQ	26	0.69	6.65	40	< 3	-	< .08	1	-	410	< .5	< .05	< 1	30
Sally Ann Creek	TGH1	8/28/09	DEQ	31	0.49	6.14	< 30	< 3	< 1	< .08	1	-	500	< .5	-	-	20

Table G-1. Recent Surface Water Metals Data for the Little Blackfoot River TPA

Waterbody Segment	Site ID	Sample Date	Organization	Hardness (mg/L)	Flow (cfs)	pH	Al (µg/L) D	As (µg/L) TR	Be (µg/L) TR	Cd (µg/L) TR	Cu (µg/L) TR	CN (µg/L) T	Fe (µg/L) TR	Pb (µg/L) TR	Hg (µg/L) TR	Se (µg/L) TR	Zn (µg/L) TR
Six Mile Creek	SIX1	7/26/08	DEQ	190	1.73	8.04	100	< 3	-	< 0.1	< 1	-	160	< .5	-	< 1	< 10
Six Mile Creek	SIX1	5/29/08	DEQ	138	5.5	8.07	30	9	-	< .08	3	-	-	< .5	-	< 1	< 10
Snowshoe Creek	SNO4	5/19/09	DEQ	225	12.73	8.07	< 30	5	-	0.9	1	-	160	< .5	-	-	< 10
Snowshoe Creek	SNO4	8/26/09	DEQ	187	9.78	7.32	< 100	< 3	-	< 0.1	< 1	-	-	< .5	-	-	< 10
Snowshoe Creek	C01SNOWC10	8/19/04	DEQ	219	3.5	6.99	< 30	9	-	< .08	1	-	< 10	< .5	-	-	< 10
Snowshoe Creek	SNO4	5/29/08	DEQ	237	2.8	7.9	< 30	< 3	-	< .08	1	-	190	< .5	-	< 1	< 10
Snowshoe Creek	SNO4	7/22/08	DEQ	200	10.08	8.39	60	< 3	-	< .08	9	-	190	< .5	-	< 1	< 10
Spotted Dog Creek	SPD4	5/21/09	DEQ	103	92.18	8.16	< 30	6	-	< .08	3	-	170	0.8	-	-	< 10
Spotted Dog Creek	C01SDOGC02	8/18/05	DEQ	-	1.08	8.1	< 30	< 3	-	< .08	2	-	20	< .5	-	-	< 10
Spotted Dog Creek	C01SDOGC01	8/18/05	DEQ	-	3.56	7.95	< 30	4	-	< .08	1	-	50	< .5	-	-	< 10
Spotted Dog Creek	SPD4	9/2/09	DEQ	144	5.45	7.91	< 100	4	-	< 0.1	< 1	-	-	< .5	-	-	< 10
Spotted Dog Creek	SPD1	7/25/08	DEQ	148	0.87	8.12	< 30	3	-	< .08	< 1	-	410	< .5	-	< 1	< 10
Spotted Dog Creek	SPD4	7/25/08	DEQ	162	12.14	8.18	< 30	4	-	< .08	< 1	-	640	< .5	-	< 1	< 10
Spotted Dog Creek	SPD1	5/30/08	DEQ	83	10.28	7.97	80	4	-	< .08	2	-	-	< .5	-	< 1	< 10
Spotted Dog Creek	SPD4	5/30/08	DEQ	113	55.38	8.04	100	< 3	-	< .08	2	-	< 50	< .5	-	< 1	< 10
Three Mile Creek	THR1	5/21/09	DEQ	157	32.54	8.09	< 30	10	-	< .08	3	-	200	< .5	-	-	< 10
Three Mile Creek	THR1	9/2/09	DEQ	217	3.73	7.69	< 30	8	-	< .08	2	-	-	< .5	-	-	< 10
Three Mile Creek	THR1	7/26/08	DEQ	207	7.03	8.03	< 30	10	-	< .08	6	-	270	< .5	-	< 1	< 10
Three Mile Creek	THR1	5/29/08	DEQ	190	38.91	7.89	< 30	10	-	< .08	4	-	-	< .5	-	< 1	< 10
Un-named Creek	ONT-B	7/28/08	AML	49	-	3.1	-	190	-	23	260	-	15000	150	< .05	-	3330
Un-named Creek	ONT2	7/23/08	DEQ	51	-	3.5	4110	13	-	10	94	-	1560	40	< .05	< 1	1580
Un-named Creek	LBF0039	10/7/08	USFS	48	-	3.8	-	< 3	-	6	40	-	460	< .5	-	-	1080
Un-named Creek	ONT1	10/6/08	DEQ	51	-	-	-	28	-	4.24	34	-	2110	16.7	< .01	-	900
Un-named Creek	LBF0043	7/20/10	USFS	-	-	4.7	-	< 3	-	4	50	-	100	20	< .05	-	650
Un-named Creek	LBF0042	10/7/08	USFS	44	-	4.6	-	238	-	3	30	-	3620	40	-	-	510
Un-named Creek	LBF0080	10/7/08	USFS	44	-	4.6	-	29	-	3	20	-	510	20	-	-	500
Un-named Creek	LBF0043	10/7/08	USFS	43	-	4.9	-	77	-	3	20	-	630	40	-	-	460
Un-named Creek	ONT1	8/27/09	DEQ	43	-	5.4	370	56	-	2.19	25	-	440	9.3	< .005	-	360
Upper Dog Creek	DOG1	5/22/09	DEQ	105	8.9	7.82	90	7	-	3.36	20	-	-	10.4	-	-	290
Upper Dog Creek	DOG1	5/28/08	DEQ	82	8.93	7.73	170	5	-	1.9	17	-	280	6	-	< 1	280
Upper Dog Creek	DOG1	8/25/09	DEQ	155	0.12	7.76	< 30	9	-	1.77	10	-	-	9.9	-	-	160
Upper Dog Creek	DOG1	7/24/08	DEQ	174	1.96	8.15	< 30	10	-	2	7	-	100	7.8	-	< 1	140
Upper Dog Creek	25-179-SW1	9/22/03	AML	145	0.19	8.10	-	4	-	< 1	-	-	140	9	-	-	110
Upper Dog Creek	DOG2	5/22/09	DEQ	99	13.28	7.88	< 30	13	-	0.88	8	-	-	13.5	-	-	80
Upper Dog Creek	DOG2	5/28/08	DEQ	86	11.92	7.83	140	15	-	0.35	10	-	350	10	-	< 1	80
Upper Dog Creek	DOG2	7/24/08	DEQ	171	3.34	8.17	< 30	26	-	1.2	6	-	330	13	-	< 1	50
Upper Dog Creek	DOG2	8/25/09	DEQ	164	0.95	7.76	< 30	35	-	0.39	8	-	-	15.1	-	-	40
Upper Dog Creek	25-179-SW2	9/22/03	AML	160	0.14	7.94	-	13	-	< 1	-	-	410	3	-	-	20
Upper Dog Creek	25-179-SW5	9/22/03	AML	142	2.50	8.14	-	13	-	< 1	< 10	-	570	12	-	-	10
Upper Dog Creek	25-179-SW4	9/22/03	AML	142	2.50	8.14	-	13	-	< 1	-	-	610	14	-	-	10
Upper Little Blackfoot River	LBF2	5/21/09	DEQ	37	171.56	6.84	40	< 3	-	0.62	2	-	-	0.7	-	-	< 10

Table G-1. Recent Surface Water Metals Data for the Little Blackfoot River TPA

Waterbody Segment	Site ID	Sample Date	Organization	Hardness (mg/L)	Flow (cfs)	pH	Al (µg/L) D	As (µg/L) TR	Be (µg/L) TR	Cd (µg/L) TR	Cu (µg/L) TR	CN (µg/L) T	Fe (µg/L) TR	Pb (µg/L) TR	Hg (µg/L) TR	Se (µg/L) TR	Zn (µg/L) TR
Upper Little Blackfoot River	LBF2	8/26/09	DEQ	55	14.45	7.31	< 30	< 3	-	< .08	1	-	-	< .5	-	-	< 10
Upper Little Blackfoot River	LBF5	8/26/09	DEQ	65	35.9	7.28	< 30	8	-	< .08	2	-	-	< .5	-	-	< 10
Upper Little Blackfoot River	LBF3	9/1/09	DEQ	52	18.39	7.81	< 30	6	-	< .08	< 1	< 5	-	< .5	-	-	< 10
Upper Little Blackfoot River	LBF4	9/1/09	DEQ	55	21.73	8.06	< 30	7	-	< .08	< 1	< 5	-	< .5	-	-	< 10
Upper Little Blackfoot River	LBF3	7/25/08	DEQ	51	29.79	7.89	40	6	-	< .08	< 1	< 5	< 50	0.8	-	< 1	< 10
Upper Little Blackfoot River	LBF1	7/21/08	DEQ	8	8.34	7.53	< 30	< 3	-	< .08	< 1	-	60	< .5	-	< 1	< 10
Upper Little Blackfoot River	LBF4	7/25/08	DEQ	58	23.82	7.91	< 30	7	-	< .08	< 1	< 5	60	< .5	-	< 1	< 10
Upper Little Blackfoot River	LBF5	7/21/08	DEQ	64	45.22	7.64	< 30	7	-	< .08	< 1	-	100	< .5	-	< 1	< 10
Upper Little Blackfoot River	LBF1	5/27/08	DEQ	6	55.94	6.43	110	< 3	-	< .08	2	-	160	< .5	-	< 1	< 10
Upper Little Blackfoot River	LBF2	5/27/08	DEQ	36	135.58	6.77	90	< 3	-	< .08	2	-	460	< .5	-	< 1	< 10
Upper Little Blackfoot River	LBF2	7/23/08	DEQ	51	20.88	7.97	< 30	< 3	-	< .08	< 1	-	< 50	< .5	-	< 1	< 10
Upper Little Blackfoot River	LBF4	5/20/09	DEQ	31	802.89	6.04	< 30	24	-	1.6	8	23	-	16.4	-	-	50
Upper Little Blackfoot River	LBF3	5/21/09	DEQ	31	394.83	6.94	60	14	-	0.75	5	< 5	-	8	-	-	30
Upper Little Blackfoot River	LBF5	5/19/09	DEQ	33	908.13	6.64	90	16	-	0.16	7	-	-	9.6	-	-	30
Upper Little Blackfoot River	LBF4	5/28/08	DEQ	31	187.67	6.93	110	7	-	< .08	3	< 5	620	2.6	-	< 1	20
Upper Little Blackfoot River	LBF0066	7/22/08	USFS	67	-	-	-	21	-	< .08	< 1	-	150	< .5	-	< 1	20
Upper Little Blackfoot River	LBF0065	7/22/08	USFS	69	-	-	-	24	-	< .08	< 1	-	230	< .5	-	< 1	20
Upper Little Blackfoot River	LBF3	5/30/08	DEQ	30	272.9	7.53	150	4	-	< .08	3	< 5	370	1.1	-	< 1	10
Upper Little Blackfoot River	LBF5	5/29/08	DEQ	29	1179.6	7.33	140	5	-	< .08	3	-	470	1.7	-	< 1	10
Upper Telegraph Creek	LOB-SW-03	10/9/08	AML	23	-	6.6	-	14	-	3	< 10	-	610	-	< 1	-	610
Upper Telegraph Creek	TGH2B	5/21/09	DEQ	10	7.76	6.15	160	8	< 1	2.04	6	-	500	1.8	-	-	180
Upper Telegraph Creek	TGH2B	8/28/09	DEQ	19	0.1	6.05	< 30	5	< 1	0.76	2	-	< 30	< .5	-	-	130
Upper Telegraph Creek	TGH3A	5/21/09	DEQ	13	90.16	6.13	170	3	< 1	1.72	5	-	550	1.4	< .05	-	50
Upper Telegraph Creek	TGH3	5/28/08	DEQ	13	63.59	6.08	260	< 3	-	0.12	5	-	440	0.8	< .05	< 1	50
Upper Telegraph Creek	LOB-SW-01	10/9/08	AML	17	-	7	-	< 5	-	< 1	< 10	-	370	-	< 1	-	30
Upper Telegraph Creek	TGH3A	8/27/09	DEQ	38	1.91	6.74	< 30	< 3	< 1	0.11	2	-	60	< .5	< .005	-	20
Upper Telegraph Creek	TGH3	7/24/08	DEQ	30	1.96	7.22	40	< 3	-	< .08	2	-	190	< .5	< .05	< 1	20

Table G-2. Recent Sediment Metals Data for the Little Blackfoot River TPA

Waterbody Segment	Site ID	Sample Date	Organization	As (µg/g)	Be (µg/)	Cd (µg/g)	Cu (µg/g)	Fe (µg/g)	Pb (µg/g)	Hg (µg/g)	Se (µg/g)	Zn (µg/g)
American Gulch Creek	DOG3	7/24/08	DEQ	63	-	0.8	34	19600	56	-	< 10	139
Carpenter Creek	CAR1	7/25/08	DEQ	11	-	0.5	37	309000	14	-	< 10	74
Lower Dog Creek	DOG8	7/22/08	DEQ	52	-	2.5	77	30400	176	-	< 10	434
Lower Little Blackfoot River	C01LTBLR01/LBF10	8/21/01	DEQ	13	-	-	37	-	25	-	< 5	122
Lower Little Blackfoot River	LBF10	7/26/08	DEQ	15	-	0.7	29	24600	28	-	< 10	129
Lower Little Blackfoot River	LBF9	7/26/08	DEQ	20	-	0.7	32	25200	31	-	< 10	144
Lower Little Blackfoot River	LBF7	7/25/08	DEQ	69	-	2.5	53	27100	127	-	< 10	358
Lower Telegraph Creek	TGH4	7/25/08	DEQ	99	-	5.1	84	39800	88	-	< 50	635

Table G-2. Recent Sediment Metals Data for the Little Blackfoot River TPA

Waterbody Segment	Site ID	Sample Date	Organization	As (µg/g)	Be (µg/)	Cd (µg/g)	Cu (µg/g)	Fe (µg/g)	Pb (µg/g)	Hg (µg/g)	Se (µg/g)	Zn (µg/g)
Monarch Creek	C01MONRC10/MCH2	8/17/04	DEQ	23.6	4.4	0.57	45	12400	133	-	2.7	120
Monarch Creek	MCH2	7/23/08	DEQ	22	-	0.9	40	14500	154	-	< 10	126
Monarch Creek	MCH1	7/23/08	DEQ	19	-	1.2	17	12200	42	-	< 10	132
O'Keefe Creek	TGH2	7/24/08	DEQ	238	-	28	65	49200	174	-	< 50	2580
Ontario Creek	ONT0	8/27/09	DEQ	30	-	3.2	37	-	71	-	-	162
Ontario Creek	ONT2A	8/27/09	DEQ	430	-	4.7	77	-	357	-	-	340
Ontario Creek	ONT2	7/23/08	DEQ	307	-	7	64	18400	296	-	< 10	569
Sally Ann Creek	TGH0	8/28/09	DEQ	33	-	0.6	45	-	25	-	-	108
Sally Ann Creek	TGH1	7/23/08	DEQ	84	-	6.5	51	40500	95	-	< 50	800
Six Mile Creek	SIX1	7/26/08	DEQ	42	-	0.5	22	15200	21	-	< 10	132
Snowshoe Creek	SNO4	7/22/08	DEQ	6	-	0.4	21	16300	13	-	< 10	59
Snowshoe Creek	C01SNOWC10	8/19/04	DEQ	< 3	-	-	28.8	-	28.8	-	4.6	105
Spotted Dog Creek	SPD4	7/25/08	DEQ	21	-	0.4	33	28700	15	-	< 10	78
Spotted Dog Creek	SPD1	7/25/08	DEQ	75	-	0.6	27	35300	16	-	< 10	91
Three Mile Creek	THR1	7/26/08	DEQ	33	-	0.3	23	19900	17	-	< 10	68
Un-named Creek	ONT1	7/23/08	DEQ	5920	-	1.5	124	242000	307	-	-	245
Upper Dog Creek	25-179-SE-38	9/23/03	AML	134	-	7	220	-	425	1.2	-	910
Upper Dog Creek	25-179-SE-37	9/23/03	AML	149	-	6	230	-	509	1.7	-	1000
Upper Dog Creek	25-179-SE-36	9/23/03	AML	130	-	7	281	-	369	0.5	-	1080
Upper Dog Creek	25-179-SE-25	9/23/03	AML	976	-	7	290	-	711	0.5	-	1340
Upper Dog Creek	25-179-SE-48	9/23/03	AML	312	-	8	291	-	776	3.3	-	1390
Upper Dog Creek	25-179-SE-24	9/23/03	AML	322	-	8	276	-	638	0.5	-	1410
Upper Dog Creek	25-179-SE-51	9/23/03	AML	166	-	9	288	-	679	2.3	-	1410
Upper Dog Creek	25-179-SE-28	9/23/03	AML	187	-	10	299	-	573	2.6	-	1410
Upper Dog Creek	25-179-SE-50	9/23/03	AML	188	-	10	326	-	741	2.5	-	1560
Upper Dog Creek	25-179-SE-7	9/23/03	AML	541	-	7	198	-	898	0.5	-	1570
Upper Dog Creek	25-179-SE-21	9/23/03	AML	169	-	10	385	-	829	0.5	-	1660
Upper Dog Creek	25-179-SE-29	9/23/03	AML	319	-	13	364	-	782	3.4	-	1670
Upper Dog Creek	25-179-SE-26	9/23/03	AML	308	-	9	313	-	668	0.5	-	1680
Upper Dog Creek	25-179-SE-27	9/23/03	AML	548	-	11	426	-	767	1.3	-	1680
Upper Dog Creek	25-179-SE-43	9/23/03	AML	207	-	11	377	-	851	2.2	-	1730
Upper Dog Creek	25-179-SE-52	9/23/03	AML	90	-	12	447	-	757	3	-	1740
Upper Dog Creek	25-179-SE-23	9/23/03	AML	188	-	12	344	-	904	0.5	-	1800
Upper Dog Creek	25-179-SE-39	9/23/03	AML	212	-	12	416	-	808	2.5	-	1810
Upper Dog Creek	25-179-SE-35	9/23/03	AML	170	-	12	497	-	473	0.5	-	1820
Upper Dog Creek	25-179-SE-30	9/23/03	AML	479	-	13	347	-	754	2.9	-	1880
Upper Dog Creek	25-179-SE-47	9/23/03	AML	361	-	13	384	-	1120	3.8	-	1890
Upper Dog Creek	25-179-SE-12	9/23/03	AML	534	-	10	279	-	900	0.5	-	1910

Table G-2. Recent Sediment Metals Data for the Little Blackfoot River TPA

Waterbody Segment	Site ID	Sample Date	Organization	As (µg/g)	Be (µg/)	Cd (µg/g)	Cu (µg/g)	Fe (µg/g)	Pb (µg/g)	Hg (µg/g)	Se (µg/g)	Zn (µg/g)
Upper Dog Creek	25-179-SE-42	9/23/03	AML	177	-	13	592	-	938	2.4	-	1970
Upper Dog Creek	25-179-SE-13	9/23/03	AML	591	-	12	301	-	1010	1.5	-	2110
Upper Dog Creek	25-179-SE-34	9/23/03	AML	162	-	14	446	-	603	1.1	-	2170
Upper Dog Creek	25-179-SE-8	9/23/03	AML	306	-	14	468	-	756	1.8	-	2190
Upper Dog Creek	25-179-SE-44	9/23/03	AML	322	-	15	568	-	1150	3.8	-	2220
Upper Dog Creek	25-179-SE-31	9/23/03	AML	309	-	16	531	-	1260	3.5	-	2360
Upper Dog Creek	25-179-SE-11	9/23/03	AML	643	-	14	450	-	1250	1.1	-	2380
Upper Dog Creek	25-179-SE-33	9/23/03	AML	473	-	16	462	-	1080	3.5	-	2380
Upper Dog Creek	25-179-SE-45	9/23/03	AML	546	-	16	486	-	1190	4.3	-	2380
Upper Dog Creek	25-179-SE-15	9/23/03	AML	604	-	15	435	-	882	1.7	-	2410
Upper Dog Creek	25-179-SE-49	9/23/03	AML	371	-	16	456	-	1200	4.1	-	2420
Upper Dog Creek	25-179-SE-46	9/23/03	AML	539	-	16	482	-	1200	4.6	-	2420
Upper Dog Creek	25-179-SE2	9/23/03	AML	682	-	14	371	27000	1030	1.7	-	2430
Upper Dog Creek	25-179-SE-20	9/23/03	AML	236	-	17	596	-	1380	3.9	-	2460
Upper Dog Creek	25-179-SE-32	9/23/03	AML	641	-	17	587	-	1240	4.3	-	2520
Upper Dog Creek	25-179-SE5	9/23/03	AML	156	-	17	690	15400	777	3.4	-	2530
Upper Dog Creek	25-179-SE-22	9/23/03	AML	278	-	17	583	-	1230	2.2	-	2590
Upper Dog Creek	25-179-SE4	9/23/03	AML	172	-	17	676	15000	882	3.7	-	2590
Upper Dog Creek	25-179-SE-14	9/23/03	AML	813	-	17	401	-	1360	1.3	-	2730
Upper Dog Creek	25-179-SE-40	9/23/03	AML	286	-	14	847	-	2830	5.5	-	2960
Upper Dog Creek	25-179-SE-41	9/23/03	AML	269	-	14	798	-	2700	4.4	-	3100
Upper Dog Creek	25-179-SE-9	9/23/03	AML	199	-	21	1060	-	2350	14	-	3170
Upper Dog Creek	DOG2	7/24/08	DEQ	235	-	18	873	26800	2010	-	< 10	3280
Upper Dog Creek	DOG1	7/24/08	DEQ	156	-	16	636	23900	2180	-	< 10	3280
Upper Dog Creek	25-179-SE-19	9/23/03	AML	336	-	26	809	-	1300	4.4	-	3640
Upper Dog Creek	25-179-SE-16	9/23/03	AML	969	-	26	582	-	1450	2.5	-	3710
Upper Dog Creek	25-179-SE-18	9/23/03	AML	261	-	29	825	-	1200	3.6	-	3920
Upper Dog Creek	25-179-SE-17	9/23/03	AML	543	-	27	711	-	1440	5.3	-	3920
Upper Dog Creek	25-179-SE-10	9/23/03	AML	747	-	26	711	-	2400	1.8	-	3990
Upper Little Blackfoot River	LBF1	7/21/08	DEQ	12	-	1	17	10900	23	-	< 10	91
Upper Little Blackfoot River	LBF2	7/23/08	DEQ	23	-	0.5	33	26200	24	-	< 10	108
Upper Little Blackfoot River	LBF3	7/25/08	DEQ	194	-	2.6	48	26200	187	-	< 10	350
Upper Little Blackfoot River	LBF5	7/21/08	DEQ	150	-	2.9	57	28700	162	-	< 10	409
Upper Little Blackfoot River	LBF4	7/25/08	DEQ	166	-	3	42	28500	164	-	< 10	432
Upper Telegraph Creek	TGH3A	8/27/09	DEQ	96	-	6.7	76	-	82	0.17	-	783
Upper Telegraph Creek	TGH3	7/24/08	DEQ	62	-	7.6	112	34800	86	-	< 10	861
Upper Telegraph Creek	TGH2B	8/28/09	DEQ	478	-	73.5	188	-	169	-	-	2560

Table G-3. Recent Nutrient Data for the Little Blackfoot River TPA

Waterbody Segment	Station ID	Organization	Date	Flow (cfs)	TP (mg/L)	SRP (mg/L)	TN (mg/L)	NO3 (mg/L)	Chlorophyll a (mg/m2)	AFDW (g/m2)
Lower Carpenter Creek	C01CARPC01	DEQ	9/15/10	0.15	0.044	-	0.2	0.005	-	-
Lower Carpenter Creek	C01CARPC01	DEQ	7/8/10	1.92	0.039	-	0.22	0.005	-	-
Lower Carpenter Creek	C01CARPC02	DEQ	7/8/10	5.92	0.045	-	0.31	0.005	-	-
Lower Carpenter Creek	C01CARPC02	DEQ	9/15/10	1.84	0.04	-	0.26	0.01	-	-
Lower Carpenter Creek	C01CARPC03	DEQ	9/16/10	1.06	0.045	-	0.28	0.005	-	18.48
Lower Carpenter Creek	C01CARPC03	DEQ	9/17/10	-	-	-	-	-	16.31	-
Lower Carpenter Creek	C01CARPC03	DEQ	7/8/10	2.60	0.061	-	0.28	0.005	-	-
Lower Carpenter Creek	CAR1	DEQ	9/30/08	2.36	0.055	-	0.1	0.01	8	-
Lower Carpenter Creek	CAR1	DEQ	7/25/08	3.69	0.056	-	0.24	0.01	<50	-
Lower Carpenter Creek	CAR2	DEQ	8/31/09	0.94	0.053	-	0.23	0.01	<50	-
Lower Dog Creek	C01DOGC01	DEQ	8/10/10	9.71	0.011	-	0.13	0.005	-	-
Lower Dog Creek	C01DOGC01	DEQ	7/1/10	33.25	0.017	-	0.17	0.005	-	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	-	-	-	-	3	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	-	-	-	-	4.63	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	-	-	-	-	5.83	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	-	-	-	-	6.79	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	-	-	-	-	7.46	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	-	-	-	-	8.58	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	-	-	-	-	8.75	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	-	-	-	-	12.88	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	-	-	-	-	14.04	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	-	-	-	-	67.84	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	-	-	-	-	173.79	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	0.029	-	0.021	0.005	-	-
Lower Dog Creek	C01DOGC03	DEQ	8/9/10	16.23	0.025	-	0.16	0.005	11.85	7.92
Lower Dog Creek	C01DOGC03	DEQ	7/1/10	73.50	0.028	-	0.26	0.005	-	-
Lower Dog Creek	C01DOGC04	DEQ	8/10/10	15.19	0.031	-	0.22	0.01	6.19	19.60
Lower Dog Creek	C01DOGC04	DEQ	7/1/10	25.86	0.026	-	0.29	0.005	-	-
Lower Dog Creek	C01DOGC05	DEQ	8/10/10	13.29	0.025	-	0.12	0.005	20.06	13.00
Lower Dog Creek	C01DOGC05	DEQ	7/1/10	43.20	0.021	-	0.17	0.005	-	-
Lower Dog Creek	C01DOGC06	DEQ	8/11/10	3.74	0.019	-	0.2	0.005	21.11	144.50
Lower Dog Creek	C01DOGC06	DEQ	7/1/10	12.77	0.023	-	0.19	0.005	-	-
Lower Dog Creek	DOG6	DEQ	10/1/08	5.65	0.035	-	0.025	0.01	4.67	-
Lower Dog Creek	DOG6	DEQ	8/25/09	8.59	0.018	-	0.09	0.005	<50	-
Lower Dog Creek	DOG6	DEQ	7/24/08	14.45	0.028	-	0.12	0.01	<50	-
Lower Dog Creek	DOG8	DEQ	9/29/08	9.96	0.035	-	0.06	0.01	11	-
Lower Dog Creek	DOG8	DEQ	7/22/08	17.35	0.038	-	0.17	0.01	37	-
Lower Dog Creek	DOG8	DEQ	8/26/09	12.17	0.023	-	0.025	0.005	<50	-
Lower Little Blackfoot River	C01LTBLR01	DEQ	7/21/05	105.00	0.027	-	-	0.005	13.78	-

Table G-3. Recent Nutrient Data for the Little Blackfoot River TPA

Waterbody Segment	Station ID	Organization	Date	Flow (cfs)	TP (mg/L)	SRP (mg/L)	TN (mg/L)	NO3 (mg/L)	Chlorophyll a (mg/m2)	AFDW (g/m2)
Lower Little Blackfoot River	CFRPO-10.2	Tri-State WQC	8/19/02	45.00	0.031	0.019	-	0.005	-	-
Lower Little Blackfoot River	CFRPO-10.2	Tri-State WQC	8/20/01	46.00	0.035	0.021	-	0.005	-	-
Lower Little Blackfoot River	LBF @ Avon	UM	8/16/01	70.20	0.027	0.011	0.053	0.003	-	-
Lower Little Blackfoot River	LBF @ Avon	UM	7/16/01	98.00	0.028	0.015	0.173	0.003	-	-
Lower Little Blackfoot River	LBF @ Avon	UM	6/18/01	250.00	0.030	0.012	0.313	0.003	-	-
Lower Little Blackfoot River	LBF @ Avon	UM	9/25/02	-	0.025	0.014	0.055	0.005	-	-
Lower Little Blackfoot River	LBF @ Avon	UM	8/23/02	-	0.024	0.016	0.055	0.005	-	-
Lower Little Blackfoot River	LBF @ Avon	UM	6/20/02	-	0.030	0.009	0.155	0.005	-	-
Lower Little Blackfoot River	LBF @ Avon	UM	9/16/01	46.10	0.010	0.005	0.138	0.008	-	-
Lower Little Blackfoot River	LBF @ Avon	UM	5/23/01	190.00	0.030	0.013	0.198	0.008	-	-
Lower Little Blackfoot River	LBF @ Avon	UM	5/3/02	-	-	0.016	-	0.009	-	-
Lower Little Blackfoot River	LBF @ Avon	UM	7/26/02	-	0.030	0.003	0.060	0.010	-	-
Lower Little Blackfoot River	LBF @ Avon	UM	5/31/02	-	0.036	0.012	0.280	0.010	-	-
Lower Little Blackfoot River	LBF @ Avon (Above)	UM	5/31/02	-	0.023	0.008	0.225	0.005	-	-
Lower Little Blackfoot River	LBF @ Elliston	UM	9/16/01	27.50	0.017	0.012	0.113	0.003	-	-
Lower Little Blackfoot River	LBF @ Elliston	UM	5/23/01	140.00	0.021	0.006	0.133	0.003	-	-
Lower Little Blackfoot River	LBF @ Elliston	UM	6/18/01	195.00	0.025	0.007	0.057	0.007	-	-
Lower Little Blackfoot River	LBF @ Elliston	UM	8/16/01	47.80	0.011	0.005	0.059	0.009	-	-
Lower Little Blackfoot River	LBF @ Elliston	UM	8/23/02	-	0.012	0.006	0.120	0.010	-	-
Lower Little Blackfoot River	LBF @ Elliston	UM	6/20/02	-	0.030	0.006	0.151	0.011	-	-
Lower Little Blackfoot River	LBF @ Elliston	UM	5/31/02	-	0.024	0.005	0.203	0.013	-	-
Lower Little Blackfoot River	LBF @ Elliston	UM	7/16/01	76.50	0.023	0.012	0.217	0.017	-	-
Lower Little Blackfoot River	LBF @ Elliston	UM	7/26/02	-	0.028	0.005	0.280	0.020	-	-
Lower Little Blackfoot River	LBF @ Elliston	UM	5/3/02	-	0.034	0.007	0.450	0.040	-	-
Lower Little Blackfoot River	LBF @ Elliston	UM	9/25/02	-	0.012	0.006	0.170	0.050	-	-
Lower Little Blackfoot River	LBF @ highway 12	UM	6/18/01	375.00	0.040	0.017	0.143	0.003	-	-
Lower Little Blackfoot River	LBF @ highway 12	UM	9/16/01	75.30	0.025	0.016	0.193	0.003	-	-
Lower Little Blackfoot River	LBF @ highway 12	UM	7/16/01	189.00	0.044	0.017	0.223	0.003	-	-
Lower Little Blackfoot River	LBF @ highway 12	UM	5/3/02	-	0.039	0.014	0.283	0.003	-	-
Lower Little Blackfoot River	LBF @ highway 12	UM	9/25/02	-	0.030	0.017	0.055	0.005	-	-
Lower Little Blackfoot River	LBF @ highway 12	UM	8/23/02	-	0.034	0.014	0.125	0.005	-	-
Lower Little Blackfoot River	LBF @ highway 12	UM	7/26/02	-	0.041	0.008	0.185	0.005	-	-
Lower Little Blackfoot River	LBF @ highway 12	UM	6/20/02	-	0.048	0.014	0.295	0.005	-	-
Lower Little Blackfoot River	LBF @ highway 12	UM	8/16/01	68.70	0.031	0.019	0.126	0.006	-	-
Lower Little Blackfoot River	LBF @ highway 12	UM	5/23/01	300.00	0.037	0.014	0.297	0.007	-	-
Lower Little Blackfoot River	LBF @ highway 12	UM	5/31/02	-	0.038	0.011	0.362	0.012	-	-
Lower Little Blackfoot River	LBF10	DEQ	9/30/08	42.28	0.031	-	0.06	0.01	9	-
Lower Little Blackfoot River	LBF10	DEQ	7/26/08	97.37	0.035	-	0.16	0.01	15	-
Lower Little Blackfoot River	LBF10	DEQ	9/1/09	58.20	0.031	-	0.15	0.005	<50	-

Table G-3. Recent Nutrient Data for the Little Blackfoot River TPA

Waterbody Segment	Station ID	Organization	Date	Flow (cfs)	TP (mg/L)	SRP (mg/L)	TN (mg/L)	NO3 (mg/L)	Chlorophyll a (mg/m2)	AFDW (g/m2)
Lower Little Blackfoot River	LBF6	DEQ	9/29/08	27.39	0.023	-	0.05	0.01	14	-
Lower Little Blackfoot River	LBF6	DEQ	8/26/09	48.86	0.011	-	0.09	0.005	<50	-
Lower Little Blackfoot River	LBF6	DEQ	7/26/08	75.09	0.021	-	0.15	0.04	<50	-
Lower Little Blackfoot River	LBF7	DEQ	9/30/08	19.19	0.021	-	0.06	0.03	0.05	-
Lower Little Blackfoot River	LBF7	DEQ	9/1/09	51.10	0.014	-	0.08	0.005	<50	-
Lower Little Blackfoot River	LBF7	DEQ	7/25/08	79.57	0.02	-	0.14	0.03	<50	-
Lower Little Blackfoot River	LBF8	DEQ	9/1/09	81.49	0.024	-	0.08	0.005	39.9	80.6
Lower Little Blackfoot River	LBF8	DEQ	9/30/08	44.05	0.034	-	0.05	0.01	-	-
Lower Little Blackfoot River	LBF8	DEQ	7/26/08	89.15	0.025	-	0.14	0.02	<50	-
Lower Little Blackfoot River	LBF9	DEQ	9/30/08	55.61	0.027	-	0.06	0.01	10	-
Lower Little Blackfoot River	LBF9	DEQ	9/1/09	63.33	0.029	-	0.13	0.005	-	-
Lower Little Blackfoot River	LBF9	DEQ	7/26/08	105.13	0.035	-	0.15	0.01	<50	-
Lower Little Blackfoot River	Little Blackfoot	UM	8/20/01	46.00	0.035	0.021	0.163	0.003	-	-
Lower Little Blackfoot River	Little Blackfoot	UM	9/25/02	40.00	0.020	0.014	0.055	0.005	-	-
Lower Little Blackfoot River	Little Blackfoot	UM	8/23/02	51.00	0.035	0.011	0.125	0.005	-	-
Lower Little Blackfoot River	Little Blackfoot	UM	7/26/02	90.00	0.041	0.007	0.165	0.005	-	-
Lower Little Blackfoot River	Little Blackfoot	UM	6/20/02	352.00	0.053	0.016	0.205	0.005	-	-
Lower Little Blackfoot River	Little Blackfoot	UM	5/31/02	418.00	0.055	0.011	0.295	0.005	-	-
Lower Little Blackfoot River	Little Blackfoot	UM	5/22/01	322.00	0.033	0.012	0.255	0.015	-	-
Lower Spotted Dog Creek	C01SDOGC01	DEQ	8/18/05	3.56	0.033	-	0.025	0.005	-	-
Lower Spotted Dog Creek	C01SDOGC03	DEQ	7/20/10	15.87	0.038	-	0.21	0.005	1.74	17.92
Lower Spotted Dog Creek	C01SDOGC03	DEQ	8/18/10	7.53	0.037	-	0.23	0.005	-	-
Lower Spotted Dog Creek	C01SDOGC03	DEQ	9/17/10	5.88	0.029	-	0.24	0.005	-	-
Lower Spotted Dog Creek	C01SDOGC04	DEQ	7/20/10	15.90	0.042	-	0.21	0.005	30.58	32.13
Lower Spotted Dog Creek	C01SDOGC04	DEQ	9/17/10	5.69	0.024	-	0.26	0.005	-	-
Lower Spotted Dog Creek	C01SDOGC04	DEQ	8/18/10	6.91	0.032	-	0.27	0.005	-	-
Lower Spotted Dog Creek	C01SDOGC05	DEQ	7/21/10	13.18	0.031	-	0.17	0.005	8.55	94.28
Lower Spotted Dog Creek	C01SDOGC05	DEQ	8/18/10	5.72	0.029	-	0.32	0.01	-	-
Lower Spotted Dog Creek	C01SDOGC06	DEQ	7/21/10	14.19	0.037	-	0.15	0.005	9.14	633.90
Lower Spotted Dog Creek	C01SDOGC06	DEQ	9/29/10	4.19	0.027	-	0.11	0.005	-	-
Lower Spotted Dog Creek	C01SDOGC06	DEQ	8/18/10	5.55	0.037	-	0.26	0.005	-	-
Lower Spotted Dog Creek	C01SDOGC07	DEQ	7/22/10	5.89	0.031	-	0.11	0.005	7.51	12.37
Lower Spotted Dog Creek	C01SDOGC07	DEQ	9/29/10	1.36	0.036	-	0.09	0.005	-	-
Lower Spotted Dog Creek	C01SDOGC07	DEQ	8/19/10	2.40	0.043	-	0.29	0.005	-	-
Lower Spotted Dog Creek	C01SDOGC08	DEQ	7/22/10	3.67	0.021	-	0.1	0.005	11.83	10.10
Lower Spotted Dog Creek	C01SDOGC08	DEQ	9/29/10	0.98	0.017	-	0.025	0.005	-	-
Lower Spotted Dog Creek	C01SDOGC08	DEQ	8/19/10	1.72	0.02	-	0.17	0.01	-	-
Lower Spotted Dog Creek	SPD2	DEQ	10/2/08	0.84	0.046	-	0.05	0.005	9	-
Lower Spotted Dog Creek	SPD2	DEQ	9/1/09	1.97	0.039	-	0.11	0.005	<50	-

Table G-3. Recent Nutrient Data for the Little Blackfoot River TPA

Waterbody Segment	Station ID	Organization	Date	Flow (cfs)	TP (mg/L)	SRP (mg/L)	TN (mg/L)	NO3 (mg/L)	Chlorophyll a (mg/m2)	AFDW (g/m2)
Lower Spotted Dog Creek	SPD2	DEQ	7/25/08	2.01	0.04	-	0.15	0.01	<50	-
Lower Spotted Dog Creek	SPD3	DEQ	10/2/08	0.80	0.039	-	0.08	0.01	0.05	-
Lower Spotted Dog Creek	SPD3	DEQ	7/25/08	10.38	0.06	-	0.25	0.01	21	-
Lower Spotted Dog Creek	SPD3	DEQ	9/2/09	5.39	0.038	-	0.21	0.005	57.9	-
Lower Spotted Dog Creek	SPD4	DEQ	7/25/08	12.14	0.061	-	0.2	0.01	4.3	-
Lower Spotted Dog Creek	SPD4	DEQ	10/2/08	1.84	0.051	-	0.06	0.005	6	-
Lower Spotted Dog Creek	SPD4	DEQ	9/2/09	5.45	0.044	-	0.17	0.005	<50	-
Snowshoe Creek	C01SNOWC01	DEQ	9/14/10	8.03	-	-	-	0.005	-	-
Snowshoe Creek	C01SNOWC01	DEQ	7/6/10	8.11	-	-	-	0.005	-	-
Snowshoe Creek	C01SNOWC01	DEQ	8/4/10	11.46	-	-	-	0.005	-	-
Snowshoe Creek	C01SNOWC02	DEQ	9/14/10	2.88	-	-	-	0.01	-	-
Snowshoe Creek	C01SNOWC02	DEQ	8/4/10	5.19	-	-	-	0.01	-	-
Snowshoe Creek	C01SNOWC02	DEQ	7/6/10	2.29	-	-	-	0.04	-	-
Snowshoe Creek	C01SNOWC03	DEQ	8/4/10	4.57	-	-	-	0.005	-	-
Snowshoe Creek	C01SNOWC03	DEQ	7/6/10	5.70	-	-	-	0.005	-	-
Snowshoe Creek	C01SNOWC03	DEQ	9/14/10	4.44	-	-	-	0.01	-	-
Snowshoe Creek	C01SNOWC04	DEQ	9/15/10	6.47	0.007	-	0.23	0.14	0.7	4.68
Snowshoe Creek	C01SNOWC04	DEQ	7/7/10	8.88	0.009	-	0.16	0.08	-	-
Snowshoe Creek	C01SNOWC04	DEQ	8/4/10	8.12	0.009	-	0.1	0.1	-	-
Snowshoe Creek	C01SNOWC10	DEQ	9/15/10	3.07	0.0025	-	0.22	0.12	485.8	22.63
Snowshoe Creek	C01SNOWC10	DEQ	7/7/10	4.49	0.01	-	0.21	0.08	-	-
Snowshoe Creek	C01SNOWC10	DEQ	8/19/04	3.50	0.002	-	-	0.08	-	-
Snowshoe Creek	C01SNOWC10	DEQ	8/4/10	3.82	0.007	-	0.12	0.09	-	-
Snowshoe Creek	SNO1	DEQ	7/22/08	11.23	-	-	-	0.11	<50	-
Snowshoe Creek	SNO1	DEQ	10/1/08	4.60	-	-	-	0.12	-	-
Snowshoe Creek	SNO1	DEQ	8/26/09	3.65	-	-	-	0.14	<50	-
Snowshoe Creek	SNO2	DEQ	7/22/08	7.02	-	-	-	0.1	<50	-
Snowshoe Creek	SNO2	DEQ	10/1/08	3.95	-	-	-	0.11	<50	-
Snowshoe Creek	SNO2	DEQ	8/26/09	6.29	-	-	-	0.13	<50	-
Snowshoe Creek	SNO3	DEQ	8/26/09	4.38	0.01	-	0.16	0.005	<50	-
Snowshoe Creek	SNO3	DEQ	7/22/08	8.00	0.017	-	0.17	0.01	<50	-
Snowshoe Creek	SNO3	DEQ	10/1/08	7.85	0.023	-	0.08	0.02	<50	-
Snowshoe Creek	SNO4	DEQ	7/22/08	10.08	0.04	-	0.17	0.01	8.93	-
Snowshoe Creek	SNO4	DEQ	10/1/08	6.88	0.064	-	0.09	0.005	<50	-
Snowshoe Creek	SNO4	DEQ	8/26/09	9.78	0.033	-	0.09	0.01	<50	-
Threemile Creek	C01TREMC01	DEQ	7/23/10	8.13	0.07	-	0.45	0.01	9.6	25.7
Threemile Creek	C01TREMC01	DEQ	9/17/10	5.09	0.049	-	0.94	0.04	-	-
Threemile Creek	C01TREMC01	DEQ	8/20/10	6.21	0.055	-	0.58	0.05	-	-
Threemile Creek	C01TREMC02	DEQ	7/23/10	3.38	0.057	-	0.43	0.03	19.73	6.95

Table G-3. Recent Nutrient Data for the Little Blackfoot River TPA

Waterbody Segment	Station ID	Organization	Date	Flow (cfs)	TP (mg/L)	SRP (mg/L)	TN (mg/L)	NO3 (mg/L)	Chlorophyll a (mg/m2)	AFDW (g/m2)
Threemile Creek	C01TREMC02	DEQ	8/20/10	2.05	0.072	-	0.66	0.16	-	-
Threemile Creek	C01TREMC02	DEQ	9/17/10	2.13	0.05	-	0.48	0.17	-	-
Threemile Creek	THR1	DEQ	9/30/08	2.10	0.064	-	0.22	0.01	9	-
Threemile Creek	THR1	DEQ	7/26/08	7.03	0.109	-	0.58	0.05	9.7	-
Threemile Creek	THR2	DEQ	9/2/09	1.51	0.077	-	0.53	0.005	46.7	-

APPENDIX H – RESPONSE TO PUBLIC COMMENT

Two comment letters were received during the public comment period. Comments were received from the Montana Chapter of the American Fisheries Society (MCAFS) and the Clark Fork Coalition (CFC). Excerpts of the comments and DEQ's comment responses are presented below. The original comment letters are held on file at DEQ and may be viewed upon request.

Montana Chapter of the American Fisheries Society

Comment #1: Although the Little Blackfoot River watershed has been considered core or critical habitat for bull trout since the 1990s, a recent review removed the critical habitat designation in 2010 (W.A. Fredenberg US Fish and Wildlife Service, personal communication)…Nonetheless, in preparing this TMDL, EPA and DEQ were under the assumption that the watershed was designated critical habitat for bull trout, and as such should have considered the thermal requirements of this federal threatened species in developing a description of the impairment status and the restoration approach. Likewise, westslope cutthroat trout occur throughout the watershed and are highly vulnerable to thermal pollution…Although the Little Blackfoot River watershed is no longer designated critical bull trout habitat, we contend that previously occupied habitat in the basin should meet suitability criteria to allow for recolonization or restoration in the future.

> **DEQ Response to Comment #1:** The sentence in **Section 2.2.2** citing 50 CFR Part 17 from 2005 that noted the Little Blackfoot River is designated as critical habitat for bull trout has been removed from the document. The document still states that bull trout and westslope cutthroat are native to the watershed (among other species). Regardless of species status designations, both TMDLs and beneficial use support determinations (i.e. 303(d) listing decisions) are designed to be protective of all beneficial uses, including the most sensitive. Regarding thermal considerations, however, there are currently no waterbodies in the Little Blackfoot River watershed listed for temperature impairment and as stated on page 1-1, "Both Montana state law (Section 75-5-701 of the Montana Water Quality Act) and section 303(d) of the federal CWA require the development of total maximum daily loads for all impaired waterbodies when water quality is impaired by a pollutant." Therefore, no temperature TMDLs are currently necessary and considering the thermal requirements of fish within the watershed is outside the scope of this document.

Comment #2: The MCAFS's past comments on TMDLs and the TMDL process addressed the DEQ's (and now the EPA's) approach and apparent unwillingness to address key water-quality constraints that harm native and wild fish, particularly the federal threatened bull trout and westslope cutthroat trout. Specifically, we are concerned that despite having substantial information implicating thermal loading as a constraint on these temperature-sensitive species, the TMDL does not develop a plan to restore water quality with respect to this major constraint on sensitive native fish species. We are encouraged that the TMDL acknowledged the role dewatering plays in limiting water quality; however, we are disappointed that temperature and flow limitations were given such limited treatment in the document.

> **DEQ Response to Comment #2:** As mentioned in Response #1, addressing temperature is beyond the scope of the document. Temperature is acknowledged as an issue in **Section 8** that should be given additional consideration and all pollution listings, including low flow alterations, are also discussed in **Section 8**. Additionally, irrigation BMPs are discussed in the discussion of

restoration approaches (**Section 9.4.5**). However, using all available data to make impairment determinations is a responsibility of the Monitoring and Assessment Section at DEQ.

Regarding temperature values and the amount of available data, exceeding a temperature threshold alone does not constitute a violation of Montana's temperature standard, which identifies an allowable departure from naturally occurring temperature conditions. Naturally occurring temperatures within a water body may be above fish thresholds, so although thresholds are typically considered, they cannot be applied as standalone conditions that have to be met or as a solitary line of evidence for determining compliance with Montana's temperature standard. Evaluating temperature impairment typically necessitates modeling, which requires not only temperature data but also shade data, corresponding flow measurements, and information on human sources (e.g. alterations to channel form and irrigation management). The assessment process is currently being revised to more explicitly incorporate temperature thresholds but must still be structured to assess compliance with the state standard, which relates to the naturally occurring condition; the public will have an opportunity to provide comments.

Comment #3: We are greatly concerned that DEQ has removed references to "pollution" such as dewatering from its current versions of previous 303(d) lists despite the obvious causality and relevance to a host of pollutants. The DEQ was aware of the potential for water temperatures to impair beneficial uses of streams in the Little Blackfoot River watershed beginning with its 1996 303(d) list, and our archived version of the 1996 303(d) list shows dewatering among the causes of impairment for much of the Little Blackfoot River and several of its tributaries.

DEQ Response to Comment #3: As noted in the document and in **Appendix A** (List of Impaired Waters) of the 2010 Integrated 305(b)/303(d) Water Quality Report, several waterbodies in the Little Blackfoot River watershed are listed by DEQ as impaired by low flow alterations (i.e., Little Blackfoot River, Snowshoe Creek, and Threemile Creek). The reporting format has changed since the 1996 303(d) List, but Montana still evaluates waterbodies and makes impairment determinations for both pollutant and non-pollutant causes. Following EPA guidance, DEQ has included the biennial 303(d) list as part of the Integrated 305(b)/303(d) Water Quality Report since the 2002 reporting cycle. Starting in 2004, EPA required states to assign assessed waters to categories, which allows for better tracking of waters impaired by pollutants versus pollution (as well as other things).

Therefore, Montana DEQ now more strictly adheres to the definition of the 303(d) list and submits a list containing only pollutant-impaired waters to EPA as part of the 303(d) list portion of the Integrated Report. As mentioned above, DEQ has and will continue to evaluate impairment for pollution causes. Because of the common linkage between pollution and pollutant causes, both the assessment and the TMDL development processes identify those linkages when possible. Since 2008 and moving forward, the Integrated Report has an appendix for those waters requiring TMDLs (**Appendix B**) and an appendix containing the list of all impaired waters (**Appendix A**). Due to sufficient credible data requirements and/or new data, some listings have changed in the Little Blackfoot River watershed since the 1996 303(d) list, but as discussed within this document and listed in **Table A-1**, numerous pollution impairment listings remain. The 2010 Integrated Report, 303(d) listing information, and previous listing cycle information are available at the Clean Water Act Information Center website (http://cwaic.mt.gov).

Comment #4: A review of water quality standards attainment record indicates that DEQ ostensible reviewed several sources of information containing temperature data for the Little Blackfoot River, yet no mention of temperature was made in the data matrix. The absence of temperature data in the matrix stands in stark contrast to the abundance of temperature data recorded at the Little Blackfoot River U.S. Geological Survey gage station near Garrison as well as a substantial amount of temperature data in the STORET database collected by DEQ in the Little Blackfoot River watershed. Despite this, the DEQ refers only to a limited 2007 dataset (**Section 8.2.1**).

We contend that during the 2000 and subsequent reviews, reviewers should have analyzed data from the USGS to conform with state law requiring DEQ to use all available data. Data collected at the USGS gage near Garrison include monthly recordings of water temperature beginning in 1983 and extending through 2010.

> **DEQ Response to Comment #4:** As mentioned in Responses #1 and #2, addressing temperature impairment is outside the scope of this document and review of all available data to make a temperature impairment determination would need to be performed by the Monitoring and Assessment Section at DEQ. The reference in **Section 8.2.1** was not meant to be an inclusive list of available temperature data and was mentioned because that dataset includes temperature measurements collected every 30 minutes as well as flow measurements and information regarding the irrigation network, all of which are typically necessary for making an impairment determination. DEQ is aware that there is quite a bit of additional temperature data for the Little Blackfoot River and several tributaries, and while the sentence in **Section 8.2.1** was not meant to be an inclusive list of available temperature data, the sentence has been edited to reference USGS and FWP data as well.
>
> Due to the cyclical nature of water quality monitoring as well as staff, budget, and time constraints, all waterbodies are not fully assessed for beneficial use support during every 303(d) listing cycle. Most waterbodies in the Little Blackfoot River watershed, including the Little Blackfoot River, have not been formally assessed for beneficial use support since the 2000 303(d) listing cycle. Thus, data collected since that time is not reflected in the listing status unless assessment work was necessary for existing 303(d) listed pollutants covered within this TMDL document. Additionally, due to submission requirements for each 303(d) list, the cutoff date for incorporated data may not coincide with the listing year (e.g., 2011 for the 2012 listing cycle). Changes in both the listing process and to the assessment database resulted in an update to the file records after 2000, but this work did not constitute a formal reassessment. The available information is not incorporated into any impairment determinations because the type of formal assessment that could have resulted in an impairment determination has not occurred since 2000.
>
> During each listing cycle, hundreds of stakeholders from all over Montana are solicited for recent data. In addition to data and information received during that solicitation, DEQ uses data collected from its own monitoring efforts and data collected by other organizations that operate monitoring programs and store their data in publicly accessible databases. In addition to the EPA STORET database, databases operated by the United States Geological Survey and the Montana Bureau of Mines and Geology contribute a significant amount of data to water quality assessments. The result of all these combined data sources is a collection of data and information of varying technical rigor that must be reviewed as an assemblage to determine

whether sufficient credible data exists to proceed with the assessment. Even if a water body is not reassessed during a listing cycle, all data received during this process are added to the assessment file to be incorporated into the next formal assessment. Queries of data from publicly accessible databases such as STORET and NWIS are typically not performed for every waterbody for each listing cycle but all of that information is compiled during the next formal reassessment.

Comment #5: Of course, dewatering is not the only factor influencing thermal loading in streams. Maintaining natural channel geometry and riparian function can minimize thermal loading potential, and this TMDL plan does address these critical components of a health stream in its sediment TMDL. Nonetheless, if the Little Blackfoot River watershed was core habitat for bull trout, this plan would insufficiently restore water quality to protect this threatened species. Likewise, thermal alterations likely limit westslope cutthroat trout, and by ignoring the proven relationship between dewatering and thermal loading, this plan does not protect this species of special concern.

DEQ Response to Comment #5: DEQ agrees that channel form and riparian health, which are both addressed in this document, are also important factors in minimizing thermal loading. TMDLs do not focus on protecting a certain species but are written to be protective of all beneficial uses and meet water quality standards as they apply to the pollutants for which each TMDL is developed. It is important to recognize that TMDL documents do not aim to be a cure-all for all problems within a watershed and are not self-implementing. The document addresses all identified pollutant water quality impairments, but this does not necessarily mean that no additional impairments remain. Furthermore, the restoration strategy in the document is only intended to apply to the known impairments and is a general strategy, not a detailed comprehensive restoration plan.

DEQ agrees that similarly to other pollutants like sediment and nutrients, dewatering can greatly affect thermal loading. As discussed in Response #2, low flow alteration impairments as well as irrigation BMPs are discussed within the document, and although temperature is outside the scope of this document, temperature impairment evaluations are complex, must consider the naturally occurring condition, and a single line of evidence such as low flow cannot be used as the listing basis.

Additionally, the integration of flow into a temperature TMDL or any TMDL within Montana has to take into consideration the "nonimpairment of water rights" section (75-5-705) of the Montana Water Quality Act, where it is stated that nothing within the water quality assessment and TMDL development part (Part 7) of the Montana Water Quality Act "may be construed to divest, impair, or diminish any water right recognized pursuant to Title 85." Nevertheless, during temperature TMDL development Montana DEQ does evaluate the potential for increased streamflows via improved water use practices, but only under conditions where the TMDL and associated targets to satisfy water quality standards cannot be construed to divest, impair, or diminish any of the water rights within the watershed. Therefore, DEQ cannot use dewatering as part of the justification for temperature impairment without first evaluating the potential for increased streamflow while concurrently assuring that no water right is divested, impaired or diminished.

Clark Fork Coalition

Comment #6: We commend DEQ on a thorough and well-organized treatment of the complex issues of sedimentation, nutrient enrichment, and metals contamination in the Little Blackfoot River and its principal tributaries. We believe the document provides a realistic diagnosis of the issues and causes, and useful guidance on general steps to address those issues.

> **DEQ Response to Comment #6:** Thank you. We appreciate the comment.

Comment #7: The CFC is concerned that the scope of the TMDL document does not explicitly address low-flow and dewatering, and especially the associated problem of elevated water temperatures. The problems are well-known and well-documented in the mainstem Little Blackfoot River and a number of its tributaries. Montana Fish, Wildlife and Parks maintains a "Dewatered Concern Areas" list—the 2003 version of that list includes 75 stream miles in the Little Blackfoot drainage, including the lower 25 miles of the lower Little Blackfoot River itself.

The CFC is aware that "low flow" is not an impairment for which DEQ prepares TMDLs. However, we believe that the widespread dewatering problems in the Little Blackfoot drainage are a contributing factor to elevated water temperatures which are negatively affecting the health of cold-water fisheries….It is unclear whether DEQ was aware of the considerable data from Montana FWP fisheries biologists which further documents water temperatures in the Little Blackfoot River above 20 degrees C for prolonged periods, a temperature regime which is known to be detrimental to survival of westslope cutthroat trout, a Montana Species of Concern.

> **DEQ Response to Comment #7:** This comment is addressed in Response # 1, 2, 4, and 5.

Comment #8: The Clark Fork Coalition requests that DEQ not delay an appropriate treatment of the elevated water temperature issue in the Little Blackfoot River. The 2012 revision of the 303(d) list should not only specifically evaluate temperature impairment data on the Little Blackfoot, but also similar data throughout the Upper Clark Fork. Meanwhile, the CFC requests that DEQ initiate, as soon as possible, a temperature TMDL on the Little Blackfoot with a temperature TMDL on tributary streams within the Upper Clark Fork TMDL planning area. This could be done in association with the upcoming nutrient TMDLs for the Upper Clark Fork. Similarly to the Little Blackfoot, numerous tributary streams in the UCF with documented dewatering and elevated water temperature problems were not included in the Upper Clark Fork Tributaries TMDLs document published in March, 2010. Since 2009, Montana FWP, the Watershed Restoration Coalition, and the Clark Fork Coalition have collected considerable additional data on low-flow and water temperature impairments in the Upper Clark Fork, which could be useful for TMDL development.

> **DEQ Response to Comment #8:** As discussed in Response #2, temperature impairment evaluations are complex and require much more than just temperature data. While it is possible that impairment evaluations may be conducted based on the existing data, additional data collection may be necessary. Also, the assessment methodology is currently being revised, which may change the information need to meet the sufficient credible data requirement for assessment. Based on these factors and DEQ's timeline for submitting the 2012 303(d) List to EPA, it is very unlikely that temperature impairment evaluations can be conducted in the Little Blackfoot and Upper Clark Fork TMDL Planning Areas for the 2012 listing cycle.

Although in some instances TMDLs are developed where data collection during TMDL development presents significant or overwhelming evidence of impairment or presents a link between a non-pollutant impairment and pollutant-related impairment (e.g., habitat alterations and sedimentation/siltation), due to time and resource constraints and to maintain process consistency, data collected on listed and unlisted streams during TMDL development typically pertains to the pollutants associated with the 303(d) listed waterbodies and the preferred approach is not to proceed with TMDL development until has made a formal impairment determination. The timing of temperature TMDL development in the Little Blackfoot and Upper Clark Fork TMDL Planning Areas is dependent on the timing and outcome of impairment evaluations for those areas, as well as TMDL priorities and available resources at DEQ. No specific commitments can be made at this time but the Clark Fork Coalition is encouraged to contact the Monitoring and Assessment and TMDL sections at DEQ to ensure DEQ is aware of available temperature-related data in both watersheds and to discuss the timeline for temperature impairment assessments and additional TMDL development.

Comment #9: We note on p. D-40 that DEQ was unable to gather information regarding a water lease previously held by the Montana Water Trust which was transferred to CFC in 2010…The water lease protected 2.52 cubic feet per second instream over a 5-year term on the mainstem Little Blackfoot River. It expired in 2011 and CFC is in negotiations with the landowner for renewal…Also, please note that, as of March 2010, the Montana Water Trust was acquired by the CFC and is no longer a stand-alone entity. The CFC now provides the technical expertise on flow restoration that the Montana Water Trust previously provided in the Upper Clark Fork basin as the TMDL document indicates on p. 9-1.

DEQ Response to Comment #9: Thank for you for the additional information. The text in **Appendix D** has been edited to reflect this information.

Comment #10: The Clark Fork Coalition would like to suggest that the scoping process for future TMDLs include a broader and more effective interaction between agency scientists, biologists, and non-profits working on native fish restoration, so that the considerable DEQ effort in preparing TMDLs not omit priority fisheries issues like water temperature. ..Specifically, we would like to work with Montana DEQ and Montana FWP to encourage the more systematic use of temperature data collected by FWP fisheries biologists in the development of TMDLs by Montana DEQ. It would behoove all parties to improve the protocols for water temperature data collection and data management so that we can address this issue efficiently and effectively.

DEQ Response to Comment #10: Each DEQ TMDL project has one or more advisory groups to offer technical, modeling, and general process guidance and feedback. Membership is voluntary and representation is solicited from local watershed groups, agricultural interests, logging interests, mining interests, fishing and recreation interests, industrial interests, local government, federal and state land management agencies, among others. The advisory group(s) is encouraged to provide input and may influence the scope of the project, such as the addition of Trout Creek to the sediment/habitat data collection effort in the Little Blackfoot River watershed; however, because of resource demands and the fact that impairment determinations are made externally to the TMDL development process, scoping decisions and especially large-scale scoping decisions such as the addition of pollutant groups with no listings within a watershed (such as temperature in the Little Blackfoot River watershed) must ultimately be made by DEQ management. For future reference, although your scope comments

at this stage are valuable in assisting with future planning and prioritization they will be most effective in the earlier stages of the TMDL development.

Particularly given the changing temperature assessment methodology and the magnitude of waters that will need to be evaluated, DEQ agrees that working with other entities that collect temperature data such as FWP will be very important to improving the efficiency and effectiveness of data collection and waterbody impairment determinations. While it is crucial for DEQ to be aware of all available data to assist with TMDL development, it is even more important that this information be incorporated at the formal assessment phase so that waterbodies have been formally assessed before the TMDL process is initiated in a watershed.

Perhaps of most importance is the fact that since 2000, the scope of TMDLs to be developed has been predominately defined by an existing court order linked to Montana's 303(d) List. Per a recent amendment to this court order, the DEQ (and EPA) still have a given set of TMDLs, based on the 2010 303(d) list, to pursue through 2014. The DEQ is looking at ways to integrate a TMDL development scoping approach like suggested above into future TMDL projects. The current 303(d) list contains more than 1,500 waterbody - pollutant combinations yet requiring TMDL development, of which more than 640 specifically have to be addressed by 2014 via an existing court order. The flexibility to pursue TMDL development for a new pollutant category not on the 303(d) list, such as temperature in the Little Blackfoot, within a watershed where TMDL development is under way for other pollutant categories, such as sediment or metals, would stress existing resources to the point where the DEQ would not be able to satisfy the current court order requirements.

ERRATA SHEET FOR THE "LITTLE BLACKFOOT RIVER WATERSHED TMDLS AND FRAMEWORK WATER QUALITY IMPROVEMENT PLAN"

This TMDL was approved by EPA on December 30, 2011. Several copies were printed and spiral bound for distribution, or sent electronically on compact disks. The original version of Appendix G has several errors in Tables G-1 and G-2. For ease of making the corrections please replace Appendix G with the attached corrected version dated 1/22/14.

If you have a bound copy, please note the tables have changed or simply print out the errata sheet and insert it in your copy of the TMDL. If you have a compact disk please add this errata sheet and Appendix G replacement to your disk or download the updated version from our website.

Appropriate corrections have already been made in the downloadable version of the TMDL located on our website at: http://deq.mt.gov/wqinfo/TMDL/finalReports.mcpx

APPENDIX G – METALS AND NUTRIENT WATER QUALITY DATA

Table G-1. Recent Surface Water Metals Data for the Little Blackfoot River TPA

Waterbody Segment	Site ID	Sample Date	Organization	Hardness (mg/L)	Flow (cfs)	pH	Al (µg/L) D	As (µg/L) TR	Be (µg/L) TR	Cd (µg/L) TR	Cu (µg/L) TR	CN (µg/L) T	Fe (µg/L) TR	Pb (µg/L) TR	Hg (µg/L) TR	Se (µg/L) TR	Zn (µg/L) TR
American Gulch Creek	DOG3	5/28/2008	DEQ	85	16.2	7.81	70	14	-	< .08	2	-	1040	1.8	-	< 1	10
American Gulch Creek	DOG3	7/24/2008	DEQ	163	0.76	8.15	< 30	14	-	< .08	< 1	-	290	< .5	-	< 1	< 10
American Gulch Creek	DOG3	5/22/2009	DEQ	99	13.37	7.64	< 30	13	-	0.55	7	-	-	6.4	-	-	70
American Gulch Creek	DOG3	8/25/2009	DEQ	149	0.85	7.64	< 30	16	-	< .08	< 1	-	-	< .5	-	-	< 10
Carpenter Creek	CAR1	5/29/2008	DEQ	157	33.68	8.17	< 30	4	-	< .08	2	-	160	< .5	-	< 1	< 10
Carpenter Creek	CAR1	7/25/2008	DEQ	222	3.69	8.45	< 30	4	-	< .08	< 1	-	70	< .5	-	< 1	< 10
Carpenter Creek	CAR1	5/19/2009	DEQ	146	29.09	8.26	< 30	4	-	0.41	2	-	-	< .5	-	-	< 10
Carpenter Creek	CAR1	8/31/2009	DEQ	187	3.58	8.29	< 30	5	-	< .08	1	-	-	< .5	-	-	< 10
Hope Creek	DOG5	5/28/2009	DEQ	94	25.93	7.87	110	< 3	-	1.02	2	-	-	0.5	-	-	< 10
Hope Creek	DOG5	8/25/2009	DEQ	197	4.47	7.79	< 30	< 3	-	< .08	< 1	-	-	< .5	-	-	< 10
Lower Dog Creek	DOG8	5/29/2008	DEQ	53	119.17	7.86	350	4	-	< .08	6	-	790	4.4	-	< 1	20
Lower Dog Creek	DOG8	7/22/2008	DEQ	121	17.35	8.22	30	6	-	< .08	2	-	360	2.3	-	< 1	< 10
Lower Dog Creek	DOG8	5/19/2009	DEQ	49	247.6	6.71	130	5	-	1.21	7	-	-	6.4	-	-	20
Lower Dog Creek	DOG8	8/26/2009	DEQ	134	12.17	7.97	< 30	8	-	< .08	3	-	-	1.7	-	-	< 10
Lower Little Blackfoot River	12324590/LBF10	3/21/2001	USGS	103	128	8	-	8	-	< 0.1	4.2	-	690	1.01	-	-	8
Lower Little Blackfoot River	12324590/LBF10	5/3/2001	USGS	79.1	383	8	-	6	-	< 0.1	3	-	701	1.79	-	-	6
Lower Little Blackfoot River	12324590/LBF10	5/22/2001	USGS	83.4	319	8.2	-	5	-	< 0.1	1.8	-	269	< 1	-	-	3
Lower Little Blackfoot River	12324590/LBF10	6/5/2001	USGS	119	455	8.1	-	7	-	0.1	2.7	-	428	1.17	-	-	6
Lower Little Blackfoot River	12324590/LBF10	9/4/2001	USGS	142	19	8.4	-	6	-	< 0.1	1.3	-	42	< 1	-	-	< 1
Lower Little Blackfoot River	12324590/LBF10	11/8/2001	USGS	130	63	8.1	-	5	-	< 0.1	0.9	-	38	< 1	-	-	1
Lower Little Blackfoot River	12324590/LBF10	4/9/2002	USGS	88	197	8.1	-	6	-	< 0.1	2.5	-	383	< 1	-	-	3
Lower Little Blackfoot River	12324590/LBF10	5/29/2002	USGS	80.2	414	8.2	-	6	-	0.04	2.9	-	591	1.41	-	-	6
Lower Little Blackfoot River	12324590/LBF10	6/4/2002	USGS	85.6	372	8.1	-	6	-	0.03	2	-	279	< 1	-	-	4
Lower Little Blackfoot River	12324590/LBF10	6/24/2002	USGS	102	289	8.4	-	6	-	0.02	1.7	-	157	< 1	-	-	2
Lower Little Blackfoot River	12324590/LBF10	8/21/2002	USGS	121	51	8.6	-	6	-	0.02	1	-	73	< 1	-	-	1
Lower Little Blackfoot River	12324590/LBF10	5/27/2003	USGS	68.2	747	7.9	-	8	-	0.1	4.9	-	-	4.38	-	-	15
Lower Little Blackfoot River	12324590/LBF10	8/27/2003	USGS	172	25	8	-	5	-	< .04	1.1	-	64	0.06	-	-	< 2
Lower Little Blackfoot River	12324590/LBF10	9/22/2003	USGS	152	40	8.2	-	5	-	< .04	2.3	-	51	0.07	-	-	1
Lower Little Blackfoot River	12324590/LBF10	11/19/2003	USGS	136	61	8.2	-	4	-	< .04	1.1	-	124	0.2	-	-	1
Lower Little Blackfoot River	12324590/LBF10	4/20/2004	USGS	95.6	168	8.3	-	5	-	< .04	1.9	-	237	0.56	-	-	3
Lower Little Blackfoot River	12324590/LBF10	5/17/2004	USGS	114	141	8.4	-	5	-	< .04	1.6	-	199	0.43	-	-	2
Lower Little Blackfoot River	12324590/LBF10	6/1/2004	USGS	105	249	8.3	-	5	-	0.03	1.7	-	215	0.46	-	-	3
Lower Little Blackfoot River	C01LTBLR01/LBF10	6/30/2004	DEQ	139	120	7.58	-	6	< 1	< 0.1	1	-	100	1	-	-	1
Lower Little Blackfoot River	12324590/LBF10	7/19/2004	USGS	130	73	8.7	-	7	-	< .04	1.2	-	61	0.08	-	-	< 2
Lower Little Blackfoot River	12324590/LBF10	8/20/2004	USGS	161	20	8.6	-	6	-	< .04	1.6	-	76	0.08	-	-	< 2
Lower Little Blackfoot River	C01LTBLR01/LBF10	7/21/2005	DEQ	130	105	7.43	-	6	< 1	< .08	1	-	70	< .5	-	-	1
Lower Little Blackfoot River	LBF10	5/29/2008	DEQ	75	1317	7.73	110	6	-	< .08	4	-	1110	1.8	-	< 1	10
Lower Little Blackfoot River	LBF7	5/29/2008	DEQ	40	1192.6	7.76	170	6	-	< .08	4	-	570	2.3	-	< 1	20
Lower Little Blackfoot River	LBF9	5/29/2008	DEQ	71	846	-	140	6	-	< .08	4	-	960	1.8	-	< 1	10
Lower Little Blackfoot River	LBF7	7/25/2008	DEQ	85	79.57	7.83	< 30	6	-	< .08	< 1	-	110	3.3	-	< 1	< 10
Lower Little Blackfoot River	LBF10	7/26/2008	DEQ	138	100.63	8.21	< 30	6	-	< .08	< 1	-	90	< .5	-	< 1	< 10
Lower Little Blackfoot River	LBF9	7/26/2008	DEQ	122	105.13	8.22	< 30	6	-	< .08	< 1	-	90	< .5	-	< 1	< 10

Table G-1. Recent Surface Water Metals Data for the Little Blackfoot River TPA

Waterbody Segment	Site ID	Sample Date	Organization	Hardness (mg/L)	Flow (cfs)	pH	Al (µg/L) D	As (µg/L) TR	Be (µg/L) TR	Cd (µg/L) TR	Cu (µg/L) TR	CN (µg/L) T	Fe (µg/L) TR	Pb (µg/L) TR	Hg (µg/L) TR	Se (µg/L) TR	Zn (µg/L) TR
Lower Little Blackfoot River	LBF10	5/20/2009	DEQ	67	1555.5	7.6	< 30	14	-	0.2	11	-	-	9.2	-	-	30
Lower Little Blackfoot River	LBF7	5/20/2009	DEQ	37	1009.6	6.65	60	15	-	0.16	7	-	-	12.1	-	-	40
Lower Little Blackfoot River	LBF9	5/20/2009	DEQ	60	1452.3	7.59	< 30	13	-	0.1	8	-	-	8.1	-	-	30
Lower Little Blackfoot River	LBF10	9/1/2009	DEQ	138	58.2	8.04	< 30	5	-	< .08	1	-	-	< .5	-	-	< 10
Lower Little Blackfoot River	LBF7	9/1/2009	DEQ	84	51.1	8.13	< 30	6	< 1	< .08	1	-	80	< .5	-	< 1	< 10
Lower Little Blackfoot River	LBF9	9/1/2009	DEQ	125	63.33	8.09	< 30	6	-	< .08	1	-	-	< .5	-	-	< 10
Lower Telegraph Creek	TGH4	5/30/2008	DEQ	15	72.4	7.1	300	< 3	-	0.11	5	-	390	1.1	< .05	< 1	40
Lower Telegraph Creek	TGH4	7/25/2008	DEQ	38	3.2	7.72	< 30	< 3	-	< .08	2	-	60	< .5	< .05	< 1	30
Lower Telegraph Creek	TGH4	5/21/2009	DEQ	16	98.38	6.2	160	4	< 1	0.87	5	-	650	1.4	< .05	-	50
Lower Telegraph Creek	TGH4	8/27/2009	DEQ	42	1.62	6.1	< 30	< 3	< 1	0.08	2	-	140	< .5	< .005	-	20
Monarch Creek	C01MONRC10/MCH2	8/17/2004	DEQ	16	1	5.86	< 100	< 3	< 1	< 0.1	< 1	-	20	< .5	-	< 1	< 10
Monarch Creek	MCH1	5/27/2008	DEQ	6	22.82	5.87	70	< 3	-	< .08	1	-	100	< .5	< .05	< 1	< 10
Monarch Creek	MCH2	5/27/2008	DEQ	9.2	13.79	6.35	130	< 3	-	< .08	3	-	190	0.8	< .05	< 1	< 10
Monarch Creek	MCH1	7/23/2008	DEQ	9	1.14	7.45	< 30	< 3	-	< .08	< 1	-	< 50	< .5	< .05	< 1	< 10
Monarch Creek	MCH2	7/23/2008	DEQ	15	1.49	7.24	40	< 3	-	< .08	< 1	-	150	< .5	< .05	< 1	< 10
Monarch Creek	MCH3	5/21/2009	DEQ	10	38.1	5.96	90	< 3	-	< .08	3	-	570	3.5	< .05	1	< 10
Monarch Creek	MCH1	8/27/2009	DEQ	9	0.93	5.08	< 30	< 3	-	< .08	< 1	-	< 30	< .5	-	< 1	< 10
Monarch Creek	MCH2	8/27/2009	DEQ	15	0.99	4.96	< 30	< 3	-	< .08	< 1	-	30	< .5	< .005	< 1	< 10
O'Keefe Creek	TGH2	5/28/2008	DEQ	11	45.71	6.6	190	< 3	-	0.25	4	-	250	0.5	< .05	-	70
O'Keefe Creek	TGH2	7/24/2008	DEQ	27	3.87	6.47	40	< 3	-	0.1	2	-	250	< .5	< .05	< 1	50
O'Keefe Creek	TGH2	5/20/2009	DEQ	10	40.21	5.96	70	3	< 1	1.92	5	-	420	1.7	-	-	70
O'Keefe Creek	TGH2	8/28/2009	DEQ	28	0.8	5.98	< 30	< 3	< 1	0.1	1	-	260	< .5	-	-	30
Ontario Creek	ONT2	5/27/2008	DEQ	9.2	134.96	6.03	180	8	-	0.09	3	-	320	2.1	< .05	< 1	20
Ontario Creek	ONT2	7/23/2008	DEQ	14	8.96	7.13	60	9	-	< .08	1	-	70	< .5	< .05	< 1	10
Ontario Creek	LBF0044	10/7/2008	USFS	17	-	6.3	100	9	-	< .08	< 1	-	110	< .5	-	-	130
Ontario Creek	ONT2	5/21/2009	DEQ	9	238.09	5.8	130	10	-	0.22	4	-	600	4.9	-	-	20
Ontario Creek	ONT2A	5/21/2009	DEQ	9	112.89	6	150	7	-	1.4	4	-	-	3.3	-	-	20
Ontario Creek	ONT2	8/26/2009	DEQ	15	5.39	5.54	< 30	10	-	< .08	1	-	40	< .5	-	-	10
Ontario Creek	ONT0	8/27/2009	DEQ	7	0.07	4.29	40	< 3	-	< .08	2	-	140	< .5	-	-	< 10
Ontario Creek	ONT2A	8/27/2009	DEQ	11	3.19	4.96	< 30	9	-	0.1	2	-	-	< .5	-	-	20
Ontario Creek	LBF0044	7/20/2010	USFS	-	-	6.8	-	6	-	< .08	< 1	-	180	< .5	< .05	-	110
Ophir Creek	OPH1	5/19/2009	DEQ	148	21.79	8.31	< 30	4	-	1.08	2	-	-	< .5	-	-	< 10
Ophir Creek	OPH1	8/31/2009	DEQ	191	1.91	8.37	< 30	5	-	< .08	1	-	-	< .5	-	-	< 10
Sally Ann Creek	TGH1	5/28/2008	DEQ	11	6.97	6.23	180	< 3	-	0.08	4	-	330	0.5	< .05	< 1	60
Sally Ann Creek	TGH1	7/23/2008	DEQ	26	0.69	6.65	40	< 3	-	< .08	1	-	410	< .5	< .05	< 1	30
Sally Ann Creek	TGH0	5/20/2009	DEQ	11	10.94	6.2	< 30	< 3	< 1	1.4	3	-	420	< .5	-	-	< 10
Sally Ann Creek	TGH1	5/20/2009	DEQ	10	33.43	6.37	70	< 3	< 1	1.35	4	-	500	1.5	-	-	50
Sally Ann Creek	TGH0	8/28/2009	DEQ	-	0.22	6.23	< 30	< 3	< 1	< .08	2	-	1170	< .5	-	-	< 10
Sally Ann Creek	TGH1	8/28/2009	DEQ	31	0.49	6.14	< 30	< 3	< 1	< .08	1	-	500	< .5	-	-	20
Six Mile Creek	SIX1	5/29/2008	DEQ	138	5.5	8.07	30	9	-	< .08	3	-	160	< .5	-	< 1	< 10
Six Mile Creek	SIX1	7/26/2008	DEQ	190	1.73	8.04	< 30	9	-	< .08	1	-	190	< .5	-	< 1	< 10
Snowshoe Creek	C01SNOWC10	8/19/2004	DEQ	219	3.5	6.99	100	< 3	< 1	< .1	< 1	-	< 10	< .5	-	< 1	< 10
Snowshoe Creek	SNO4	5/29/2008	DEQ	237	2.8	7.9	< 30	< 3	-	< .08	1	-	190	< .5	-	< 1	< 10
Snowshoe Creek	SNO4	7/22/2008	DEQ	200	10.08	8.39	60	< 3	-	< .08	9	-	160	< .5	-	< 1	< 10
Snowshoe Creek	SNO4	5/19/2009	DEQ	225	12.73	8.07	< 30	5	-	0.9	1	-	-	< .5	-	-	< 10

Table G-1. Recent Surface Water Metals Data for the Little Blackfoot River TPA

Waterbody Segment	Site ID	Sample Date	Organization	Hardness (mg/L)	Flow (cfs)	pH	Al (µg/L) D	As (µg/L) TR	Be (µg/L) TR	Cd (µg/L) TR	Cu (µg/L) TR	CN (µg/L) T	Fe (µg/L) TR	Pb (µg/L) TR	Hg (µg/L) TR	Se (µg/L) TR	Zn (µg/L) TR
Snowshoe Creek	SNO4	8/26/2009	DEQ	187	9.78	7.32	< 30	< 3	-	< .08	2	-	-	< .5	-	-	< 10
Spotted Dog Creek	C01SDOGC01	8/18/2005	DEQ	-	3.56	7.95	< 100	4	< 1	< .1	< 1	-	50	< .5	< 0.1	< 1	< 10
Spotted Dog Creek	C01SDOGC02	8/18/2005	DEQ	-	1.08	8.1	< 100	< 3	< 1	< .1	< 1	-	20	< .5	< 0.1	< 1	< 10
Spotted Dog Creek	SPD1	5/30/2008	DEQ	83	10.28	7.97	80	4	-	< .08	2	-	410	< .5	-	< 1	< 10
Spotted Dog Creek	SPD4	5/30/2008	DEQ	113	55.38	8.04	100	< 3	-	< .08	2	-	640	< .5	-	< 1	< 10
Spotted Dog Creek	SPD1	7/25/2008	DEQ	148	0.87	8.12	< 30	3	-	< .08	< 1	-	< 50	< .5	-	< 1	< 10
Spotted Dog Creek	SPD4	7/25/2008	DEQ	162	12.14	8.18	< 30	4	-	< .08	< 1	-	170	< .5	-	< 1	< 10
Spotted Dog Creek	SPD4	5/21/2009	DEQ	103	92.18	8.16	< 30	6	-	< .08	3	-	-	0.8	-	-	< 10
Spotted Dog Creek	SPD4	9/2/2009	DEQ	144	5.45	7.91	< 30	4	-	< .08	1	-	-	< .5	-	-	< 10
Three Mile Creek	THR1	5/29/2008	DEQ	190	38.91	7.89	< 30	10	-	< .08	4	-	270	< .5	-	< 1	< 10
Three Mile Creek	THR1	7/26/2008	DEQ	207	7.03	8.03	< 30	10	-	< .08	6	-	200	< .5	-	< 1	< 10
Three Mile Creek	THR1	5/21/2009	DEQ	157	32.54	8.09	< 30	10	-	< .08	3	-	-	< .5	-	-	< 10
Three Mile Creek	THR1	9/2/2009	DEQ	217	3.73	7.69	< 30	8	-	< .08	2	-	-	< .5	-	-	< 10
Un-named Creek	ONT1	7/23/2008	DEQ	51	-	3.5	4110	13	-	10	94	-	1560	40	< .05	< 1	1580
Un-named Creek	ONTB	7/28/2008	AML	49	-	3.1	-	190	-	23	260	-	15000	150	< .05	-	3330
Un-named Creek	ONT1	10/6/2008	DEQ	51	-	-	-	28	-	4.24	34	-	2110	16.7	< .01	-	900
Un-named Creek	LBF0039	10/7/2008	USFS	48	-	3.8	-	< 3	-	6	40	-	460	< .5	-	-	1080
Un-named Creek	LBF0042	10/7/2008	USFS	44	-	4.6	-	238	-	3	30	-	3620	40	-	-	510
Un-named Creek	LBF0043	10/7/2008	USFS	43	-	4.9	-	77	-	3	20	-	630	40	-	-	460
Un-named Creek	LBF0080	10/7/2008	USFS	44	-	4.6	-	29	-	3	20	-	510	20	-	-	500
Un-named Creek	ONT1	8/27/2009	DEQ	43	0.07	5.4	370	56	-	2.19	25	-	440	9.3	< .005	-	360
Un-named Creek	LBF0043	7/20/2010	USFS	-	-	4.7	-	< 3	-	4	50	-	100	20	< .05	-	650
Upper Dog Creek	25-179-SW1	9/22/2003	AML	145	0.19	8.1	-	4	-	< 1	-	-	140	9	-	-	110
Upper Dog Creek	25-179-SW2	9/22/2003	AML	160	0.14	7.94	-	13	-	< 1	-	-	410	3	-	-	20
Upper Dog Creek	25-179-SW4	9/22/2003	AML	142	2.5	8.14	-	13	-	< 1	-	-	610	14	-	-	10
Upper Dog Creek	25-179-SW5	9/22/2003	AML	142	2.5	8.14	-	13	-	< 1	< 10	-	570	12	-	-	10
Upper Dog Creek	DOG1	5/28/2008	DEQ	82	8.93	7.73	170	5	-	1.9	17	-	280	6	-	< 1	280
Upper Dog Creek	DOG2	5/28/2008	DEQ	86	11.92	7.83	140	15	-	0.35	10	-	350	10	-	< 1	80
Upper Dog Creek	DOG1	7/24/2008	DEQ	174	1.96	8.15	< 30	10	-	2	7	-	100	7.8	-	< 1	140
Upper Dog Creek	DOG2	7/24/2008	DEQ	171	3.34	8.17	< 30	26	-	1.2	6	-	330	13	-	< 1	50
Upper Dog Creek	DOG1	5/22/2009	DEQ	105	8.9	7.82	90	7	-	3.36	20	-	-	10.4	-	-	290
Upper Dog Creek	DOG2	5/22/2009	DEQ	99	13.28	7.88	< 30	13	-	0.88	8	-	-	13.5	-	-	80
Upper Dog Creek	DOG1	8/25/2009	DEQ	155	0.12	7.76	< 30	9	-	1.77	10	-	-	9.9	-	-	160
Upper Dog Creek	DOG2	8/25/2009	DEQ	164	0.95	7.76	< 30	35	-	0.39	8	-	-	15.1	-	-	40
Upper Little Blackfoot River	LBF1	5/27/2008	DEQ	6	55.94	6.43	110	< 3	-	< .08	2	-	160	< .5	-	< 1	< 10
Upper Little Blackfoot River	LBF2	5/27/2008	DEQ	36	135.58	6.77	90	< 3	-	< .08	2	-	460	< .5	-	< 1	< 10
Upper Little Blackfoot River	LBF4	5/28/2008	DEQ	31	187.67	6.93	110	7	-	< .08	3	< 5	620	2.6	-	< 1	20
Upper Little Blackfoot River	LBF5	5/29/2008	DEQ	29	1179.6	7.33	140	5	-	< .08	3	-	470	1.7	-	< 1	10
Upper Little Blackfoot River	LBF3	5/30/2008	DEQ	30	272.9	7.53	150	4	-	< .08	3	< 5	370	1.1	-	< 1	10
Upper Little Blackfoot River	LBF1	7/21/2008	DEQ	8	8.34	7.53	< 30	< 3	-	< .08	< 1	-	60	< .5	-	< 1	< 10
Upper Little Blackfoot River	LBF5	7/21/2008	DEQ	64	45.22	7.64	< 30	7	-	< .08	< 1	-	100	< .5	-	< 1	< 10
Upper Little Blackfoot River	LBF0065	7/22/2008	USFS	69	-	-	-	24	-	< .08	< 1	-	230	< .5	-	< 1	20
Upper Little Blackfoot River	LBF0066	7/22/2008	USFS	67	-	-	-	21	-	< .08	< 1	-	150	< .5	-	< 1	20
Upper Little Blackfoot River	LBF2	7/23/2008	DEQ	51	20.88	7.97	< 30	< 3	-	< .08	< 1	-	< 50	< .5	-	< 1	< 10
Upper Little Blackfoot River	LBF3	7/25/2008	DEQ	51	29.79	7.89	40	6	-	< .08	< 1	< 5	< 50	0.8	-	< 1	< 10

Table G-1. Recent Surface Water Metals Data for the Little Blackfoot River TPA

Waterbody Segment	Site ID	Sample Date	Organization	Hardness (mg/L)	Flow (cfs)	pH	Al (µg/L) D	As (µg/L) TR	Be (µg/L) TR	Cd (µg/L) TR	Cu (µg/L) TR	CN (µg/L) T	Fe (µg/L) TR	Pb (µg/L) TR	Hg (µg/L) TR	Se (µg/L) TR	Zn (µg/L) TR
Upper Little Blackfoot River	LBF4	7/25/2008	DEQ	58	23.82	7.91	< 30	7	-	< .08	< 1	< 5	60	< .5	-	< 1	< 10
Upper Little Blackfoot River	LBF5	5/19/2009	DEQ	33	908.13	6.64	90	16	-	0.16	7	-	-	9.6	-	-	30
Upper Little Blackfoot River	LBF4	5/20/2009	DEQ	31	802.89	6.04	< 30	24	-	1.6	8	23	-	16.4	-	-	50
Upper Little Blackfoot River	LBF2	5/21/2009	DEQ	37	171.56	6.84	40	< 3	-	0.62	2	-	-	0.7	-	-	< 10
Upper Little Blackfoot River	LBF3	5/21/2009	DEQ	31	394.83	6.94	60	14	-	0.75	5	< 5	-	8	-	-	30
Upper Little Blackfoot River	LBF2	8/26/2009	DEQ	55	14.45	7.31	< 30	< 3	-	< .08	1	-	-	< .5	-	-	< 10
Upper Little Blackfoot River	LBF5	8/26/2009	DEQ	65	35.9	7.28	< 30	8	-	< .08	2	-	-	< .5	-	-	< 10
Upper Little Blackfoot River	LBF3	9/1/2009	DEQ	52	18.39	7.81	< 30	6	-	< .08	< 1	< 5	-	< .5	-	-	< 10
Upper Little Blackfoot River	LBF4	9/1/2009	DEQ	55	21.73	8.06	< 30	7	-	< .08	< 1	< 5	-	< .5	-	-	< 10
Upper Telegraph Creek	TGH3	5/28/2008	DEQ	13	63.59	6.08	260	< 3	-	0.12	5	-	440	0.8	< .05	< 1	50
Upper Telegraph Creek	TGH3	7/24/2008	DEQ	30	1.96	7.22	40	< 3	-	< .08	2	-	190	< .5	< .05	< 1	20
Upper Telegraph Creek	LOB-SW-01	10/9/2008	AML	17	-	7	-	< 5	-	< 1	< 10	-	370	-	< 1	-	30
Upper Telegraph Creek	LOB-SW-03	10/9/2008	AML	23	-	6.6	-	14	-	3	< 10	-	610	-	< 1	-	610
Upper Telegraph Creek	TGH2B	5/21/2009	DEQ	10	7.76	6.15	160	8	< 1	2.04	6	-	500	1.8	-	-	180
Upper Telegraph Creek	TGH3A	5/21/2009	DEQ	13	90.16	6.13	170	3	< 1	1.72	5	-	550	1.4	< .05	-	50
Upper Telegraph Creek	TGH3A	8/27/2009	DEQ	38	1.91	6.74	< 30	< 3	< 1	0.11	2	-	60	< .5	< .005	-	20
Upper Telegraph Creek	TGH2B	8/28/2009	DEQ	19	0.1	6.05	< 30	5	< 1	0.76	2	-	< 30	< .5	-	-	130

D = Dissolved; T = Total; TR = Total Recoverable

Table G-2. Recent Sediment Metals Data for the Little Blackfoot River TPA*

Waterbody Segment	Site ID	Sample Date	Organization	As	Be	Cd	Cu	Fe	Pb	Hg	Se	Zn
American Gulch Creek	DOG3	7/24/2008	DEQ	63	-	0.8	34	19600	56	-	< 10	139
Carpenter Creek	CAR1	7/25/2008	DEQ	11	-	0.5	37	309000	14	-	< 10	74
Lower Dog Creek	DOG8	7/22/2008	DEQ	52	-	2.5	77	30400	176	-	< 10	434
Lower Little Blackfoot River	C01LTBLR01/LBF10	8/21/2001	DEQ	13	< 5	< 1	37	15600	25	-	< 5	122
Lower Little Blackfoot River	LBF10	7/26/2008	DEQ	15	-	0.7	29	24600	28	-	< 10	129
Lower Little Blackfoot River	LBF9	7/26/2008	DEQ	20	-	0.7	32	25200	31	-	< 10	144
Lower Little Blackfoot River	LBF7	7/25/2008	DEQ	69	-	2.5	53	27100	127	-	< 10	358
Lower Telegraph Creek	TGH4	7/25/2008	DEQ	99	-	5.1	84	39800	88	-	< 50	635
Monarch Creek	C01MONRC10/MCH2	8/17/2004	DEQ	23.6	4.4	0.57	45	12400	133	< 1	2.7	120
Monarch Creek	MCH2	7/23/2008	DEQ	22	-	0.9	40	14500	154	-	< 10	126
Monarch Creek	MCH1	7/23/2008	DEQ	19	-	1.2	17	12200	42	-	< 10	132
O'Keefe Creek	TGH2	7/24/2008	DEQ	238	-	28	65	49200	174	-	< 50	2580
Ontario Creek	ONT0	8/27/2009	DEQ	30	-	3.2	37	-	71	-	-	162
Ontario Creek	ONT2A	8/27/2009	DEQ	430	-	4.7	77	-	357	-	-	340
Ontario Creek	ONT2	7/23/2008	DEQ	307	-	7	64	18400	296	-	< 10	569
Sally Ann Creek	TGH0	8/28/2009	DEQ	33	-	0.6	45	-	25	-	-	108
Sally Ann Creek	TGH1	7/23/2008	DEQ	84	-	6.5	51	40500	95	-	< 50	800
Six Mile Creek	SIX1	7/26/2008	DEQ	42	-	0.5	22	15200	21	-	< 10	132
Snowshoe Creek	SNO4	7/22/2008	DEQ	6	-	0.4	21	16300	13	-	< 10	59
Snowshoe Creek	C01SNOWC10	8/19/2004	DEQ	< 3	1.3	0.68	28.8	11600	28.8	< 1	4.6	105
Spotted Dog Creek	SPD4	7/25/2008	DEQ	21	-	0.4	33	28700	15	-	< 10	78
Spotted Dog Creek	SPD1	7/25/2008	DEQ	75	-	0.6	27	35300	16	-	< 10	91
Three Mile Creek	THR1	7/26/2008	DEQ	33	-	0.3	23	19900	17	-	< 10	68
Un-named Creek	ONT1	7/23/2008	DEQ	5920	-	1.5	124	242000	307	-	< 500	245
Upper Dog Creek	25-179-SE-10	9/23/2003	AML	747	-	26	711	-	2400	1.8	-	3990

Table G-2. Recent Sediment Metals Data for the Little Blackfoot River TPA*

Waterbody Segment	Site ID	Sample Date	Organization	As	Be	Cd	Cu	Fe	Pb	Hg	Se	Zn
Upper Dog Creek	25-179-SE-11	9/23/2003	AML	643	-	14	450	-	1250	1.1	-	2380
Upper Dog Creek	25-179-SE-12	9/23/2003	AML	534	-	10	279	-	900	0.5	-	1910
Upper Dog Creek	25-179-SE-13	9/23/2003	AML	591	-	12	301	-	1010	1.5	-	2110
Upper Dog Creek	25-179-SE-14	9/23/2003	AML	813	-	17	401	-	1360	1.3	-	2730
Upper Dog Creek	25-179-SE-15	9/23/2003	AML	604	-	15	435	-	882	1.7	-	2410
Upper Dog Creek	25-179-SE-16	9/23/2003	AML	969	-	26	582	-	1450	2.5	-	3710
Upper Dog Creek	25-179-SE-17	9/23/2003	AML	543	-	27	711	-	1440	5.3	-	3920
Upper Dog Creek	25-179-SE-18	9/23/2003	AML	261	-	29	825	-	1200	3.6	-	3920
Upper Dog Creek	25-179-SE-19	9/23/2003	AML	336	-	26	809	-	1300	4.4	-	3640
Upper Dog Creek	25-179-SE2	9/23/2003	AML	682	-	14	371	27000	1030	1.7	-	2430
Upper Dog Creek	25-179-SE-20	9/23/2003	AML	236	-	17	596	-	1380	3.9	-	2460
Upper Dog Creek	25-179-SE-21	9/23/2003	AML	169	-	10	385	-	829	0.5	-	1660
Upper Dog Creek	25-179-SE-22	9/23/2003	AML	278	-	17	583	-	1230	2.2	-	2590
Upper Dog Creek	25-179-SE-23	9/23/2003	AML	188	-	12	344	-	904	0.5	-	1800
Upper Dog Creek	25-179-SE-24	9/23/2003	AML	322	-	8	276	-	638	0.5	-	1410
Upper Dog Creek	25-179-SE-25	9/23/2003	AML	976	-	7	290	-	711	0.5	-	1340
Upper Dog Creek	25-179-SE-26	9/23/2003	AML	308	-	9	313	-	668	0.5	-	1680
Upper Dog Creek	25-179-SE-27	9/23/2003	AML	548	-	11	426	-	767	1.3	-	1680
Upper Dog Creek	25-179-SE-28	9/23/2003	AML	187	-	10	299	-	573	2.6	-	1410
Upper Dog Creek	25-179-SE-29	9/23/2003	AML	319	-	13	364	-	782	3.4	-	1670
Upper Dog Creek	25-179-SE-30	9/23/2003	AML	479	-	13	347	-	754	2.9	-	1880
Upper Dog Creek	25-179-SE-31	9/23/2003	AML	309	-	16	531	-	1260	3.5	-	2360
Upper Dog Creek	25-179-SE-32	9/23/2003	AML	641	-	17	587	-	1240	4.3	-	2520
Upper Dog Creek	25-179-SE-33	9/23/2003	AML	473	-	16	462	-	1080	3.5	-	2380
Upper Dog Creek	25-179-SE-34	9/23/2003	AML	162	-	14	446	-	603	1.1	-	2170
Upper Dog Creek	25-179-SE-35	9/23/2003	AML	170	-	12	497	-	473	0.5	-	1820
Upper Dog Creek	25-179-SE-36	9/23/2003	AML	130	-	7	281	-	369	0.5	-	1080
Upper Dog Creek	25-179-SE-37	9/23/2003	AML	149	-	6	230	-	509	1.7	-	1000
Upper Dog Creek	25-179-SE-38	9/23/2003	AML	134	-	7	220	-	425	1.2	-	910
Upper Dog Creek	25-179-SE-39	9/23/2003	AML	212	-	12	416	-	808	2.5	-	1810
Upper Dog Creek	25-179-SE4	9/23/2003	AML	172	-	17	676	15000	882	3.7	-	2590
Upper Dog Creek	25-179-SE-40	9/23/2003	AML	286	-	14	847	-	2830	5.5	-	2960
Upper Dog Creek	25-179-SE-41	9/23/2003	AML	269	-	14	798	-	2700	4.4	-	3100
Upper Dog Creek	25-179-SE-42	9/23/2003	AML	177	-	13	592	-	938	2.4	-	1970
Upper Dog Creek	25-179-SE-43	9/23/2003	AML	207	-	11	377	-	851	2.2	-	1730
Upper Dog Creek	25-179-SE-44	9/23/2003	AML	322	-	15	568	-	1150	3.8	-	2220
Upper Dog Creek	25-179-SE-45	9/23/2003	AML	546	-	16	486	-	1190	4.3	-	2380
Upper Dog Creek	25-179-SE-46	9/23/2003	AML	539	-	16	482	-	1200	4.6	-	2420
Upper Dog Creek	25-179-SE-47	9/23/2003	AML	361	-	13	384	-	1120	3.8	-	1890
Upper Dog Creek	25-179-SE-48	9/23/2003	AML	312	-	8	291	-	776	3.3	-	1390
Upper Dog Creek	25-179-SE-49	9/23/2003	AML	371	-	16	456	-	1200	4.1	-	2420
Upper Dog Creek	25-179-SE5	9/23/2003	AML	156	-	17	690	15400	777	3.4	-	2530
Upper Dog Creek	25-179-SE-50	9/23/2003	AML	188	-	10	326	-	741	2.5	-	1560
Upper Dog Creek	DOG2	7/24/2008	DEQ	235	-	18	873	26800	2010	-	< 10	3280
Upper Dog Creek	DOG1	7/24/2008	DEQ	156	-	16	636	23900	2180	-	< 10	3280
Upper Dog Creek	25-179-SE-51	9/23/2003	AML	166	-	9	288	-	679	2.3	-	1410
Upper Dog Creek	25-179-SE-52	9/23/2003	AML	90	-	12	447	-	757	3	-	1740
Upper Dog Creek	25-179-SE-7	9/23/2003	AML	541	-	7	198	-	898	0.5	-	1570

Table G-2. Recent Sediment Metals Data for the Little Blackfoot River TPA*

Waterbody Segment	Site ID	Sample Date	Organization	As	Be	Cd	Cu	Fe	Pb	Hg	Se	Zn
Upper Dog Creek	25-179-SE-8	9/23/2003	AML	306	-	14	468	-	756	1.8	-	2190
Upper Dog Creek	25-179-SE-9	9/23/2003	AML	199	-	21	1060	-	2350	14	-	3170
Upper Little Blackfoot River	LBF1	7/21/2008	DEQ	12	-	1	17	10900	23	-	< 10	91
Upper Little Blackfoot River	LBF2	7/23/2008	DEQ	23	-	0.5	33	26200	24	-	< 10	108
Upper Little Blackfoot River	LBF3	7/25/2008	DEQ	194	-	2.6	48	26200	187	-	< 10	350
Upper Little Blackfoot River	LBF5	7/21/2008	DEQ	150	-	2.9	57	28700	162	-	< 10	409
Upper Little Blackfoot River	LBF4	7/25/2008	DEQ	166	-	3	42	28500	164	-	< 10	432
Upper Telegraph Creek	TGH3A	8/27/2009	DEQ	96	-	6.7	76	-	82	0.17	-	783
Upper Telegraph Creek	TGH3	7/24/2008	DEQ	62	-	7.6	112	34800	86	-	< 10	861
Upper Telegraph Creek	TGH2B	8/28/2009	DEQ	478	-	73.5	188	-	169	-	-	2560

*All sediment samples presented in units of µg/g

Table G-3. Recent Nutrient Data for the Little Blackfoot River TPA

Waterbody Segment	Station ID	Organization	Date	Flow (cfs)	TP (mg/L)	SRP (mg/L)	TN (mg/L)	NO3 (mg/L)	Chlorophyll a (mg/m2)	AFDW (g/m2)
Lower Carpenter Creek	C01CARPC01	DEQ	9/15/10	0.15	0.044	-	0.2	0.005	-	-
Lower Carpenter Creek	C01CARPC01	DEQ	7/8/10	1.92	0.039	-	0.22	0.005	-	-
Lower Carpenter Creek	C01CARPC02	DEQ	7/8/10	5.92	0.045	-	0.31	0.005	-	-
Lower Carpenter Creek	C01CARPC02	DEQ	9/15/10	1.84	0.04	-	0.26	0.01	-	-
Lower Carpenter Creek	C01CARPC03	DEQ	9/16/10	1.06	0.045	-	0.28	0.005	-	18.48
Lower Carpenter Creek	C01CARPC03	DEQ	9/17/10	-	-	-	-	-	16.31	-
Lower Carpenter Creek	C01CARPC03	DEQ	7/8/10	2.60	0.061	-	0.28	0.005	-	-
Lower Carpenter Creek	CAR1	DEQ	9/30/08	2.36	0.055	-	0.1	0.01	8	-
Lower Carpenter Creek	CAR1	DEQ	7/25/08	3.69	0.056	-	0.24	0.01	<50	-
Lower Carpenter Creek	CAR2	DEQ	8/31/09	0.94	0.053	-	0.23	0.01	<50	-
Lower Dog Creek	C01DOGC01	DEQ	8/10/10	9.71	0.011	-	0.13	0.005	-	-
Lower Dog Creek	C01DOGC01	DEQ	7/1/10	33.25	0.017	-	0.17	0.005	-	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	-	-	-	-	3	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	-	-	-	-	4.63	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	-	-	-	-	5.83	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	-	-	-	-	6.79	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	-	-	-	-	7.46	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	-	-	-	-	8.58	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	-	-	-	-	8.75	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	-	-	-	-	12.88	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	-	-	-	-	14.04	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	-	-	-	-	67.84	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	-	-	-	-	173.79	-
Lower Dog Creek	C01DOGC02	DEQ	8/6/07	-	0.029	-	0.021	0.005	-	-
Lower Dog Creek	C01DOGC03	DEQ	8/9/10	16.23	0.025	-	0.16	0.005	11.85	7.92
Lower Dog Creek	C01DOGC03	DEQ	7/1/10	73.50	0.028	-	0.26	0.005	-	-
Lower Dog Creek	C01DOGC04	DEQ	8/10/10	15.19	0.031	-	0.22	0.01	6.19	19.60
Lower Dog Creek	C01DOGC04	DEQ	7/1/10	25.86	0.026	-	0.29	0.005	-	-
Lower Dog Creek	C01DOGC05	DEQ	8/10/10	13.29	0.025	-	0.12	0.005	20.06	13.00
Lower Dog Creek	C01DOGC05	DEQ	7/1/10	43.20	0.021	-	0.17	0.005	-	-
Lower Dog Creek	C01DOGC06	DEQ	8/11/10	3.74	0.019	-	0.2	0.005	21.11	144.50
Lower Dog Creek	C01DOGC06	DEQ	7/1/10	12.77	0.023	-	0.19	0.005	-	-
Lower Dog Creek	DOG6	DEQ	10/1/08	5.65	0.035	-	0.025	0.01	4.67	-
Lower Dog Creek	DOG6	DEQ	8/25/09	8.59	0.018	-	0.09	0.005	<50	-

Table G-3. Recent Nutrient Data for the Little Blackfoot River TPA

Waterbody Segment	Station ID	Organization	Date	Flow (cfs)	TP (mg/L)	SRP (mg/L)	TN (mg/L)	NO3 (mg/L)	Chlorophyll a (mg/m2)	AFDW (g/m2)
Lower Dog Creek	DOG6	DEQ	7/24/08	14.45	0.028	-	0.12	0.01	<50	-
Lower Dog Creek	DOG8	DEQ	9/29/08	9.96	0.035	-	0.06	0.01	11	-
Lower Dog Creek	DOG8	DEQ	7/22/08	17.35	0.038	-	0.17	0.01	37	-
Lower Dog Creek	DOG8	DEQ	8/26/09	12.17	0.023	-	0.025	0.005	<50	-
Lower Little Blackfoot River	C01LTBLR01	DEQ	7/21/05	105.00	0.027	-	-	0.005	13.78	-
Lower Little Blackfoot River	CFRPO-10.2	Tri-State WQC	8/19/02	45.00	0.031	0.019	-	0.005	-	-
Lower Little Blackfoot River	CFRPO-10.2	Tri-State WQC	8/20/01	46.00	0.035	0.021	-	0.005	-	-
Lower Little Blackfoot River	LBF @ Avon	UM	8/16/01	70.20	0.027	0.011	0.053	0.003	-	-
Lower Little Blackfoot River	LBF @ Avon	UM	7/16/01	98.00	0.028	0.015	0.173	0.003	-	-
Lower Little Blackfoot River	LBF @ Avon	UM	6/18/01	250.00	0.030	0.012	0.313	0.003	-	-
Lower Little Blackfoot River	LBF @ Avon	UM	9/25/02	-	0.025	0.014	0.055	0.005	-	-
Lower Little Blackfoot River	LBF @ Avon	UM	8/23/02	-	0.024	0.016	0.055	0.005	-	-
Lower Little Blackfoot River	LBF @ Avon	UM	6/20/02	-	0.030	0.009	0.155	0.005	-	-
Lower Little Blackfoot River	LBF @ Avon	UM	9/16/01	46.10	0.010	0.005	0.138	0.008	-	-
Lower Little Blackfoot River	LBF @ Avon	UM	5/23/01	190.00	0.030	0.013	0.198	0.008	-	-
Lower Little Blackfoot River	LBF @ Avon	UM	5/3/02	-	-	0.016	-	0.009	-	-
Lower Little Blackfoot River	LBF @ Avon	UM	7/26/02	-	0.030	0.003	0.060	0.010	-	-
Lower Little Blackfoot River	LBF @ Avon	UM	5/31/02	-	0.036	0.012	0.280	0.010	-	-
Lower Little Blackfoot River	LBF @ Avon (Above)	UM	5/31/02	-	0.023	0.008	0.225	0.005	-	-
Lower Little Blackfoot River	LBF @ Elliston	UM	9/16/01	27.50	0.017	0.012	0.113	0.003	-	-
Lower Little Blackfoot River	LBF @ Elliston	UM	5/23/01	140.00	0.021	0.006	0.133	0.003	-	-
Lower Little Blackfoot River	LBF @ Elliston	UM	6/18/01	195.00	0.025	0.007	0.057	0.007	-	-
Lower Little Blackfoot River	LBF @ Elliston	UM	8/16/01	47.80	0.011	0.005	0.059	0.009	-	-
Lower Little Blackfoot River	LBF @ Elliston	UM	8/23/02	-	0.012	0.006	0.120	0.010	-	-
Lower Little Blackfoot River	LBF @ Elliston	UM	6/20/02	-	0.030	0.006	0.151	0.011	-	-
Lower Little Blackfoot River	LBF @ Elliston	UM	5/31/02	-	0.024	0.005	0.203	0.013	-	-
Lower Little Blackfoot River	LBF @ Elliston	UM	7/16/01	76.50	0.023	0.012	0.217	0.017	-	-
Lower Little Blackfoot River	LBF @ Elliston	UM	7/26/02	-	0.028	0.005	0.280	0.020	-	-
Lower Little Blackfoot River	LBF @ Elliston	UM	5/3/02	-	0.034	0.007	0.450	0.040	-	-
Lower Little Blackfoot River	LBF @ Elliston	UM	9/25/02	-	0.012	0.006	0.170	0.050	-	-
Lower Little Blackfoot River	LBF @ highway 12	UM	6/18/01	375.00	0.040	0.017	0.143	0.003	-	-
Lower Little Blackfoot River	LBF @ highway 12	UM	9/16/01	75.30	0.025	0.016	0.193	0.003	-	-
Lower Little Blackfoot River	LBF @ highway 12	UM	7/16/01	189.00	0.044	0.017	0.223	0.003	-	-
Lower Little Blackfoot River	LBF @ highway 12	UM	5/3/02	-	0.039	0.014	0.283	0.003	-	-
Lower Little Blackfoot River	LBF @ highway 12	UM	9/25/02	-	0.030	0.017	0.055	0.005	-	-
Lower Little Blackfoot River	LBF @ highway 12	UM	8/23/02	-	0.034	0.014	0.125	0.005	-	-
Lower Little Blackfoot River	LBF @ highway 12	UM	7/26/02	-	0.041	0.008	0.185	0.005	-	-
Lower Little Blackfoot River	LBF @ highway 12	UM	6/20/02	-	0.048	0.014	0.295	0.005	-	-
Lower Little Blackfoot River	LBF @ highway 12	UM	8/16/01	68.70	0.031	0.019	0.126	0.006	-	-
Lower Little Blackfoot River	LBF @ highway 12	UM	5/23/01	300.00	0.037	0.014	0.297	0.007	-	-
Lower Little Blackfoot River	LBF @ highway 12	UM	5/31/02	-	0.038	0.011	0.362	0.012	-	-
Lower Little Blackfoot River	LBF10	DEQ	9/30/08	42.28	0.031	-	0.06	0.01	9	-
Lower Little Blackfoot River	LBF10	DEQ	7/26/08	97.37	0.035	-	0.16	0.01	15	-
Lower Little Blackfoot River	LBF10	DEQ	9/1/09	58.20	0.031	-	0.15	0.005	<50	-
Lower Little Blackfoot River	LBF6	DEQ	9/29/08	27.39	0.023	-	0.05	0.01	14	-
Lower Little Blackfoot River	LBF6	DEQ	8/26/09	48.86	0.011	-	0.09	0.005	<50	-
Lower Little Blackfoot River	LBF6	DEQ	7/26/08	75.09	0.021	-	0.15	0.04	<50	-
Lower Little Blackfoot River	LBF7	DEQ	9/30/08	19.19	0.021	-	0.06	0.03	0.05	-

Table G-3. Recent Nutrient Data for the Little Blackfoot River TPA

Waterbody Segment	Station ID	Organization	Date	Flow (cfs)	TP (mg/L)	SRP (mg/L)	TN (mg/L)	NO3 (mg/L)	Chlorophyll a (mg/m2)	AFDW (g/m2)
Lower Little Blackfoot River	LBF7	DEQ	9/1/09	51.10	0.014	-	0.08	0.005	<50	-
Lower Little Blackfoot River	LBF7	DEQ	7/25/08	79.57	0.02	-	0.14	0.03	<50	-
Lower Little Blackfoot River	LBF8	DEQ	9/1/09	81.49	0.024	-	0.08	0.005	39.9	80.6
Lower Little Blackfoot River	LBF8	DEQ	9/30/08	44.05	0.034	-	0.05	0.01	-	-
Lower Little Blackfoot River	LBF8	DEQ	7/26/08	89.15	0.025	-	0.14	0.02	<50	-
Lower Little Blackfoot River	LBF9	DEQ	9/30/08	55.61	0.027	-	0.06	0.01	10	-
Lower Little Blackfoot River	LBF9	DEQ	9/1/09	63.33	0.029	-	0.13	0.005	-	-
Lower Little Blackfoot River	LBF9	DEQ	7/26/08	105.13	0.035	-	0.15	0.01	<50	-
Lower Little Blackfoot River	Little Blackfoot	UM	8/20/01	46.00	0.035	0.021	0.163	0.003	-	-
Lower Little Blackfoot River	Little Blackfoot	UM	9/25/02	40.00	0.020	0.014	0.055	0.005	-	-
Lower Little Blackfoot River	Little Blackfoot	UM	8/23/02	51.00	0.035	0.011	0.125	0.005	-	-
Lower Little Blackfoot River	Little Blackfoot	UM	7/26/02	90.00	0.041	0.007	0.165	0.005	-	-
Lower Little Blackfoot River	Little Blackfoot	UM	6/20/02	352.00	0.053	0.016	0.205	0.005	-	-
Lower Little Blackfoot River	Little Blackfoot	UM	5/31/02	418.00	0.055	0.011	0.295	0.005	-	-
Lower Little Blackfoot River	Little Blackfoot	UM	5/22/01	322.00	0.033	0.012	0.255	0.015	-	-
Lower Spotted Dog Creek	C01SDOGC01	DEQ	8/18/05	3.56	0.033	-	0.025	0.005	-	-
Lower Spotted Dog Creek	C01SDOGC03	DEQ	7/20/10	15.87	0.038	-	0.21	0.005	1.74	17.92
Lower Spotted Dog Creek	C01SDOGC03	DEQ	8/18/10	7.53	0.037	-	0.23	0.005	-	-
Lower Spotted Dog Creek	C01SDOGC03	DEQ	9/17/10	5.88	0.029	-	0.24	0.005	-	-
Lower Spotted Dog Creek	C01SDOGC04	DEQ	7/20/10	15.90	0.042	-	0.21	0.005	30.58	32.13
Lower Spotted Dog Creek	C01SDOGC04	DEQ	9/17/10	5.69	0.024	-	0.26	0.005	-	-
Lower Spotted Dog Creek	C01SDOGC04	DEQ	8/18/10	6.91	0.032	-	0.27	0.005	-	-
Lower Spotted Dog Creek	C01SDOGC05	DEQ	7/21/10	13.18	0.031	-	0.17	0.005	8.55	94.28
Lower Spotted Dog Creek	C01SDOGC05	DEQ	8/18/10	5.72	0.029	-	0.32	0.01	-	-
Lower Spotted Dog Creek	C01SDOGC06	DEQ	7/21/10	14.19	0.037	-	0.15	0.005	9.14	633.90
Lower Spotted Dog Creek	C01SDOGC06	DEQ	9/29/10	4.19	0.027	-	0.11	0.005	-	-
Lower Spotted Dog Creek	C01SDOGC06	DEQ	8/18/10	5.55	0.037	-	0.26	0.005	-	-
Lower Spotted Dog Creek	C01SDOGC07	DEQ	7/22/10	5.89	0.031	-	0.11	0.005	7.51	12.37
Lower Spotted Dog Creek	C01SDOGC07	DEQ	9/29/10	1.36	0.036	-	0.09	0.005	-	-
Lower Spotted Dog Creek	C01SDOGC07	DEQ	8/19/10	2.40	0.043	-	0.29	0.005	-	-
Lower Spotted Dog Creek	C01SDOGC08	DEQ	7/22/10	3.67	0.021	-	0.1	0.005	11.83	10.10
Lower Spotted Dog Creek	C01SDOGC08	DEQ	9/29/10	0.98	0.017	-	0.025	0.005	-	-
Lower Spotted Dog Creek	C01SDOGC08	DEQ	8/19/10	1.72	0.02	-	0.17	0.01	-	-
Lower Spotted Dog Creek	SPD2	DEQ	10/2/08	0.84	0.046	-	0.05	0.005	9	-
Lower Spotted Dog Creek	SPD2	DEQ	9/1/09	1.97	0.039	-	0.11	0.005	<50	-
Lower Spotted Dog Creek	SPD2	DEQ	7/25/08	2.01	0.04	-	0.15	0.01	<50	-
Lower Spotted Dog Creek	SPD3	DEQ	10/2/08	0.80	0.039	-	0.08	0.01	0.05	-
Lower Spotted Dog Creek	SPD3	DEQ	7/25/08	10.38	0.06	-	0.25	0.01	21	-
Lower Spotted Dog Creek	SPD3	DEQ	9/2/09	5.39	0.038	-	0.21	0.005	57.9	-
Lower Spotted Dog Creek	SPD4	DEQ	7/25/08	12.14	0.061	-	0.2	0.01	4.3	-
Lower Spotted Dog Creek	SPD4	DEQ	10/2/08	1.84	0.051	-	0.06	0.005	6	-
Lower Spotted Dog Creek	SPD4	DEQ	9/2/09	5.45	0.044	-	0.17	0.005	<50	-
Snowshoe Creek	C01SNOWC01	DEQ	9/14/10	8.03	-	-	-	0.005	-	-
Snowshoe Creek	C01SNOWC01	DEQ	7/6/10	8.11	-	-	-	0.005	-	-
Snowshoe Creek	C01SNOWC01	DEQ	8/4/10	11.46	-	-	-	0.005	-	-
Snowshoe Creek	C01SNOWC02	DEQ	9/14/10	2.88	-	-	-	0.01	-	-
Snowshoe Creek	C01SNOWC02	DEQ	8/4/10	5.19	-	-	-	0.01	-	-
Snowshoe Creek	C01SNOWC02	DEQ	7/6/10	2.29	-	-	-	0.04	-	-

Table G-3. Recent Nutrient Data for the Little Blackfoot River TPA

Waterbody Segment	Station ID	Organization	Date	Flow (cfs)	TP (mg/L)	SRP (mg/L)	TN (mg/L)	NO3 (mg/L)	Chlorophyll a (mg/m2)	AFDW (g/m2)
Snowshoe Creek	C01SNOWC03	DEQ	8/4/10	4.57	-	-	-	0.005	-	-
Snowshoe Creek	C01SNOWC03	DEQ	7/6/10	5.70	-	-	-	0.005	-	-
Snowshoe Creek	C01SNOWC03	DEQ	9/14/10	4.44	-	-	-	0.01	-	-
Snowshoe Creek	C01SNOWC04	DEQ	9/15/10	6.47	0.007	-	0.23	0.14	0.7	4.68
Snowshoe Creek	C01SNOWC04	DEQ	7/7/10	8.88	0.009	-	0.16	0.08	-	-
Snowshoe Creek	C01SNOWC04	DEQ	8/4/10	8.12	0.009	-	0.1	0.1	-	-
Snowshoe Creek	C01SNOWC10	DEQ	9/15/10	3.07	0.0025	-	0.22	0.12	485.8	22.63
Snowshoe Creek	C01SNOWC10	DEQ	7/7/10	4.49	0.01	-	0.21	0.08	-	-
Snowshoe Creek	C01SNOWC10	DEQ	8/19/04	3.50	0.002	-	-	0.08	-	-
Snowshoe Creek	C01SNOWC10	DEQ	8/4/10	3.82	0.007	-	0.12	0.09	-	-
Snowshoe Creek	SNO1	DEQ	7/22/08	11.23	-	-	-	0.11	<50	-
Snowshoe Creek	SNO1	DEQ	10/1/08	4.60	-	-	-	0.12	-	-
Snowshoe Creek	SNO1	DEQ	8/26/09	3.65	-	-	-	0.14	<50	-
Snowshoe Creek	SNO2	DEQ	7/22/08	7.02	-	-	-	0.1	<50	-
Snowshoe Creek	SNO2	DEQ	10/1/08	3.95	-	-	-	0.11	<50	-
Snowshoe Creek	SNO2	DEQ	8/26/09	6.29	-	-	-	0.13	<50	-
Snowshoe Creek	SNO3	DEQ	8/26/09	4.38	0.01	-	0.16	0.005	<50	-
Snowshoe Creek	SNO3	DEQ	7/22/08	8.00	0.017	-	0.17	0.01	<50	-
Snowshoe Creek	SNO3	DEQ	10/1/08	7.85	0.023	-	0.08	0.02	<50	-
Snowshoe Creek	SNO4	DEQ	7/22/08	10.08	0.04	-	0.17	0.01	8.93	-
Snowshoe Creek	SNO4	DEQ	10/1/08	6.88	0.064	-	0.09	0.005	<50	-
Snowshoe Creek	SNO4	DEQ	8/26/09	9.78	0.033	-	0.09	0.01	<50	-
Threemile Creek	C01TREMC01	DEQ	7/23/10	8.13	0.07	-	0.45	0.01	9.6	25.7
Threemile Creek	C01TREMC01	DEQ	9/17/10	5.09	0.049	-	0.94	0.04	-	-
Threemile Creek	C01TREMC01	DEQ	8/20/10	6.21	0.055	-	0.58	0.05	-	-
Threemile Creek	C01TREMC02	DEQ	7/23/10	3.38	0.057	-	0.43	0.03	19.73	6.95
Threemile Creek	C01TREMC02	DEQ	8/20/10	2.05	0.072	-	0.66	0.16	-	-
Threemile Creek	C01TREMC02	DEQ	9/17/10	2.13	0.05	-	0.48	0.17	-	-
Threemile Creek	THR1	DEQ	9/30/08	2.10	0.064	-	0.22	0.01	9	-
Threemile Creek	THR1	DEQ	7/26/08	7.03	0.109	-	0.58	0.05	9.7	-
Threemile Creek	THR2	DEQ	9/2/09	1.51	0.077	-	0.53	0.005	46.7	-