Montana Department of
ENVIRONMENTAL QUALITY

Final -

Flathead – Stillwater Planning Area Nutrient, Sediment, and Temperature TMDLs and Water Quality Improvement Plan



December 2014

Steve Bullock, Governor
Tom Livers, Director DEQ

Document Number C11-TMDL-02aF

The latest controlled version of this document is located on the DEQ website (http://deq.mt.gov). Printed copies are not controlled. Document users are responsible for ensuring printed copies are valid prior to use.

Prepared by:
Water Quality Planning Bureau
Watershed Management Section

Contributors:
Water Quality Planning Bureau
Watershed Management Section
Paul Kusnierz, Sediment and Temperature Project Manager
Christina Staten, Project Coordinator
Dean Yashan, Watershed Management Section Supervisor
Jim Bond, Previous Sediment Project Manager

Information Management and Technical Services Section
Eric Regensburger, Modeling Assistance
Erik Makus, Modeling Assistance
Kyle Flynn, Modeling Assistance

U.S. Environmental Protection Agency
Jason Gildea, Nutrient Project Manager

Tetra Tech, Inc.

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 U.S. EPA Region 8. 2014. Flathead – Stillwater Planning Area Nutrient, Sediment, and Temperature TMDLs and Water Quality Improvement Plan. Helena, MT: Montana Dept. of Environmental Quality.

ACKNOWLEDGEMENTS

DEQ would like to acknowledge multiple entities for their contributions to the development of the total maximum daily loads (TMDLs) contained in this document. This project was a joint effort with the Montana Office of the U.S. Environmental Protection Agency (EPA) and DEQ would like to thank the EPA staff that contributed to the completion of this project. Additionally, Tetra Tech, Inc. provided significant contributions toward completion of this project including development of the Flathead Lake watershed LSPC water quality model and authoring portions of this document.

DEQ would like to thank the following entities and staff for their comments, contributions, and assistance with this project: the Flathead Conservation District; the Flathead National Forest, particularly Craig Kendall; Brian Sugden with the Plum Creek Timber Company; the staff at the Whitefish Lake Institute, particularly Mike Koopal; the Montana Department of Natural Resources and Conservation, particularly Marc Vessar; Montana Fish, Wildlife & Parks; the Flathead Lakers; the Confederated Salish and Kootenai Tribes; and the cities and counties of the Flathead Lake watershed for providing data and for their willingness to work with DEQ during development of allocations. Draft versions of source assessment reports, modeling technical reports, and this document were sent to stakeholders for review and input. The involvement of all reviewers led to improvements in this document and the Flathead Lake water quality model, and is greatly appreciated.

TABLE OF CONTENTS

Acronym List xi
Document Summary DS-1
1.0 Project Overview 1-1
1.1 Why We Write TMDLs 1-3
1.2 Water Quality Impairments and TMDLs Addressed by this Document 1-4
1.3 What This Document Contains 1-7
2.0 Flathead-Stillwater TMDL Planning Area Description 2-1
2.1 Flathead-Stillwater TPA Description 2-1
2.1.1 Location 2-1
2.1.2 Topography 2-1
2.1.3 Climate 2-1
2.1.4 Surface Water 2-1
2.1.5 Population 2-2
2.1.6 Land Cover 2-2
2.2 Other Watershed Characterizations 2-2
3.0 Montana Water Quality Standards 3-1
3.1 Stream Classifications and Designated Beneficial Uses 3-1
3.2 Numeric and Narrative Water Quality Standards 3-3
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
4.5 Implementing TMDL Allocations 4-5
5.0 Nutrient TMDL Components 5-1
5.1 Effects of Excess Nutrients on Beneficial Uses 5-1
5.2 Stream Segments of Concern 5-1
5.3 Information Sources and Assessment Methods 5-3
5.4 Water Quality Targets 5-4
5.4.1 Nutrient Water Quality Standards 5-4
5.4.2 Nutrient Target Values 5-4
5.4.3 Existing Conditions and Comparison to Targets 5-5
5.4.4 Dissolved Oxygen (DO) Impairments 5-11

5.4.5 Nutrient TMDL Development Summary 5-11
5.5 Source Assessment and Quantification 5-12
5.5.1 Source Assessment Approach 5-12
5.5.2 LSPC 5-12
5.5.3 Source Categories 5-16
5.6 Source Assessments, TMDLs, Allocations, and Reductions for Each Stream 5-29
5.6.1 Approach to TMDL Development, Allocations, Wasteload Allocations, and Current Loading 5-30
5.6.2 Upper Ashley Creek MT76O002_010 5-39
5.6.3 Middle Ashley Creek MT76O002_020 5-41
5.6.4 Lower Ashley Creek MT76O002_030 5-47
5.6.5 Spring Creek MT76O002_040 5-55
5.7 Seasonality and Margin of Safety 5-61
5.7.1 Seasonality 5-61
5.7.2 Margin of Safety 5-62
5.8 Uncertainty 5-62
5.8.1 Water Quality Conditions (Discrete Samples) 5-62
5.8.2 Water Quality Targets 5-63
5.8.3 Source Assessment 5-63
5.8.4 Wetlands 5-63
5.9 Protection of Downstream Uses 5-64
6.0 Sediment TMDL Components 6-1
6.1 Effects of Excess Sediment on Beneficial Uses 6-1
6.2 Stream Segments of Concern 6-1
6.3 Information Sources and Assessment Methods 6-3
6.3.1 Summary of Information Sources 6-3
6.3.2 DEQ Assessment Files 6-3
6.3.3 DEQ's 2008 Sediment and Habitat Assessments 6-3
6.3.4 Other Data and Reports 6-4
6.4 Water Quality Targets 6-5
6.4.1 Targets 6-5
6.4.2 Existing Conditions and Comparison to Targets 6-13
6.5 Source Assessment and Quantification 6-31
6.5.1 Percent Sediment Contribution from Each Source Type 6-32
6.5.2 Eroding Streambank Sediment Assessment 6-36

6.5.3 Upland Erosion Assessment....6-38
6.5.4 Unpaved Road Sediment Assessment....6-39
6.5.5 Permitted Point Sources....6-40
6.5.6 Source Assessment Summary....6-44
6.6 TMDL and Allocations....6-44
6.6.1 Application of Percent Reductions....6-44
6.6.2 Development of Sediment Allocations by Source Categories....6-45
6.6.3 Allocations and TMDL for Each Segment....6-46
6.7 Seasonality and Margin of Safety....6-49
6.7.1 Seasonality....6-49
6.7.2 Margin of Safety....6-50
6.8 Uncertainty and Adaptive Management....6-50
6.8.1 Sediment and Habitat Data Collection and Target Development....6-51
6.8.2 Source Assessments and Load Reduction Analyses....6-52
7.0 Temperature TMDL Components....7-1
7.1 Effects of Temperature on Beneficial Uses....7-1
7.2 Stream Segments of Concern....7-1
7.2.1 Fish Presence and Temperatures of Concern....7-3
7.3 Information Sources and Data Collection....7-4
7.3.1 DEQ Assessment Files....7-5
7.3.2 Ashley Creek and Whitefish River TMDL Field Data Collection....7-5
7.3.3 Other Information Sources....7-10
7.4 Water Quality Targets....7-10
7.4.1 Framework for Interpreting Montana's Temperature Standard....7-11
7.4.2 Temperature Targets and Target Values....7-11
7.4.3 Target Values Summary....7-15
7.5 Approach to Source Assessment, TMDLs, Allocations, and Reductions....7-16
7.5.1 Source Assessment Using QUAL2K Models....7-16
7.5.2 Wastewater Treatment Plant Source Assessment....7-17
7.5.3 Ashley Creek and Whitefish River Temperature TMDLs....7-17
7.5.4 Temperature TMDL Allocations, Wasteload Allocations, Existing Loads, and Reductions....7-19
7.6 Source Assessment, Existing Conditions and Comparison to Targets, and Example TMDLs and Allocations for Each Stream....7-22
7.6.1 Ashley Creek....7-22
7.6.2 Whitefish River....7-38

7.6.3 Achieving Temperature Allocations 7-47
7.7 Seasonality and Margin of Safety 7-51
7.8 Uncertainty and Adaptive Management 7-51
8.0 Non-Pollutant Impairments, Previously Completed TMDLs, and Future TMDL Development 8-1
8.1 Non-Pollutant Impairments 8-1
8.2 Non-Pollutant Impairment Cause Descriptions 8-2
8.3 Monitoring and Best Management Plans (BMPs) for Non-Pollutant Affected Streams 8-3
8.4 Previously Completed TMDLs 8-4
8.5 Future TMDL Development 8-5
9.0 Water Quality Improvement Plan 9-1
9.1 Purpose of Improvement Strategy 9-1
9.2 Water Quality Restoration Objective 9-1
9.3 Role of DEQ, Other Agencies, and Stakeholders 9-2
9.4 Restoration Approaches by Pollutant 9-3
9.4.1 Nutrient Restoration Approach 9-3
9.4.2 Sediment Restoration Approach 9-4
9.4.3 Temperature Restoration Approach 9-5
9.4.4 Non-Pollutant Restoration Approach 9-6
9.5 Restoration Approaches by Source 9-6
9.5.1 Agriculture Sources 9-7
9.5.2 Riparian Areas, Wetlands, and Floodplains 9-11
9.5.3 Beaver Populations and Sediment Yields 9-13
9.5.4 Roads 9-13
9.5.5 Forestry and Timber Harvest 9-15
9.5.6 Storm Water Construction Permitting and BMPs 9-15
9.5.7 Residential/Urban Development 9-16
9.5.8 Nonpoint Source Pollution Education 9-18
9.6 Potential Funding and Technical Assistance Sources 9-18
9.6.1 Section 319 Nonpoint Source Grant Program 9-18
9.6.2 Future Fisheries Improvement Program 9-19
9.6.3 Renewable Resource Project Planning Grants 9-19
9.6.4 Environmental Quality Incentives Program 9-19
9.6.5 Montana Partners for Fish and Wildlife 9-19
9.6.6 Wetland Reserve Easements 9-19
9.6.7 Montana Wetland Council 9-20

9.6.8 Montana Natural Heritage Program 9-20
9.6.9 Montana Aquatic Resources Services, Inc. 9-20
10.0 Monitoring Strategy and Adaptive Management 101
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 10-3
10.3.1 Nutrients 10-3
10.3.2 Sediment 10-4
10.3.3 Temperature 10-4
10.4 Source Assessment Refinement 10-4
10.4.1 Nutrients 10-4
10.4.2 Sediment 10-5
10.4.3 Temperature 10-5
11.0 Stakeholder and Public Participation 11-1
11.1 Participants and Roles 11-1
11.2 Response to Public Comments 11-2
12.0 References 12-1

APPENDICES

Appendix A – Regulatory Framework and Reference Condition Approach
Appendix B – Chemistry, Flow, Fish Distribution, and Permitted Point Sources Data for the Flathead – Stillwater TMDL Planning Area
Appendix C – Sheppard/Logan Road BMPs Since 2004
Appendix D – Sediment Total Maximum Daily Loads
Appendix E – QUAL2K Stream Temperature Modeling for Ashley Creek and the Whitefish River
Appendix F – Response to Public Comments

ATTACHMENTS

Attachment A – Flathead Stillwater TMDL Planning Area Sediment and Habitat Assessment Summary Report
Attachment B – Summary of Permitted Point Sources in the Flathead Lake Basin
Attachment C – Summary of Urban Stormwater Sources in the Flathead Lake Basin

LIST OF TABLES

Table DS-1. List of Impaired Waterbodies and their Impaired Uses in the Flathead-Stillwater TMDL Planning Area with Nutrient, Sediment, and Temperature TMDLs Contained in this Document..... DS-3

Table 1-1. Water Quality Impairment Causes for the Flathead-Stillwater TMDL Planning Area Addressed within this Document....1-5
Table 2-1. Active USGS Gage Stations in the Flathead-Stillwater TPA....2-2
Table 3-1. Impaired Waterbodies and their Use Classes and Impaired Designated Uses in the Flathead – Stillwater TMDL Planning Area....3-2
Table 5-1. Waterbody Segments in the Ashley Creek Watershed with Nutrient Probable Causes on the 2014 303(d) List....5-3
Table 5-2. Nutrient Targets for the Flathead-Stillwater TMDL Planning Area....5-5
Table 5-3. Nutrient Data Summary for Upper Ashley Creek....5-7
Table 5-4.Nutrient Assessment Method Evaluation Results for Upper Ashley Creek....5-7
Table 5-5. Nutrient Data Summary for Middle Ashley Creek....5-8
Table 5-6. Nutrient Assessment Method Evaluation Results for Middle Ashley Creek....5-8
Table 5-7. Nutrient Data Summary for Lower Ashley Creek....5-9
Table 5-8. Nutrient Assessment Method Evaluation Results for Lower Ashley Creek....5-9
Table 5-9. Nutrient Data Summary for Spring Creek....5-10
Table 5-10. Nutrient Assessment Method Evaluation Results for Spring Creek....5-11
Table 5-11. Summary of Nutrient TMDL Development Determinations....5-12
Table 5-12. Agricultural Land Use Summary....5-18
Table 5-13. LSPC Agricultural Fertilizer Categories....5-18
Table 5-14. Permitted Point Sources in the Ashley Creek Watershed....5-21
Table 5-15. Septic System Distribution in the Ashley Creek Watershed....5-26
Table 5-16. Area of Timber Harvest in the Ashley Creek Watershed Simulated in LSPC....5-27
Table 5-17. Road Length in the Ashley Creek Watershed (miles)....5-29
Table 5-18. Urban Lands in the Ashley Creek Watershed (acres)....5-29
Table 5-19. Spatial Distribution of the Kalispell MS4 in the Ashley Creek Watershed....5-33
Table 5-20. Estimated Summer MS4 TN and TP Loads....5-34
Table 5-21. TN and TP load Reduction Factors....5-35
Table 5-22. Existing TN Load Estimates and WLAs for the Kalispell MS4 during the Growing Season....5-35
Table 5-23. Existing TP Load Estimates and WLAs for the Kalispell MS4 during the Growing Season....5-35
Table 5-24. TN Loading and Reductions from Permitted Construction Sites....5-36
Table 5-25. TP Loading and Reductions from Permitted Construction Sites....5-37
Table 5-26. Existing and Allowable TN Loading from Permitted Industrial Sites....5-38
Table 5-27. Existing and Allowable TP Loading from Permitted Industrial Sites....5-38
Table 5-28. Example TN TMDL, Current Loads, and Allowable Loads for Upper Ashley Creek (at an Example Flow of 8.35 cfs)....5-41
Table 5-29. Example TN TMDL, Current Loads, and Allowable Loads for Middle Ashley Creek (at an Example Flow of 14.91 cfs)....5-47
Table 5-30. Example TP TMDL, Current Loads, and Allowable Loads for Middle Ashley Creek (at an Example Flow of 14.91 cfs)....5-47
Table 5-31. Example TN TMDL, Current Loads, and Allowable Loads for Lower Ashley Creek (at an Example Flow of 13.6 cfs)....5-54
Table 5-32. Example TP TMDL, Current Loads, and Allowable Loads for Lower Ashley Creek (at an Example Flow of 13.6 cfs)....5-55
Table 5-33. Example TN TMDL, Current Loads, and Allowable Loads for Spring Creek (at an Example Flow of 4.6 cfs)....5-61
Table 5-34. Example TP TMDL, Current Loads, and Allowable Loads for Spring Creek (at an Example Flow of 4.6 cfs)....5-61

Table 6-1. Stratified Reach Types and Sampling Site Representativeness within the Flathead-Stillwater TMDL Planning Area....6-4
Table 6-2. Sediment Targets for the Flathead-Stillwater TMDL Planning Area....6-6
Table 6-3. Residual pool depth and pool count summary data for the 2008 Flathead-Stillwater and PIBO datasets....6-10
Table 6-4. Existing sediment-related data for upper Ashley Creek relative to targets....6-14
Table 6-5. Bioassessment data for upper Ashley Creek....6-14
Table 6-6. Existing sediment-related data for middle Ashley Creek relative to targets....6-16
Table 6-7. Bioassessment data for Ashley Creek upstream of the Kalispell WWTP....6-17
Table 6-8. Existing sediment-related data for Fish Creek relative to targets....6-18
Table 6-9. Bioassessment data for Fish Creek....6-18
Table 6-10. Existing sediment-related data for Haskill Creek relative to targets....6-21
Table 6-11. Bioassessment data for Haskill Creek....6-21
Table 6-12. Existing sediment-related data for Logan Creek relative to targets....6-23
Table 6-13. Bioassessment data for Logan Creek....6-23
Table 6-14. Existing sediment-related data for Shepard Creek relative to targets....6-26
Table 6-15. Bioassessment data for Sheppard Creek....6-26
Table 6-16. Synoptic sampling of the Stillwater River upstream and downstream of lakes in the system on 5/20/2014....6-30
Table 6-17. Bioassessment data for the Stillwater River....6-31
Table 6-18. Existing and reduced sediment loads from eroding streambanks in specific segments of the Flathead-Stillwater TPA....6-37
Table 6-19. Existing and reduced sediment loads from upland erosion in specific segments of the Flathead-Stillwater TPA....6-39
Table 6-20. Existing and reduced sediment loads from unpaved roads in specific segments of the Flathead-Stillwater TPA....6-40
Table 6-21. Sediment loading and reductions from the Kalispell small MS4....6-42
Table 6-22 Sediment loading and reductions from permitted construction sites....6-43
Table 6-23 Sediment loading from permitted industrial sites....6-44
Table 6-24. Sediment Source Assessment and Example Allocations and TMDL for upper Ashley Creek....6-47
Table 6-25. Sediment Source Assessment and Example Allocations and TMDL for middle Ashley Creek....6-47
Table 6-26. Sediment Source Assessment and Example Allocations and TMDL for lower Ashley Creek....6-47
Table 6-27. Sediment Source Assessment and Example Allocations and TMDL for Haskill Creek....6-48
Table 6-28. Sediment Source Assessment and Example Allocations and TMDL for Logan Creek....6-48
Table 6-29. Sediment Source Assessment, Allocations and TMDL for Sheppard Creek....6-48
Table 6-30. Sediment Source Assessment and Example Allocations and TMDL for the Stillwater River....6-49
Table 7-1. Temperature reduction from the Baseline Scenario using the Shade and 15% Reduction of Water Withdrawn for Irrigation Scenario and the Shade Scenario....7-14
Table 7-2. Temperature-influencing Targets for Ashley Creek and the Whitefish River....7-16
Table 7-3. Comparison of differences in maximum and minimum temperatures on the hottest day of August between the shade scenario and the shade with the Kalispell WWTP (13.05 miles from the mouth) discharging at the average naturally occurring stream temperature (61.95°F) scenario at locations downstream of the effluent discharge....7-29
Table 7-4. Upper Ashley Creek example instantaneous and daily TMDL, LA, and explicit MOS....7-34

Table 7-5. Upper Ashley Creek example reduction based on the modeled instantaneous existing condition and example LA and an explicit MOS 7-34
Table 7-6. Middle Ashley Creek example instantaneous and daily TMDL, LA, and explicit MOS 7-36
Table 7-7. Middle Ashley Creek example reduction based on the modeled instantaneous existing condition and example LA with an explicit MOS 7-36
Table 7-8. Lower Ashley Creek example instantaneous and daily TMDL, LA, and WLA 7-38
Table 7-9. Lower Ashley Creek example reduction based on the modeled instantaneous existing condition and the example TMDL with no explicit MOS 7-38
Table 7-10. Whitefish River example instantaneous and daily TMDL, LAs, WLAs, and explicit MOS 7-46
Table 7-11. Whitefish River example reduction based on the modeled instantaneous existing condition and the example LA, WLAs, and explicit MOS 7-47
Table 8-1. Waterbody Segments in the Flathead and Flathead – Stillwater TMDL Planning Areas with Non-Pollutant Impairments in the 2014 Water Quality Integrated Report 8-1
Table 8-2. TMDLs Previously Completed in the Flathead Lake Watershed 8-4
Table 8-3. Waterbodies in the Flathead and Flathead – Stillwater TMDL Planning Areas with Pollutant Impairments on the 2014 303(d) List Not Addressed in this Document 8-5
Table 10-1. DEQ Nutrient Monitoring Parameter Requirements 10-3

LIST OF FIGURES

Figure 1-1. Nutrient, Sediment, and Temperature Impaired Waterbodies in the Flathead-Stillwater TMDL Planning Area 1-2
Figure 2-1. Location of the Flathead-Stillwater TMDL Planning Area 2-3
Figure 2-2. Topography of the Flathead-Stillwater TMDL Planning Area 2-4
Figure 2-3. Average annual precipitation in the Flathead-Stillwater TMDL Planning Area 2-5
Figure 2-4. Average annual temperature in the Flathead-Stillwater TMDL Planning Area 2-6
Figure 2-5. Surface water hydrography of the Flathead-Stillwater TMDL Planning Area 2-7
Figure 2-6. Population Density of the Flathead-Stillwater TMDL Planning Area 2-8
Figure 2-7. Land cover of the Flathead-Stillwater TMDL Planning Area 2-9
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. Nutrient Impairments in the Ashley Creek Watershed 5-2
Figure 5-2. LSPC Model Subbasins in the Ashley Creek Watershed. 5-15
Figure 5-3. Agriculture and Land Cover in the Ashley Creek Watershed 5-17
Figure 5-4. Forest Fire in the Ashley Creek Watershed 5-20
Figure 5-5. Permitted Point Sources in the Ashley Creek Watershed 5-22
Figure 5-6. Wetlands along upper Ashley Creek 5-24
Figure 5-7. Box-and-Whisker Plots for TN along Ashley Creek from Ashley Lake to near the Mouth 5-25
Figure 5-8. Box-and-Whisker Plots for TP along Ashley Creek from Ashley Lake to near the Mouth 5-25
Figure 5-9. Road Network in the Ashley Creek Watershed. 5-28
Figure 5-10. Example TMDL for TP from 0 to 6 cfs 5-31
Figure 5-11. WLA for total phosphorus from the Kalispell Wastewater Treatment Plant. 5-32
Figure 5-12. Contribution of TN Sources to Upper Ashley Creek during the Summer Growing Season. 5-39
Figure 5-13. Measured TN loads in Comparison to the TMDL 5-40
Figure 5-14. Contribution of TN Sources to Middle Ashley Creek during the Summer Growing Season. 5-42

Figure 5-15. Contribution of TP Sources to Middle Ashley Creek during the Summer Growing Season 5-43
Figure 5-16. Measured TN loads in Comparison to the TMDL..... 5-44
Figure 5-17. Measured TP loads in Comparison to the TMDL. 5-45
Figure 5-18. Contribution of TN Sources to Lower Ashley Creek during the Summer Growing Season 5-48
Figure 5-19. Contribution of TP Sources to Lower Ashley Creek during the Summer Growing Season..... 5-49
Figure 5-20. Measured TN loads in Lower Ashley Creek in Comparison to the TMDL 5-50
Figure 5-21. WLA for TN from the Kalispell WWTP 5-51
Figure 5-22. Measured TP loads in Comparison to the TMDL 5-52
Figure 5-23. WLA for TP from the Kalispell WWTP 5-53
Figure 5-24. Contribution of TN Sources to Spring Creek during the Summer Growing Season..... 5-56
Figure 5-25. Contribution of TP Sources to Spring Creek during the Summer Growing Season 5-57
Figure 5-26. Measured TN loads in Comparison to the TMDL..... 5-58
Figure 5-27. Measured TP loads in Comparison to the TMDL 5-59
Figure 6-1. Streams segments evaluated in this document and sampling sites on these segments 6-2
Figure 6-2. The Stillwater River near Kalispell, MT 6-28
Figure 6-3. Eroding banks on the Stillwater River..... 6-29
Figure 6-4. Eroding banks exacerbated by vegetation removal on the Stillwater River 6-29
Figure 6-5. Coir fabric and willow plantings on the Stillwater River..... 6-29
Figure 6-6. Rip rap on the Stillwater River 6-30
Figure 6-7. Percent contribution of sediment sources to upper Ashley Creek at the downstream end of the segment 6-33
Figure 6-8. Percent contribution of sediment sources to middle Ashley Creek at the downstream end of the segment 6-33
Figure 6-9. Percent contribution of sediment sources to lower Ashley Creek at the mouth (i.e., the entire Ashley Creek watershed) 6-34
Figure 6-10. Percent contribution of sediment sources to the Haskill Creek watershed..... 6-34
Figure 6-11. Percent contribution of sediment sources to the Logan Creek watershed..... 6-35
Figure 6-12. Percent contribution of sediment sources to the Sheppard Creek watershed..... 6-35
Figure 6-13. Percent contribution of sediment sources to the Stillwater River watershed..... 6-36
Figure 7-1. Ashley Creek and the Whitefish River watersheds and the four corresponding segments for which TMDLs are presented in this document 7-2
Figure 7-2. Temperature data logger and Solar Pathfinder sampling sites on Ashley Creek 7-7
Figure 7-3. Temperature data logger and Solar Pathfinder sampling sites on the Whitefish River 7-8
Figure 7-4. Instream Temperatures Allowed by Montana's B-1, B-2, and C-2 Classification Temperature Standards 7-18
Figure 7-5. Maximum temperatures for measured data and the QUAL2K Baseline Scenario at Ashley Creek sampling sites 7-23
Figure 7-6. Maximum temperatures for QUAL2K Baseline and Shade scenarios at Ashley Creek sampling sites 7-24
Figure 7-7. Maximum temperatures for QUAL2K Baseline, Shade scenarios, and Shade scenario with the Kalispell WWTP discharging at the average naturally occurring stream temperature at Ashley Creek sampling sites..... 7-25
Figure 7-8. Temperature change in Ashley Creek at various stream temperatures caused by the Kalispell WWTP at a stream discharge of 7.62 cfs and a WWTP effluent discharge of 4.1 cfs at 68.18°F 7-28

Figure 7-9. Difference between the baseline (existing) condition and the naturally occurring condition (implementation of all reasonable land, soil and water conservation practices) maximum temperatures at temperature data logger sites on upper Ashley Creek 7-30
Figure 7-10. Difference between the baseline (existing) condition and the naturally occurring condition (implementation of all reasonable land, soil and water conservation practices) maximum temperatures at temperature data logger sites on middle Ashley Creek 7-31
Figure 7-11. Difference between the baseline (existing) condition and the naturally occurring condition (implementation of all reasonable land, soil and water conservation practices) maximum temperatures at temperature data logger sites on lower Ashley Creek 7-32
Figure 7-12. Maximum temperatures for measured data and the QUAL2K Baseline Scenario at Whitefish River sampling sites 7-39
Figure 7-13. Maximum temperatures for QUAL2K Baseline and Shade scenarios at Whitefish River sampling sites 7-40
Figure 7-14. Difference between the baseline (existing) condition and the naturally occurring condition (implementation of all reasonable land, soil and water conservation practices) maximum temperatures at temperature data logger sites on the Whitefish River 7-44
Figure 7-15. Aerial photographs of lower Ashley Creek near the mouth in 1937 (top image) and 2009 (bottom image) 7-47
Figure 7-16. Aerial photographs of the Whitefish River near the mouth in 1938 (left image) and 2009 (right image) 7-48
Figure 7-17. Aerial photographs of a portion of middle Ashley Creek in 1937 (top image) and 2009 (bottom image) 7-49

ACRONYM LIST

Acronym	Definition
AFDM	Ash Free Dry Mass
AFO	Animal Feeding Operation
ARM	Administrative Rules of Montana
BMPs	Best Management Practices
BNSF	Burlington Northern and Santa Fe
CAFO	Concentrated (or Confined) Animal Feeding Operations
CFR	Code of Federal Regulations
CWA	Clean Water Act
DEQ	Department of Environmental Quality (Montana)
DMR	Discharge Monitoring Report
DNRC	Department of Natural Resources & Conservation (Montana)
DO	Dissolved Oxygen
EPA	Environmental Protection Agency (U.S.)
EQIP	Environmental Quality Incentives Program
FWP	Fish, Wildlife & Parks (Montana)
GIS	Geographic Information System
HBI	Hilsenhoff Biotic Index
HSPF	Hydrologic Simulation Program FORTRAN
HT	Holding Time
HUC	Hydrologic Unit Code
ID	Identification
INFISH	Inland Native Fish Strategy
IR	Integrated Report
LA	Load Allocation
LSPC	Loading Simulation Program C++ (HSPF)
LWD	Large Woody Debris
MCA	Montana Code Annotated
MDT	Montana Department of Transportation
MEANSS	Method for Estimating Attenuation of Nutrients from Septic Systems
MFISH	Montana Fisheries Information System
MOS	Margin of Safety
MPDES	Montana Pollutant Discharge Elimination System
MSU	Montana State University
NAIP	National Agricultural Imagery Program
NHD	National Hydrography Dataset
NLCD	National Land Cover Dataset
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NRCS	Natural Resources Conservation Service
NWIS	National Water Information System
PCB	PolyChlorinated Biphenyls
PIBO	PACFISH/INFISH Biological Opinion
QA	Quality Assurance
QC	Quality Control

Acronym	Definition
RSI	Riffle Stability Index
SAP	Sampling and Analysis Plan
SMZ	Streamside Management Zone
STORET	EPA STOrage and RETrieval database
SWMP	Storm Water Management Program (DEQ)
SWPPP	Storm Water Pollution Prevention Plan
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
USFS	United States Forest Service
USGS	United States Geological Survey
UUILT	Ultimate Upper Incipient Lethal Temperature
WEPP	Water Erosion Prediction Project
WLA	Wasteload Allocation
WRP	Watershed Restoration Plan
WWTP	Wastewater Treatment Plant

DOCUMENT SUMMARY

This document presents a total maximum daily load (TMDL) and water quality improvement plan for seven impaired tributaries to the Flathead River within the Flathead – Stillwater TMDL Planning Area, including Ashley, Haskill, Logan, Sheppard, and Spring creeks and the Stillwater and Whitefish rivers (see **Figure 1-1**).

The Montana Department of Environmental Quality (DEQ) develops TMDLs and submits them to the U.S. Environmental Protection Agency (EPA) for approval. The Montana Water Quality Act requires DEQ to develop TMDLs 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 Flathead-Stillwater TMDL Planning Area (TPA) is located in Flathead and Lincoln counties and includes the Whitefish River, Stillwater River, and Ashley Creek watersheds. The impaired tributaries originate in the Salish Mountains and Whitefish Range, located in the northern and western portions of the planning area. The TPA encompasses about 1,430 square miles, with federal, state, and private land ownership.

DEQ determined that seven tributaries, encompassing nine waterbody segments, within the Flathead – Stillwater TPA do not meet the applicable water quality standards. The scope of the TMDLs in this document addresses problems with nutrients, sediment, and temperature, and 18 TMDLs are included that address 23 pollutant impairments (**Table DS-1**).

Nutrients

Seven nutrient TMDLs are provided for two streams in Flathead-Stillwater TPA. These nutrient TMDLs are written for total nitrogen and total phosphorus impairments on three waterbody segments of Ashley Creek and the Spring Creek waterbody segment (**Table DS-1**). The nutrient TMDLs also address impairment for dissolved oxygen and nitrate on Ashley Creek and Spring Creek. Nutrient and/or biological data in these streams indicate nutrients are present in concentrations that can cause algal growth that harms recreation and aquatic life beneficial uses. Water quality restoration goals for nutrients were based on Montana's numeric nutrient criteria, measures of algal growth/density, and biological metrics for macroinvertebrates and periphyton. DEQ's water quality assessment methods for nutrient impairment are designed to evaluate the most sensitive use, thus ensuring protection of all designated uses. For streams in western Montana, the most sensitive uses assessed for nutrients are aquatic life and primary contact recreation.

Nutrient sources include: septic systems, point source discharges, urban areas, natural background, and agriculture. TMDL examples based on monitoring data indicate reductions between 17% and 91% are necessary. Meeting wasteload allocations and permit requirements for point source discharges and implementing the recommended best management plans (BMPs) for nonpoint sources discussed in this plan, are anticipated to achieve the reduction goals and meet the TMDLs.

Sediment

DEQ determined that sediment impairs aquatic life in Ashley, Haskill, Logan, and Sheppard creeks and the Stillwater River, and DEQ provides sediment TMDLs for seven waterbody segments (**Table DS-1**).

Fish Creek is on the 2014 303(d) List for sediment impairment, but data collected to support TMDL development indicate that it is no longer impaired for sediment and will be removed from the 303(d) list. For the five streams with sediment TMDLs, excess sediment is limiting their ability to support aquatic life. Water quality restoration goals for sediment were established on the basis of fine sediment levels in trout spawning areas and aquatic insect habitat, stream morphology and available in-stream habitat as it related to the effects of sediment, 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. DEQ's water quality assessment methods for sediment impairment are designed to evaluate the most sensitive use, thus ensuring protection of all designated uses. For streams in western Montana, the most sensitive use assessed for sediment is aquatic life.

Sediment loads are quantified for natural background conditions and for the following sources: bank erosion, hillslope erosion, roads, and point sources. The most significant sources include: bank erosion, natural sources, and in some cases agriculture and urban areas. The Flathead-Stillwater TPA sediment TMDLs indicate that reductions in sediment loads ranging from 0.2% to 34% 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, for harvesting timber, and for developing subdivisions. In addition, they includes BMPs for expanding riparian buffer areas and using other land, soil, and water conservation practices that improve stream channel conditions and associated riparian vegetation.

Temperature

DEQ determined that temperature impairs aquatic life in Ashley Creek and the Whitefish River, and DEQ provides a TMDL for each stream. Historic removal of riparian vegetation, which is important for regulating stream temperature by providing shade, is the primary cause of impairment. Water quality restoration goals focus on improving riparian shade; however, maintaining stable stream channel morphology and instream flow conditions during the hottest months of the summer are also important for meeting the TMDLs. DEQ believes that once these water quality goals are met, all water uses currently affected by temperature will be restored given all reasonable land, soil, and water conservation practices. DEQ's water quality assessment methods for temperature impairment are designed to evaluate the most sensitive use, thus ensuring protection of all designated uses. For streams in western Montana, the most sensitive uses assessed for temperature is aquatic life.

The Ashley Creek temperature model indicates that reductions in maximum daily water temperatures up to 10.8°F are necessary. The Whitefish River temperature model indicates that reductions in maximum daily water temperature up to 0.99°F are necessary. General strategies for achieving the instream water temperature reduction goals are also presented in this plan and include BMPs for managing riparian areas.

Water Quality Improvement Measures

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 document, 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.

Most water quality improvement measures are based on voluntary measures. However, federal law requires that water quality discharge permits be consistent with the assumptions and requirements of wasteload allocations (WLAs) for streams with EPA-approved TMDLs. The Flathead-Stillwater TPA has permitted discharges to Ashley and Spring creeks and the Stillwater and Whitefish rivers. When these discharge permits are renewed, the WLAs contained within each permit must be consistent with the assumptions and requirements of the WLAs provided in this document.

Table DS-1. List of Impaired Waterbodies and their Impaired Uses in the Flathead-Stillwater TMDL Planning Area with Nutrient, Sediment, and Temperature TMDLs Contained in this Document

Waterbody & Location Description	TMDL Prepared	TMDL Pollutant Category	Impaired Use(s)
Ashley Creek, Ashley Lake to Smith Lake	Total Nitrogen	Nutrients	Aquatic Life, Primary Contact Recreation
	Sediment	Sediment	Aquatic Life
	Temperature	Temperature	Aquatic Life
Ashley Creek, Smith Lake to Kalispell Airport Road	Total Nitrogen	Nutrients	Aquatic Life, Primary Contact Recreation
	Total Phosphorus	Nutrients	Aquatic Life, Primary Contact Recreation
	Sediment	Sediment	Aquatic Life
	Temperature	Temperature	Aquatic Life
Ashley Creek, Kalispell Airport Road to mouth (Flathead River)	Total Nitrogen	Nutrients	Aquatic Life, Primary Contact Recreation
	Total Phosphorus	Nutrients	Aquatic Life, Primary Contact Recreation
	Sediment	Sediment	Aquatic Life
	Temperature	Temperature	Aquatic Life
Haskill Creek, Haskill Basin Pond to mouth (Whitefish River)	Sediment	Sediment	Aquatic Life
Logan Creek, Headwaters to Tally Lake	Sediment	Sediment	Aquatic Life
Sheppard Creek, Headwaters to mouth (Griffin Creek)	Sediment	Sediment	Aquatic Life
Spring Creek, Headwaters to mouth (Ashley Creek)	Total Nitrogen	Nutrients	Aquatic Life, Primary Contact Recreation
	Total Phosphorus	Nutrients	Aquatic Life, Primary Contact Recreation
Stillwater River, Logan Creek to mouth	Sediment	Sediment	Aquatic Life
Whitefish River, Whitefish Lake to mouth (Stillwater River)	Temperature	Temperature	Aquatic Life

1.0 PROJECT OVERVIEW

This document presents an analysis of water quality information and establishes total maximum daily loads (TMDLs) for nutrients, sediment, and temperature problems in the Flathead-Stillwater TMDL Planning Area (TPA). This document also presents a general framework for resolving these problems. **Figure 1-1** below shows the nutrient, sediment, and temperature impaired waterbodies.

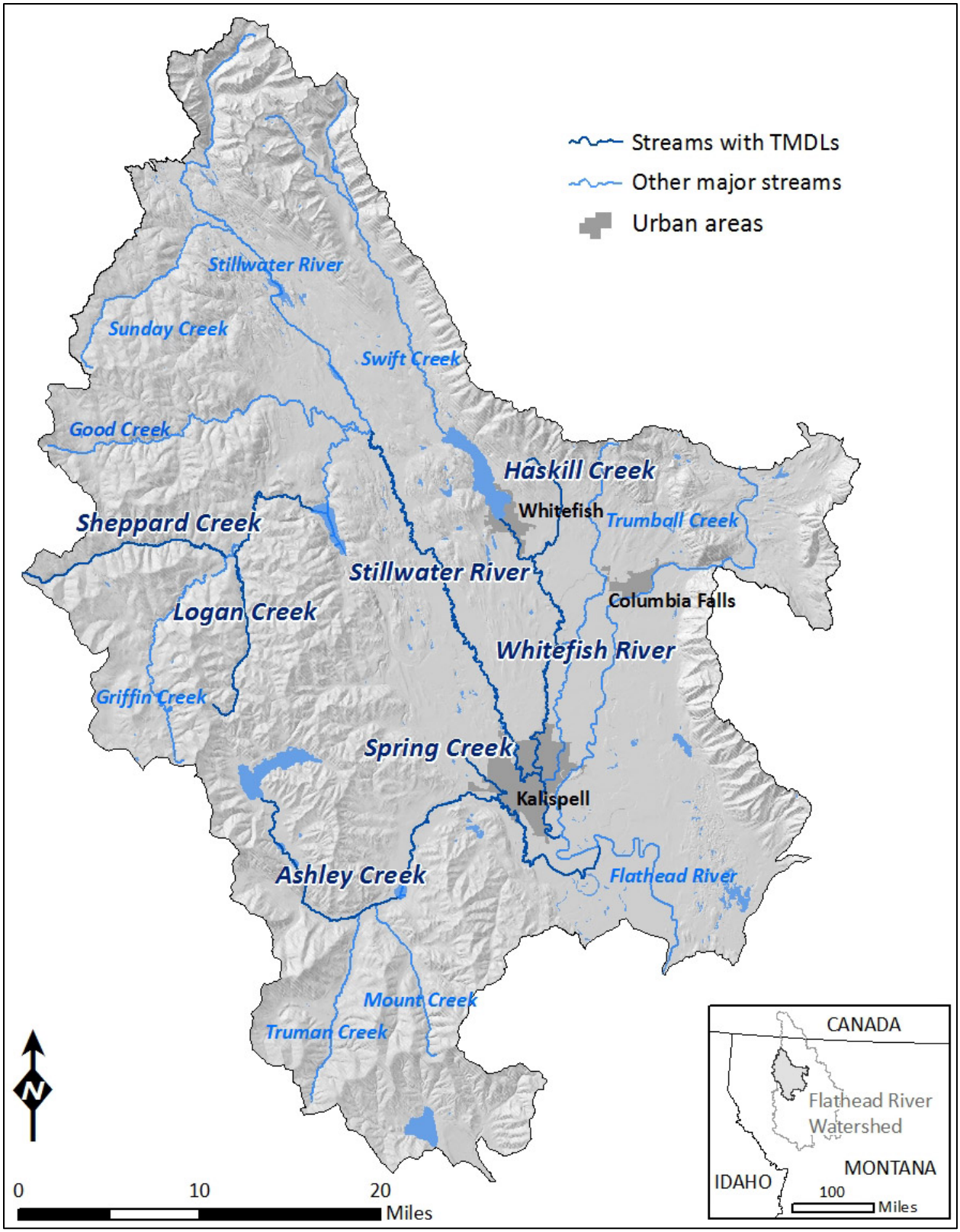


Figure 1-1. Nutrient, Sediment, and Temperature Impaired Waterbodies in the Flathead-Stillwater TMDL Planning Area

1.1 WHY WE WRITE TMDLS

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.

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

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

Each waterbody in Montana has a set of designated uses from the list above. Montana has established water quality standards to protect these uses, and a waterbody that does not meet one or more standards is called an impaired water. Each state must monitor their waters to track if they are supporting their designated uses, and every two years the Montana Department of Environmental Quality (DEQ) prepares 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. The 303(d) list portion of the IR includes all of those waterbody segments impaired by a pollutant, which require a TMDL, whereas TMDLs are not required for non-pollutant causes of impairments. 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 (see **Sections 9.0** and **10.0** of this document).

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 impairment causes from the "2014 Water Quality Integrated Report" (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2014) that are addressed in this document (also see **Figures 5-1**, **6-1**, and **7-1** for maps of those waterbodies). Each pollutant impairment falls within a TMDL pollutant category (e.g., nutrients, sediment, or temperature), and this document is organized by those categories.

New data assessed during this project identified new sediment and temperature impairment causes for two waterbodies: Ashley and Haskill creeks. These impairment causes are identified in **Table 1-1** and noted as not being on the 2014 303(d) List (within the integrated report). Instead, these impairments will be documented within DEQ assessment files and incorporated into the 2016 IR.

TMDLs are completed for each waterbody – pollutant combination, and this document contains 18 TMDLs that address 23 pollutant 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** also provides some basic water quality solutions to address those non-pollutant causes not specifically addressed by TMDLs in this document.

This document only addresses the impairments identified in **Table 1-1** below, and only includes waterbodies within the Flathead – Stillwater TMDL Planning Area. DEQ recognizes that there are other pollutant listings within the overall Flathead Lake watershed that have not been addressed via this project or previous TMDL projects in the watershed. This is because DEQ sometimes develops TMDLs in a watershed at varying phases, with a focus on one or a couple of specific pollutant types. **Section 8.0** provides tables of both pollutant and non-pollutant listings that have not been addressed in the Flathead Lake watershed, discusses future TMDL work to be completed, and includes information on previously completed TMDLs within the Flathead Lake watershed. Additionally, Flathead and Whitefish lakes are identified as impaired for sediment within the 2014 303(d) List. DEQ performed updated sediment water quality assessments for each lake and concluded that neither lake is impaired for sediment. Therefore, no sediment TMDLs are required for Flathead Lake or Whitefish Lake.

Table 1-1. Water Quality Impairment Causes for the Flathead-Stillwater TMDL Planning Area Addressed within this Document

Waterbody & Location Description [1]	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status [2]	Included in 2014 Integrated Report [3]
Ashley Creek, Ashley Lake to Smith Lake	MT76O002_010	Alteration in stream-side or littoral vegetative covers	Not Applicable; Non-pollutant	Addressed by Sediment and Temperature TMDLs	Yes
		Chlorophyll-*a*	Not Applicable; Non-pollutant	Addressed by TN TMDL	Yes
		Nitrogen (Total)	Nutrients	TN TMDL completed	Yes
		Oxygen, Dissolved	Dissolved Oxygen	Addressed by TN TMDL	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
		Temperature, water	Temperature	Temperature TMDL completed	Yes
Ashley Creek, Smith Lake to Kalispell Airport Road	MT76O002_020	Nitrogen (Total)	Nutrients	TN TMDL completed	Yes
		Phosphorus (Total)	Nutrients	TP TMDL completed	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL completed	No
		Temperature, water	Temperature	Temperature TMDL completed	No
Ashley Creek, Kalispell airport road to mouth (Flathead River)	MT76O002_030	Alteration in stream-side or littoral vegetative covers	Not Applicable; Non-pollutant	Addressed by Sediment and Temperature TMDLs	Yes
		Chlorophyll-*a*	Not Applicable; Non-pollutant	Addressed by TN and TP TMDLs	Yes
		Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrients	Addressed by TN TMDL	Yes
		Nitrogen (Total)	Nutrients	TN TMDL completed	Yes
		Oxygen, Dissolved	Dissolved Oxygen	Addressed by TN and TP TMDLs	Yes
		Phosphorus (Total)	Nutrients	TP TMDL completed	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL completed	No
		Temperature, water	Temperature	Temperature TMDL completed	Yes
Haskill Creek, Haskill Basin Pond to mouth (Whitefish River)	MT76P003_070	Sedimentation/Siltation	Sediment	Sediment TMDL completed	No
Logan Creek, Headwaters to Tally Lake	MT76P001_030	Other flow regime alterations	Not Applicable; Non-pollutant	Addressed by sediment TMDL	Yes
		Physical substrate habitat alterations	Not Applicable; Non-pollutant	Addressed by sediment TMDL	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes

Table 1-1. Water Quality Impairment Causes for the Flathead-Stillwater TMDL Planning Area Addressed within this Document

Waterbody & Location Description [1]	Waterbody ID	Impairment Cause	Pollutant Category	Impairment Cause Status [2]	Included in 2014 Integrated Report [3]
Sheppard Creek, Headwaters to mouth (Griffin Creek)	MT76P001_050	Alteration in stream-side or littoral vegetative covers	Not Applicable; Non-pollutant	Addressed by sediment TMDL	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
Spring Creek, Headwaters to mouth (Ashley Creek)	MT76O002_040	Nitrate/Nitrite (Nitrite + Nitrate as N)	Nutrients	Addressed by TN TMDL	Yes
		Nitrogen (Total)	Nutrients	TN TMDL completed	Yes
		Oxygen, Dissolved	Dissolved Oxygen	Addressed by TN and TP TMDLs	Yes
		Phosphorus (Total)	Nutrients	TP TMDL completed	Yes
Stillwater River, Logan Creek to mouth	MT76P001_010	Alteration in stream-side or littoral vegetative covers	Not Applicable; Non-pollutant	Addressed by sediment TMDL	Yes
		Sedimentation/Siltation	Sediment	Sediment TMDL completed	Yes
Whitefish River, Whitefish Lake to mouth (Stillwater River)	MT76P003_010	Temperature, water	Temperature	Temperature TMDL completed	Yes

[1] All waterbody segments within Montana's Water Quality Integrated Report are indexed to the National Hydrography Dataset (NHD)
[2] TN = Total Nitrogen, TP = Total Phosphorus
[3] Impairment causes not in the "2014 Water Quality Integrated Report" were recently identified and will be included in the 2016 Integrated Report

1.3 WHAT THIS DOCUMENT CONTAINS

This document addresses all of the required components of a TMDL and includes an implementation and monitoring strategy. The TMDL components are summarized within the main body of the document. Additional technical details are contained in the appendices and attachments. In addition to this introductory section, this document includes:

Section 2.0 Flathead-Stillwater TMDL Planning Area Description:
Describes the physical characteristics and social profile of the planning area, which includes the Ashely Creek, Whitefish River, and Stillwater River watersheds.

Section 3.0 Montana Water Quality Standards
Discusses the water quality standards that apply to the waterbodies in the Flathead – Stillwater TMDL Planning Area.

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

Sections 5.0 – 7.0 Nutrients, Sediment, and Temperature 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 Non-Pollutant Impairments, Previously Completed TMDLs, and Future TMDL Development:
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 and discusses previously completed TMDLs and potential future TMDL development work in the Flathead Lake watershed.

Section 9.0 Water Quality Improvement Plan:
Discusses water quality restoration objectives and a strategy to meet the identified objectives and TMDLs.

Section 10.0 Monitoring Strategy and Adaptive Management:
Describes a water quality monitoring plan for evaluating the long-term effectiveness of the "Flathead – Stillwater Planning Area Nutrient, Sediment, and Temperature TMDLs and Water Quality Improvement Plan."

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

2.0 FLATHEAD-STILLWATER TMDL PLANNING AREA DESCRIPTION

This section includes a brief profile of the Flathead-Stillwater Total Maximum Daily Load (TMDL) Planning Area (TPA).

2.1 FLATHEAD-STILLWATER TPA DESCRIPTION

The following information provides a general description of the Flathead-Stillwater TMDL Planning Area including a discussion of location, topography, climate, surface water, population and land cover.

2.1.1 Location

The Flathead-Stillwater TPA encompasses approximately 1,430 square miles in northwestern Montana. The planning area is bounded in the north by the Whitefish Mountain Range, the east by the and Swan Mountain Range, in the west by the Upper Kootenai and Fisher River drainages, and in the south by Flathead Lake. Most of the planning area resides in Flathead County with Kalispell, MT being the largest population center. A small northern and western portion also extends into Lincoln County. The general TPA location is mapped in **Figure 2-1.**

2.1.2 Topography

Elevations in the Flathead-Stillwater TPA range from approximately 2,887 feet above sea level at the mouth of the Flathead River and the inlet of Flathead Lake, to approximately 7,450 feet atop the summit of Whitefish Mountain. Valley bottom elevations range from around 3,000 to 3,500 feet. Elevation is mapped on **Figure 2-2.**

2.1.3 Climate

Climate in the Flathead-Stillwater TPA varies greatly. Precipitation ranges from 15 inches per year in the central valley surrounding Kalispell to over 76 inches in the Whitefish and Swan Mountains. Precipitation trends closely follow elevation; significant moisture falls in the mountains and the quantity gradually decreases with elevation.

According to data provided by the Western Regional Climate Center for Kalispell, the average maximum temperature (82°F) occurs in July while the average minimum temperature (14°F) most often occurs in January. The average annual snowfall in Kalispell is 53 inches. Precipitation and temperature averages are mapped in **Figures 2-3** and **2-4**.

2.1.4 Surface Water

All surface water in the Flathead-Stillwater TPA drains into Flathead Lake through the Flathead River in the southern portion of the planning area. The Stillwater Watershed 4th Code Hydrologic Unit (HUC 17010210) is completely contained within the TPA, as is a northern portion of the Flathead Lake Watershed (HUC 17010208). These waters are part of the larger Columbia River basin which eventually discharges into the Pacific Ocean. Surface hydrography is mapped in **Figure 2-5**.

The United States Geological Survey (USGS) has established numerous surface water monitoring and gaging stations in the planning area. As indicated in **Figure 2-5** and detailed in **Table 2-1**, five sites are actively recording continuous data as of August 2014. Data from these USGS gage stations show, as with most snowpack dominated systems, that stream flows most often peak during June and reach a

minimum in October. Discharge is relatively constant from October through March, with runoff occurring from May to July.

Table 2-1. Active USGS Gage Stations in the Flathead-Stillwater TPA

Station ID	Station Description	Latitude	Longitude	Data Range*
12369000	Flathead River near Bigfork MT	48.092325	-114.115369	1969-present
12366500	Flathead River at Foys Bend nr Kalispell MT	48.154311	-114.248925	1909-present
12365700	Stillwater River at Lawrence Park, at Kalispell	48.21725	-114.313736	2004-present
12366080	Whitefish River nr mouth at Kalispell, MT	48.225928	-114.292661	2004-present
12363000	Flathead River at Columbia Falls MT	48.361633	-114.184425	1922-present

*Data not continuous for entire period of record

2.1.5 Population

The population of the Flathead-Stillwater TPA estimated using 2010 census block densities, is 82,400 people. This population is concentrated around the urban areas of Kalispell, Whitefish, and Columbia Falls. According to the U.S. Census Bureau, 20,972 people lived in Kalispell in 2013 while 6,649 lived in Whitefish and slightly fewer than 5,000 lived in Columbia Falls. Large tracts of land are also identified as uninhabited, mostly in the mountainous land managed by the U.S. Forest Service. Two major interstate highways bisect the planning area and have experienced focused development along their routes. U.S. Highway 93 connects Whitefish and Kalispell and continues north and south out of the TPA. U.S. Highway 2 runs in a general east-west fashion going through Columbia Falls. The Glacier Park International Airport, served by four major airlines, is situated eight miles northeast of Kalispell. Population density is mapped in **Figure 2-6**.

2.1.6 Land Cover

Land cover within the Flathead-Stillwater TPA is dominated by conifer forests. Human land uses, including various intensities of development, are common along the Flathead, Stillwater, and Whitefish River Valleys. Agricultural practices are also present in the valleys. Most land identified as recently disturbed relates to forest harvest, however, the extent of the 2007 Brush Creek fire in the Sheppard Creek watershed is also evident. Land cover is mapped in **Figure 2-7**.

2.2 OTHER WATERSHED CHARACTERIZATIONS

Department of Environmental Quality (DEQ) has characterized portions of the Flathead-Stillwater TPA in other documents. These include characterizations for the Ashley Creek (Tetra Tech, Inc., 2014a), Haskill Creek (River Design Group, 2007a), Stillwater River (River Design Group, 2007b), and Whitefish River (PBS&J, 2006) watersheds. Additional information regarding climate, topography, population, etc., specific to each subwatershed, can be found in the documents.

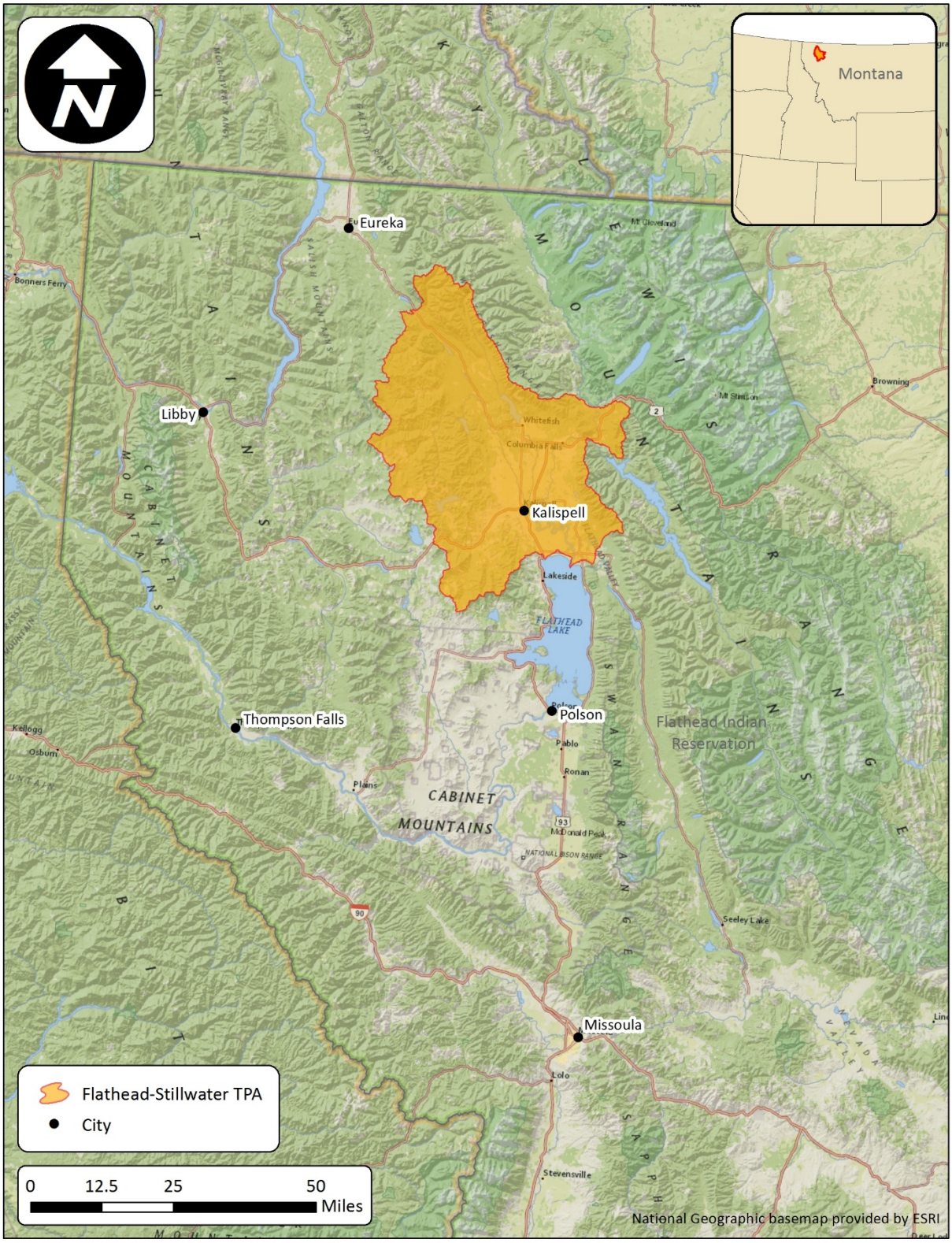


Figure 2-1. Location of the Flathead-Stillwater TMDL Planning Area

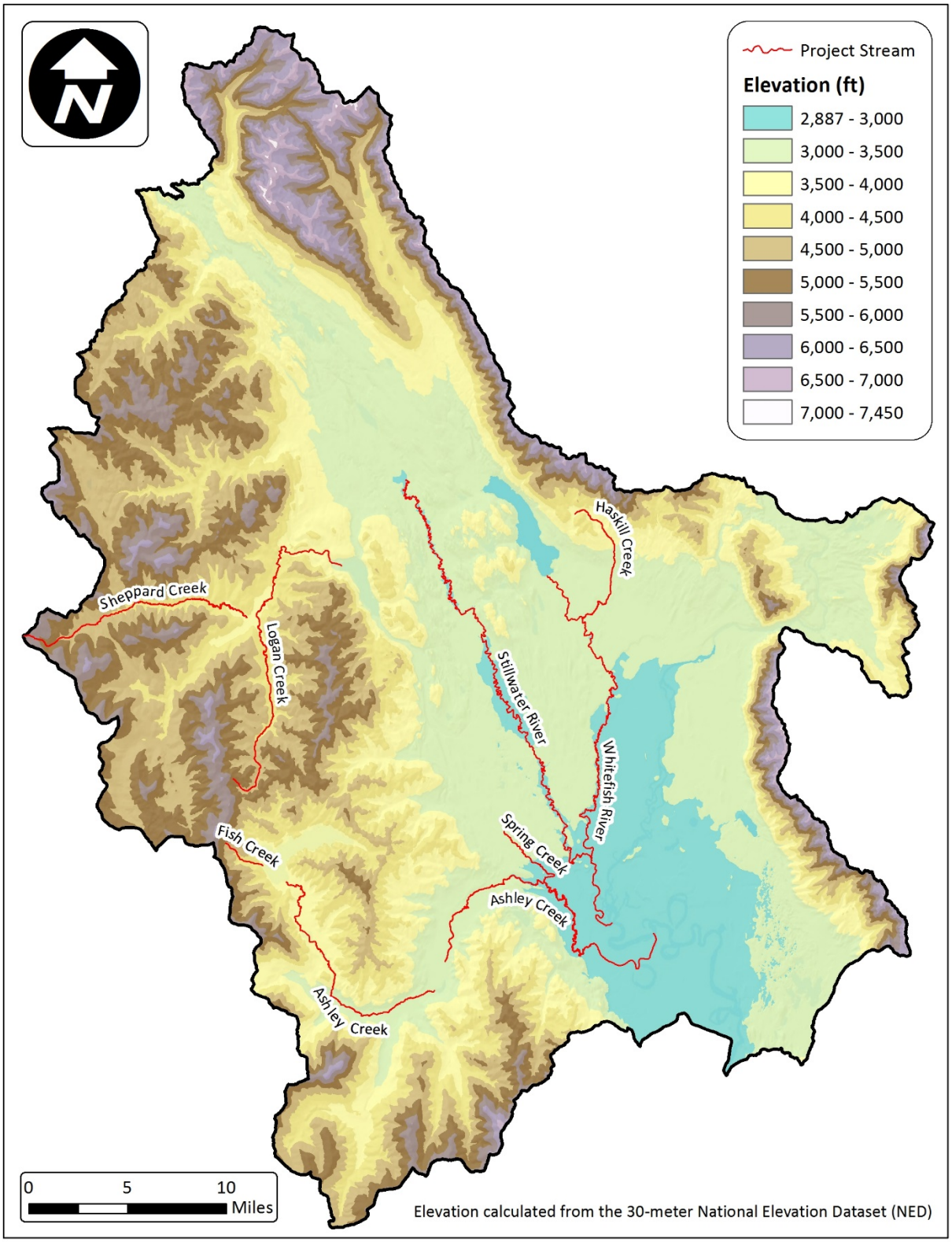


Figure 2-2. Topography of the Flathead-Stillwater TMDL Planning Area

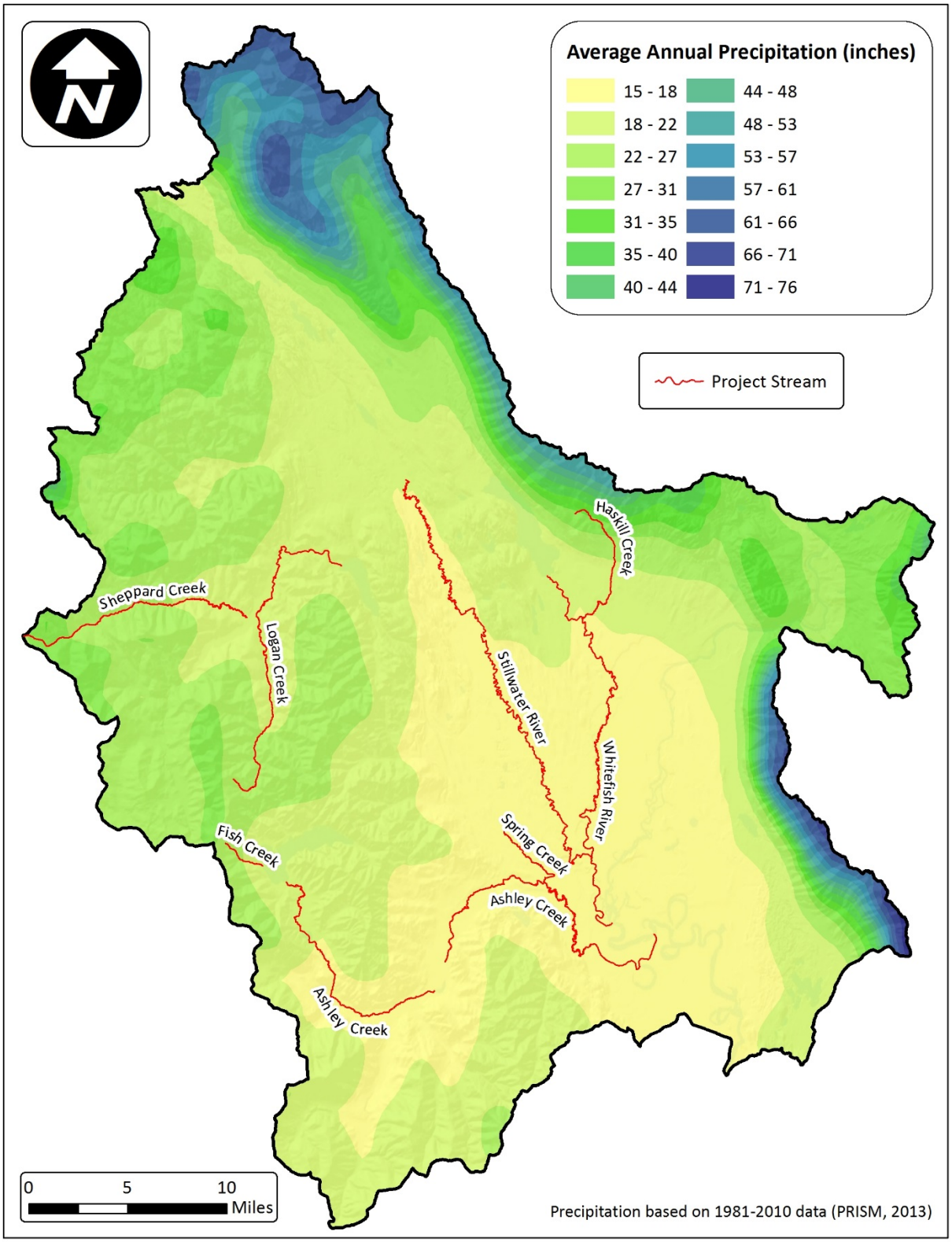


Figure 2-3. Average annual precipitation in the Flathead-Stillwater TMDL Planning Area

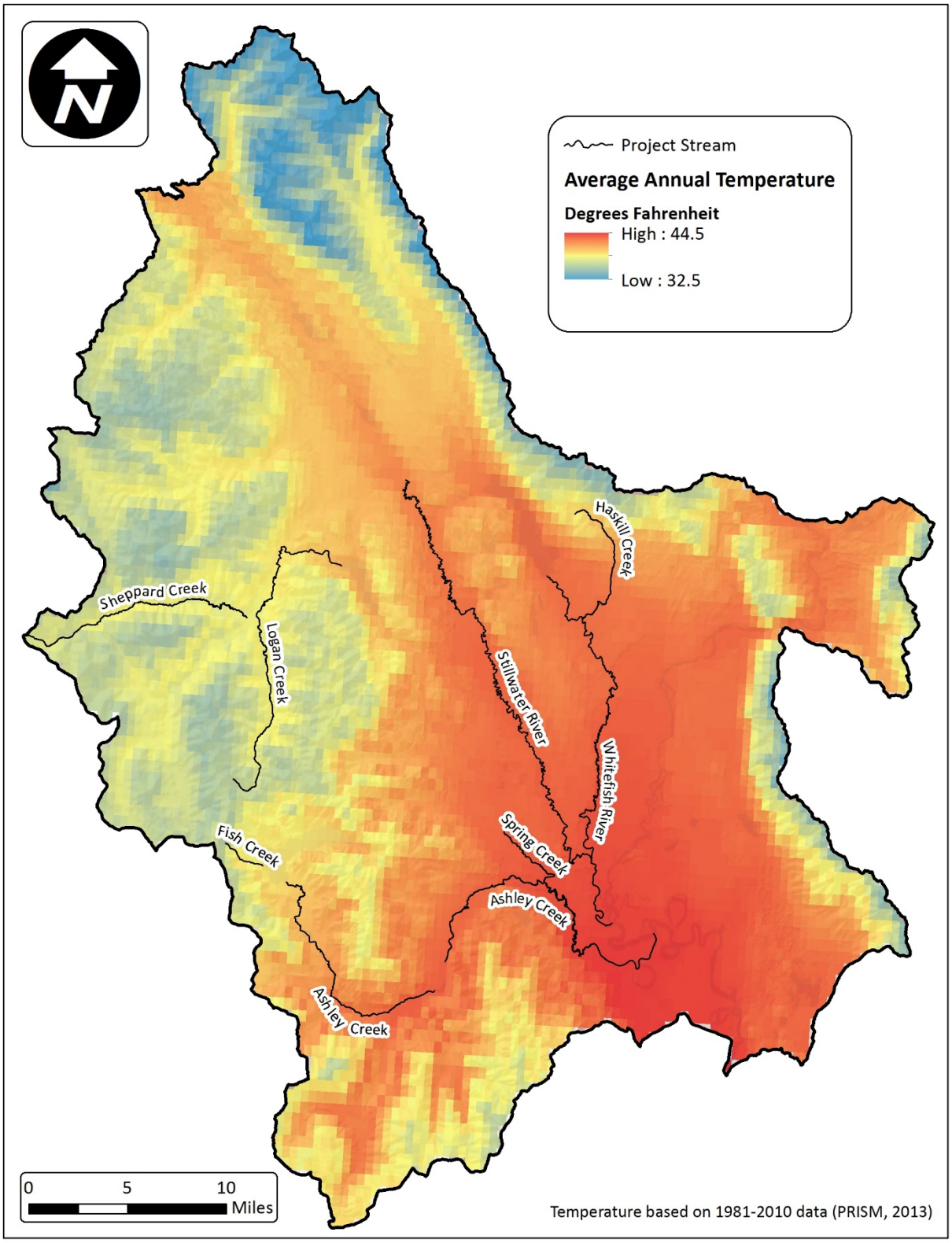


Figure 2-4. Average annual temperature in the Flathead-Stillwater TMDL Planning Area

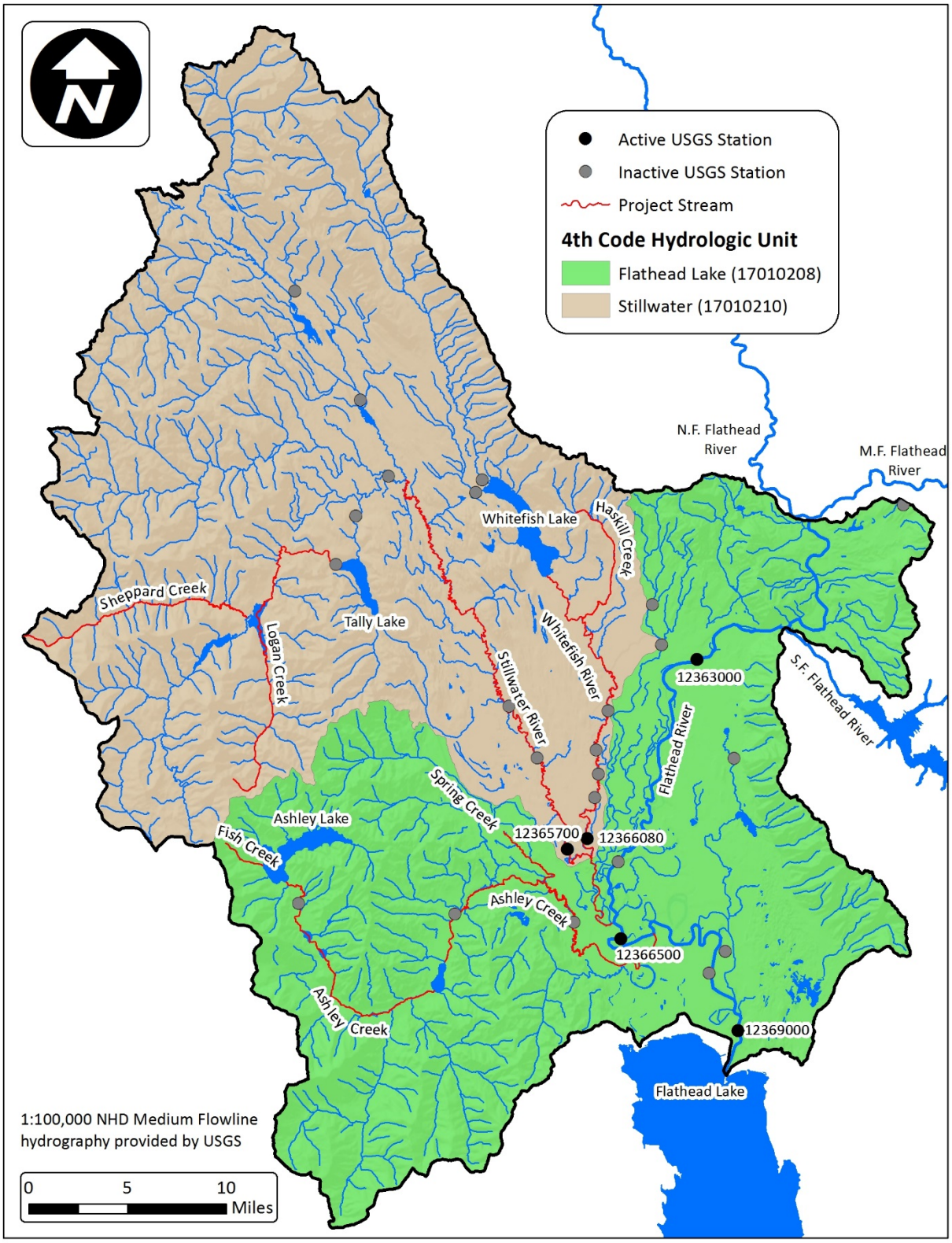


Figure 2-5. Surface water hydrography of the Flathead-Stillwater TMDL Planning Area

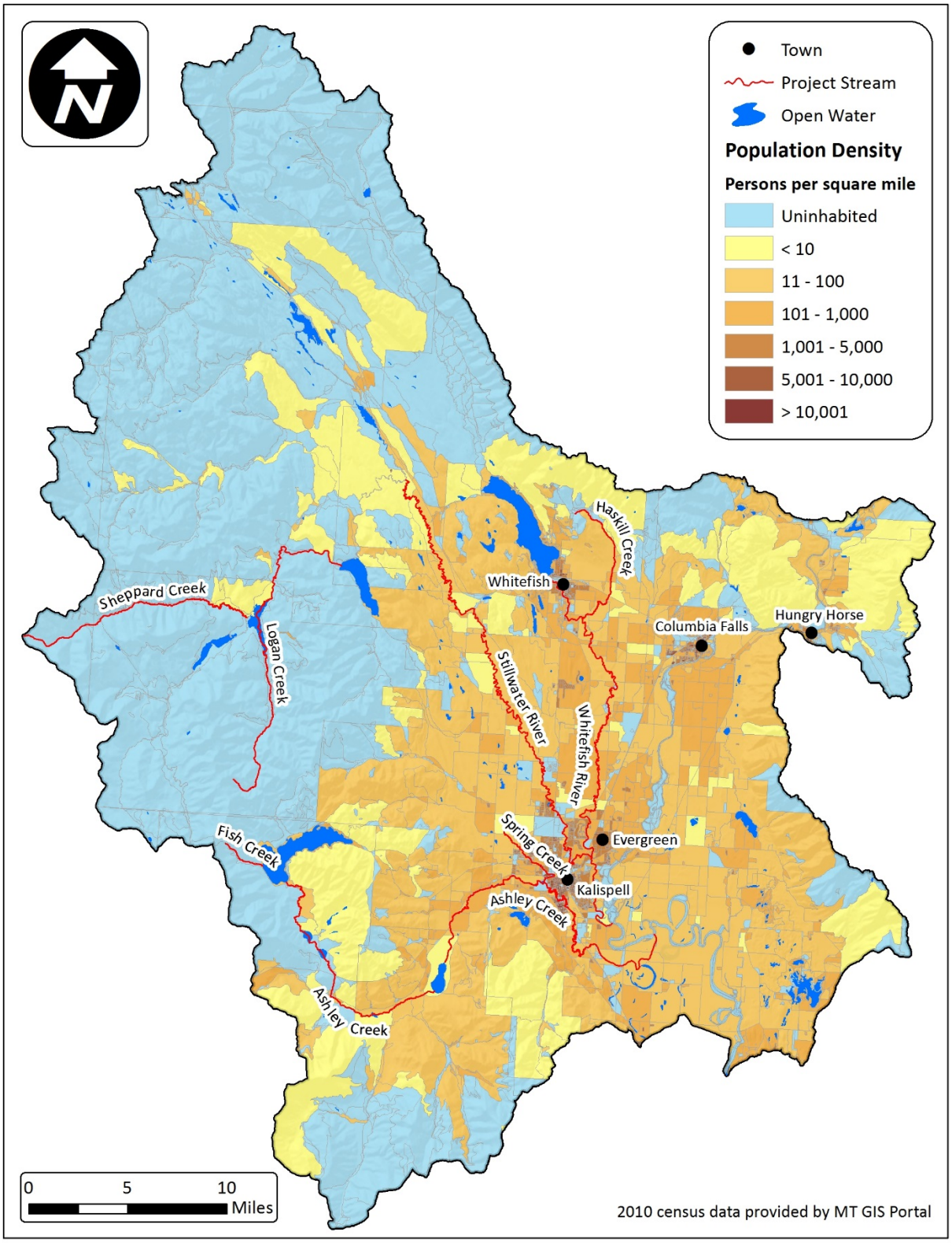


Figure 2-6. Population Density of the Flathead-Stillwater TMDL Planning Area

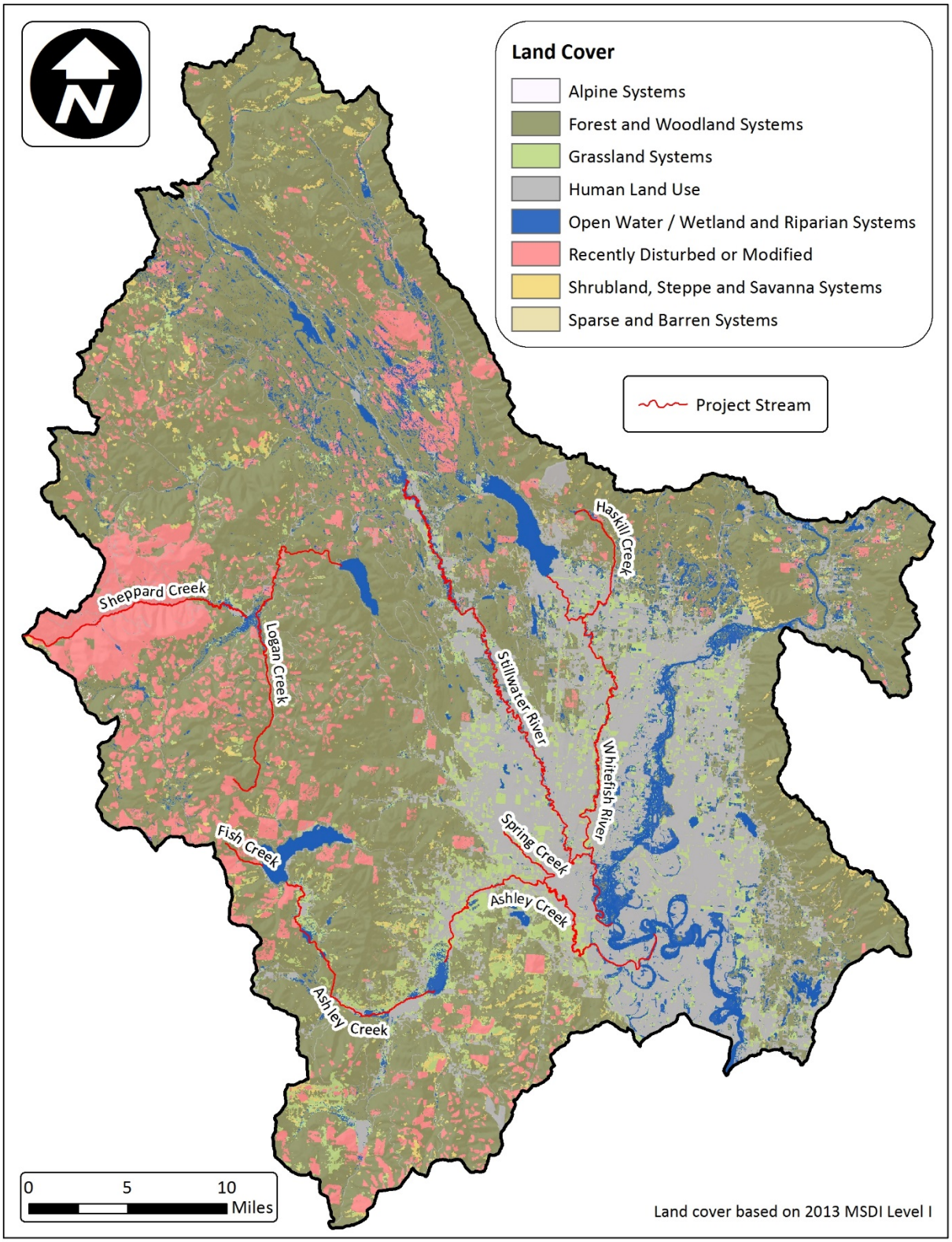


Figure 2-7. Land cover of the Flathead-Stillwater TMDL Planning Area

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 Total Maximum Daily Loads (TMDLs) and allocations.

Montana's water quality standards and water quality standards in general include three 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

Montana's water quality standards also incorporate prohibitions against water quality degradation as well as point source permitting and other water quality protection requirements.

Nondegradation provisions are not applicable to the TMDLs developed within this document because of the impaired nature of the streams addressed. Those water quality standards that apply to this document are reviewed briefly below. More detailed descriptions of Montana's water quality standards may be found in the Montana Water Quality Act (75-5-301,302 Montana Code Annotated (MCA)), Montana's Surface Water Quality Standards and Procedures (Administrative Rules of Montana (ARM) 17.30.601-670); Circular DEQ-7, Montana Numeric Water Quality Standards (Montana Department of Environmental Quality, 2012a); and Circular DEQ-12A, Montana Base Numeric Nutrient Standards (Montana Department of Environmental Quality, 2014b).

3.1 STREAM CLASSIFICATIONS AND DESIGNATED BENEFICIAL USES

Waterbodies are classified based on their designated uses. All Montana waters are classified for multiple uses. The streams in the Flathead – Stillwater TMDL Planning Area have multiple classifications, including A-1, B-1, B-2, and C-2 (**Table 3-1**). A-1 classifications are for high quality waters with the principal use as a public water supply. For a B-1, B-2, and C-2 classifications, the 'B' and 'C' denote the specific level of protection applied to designated uses and the '1' and '2' denote the suitability for growth and propagation of salmonid fishes and associated aquatic life. **Table A2-1** in **Appendix A** defines the uses, their levels of protection, and growth and propagation suitability for each of these stream classifications.

Majority of the streams in the planning area are classified B-1, and waters classified as B-1 are to be maintained suitable to support all of the following uses ((Administrative Rules of Montana (ARM) (17.30.623(1), State of Montana, 2014):

- Drinking, culinary, and food processing purposes, after conventional treatment (Drinking Water)
- Bathing, swimming, and recreation (Primary Contact Recreation)
- Growth and propagation of salmonid fishes and associated aquatic life, waterfowl, and furbearers (Aquatic Life)
- Agricultural and industrial water supply

B-2 streams must be maintained suitable for these same uses, but only *marginal* propagation of salmonid fishes and associated aquatic life. C-2 streams must be maintained suitable for the same uses as B-2 streams, with the exception of drinking water.

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 A**. Department of Environmental Quality's (DEQ) water quality assessment methods are designed to evaluate the most sensitive uses for each pollutant group addressed within this document, thus ensuring protection of all designated uses (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2011). For streams in Western Montana, the most sensitive use assessed for sediment and temperature is aquatic life, and for nutrients is aquatic life and primary contact recreation. DEQ determined that nine waterbody segments in the Flathead – Stillwater TMDL Planning Area do not meet the nutrient, sediment, and/or temperature water quality standards (**Table 3-1**).

Table 3-1. Impaired Waterbodies and their Use Classes and Impaired Designated Uses in the Flathead – Stillwater TMDL Planning Area

Waterbody & Location Description	Waterbody ID	Use Class	Impairment Cause*	Impaired Use(s)
Ashley Creek, Ashley Lake to Smith Lake	MT76O002_010	B-1	Total Nitrogen	Aquatic Life, Primary Contact Recreation
			Sediment	Aquatic Life
			Temperature	Aquatic Life
Ashley Creek, Smith Lake to Kalispell Airport Road	MT76O002_020	B-2	Total Nitrogen	Aquatic Life, Primary Contact Recreation
			Total Phosphorus	Aquatic Life, Primary Contact Recreation
			Sediment	Aquatic Life
			Temperature	Aquatic Life
Ashley Creek, Kalispell airport road to mouth (Flathead River)	MT76O002_030	C-2	Total Nitrogen	Aquatic Life, Primary Contact Recreation
			Total Phosphorus	Aquatic Life, Primary Contact Recreation
			Sediment	Aquatic Life
			Temperature	Aquatic Life
Haskill Creek, Haskill Basin Pond to mouth (Whitefish River)	MT76P003_070	A-1	Sediment	Aquatic Life
Logan Creek, Headwaters to Tally Lake	MT76P001_030	B-1	Sediment	Aquatic Life
Sheppard Creek, Headwaters to mouth (Griffin Creek)	MT76P001_050	B-1	Sediment	Aquatic Life
Spring Creek, Headwaters to mouth (Ashley Creek)	MT76O002_040	B-1	Total Nitrogen	Aquatic Life, Primary Contact Recreation
			Total Phosphorus	Aquatic Life, Primary Contact Recreation
Stillwater River, Logan Creek to mouth	MT76P001_010	B-2	Sediment	Aquatic Life
Whitefish River, Whitefish Lake to mouth (Stillwater River)	MT76P003_010	B-2	Temperature	Aquatic Life

* Only includes those pollutant impairments addressed by TMDLs in this document

3.2 NUMERIC AND NARRATIVE 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, frequency, and duration of specific pollutants so as not to impair designated uses.

Numeric standards apply to pollutants that are known to have adverse effects on human health or aquatic life (e.g., metals, nutrients, organic chemicals, and other toxic constituents). Human health standards are set at levels that protect against long-term (lifelong) exposure via drinking water and other pathways such as fish consumption, as well as short-term exposure through direct contact such as swimming. Numeric standards also apply to other designated uses such as protecting irrigation and stock water quality for agriculture.

Narrative standards are developed when there is insufficient information to develop numeric standards and/or the natural variability makes it impractical to develop numeric standards. Narrative standards describe the allowable or desired condition. This condition is often defined as an allowable increase above "naturally occurring." DEQ often uses the naturally occurring condition, called a "reference condition," to help determine whether or not narrative standards are being met (see **Appendix A**).

For the Flathead – Stillwater TMDL Planning Area, a combination of numeric and narrative standards are applicable. The numeric standards apply to nutrients, and narrative standards are applicable for sediment and temperature, as well as nutrients. The specific numeric and narrative standards are summarized in **Appendix A**.

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 = ΣWLA + ΣLA, 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.

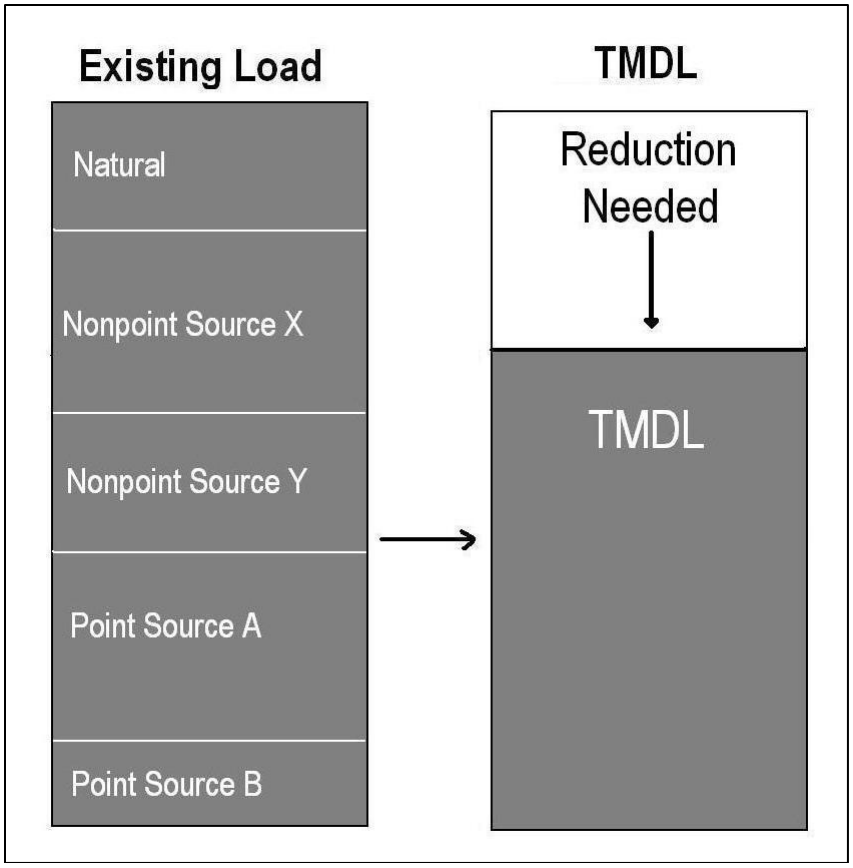


Figure 4-1. Schematic Example of TMDL Development

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 or eroding streambanks) 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 code of federal regulation (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 a "TMDL" is specifically defined as a "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. 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 load allocations (LA) for natural and nonpoint sources. Although some flexibility in allocations is possible, the sum of all allocations must meet the TMDL for all segments of the waterbody. **Figure 4-2** shows multiple point and nonpoint source allocations; however, composite allocations may be used in some cases where data is limited. Composite wasteload or load allocations provide stakeholders with flexibility in addressing sources, allowing them to choose where to focus remediation or restoration efforts.

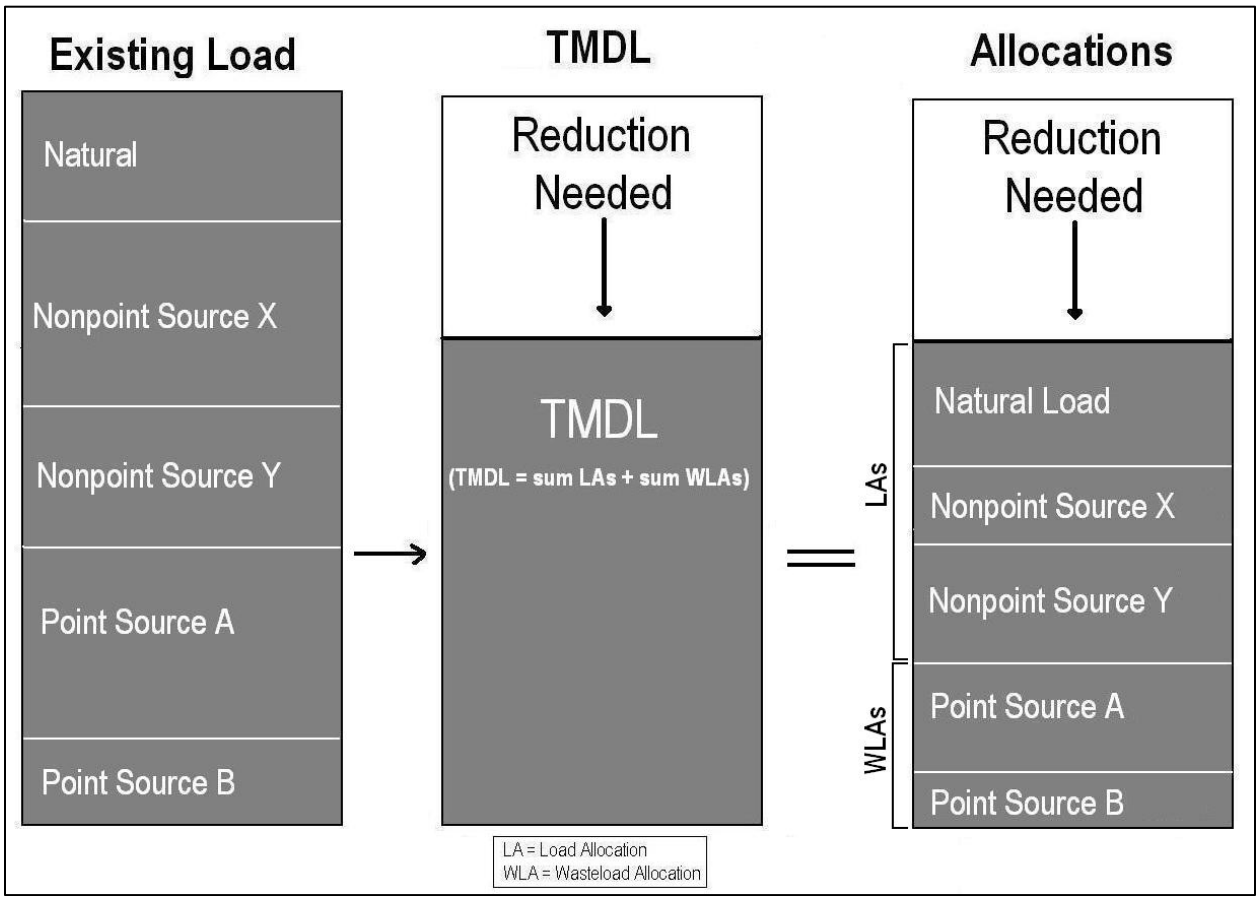


Figure 4-2. Schematic Diagram of a TMDL and its Allocations

TMDLs must also incorporate a margin of safety. The margin of safety accounts for the uncertainty, or any lack of knowledge, about the relationship between the pollutant loads and the quality of the receiving waterbody. The margin of safety may be applied implicitly by using conservative assumptions in the TMDL development process, or explicitly by setting aside a portion of the allowable loading (i.e., a TMDL = WLA + LA + MOS) (U.S. Environmental Protection Agency, 1999b). The margin of safety is a required component to help ensure that water quality standards will be met when all allocations are achieved. In Montana, TMDLs typically incorporate implicit margins of safety.

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions. For TMDLs in this document where there is a combination of nonpoint sources and one or more permitted point sources discharging into an impaired stream reach, the permitted point source WLAs are not dependent on implementation of the LAs. Instead, Department of Environmental Quality (DEQ) sets the WLAs and LAs at levels necessary to achieve water quality standards throughout the watershed. For the temperature TMDLs the LAs are developed independently of the permitted point source WLA such that they would satisfy the naturally occurring target conditions within the stream reach immediately above the point source. In order to ensure that the water quality standard is achieved below the point source discharge, the WLA is based on the point source's discharge not exceeding the allowable increase above naturally occurring conditions.

For the nutrient TMDLs, the LAs are developed independently of the permitted point source WLA such that they would satisfy the TMDL target concentration within the stream reach immediately above the point source. In order to ensure that the water quality standard or target concentration is achieved below the point source discharge, the WLA is based on the point source's discharge concentration set equal to the standard or target concentration for each pollutant unless the loading from an individual point source is negligible based on no measureable impacts to water quality.

4.5 IMPLEMENTING TMDL ALLOCATIONS

The Clean Water Act (CWA) and Montana state law (Section 75-5-703 of the Montana Water Quality Act) require wasteload allocations to be incorporated into appropriate discharge permits, thereby providing a regulatory mechanism to achieve load reductions from point sources. Because of limited state and federal regulatory requirements, nonpoint source reductions linked to LAs are implemented primarily through voluntary measures, although there are some important nonpoint source regulatory requirements, such as Montana streamside management zone (SMZ) law and applicable septic system requirements. This document contains several key components to assist stakeholders in implementing nonpoint source controls. **Section 9.0** provides a water quality improvement plan that discusses restoration strategies by pollutant group and source category, and provides recommended best management practices (BMPs) per source category (e.g., grazing, cropland, urban, etc.). **Section 9.6** discusses potential funding sources that stakeholders can use to implement BMPs for nonpoint sources. Other site specific pollutant sources are discussed throughout the document, and can be used to target implementation activities. DEQ's Watershed Protection Section (Nonpoint Source Program) helps to coordinate water quality improvement projects for nonpoint sources of pollution throughout the state and provides resources to stakeholders to assist in nonpoint source BMPs. Montana's Nonpoint Source Management Plan (available at http://www.deq.mt.gov/wqinfo/nonpoint/nonpointsourceprogram.mcpx) further discusses nonpoint source implementation strategies at the state level.

DEQ uses an adaptive management approach to implementing TMDLs to ensure that water quality standards are met over time (outlined in **Section 10.0**). This includes a monitoring strategy and an implementation review that is required by Montana statute (Section 75-5-703 of the Montana Water Quality Act). TMDLs may be refined as new data become available, land uses change, or as new sources are identified.

5.0 NUTRIENT TMDL COMPONENTS

This portion of the document focuses on nutrients as a cause of water quality impairment to Ashley Creek. It describes: (1) how excess nutrients impairs beneficial uses, (2) the affected stream segments, (3) the currently available data pertaining to nutrient impairments in the watershed, (4) the sources of nutrients, and (5) the proposed nutrient total maximum daily loads (TMDLs) and their rationales.

5.1 EFFECTS OF EXCESS NUTRIENTS ON BENEFICIAL USES

Nitrogen and phosphorus are natural background chemical elements required for the healthy and stable functioning of aquatic ecosystems. Streams in particular are dynamic systems that depend on a balance of nutrients, and are affected by organic and inorganic nutrient additions, consumption by autotrophic and heterotrophic organisms, cycling of biologically fixed inorganic N and P into higher trophic levels, and cycling of organically fixed nutrients into inorganic forms with biological decomposition. Additions from natural landscape erosion, groundwater discharge, and in-stream uptake and biological decomposition all are components of the balance between organic and inorganic nutrient forms. Human influences may alter nutrient cycling pathways, potentially causing damage to biological stream function and water quality degradation.

Excess nitrogen in the form of dissolved ammonia (ammonia ion; which is typically associated with human sources) can be toxic to aquatic life. Elevated nitrates in drinking water can inhibit normal hemoglobin function in infants. Besides 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 dissolved oxygen, which can kill fish and other forms of aquatic life, and also decreases pH which can affect sensitive membranes on fish and other aquatic species. Nutrient concentrations in surface water can lead to blue-green algae blooms (Priscu, 1987), which can produce toxins lethal to aquatic life, wildlife, livestock, and humans.

Aside from toxicity, nuisance algae can shift the macroinvertebrate community structure, which also may affect fish that feed on macroinvertebrates (U.S. Environmental Protection Agency, 2010). Additionally, changes in water clarity, fish community structure, and aesthetics can harm recreational uses, such as fishing, swimming, and boating (Suplee et al., 2009). Nuisance algae can increase treatment costs of drinking water or pose health risks if ingested in drinking water (World Health Organization, 2003).

5.2 STREAM SEGMENTS OF CONCERN

In the 2014 Integrated Report, using data collected over the preceding decade, Department of Environmental Quality (DEQ) determined that four waterbody segments in the Ashley Creek watershed (one tributary and three Ashley Creek segments) currently do not meet the nutrient water quality standards (**Figure 5-1** and **Table 5-1**).

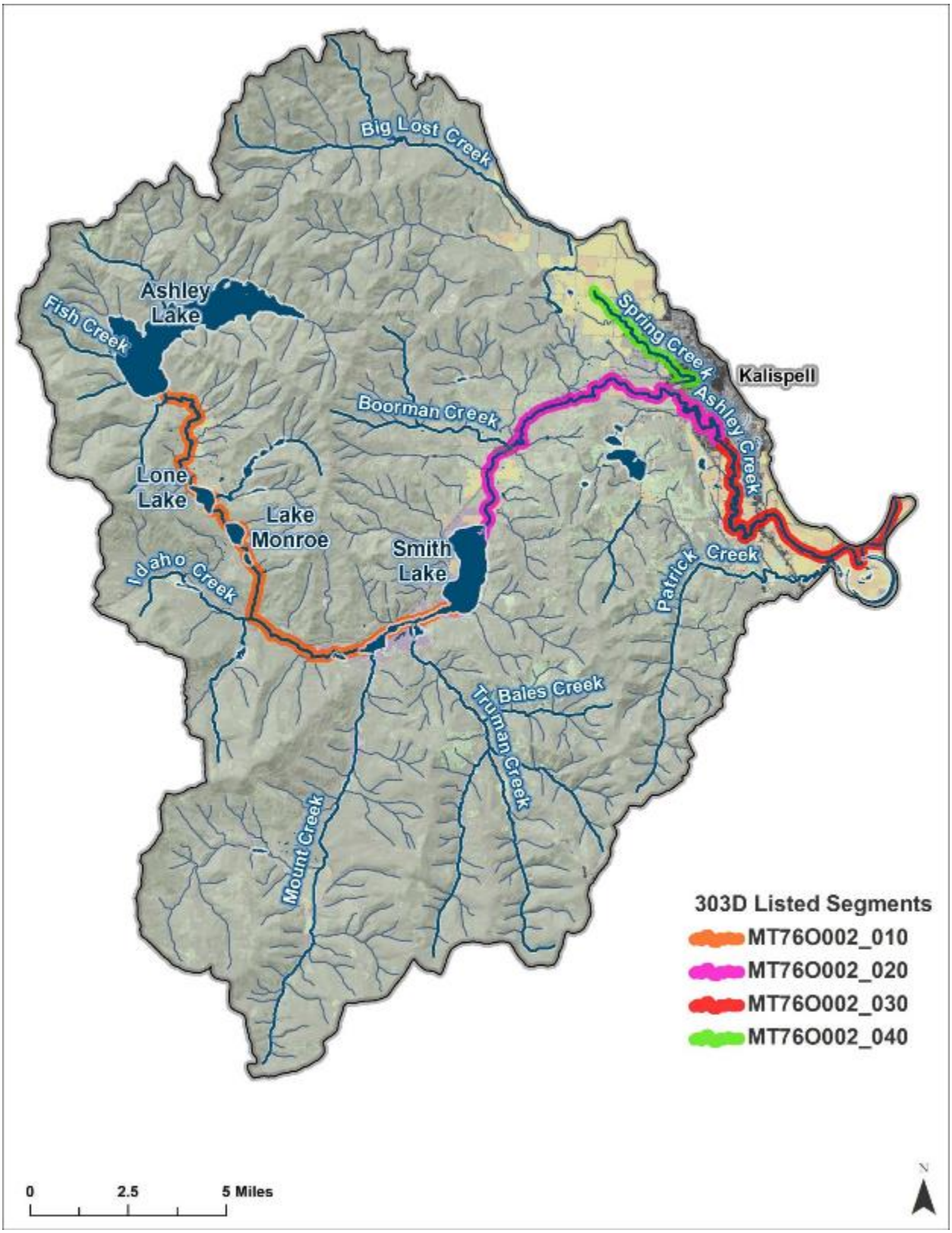


Figure 5-1. Nutrient Impairments in the Ashley Creek Watershed

Table 5-1. Waterbody Segments in the Ashley Creek Watershed with Nutrient Probable Causes on the 2014 303(d) List.

Stream Segment	Waterbody ID	Pollutant
(Upper) Ashley Creek, Ashley Lake to Smith Lake	MT76O002_010	Chlorophyll-*a* Dissolved Oxygen Total Nitrogen
(Middle) Ashley Creek, Smith Lake to bridge crossing on Kalispell Airport Rd	MT76O002_020	Total Phosphorus Total Nitrogen
(Lower) Ashley Creek, bridge crossing on Kalispell airport road to the Flathead River	MT76O002_030	Chlorophyll-*a* Dissolved Oxygen Nitrate/Nitrite Total Nitrogen Total Phosphorus
Spring Creek, headwaters to mouth (Ashley Creek)	MT76O002_040	Dissolved Oxygen Nitrate/Nitrite Total Nitrogen Total Phosphorus

5.3 INFORMATION SOURCES AND ASSESSMENT METHODS

To assess nutrient conditions for TMDL development, DEQ compiled nutrient data and undertook additional monitoring. The following data sources represent the primary information used to characterize water quality.

1) **DEQ TMDL Sampling:** DEQ conducted water quality sampling from 2003 through 2012 to update impairment determinations and assist with the development of nutrient TMDLs. Much of the data was collected during 2003, 2005, 2007-2008, and 2012. All waterbody segments were sampled over a minimum of three years.

Sample locations were generally such that they provided a comprehensive upstream to downstream view of nutrient levels. The location of sample collection also allowed for analysis of potential source impacts (e.g., changes in land use, septic influence). All data used in TMDL development was collected during the summer growing season for algae in the Northern Rockies Level III Ecoregion (July 1 – September 30).

Nutrient chemistry sampling included total nitrogen (TN), total phosphorus (TP), and nitrate/nitrite (NO_3 + NO_2). In some cases total Kjeldahl nitrogen (TKN) was sampled instead of TN. TN was then calculated as the sum of TKN and NO_3 + NO_2. Benthic algae samples were collected from Ashley Creek in 2005 and Spring Creek in 2012. These samples were analyzed for chlorophyll-*a* concentration. Macroinvertebrate samples were collected from Spring Creek in 2005. Ash free dry mass (AFDM) is a measurement that captures both living and dead algal biomass and is particularly helpful for streams where some or all of the algae are dead (because chlorophyll-*a* measures only living algae). AFDM was only measured for Spring Creek. Periphyton was measured in Ashley Creek (upper and lower segments) and Spring Creek.

2) **DEQ Assessment Files:** These files contain information used to make the existing nutrient impairment determinations.

Growing season nutrient data used for impairment assessment purposes and TMDL development are included in **Table B-1** of **Appendix B**. Other nutrient data from the watershed are publicly available

through the Environmental Protection Agency's (EPA) STOrage and RETrieval database (STORET) and DEQ's EQuIS water quality databases. Data also is available from the U.S. Geological Survey through their National Water Information System (NWIS).

Additional sources of information used to develop TMDL components include the following:

- Streamflow data
- Geographic Information System (GIS) data layers
- Outside agency and university websites and documentation
- Land-use information

The above information and water quality data are used to compare existing conditions to waterbody restoration goals (targets), to assess nutrient pollutant sources, and to help determine TMDL allocations. Field data sheets were reviewed to rule out irregularities in collection methods or sample quality assurance/quality control (QA/QC). Laboratory methods and QA/QC criteria were also reviewed to ensure these values were accurate. No QA/QC problems were identified.

5.4 WATER QUALITY TARGETS

TMDL water quality targets are numeric indicator values used to evaluate whether water quality standards have been met. These are discussed further in **Section 4.0**. This section presents nutrient water quality targets and compares them with recently collected nutrient data in the Ashley Creek watershed following DEQ's assessment methodology (Suplee and Sada de Suplee, 2011). To be consistent with DEQ's assessment methodology, and because of improvements in analytical methods, only data from the past 10 years are included in the review of existing data.

5.4.1 Nutrient Water Quality Standards

DEQ has developed numeric nutrient criteria for nitrogen and phosphorus to reflect the intent of the narrative standard requiring that state surface waters must be free from substances attributable to municipal, industrial, or agricultural practices or other discharges that produce nuisance conditions; create concentrations or combinations of material toxic or harmful to aquatic life; or create conditions that produce undesirable aquatic life [Administrative Rules of Montana (ARM) 17.30.637(1)]. The state-approved numeric criteria for TN and TP are in DEQ's Circular DEQ-12A, and are awaiting formal approval by EPA under the federal Clean Water Act. These numeric criteria are the basis for the nutrient TMDL targets consistent with EPA's TMDL development guidance (http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/ strategy/) and federal regulations (40 code of federal regulations (CFR) §131.11(a) & (b)).

5.4.2 Nutrient Target Values

Nutrient water quality targets include nutrient concentrations in surface waters and measures of benthic algae chlorophyll-*a* (a form of undesirable aquatic life at elevated concentrations). The target concentrations for nitrogen and phosphorus are established at levels believed to protect aquatic life and recreation. Since 2002, DEQ has conducted a number of studies in order to develop numeric criteria for nutrients (N and P forms). Nutrient criteria for TN and TP, and threshold concentrations for chlorophyll-*a*, are based on two factors: (1) the results of public perception surveys (Suplee et al., 2009) on what level of algae was perceived as undesirable and (2) the outcome of nutrient stressor-response studies

that determine nutrient concentrations that will maintain algal growth below undesirable and harmful levels (Suplee and Watson, 2013; Suplee et al., 2008).

Nutrient targets for TN and TP, based on the numeric criteria in DEQ-12A, and chlorophyll-*a*, and ash-free dry mass (AFDM) target concentrations, based on Suplee and Watson (2013), are presented in **Table 5-2**. The NO_3+NO_2 target is based on research by DEQ Suplee et al. (2008) and Suplee (11/14/2013) and can also be found in **Table 5-2**. DEQ has determined that the values for NO_3+NO_2, TN, and TP provide an appropriate numeric translation of the applicable narrative nutrient water quality standards based on existing water quality data in the Flathead-Stillwater project area. The target values are based on the most sensitive uses; therefore, the nutrient TMDLs are protective of all designated uses.

Macroinvertebrates and periphyton were also included in the nutrient target suite for streams in the Northern Rockies ecoregion as a biometric indicator. For macroinvertebrates, the Hilsenhoff Biotic Index (HBI) score is used. The HBI value increases as the amount of pollution tolerant macroinvertebrates in a sample increases; the macroinvertebrate target is an HBI score equal to or less than 4.0 (Suplee and Sada de Suplee, 2011) (**Table 5-2**). Benthic diatoms, or periphyton, are a type of algae that grow on the stream bottom, and there are certain taxa that tend to increase as nutrient concentrations increase. The diatom target is a periphyton sample with a ≤51% probability of impairment by nutrients (Suplee and Sada de Suplee, 2011) (**Table 5-2**).

Because numeric nutrient chemistry is established to maintain algal levels below target chlorophyll-*a* concentrations and AFDM, target attainment applies and is evaluated during the summer growing season (July 1–September 30 for the Northern Rockies Ecoregion) when algal growth will most likely affect beneficial uses.

Table 5-2. Nutrient Targets for the Flathead-Stillwater TMDL Planning Area.

Parameter	Northern Rockies Level III Ecoregion Target Value
Nitrate[1]	≤ 0.100 mg/L
Total Nitrogen[2]	≤ 0.275 mg/L
Total Phosphorus[2]	≤ 0.025 mg/L
Chlorophyll-*a*[2]	≤ 120 mg/m²
Ash Free Dry Mass[2]	≤ 35 g /m^2
Hilsenhoff's Biotic Index[3]	< 4.0
Periphyton[3]	≤ 51%

[1] Value is from Suplee (11/14/2013) and Suplee et al., (2008).
[2] Value is from Suplee and Watson (2013).
[3] Value is from Suplee and Sada de Suplee (2011).

5.4.3 Existing Conditions and Comparison to Targets

To evaluate whether attainment of nutrient targets has been met, the existing water quality conditions in each waterbody segment are compared to the water quality targets in **Table 5-2** using the methodology in DEQ guidance document "2011 Assessment Methodology for Determining Wadeable Stream Impairment due to Excess Nitrogen and Phosphorus Levels" (Suplee and Sada de Suplee, 2011). This approach provides DEQ with updated impairment determinations for TMDL development. Because the original impairment listings are based on old data or were listed before developing the numeric criteria, each stream segment will be evaluated for impairment based on nitrate, TN, and TP data collected within the past 10 years.

The assessment methodology uses 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 not attained when nutrient chemistry data shows a target exceedance rate of >20% (Exact Binomial Test), when mean water quality nutrient chemistry exceeds target values (Student T-test), or when a single chlorophyll-*a* exceeds benthic algal target concentrations (125 mg/m^2 or 35 g Ash Free Dry Weight/m^2). Where water chemistry and algae data do not provide a clear determination of impairment, or where other limitations exist, macroinvertebrate and periphyton biometrics are considered in further evaluating compliance with nutrient targets. Lastly, inherent to any impairment determination, is the existence of human sources of pollutant loading. Human-caused 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 than for a listed nutrient. This can result in a different number of allowable exceedances for nutrients within a single stream segment. Such tests help assure that assessment reaches do not vacillate between listed and delisted status by the change in results from a single additional sample. When applying the T-test for assessment and sample values that were below detection limits, one-half the detection limit was used.

Through a continuous improvement process, DEQ will routinely evaluate the above nutrient assessment method and may incorporate updates as more tools and information become available and as the science improves. Any future assessments would apply the updated or revised method.

5.4.3.1 Upper Ashley Creek (MT76O002_010)

Upper Ashley Creek is on the 2014 303(d) List as impaired for TN, chlorophyll-*a,* and dissolved oxygen. This impaired segment of Ashley Creek begins at the outlet of Ashley Lake and flows south and then east 15.64 miles until it discharges to Smith Lake.

Summary nutrient data statistics and assessment method evaluation results for upper Ashley Creek are provided in **Table 5-3** and **Table 5-4**, respectively. Forty nitrate samples were collected from 2003-2005; values ranged from <0.01 to 0.03 mg/L with no samples exceeding the nitrate target of 0.100 mg/L. Forty TKN samples were collected between 2003 and 2005; values ranged from <0.1 to 1.5 mg/L. Thirty-nine TN concentrations were calculated from the nitrate and TKN samples; values ranged from 0.049 to 1.5mg/L with 22 samples exceeding the TN target of 0.275 mg/L. Forty TP samples were collected between 2003 and 2005; values ranged from 0.008 to 0.48 mg/L with five samples exceeding the TP target of 0.025 mg/L.

Three chlorophyll-*a* samples were collected from upper Ashley Creek in 2005. Chlorophyll-*a* values ranged from 34 to 74 mg/m² with none exceeding the target of 120 mg/m². One periphyton sample was collected in 2008. No macroinvertebrate or AFDM samples were collected in upper Ashley Creek.

Dissolved oxygen (DO) was monitored once at each of four sites along upper Ashley Creek in September 2005. The concentrations ranged from 4.5 to 5.7 mg/L. All four results were below the DO *1-Day Minimum* (i.e., instantaneous according to DEQ (2012a) standard for *Early Life Stages* of fish and other aquatic life, which is 8.0 mg/L for B-1 classified streams (Montana Department of Environmental Quality, 2012a).

Assessment results shown in **Table 5-4** indicate that upper Ashley Creek is impaired for TN based on proposed criteria for the Northern Rockies Level III Ecoregion. As a result, a TMDL will be written for the nutrient probable causes of TN. Per DEQ's assessment methodology for nutrients, if TN and/or TP exceed the targets and the exceedance rate, and chlorophyll-*a* (or periphyton) measurements are less than the targets, then results suggest that algal sampling may have missed peaks of benthic algal biomass. In the case of upper Ashley Creek, the stream will remain listed as impaired for chlorophyll-*a*, and the TN TMDL will address the impairment. The DO impairment is further discussed in **Section 5.4.4**.

Table 5-3. Nutrient Data Summary for Upper Ashley Creek.

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1] (mg/L)	Max (mg/L)	Mean (mg/L)
Nitrate, mg/L	2003-2005	40	< 0.01	0.03	0.006[2]
TN, mg/L	2003-2005	39	0.049	1.5	0.38
TP, mg/L	2003-2005	40	0.008	0.48	0.0165
Chlorophyll-*a*, mg/m^2	2005	3	34	74	50
AFDM, g/m^2	NA	0	NA	NA	NA
Macroinvertebrate HBI	NA	0	NA	NA	NA
Periphyton	2008	1	NA	NA	NA

[1] Values preceded by a less than ("<") symbol are detection limits for that parameter. The actual sample value was below the detection limit.

[2] The value of 0.005 mg/L, which is one-half of the detection limit of 0.01 mg/L, was used to calculate the mean for all samples reported as less than the detection limit.

Table 5-4.Nutrient Assessment Method Evaluation Results for Upper Ashley Creek.

Nutrient Parameter	Sample Size	Target Value (mg/l)	Target Exceed	Binomial Test Result	T-test Result	Chlorophyll-*a* Test Result	AFDM Test Result	Macroinvertebrate Test Result	Periphyton Test Result	TMDL Required?
Nitrate	40	0.100	0	PASS	PASS	PASS	NA	NA	FAIL	NO
TN	39	0.275	22	FAIL	FAIL					YES
TP	40	0.025	5	PASS	PASS					NO

5.4.3.2 Middle Ashley Creek (MT76O002_020)

Middle Ashley Creek is listed for TN and TP on the 2014 303(d) List; the segment was not on the 2012 303(d) List. DEQ's Monitoring and Assessment section recently performed an assessment of this waterbody segment and determined that it is impaired for TN and TP. Middle Ashley Creek begins at the outlet of Smith Lake and flows northeast, east, then southeast for 14.17 miles to Kalispell Airport Road.

Summary nutrient data statistics and assessment method evaluation results for middle Ashley Creek are provided in **Table 5-5** and **Table 5-6**, respectively. Thirty-eight nitrate samples were collected between 2003 and 2005; values ranged from <0.01 to 0.07 mg/L with no samples exceeding the nitrate target of 0.100 mg/L. Thirty-eight TKN samples were collected between 2003 and 2005; values ranged from 0.56 to 1.7 mg/L. Thirty-eight TN concentrations were calculated from the nitrate and TKN samples; values ranged from 0.565 to 1.7 mg/L with all 38 samples exceeding the TN target of 0.275 mg/L. Forty-eight TP samples were collected between 2003 and 2008; values ranged from <0.001 to 0.059 mg/L with 27 samples exceeding the TP target of 0.025 mg/L.

Four chlorophyll-*a* samples were collected from middle Ashley Creek in 2005. Chlorophyll-*a* values ranged from 11 to 57 mg/m² with none exceeding the target of 120 mg/m². There were no macroinvertebrate, AFDM, or periphyton samples collected from middle Ashley Creek.

Assessment results shown in **Table 5-6** indicate that middle Ashley Creek is impaired for TN and TP. As a result TMDLs will be written for these nutrient probable causes.

Table 5-5. Nutrient Data Summary for Middle Ashley Creek.

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1] (mg/L)	Max (mg/L)	Mean (mg/L)
Nitrate, mg/L	2003-2005	38	<0.01	0.07	0.007[2]
TN, mg/L	2003-2005	38	0.565	1.7	0.868
TP, mg/L	2003-2005, 2007, 2008	48	<0.001	0.059	0.029
Chlorophyll-*a*, mg/m^2	2005	4	11	57	50
AFDM, g/m^2	NA	0	NA	NA	NA
Macroinvertebrate HBI	NA	0	NA	NA	NA
Periphyton	NA	0	NA	NA	NA

[1] Values preceded by a less than ("<") symbol are detection limits for that parameter. The actual sample value was below the detection limit.
[2] The value of 0.005 mg/L, which is one-half of the detection limit of 0.01 mg/L, was used to calculate the mean for all samples reported as less than the detection limit.

Table 5-6. Nutrient Assessment Method Evaluation Results for Middle Ashley Creek.

Nutrient Parameter	Sample Size	Target Value (mg/l)	Target Exceed	Binomial Test Result	T-test Result	Chlorophyll-*a* Test Result	AFDM Test Result	Macroinvertebrate Test Result	Periphyton Test Result	TMDL Required?
Nitrate	38	0.100	0	PASS	PASS	PASS	NA	NA	NA	NO
TN	38	0.275	38	FAIL	FAIL					YES
TP	48	0.025	27	FAIL	FAIL					YES

5.4.3.2 Lower Ashley Creek (MT76O002_030)

Lower Ashley Creek is on the 2014 303(d) List as impaired for nitrate/nitrite, TN, TP, chlorophyll-*a*, and dissolved oxygen. This impaired segment of Ashley Creek begins at the Kalispell Airport Road and generally flows southeast and east 13.17 miles until it discharges to the Flathead River.

Summary nutrient data statistics and assessment method evaluation results for lower Ashley Creek are provided in **Table 5-7** and **Table 5-8**, respectively. Twelve nitrate samples were collected between 2003 and 2005; values ranged from 0.03 to 3.93 mg/L with eleven samples exceeding the target of 0.100 mg/L. Twelve TKN samples were collected between 2003 and 2005; values ranged from 0.78 to 1.8 mg/L. Twelve TN concentrations were calculated from TKN and nitrate plus nitrite samples; values ranged from 0.83 to 5.11 mg/L with all twelve samples exceeding the TN target of 0.275 mg/L. Twenty

TP samples were collected between 2003 and 2008; values ranged from 0.019 to 0.089 mg/L with 18 samples exceeding the TP target of 0.025 mg/L.

One chlorophyll-*a* sample was collected from this segment of Ashley Creek in 2005. Chlorophyll-*a* was 69 mg/m² and did not exceed the target of 120 g/m². One periphyton sample was collected in 2008. No macroinvertebrate or AFDM samples were collected.

DO was monitored four sites along lower Ashley Creek from 2004-2008; the concentrations ranged from 2.64 to 14.7 mg/L. Eight concentrations were below the DO *1-Day Minimum* (i.e., instantaneous according to DEQ (2012a) standard for *Early Life Stages* of fish and other aquatic life, which is 8.0 mg/L for C-2 classified streams (Montana Department of Environmental Quality, 2012a).

Assessment results shown in **Table 5-8** indicate that lower Ashley Creek is impaired for nitrate, TN, and TP. TMDLs will be written for TN and TP. It is assumed that nitrate will be addressed by the TN TMDL. Per DEQ's assessment methodology for nutrients, if TN and/or TP exceed the targets and the exceedance rate, and chlorophyll-*a* (or periphyton) measurements are less than the targets, then results suggest that algal sampling may have missed peaks of benthic algal biomass. In the case of lower Ashley Creek, the stream will remain listed as impaired for chlorophyll-*a*, and both the TN and TP TMDLs will address the impairment. The DO impairment is further discussed in **Section 5.4.4**.

Table 5-7. Nutrient Data Summary for Lower Ashley Creek.

Nutrient Parameter	Sample Timeframe	Sample Size	Min (mg/L)	Max (mg/L)	Mean (mg/L)
Nitrate, mg/L	2003-2005,	12	0.03	3.93	2.06
TN, mg/L	2003-2005, 2008	12	0.83	5.11	3.14
TP, mg/L	2003-2005, 2007, 2008	20	0.019	0.089	0.059
Chlorophyll-*a*, mg/m^2	2005	1	69	69	69
AFDM, g/m^2	NA	0	NA	NA	NA
Macroinvertebrate HBI	NA	0	NA	NA	NA
Periphyton	2008	1	NA	NA	NA

Table 5-8. Nutrient Assessment Method Evaluation Results for Lower Ashley Creek.

Nutrient Parameter	Sample Size	Target Value (mg/l)	Target Exceed	Binomial Test Result	T-test Result	Chlorophyll-*a* Test Result	AFDM Test Result	Macroinvertebrate Test Result	Periphyton Test Result	TMDL Required?
Nitrate	12	0.100	11	FAIL	FAIL	PASS	NA	NA	PASS	YES
TN	12	0.275	12	FAIL	FAIL					YES
TP	20	0.025	18	FAIL	FAIL					YES

5.4.3.3 Spring Creek (MT76O002_040)

Spring Creek is on the 2014 303(d) List as impaired for nitrate/nitrite, TN, TP, and dissolved oxygen. The impaired segment of Spring Creek begins at the headwaters and flows southeast 4.8 miles until it discharges to middle Ashley Creek (the segment from Smith Lake to Kalispell Airport Road).

Summary nutrient data statistics and assessment method evaluation results for Spring Creek are provided in **Table 5-9** and **Table 5-10**, respectively. Fourteen nitrate samples were collected in 2005, 2007, and 2012 (one 2012 sample was excluded from analyses); values ranged from < 0.01 to 0.81 mg/L with nine samples exceeding the nitrate target of 0.100 mg/L. Nine TN samples were collected and evaluated using persulfate digestion in 2007 and 2012 (one 2012 sample was excluded from analyses). Five additional TN concentrations were calculated from TKN and nitrate plus nitrite data from 2005. The combined dataset of TN values ranged from 0.25 to 1.3 mg/L with 12 samples exceeding the TN target of 0.275 mg/L. Fourteen TP samples were collected in 2005, 2007, and 2012; values ranged from <0.003 to 0.079 mg/L with two samples exceeding the TP target of 0.025 mg/L.

Three chlorophyll-*a* and one AFDM samples were collected from Spring Creek in 2005 and 2012. Chlorophyll-*a* values ranged from 10 to 20 mg/m² with none exceeding the target of 125 mg/m². The single AFDM sample did not exceed the target of 35 g/m^2. There were two macroinvertebrate samples collected from Spring Creek in 2005 and 10 periphyton samples collected between 2003 and 2008.

According to DEQ's assessment record (Montana Department of Environmental Quality, 2014d), nine instantaneous DO results from four sampling sites ranged from 6.2 to 9.18 mg/L. Five of these DO values were lower than the *1-Day Minimum* standard for B-1 classified streams, which is 8.0 mg/L for *Early Life Stages* of fish and other aquatic life. The *1-Day Minimum* DO standards are considered to be instantaneous concentrations that must be achieved at all times (Montana Department of Environmental Quality, 2012a).

Assessment results shown in **Table 5-10** indicate that Spring Creek is impaired for nitrate, TN, and TP. As a result a TMDL will be written for TN and TP to address these nutrient probable causes. The nitrate impairment will be addressed by the TN TMDL. The dissolved oxygen impairment is further discussed in **Section5.4.4**.

Table 5-9. Nutrient Data Summary for Spring Creek.

Nutrient Parameter	Sample Timeframe	Sample Size	Min[1] (mg/L)	Max (mg/L)	Mean (mg/L)
Nitrate, mg/L	2005, 2007, 2012	13[2]	< 0.01	0.81	0.315[3]
TN, mg/L	2005, 2007, 2012	13[2]	0.25	1.3	0.576
TP, mg/L	2005, 2007, 2012	14	< 0.003	0.079	0.015[3]
Chlorophyll-*a*, mg/m2	2012	3	10	20	18
AFDM, g/m2	2012	1	NA	NA	NA
Macroinvertebrate HBI	2005	2	7.49	7.56	--
Periphyton	2003, 2005, 2007, 2008	10	NA	NA	NA

TN = total nitrogen, TP = total phosphorus, NN = nitrate + nitrite

[1] Values preceded by a less than ("<") symbol are detection limits for that parameter. The actual sample value was below the detection limit.

[2] One sample was excluded from assessment analysis due to lack of spatial independence.

[3] The values of 0.005 mg/L for NN and 0.0015 mg/L for Total Phosphorus , which are one-half of the detection limits, were used to calculate the mean for all samples reported as less than the detection limit.

Table 5-10. Nutrient Assessment Method Evaluation Results for Spring Creek.

Nutrient Parameter	Sample Size	Target Value (mg/l)	Target Exceed	Binomial Test Result	T-test Result	Chlorophyll-*a* Test Result	AFDM Test Result	Macroinvertebrate Test Result	Periphyton Test Result	TMDL Required?
Nitrate	13	0.100	9	FAIL	FAIL	PASS	PASS	FAIL	PASS	YES
TN	14	0.275	12	FAIL	FAIL					YES
TP	14	0.025	2	FAIL	PASS					YES

5.4.4 Dissolved Oxygen (DO) Impairments

Most aquatic life requires oxygen for survival, and most are dependent upon DO in the water column. Free-flowing and unpolluted streams typically have dissolved oxygen (DO) concentrations that support fish and other aquatic life. However, when too much or too little DO is present it can be harmful. In addition, large fluctuations in DO levels over relatively short periods of time (e.g., daily) can stress aquatic organisms.

DO is generally considered a response variable in streams and lakes. In other words, there are usually no anthropogenic sources that directly add or remove DO from a stream. Instead, DO usually responds to other anthropogenic and natural variables such as nutrients, algae, macrophytes, stream temperature, habitat alteration, excess sediment, stream dynamics, lake and wetland dynamics, elevation, reaeration rate, and sediment oxygen demand. The DO concentration in any waterbody at any given time is a function of a combination of all of those variables.

In upper Ashley Creek, lower Ashley Creek, and Spring Creek, DO concentrations have been measured that are lower than the Montana DEQ criteria, and the segments are listed as impaired because of "low dissolved oxygen." However, there are currently limited data for each segment, and the assessment records do not identify the cause of the low DO concentrations. Based on the existing sources in the watershed, DEQ believes that the cause of low DO is potentially related to excess nutrients, algae/macrophyte growth and decomposition, and stream/lake/wetland dynamics. Elevated stream temperatures (discussed in **Section 7)** may also be contributing to the low DO concentrations.

It is difficult to estimate a load of DO to a stream and allocate to the various sources. Rather, DO impairments are usually addressed through the primary causal variables such as nutrients, temperature, or sediment. In the case of upper and lower Ashley Creek, DEQ is addressing the DO impairment through the implementation of nutrient, temperature, and sediment TMDLs. In Spring Creek, DEQ is addressing the DO impairment with the nutrient TMDLs. Additional monitoring and an adaptive management strategy for dissolved oxygen are described in **Sections 9 and 10**.

5.4.5 Nutrient TMDL Development Summary

Table 5-11 summarizes the nutrient impairment determinations for the Ashley Creek watershed described previously, along with the summary of the nutrient pollutants for which TMDLs will be prepared based on DEQ's updated assessments for these streams. Changes from the 2012 303(d) List are due to a number of reasons. The original listings were based on limited data collection and do not

represent the best available information. Significant data collection has taken place since original impairment determinations, and the improved assessment method was used to evaluate available data. The updated impairment determinations are reflected in the 2014 Water Quality Integrated Report (IR). As shown in **Table 5-11,** a total of seven separate nutrient TMDLs will be developed for four stream segments. These seven TMDLs address nine nutrient impairment causes, three dissolved oxygen, and two chlorophyll-*a* (non-pollutant) impairment causes.

Table 5-11. Summary of Nutrient TMDL Development Determinations.

Stream Segment	Waterbody ID	2014 303 (d) Nutrient Impairment(s)	TMDLs Prepared
(Upper) Ashley Creek, Ashley Lake to Smith Lake	MT76O002_010	Chlorophyll-*a*[(1)], Dissolved Oxygen[(2)], Total Nitrogen	Total Nitrogen
(Middle) Ashley Creek, Smith Lake to Kalispell Airport Road	MT76O002_020	Total Nitrogen Total Phosphorus	Total Nitrogen, Total Phosphorus
(Lower) Ashley Creek, Kalispell Airport Road to mouth (Flathead River)	MT76O002_030	Dissolved Oxygen[(2)], Chlorophyll-*a*[(1)], Nitrate/nitrite[(3)], Total Nitrogen, Total Phosphorus	Total Nitrogen, Total Phosphorus
Spring Creek, headwaters to mouth (Ashley Creek)	MT76O002_040	Dissolved oxygen[(2)], Nitrate/nitrite[(3)], Total Nitrogen, Total Phosphorus	Total Nitrogen, Total Phosphorus

[1] Non-pollutant; this impairment cause is addressed via nutrient TMDLs.
[2] The upper and lower Ashley Creek and Spring Creek dissolved oxygen impairment causes are addressed via the nutrient TMDLs within this section.
[3] The nitrate/nitrite impairment cause is addressed via TN TMDLs.

5.5 SOURCE ASSESSMENT AND QUANTIFICATION

This section provides the overall approach used for source assessment, TMDL development, allocations, and reductions. This approach was applied to each of the four stream segments and is discussed further in **Section 5.6**.

5.5.1 Source Assessment Approach

Source characterization links nutrient sources and nutrient loading to streams and their associated water quality response, and supports the formulation of the load allocation portion of the TMDL. As described in **Section 5.4.2**, nitrate, TN, and TP water quality targets are applicable during the summer growing season (i.e., July 1 – September 30). Consequently, source characterizations are focused mainly on sources and mechanisms that influence nutrient contributions during this period. Source characterization and assessment was conducted using a computer watershed model, the Loading Simulation Program C++ (LSPC) described in the Model Report (Tetra Tech, Inc., 2014b). Simulated loading estimates and load allocations are established for the summer growing season time period and are based on the calibrated LSPC model results.

5.5.2 LSPC

The EPA-approved LSPC model (http://www.epa.gov/athens/wwqtsc/html/lspc.html) was selected for the Flathead-Stillwater TMDL Planning Area (TPA) and the Ashley Creek watershed. LSPC is a watershed

modeling system that includes streamlined Hydrologic Simulation Program FORTRAN (HSPF) algorithms for simulating hydrology, sediment, and general water quality on land as well as a stream fate and transport model (Tetra Tech, 2012).

5.5.2.1 Model Description

The LSPC modeling system links upstream contributions to downstream segments, allowing users to freely model subareas while maintaining a top-down approach (i.e., from upstream reaches to downstream segments). The model simulates watershed hydrology and pollutant transport, as well as stream hydraulics and in-stream water quality. It is capable of dynamically simulating flow, nutrients, sediments, as well as other conventional pollutants for pervious and impervious lands and waterbodies of varying order on a sub-daily time step.

LSPC's algorithms are identical to a subset of those in the EPA-supported HSPF watershed model. LSPC is distributed by EPA's Office of Research and Development in Athens, Georgia, and is a component of EPA's National Total Maximum Daily Load (TMDL) Toolbox (http://www.epa.gov/athens/wwqtsc/index.html). A brief overview of the underlying HSPF model is provided below; additional detailed discussions of HSPF-simulated processes and model parameters is available in the HSPF User's Manual (Bicknell et al., 2004) and in the Model Report (Tetra Tech, Inc., 2014b)

HSPF is a comprehensive watershed and receiving water quality modeling framework that was originally developed in the mid-1970s. Over the past decade it has been used to develop hundreds of EPA-approved TMDLs, and it is generally considered one of the most advanced hydrologic and watershed loading models available. The hydrologic portion of the model is based on the Stanford Watershed Model (Crawford and Linsley, 1966), which was one of the pioneering watershed models. The HSPF framework is developed modularly, with different components that can be assembled in different ways, depending on the objectives of the individual project. Major modules relevant to the Flathead-Stillwater TPA and the Ashley Creek watershed include the following:

- PERLND/IMPLND for simulating watershed processes on pervious/impervious land areas
- SEDMNT/SOLIDS for simulating production and removal of sediment/solids from pervious/impervious land
- PQUAL/IQUAL for simulating production and removal of pollutants from pervious/impervious land
- RCHRES for simulating flow and hydraulic processes in streams and vertically mixed lakes
- SEDTRN for simulating transport, deposition, and scour of sediment in modeled waterbodies
- RQUAL for simulating transport, transformations, and loss of pollutants in modeled waterbodies

All of these modules include many sub-modules that calculate hydrologic, sediment, and water quality processes in the watershed. Many options are available for both simplified and complex process formulations.

Spatially, the Flathead-Stillwater TPA and Ashley Creek specifically are divided into a series of subbasins representing the drainage areas that contribute to each of the stream reaches, as described subsequently in the model setup (**Section 5.5.2.2**). The subbasins are then further subdivided into segments representing different land uses and then these land use segments are divided into pervious and impervious fractions. Meteorological forcing data are used to simulate impacts of precipitation, air

temperature, and evapotranspiration on runoff and groundwater flow from the land use segments. The stream network links the surface runoff and groundwater flow contributions from each of the land segments in the subbasins, and routes them through the waterbodies using storage routing techniques. The stream model includes precipitation and evaporation from the water surfaces, as well as flow contributions from the watershed, tributaries, and upstream stream reaches. Flow withdrawals can also be accommodated. The stream network is constructed to represent all the major tributary streams and different portions of stream reaches where significant changes in water quality occur. For full details, see the Model Report (Tetra Tech, Inc., 2014b).

LSPC was used to estimate nutrient loading from various sources within the watershed. Specific information regarding LSPC and how it was used for the Ashley Creek watershed can be found in the Model Report (Tetra Tech, Inc., 2014b).

5.5.2.2 Model Setup Overview

The Ashley Creek watershed was divided into 33 subbasins within the model, including subbasins for each stream segment requiring a TMDL (**Figure 5-2**). Each subbasin was further divided into areas with unique land use, soil attributes, and land management practices (e.g., timber harvest on forest lands, fertilization on crop lands) called hydrologic response units (HRUs). HRUs are not spatially connected within each subbasin, and all HRUs route directly into the stream reach. The model hydrology was calibrated as part of the larger Flathead Lake watershed LSPC model, which was developed to support other TMDLs in the region. The Flathead LSPC model was calibrated to continuous flow monitoring at eight United States Geological Survey (USGS) gages, which allowed for the specification of hydrology response from each of the land uses in the model. As a result, upland land use hydrology was considered to be well represented in Ashley Creek by virtue of the calibration to other locations in the same region.

Refinements to the hydrology calibration in the Ashley Creek watershed were made based on long-term estimated outflows at Ashley Lake, and short-term flow monitoring data below Smith Lake and within Kalispell. As a result, the model includes some loss to groundwater in areas where Ashley Creek is likely connected to the gravel aquifer and flow is lost from the creek channel. Water quality calibration used observed data from multiple monitoring stations along the length of Ashley Creek using data collected by several different agencies. The model uses hourly inputs and can generate outputs on timescales ranging from hourly to annual. Because the nutrient targets apply from July 1 through September 30, model outputs summarized in source assessments are for that time frame only. Model output spanning October 2002 through September 2012 was used in preparation of the source assessment.

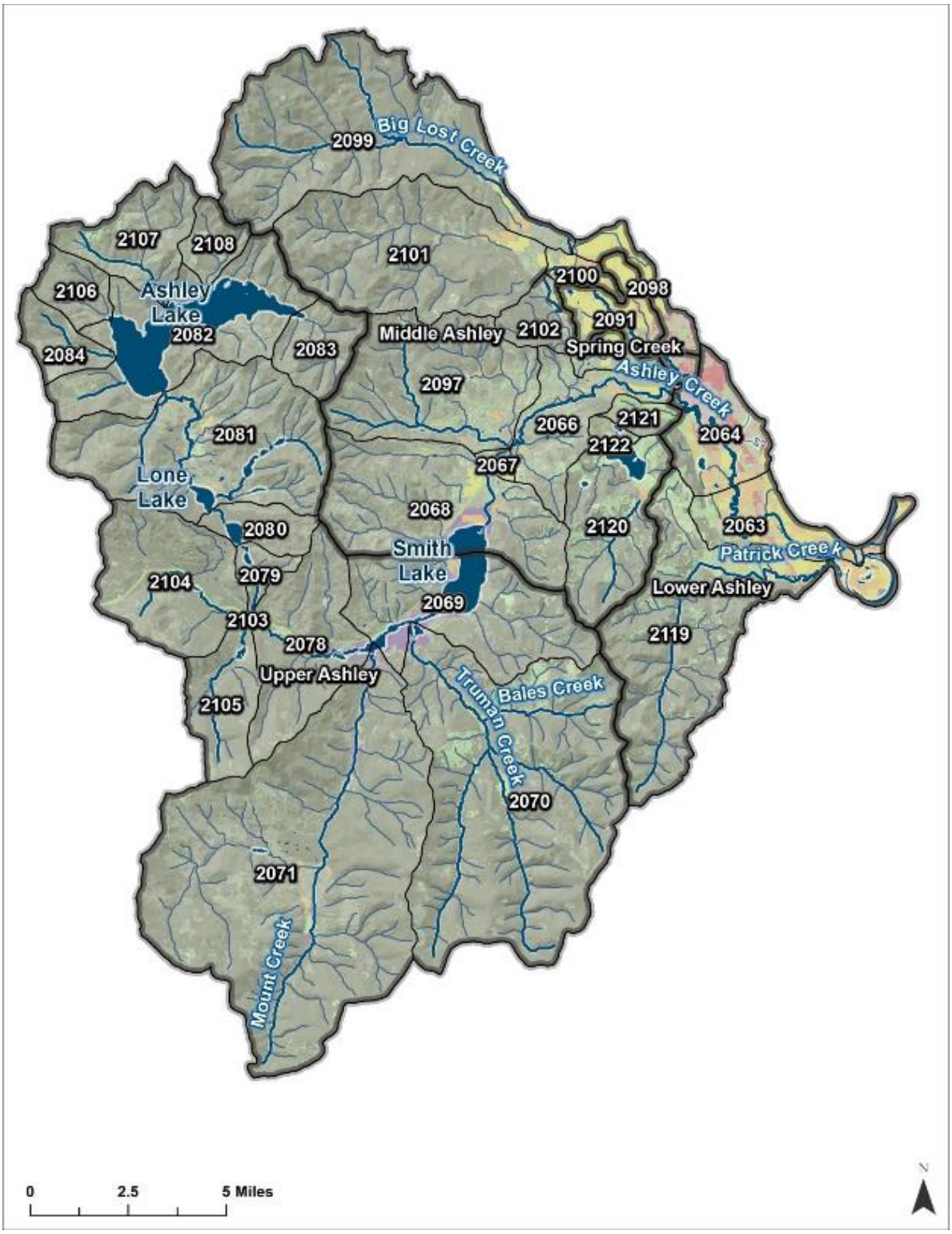


Figure 5-2. LSPC Model Subbasins in the Ashley Creek Watershed.

During model development, the Technical Advisory Group identified an area in the northern part of the Ashley Creek watershed where streams are not connected to Ashley Creek. In other words, the surface streams drain back into the stream beds and dry up without discharging to a downstream location.

Identified creeks include Big Lost Creek and McMannamy Draw, among others. These subbasins are identified in **Figure 5-2** as 2098, 2099, 2100, and 2101. Because these subbasins drain to groundwater and do not provide any surface water to Ashley Creek, they do not deliver any pollutant loads within the model or within the TMDL framework. When land area totals for middle Ashley Creek are presented in this document, these subbasins are included since they are technically part of the watershed. However, any source loading from these subbasins is excluded from the modeling analysis.

During water quality calibration it became clear there was a source of nutrient loading between Ashley Lake and Smith Lake that was not accounted for the in model. The source was identified as being a large wetland complex between the lakes and surrounding Smith Lake. As a result, the model was configured to release a constant load of nutrients from Smith Lake into Ashley Creek. See **Section 5.5.3.8** for more details regarding the wetlands and the addition of nutrient loads to the model.

5.5.3 Source Categories

The following source categories were considered in the LSPC model:

- Agriculture
- Atmospheric Deposition
- Bank Erosion
- Forest Fire
- Golf Courses
- Natural Background
- Point Sources
- Septic Systems
- Timber Harvest
- Unpaved Roads
- Urban Areas

Assessments of loading by source category for each of the impaired reaches are provided in **Section 5.6**. A summary of each of the source categories is provided in the following subsections. Details regarding how these are simulated with the LSPC model are provided in a separate Model Report (Tetra Tech, Inc., 2014b).

5.5.3.1 Agriculture

A detailed analysis of agriculture was completed in the Flathead Valley and is summarized in *The Flathead Valley Agricultural Impacts Report* (Wendt, 2011). The Wendt report provides details regarding:

- Types of crops (e.g., hay, cereal grains, oilseeds, pulse crops, seed potatoes, and summer fallow or other agricultural practices) and where they are located
- Types and numbers of livestock and locations of concentrated animal feeding operations (CAFOs)
- Locations of irrigated lands and types of irrigation
- Types and magnitudes of fertilizers applied to agricultural lands
- Assessment of trends in agriculture in the Flathead Valley

As shown in **Figure 5-3**, the Wendt study area covered most of the agricultural areas in the Ashley Creek watershed, but only approximately 14 percent of the total watershed area. The 2006 National Land Cover Dataset (NLCD; (Multi-Resolution Land Characteristics Consortium, 2006)) was used to characterize agricultural areas outside the Wendt study area. A summary of the agricultural lands is provided in **Table 5-12**.

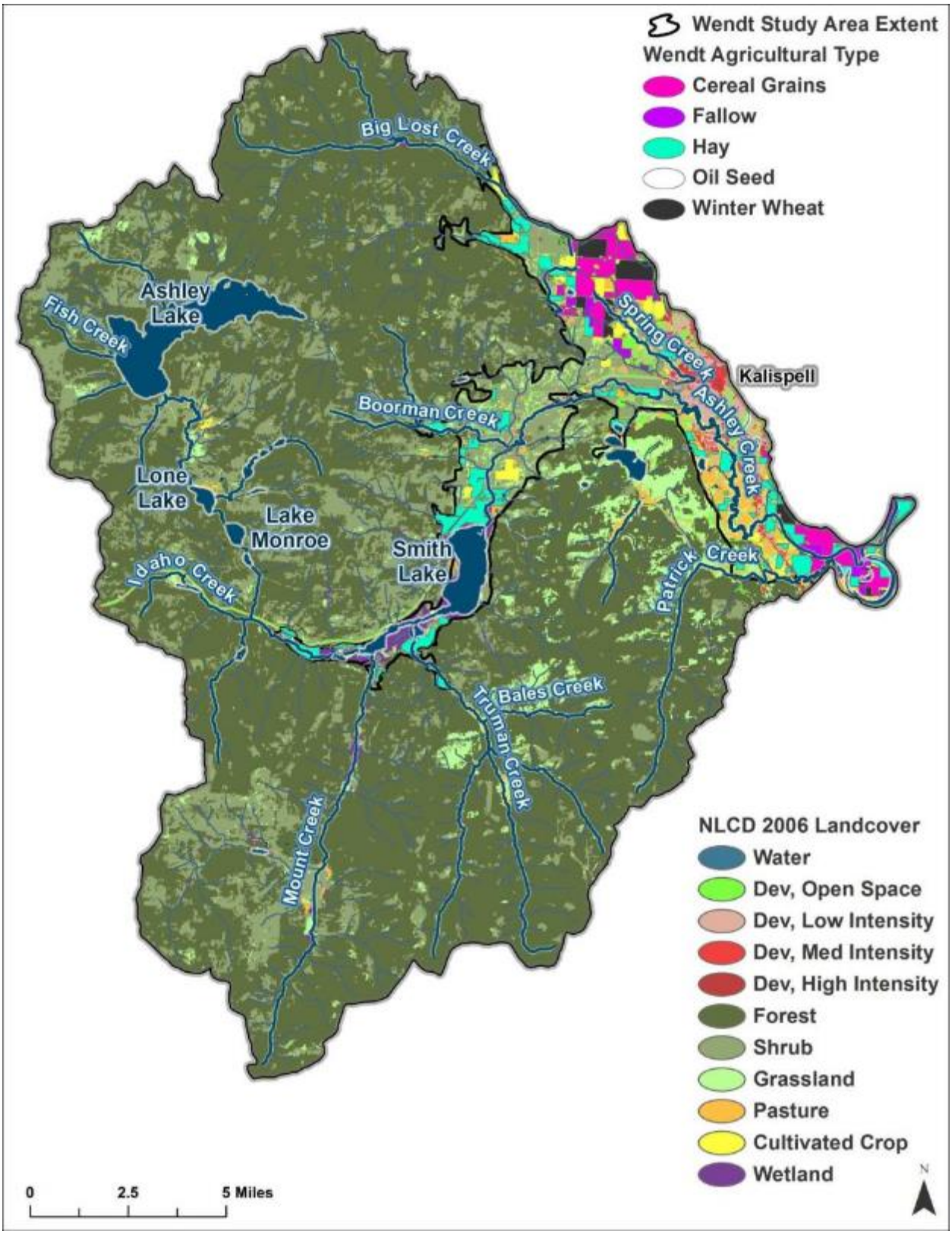


Figure 5-3. Agriculture and Land Cover in the Ashley Creek Watershed

Table 5-12. Agricultural Land Use Summary.

Land use	Upper Ashley Creek	Middle Ashley Creek	Spring Creek	Lower Ashley Creek	Ashley Creek Watershed
Cereal Grains [(1)]	0	784	606	670	2,060
Cultivated Crops [(1),(2),(3)]	38	794	389	414	1,635
Fallow [(1)]	26	109	109	344	588
Hay [(1)]	519	1,731	116	1,225	3,591
Oil Seed [(1)]	0	0	0	17	17
Pasture/Hay [(2)]	464	888	154	1,915	3,421
Winter Wheat [(1)]	0	386	291	121	798
Total	**1,047**	**4,693**	**1,665**	**4,706**	**12,111**
% of Watershed	1%	7%	61%	22%	6%

Units are acres.
[1] Agricultural land uses are from Wendt (2011).
[2] Agricultural land uses are from Multi-Resolution Land Characteristics Consortium (2006).
[3] Cultivated crops include such crops as peas & lentils, and seed potatoes.

As shown in **Table 5-13**, agricultural lands were placed into three categories (low, medium, and high) in the LSPC model based on fertilizer application rates presented by Wendt (2011). Areas outside the Wendt study area were assigned to the medium category in the absence of site specific data on fertilizer application rates. It was assumed that livestock grazing occurred primarily on lands classified as pasture by Wendt or NLCD (Multi-Resolution Land Characteristics Consortium, 2006). The number of cattle, sheep, and pigs in the Ashley Creek watershed was estimated using the *Montana 2012 Agricultural Statistics* (Montana Department of Agriculture and U.S. Department of Agriculture, National Agricultural Statistics Service, 2012). Nutrient loading rates from livestock manure were obtained online from Natural Resources Conservation Service (NRCS) (1995).

Table 5-13. LSPC Agricultural Fertilizer Categories.

Crop Type	Fertilization Category
Pasture/Hay	Pasture
Fallow	Cropland Low
Hay	
Annual Cropland	Cropland Medium
Oil Seed	
Other	
Cereal Grain	Cropland High
Peas & Lentils	
Seed Potatoes	
Winter Wheat	

5.5.3.2 Atmospheric Deposition

Dry deposition occurs when pollutants are transported via wind and are deposited due to gravitational force. Dry deposition typically occurs in a more constant pattern than wet deposition, where pollutants collide with water in the atmosphere and are transported to the watershed surface during precipitation events. Both dry and wet nitrogen deposition was simulated with the LSPC model using data obtained from the EPA's Clean Air Status and Trends Network (CASTNET) station in Glacier National Park (within the Flathead Lake watershed).

5.5.3.3 Bank Erosion

While the LSPC model does not directly simulate bank erosion, land surface scour (representing erosion in the headwater tributaries) and bed degradation in the modeled stream reaches are two processes in the model that together serve as a proxy for representing bank erosion. Bed degradation in a one-dimensional reach model, such as LSPC, serves as a proxy for generalized stream channel erosion, which includes both the bank and the bed as sediment sources. Careful calibration was performed to compare model response to Total Suspended Solids (TSS) monitoring data throughout the watershed. Parameters related to both settling and scour were adjusted to obtain a good overall fit to monitoring data at low and high flows.

5.5.3.4 Fire

Fire is a natural part of the Ashley Creek ecosystem and many species have evolved to exist with the disturbance. Fire perimeters in the project area from 1919-2008 were obtained from the U.S. Forest Service (Flathead National Forest) and Department of Natural Resources & Conservation (DNRC). In the Ashley Creek watershed, only one fire occurred during the period of record. The burn occurred in the Truman Creek subwatershed in 1990 and covered 160.7 acres (**Figure 5-4**). Burned lands, resulting from forest fires, were modeled dynamically to simulate the changes in water and pollutant yield that occur over time as a result of re-growth of the forest, post-fire. However, the fire in the Truman Creek subwatershed occurred prior to the beginning of the model simulation used to develop the source assessment (October 2002), so forest fire was not considered further.

5.5.3.5 Golf Courses

Of the land uses in the urban landscape, turf is the most intensively managed (King et al., 2007). In many cases, chemical additions on golf courses are similar to, and often greater than, those used in intensive agriculture (Winter and Dillon, 2006). There is only a portion of one golf course in the Ashley Creek watershed (i.e., approximately 16 acres in the lower Ashley Creek subwatershed). The golf course was simulated as a separate land use category using nutrient concentrations based on fertilizer application rates on the Buffalo Hills Golf Course.

5.5.3.6 Natural Background

For purposes of this analysis, loading of nutrients from the following land types was considered to be, and is reported as, natural background: barren, forest, herbaceous, snow/ice, water, and wetland. Additionally, a considerable portion of the contributions reported in **Section 5.6** from bank erosion, atmospheric deposition, and forest fire are also likely natural in origin. The fractions attributable to natural and anthropogenic sources have not been defined at this time, but may be estimated at a later date to support TMDL implementation, or other assessments.

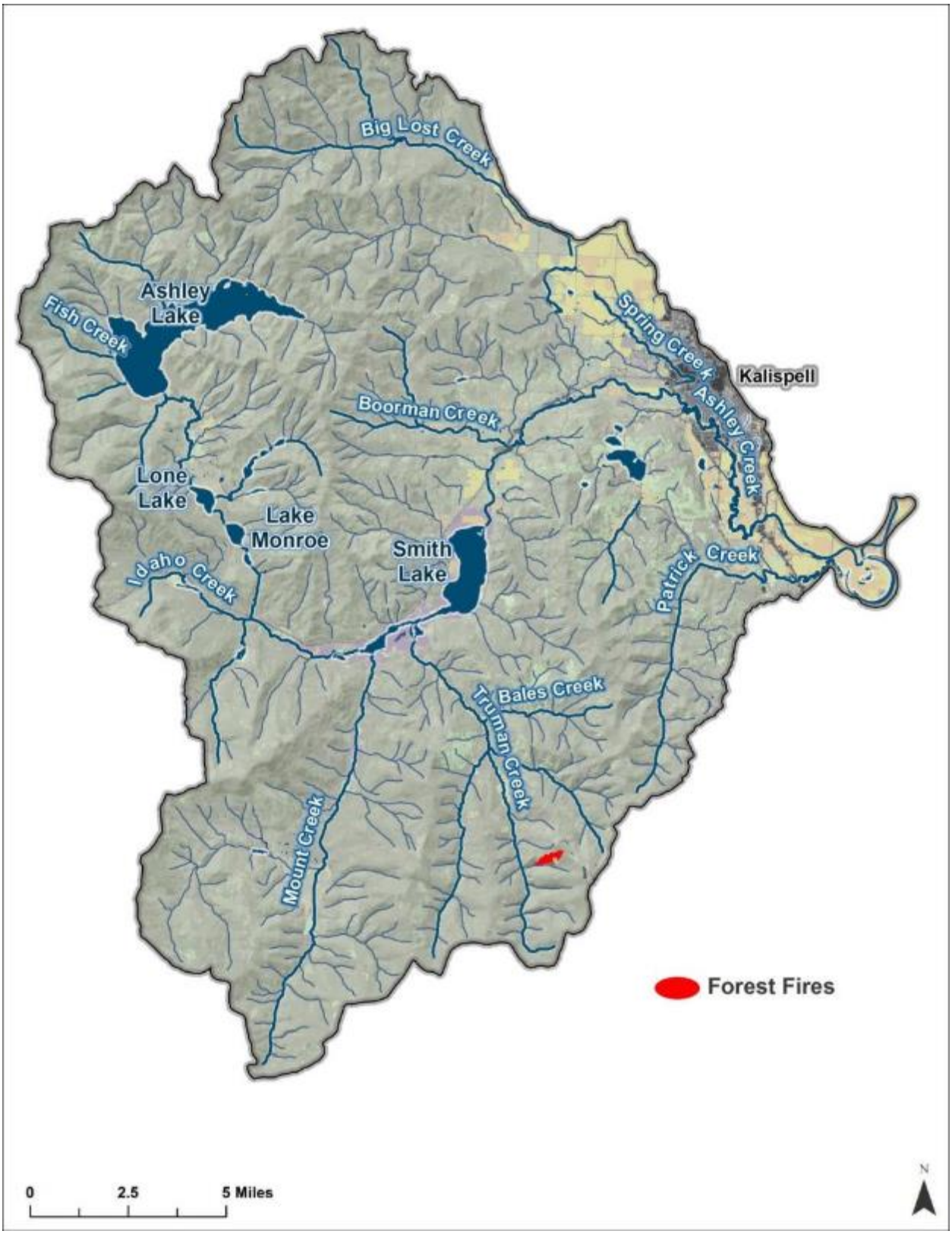


Figure 5-4. Forest Fire in the Ashley Creek Watershed

5.5.3.7 Point Sources

The state of Montana has regulatory authority for all point source discharges to surface waterbodies, including those discharges that are composed of stormwater runoff. The permitted national pollutant discharge elimination system (NPDES) facilities within the Ashley Creek watershed are listed in **Table 5-14** and shown in **Figure 5-5**.

The city of Kalispell's wastewater treatment plant (WWTP) discharge was input into the LSPC model as daily time series of flow and pollutant concentration using data provided by the city of Kalispell. Stormwater discharges were simulated as urban land in LSPC as a function of build-up and wash-off of pollutants from the land surface, adjusted using stormwater monitoring data from Kalispell and Big Fork. Stormwater infrastructure (e.g., conveyances, ponds) was not explicitly modeled. However, it is assumed that the loads from urban lands produced by LSPC generally accounted for existing best management plans (BMPs) given that loading from urban lands was informed using local stormwater monitoring data in watersheds where BMPs were present. The LSPC model was set up to produce output explicitly from the geographic area included within the boundaries of the City of Kalispell Small MS4 (MTR040005), to which the City of Kalispell and Montana Department of Transportation are co-permittees. It is not possible to produce output for the individual industrial and construction facilities, given their small size (maximum of approximately 23 acres).

Table 5-14. Permitted Point Sources in the Ashley Creek Watershed.

NPDES ID	Facility Name	Permit Type	Discharge To	Size (acres)
MT0021938	City of Kalispell WWTP	Individual	lower Ashley Creek	n/a
MTR000251	Wisher's Auto Recycling	General: Storm Water - Industrial Activity	lower Ashley Creek	22.27
MTR000419	Building Materials Holding Corp. - BMC West Truss Plant	General: Storm Water - Industrial Activity	lower Ashley Creek	6.3
MTR000447	UPS - Kalispell	General: Storm Water - Industrial Activity	middle Ashley Creek	4.0
MTR000531	City of Kalispell WWTP	General: Storm Water - Industrial Activity	lower Ashley Creek	17.04
MTR040005	City of Kalispell Small MS4	General: Storm Water - Small MS4 (Municipal Separate Storm Sewer System)	Spring Creek, middle Ashley Creek, lower Ashley Creek	3,928
MTR103908	Montana Department of Transportation - Kalispell Bypass US 93 Bike path Connection	General: Storm Water - Construction Activity	lower Ashley Creek	9
MTR105263	NELCON INC - Town Pump - Kalispell No 5	General: Storm Water - Construction	lower Ashley Creek	22
MTR105434	LHC INC - KBP Three Mile Drive	General: Storm Water - Construction	Spring Creek	15
MTR105578	Willow Creek Subdivision	General: Storm Water - Construction	lower Ashley Creek	23

n/a = not applicable

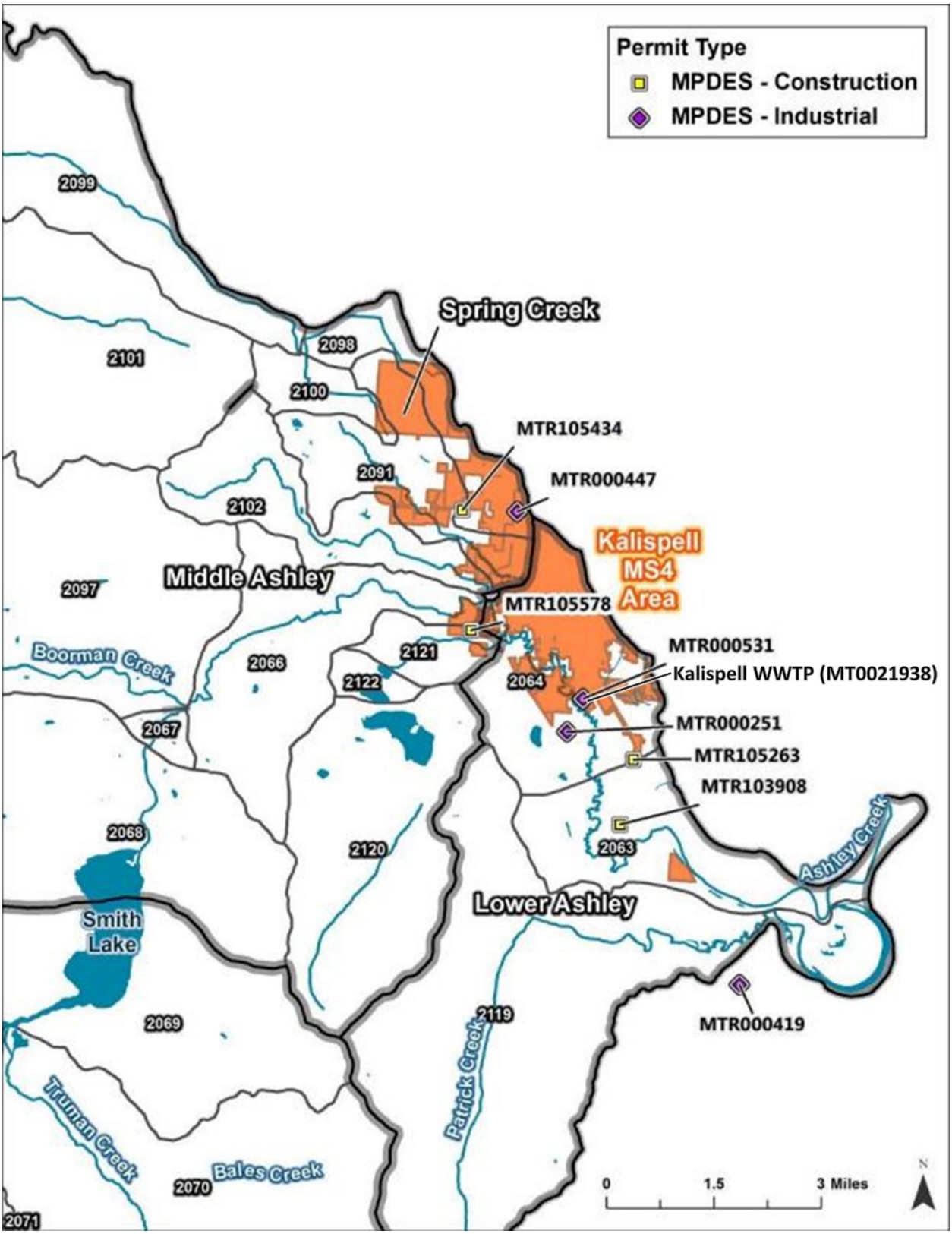


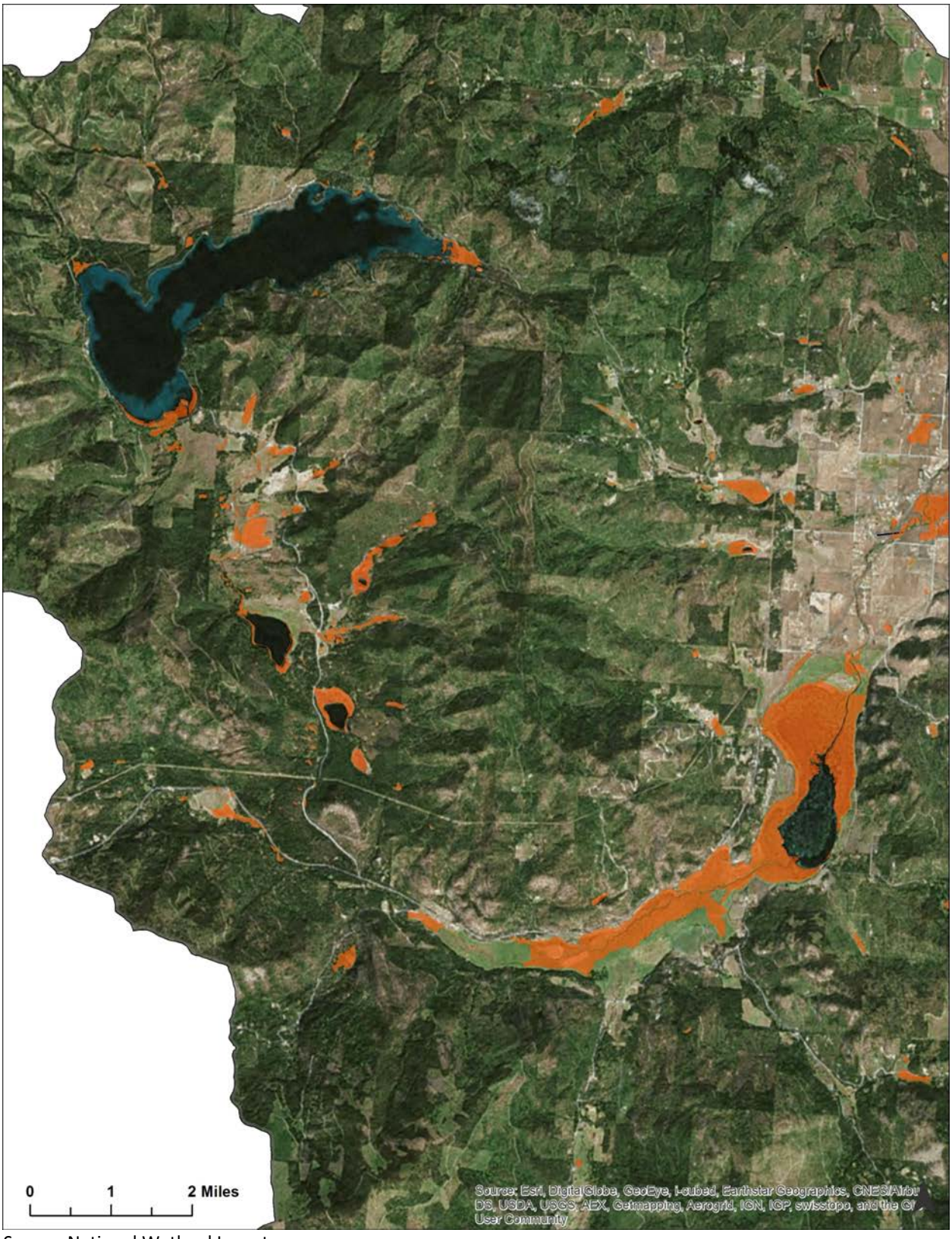
Figure 5-5. Permitted Point Sources in the Ashley Creek Watershed

5.5.3.8 Smith Lake Area

A large complex of wetlands is present in the watershed between Ashley Lake and Smith Lake, and extends to surround Smith Lake (**Figure 5-6**, wetlands shown in orange). Altogether there are about 2,700 acres of wetlands – over four square miles – in this region of the watershed. During water quality calibration it became clear there was a source of nutrient loading between Ashley Lake and Smith Lake that was not accounted for the in model. TN and TP monitoring data collected along the mainstem of Ashley Creek are shown in **Figure 5-7** and **Figure 5-8**, respectively[1]. The plots show an increase in both TN and TP between Sites AC1 and AC5, which are located between the Ashley Lake outlet and Marquardt Ln (downstream of Smith Lake). The increase in nutrients in this area could not be reasonably related to any source in the watershed. Wetlands are known to have a large capacity to absorb nutrients, but they can also release nutrients under some circumstances. Using monitoring data as a guide, the model was configured to release a constant load of nutrients from Smith Lake into Ashley Creek. The load corresponded to an increase in TP of 0.02 mg/L and an increase of TN of 0.5 mg/L.

It is important to note that there is a great deal of uncertainty about the balance of loading between the wetlands and other upstream sources. The load attributed to the wetlands may be overestimated or underestimated. Other sources may be present that are not accounted for by the model and the load assessment. Future monitoring and investigation are needed to develop a better understanding of the system to more accurately characterize nutrient loads. Adaptive management can be used to respond to changes in load attribution as further study provides better information about the relative magnitude of sources (see **Section 9**).

[1] The monitoring data used to generate the plots includes data not used in the assessments in **Section 5.4.3**. The previous assessments used only growing season values for regulatory purposes, while the two box and whiskers plots use all available monitoring data (from sites with greater than 15 data points) regardless of season (see Tetra Tech 2014b). Using all of the data provides a better statistical indication of trend.



Source: National Wetland Inventory.

Figure 5-6. Wetlands along upper Ashley Creek

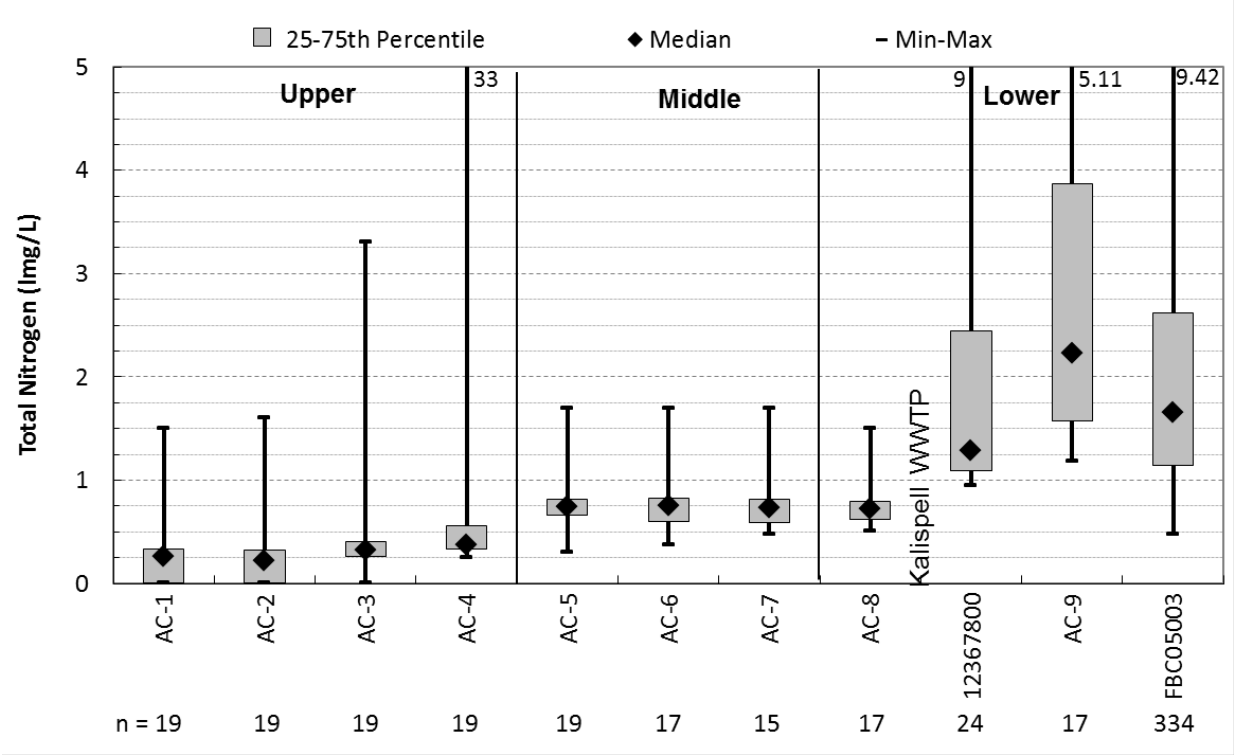


Figure 5-7. Box-and-Whisker Plots for TN along Ashley Creek from Ashley Lake to near the Mouth

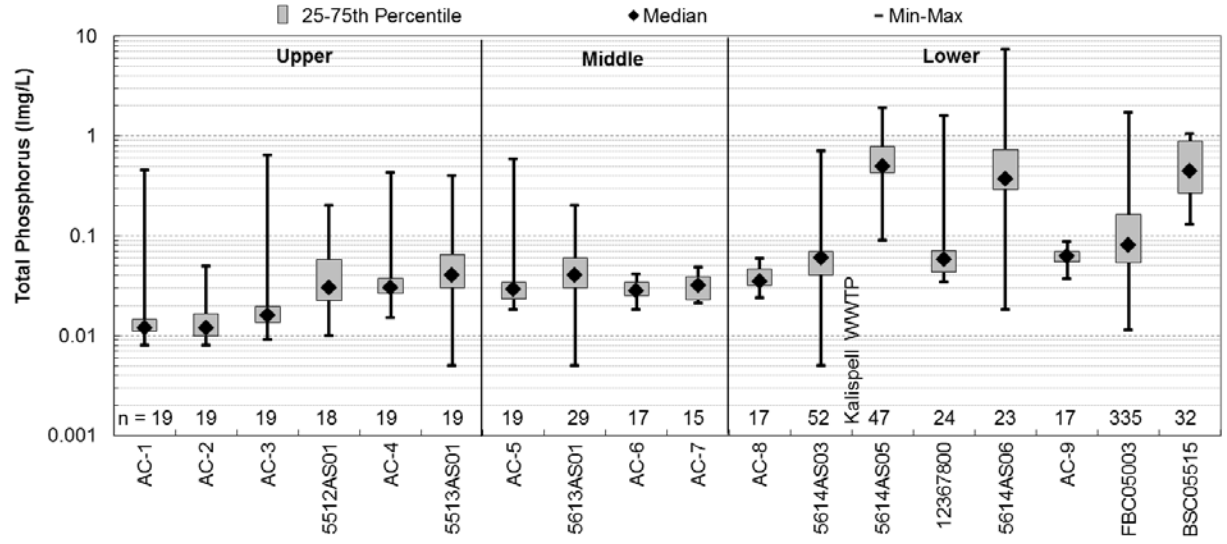


Figure 5-8. Box-and-Whisker Plots for TP along Ashley Creek from Ashley Lake to near the Mouth

5.5.3.9 Septic Systems

Septic systems, even when operating as designed, can contribute nutrients to surface water through subsurface pathways. A simple model, the Method for Estimating Attenuation of Nutrients from Septic Systems (MEANSS), was used to incorporate the previously mentioned variables and provide coarse estimates of the nitrate and TP loads to each waterbody (see the model report (Tetra Tech, Inc., 2014b)).

The number of septic systems in the watershed was estimated based on land uses and cadastral data. It is estimated there are a total of 3,353 septic systems in the Ashley Creek watershed (**Table 5-15**). Approximately 416 of these are located within the internally drained portions of the watershed.

Table 5-15. Septic System Distribution in the Ashley Creek Watershed.

Watershed	No. of septic systems at specified distance (feet) from a stream				Total Number of Septic Systems
	< 100	100 to 500	500 to 5,000	5,000 to 20,000	
Upper	92	182	343	40	657
Middle	67	330	1,213	97	1,707
Spring	7	48	106	0	161
Lower	16	180	618	14	828
Sum	**182**	**740**	**2,280**	**151**	***3,353***

The daily load from each septic 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 and no site-specific data were available, it was assumed that all septic systems are working properly (i.e., 0% failure rate). Without any reliable data it was assumed that all septic tanks are conventional systems consisting of a septic tank and drain field. Conservative assumptions were used for the load estimates of nitrate and TP to surface waters (i.e. low nutrient removal efficiency).

Key assumptions for this method are as follows:

- All septic systems in a watershed are conventional
- The loading rate before attenuation for nitrate from conventional systems is 30.5 lbs/yr
- The loading rate before attenuation for phosphorus from conventional systems is 6.44 lbs/yr
- Load reductions are dependent on soil type and distance from surface water as described in the Model Report (Tetra Tech, Inc., 2014b).

The typical loading rate to streams was estimated using MEANSS and then added to the LSPC model as daily point sources. These point sources were calculated independently for each subbasin based on the number of septic tanks assigned to the specific subbasin and the delivered load calculated for each system.

Because this modeling exercise assumes a 0% failure rate, for a TMDL to be achieved it is assumed that any failing septic systems would be identified and repaired. This method estimates the load from septic systems as the wastewater enters a stream. It does not account for uptake that occurs once the nutrients enter a stream (Ensign and Doyle, 2006; Valett et al., 2002).

The MEANSS model incorporates many assumptions and as a result there is uncertainty in the loading estimates. It is meant to develop coarse estimates of nutrient loading from septic systems in the Ashley Creek watershed. As part of the implementation of a watershed restoration plan (**Section 9**) more refined models or site-specific water quality studies could be used to reduce uncertainty in estimates of nutrient loading from septic systems.

5.5.3.10 Timber Harvest

As described in Ashley Creek Watershed Characterization (Tetra Tech, Inc., 2014a) there has been considerable timber harvest in the Ashley Creek watershed (**Table 5-16**). Much of the harvest occurred on private lands where no spatial or temporal data are available describing how much harvest, of what type, occurred when. In the absence of data for much of the watershed and for LSPC model set up, it was assumed that areas converted from "forest" to "shrub" or "grassland" between NLCD snapshots (2001 and 2006), and that were not within a burned area, were timber harvest. This approach likely underestimates the total area of forest that has been harvested, but captures those areas thought most likely to have an impact from the perspective of water, sediment, and nutrient yield.

Table 5-16. Area of Timber Harvest in the Ashley Creek Watershed Simulated in LSPC.

Subwatershed	Area (acres)
upper Ashley Creek	2,415
middle Ashley Creek	1,169
lower Ashley Creek	283
Spring Creek	1

5.5.3.11 Unpaved Roads

A database of the road network in the Flathead Lake watershed was developed and is described in a technical memorandum (United States Environmental Protection Agency, 2010). There are 409 miles of unpaved roads in the Ashley Creek watershed (**Figure 5-9** and **Table 5-17**).

Set up of the LSPC model for roads was based on results from Water Erosion Prediction Project (WEPP) modeling for roads from 240 road segments in the Swan River watershed obtained from Atkins (2012) and the Flathead National Forest (Kendall, Craig personal communication 2013[2]). The 240 road segments represented existing roads in the Flathead watershed with the full range of BMP implementation (from no BMPs to full BMP implementation) and are assumed to represent the "average" road in the Ashley Creek watershed. The WEPP results indicated that very little sediment is delivered from the road surface to streams beyond a distance of 100 meters. As a result, only those road segments within 100 meters of streams shown on the high resolution National Hydrography Database (NHD) are included in the LSPC model (**Table 5-17**). Road loading rates in the LSPC model were calibrated using the WEPP results and literature values (Sugden and Woods, 2007).

[2] Personal communication with Craig Kendall, U.S. Forest Service. February 19, 2013

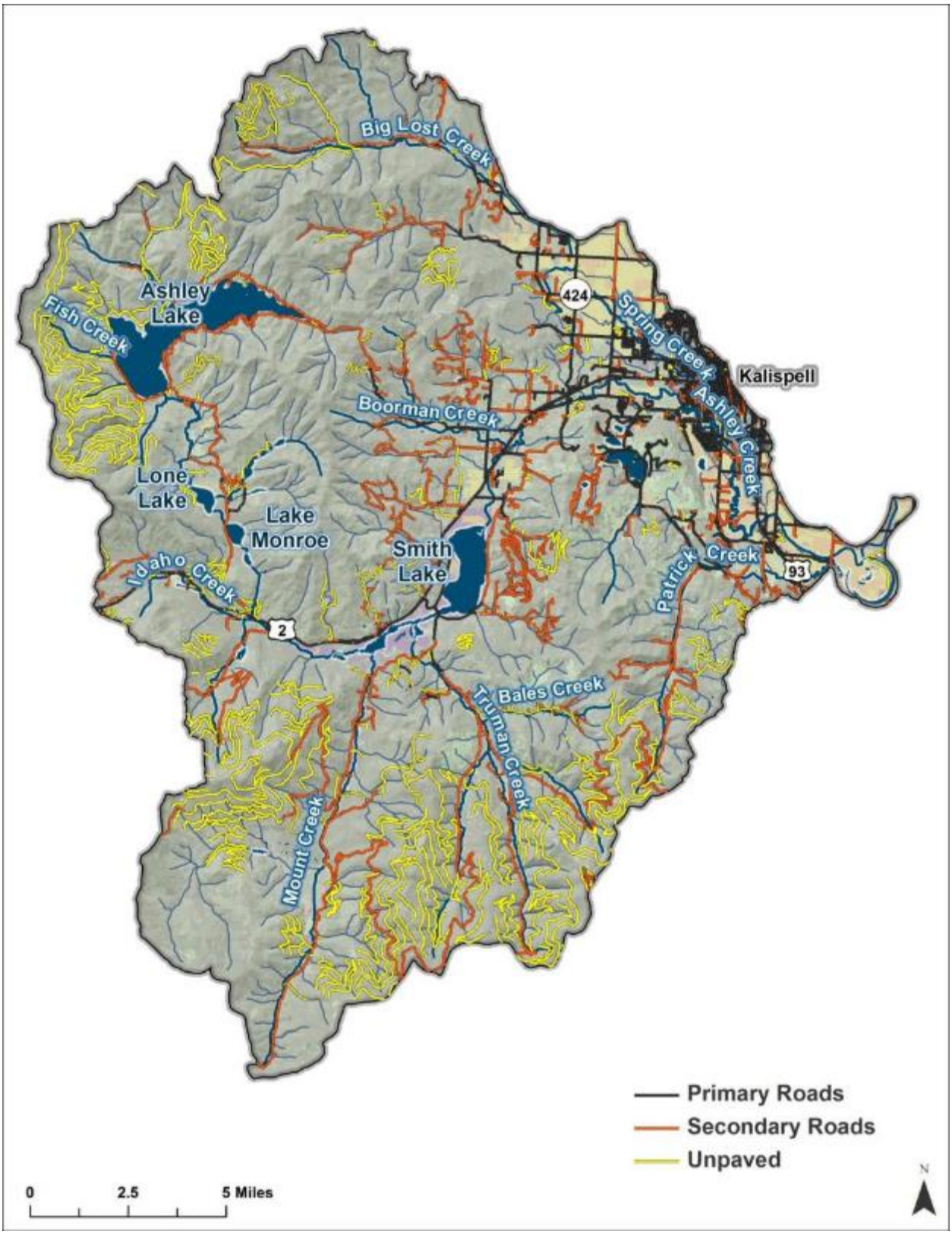


Figure 5-9. Road Network in the Ashley Creek Watershed.

Table 5-17. Road Length in the Ashley Creek Watershed (miles).

Subwatershed	Total	Within 100 Meters of Perennial Streams
lower Ashley Creek	26	5
middle Ashley Creek	55	19
Spring Creek	2	0
upper Ashley Creek	327	68
Total	**409**	**92**

5.5.3.12 Urban Areas

According to the 2006 NLCD (Multi-Resolution Land Characteristics Consortium, 2006), approximately 3% of the Ashley Creek watershed is classified as urban land, with the largest concentration in the lower portion of the watershed within the city limits of Kalispell (**Table 5-18** and **Figure 5-3**). This urban area includes, but is not limited to, the City of Kalispell's MS4 boundary.

Table 5-18. Urban Lands in the Ashley Creek Watershed (acres).

Urban Land Classification	Upper Ashley Creek	Middle Ashley Creek	Spring Creek	Lower Ashley Creek	Ashley Creek Watershed
Developed, High Intensity	0	24	42	139	205
Developed, Low Intensity	228	838	234	1,700	3,000
Developed, Medium Intensity	20	141	121	678	960
Developed, Open Space	296	1,081	268	1,003	2,648
Total	**544**	**2,084**	**665**	**3,521**	**6,814**
Percent of Watershed	0%	3%	24%	16%	3%

5.6 SOURCE ASSESSMENTS, TMDLS, ALLOCATIONS, AND REDUCTIONS FOR EACH STREAM

The below sections describe the most significant natural, non-permitted, and permitted sources of nutrients in more detail, establish TMDLs and load allocations, provide nutrient loading estimates for non-point and permitted point source categories to nutrient-impaired stream segments, and estimate reductions necessary to meet water quality targets for the following stream segments:

- upper Ashley Creek (MT76O002_010)
- middle Ashley Creek (MT76O002_020)
- lower Ashley Creek (MT76O002_030)
- Spring Creek (MT76O002_040)

The existing loads are used to estimate load reductions by comparing them to the allowable (TMDL) load and computing a required percent reduction to meet the TMDL. The following addresses each of the impaired segments separately. The example TMDLs and all TMDL calculations in this section are based on the observed data contained in DEQ's assessment record (**Table B-1**, **Appendix B**). The assessment record is based on growing season data (July 1 – September 30) from the last 10 years. An analysis of a more comprehensive data set (year round data from a longer period of record) has been conducted to provide insights into possible source locations and is presented in Tetra Tech (2014a). The LSPC model was used to describe the existing nutrient loads among the potentially significant source categories (e.g., septic systems, agriculture, point sources).

5.6.1 Approach to TMDL Development, Allocations, Wasteload Allocations, and Current Loading

Because the targets are applied during the summer growing season for algae in the Northern Rockies Level III Ecoregion (July 1 – September 30), the nutrient TMDLs and all associated allocations only apply during this same period of July 1 through September 30. The TMDL calculations for TN and TP are based on **Equation 1**:

Equation 1. TMDL= 5.4 * *X* * *Y*

TMDL= Total Maximum Daily Load in lbs/day
X = *water quality target* **(Table 5-2***; in mg/L)*
Y = streamflow in cubic feet per second
5.4 = conversion factor

Note that the TMDL is not static; as flow increases the allowable (TMDL) load increases as shown by the total phosphorus example in **Figure 5-10**. For upper Ashley Creek the TMDL allocations are composited into a single load allocation to all nonpoint sources, including natural background sources (**Equation 2**). This is done because all sources are nonpoint in the upper watershed. Allocations for middle and lower Ashley and Spring creeks consist of a composite load allocation (LA) for all nonpoint sources, including natural background sources, and the sum of individual wasteload allocations (∑WLA) to the point sources, including permitted stormwater (**Equation 3**). In the absence of an explicit margin of safety (MOS), the TMDLs for TN and TP in each waterbody are equal to the sum of the individual loads as follows:

Equation 2. TMDL = LA (upper watershed)

LA = Composite Load Allocation to all nonpoint sources including natural background sources

Equation 3. TMDL = LA + ∑WLA (middle and lower watershed)

LA = Composite Load Allocation to all nonpoint sources including natural background sources
∑WLA = Sum of *Waste Load Allocations to the permitted point sources*

The allocation approaches for the Kalispell WWTP, Kalispell MS4, and construction and industrial stormwater permits are provided in the following sections.

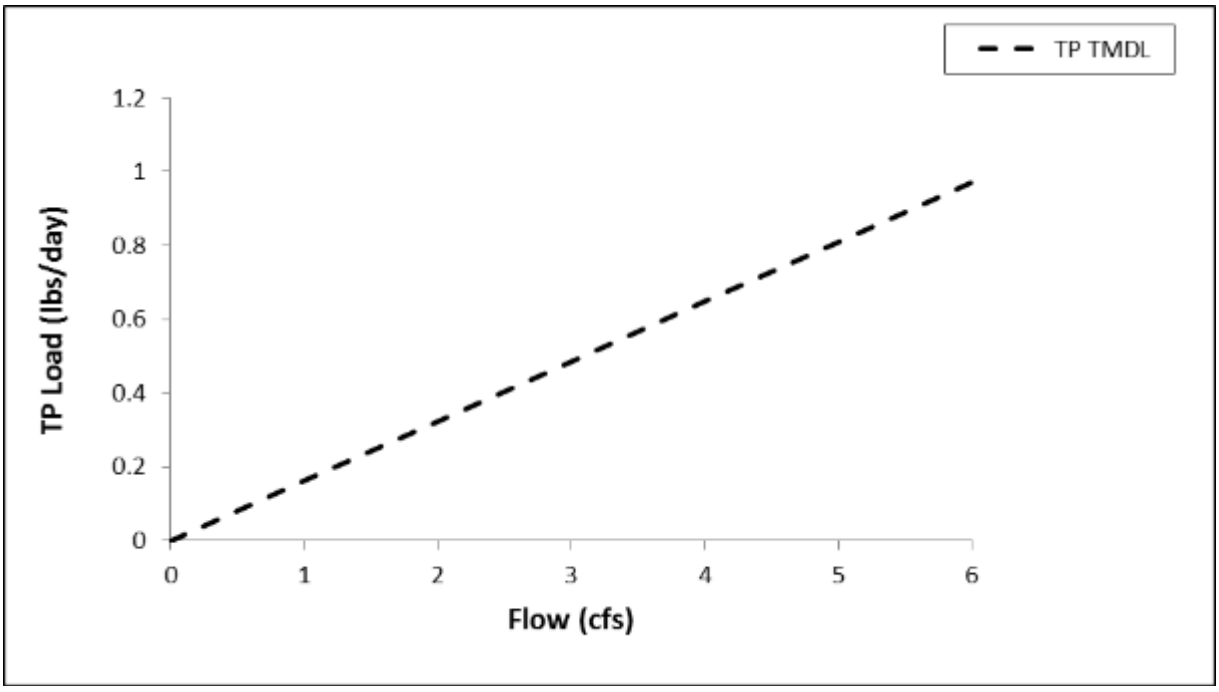


Figure 5-10. Example TMDL for TP from 0 to 6 cfs

5.6.1.1 Approach to the Kalispell WWTP Wasteload Allocation

As required by the state of Montana, ARM 17.30.637(2), "no wastes may be discharged such that the wastes, either alone or in combination with other wastes, will violate, or can reasonably be expected to violate, any of the standards". For a WWTP and other permitted dischargers, this means that a discharge concentration must be less than or equal to an applicable numeric water quality standard if the reach immediately upstream where the discharge occurs is already exceeding the standard. If the reach immediately upstream of the WWTP discharge is determined to be unimpaired for TN and/or TP, the WLA will be modified based on a mass-balance approach if there is sufficient assimilative capacity in the receiving water. In either case, the development of the WLAs is consistent with the reasonable assurance approach defined within **Section 4.4**.

Establishing the Total Allowable Load

The TMDL target values provide a numeric translation of the applicable narrative standard found in ARM 17.30.637(1)(e). The state-approved numeric nutrient criteria provide the basis for the TMDL targets. The reach of Ashley Creek immediately upstream of the Kalispell WWTP discharge is impaired for TP and TN, based on application of DEQ's nutrient assessment methodology (Suplee and Sada de Suplee, 2011). To ensure the Kalispell WWTP discharge does not cause or contribute to a violation of water quality standards, the WLAs for TP and TN are based on a discharge concentration equal to the nutrient target concentration multiplied by the WWTP discharge flow. As the nutrient criteria are seasonal (July 1- Sept 30), the WLA only applies during this time period. The resulting nutrient WLA for TP and TN is based on **Equation 4**:

Equation 4.

$$WLA = 5.4 * X * Y$$

WLA = Wasteload Allocation in lbs/day
X = applicable water quality target for Ashley Creek (0.275 mg/L TN and 0.025 mg/L TP)
Y = WWTP discharge in cubic feet per second

5.4 = conversion factor

Note that the WLA is not static, as flow increases the WLA increases as shown by the total phosphorus example in **Figure 5-11.**

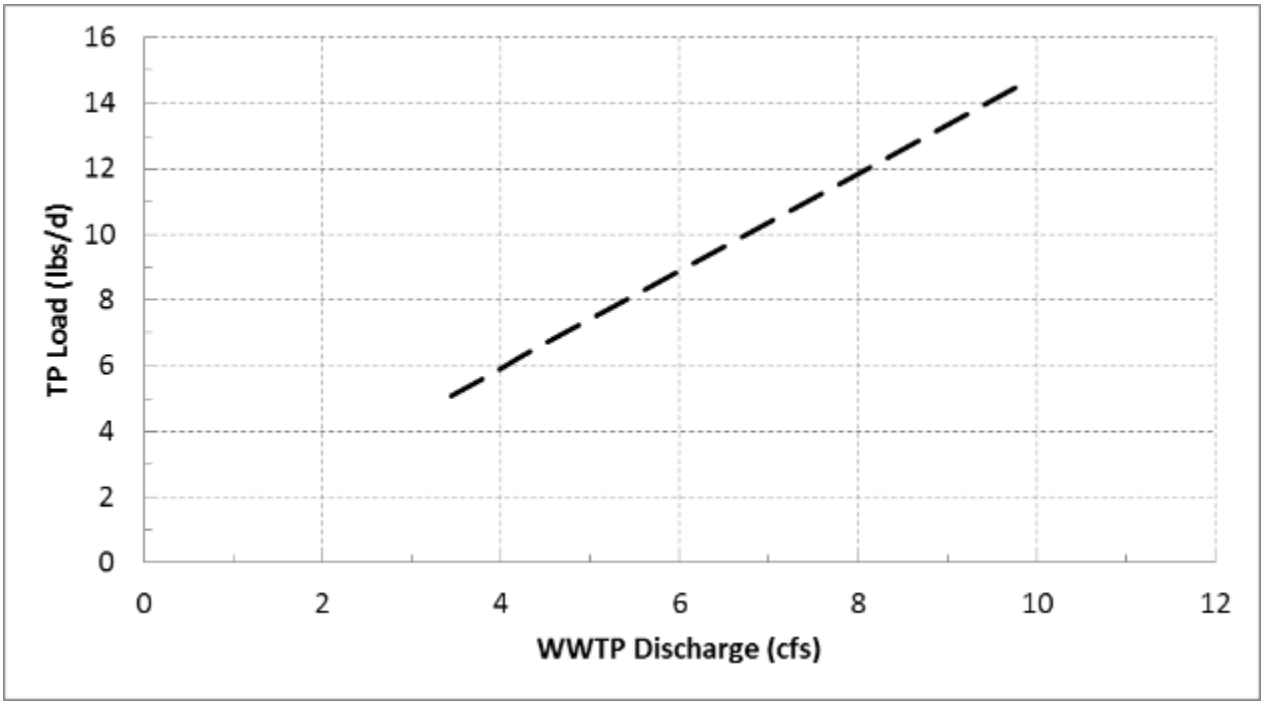


Figure 5-11. WLA for total phosphorus from the Kalispell Wastewater Treatment Plant.
The line representing the WLA is shown over the range of discharges from the WWTP during the summer growing season from water years 2002 through 2012.

For the purpose of setting Montana Pollutant Discharge Elimination System (MPDES) discharge permit conditions, **Equation 4** is always satisfied if the discharge concentration is equal to or less than the target concentration during the applicable time period (in this case, the summer growing season). Therefore, the permit WLA can be satisfied by applying a concentration-based requirement on the discharge as opposed to establishing a load. If a concentration-based approach is not used for MPDES permit integration, then the WLA should be based on the target concentration multiplied by the existing WWTP discharge flow (as opposed to the design flow). Using a concentration-based approach does not result in a load cap and can be used to simplify MPDES permit development.

For **Equation 4**, the target concentration is lower than current limits of technology for treatment of wastewater effluent, which will likely require staged implementation of the WLA as discussed below.

Mixing Zone Allowance

If water quality in Ashley Creek in the reach immediately upstream of the Kalispell WWTP discharge location improves to the point where the water quality targets or adopted numeric nutrient standards are met, then the WLA may be modified as assimilative capacity has been created in the receiving water. This increase would be based on a mass-balance calculation that ensures that water quality standards and/or TMDL targets are met at the end of the mixing zone during July 1 through September 30 under

14Q5 flow conditions. For a given stream, 14Q5 refers to the 14-day low flow with a recurrence interval of 5 years.

A mixing zone would be calculated the same regardless of whether or not numeric nutrient standards are adopted into rule. The 75th percentile of the available upstream water quality data will be used to determine assimilative capacity of TN and TP.

If it is determined that there is assimilative capacity at the WWTP, the WLAs for lower Ashley Creek will need to be adjusted.

Staged Implementation of Nutrient Wasteload Allocations

The TMDL target for TN and TP represents concentrations below the current limits of treatment technology. MPDES permits provide a regulatory mechanism for implementing the TMDL via the variance process, to address affordability issues and concerns about the limits of treatment technology. The variance (75-5-313 Montana Code Annotated (MCA)) allows Montana to implement numeric nutrient criteria in a staged manner thus allowing enough time to address all point and nonpoint sources of nutrient pollution and allow for advancements in treatment technology and associated affordability.

The WLAs for the Kalispell WWTP defined in this document allow staged implementation consistent with the variance process (Montana Department of Environmental Quality, 2014c; 2014a). When the city of Kalispell renews its MPDES permit, it can apply for a variance as part of a staged implementation approach for the WLAs defined in **Sections 5.6.4.3** and **Section 5.6.4.4**. The variance will be implemented as defined within Montana State Law (75-5-313, MCA) and the rule as adopted. If the variance is granted, the city of Kalispell will have 20 years from the time they receive the variance to meet the numeric nutrient standards. The MPDES permit for the Kalispell WWTP is currently in the renewal process. The first stage of the variance process for a WWTP facility like Kalispell's generally requires treatment levels of 10 mg/L for TN and 1 mg/L for TP. The Kalispell WWTP currently satisfies these TN and TP treatment levels.

5.6.1.2 Kalispell MS4 (MTR040005) Loading

Stormwater within the city of Kalispell is regulated under the *General Permit for Storm Water Discharge Associated with Small Municipal Separate Storm Water Sewer System* (MS4) (MTR040000). The city shares the permit with the Montana Department of Transportation. The permit applies within the Kalispell city limits, including a total area of approximately 3,931 acres in the Ashley Creek watershed (**Table 5-19**).

Table 5-19. Spatial Distribution of the Kalispell MS4 in the Ashley Creek Watershed

Subwatershed	Acres
upper Ashley Creek	0
middle Ashley Creek[(1)]	2,012
Spring Creek	952
lower Ashley Creek	1,919
Ashley Creek[(2)] watershed	3,931

[1]Middle Ashley Creek includes the quantity reported for Spring Creek.
[2]This is the cumulative total for the entire Ashley Creek watershed.

The permit does not include effluent limits but does have benchmark goals of 0.41 and 2.00 mg/L for TP and TN, respectively, and requires the development and implementation of a stormwater management

program (SWMP) to minimize sediment loading to surface waters. The SWMP must include six minimum control measures: (1) public education and outreach; (2) public involvement/participation; (3) detection and elimination of illicit discharge; (4) control of stormwater runoff from construction sites; (5) management of post-construction stormwater in new development and redevelopment; and (6) pollution prevention/good housekeeping. Additionally, the permit requires monitoring at two sites, one representing a residential area and the other representing a commercial/industrial area.

The estimated average summer growing season (July 1 – September 30) TP and TN loads from the Kalispell MS4 based on the LSPC model are shown in **Table 5-20**. As described in the Model Report (Tetra Tech, Inc., 2014b), the Kalispell MS4 infrastructure (i.e., individual sewers and existing BMPs) was not explicitly modeled in the Flathead Lake watershed. Rather, the model used the MS4 footprint, land use categories, and the measured stormwater data to simulate runoff from the urban area.

Table 5-20. Estimated Summer MS4 TN and TP Loads

Subwatershed	Summer Growing Season (lbs/season)	
	TN	TP
upper Ashley Creek	0	0
middle Ashley Creek[(1)]	417	26
Spring Creek	384	24
lower Ashley Creek watershed[(2)]	1,472	97

[1]Middle Ashley Creek includes the load for Spring Creek.
[2]This is the cumulative load for the entire Ashley Creek watershed.
Note: The TN and TP loads were rounded to the nearest integer.

The Kalispell MS4 does not continuously discharge, and it only sporadically discharges during the dry summer growing season. Because of this, daily TN and TP WLAs have not been calculated in this document, and no example WLAs are provided in **Section 5.6.2** for a typical summer flow event where there should be no stormwater discharges to Ashley or Spring creeks. Consistent with EPA guidance (U.S. Environmental Protection Agency, 2002), the Kalispell MS4 (MTR040005) is instead assigned wasteload allocations for TN and TP for the algae growing season. These allocations are based on the modeled existing loads with reductions based on BMP application scenarios. Growing season load reductions for the MS4 were calculated based on typical BMP effectiveness factors as identified in the literature. Load reduction factors (**Table 5-21**) are primarily from two sources – the National Pollutant Removal Performance Database: Version 3 (Center for Watershed Protection, 2007) and the Runoff Reduction Method developed by the Center for Watershed Protection and the Chesapeake Stormwater Network (Hirschman et al., 2008). Average percent reduction values for TN and TP for the suite of BMPs listed in **Tables 5-21** are 30% and 44%, respectively. These values were used to approximate the reduction in loading that additional BMP implementation across all land-use categories within the MS4 could achieve during the growing season, assuming none of these practices are in place currently. Based on these assumptions, growing season WLAs are shown in **Tables 5-22** and **5-23**.

Though the numeric WLAs represent a reasonable estimate of the growing season loading after implementation of stormwater permit requirements, the WLAs are not intended to add concentration or load limits to the permit. Consistent with EPA guidance (U.S. Environmental Protection Agency, 2002), DEQ assumes the WLA will be met by adhering to the permit requirements and reducing either the TN and TP concentrations and/or the discharge volumes, with the percent reduction values of 30% and 44% representing permit implementation goals. As identified in the permit, monitoring data should continue to be evaluated to assess BMP performance and help determine whether and where additional BMP

implementation may be necessary. Additional work may be needed in the future to better identify the nutrient sources and BMPs already in place within the system. Also, a stormwater runoff model (such as SWMM) would help to better estimate the load and impact from the MS4.

Table 5-21. TN and TP load Reduction Factors

Structural BMP	Annual Percent Removal	
	Total Nitrogen	Total Phosphorus
Extended Detention Wet Pond[1]	30%	50%
Extended Detention Stormwater Wetland[1]	25%	50%
Extended Detention Dry Basin[2]	24%	20%
Dry Basin (no extended detention) [2]	5%	15%
Bioretention[2]	64%	55%
Sand Filter[1]	30%	60%
Vegetated Filter Strip[2]	30%	60%
Average	30%	44%

[1] (Hirschman et al., 2008)
[2] (Center for Watershed Protection, 2007)

Table 5-22. Existing TN Load Estimates and WLAs for the Kalispell MS4 during the Growing Season

Segment	Existing Load (pounds/growing season)	Percent Reduction[3]	WLA[3] (pounds/growing season)
middle Ashley Creek[1]	417	30%	292
Spring Creek	384	30%	269
lower Ashley Creek[2]	1,472	30%	1,030

[1]Middle Ashley Creek includes the load for Spring Creek.
[2]Includes the loads from Spring Creek and middle Ashley Creek.
[3]These values are not intended to add concentration or load limits to the MS4 permit; meeting permit BMP and other requirements equates to meeting the TN WLAs

Table 5-23. Existing TP Load Estimates and WLAs for the Kalispell MS4 during the Growing Season

Segment	Existing Load (pounds/growing season)	Percent Reduction[3]	WLA[3] (pounds/growing season)
middle Ashley Creek[1]	26	44%	15
Spring Creek	24	44%	13
lower Ashley Creek[2]	97	44%	54

[1]Middle Ashley Creek includes the load for Spring Creek.
[2]Includes the loads from Spring Creek and middle Ashley Creek.
[3]These values are not intended to add concentration or load limits to the MS4 permit; meeting permit BMP and other requirements equates to meeting the TP WLAs

5.6.1.3 Construction Storm Water Permits (MTR100000)

Because construction activities at a site are temporary and relatively short term, 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 contribute nutrients (TN and TP) if proper BMPs are not implemented and maintained. Each construction stormwater permittee is required to develop a Storm Water Pollution Prevention Plan (SWPPP) that identifies the stormwater BMPs that will be in place during construction. Before a permit is terminated, disturbed areas must 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.

The permit files were reviewed to determine the amount of disturbed land associated with each permit. The estimated level of disturbance ranged from 9 to 23 acres (see **Table 5-14**). The permits are for a range of construction projects including road/highway, home, business, and stormwater improvements. The SWPPPs contain BMPs such as silt fencing, retention basins, fiber rolls, erosion control blankets, and vegetated buffers.

To estimate nutrient loading from permitted construction sites without BMPs in place DEQ used an approach similar to that in DEQ (2011). For this approach, the average existing annual loading rates for bluffs (i.e., bare, un-vegetated lands) in the LSPC model (1.02 lbs/acre/year TN and 0.098 lbs/acre/year TP) were used to represent construction sites with inadequate BMP implementation. These values were then multiplied by the total disturbed acreage associated with construction storm water permits in each applicable watershed (**Table 5-14**). This approach provides a very conservative estimate of nutrient loads. In reality, each site is required to have BMPs in place and/or native vegetation that prevents runoff and erosion at the rates used to calculate the nutrient loads.

The average BMP reduction values presented in **Table 5-21** were applied to the existing loads (without BMPs) to estimate the reduction in loading associated with following proper BMPs and adhering to permit requirements. The examples shown in **Tables 5-24** and **5-25** are presented to illustrate what kind of load reductions would be achieved by following permit requirements, including SWPPP development and implementation. Because of the low levels of nutrient loading and the existence of BMP requirements, WLAs are not developed for construction stormwater permits.

Table 5-24. TN Loading and Reductions from Permitted Construction Sites

Watershed	Loading Rate (lbs/acre/year)[1]	Disturbed Area(acres)[2]	Load *without* BMPs (lbs/year)[3]	Percent Reduction	Load *with* BMPs (lbs/year)[4]
Spring Creek	1.02	15	15.3	30%	10.7
middle Ashley Creek [5]	1.02	15	15.3	30%	10.7
lower Ashley Creek [6]	1.02	69	70.4	30%	49.3

[1] Average loading rate from the LSPC model results (Tetra Tech, Inc., 2014b).
[2] Average annual area disturbed by construction activities.
[3] Annual load without adequate BMPs (i.e., existing load), which is calculated as the loading rate multiplied by the disturbed area.
[4] Load with BMPs implemented
[5] Includes the area and load from Spring Creek.
[6] Includes the area and loads from Spring Creek and middle Ashley Creek.

Table 5-25. TP Loading and Reductions from Permitted Construction Sites

Watershed	Loading Rate (lbs/acre/year)[1]	Disturbed Area (acres)[2]	Load without BMPs (lbs/year)[3]	Percent Reduction	Load with BMPs (lbs/year)[4]
Spring Creek	0.098	15	1.5	44%	0.84
middle Ashley Creek [5]	0.098	15	1.5	44%	0.84
lower Ashley Creek [6]	0.098	69	6.8	44%	3.8

[1] Average loading rate from the LSPC model results (Tetra Tech, Inc., 2014b).
[2] Average annual area disturbed by construction activities.
[3] Annual load without adequate BMPs (i.e., existing load), which is calculated as the loading rate multiplied by the disturbed area.
[4] Load with BMPs implemented
[5] Includes the area and load from Spring Creek.
[6] Includes the area and loads from Spring Creek and middle Ashley Creek.

5.6.1.4 Industrial Storm Water Permits (MTR000000)

There are currently four facilities that are regulated under the *General Permit for Storm Water Discharges Associated with Industrial Activity* (MTR000000) that could be contributing to segments of concern (see **Table 5-14**). These permits regulate the direct discharge of stormwater draining the facility and its grounds. Under the stipulations of the permits, the facilities maintain an approved SWPPP. The SWPPP sets forth the procedures, methods, and equipment used to prevent the pollution of stormwater discharges. In addition, the SWPPP describes general practices used to reduce pollutants in stormwater discharges. The SWPPPs contain BMPs such as using conveyances that minimize contact between runoff and sediment and other pollutants and retention basins that allow sediment to settle and water to infiltrate into the ground.

The sites range in size from 4.0 to 22.27 acres (**Table 5-14**). Existing loading from the industrial sites were estimated by multiplying the LSPC loading rates for urban impervious lands in Kalispell (6.78 lbs/acre/year TN and 0.437 lbs/acre/year TP) by the acreage of the facilities. This approach provides a very conservative estimate of nutrient loads. In reality, each site is required to have BMPs in place and/or native vegetation that prevents runoff and erosion at the rates used to calculate the nutrient loads. The BMP loads were estimated using the average BMP reduction values presented in **Table 5-21.**

The examples shown in **Tables 5-26** and **5-27** are presented to illustrate what kind of load reductions would be achieved by following permit requirements, including SWPP development and implementation. Because of the low levels of nutrient loading and the existence of BMP requirements, WLAs are not developed for the industrial stormwater permits.

Table 5-26. Existing and Allowable TN Loading from Permitted Industrial Sites

NPDES ID	Facility Name	Ashley Creek Subwatershed	Facility Area (acres)	Loading Rate (lbs/acre/year)[1]	Existing Load (lbs/year)[2]	Percent Reduction	BMP Load (lbs/year)
MTR000251	Wisher's Auto Recycling	Lower	22.27	6.78	150.99	30%	105.7
MTR000419	Building Materials Holding Corp. - BMC West Truss Plant	Lower	6.30	6.78	42.71	30%	29.9
MTR000447	UPS - Kalispell	Middle	4.00	6.78	27.12	30%	19.0
MTR000531	City of Kalispell WWTP	Lower	17.04	6.78	115.53	30%	80.9

[1] Average loading rate from the LSPC model results (Tetra Tech, Inc., 2014b).
[2] The existing load that is calculated as the loading rate multiplied by the facility area.
Facility Area, Average LSPC Model Loading Rate, and Existing Load are rounded to the nearest one-hundredth of the displayed unit.

Table 5-27. Existing and Allowable TP Loading from Permitted Industrial Sites

NPDES ID	Facility Name	Ashley Creek Subwatershed	Facility Area (acres)	Loading Rate (lbs/acre/year)[1]	Existing Load (lbs/year)[2]	Percent Reduction	BMP Load (lbs/year)
MTR000251	Wisher's Auto Recycling	Lower	22.27	0.437	9.73	44%	5.4
MTR000419	Building Materials Holding Corp. - BMC West Truss Plant	Lower	6.30	0.437	2.75	44%	1.5
MTR000447	UPS - Kalispell	Middle	4.00	0.437	1.75	44%	1.0
MTR000531	City of Kalispell WWTP	Lower	17.04	0.437	7.45	44%	4.2

[1] Average loading rate from the LSPC model results (Tetra Tech, Inc., 2014b).
[2] The existing load that is calculated as the loading rate multiplied by the facility area.
Facility Area, Average LSPC Model Loading Rate, and Existing Load are rounded to the nearest one-hundredth of the displayed unit.

5.6.2 Upper Ashley Creek MT76O002_010

5.6.2.1 Assessment of Water Quality Results for Upper Ashley Creek

This reach of Ashley Creek begins at the outlet of Ashley Lake and flows south and east 15.64 miles, through Lone Lake and Lake Monroe, before discharging into Smith Lake. Wetlands are common in this reach. Lake Monroe is surrounded by wetland and the lower four miles of this reach flow through a broad, floodplain wet meadow/emergent marsh complex before discharging into Smith Lake. Land cover in the upper Ashley Creek watershed is largely forest which has been harvested to varying degrees over time. Seasonal cabins and year-round homes with septic systems surround Ashley Lake. Agricultural land uses, primarily hay and grazing, also occur at lower elevations in the valley.

As discussed in **Section 5.4.3.1**, and based on the data set contained in DEQ's assessment record, one-half of TN samples exceeded the target (0.275 mg/L) at three sites (AC-1, AC-2, and AC-3); all TN concentrations were at or exceeded the target at the most downstream site (AC-4). Altogether, 22 of 40 TN samples in upper Ashley Creek exceeded the target. TN concentrations appear to increase from the Ashly Lake outlet to the downstream end of the segment (**Figure 5-7**).

5.6.2.2 Assessment of Loading by Source Categories for Upper Ashley Creek

Based on the LSPC model, the bulk of the total nitrogen loading during the summer growing season is from the Smith Lake area, atmospheric deposition, and natural sources (**Figure 5-12**), making up approximately 71%, 13%, and 8% of the total load, respectively. Other sources comprise only 8% of the total load, with septic systems at 6%. Agriculture, timber harvest, and unpaved roads make up the remaining 2% of the total load. Note that a portion of atmospheric deposition can be linked to an additional form of natural background loading.

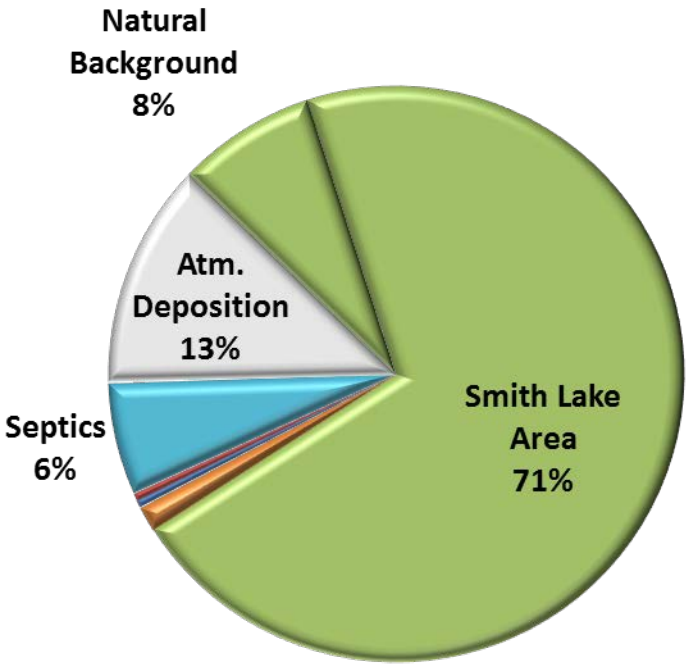
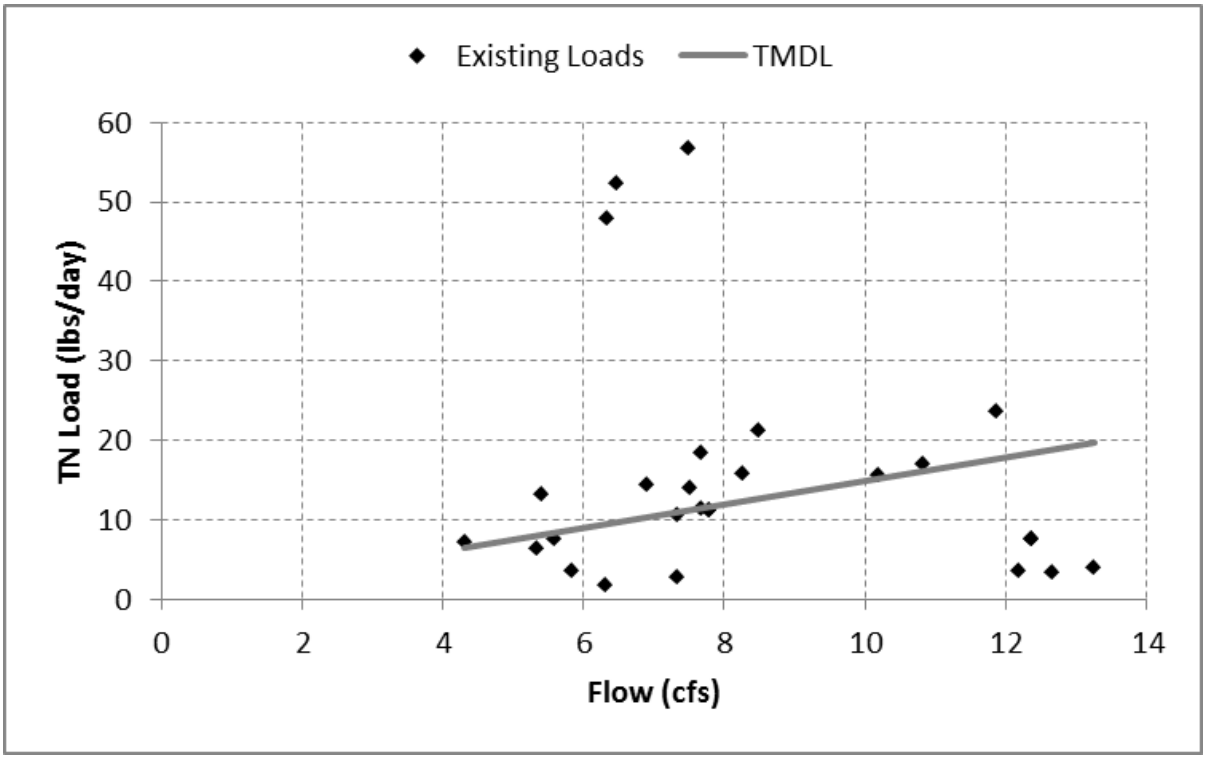


Figure 5-12. Contribution of TN Sources to Upper Ashley Creek during the Summer Growing Season.

5.6.2.3 TN TMDL, Allocations, Current Loading, and Reductions for Upper Ashley Creek

Figure 5-13 shows the TN TMDL for upper Ashley Creek. The TMDL is shown as a line which represents the TN target (0.275 mg/L) multiplied by flow. Measured loads are also plotted on the graph and demonstrate that nutrient reductions are necessary to meet the TMDL over a wide range of flows. Based on the measured data, TN loads need to be reduced by 4 to 82%, with a median reduction of 28%. At times, measured loads are below the TMDL and no reductions are necessary.



All points on or below the gray line are meeting the TMDL.

Figure 5-13. Measured TN loads in Comparison to the TMDL.

Because a proportion of the existing loads are greater than the TMDL, reductions are necessary to meet the water quality target for TN. Although the source assessment for the upper Ashley Creek subwatershed indicates that septic systems contribute the most controllable human-caused TN loading (see **Figure 5-12**); the origination of loading in the Smith Lake area could also be linked to human-caused TN loading from agriculture or other existing or historical land uses. Load reductions should focus on limiting and controlling TN loading from controllable sources. Meeting load allocations for upper Ashley Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 9**.

The TMDL is also defined as the summation of allocations to point and nonpoint sources. Because no point sources are permitted to discharge in the upper Ashley Creek watershed, the TMDL for upper Ashley Creek is represented by **Equation 2.**

TMDL = LA

The loading in upper Ashley Creek is allocated to nonpoint sources and natural background conditions. Rather than prescribing specific LAs to each of the nonpoint sources, a composite load allocation is

presented. This is done to account for the fact that loading from the various nonpoint sources changes with location, time, and flow. It also accounts for the uncertainty regarding the origination of the TN loading from the Smith Lake Area, giving watershed stakeholders flexibility in deciding the best method for implementing nonpoint source reductions.

5.6.2.4 Example TMDL

This section of the document provides an example TMDL, existing load, and allocations based on a single flow rate and in-stream concentration. Note that the upper Ashley Creek TMDLs and allocations apply, and will vary, across the range of flows that may be observed during the summer growing season.

The following is an example of the TMDL, existing load, and allocation using an *average* observed flow of 8.35 cfs, using TN data contained in DEQ's assessment record (refer to **Table B-1** in **Appendix B** for a tabular summary of the data used for the TMDL calculations). The example TN TMDL, load allocation, and current loading for a flow of 8.35 cfs are summarized in **Table 5-28**.

Total Nitrogen

The TN TMDL target is 0.275 mg/L, and the *average* observed concentration is 0.38 mg/L.

TMDL = (target)(flow)(5.4)
= (0.275 mg/L) (8.35 cfs) (5.4)
= 12.40 lbs/day

Existing Load = (observed)(flow)(5.4)
= (0.38 mg/L) (8.35 cfs) (5.4)
= 17.13 lbs/day

Table 5-28. Example TN TMDL, Current Loads, and Allowable Loads for Upper Ashley Creek (at an Example Flow of 8.35 cfs)

TN Sources	Existing Load (lbs/day) [1]	Percent Reduction	Allowable Load (lbs/day) [2]
Nonpoint Sources + Natural Background	17.13	28%	LA = 12.40
Total	**17.13**	**28%**	**TMDL = 12.40**

[1] The total load (17.13lb/day) is based on a flow of 8.35 cfs and average measured TN concentration of 0.38 mg/L.
[2] The total allowable load is based on a flow of 8.35 cfs and the TMDL target of 0.275 mg/L.

5.6.2.5 Dissolved Oxygen

As discussed in **Section 5.4.4**, the TN TMDL for upper Ashley Creek provides a surrogate TMDL and allocations to addresses the dissolved oxygen (DO) impairment cause to the upper Ashley Creek waterbody segment. Water quality improvements that address excess TN loading should result in improved (i.e., increased) DO concentrations.

5.6.3 Middle Ashley Creek MT76O002_020

5.6.3.1 Assessment of Water Quality Results for Middle Ashley Creek

Middle Ashley Creek begins at the outlet from Smith Lake and flows northeast, east, then southeast for 14.17 miles to Kalispell Airport Road. The contributing drainage area to middle Ashley Creek includes

upper Ashley Creek (discussed above) and Spring Creek (discussed in **Section 5.6.5**). Land cover is predominantly forested, with approximately 7% in agricultural uses and 3% urban use. There are an estimated 1,707 septic systems within the subwatershed (not including septic systems in upper Ashley Creek and Spring Creek). A portion of the City of Kalispell's Small MS4 (MTR040005) is also within the middle Ashley Creek subwatershed. One industrial site (UPS [MTR000447]) and one construction site (LHC, Inc. [MTR105434]) are authorized to discharge within this reach.

As discussed in **Section 5.4.3.1**, and based on the data set contained in DEQ's assessment record (**Table B-1**, **Appendix B**), 38 of 38 TN samples and 27 of 48 TP samples collected in middle Ashley Creek exceeded the targets.

5.6.3.2 Assessment of Loading by Source Categories for Middle Ashley Creek

Figure 5-14 and **Figure 5-15** show the percentage of TN and TP loading from the various sources in middle Ashley Creek, respectively (based on the LSPC model). Similar to upper Ashley Creek, the major source of TN during the summer growing season is the Smith Lake area (58%). This is followed by septic systems, atmospheric deposition, natural background, agriculture, urban areas, and timber harvest.

A similar source composition is shown for TP (**Figure 5-15**) with the Smith Lake area, septic systems, natural background, agriculture, urban areas, unpaved roads, and timber harvest as primary sources. Note that a portion of atmospheric deposition can be linked to an additional form of natural background loading.

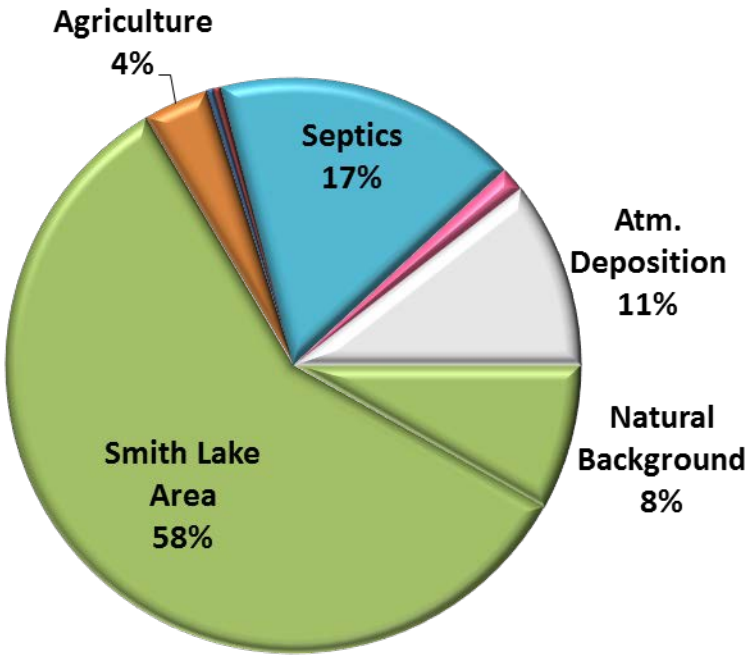


Figure 5-14. Contribution of TN Sources to Middle Ashley Creek during the Summer Growing Season.

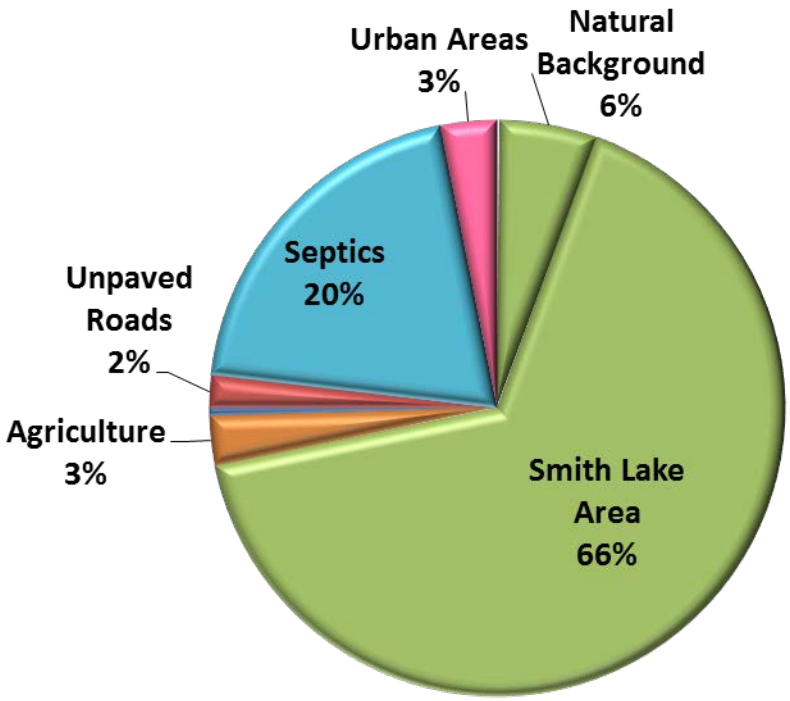
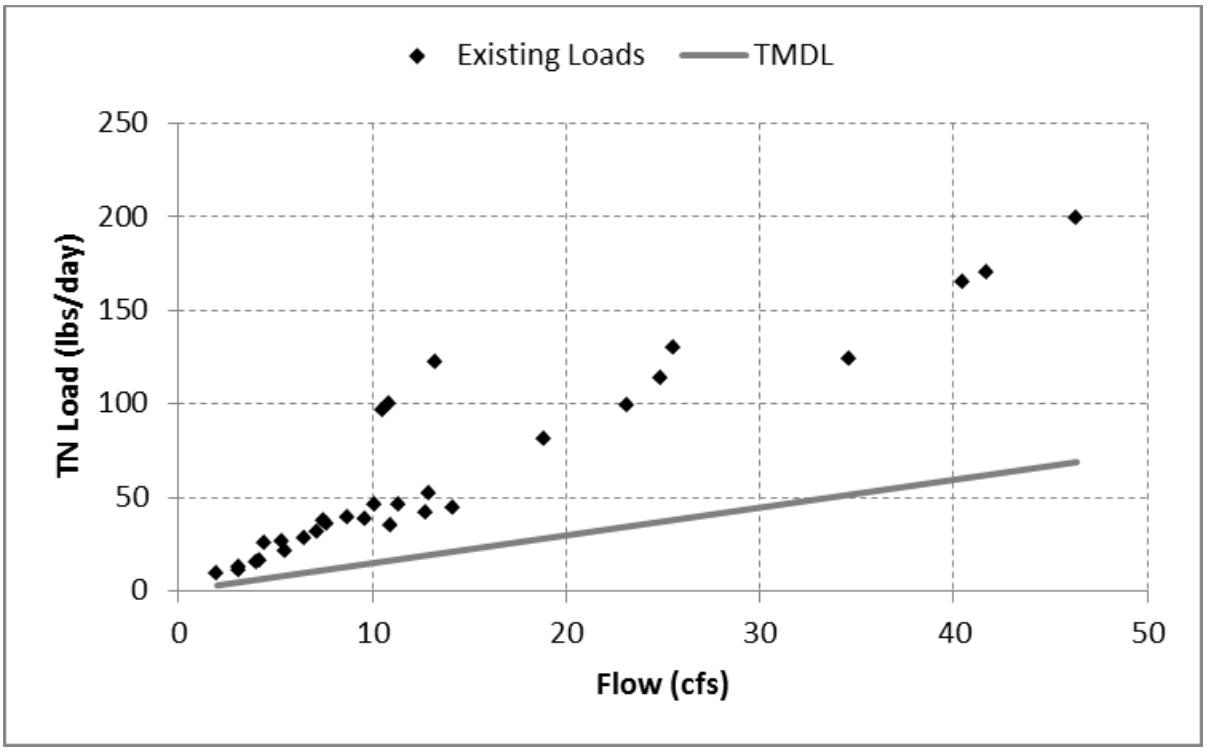


Figure 5-15. Contribution of TP Sources to Middle Ashley Creek during the Summer Growing Season

5.6.3.3 TN TMDL, Allocations, Current Loading, and Reductions for Middle Ashley Creek

Figure 5-16 shows the TN TMDL for middle Ashley Creek. The TMDL is shown as a line which represents the TN target (0.275 mg/L) multiplied by flow. Measured loads are also plotted on the graph and demonstrate that nutrient reductions are necessary to meet the TMDL over a wide range of flows. Based on the measured data, TN loads need to be reduced by 53 to 84%, with a median reduction of 65%.



All points above the gray line are not meeting the TMDL.

Figure 5-16. Measured TN loads in Comparison to the TMDL

Because the existing loads are greater than the TMDL, reductions are necessary to meet the water quality target for TN. Although the source assessment for the middle Ashley Creek subwatershed indicates that septic systems, agriculture, urban areas, and timber harvest contribute the most controllable human-caused TN loading (see **Figure 5-14**); the origination of loading in the Smith Lake area could also be linked to human-caused TN loading from agriculture or other existing or historical land uses. Load reductions should focus on limiting and controlling TN loading from controllable sources. Meeting load allocations for middle Ashley Creek may be achieved through a variety of water quality planning and implementation actions which are addressed in **Section 9**.

The TMDL is also defined as the summation of allocations to point and nonpoint sources. The TN TMDL includes a WLA for the permitted MS4 stormwater discharge and a composite LA for nonpoint sources (including natural background) and is expressed via **Equation 3** as:

$$\mathbf{TMDL = WLA_{Kalispell\ MS4} + LA}$$

5.6.3.3.1 Kalispell MS4

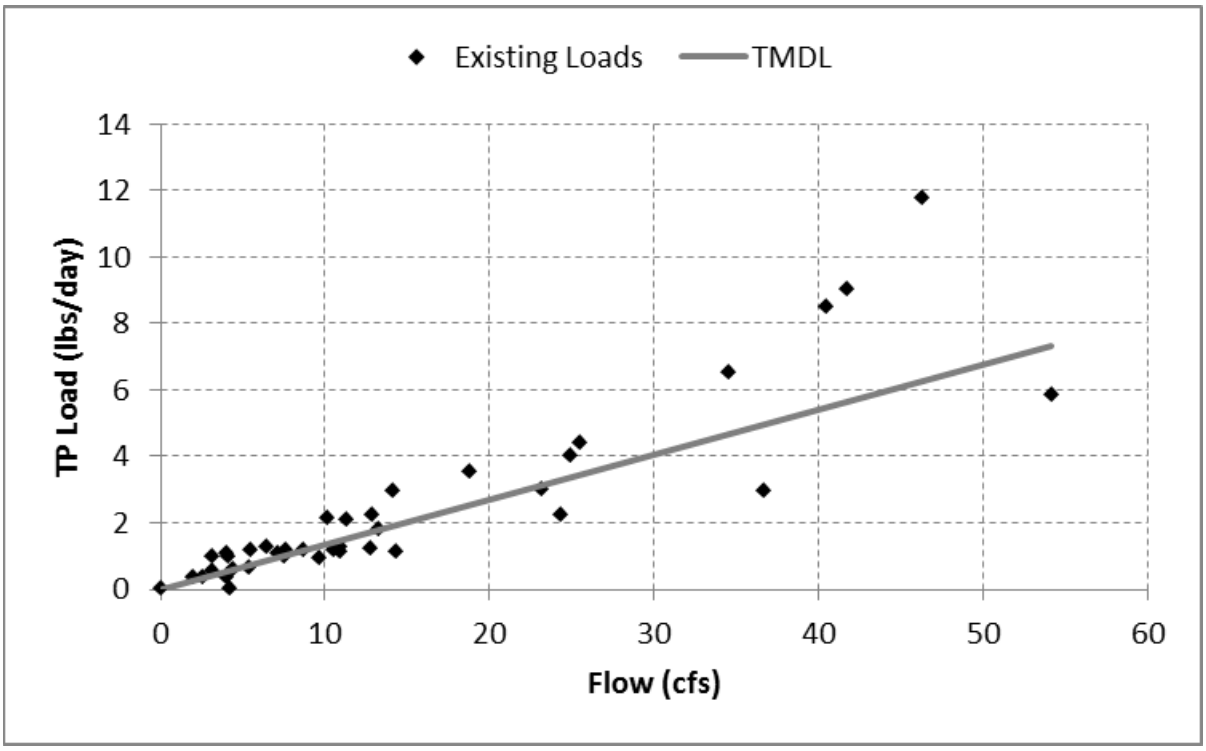
The Kalispell MS4 system does not continuously discharge, and it only sporadically discharges during the dry summer growing season. Because of this, a daily WLA has not been calculated. Instead, a growing season TN WLA of 292 lbs is developed for the MS4 system as defined in **Section 5.6.1.2**. This WLA is not intended to add a concentration or load limit to the existing or future stormwater MS4 permits; implementation is instead based solely on the City of Kalispell following the monitoring and BMP requirements as outlined in their general stormwater permit. This requirement also applies to the Montana Department of Transportation as the MS4 co-permittee.

5.6.3.3.2 Load Allocations

The remainder of the loading in middle Ashley Creek is allocated to nonpoint sources and natural background conditions. Rather than prescribing specific LAs to each of the nonpoint sources, a composite LA is presented. This is done to account for the fact that loading from the various nonpoint sources changes with location, time, and flow. It also accounts for the uncertainty regarding the origination of the TN loading from the Smith Lake Area, giving watershed stakeholders flexibility in deciding the best method for implementing nonpoint source reductions.

5.6.3.4 TP TMDL, Allocations, Current Loading, and Reductions for Middle Ashley Creek

Figure 5-17 shows the TP TMDL for middle Ashley Creek. The TMDL is shown as a line which represents the TP target (0.025 mg/L) multiplied by flow. Measured loads are also plotted on the graph and demonstrate that nutrient reductions are necessary to meet the TMDL over a wide range of flows. Based on the measured data, TN loads need to be reduced by 4 to 58%, with a median reduction of 36%.



All points on or below the gray line are meeting the TMDL.

Figure 5-17. Measured TP loads in Comparison to the TMDL.

Because a proportion of the existing loads are greater than the TMDL, reductions are necessary to meet the water quality target for TP. Although the source assessment for the middle Ashley Creek subwatershed indicates that septic systems, agriculture, urban areas, and unpaved roads contribute the most controllable human-caused TP loading (see **Figure 5-15**); the origination of loading in the Smith Lake area could also be linked to human-caused TP loading from agriculture or other existing or historical land uses. Load reductions should focus on limiting and controlling TP loading from controllable sources. Meeting load allocations for middle Ashley Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 9**.

The TMDL is also defined as the summation of allocations to point and nonpoint sources. The TP TMDL includes a WLA for the permitted MS4 stormwater discharge and a composite LA for nonpoint sources (including natural background) and is expressed via **Equation 3** as:

$$\mathbf{TMDL = WLA_{Kalispell\ MS4} + LA}$$

5.6.3.4.1 Kalispell MS4

The Kalispell MS4 system does not continuously discharge, and it only sporadically discharges during the dry summer growing season. Because of this, a daily WLA has not been calculated. Instead, a growing season TP WLA of 15 lbs is developed for the MS4 system as defined in **Section 5.6.1.2**. This WLA is not intended to add a concentration or load limit to the existing or future stormwater MS4 permits; implementation is instead based solely on the City of Kalispell following the monitoring and BMP requirements as outlined in their general stormwater permit. This requirement also applies to the Montana Department of Transportation as the MS4 co-permittee.

5.6.3.4.2 Load Allocations

The remainder of the loading in middle Ashley Creek is allocated to nonpoint sources and natural background conditions. Rather than prescribing specific LAs to each of the nonpoint sources, a composite load allocation is presented. This is done to account for the fact that loading from the various nonpoint sources changes with location, time, and flow. It also accounts for the uncertainty regarding the origination of the TP loading from the Smith Lake Area, giving watershed stakeholders flexibility in deciding the best method for implementing nonpoint source reductions.

5.6.3.5 Example TMDL

This section of the document provides an example TMDL, existing load, and allocations based on a single flow rate and in-stream concentration. Note that the middle Ashley Creek TMDLs and allocations apply, and will vary, across the range of flows that may be observed during the summer growing season.

The following is an example of the TMDLs, existing loads, and allocations using an *average* observed flow of 14.91 cfs, using data contained in DEQ's assessment record (refer to **Table B-1** in **Appendix B** for a tabular summary of the data used for the TMDL calculations). The example TMDL, load allocation, and current loading for a flow of 14.91 cfs are summarized in **Table 5-29** for TN and **Table 5-30** for TP**.**

Total Nitrogen

The TN TMDL target is 0.275 mg/L, and the *average* observed concentration is 0.84 mg/L.

TMDL = (target)(flow)(5.4)
= (0.275 mg/L) (14.91 cfs) (5.4)
= 22.14 lbs/day

Existing Load = (observed)(flow)(5.4)
= (0.84 mg/L) (14.91 cfs) (5.4)
= 67.63 lbs/day

Total Phosphorus

The TP TMDL target is 0.025 mg/L, and the *average* observed concentration is 0.03 mg/L.

TMDL = (target)(flow)(5.4)
= (0.025 mg/L) (14.91 cfs) (5.4)
= 2.01 lbs/day

Existing Load = (observed)(flow)(5.4)
= (0.03 mg/L) (14.91 cfs) (5.4)
= 2.42 lbs/day

Table 5-29. Example TN TMDL, Current Loads, and Allowable Loads for Middle Ashley Creek (at an Example Flow of 14.91 cfs)

TN Sources	Existing Load (lbs/day) [1]	Percent Reduction	Allowable Load (lbs/day)
Kalispell MS4	NA [2]	NA [2]	NA [2]
Nonpoint Sources + Natural Background	67.63	67%	LA = 22.14
Total	**67.63**	**67%**	**TMDL = 22.14** [3]

[1] The total load (67.63 lb/day) is based on a flow of 14.91 cfs and average measured TN concentration of 0.38 mg/L.
[2] This example is for an average growing season day with no storm events and no discharges from the Kalispell MS4 system. See **Section 5.6.1** for additional information.
[3] The total allowable load is based on a flow of 14.91 cfs and the TMDL target of 0.275 mg/L.
Note: All values are rounded to the nearest one-hundredth. The summation of values per column may not sum to the values shown in the Total row due to rounding.

Table 5-30. Example TP TMDL, Current Loads, and Allowable Loads for Middle Ashley Creek (at an Example Flow of 14.91 cfs)

TP Sources	Existing Load (lbs/day) [1]	Percent Reduction	Allowable Load (lbs/day)
Kalispell MS4	NA [2]	NA [2]	NA [2]
Nonpoint Sources + Natural Background	2.42	17%	LA = 2.01
Total	**2.42**	**17%**	**TMDL = 2.01** [3]

[1] The total load (2.01 lb/day) is based on a flow of 14.91 cfs and average measured TP concentration of 0.03 mg/L.
[2] This example is for an average growing season day with no storm events and no discharges from the Kalispell MS4 system. See **Section 5.6.1** for additional information.
[3] The total allowable load is based on a flow of 14.91 cfs and the TMDL target of 0.025 mg/L.
Note: All values are rounded to the nearest one-hundredth. The summation of values per column may not sum to the values shown in the Total row due to rounding.

5.6.4 Lower Ashley Creek MT76O002_030

5.6.4.1 Assessment of Water Quality Results for Lower Ashley Creek

This impaired segment of Ashley Creek begins at the Kalispell Airport Road and generally flows southeast and east 13.17 miles until it discharges to the Flathead River. This reach flows through primarily agriculture, residential, and urban areas. The contributing watershed encompasses an area of 324 square miles, including the Upper and middle Ashley Creek subwatersheds (described previously) and Spring Creek (discussed in **Section 5.6.5**). There are an estimated 3,353 septic systems within the watershed contributing to the impaired segment. A portion of the City of Kalispell's Small MS4 (MTR040005) also contributes to lower Ashley Creek. Also, the City of Kalispell's WWTP is authorized to discharge wastewater and four industrial sites and one construction site are authorized to discharge stormwater within the subwatershed contributing to this reach.

As discussed in **Section 5.4.3.3**, and based on the data set contained in DEQ's assessment record, all of the TN samples evaluated as part of DEQ's impairment assessment exceeded the target (0.275 mg/L). All of the TP concentrations exceeded the target (0.025 mg/L), except at site C11AHLYC01 near the mouth where most of the TP concentrations exceed the target. Altogether, 12 of 12 TN concentrations and 18 of 20 TP concentrations exceeded the targets. As shown in **Figure 5-7** and **Figure 5-8** , both TN and TP concentrations increase downstream from the Kalispell WWTP discharge.

5.6.4.2 Assessment of Loading by Source Categories for Lower Ashley Creek

Figure 5-18 and **Figure 5-19** show the percentage of TN and TP loading from the various sources in lower Ashley Creek, respectively (based on the LSPC model). Both pie charts represent cumulative loads including upper Ashley Creek, middle Ashley Creek, and Spring Creek. The LSPC model results indicate that the Smith Lake area is the greatest contributor of nitrogen to lower Ashley Creek (35 percent). Point sources (i.e., the Kalispell WWTP MT0021938) contribute 30% followed by septic systems at 15%. The remaining sources (atmospheric deposition, natural background, agriculture, and urban) each comprise less than 7% of the total estimated load.

The Smith Lake area is also the largest source of phosphorus, at 46% of the total load. This is followed by septic systems (20%) and the Kalispell WWTP (16%). Urban, natural background, agriculture, and unpaved roads contribute the remainder, each at less than 8%. Note that a portion of atmospheric deposition can be linked to an additional form of natural background loading.

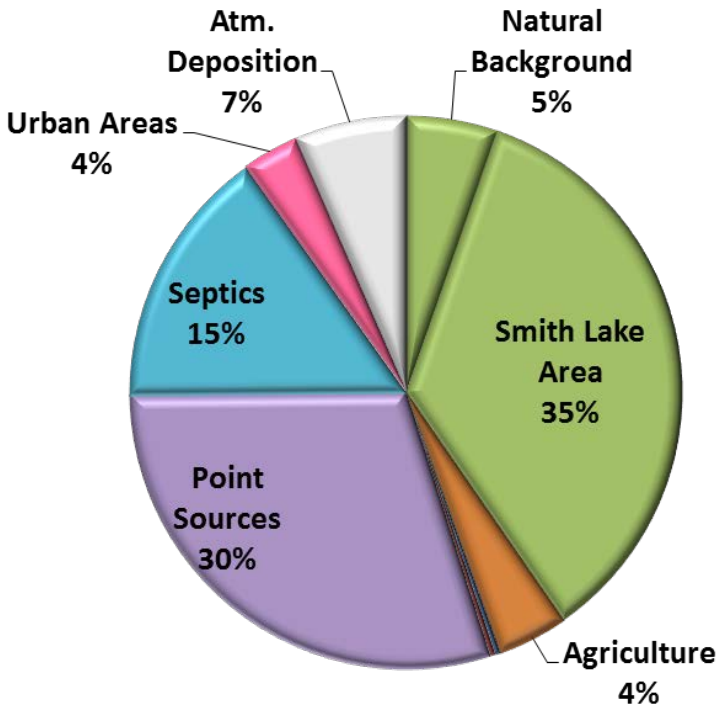


Figure 5-18. Contribution of TN Sources to Lower Ashley Creek during the Summer Growing Season

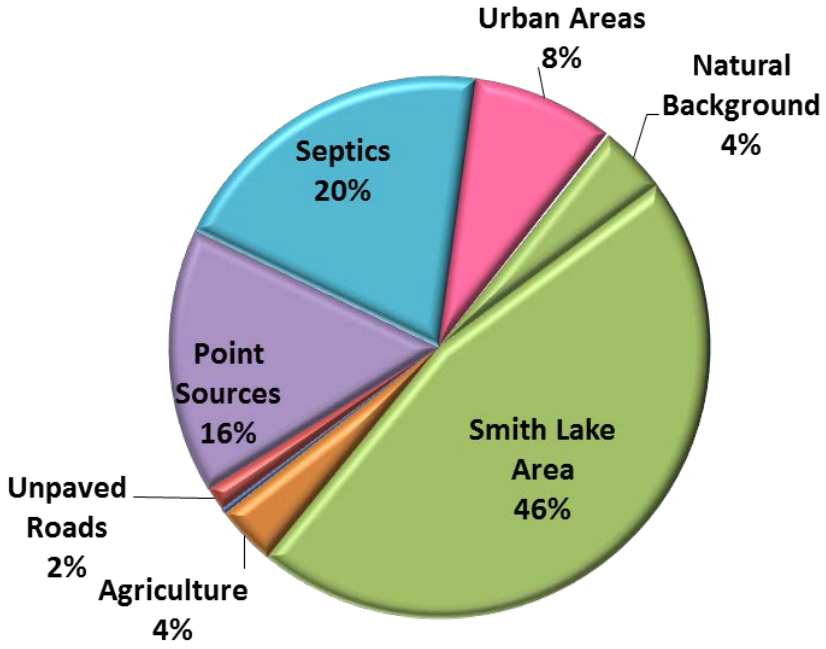
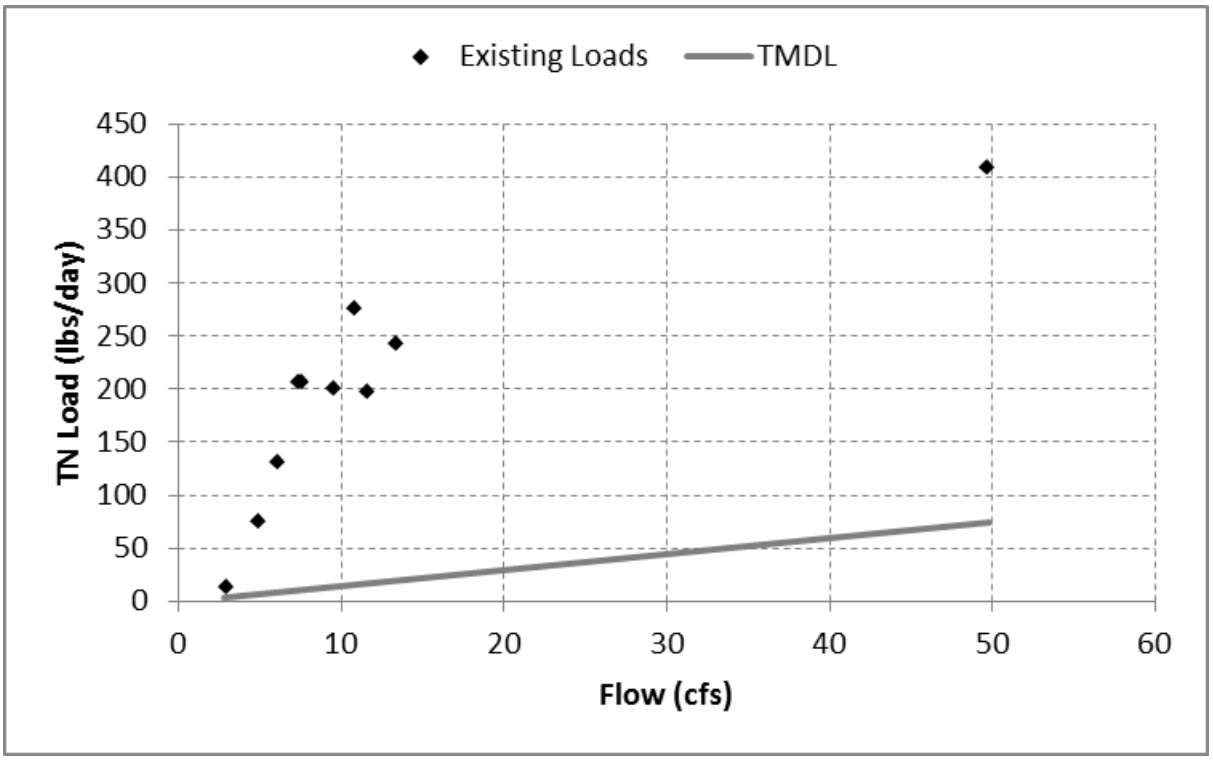


Figure 5-19. Contribution of TP Sources to Lower Ashley Creek during the Summer Growing Season

5.6.4.3 TN TMDL, Allocations, Current Loading, and Reductions for Lower Ashley Creek

Figure 5-20 shows the TN TMDL for lower Ashley Creek. The TMDL is shown as a line which represents the TN target (0.275 mg/L) multiplied by flow. Measured loads are also plotted on the graph and demonstrate that nutrient reductions are necessary to meet the TMDL over a wide range of flows. Based on the measured data, TN loads need to be reduced by 67 to 97%, with a median reduction of 92%.



All points above the gray line are not meeting the TMDL.

Figure 5-20. Measured TN loads in Lower Ashley Creek in Comparison to the TMDL

Because the existing loads are greater than the TMDL, reductions are necessary to meet the water quality target for TN. Although the source assessment for the lower Ashley Creek subwatershed indicates that point sources and septic systems contribute the most controllable human-caused TN loading (see **Figure 5-18**); the origination of loading in the Smith Lake area could also be linked to human-caused TN loading from agriculture or other existing or historical land uses. Load reductions should focus on limiting and controlling TN loading from controllable sources. Meeting load allocations for lower Ashley Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 9**.

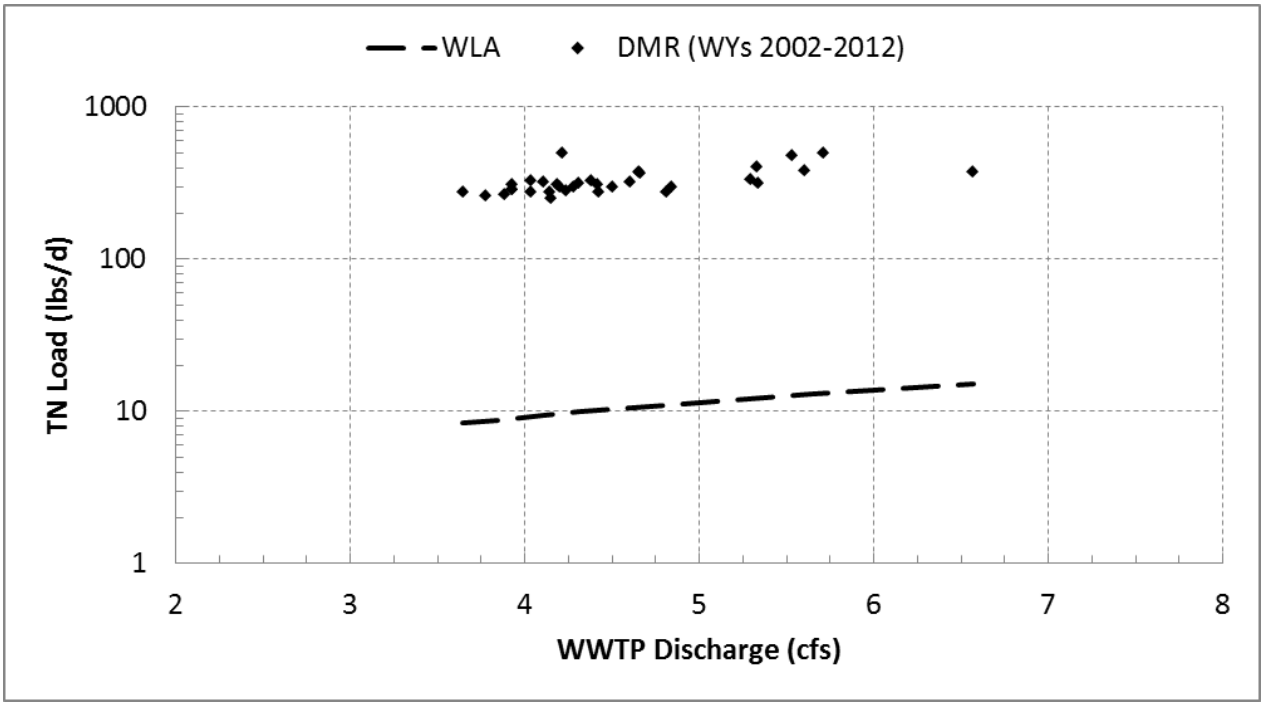
The TMDL is also defined as the summation of allocations to point and nonpoint sources. The TN TMDL includes separate WLAs for the permitted MS4 stormwater discharge and treated wastewater from the Kalispell WWTP and a composite LA for nonpoint sources (including natural background) and is expressed via **Equation 3** as:

$$\mathbf{TMDL = WLA_{Kalispell\ WWTP\ (wastewater)} + WLA_{Kalispell\ MS4} + LA}$$

5.6.4.3.1 Kalispell WWTP

The TN WLA for the City of Kalispell's WWTP is based on meeting the end of pipe criteria of 0.275 mg/L during the summer algae growing season of July 1 through September 30. Meeting this concentration "at the end of pipe" means that no maximum flow or load limits are necessary. **Figure 5-21** shows measured effluent data compared to the flow-variable WLA. Recent TN Discharge Monitoring Report (DMR) data for 30-day average discharge concentrations for June and July 2014 are approximately 6 mg/L. This represents one of the highest levels of TN treatment for a WWTP discharge in Montana. Yet,

a 95% reduction is still required to meet the WLA concentration, thus justifying a staged WLA implementation if a variance is granted as discussed in **Section 5.6.1.1.**



The dashed line representing the WLA is shown over the range of discharges from the WWTP during the summer growing season from water years 2002 through 2012.

Figure 5-21. WLA for TN from the Kalispell WWTP

5.6.4.3.2 Kalispell MS4

The Kalispell MS4 system does not continuously discharge, and it only sporadically discharges during the dry summer growing season. Because of this, a daily WLA has not been calculated. Instead, a growing season TN WLA of 1030 lbs is developed for the MS4 system as defined in **Section 5.6.1.2**. This WLA is not intended to add a concentration or load limit to the existing or future stormwater MS4 permits; implementation is instead based solely on the City of Kalispell following the monitoring and BMP requirements as outlined in their most recent permit. This requirement also applies to the Montana Department of Transportation as the MS4 co-permittee.

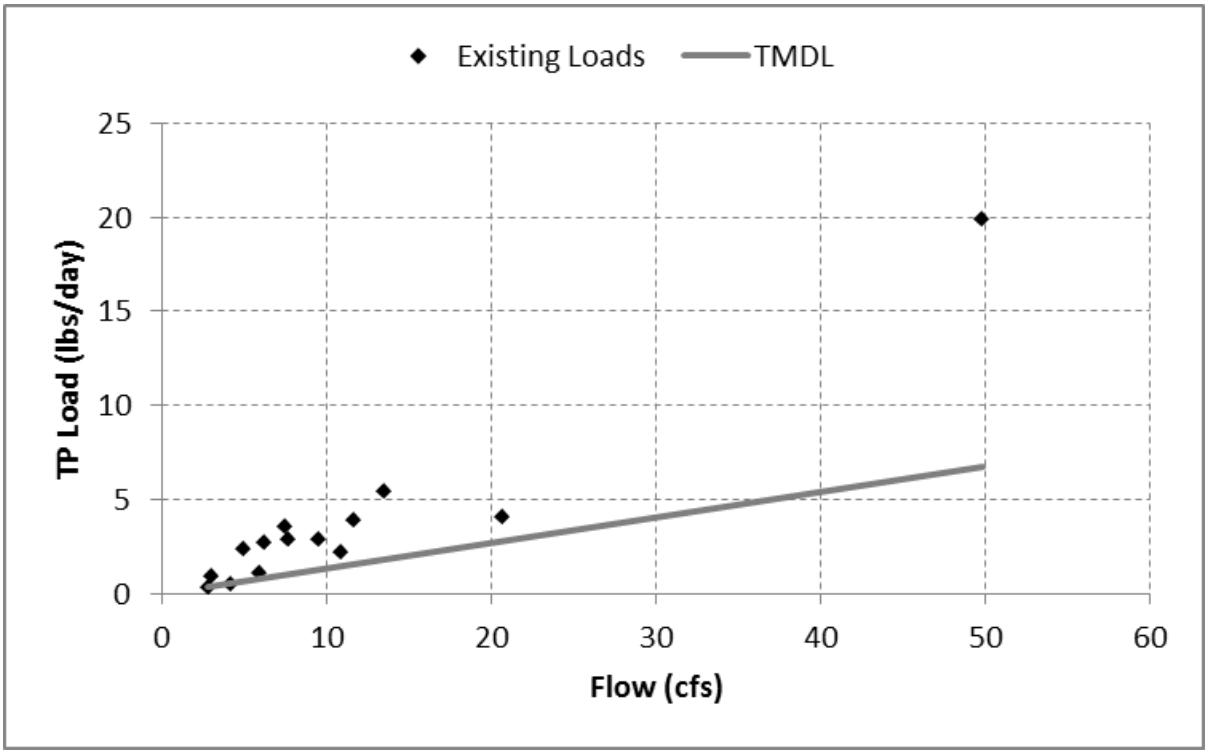
5.6.4.3.3 Load Allocations

The remainder of the loading in lower Ashley Creek is allocated to nonpoint sources and natural background conditions. Rather than prescribing specific LAs to each of the nonpoint sources, a composite load allocation is presented. This is done to account for the fact that loading from the various nonpoint sources changes with location, time, and flow. It also accounts for the uncertainty regarding the origination of the TN loading from the Smith Lake Area, giving watershed stakeholders flexibility in deciding the best method for implementing nonpoint source reductions.

5.6.4.4 TP TMDL, Allocations, Current Loading, and Reductions for Lower Ashley Creek

Figure 5-22 shows the TP TMDL for lower Ashley Creek. The TMDL is shown as a line which represents the TP target (0.025 mg/L) multiplied by flow. Measured loads are also plotted on the graph and

demonstrate that nutrient reductions are necessary to meet the TMDL over a wide range of flows. Based on the measured data, TP loads need to be reduced by 26 to 71%, with a median reduction of 63%.



All points on or below the gray line are meeting the TMDL.

Figure 5-22. Measured TP loads in Comparison to the TMDL

Because a proportion of the existing loads are greater than the TMDL, reductions are necessary to meet the water quality target for TP. Although the source assessment for the lower Ashley Creek watershed indicates that septic systems, point sources, urban areas, and agriculture contribute the most controllable human-caused TP loading (see **Figure 5-19**); the origination of loading in the Smith Lake area could also be linked to human-caused TP loading from agriculture or other existing or historical land uses. Load reductions should focus on limiting and controlling TP loading from controllable sources. Meeting load allocations for lower Ashley Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 9**.

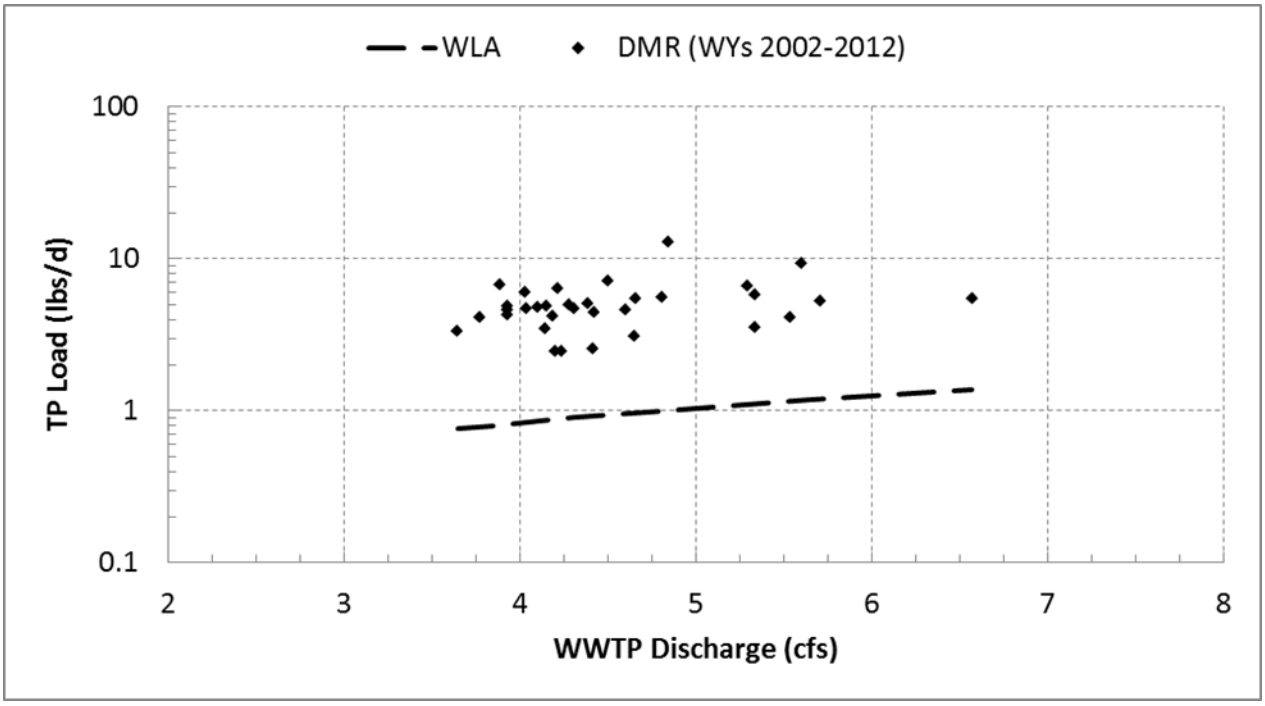
The TMDL is also defined as the summation of allocations to point and nonpoint sources. The TP TMDL includes separate WLAs for the permitted MS4 stormwater discharge and treated wastewater from the Kalispell WWTP and includes a composite LA for nonpoint sources (including natural background) and is expressed via **Equation 3** as:

$$\mathbf{TMDL = WLA_{Kalispell\ WWTP\ (wastewater)} + WLA_{Kalispell\ MS4} + LA}$$

5.6.4.4.1 Kalispell WWTP

The TP WLA for the City of Kalispell's WWTP is based on meeting the end of pipe criteria of 0.025 mg/L during the summer algae growing season of July 1 through September 30. Meeting this concentration "at the end of pipe" means that no maximum flow or load limits are necessary. **Figure 5-23** shows measured effluent data compared to the flow-variable WLA. Recent TP Discharge Monitoring Report

(DMR) data for 30-day average discharge concentrations for June and July 2014 are approximately 0.085 mg/L. This represents one of the highest levels of TP treatment for a WWTP discharge in Montana. Yet, a 70% reduction is still required to meet the WLA concentration, thus justifying a staged WLA implementation if a variance is granted as discussed in **Section 5.6.1.1.**



The dashed line representing the WLA is shown over the range of discharges from the WWTP during the summer growing season from water years 2002 through 2012.

Figure 5-23. WLA for TP from the Kalispell WWTP

5.6.4.4.2 Kalispell MS4

The Kalispell MS4 system does not continuously discharge, and it only sporadically discharges during the dry summer growing season. Because of this, a daily WLA has not been calculated. Instead, a growing season TP WLA of 54 lbs is developed for the MS4 system as defined in **Section 5.6.1.2**. This WLA is not intended to add a concentration or load limit to the existing or future stormwater MS4 permits; implementation is instead based solely on the City of Kalispell following the monitoring and BMP requirements as outlined in their most recent permit. This requirement also applies to the Montana Department of Transportation as the MS4 co-permittee.

5.6.4.4.3 Load Allocations

The remainder of the loading in lower Ashley Creek is allocated to nonpoint sources and natural background conditions. Rather than prescribing specific LAs to each of the nonpoint sources, a composite load allocation is presented. This is done to account for the fact that loading from the various nonpoint sources changes with location, time, and flow. It also accounts for the uncertainty regarding the origination of the TP loading from the Smith Lake Area, giving watershed stakeholders flexibility in deciding the best method for implementing nonpoint source reductions.

5.6.4.5 Example TMDL

This section of the document provides an example TMDL, existing load, and allocations based on a single flow rate and in-stream concentration. Note that the lower Ashley Creek TMDLs and allocations apply, and will vary, across the range of flows that may be observed during the summer growing season.

The following is an example of the TMDLs, existing loads, and allocations using an *average* observed flow of 13.6 cfs, using data contained in DEQ's assessment record (refer to **Table B-1** in **Appendix B** for a tabular summary of the data used for the TMDL calculations). The example TMDL, load allocation, and current loading for a flow of 13.6 cfs are summarized in **Table 5-31** for TN and **Table 5-32** for TP.

Total Nitrogen

The TN TMDL target is 0.275 mg/L, and the *average* observed concentration is 3.14 mg/L.

TMDL = (target)(flow)(5.4)
= (0.275 mg/L) (13.6 cfs) (5.4)
= 20.20 lbs/day

Existing Load = (observed)(flow)(5.4)
= (3.14 mg/L) (13.6 cfs) (5.4)
= 230.60 lbs/day

Total Phosphorus

The TP TMDL target is 0.025 mg/L, and the *average* observed concentration is 0.06 mg/L.

TMDL = (target)(flow)(5.4)
= (0.025 mg/L) (13.6 cfs) (5.4)
= 1.84 lbs/day

Existing Load = (observed)(flow)(5.4)
= (0.06 mg/L) (13.6 cfs) (5.4)
= 4.41 lbs/day

Table 5-31. Example TN TMDL, Current Loads, and Allowable Loads for Lower Ashley Creek (at an Example Flow of 13.6 cfs)

TN Sources	Existing Load (lbs/day) [1]	Percent Reduction	Allowable Load (lbs/day)
Kalispell MS4	NA [2]	NA [2]	NA [2]
Kalispell WWTP (Wastewater)	68.70 [3]	91% [3]	WLA = 6.22 [3]
Nonpoint Sources + Natural Background	161.90	91%	LA = 13.98
Total	**230.60**	**91%**	**TMDL = 20.20** [4]

[1] The total load (230.60 lb/day) is based on a flow of 13.6 cfs and average measured TN concentration of 3.14 mg/L.
[2] This example is for an average growing season day with no storm events and no discharges from the Kalispell MS4 system. See **Section 5.6.1** for additional information.
[3] The WLA for Kalispell WWTP (wastewater) is derived from end-of-pipe criteria and an average summer growing season discharge of 4.19 cfs. The existing load and percent reductions are based on modeled loading at a downstream location after uptake within Ashley Creek. The actual WWTP load contributed to Ashley Creek, if measured at the WWTP discharge, would be closer to 136 lbs/day, and the required reduction to meet the WLA would be approximately 95% as discussed in **Section 5.6.4.3.1**.
[4] The total allowable load is based on a flow of 13.6 cfs and the TMDL target of 0.275 mg/L.
Note: All values are rounded to the nearest one-hundredth. The summation of values per column may not sum to the values shown in the Total row due to rounding.

Table 5-32. Example TP TMDL, Current Loads, and Allowable Loads for Lower Ashley Creek (at an Example Flow of 13.6 cfs)

TP Sources	Existing Load (lbs/day) [1]	Percent Reduction	Allowable Load (lbs/day)
Kalispell MS4	NA [2]	NA [2]	NA [2]
Kalispell WWTP (Wastewater)	0.70 [3]	19% [3]	WLA = 0.57 [3]
Nonpoint Sources + Natural Background	3.71	66%	LA = 1.27
Total	**4.41**	**58%**	**TMDL = 1.84** [4]

[1] The total load (230.60 lb/day) is based on a flow of 13.6 cfs and average measured TP concentration of 0.06 mg/L.
[2] This example is for an average growing season day with no storm events and no discharges from the Kalispell MS4 system. See **Section 5.6.1** for additional information.
[3] The WLA for Kalispell WWTP (wastewater) is derived from end-of-pipe criteria and an average summer growing season discharge of 4.19 cfs. The existing load and percent reductions are based on modeled loading at a downstream location after uptake within Ashley Creek. The actual WWTP load contributed to Ashley Creek, if measured at the WWTP discharge, would be closer to 1.9 lbs/day, and the required reduction to meet the WLA would be approximately 70% as discussed in **Section 5.6.4.4.1**.
[4] The total allowable load is based on a flow of 13.6 cfs and the TMDL target of 0.025 mg/L.
Note: All values are rounded to the nearest one-hundredth. The summation of values per column may not sum to the values shown in the Total row due to rounding.

5.6.4.6 Dissolved Oxygen and Nitrate/Nitrite

As discussed in **Section 5.4.4**, the TN and TP TMDLs for lower Ashley Creek provide surrogate TMDLs and allocations to addresses the dissolved oxygen (DO) impairment cause to the lower Ashley Creek waterbody segment. Water quality improvements that address excess TN and TP loading should result in improved (i.e., increased) DO concentrations. Additionally, the TN TMDL for lower Ashley Creek provides a surrogate TMDL and allocations to address the nitrate/nitrite impairment cause to this segment of Ashley Creek. Water quality improvements that address excess TN loading will additionally result in decreased nitrate/nitrite loading and associated decreased nitrate/nitrite concentrations.

5.6.5 Spring Creek MT76O002_040

5.6.5.1 Assessment of Water Quality Results for Spring Creek

Spring Creek flows southeast 4.8 miles through largely agriculture, rural residential, and urban lands until it joins Ashley Creek (the middle segment from Smith Lake to Kalispell Airport Road). The contributing subwatershed is small: only 2,744 acres. There are an estimated 161 septic systems in the subwatershed. A portion of the City of Kalispell's Small MS4 and one construction site discharge stormwater to Spring Creek.

As discussed in **Section 5.4.3.3**, and based on the data set contained in DEQ's assessment record, almost all of the TN concentrations exceeded the target (0.275 mg/L). Most of the TP concentrations did not exceed the target (0.025 mg/L); one sample at each of sites C11SPRGC31 and C11SPRGC30 exceeded the TP target. Altogether, 12 of 13 TN concentrations and 2 of 14 TP concentrations exceeded the targets.

Nine of 13 nitrate results exceeded their target (0.100 mg/L) and nitrate failed the assessment tests. While chlorophyll-*a*, ash free dry weight, and periphyton test results passed, the macroinvertebrates test results failed. The assessment test failures of nitrate and macroinvertebrates are indicative of nutrient causes of impairments; these nutrient causes of impairment will be addressed through TP and TN TMDLs.

5.6.5.2 Assessment of Loading by Source Categories for Spring Creek

The LSPC model results indicate that septic systems contribute roughly half the nitrogen load to Spring Creek during the summer growing season (**Figure 5-24**), with agriculture and urban areas contributing the bulk of the remaining load. The source load distribution for phosphorus is similar (**Figure 5-25**). The model focused only on the land use within the valley contributing to Spring Creek, and did not account for any flows that may originate in hydraulically unconnected watersheds like Big Lost Creek, which may contribute subsurface flows to Spring Creek at various times of the year. This has likely led to underestimating the natural background contribution portion of the loading for TN and TP.

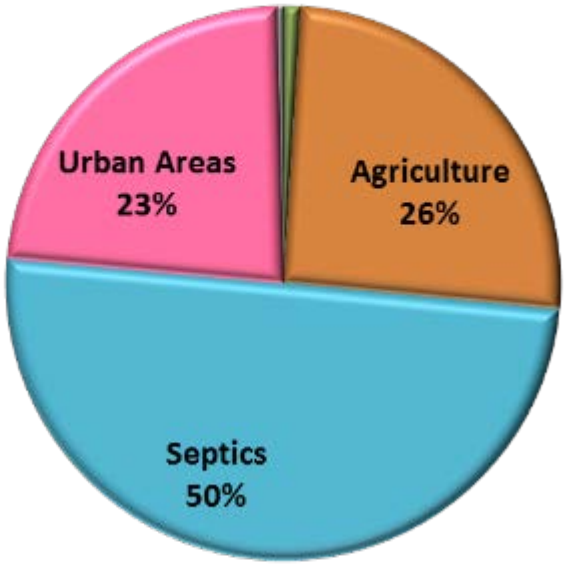


Figure 5-24. Contribution of TN Sources to Spring Creek during the Summer Growing Season

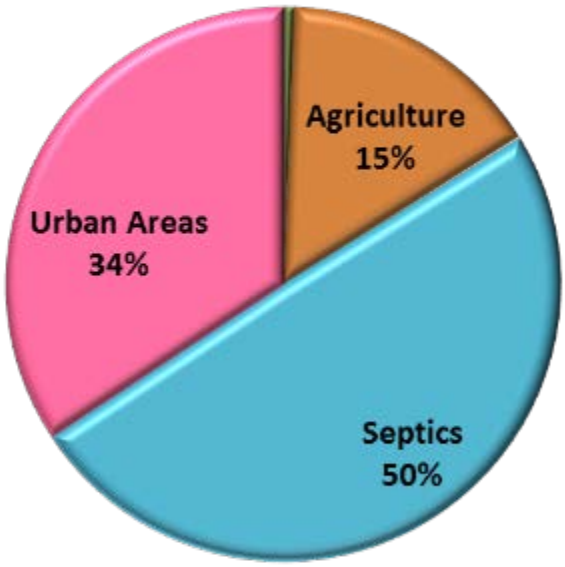
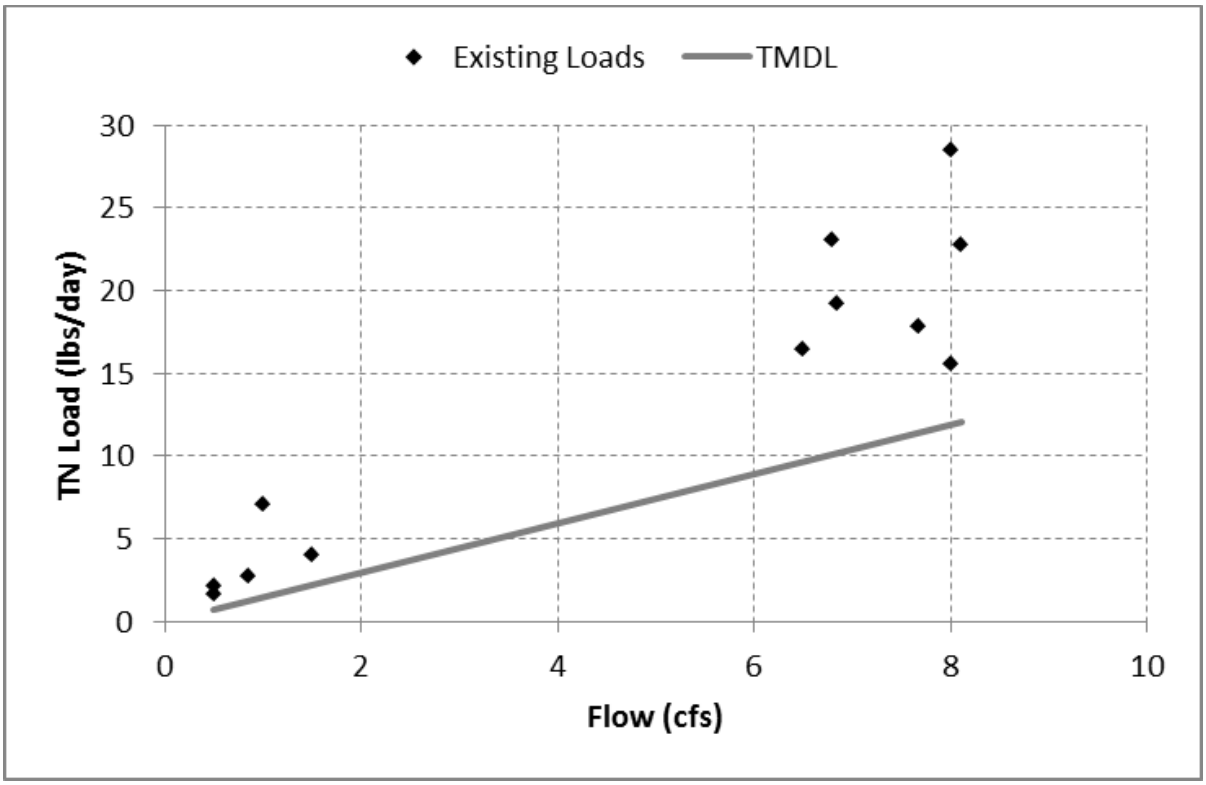


Figure 5-25. Contribution of TP Sources to Spring Creek during the Summer Growing Season

5.6.5.3 TN TMDL, Allocations, Current Loading, and Reductions for Spring Creek

Figure 5-26 shows the TN TMDL for Spring Creek. The TMDL is shown as a line which represents the TN target (0.275 mg/L) multiplied by flow. Measured loads are also plotted on the graph and demonstrate that nutrient reductions are necessary to meet the TMDL over a wide range of flows. Based on the measured data, TN loads need to be reduced by 24 to 79%, with a median reduction of 51%.



All points above the gray line are not meeting the TMDL.

Figure 5-26. Measured TN loads in Comparison to the TMDL.

Because the existing loads are greater than the TMDL, reductions are necessary to meet the water quality target for TN. The source assessment for the Spring Creek watershed indicates that septic systems, agriculture, and urban contribute the most controllable human-caused TN loading; load reductions should focus on limiting and controlling TN loading from these sources. Meeting load allocations for Spring Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 9.0**.

The TMDL is also defined as the summation of allocations to point and nonpoint sources. The TN TMDL includes a WLA for the permitted MS4 stormwater discharge and a composite LA for nonpoint sources (including natural background) and is expressed via **Equation 3** as:

$$\mathbf{TMDL = WLA_{Kalispell\ MS4} + LA}$$

5.6.5.3.1 Kalispell MS4

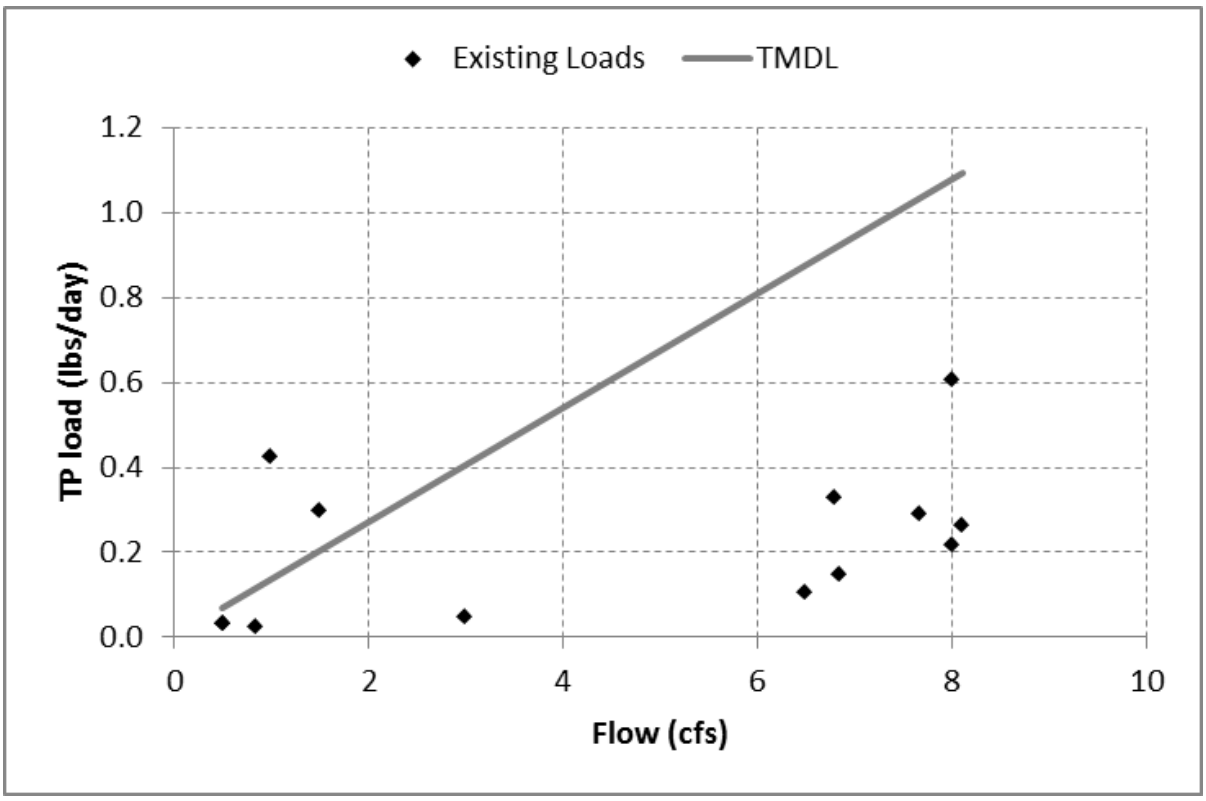
The Kalispell MS4 system does not continuously discharge, and it only sporadically discharges during the dry summer growing season. Because of this, a daily WLA has not been calculated. Instead, a growing season TN WLA of 269 lbs is developed for the MS4 system as defined in **Section 5.6.1.2**. This WLA is not intended to add a concentration or load limit to the existing or future stormwater MS4 permits; implementation is instead based solely on the City of Kalispell following the monitoring and BMP requirements as outlined in their general stormwater permit. This requirement also applies to the Montana Department of Transportation as the MS4 co-permittee.

5.6.5.3.2 Load Allocations

The remainder of the loading in Spring Creek is allocated to nonpoint sources and natural background conditions. Rather than prescribing specific LAs to each of the nonpoint sources, a composite load allocation is presented. This is done to account for the fact that loading from the various nonpoint sources changes with location, time, and flow. Also, this method gives watershed stakeholders flexibility in deciding the best method for implementing nonpoint source reductions.

5.6.5.4 TP TMDL, Allocations, Current Loading, and Reductions for Spring Creek

Figure 5-27 shows the TP TMDL for Spring Creek. The TMDL is shown as a line which represents the TP target (0.025 mg/L) multiplied by flow. Measured loads are also plotted on the graph and demonstrate that nutrient reductions are necessary to meet the TMDL over a wide range of flows. Based on the measured data, TP loads need to be reduced by 32 to 68%, with a median reduction of 50%.



All points on or below the gray line are meeting the TMDL.

Figure 5-27. Measured TP loads in Comparison to the TMDL

Because a proportion of the existing loads are greater than the TMDL, reductions are necessary to meet the water quality target for TP. The source assessment for the Spring Creek watershed indicates that septic systems, agriculture, and urban contribute the most controllable human-caused TP loading; load reductions should focus on limiting and controlling TP loading from these sources. Meeting load allocations for Spring Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 9.0**.

The TMDL is also defined as the summation of allocations to point and nonpoint sources. The TP TMDL includes a WLA for the permitted MS4 stormwater discharge and includes a composite LA for nonpoint sources (including natural background) and is expressed via **Equation 3** as:

$$\mathbf{TMDL = WLA_{Kalispell\ MS4} + LA}$$

5.6.5.4.1 Kalispell MS4

The Kalispell MS4 system does not continuously discharge, and it only sporadically discharges during the dry summer growing season. Because of this, a daily WLA has not been calculated. Instead, a growing season TP WLA of 13 lbs is developed for the MS4 system as defined in **Section 5.6.1.2**. This WLA is not intended to add a concentration or load limit to the existing or future stormwater MS4 permits; implementation is instead based solely on the City of Kalispell following the monitoring and BMP requirements as outlined in their general stormwater permit. This requirement also applies to the Montana Department of Transportation as the MS4 co-permittee.

5.6.5.4.2 Load Allocations

The remainder of the loading in Spring Creek is allocated to nonpoint sources and natural background conditions. Rather than prescribing specific LAs to each of the nonpoint sources, a composite load allocation is presented. This is done to account for the fact that loading from the various nonpoint sources changes with location, time, and flow. Also, this method gives watershed stakeholders flexibility in deciding the best method for implementing nonpoint source reductions.

5.6.5.5 Example TMDL

This section of the document provides an example TMDL, existing load, and allocations based on a single flow rate and in-stream concentration. Note that the Spring Creek TMDLs and allocations apply, and will vary, across the range of flows that may be observed during the summer growing season.

The following is an example of the TMDLs, existing loads, and allocations using an *average* observed flow of 4.6 cfs, using data contained in DEQ's assessment record (refer to **Table B-1** in **Appendix B** for a tabular summary of the data used for the TMDL calculations). The example TMDL, load allocation, and current loading for a flow of 4.6 cfs are summarized in **Table 5-33** for TN and **Table 5-34** for TP.

Total Nitrogen

The TN TMDL target is 0.275 mg/L, and the *average* observed concentration is 0.59 mg/L.

TMDL = (target)(flow)(5.4)
= (0.275 mg/L) (4.6 cfs) (5.4)
= 6.83 lbs/day

Existing Load = (observed)(flow)(5.4)
= (0.59 mg/L) (4.6 cfs) (5.4)
= 14.66 lbs/day

Total Phosphorus

The TP TMDL target is 0.025 mg/L, and the *average* observed concentration is 0.079 mg/L.

TMDL = (target)(flow)(5.4)
= (0.025 mg/L) (4.6 cfs) (5.4)
= 0.62 lbs/day

Existing Load = (observed)(flow)(5.4)
= (0.079 mg/L) (4.6 cfs) (5.4)
= 1.96 lbs/day

Table 5-33. Example TN TMDL, Current Loads, and Allowable Loads for Spring Creek (at an Example Flow of 4.6 cfs).

TN Sources	Existing Load (lbs/day) [1]	Percent Reduction	Allowable Load (lbs/day)
Kalispell MS4	NA [2]	NA [2]	NA [2]
Nonpoint Sources + Natural Background	14.66	53%	LA = 6.83
Total	**14.66**	**53%**	**TMDL = 6.83** [3]

[1] The total load (14.66 lb/day) is based on a flow of 4.6 cfs and average measured TN concentration of 0.59 mg/L.
[2] This example is for an average growing season day with no storm events and no discharges from the Kalispell MS4 system. See **Section 5.6.1** for additional information.
[3] The total allowable load is based on a flow of 4.6 cfs and the TMDL target of 0.275 mg/L.
Note: All values are rounded to the nearest one-hundredth.

Table 5-34. Example TP TMDL, Current Loads, and Allowable Loads for Spring Creek (at an Example Flow of 4.6 cfs)

TP Sources	Existing Load (lbs/day) [1]	Percent Reduction	Allowable Load (lbs/day)
Kalispell MS4	NA [2]	NA [2]	NA [2]
Nonpoint Sources + Natural Background	1.96	68%	LA = 0.62
Total	**1.96**	**68%**	**TMDL = 0.62** [3]

[1] The total load (1.96 lb/day) is based on a flow of 4.6 cfs and average measured TP concentration of 0.079 mg/L.
[2] This example is for an average growing season day with no storm events and no discharges from the Kalispell MS4 system. See Section 5.6.1 for additional information.
[3] The total allowable load is based on a flow of 4.6 cfs and the TMDL target of 0.025 mg/L.
Note: All values are rounded to the nearest one-hundredth.

5.6.5.6 Dissolved Oxygen and Nitrate/Nitrite

As discussed in **Section 5.4.4**, the TN and TP TMDLs for Spring Creek provide surrogate TMDLs and allocations to addresses the dissolved oxygen (DO) impairment cause to Spring Creek. Water quality improvements that address excess TN and TP loading should result in improved (i.e., increased) DO concentrations. Additionally, the TN TMDL for Spring Creek provides a surrogate TMDL and allocations to address the nitrate/nitrite impairment cause to Spring Creek. Water quality improvements that address excess TN loading will additionally result in decreased nitrate/nitrite loading and associated decreased nitrate/nitrite concentrations.

5.7 SEASONALITY AND MARGIN OF SAFETY

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 Flathead-Stillwater TPA nutrient TMDL development process.

5.7.1 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 nutrients

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 growing season for algae (July 1st – 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 summer growing season to coincide with applicable nutrient targets.

5.7.2 Margin of Safety

A margin of safety is a required component of TMDL development. The margin of safety 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 (e.g., 0.100 mg/L nitrate, 0.300 mg/L TN, 0.030 mg/L TP) were used to calculate allowable loads (TMDLs). Allowable exceedances of nutrient targets 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.
- 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.

5.8 UNCERTAINTY

Uncertainties in the accuracy of field data, nutrient targets, source assessment, loading calculations, and other considerations are inherent when assessing and evaluating environmental variables for TMDL development. Specific sources of uncertainty are discussed in the following sections. However, mitigation and reduction of uncertainties through adaptive management approaches is a key component of ongoing TMDL implementation and evaluation, as described in **Section 9.0**. The process of adaptive management is predicated on the basis that TMDL targets, allocations, and the analyses supporting them are not static, but are subject to modification and adjustment as new information and relationships are understood. Since 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.

5.8.1 Water Quality Conditions (Discrete Samples)

It was assumed that discrete water-quality samples for Ashley Creek and Spring Creek are representative of current conditions. However, much of the data in the middle and upper segments of Ashley Creek were collected more than five years ago, and conditions in the stream may have changed since then. Additionally, some of the major tributaries to Ashley Creek (Mount Creek, Truman Creek) have few recently collected water quality data.

While there are numerous nutrient samples collected in each of the listed segments, chlorophyll-*a* data are limited and are only available from 2005 in Ashley Creek. Since this is a primary response variable

that integrates nutrient exposure over time, additional monitoring should be completed to determine the extent of the chlorophyll/algae problems and their interaction with other response variables such as DO and pH. Similarly, DO data also were limited to a few number of grab samples that were mostly collected during the middle of the day. Thus the extent of diurnal variability in primary productivity, and associated excursion frequency is difficult to ascertain. Additional monitoring is recommended to determine the source and magnitude of daily DO changes and its linkage to nutrient loading.

5.8.2 Water Quality Targets

It was assumed that Ashley Creek and Spring Creek are similar to other streams that were used to develop the Northern Rockies ecoregion nutrient targets (uncertainties in the target development are discussed in Suplee and Watson (2013). However, both streams appear to have characteristics that are unique within the region. Ashley Creek has extensive wetland complexes and multiple in-channel lakes. Spring Creek originates from a low-elevation spring and not in the mountainous headwater regions like other Northern Rockies streams. Also, both streams have unusually high TN and TP concentrations for this region, often requiring large load reductions to meet the water quality targets and TMDLs. Additional studies are recommended in both streams to better define the natural background sources and determine if either creek warrants site-specific criteria that differ from the Northern Rockies ecoregion targets used for TMDL development in this document.

As described in Section 4.0 of the "Scientific and Technical Basis of the Numeric Nutrient Criteria for Montana's Wadeable Streams and Rivers—Update 1," DEQ recognizes that other reach-specific exceptions to the ecoregional criteria may be identified in the future and can be addressed on a case-by-case basis going forward (Suplee and Watson, 2013). If further investigation reveals that the TMDL targets cannot be achieved because of natural (non-human) loading, then these TMDL targets could be adjusted concurrent with the development of site specific nutrient criteria for either Ashley Creek or Spring Creek.

A future TN or TP target modification would have no impact on nonpoint sources or on the MS4 or other stormwater-permitted facilities. It would only affect the Kalispell WWTP WLA via a potential loading increase allowance consistent with any increases in upstream nutrient criteria, although resolution may not be necessary for about twenty years because of the variance process options allowed within state law (Montana Department of Environmental Quality, 2014c; 2014a) addressing point source nutrient discharge compliance for a facility such as the Kalispell WWTP.

5.8.3 Source Assessment

The assessment of nitrogen and phosphorus loading by source category reported in the previous sections is based largely on the results of an LSPC model, configured and calibrated for the Flathead-Stillwater TPA and the Ashley Creek watershed. Calibrations generally yielded acceptable results, however, there were difficulties in some locations of the watershed, in particular with several of the lakes in the watershed (e.g., Ashley Lake, Smith Lake, etc.), as well as a large wetland complex upstream of Smith Lake which potentially results in enhanced loadings. Calibration results and model uncertainty in the context of parameter and model uncertainty are described in detail in a separate section the Model Report (Tetra Tech, Inc., 2014b).

5.8.4 Wetlands

As stated previously, both measured data and model results suggest that an increase in nutrient loading occurs between Ashley Lake and Smith Lake; the region has been identified to contain a substantial

amount of organic soils (>3,000 acres; Dean Sirucek, Flathead County Conservation District, personal communication, September 3, 2014) as well having an active wetland complex. Since DEQ was unable to quantitatively identify the cause of this loading increase, it was assumed that the nutrient loading is attributable to wetland dynamics and nutrient cycling. It is possible, however, that other sources may be present in this portion of the watershed and may be contributing to the nutrient load. Further investigation is needed to determine the exact source of the nutrient loading in upper Ashley Creek.

5.9 PROTECTION OF DOWNSTREAM USES

The Clean Water Act requires states and tribes to consider and protect downstream uses when setting water quality standards and developing TMDLs. Flathead Lake is located downstream of Ashley Creek, and it is currently listed as impaired because of TN and TP. TMDLs completed for the lake in 2001 required a 15% reduction in both TN and TP to achieve water quality standards. However, no allocations were provided in the TMDL. A phased approach was proposed to give the agencies time to assess watershed sources and develop a water quality model to help quantify loads to the lake. Phase II of the TMDL is still ongoing, which may require additional nutrient load reductions in Ashley Creek and/or Spring Creek to meet annual load limits. If needed, nutrient TMDLs for Ashley Creek and Spring Creek will either be revised in the future to incorporate the findings of the Phase II Flathead Lake nutrient TMDLs or a new layer of allocations may instead be applied to address the annual loading since the existing allocations to the Ashley Creek watershed only apply during the algae growing season. In addition to Ashley Creek and Spring Creek, Flathead Lake Phase II TMDL allocations would also be applied to other tributaries throughout the Flathead Lake watershed. There are several approaches that could be used for setting these allocations. This could include allocations to multiple pollutant sources within a specific tributary, or application of load reductions to specific pollutant sources types across multiple tributaries. Note that tributary allocations can be developed for a downstream lake's TMDL without writing a TMDL specific to each tributary.

6.0 SEDIMENT TMDL COMPONENTS

This portion of the document focuses on sediment as a cause of water quality impairment in the Flathead-Stillwater Total Maximum Daily Loads (TMDL) Planning Area (TPA). It describes: (1) how excess sediment impairs beneficial uses, (2) the affected stream segments, (3) the currently available data pertaining to sediment impairments in the watershed, (4) the sources of sediment based on recent studies, and (5) the proposed sediment TMDLs and their rationales.

6.1 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 and wetland vegetation and natural instream barriers such as large woody debris (LWD), 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 fry. 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 cause water to appear murky and discolored, negatively impacting recreational use, and can increase filtration costs for water treatment facilities that provide safe drinking water.

6.2 STREAM SEGMENTS OF CONCERN

A total of five waterbody segments in the Flathead-Stillwater TPA appeared on the 2014 Montana 303(d) List for sediment impairments (**Figure 6-1**): upper Ashley Creek from Ashley Lake to Smith Lake (MT76O002_010), Fish Creek from the headwaters to the mouth at Ashley Lake (MT76O002_050), Logan Creek from the headwaters to Tally Lake (MT76P001_030), Sheppard Creek from the headwaters to the mouth at Griffin Creek (MT76P001_050) and the Stillwater River from Logan Creek to the mouth (MT76P001_010). Middle Ashley Creek from Smith Lake to the Kalispell Airport Road (MT76O002_020), lower Ashley Creek from the Kalispell Airport Road to the mouth at the Flathead River (MT76O002_030), and Haskill Creek from Haskill Basin Pond to the mouth at the Whitefish River (MT76P003_070) did not appear on the 2014 303(d) List for sediment impairments but are evaluated in this document. All of these segments except for middle Ashley Creek are also impaired for various forms of habitat alterations (**Table 1-1**), which are non-pollutant causes 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.

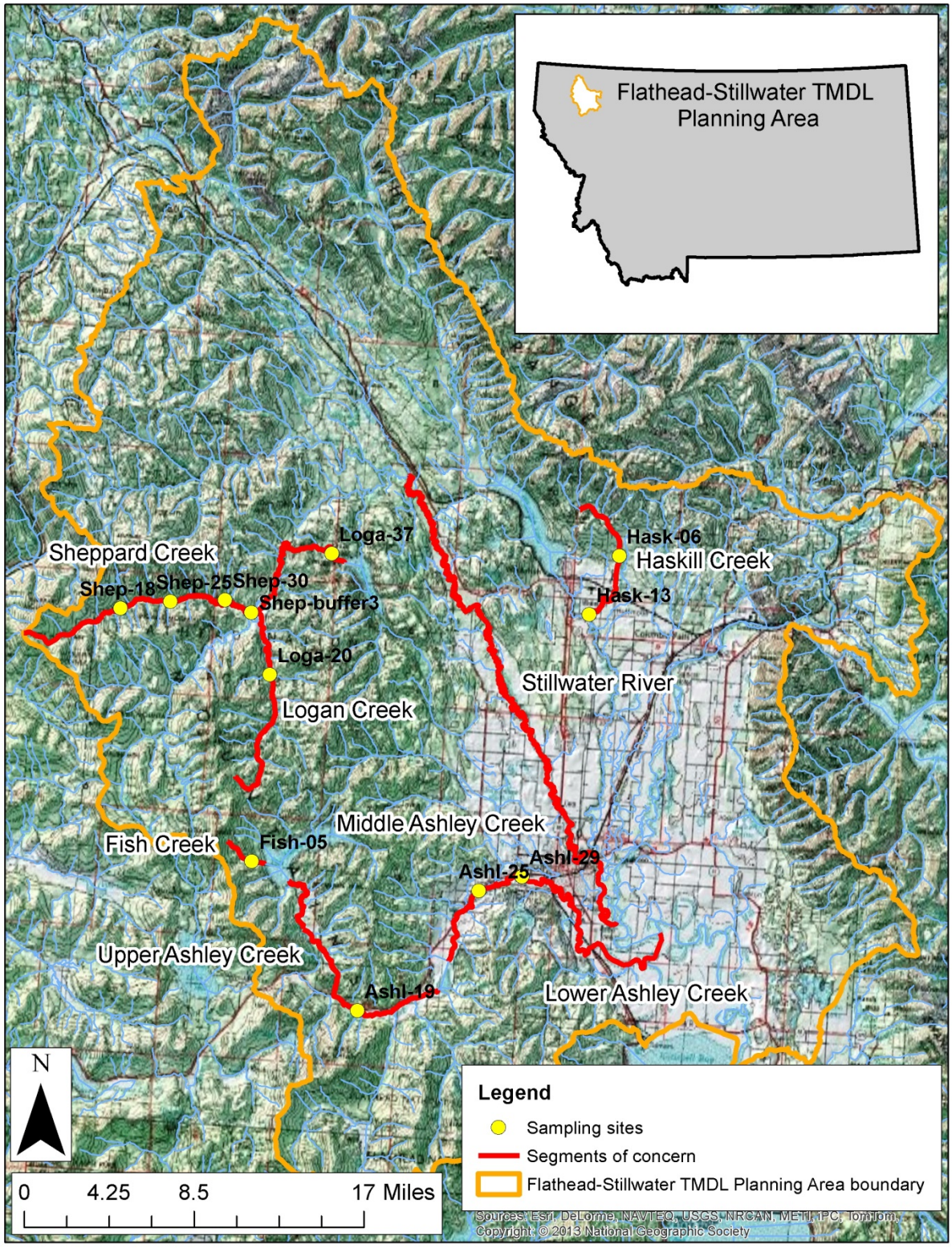


Figure 6-1. Streams segments evaluated in this document and sampling sites on these segments

6.3 INFORMATION SOURCES AND ASSESSMENT METHODS

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 6.6**, is focused on quantifying sources of sediment loading within the watershed.

6.3.1 Summary of Information Sources

To characterize sediment conditions for TMDL development purposes, a sediment data compilation was completed and additional monitoring was performed during 2008. The below listed data sources represent the primary information used to characterize water quality and/or develop TMDL targets.

- Department of Environmental Quality (DEQ) Assessment Files
- DEQ 2008 Sediment and Habitat Assessments (**Attachment A**)
- US Forest Service Pacfish/Infish Biological Opinion (PIBO) program data
- Other Data and Reports

6.3.2 DEQ Assessment Files

The DEQ assessment files contain information used to make the existing sediment impairment determinations. The assessment files include a summary of physical, biological, and habitat data collected and/or compiled by DEQ. 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 rationales.

6.3.3 DEQ's 2008 Sediment and Habitat Assessments

To aid in TMDL development, field measurements of channel morphology and riparian and instream habitat parameters were collected in September 2008 from 10 reaches within six of the eight segments of concern (**Figure 6-1**; note: Shep-30 and Shep-buffer3 were not sampled and only have descriptive information). An additional 10 reaches within the Flathead-Stillwater TPA were sampled during the same time period; descriptions of these sites and the associated data can be found in **Attachment A**.

Initially, all streams were assessed aerially to characterize reaches by four main attributes not linked to human activity: stream order, valley gradient, valley confinement, and ecoregion. These attributes represent main factors influencing stream morphology, which in turn influence sediment transport and deposition.

The next step in the aerial assessment involved identifying near-stream land uses, since land management practices can influence stream morphology and sediment characteristics. The result was stratifying streams 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, allowed DEQ to select monitoring reaches. Although ownership is not part of the reach type category, most reach type categories contain predominantly either private or public lands.

Monitoring reaches on sediment-listed streams were chosen to represent various reach characteristics, land-use categories, and human-caused influences. There was a preference toward sampling those reaches where human influences would most likely demonstrate impairment conditions, since one step in the TMDL development process is to further characterize sediment impairment conditions. Thus, this

is a targeted sampling design that aims to assess a representative subset of reach types, while ensuring that reaches within each 303(d) listed waterbody with potential sediment impairment conditions are incorporated into the overall evaluation. Typically, the effects of excess sediment are most apparent in low-gradient, unconfined streams (Nolan and Marron, 1985; Nolan and Marron, 1988; Coats et al., 1985; Montgomery and Buffington, 1997) larger than 1st order (i.e., having at least one tributary; (Strahler, 1952)); this stream type was the focus of the field effort (**Table 6-1**). Although the TMDL development process necessitates this targeted sampling design, DEQ acknowledges this approach results in less certainty regarding conditions in 1st order streams and higher-gradient reaches, and that conditions within sampled reaches do not necessarily represent conditions throughout the entire stream.

Table 6-1. Stratified Reach Types and Sampling Site Representativeness within the Flathead-Stillwater TMDL Planning Area

Level III Ecoregion	Reach Type	Reach ID	Number Sampled
Canadian Rockies	CR-0-2-U	EFSC-12	1
	CR-2-2-U	STIL-12; WFSC-08	2
	CR-2-4-U	STIL-19; STIL-23	2
Northern Rockies	NR-0-2-U	EFSC-15	1
	NR-0-3-U	**HASK-13**; **LOGA-20**; **SHEP-25**; WFSC-18	4
	NR-0-4-U	**ASHL-19**; **ASHL-25**; **ASHL-29**; LOGA-45; STIL-33	5
	NR-2-2-U	EFSC-16; **SHEP-18**	2
	NR-2-3-U	**HASK-06**	1
	NR-2-4-U	**LOGA-37**	1
	NR-4-1-U	**FISH-05**	1

Note: Bold reach IDs are within the segments of concern and are explicitly discussed in **Section 6.4.2**

The field parameters assessed in 2008 include measures of stream channel morphology, fine sediment, stream habitat, riparian vegetation, and streambank erosion (Montana Department of Environmental Quality, 2012b). Although the sampling areas are frequently referred to as "sites" within this document, to help increase sample sizes and capture variability within assessed streams, stream reaches ranging from 500 to 2,000 feet in length (depending on the channel bankfull width) were assessed. Sampling reaches were broken into five cells of equal length. Generally, a single cross section measurement, pebble count, and riffle grid toss are performed in each cell, and stream habitat, riparian, and bank erosion measures are performed throughout the reach. Field parameters are briefly described in **Section 6.4**, and summaries of all field data and sampling protocols are contained in the 2009 Sediment and Habitat Assessment report (**Attachment A**).

6.3.4 Other Data and Reports

Several other documents that provide historical context to sediment sources, describe the sensitivity of watersheds to disturbance, provide information about current conditions or sources, and describe restoration work that has taken place were also used to help evaluate conditions within the stream segments of concern. These documents include the: *State Forest Land Management Plan* (Montana Department of Natural Resources and Conservation, 2011) and *Revised Phase 1 Total Maximum Daily Load Report for the Stillwater River, Northwest Montana* (River Design Group, Inc., 2003), as well as other Department of Natural Resources & Conservation (DNRC), U.S. Forest Service (USFS), and contractor documents. Physical habitat and fish data collected by the USFS and DNRC was used to augment source assessment for individual streams.

6.4 WATER QUALITY TARGETS

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

In developing targets, natural variation within and among streams must be considered. As discussed in more detail in **Section 3.0** and **Appendix A**, 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 using reference site data, but modeling, professional judgment, and literature values may also be used. 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 past and current land use. Although sediment water quality targets typically relate most directly to the aquatic life beneficial use, the targets protect 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 from climate, bedrock, soils, hydrology, and other natural physiochemical differences, yet it allows differentiation between natural conditions and widespread or significant alterations of biology, chemistry, or hydrogeomorphology from human activity.

The basis for each water quality target value varies depending on the availability of reference data and sampling method comparability to the 2008 data. As discussed in **Appendix A**, there are several statistical approaches 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, how representative the data is, data variability, how severe human disturbance is to streams in the watershed, and the size of the dataset.

Additionally, the target value for some parameters may apply to all streams in the Flathead-Stillwater TPA, whereas others may be stratified by bankfull width, reach type characteristics (e.g., 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 that are achievable. MOS is discussed in additional detail in **Section 6.8.2**.

6.4.1 Targets

The sediment water quality targets for the Flathead-Stillwater TPA area are summarized in **Table 6-2** and described in detail in the sections that follow. These sediment-related targets are based on reference data from the Northern Rockies portion of the PIBO dataset, and sample data from East Fork Swift Creek and West Fork Swift Creek (both determined to be fully supporting by DEQ) during a 2008 DEQ sampling

effort. The raw data from the Flathead-Stillwater TMDL Planning Area (TPA) is available by request from DEQ.

Consistent with Environmental Protection Agency (EPA) guidance for sediment TMDLs (U.S. Environmental Protection Agency, 1999b), water quality targets for the Flathead-Stillwater TPA 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 or more target values does not necessarily equate to a determination that the information supports impairment; the relative 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 in **Table 6-2**, or special interpretation of the data relative to the sediment target values. Six of the targets described in **Table 6-2** (percentage of surface fine sediment in riffles < 2mm and < 6mm, percentage of surface fine sediment < 6mm in pool tails, bankfull width/depth ratio, residual pool depth, and pools/mile) are considered primary indicators of sediment impairment and are used by DEQ when making a sediment and/or habitat impairment determination (Kusnierz et al., 2013).

Table 6-2. Sediment Targets for the Flathead-Stillwater TMDL Planning Area

Parameter Type	Target Description	Criterion
Fine Sediment	Percentage of surface fine sediment in riffles via pebble count (reach average)[1]	A, B, & C channel types: 6 mm ≤ 17%; 2 mm ≤ 10% E channel types: 6 mm ≤ 30%; 2 mm ≤ 15%
	Percentage of surface fine sediment < 6mm in pool tails (reach average)[1]	Potential A & B channel types: ≤ 9% Potential C channel type: ≤ 24%
Channel Form and Stability	Riffle stability index	Potential B channel types only: ≤ 85
	Bankfull width/depth ratio (reach average; +/- 2.0 units)[1]	Potential A & E channel types: < 12 Potential B & C channel types: > 12
	Entrenchment ratio (reach average; +/- 0.2 units)	Potential A channel types: < 1.4 Potential B channel types: 1.4 – 2.2 Potential C & E channel types: > 2.2
Instream Habitat	Residual pool depth (reach average)[1]	< 38’ bankfull width: ≥ 0.8 feet ≥ 38’ bankfull width: ≥ 1.3 feet
	Pools/mile[1]	< 38’ bankfull width: ≥ 36 ≥ 38’ bankfull width: ≥ 25
Sediment Source	Significant and controllable sediment sources	Identification of significant and controllable anthropogenic sediment sources throughout the watershed and implementation of all appropriate best management practices
Biological Indices	Macroinvertebrate bioassessment metric	O/E ≥ 0.90
	Periphyton Increaser Taxa	Probability of Impairment ≤ 51%

[1] Primary indicator used to determine sediment and habitat impairment (Kusnierz et al., 2013)

6.4.1.1 Fine Sediment

The percent of surface fines <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 aquatic life beneficial use. 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 Bjornn, 1984; Weaver and Fraley, 1991; Shepard et al., 1984; Suttle et al., 2004; Fudge et al., 2008). 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 (Bjornn and Reiser, 1991; Mebane, 2001; Relyea et al., 2000). Bryce (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; however, because increasing concentrations of fine sediment are known to harm aquatic life, targets are developed using a conservative statistical approach consistent with **Appendix A** and consistent with Montana's water quality standard for sediment as described in **Section 3.2**in order to protect all beneficial uses.

Percent Surface 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 2008 were performed in three riffles per sampling reach for a minimum of 300 particles.

Riffle pebble count reference data collected for the PIBO dataset (1998 – 2003) were combined with pebble count data from East Fork Swift Creek and West Fork Swift Creek (n = 21) to determine the target for riffle substrate percent fine sediment <6 mm. This target is less than or equal to 17% based on the 75th percentile of the combined PIBO and DEQ datasets. PIBO data are not available for <2 mm but three sites on East Fork Swift Creek and two sites on West Fork Swift Creek were sampled for riffle fines <2 mm in 2008. These values ranged from 3 – 13%. Due to the lack of reference data, the target for <2 mm will be 10% based on the macroinvertebrate minimum effect level found by Bryce et al. (2010). Rosgen E channels tend to have a higher percentage of fine sediment than A, B, and C channels (which compose all of the 2008 DEQ assessment reaches); the PIBO riffle pebble count dataset was composed of B and C stream types. Although there is no robust dataset for E channel types in the Flathead-Stillwater TPA, (Bengeyfield, 2004) sampled 115 E channel reference sites in the Beaverhead Deerlodge National Forest; the target from this database is 30% fine sediment <6 mm with no data for particles <2 mm.

For A, B, and C channel types, 17% <6 mm and 10% <2 mm will be applied as fine sediment targets for riffle pebble counts. The target for riffle pebble count <6 mm is similar to that set in other TMDL documents within the Northern Rockies (e.g., Tobacco/Grave Creek/Prospect Creek/Kootenai-Fisher/Thompson: 15%, Yaak/Flathead Headwaters/St. Regis: 20%). The E channel target for riffle pebble fines <6 mm is 30%. Since the fine sediment <2 mm target for A, B, and C channels is roughly half of the

<6 mm target, this relationship was used to determine that 15% <2 mm will be applied as the riffle fine sediment target for E channels. The pebble count target values for E channels will carry less weight than for the other channel types because they are based on another ecoregion and have a higher level of uncertainty. Target values should be compared to the reach average value from pebble counts.

Percent Surface Fine Sediment <6mm in Pool Tails
Grid toss measurements in pool tails are a measure used to assess the level of fine sediment accumulation in potential fish spawning sites. A 49-point grid toss (Kramer et al., 1993) was used to estimate the percent surface fine sediment < 6mm in pool tails in the Flathead-Stillwater TPA, and three tosses, or 147 points, were performed and the average calculated for the spawning gravel substrate portion of each assessed pool tail. Riffle grid tosses were performed at all pool tails with potential spawning gravel (i.e., not all cobble).

For the pool tail grid toss targets, PIBO and the DEQ East Fork Swift Creek and West Fork Swift Creek pool tail data was used. The 75th percentiles of this combined dataset are 9% for A and B channel types and 24% for the C channels type. There is no target for the E channel type as the reference dataset only contained fine sediment pool tail values from two sites. The fines values from the 2008 DEQ dataset are likely lower than if they had been collected by PIBO as the DEQ method excludes pool tails where the assessor determined sediment was too coarse for spawning. This was done so that pools with substrate too large for fish to move and thus had no spawning potential, would not skew the dataset for a stream that does have pools with suitable spawning habitat. However, to be more comparable to available reference data, DEQ is changing its method to match PIBO protocols for pool tail grid toss. This change should be considered during future collection and evaluation of grid toss data in this project area, as a different target value may be necessary.

Reference data sets used for target setting for other TMDLs in the Northern Rockies ecoregion such as St Regis, Grave Creek, Prospect Creek, and Tobacco resulted in pool tail grid toss targets between 8% and 10%. For A and B channel types the pool tail grid toss target for fine sediment <6mm will be ≤ 9% for C and E channels, the target will be 26% <6 mm. Only two E channels were part of the dataset used to develop the target. As a result this target will carry less weight in E channels.

6.4.1.2 Channel Form and Stability
Parameters related to channel form indicate a stream's ability to store and transport sediment. Stream gradient and valley confinement are two significant controlling factors that determine stream form and function, however, alterations to the landscape and sediment input beyond naturally occurring amounts can affect channel form. Numerous scientific studies have found trends and common relationships between channel dimensions in properly functioning stream systems and those with a sediment imbalance. Two stream channel measurements and an indicator of stream bedload stability are used as targets in the Flathead-Stillwater TPA and are described below.

Width/Depth Ratio and Entrenchment Ratio
The width/depth ratio and the entrenchment ratio provide 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 (e.g., 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 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 when 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 indicate that stream energy is concentrated in-channel during flood events versus having energy dissipate to 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 as the average of five riffle cross-section measurements from each reach. In addition the potential stream type for each site was determined using valley type and parent material. The targets for width/depth ratio and entrenchment are based on those developed by (Rosgen, 1996) for specific stream types (see **Table 6-2**).

Riffle Stability Index

The Riffle Stability Index (RSI); (Kappesser, 2002) describes the mobile portion of substrate in a riffle. RSI has been shown to correlate with pool volume and to differ between reference and managed sites (Cross and Everest, 1995; Kappesser, 2002). In addition, (Cross and Everest, 1995) found bull trout (*Salvelinus confluentus*) redds nearly exclusively in reference streams with RSI less than 65. (Kappesser, 2002) suggests that when RSI values are greater than 85 in Rosgen B channel types they indicates poor watershed condition; therefore, the target for RSI in the Flathead-Stillwater TPA is 85 and is applicable to potential Rosgen B channel types.

6.4.1.3 Instream Habitat Measures

For instream habitat measures (i.e., residual pool depth and pool frequency), there is available reference data from PIBO. Both of the instream habitat measures are important indicators of sediment input and movement as well as fish and aquatic life support. However, 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.

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 (Bonneau, 1998; Nielson et al., 1994; 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 reduce fish condition by altering habitat, food availability, and productivity (May and Lee, 2004; Sullivan and Watzin, 2010). Residual pool depth is typically greater in larger systems.

Although the residual pool depth measure is similar between DEQ's method and PIBO's methods, the definition of a pool varies between the two methods. The core definition of a pool for the PIBO protocol is defined as a depression in the streambed bounded by a "head crest" at the upstream end and "tail

crest" at the downstream end with a maximum depth that is at least 1.5 times the pool tail depth and spans at least half of the wetted channel width (Archer et al., 2012). The DEQ method uses the PIBO definition of a pool but rather than including only pools that span at least half of the wetted width, pools are classified as large (> 2/3 bankfull channel width), medium (1/3 – 2/3 bankfull channel width), or small (< 1/3 bankfull channel width). When comparing the 2008 DEQ data for the Flathead-Stillwater TPA to the PIBO-based target, data from medium and large pools were combined. In comparison to the PIBO dataset, the 2008 sample dataset could have a smaller residual pool depth and a greater number of pools per mile since the DEQ protocol included smaller pools. However, residual pool depths in the sample dataset are generally not noticeably less than the PIBO depths (**Table 6-3**), indicating the slight protocol differences are not an issue and the reference dataset is appropriate to use for setting residual pool depth targets.

Table 6-3. Residual pool depth and pool count summary data for the 2008 Flathead-Stillwater and PIBO datasets

Dataset	Residual pool depth (feet)					Pools/mile				
	Min	25th	Median	75th	Max	Min	25th	Median	75th	Max
2008 Flathead-Stillwater	0.8	1.1	1.3	1.5	2.2	5	34	42	49	148
2001–2012 PIBO	0.6	0.9	1.2	1.9	4.6	4	28	40	56	261

The residual pool depth target differs based on the bankfull width of the stream site being sampled. The 25th percentile of the PIBO dataset combined with the DEQ East Fork Swift Creek and West Fork Swift Creek data for sites less than 38 feet bankfull width ($\geq$ 0.8 feet) and for sites at least 38 feet bankfull width ($\geq$ 1.3 feet) were chosen as targets for streams in the Flathead-Stillwater TPA. The target values should be assessed 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 2008 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.

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 aquatic life beneficial use for many of the same reasons associated with the residual pool depth discussed above and also because it can be a major driver of fish density (Muhlfeld et al., 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.

Similar to the residual pool depth values, protocol differences generally did not result in noticeable differences in the pool frequency (**Table 6-3**), indicating the PIBO reference dataset is suitable for setting targets. As with residual pool depth, the 25th percentile of the combined PIBO and East Fork Swift Creek and West Fork Swift Creek dataset were used to identify targets for stream reaches less than 38 feet bankfull width ($\geq$ 36 pools/mile) and for reaches at least 38 feet bankfull width ($\geq$ 25 pools/mile) for streams in the Flathead-Stillwater TPA. Pools per mile should be calculated based the number of measured pools per reach and then scaled up to give a frequency per mile.

6.4.1.4 Sediment Supply and Sources

Anthropogenic Sediment 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 Geographic Information System (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 6.6**, with additional information in **Attachments A, B, and C** and **Appendices B** and **C**.

6.4.1.5 Biological Indices

Macroinvertebrates

Siltation exerts a direct influence on benthic macroinvertebrates assemblages by filling in spaces between gravel and by limiting attachment sites. Macroinvertebrate assemblages respond to siltation with a shift towards an increase in biomass of burrowing species as fine sediment increases (Suttle et al., 2004). Macroinvertebrate bioassessment scores are an assessment of the macroinvertebrate assemblage at a site, and DEQ uses one bioassessment method to evaluate stream 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 macroinvertebrate assessment tool used by DEQ is the Observed/Expected model (O/E). The rationale and methodology for the index are presented in (Montana Department of Environmental Quality, 2012d; Feldman and Jessup, 2012). 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 for all Montana streams is any O/E value < 0.90. Therefore, an O/E score of ≥ 0.90 is established as a sediment target in the Flathead-Stillwater TPA.

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. 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 the macroinvertebrate target does not necessarily indicate a waterbody is fully supporting its aquatic life beneficial use. Measures that indicate an imbalance in sediment supply and/or transport capacity will be used in concert with macroinvertebrate data for TMDL development determinations.

The O/E model is very sensitive to the macroinvertebrate collection method and DEQ has determined that it is not appropriate to use the O/E model to evaluate macroinvertebrate health using samples

collected by the Hess or Surber methods. Unless noted otherwise, macroinvertebrate samples discussed within this document were collected according to DEQ protocols.

Periphyton

Periphyton are algae that live attached to or in close proximity to the stream bottom. Algae are ubiquitous in Montana surface waters, easy to collect, and represented by large numbers of species. Measures of the structure of algal associations, such as species diversity and dominance, can be useful indicators of water quality impacts and ecological disturbance.

DEQ collected periphyton from reference streams and from streams known to have excess sediment and used statistical analysis to identify taxa that tend to increase in the presence of excess sediment (Teply, 2010a; 2010b). Algal community composition and dynamics differs geographically, and DEQ has developed ecoregion-specific periphyton sediment metrics. The rationale and methodology for the periphyton-based metrics is presented in the DEQ Periphyton Standard Operating Procedure (Montana Department of Environmental Quality, 2011b). The metric is reported as a percent probability of impairment. According to (Montana Department of Environmental Quality, 2011b), a probability of impairment > 51% indicates sediment may be impairing aquatic life but should be used in conjunction with other data when assessing stream condition. Therefore, ≤ 51% probability of impairment will be applied as a target for the Flathead-Stillwater TPA, and it will be interpreted in the context of other indicators of sediment impairment for each stream.

6.4.1.6 Other Measurements

Percent Subsurface Fine Sediment < 6mm in spawning habitat via McNeil Core

The subsurface substrate in gravel-bottomed rivers tends to be finer than that of the surface layer (Parker and Klingeman, 1982). Because salmonid embryo development takes place in subsurface substrate, the percentage of subsurface fine sediment can be an important indicator of harm to aquatic life. Although the creation of redds by salmonids effectively reduces the amount of fines compared to non-redd substrate (MacDonald et al., 2010; McNeil and Ahnell, 1964), over time, the interstices can refill with fine sediment (Zimmerman and Lapointe, 2005). DEQ not does typically collect subsurface sediment data, however, Montana Fish Wildlife and Parks (FWP) has collected McNeil Core (McNeil and Ahnell, 1964) data from bull and cutthroat trout spawning habitat in the Stillwater River and its tributaries (River Design Group, Inc., 2003; Montana Department of Natural Resources and Conservation, 2011). The most downstream site where this data is collected is about 0.25 mile upstream of the Highway 93 crossing in Stryker, MT, well upstream of the listed segment of the Stillwater River. Because this data has been collected at a limited number of locations that are not within sediment-listed segments and it is not typically collected by DEQ, a specific target will not be assigned to subsurface fine sediment in spawning habitat. However, when available, this information may be useful for describing fine sediment levels.

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. Because LWD values can vary widely depending on the historical vegetation and land use there is no specific target for LWD; instead data collected by DEQ in 2008 can be used to track changes at sites over time and to inform the planning of restoration work on sediment-listed streams in the Flathead-Stillwater TPA.

Riparian Understory Shrub Cover

Interactions between the stream channel and the riparian vegetation along the streambanks are vital to the support of the aquatic life beneficial use. 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 can provide shading, cover, and habitat for fish. During assessments conducted in 2008, ground cover, understory shrub cover and overstory vegetation were cataloged at 10 to 20 foot intervals along the greenline at the bankfull channel margin along both sides of the stream channel for each monitoring reach (Watershed Consulting, LLC, 2009). 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 conifer forest. While there is specific target for riparian understory shrub, the data collected by DEQ in 2008 (**Attachment A**) can be used like that for LWD to track changes over time and inform restoration planning.

6.4.2 Existing Conditions and Comparison to Targets

This section includes a comparison of existing data with water quality targets, along with a TMDL development determination for each stream segment of concern in the Flathead-Stillwater TPA (**Section 6.2**). The TMDL development determination is whether or not recent data supports the impairment listing and whether a TMDL will or will not be completed, but it is not a formal impairment assessment. All waterbodies reviewed in this section are either listed for sediment impairment on the 2014 303(d) List or are suspected to be impaired by sediment. Although inclusion on the 303(d) list indicates impaired water quality, a comparison of water quality targets with existing data helps define the level of impairment and establishes a benchmark to help evaluate the effectiveness of restoration efforts. Images showing stream and streambank conditions for each of the following stream segments are found in Sections 3 and 4 respectively of **Attachment A**.

6.4.2.1 Upper Ashley Creek (MT76O002_010)

Upper Ashley Creek (MT76O002_010) is listed for sedimentation/siltation on the 2014 303(d) List. In addition, this segment is also listed for alteration in streamside or littoral vegetative covers, which is a non-pollutant listing commonly linked to sediment impairment. It was originally listed in 1988 because of excess sediment associated with crop production, grazing in riparian zones, and loss of riparian habitat. This segment flows 15.64 miles from Ashley Lake to Smith Lake through glacial till, which easily erodes, and areas of agriculture.

Physical Condition and Sediment Sources

The DEQ assessment file states that portions of this segment have been straightened and flow through grazed meadows. In some areas, rip rap is failing and high eroding banks are present. However, in other areas cattle are fenced out of the riparian zone and where there is no riprap, vegetation consists of sedges and grasses. It was noted that fine sediment is high in the upper part of the reach and downstream of Highway 2. Macroinvertebrate samples collected in the early 2000s indicated that fine sediment may be reducing access to stony substrate (Bollman, 2003a). Watershed Consulting, LLC (2002) identified a lack of willows, severe erosion, fine sediment deposition, and channelization within this segment. Erosion was likely exacerbated by high flows in 1997 and 1998; in areas where riparian grazing was restricted, shrub regeneration was occurring (Watershed Consulting, LLC, 2002).

In 2008, DEQ collected sediment and habitat data at one site on upper Ashley Creek (ASHL-19; **Figure 6-1**). This site was located in an area where there are active agricultural and grazing practices (**Attachment A**). The stream at this site had been channelize and was incised; there was active streambank erosion and lateral cutting. Pugging was observed adjacent to the channel. Streambanks were composed of sand and clay and most observed bank erosion was attributed to cropland (hay) and riparian grazing. Vegetation consisted primarily of grasses with very little woody vegetation (hawthorn, red osier dogwood).

Comparison with Water Quality Targets

The existing physical data in comparison with the targets for upper Ashley Creek are summarized in **Table 6-4**. The bioassessment data are located in **Table 6-5**. All bolded cells are not meeting the target; depending on the target parameter, this may equate to being below or above the target value.

Table 6-4. Existing sediment-related data for upper Ashley Creek relative to targets

Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean Bankfull Width (feet)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)	Channel Form (median)			Instream Habitat	
					% <6 mm[1]	% <2 mm[1]	Pool % <6mm[1]	W/D Ratio[1]	Entrenchment Ratio	Riffle Stability Index	Residual Pool Depth (feet)[1]	Pools / Mile[1]
ASHL-19	2008	15.5	**B4c**	E4[2]	**33**	14	19	11	**1.5**	--	1.2	37

[1] Primary indicator used to determine sediment and habitat impairment (Kusnierz et al., 2013)

[2] This classification is based on the review of aerial imagery and does not agree with the determination of B4 in **Attachment A**

Table 6-5. Bioassessment data for upper Ashley Creek

Values that do not meet the target threshold (0.90 for O/E and 51% for periphyton) are in bold.

Station ID	Collection Date	Collection Method	O/E	Periphyton
C11AHLYC06	9/16/2008	EMAP	--	33%

Summary and TMDL Development Determination

For fine sediment, the riffle pebble count < 6 mm exceeded the target value for a potential E stream and the riffle pebble count < 2 mm was 1% below the target. All channel form parameters except entrenchment ratio met the target values. Residual pool depth and pools/mile parameters also met the target values. The single periphyton sample for the segment was well within the target range. These results indicate that while the channel appears stable, there potentially is excess fine sediment moving through the system. Sampling additional sites, especially in forested areas, would be necessary to clearly determine whether upper Ashley Creek is meeting the water quality standard for sediment.

Crop production, grazing in riparian zones, and loss of riparian habitat were originally identified as substantial sediment sources to upper Ashley Creek. Evaluation performed by Wastershed Consulting (2002), and data collected by DEQ in 2008 (**Attachment A**) indicate that these sources continue to contribute fine sediment to the segment and that restoration and implementation of best management practices will reduce sediment input from these sources. Based on current land management practices

that are contributing human sources of sediment, the sensitivity of soils in the segment to erosion, the active human-caused erosion observed, and the inconclusive comparison of recent instream data to the targets, upper Ashley Creek will remain listed as impaired for sediment and a TMDL will be written.

6.4.2.2 Middle Ashley Creek (MT76O002_020)

Middle Ashley Creek (MT76O002_020) is not currently listed for sedimentation/siltation on the 2014 303(d) List. Because middle Ashley Creek is directly downstream of a sediment-listed segment (upper Ashley Creek; MT76O002_010) and land use is similar, it is being evaluated for sediment impacts to beneficial uses. This segment flows 14.17 miles from Smith Lake to the Kalispell Airport Road through glacial till and areas of agricultural production.

Physical Condition and Sediment Sources

Watershed Consulting, LLC (2002) identified portions of this segment as having a "dredged, uniform channel;" in addition, livestock was grazed along the stream and in some locations riparian vegetation was noted to be nonexistent. However, Watershed Consulting, LLC (2002) noted that some riparian fencing had been installed at the time of the 2001 field investigation.

In 2008, DEQ collected sediment and habitat data at two sites on middle Ashley Creek (ASHL-25 and ASHL-29; **Figure 6-1**). ASHL-25 was the upstream site in this segment and was located in an urban setting (**Attachment A**) between the Great Northern Historical Trail and Whalebone Drive. There was no cropland, grazing, or development along the site. The stream at this site appeared to have been channelized and some rip rap was present. Streambanks were composed primarily of coarse gravel, cobbles, and boulders with lesser amounts of fine gravel, sand, and clay. There was some natural bank erosion occurring. Vegetation consisted mostly of cottonwoods and shrubs with some reed canary grass. Impacts to the stream channel by beaver were noted.

ASHL-29 was located downstream of ASHL-25 and the Dern Road crossing. There was cropland and grazing along the site, but it appeared that the riparian area had been excluded from grazing (**Attachment A**). Most of the land use impacts at this site appeared historical and included vegetation removal and rip rap and rock barb installation. Streambanks were composed of a mix of coarse gravel, cobbles, boulders, fine gravel, sand and clay. Bank erosion was occurring throughout the site with the majority being attributed to past cropland and riparian grazing practices. Vegetation consisted primarily of reed canary grass but also contained woody shrubs and samplings.

Comparison with Water Quality Targets

The existing physical data in comparison with the targets for middle Ashley Creek are summarized in **Table 6-6**. There is currently no DEQ bioassessment data available for this segment. All bolded cells are not meeting the target; depending on the target parameter, this may equate to being below or above the target value.

Table 6-6. Existing sediment-related data for middle Ashley Creek relative to targets
Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean Bankfull Width (feet)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)	Channel Form (median)			Instream Habitat	
					% <6 mm[1]	% <2 mm[1]	Pool % <6 mm[1]	W/D Ratio[1]	Entrenchment Ratio	Riffle Stability Index	Residual Pool Depth (feet)[1]	Pools / Mile[1]
ASHL-25	2008	24	C4	C4	**20**	7	14	26	9.4	--	2.2	37
ASHL-29	2008	21.4	B4c	B4c	**29**	**13**	**55**	26	1.6	**100**	2.0	53

[1] Primary indicator used to determine sediment and habitat impairment (Kusnierz et al., 2013)

Summary and TMDL Development Determination
For fine sediment, the riffle pebble count < 6 mm exceeded the target at both sites while the riffle pebble count <2 mm and the pool grid toss results exceeded the target value only at ASHL-29. The channel form parameters met the target values at both sites with the exception of Riffle Stability Index which exceeded the target at ASHL-29 and indicates an unstable streambed. Residual pool depth and pools/mile parameters met the target values at both sites.

Although the two sites used for this assessment did not indicate that existing land use practices are a current source of sediment to middle Ashley Creek, historical practices are still having an effect. Aerial imagery shows that there are substantial portions of middle Ashley Creek that appear to be channelized and lacking riparian cover. In addition, sources of sediment in upper Ashley Creek are likely contributing fine sediment to this segment. This segment appears to generally have a wider riparian buffer than upper Ashley Creek; however, crop production remains a potential fine sediment source. The high percent fines values and Riffle Stability Index measured at ASHL-29 by DEQ in 2008 indicate a fine sediment problem within the segment. Based on the upstream and within segment human-caused sources of sediment and the comparison of recent instream data to the targets, middle Ashley Creek is impaired for sediment and a TMDL will be written.

6.4.2.3 Lower Ashley Creek (MT76O002_030)

Lower Ashley Creek (MT76O002_030) is not currently listed for sedimentation/siltation on the 2014 303(d) List. It is however, listed for alteration in streamside or littoral vegetative covers, which is a non-pollutant listing commonly linked to sediment impairment. Because lower Ashley Creek is downstream of a sediment-listed segment (upper Ashley Creek; MT76O002_010) and middle Ashley Creek and land use is similar, it is being evaluated for sediment impacts to beneficial uses. This segment flows 13.17 miles from Kalispell Airport Road to the mouth (Flathead River) through glacial till and areas of urbanization and agriculture.

Physical Condition and Sediment Sources
The DEQ assessment file states that portions of this stream segment have been straightened and the channel appears overwidened. In some areas the riparian area is well vegetated while in others there is little to no riparian vegetation present due to agricultural activities. The assessment file also references observations from 1987 indicating that the substrate was sand and silt. Macroinvertebrate samples

collected in the early 2000s indicated that fine sediment may be affecting stony substrates (Bollman, 2003a).

Comparison with Water Quality Targets

No physical data was collected by DEQ during the 2008 sampling. As a result, there is no physical data available for comparison to targets. However, there was one periphyton sample collected upstream of the Kalispell Wastewater Treatment Plant (WWTP), at the upstream extent of the segment (**Table 6-7**). This sample indicated a low likelihood of sediment impairment.

Table 6-7. Bioassessment data for Ashley Creek upstream of the Kalispell WWTP

Values that do not meet the target threshold (0.90 for O/E and 51% for periphyton) are in bold.

Station ID	Collection Date	Collection Method	O/E	Periphyton
C11AHLYC03	9/16/2008	EMAP	--	26%

Summary and TMDL Development Determination

The DEQ assessment record for lower Ashely Creek indicates the possibility of a fine sediment problem. The conditions in upper and middle Ashley Creek and the resulting sediment impairments (**Sections 6.4.2.1** and **6.4.2.2**) provide additional evidence that fine sediment values in lower Ashley Creek have a high probability of being elevated. Finally, this segment is currently listed for alteration in streamside or littoral vegetative covers, which is often linked to a sediment listing due to the increased loading that can result from removal of riparian vegetation. Based on this evidence, a TMDL will be written for lower Ashley Creek.

6.4.2.4 Fish Creek (MT76O002_050)

Fish Creek (MT76O002_050) is listed for sedimentation/siltation and solids (suspended/bedload) on the 2014 303(d) List. It was originally listed in 1992 because of excess sediment associated with silvicultural activities and unknown sources. This segment flows 2.39 miles from the headwaters to Ashley Lake through dense forest.

Physical Condition and Sediment Sources

Pre-1997 field assessment information in the DEQ assessment file states that Fish Creek had excessive bank instability and embeddedness and some channel instability. The assessment file also states that Montana FWP did work to improve channel stability in the 1980's to address sediment input from roads and timber harvest activities. Bollman (2004) performed a habitat assessment of Fish Creek at a site located 300 feet upstream from the Ashley Lake Road Crossing (C11FISHC10) and found that although overall habitat was in good condition, benthic substrate was embedded and there was moderate sediment deposition. Bollman (2004) also performed a bioassessment at the site and determined that the macroinvertebrate community was: "typical of near-pristine montane stream environs." The DEQ assessment file was updated for the 2014 Integrated Report (IR) as a result of a nutrient assessment that DEQ performed. Observations in the updated assessment include a stable stream channel, lush riparian area, best management plans (BMPs) in place on roads, and no grazing occurring.

In 2008, DEQ collected sediment and habitat data at one site on Fish Creek (FISH-05; **Figure 6-1**). This site was located in an area where timber harvest has occurred outside of the streamside management zone. The stream at this site had LWD that is forming pools with some surficial silt observed. Banks were composed of mostly sand and clay and all observed bank erosion was attributed to natural sources. Forest canopy was present along the stream within the riparian buffer; outside of this buffer the forest

had been harvested and was in a state of regeneration. The riparian buffer contained a diverse community of native shrubs and forbs.

Comparison with Water Quality Targets

The existing physical data in comparison with the targets for Fish Creek are summarized in **Table 6-8**. The bioassessment data are located in **Table 6-9**. All bolded cells are not meeting the target; depending on the target parameter, this may equate to being below or above the target value.

Table 6-8. Existing sediment-related data for Fish Creek relative to targets

Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean Bankfull Width (feet)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)	Channel Form (median)			Instream Habitat	
					% <6 mm[1]	% <2 mm[1]	Pool % <6 mm[1]	W/D Ratio[1]	Entrenchment Ratio	Riffle Stability Index	Residual Pool Depth (feet)[1]	Pools / Mile[1]
FISH-05	2008	8.54	A4	A4	16	7	3	9	**2.7**	**--**	0.8	148

[1] Primary indicator used to determine sediment and habitat impairment (Kusnierz et al., 2013)

Table 6-9. Bioassessment data for Fish Creek

Values that do not meet the target threshold (0.90 for O/E and 51% for periphyton) are in bold.

Station ID	Collection Date	Collection Method	O/E	Periphyton
C11FISHC01	7/9/2012	MAC R 500	**0.88**	--
C11FISHC01	8/13/2012	EMAP	--	37%
C11FISHC01	7/17/2013	EMAP	--	30%
C11FISHC02	7/9/2012	MAC R 500	**0.85**	**--**
C11FISHC03	7/9/2012	MAC R 500	0.95	**--**
C11FISHC10	10/16/2003	KICK – EMAP	**0.60**[1]	**61%**
C11FISHC10	9/8/2006	EMAP	--	**65%**
C11FISHC10	8/13/2012	EMAP	--	**57%**
C11FISHC10	7/17/2013	EMAP	--	41%
FC01	9/13/2005	EMAP	--	19%
FC02	9/13/2005	EMAP	--	32%
FC03	9/13/2005	EMAP	--	41%

[1]This sample was collected using the "Kick" method, not the "MAC R 500" method, which the O/E model was developed for. Therefore, caution should be used when interpreting this data.

Summary and TMDL Development Determination

All physical targets except for entrenchment ratio were met for Fish Creek (**Table 6-8**). However, entrenchment ratio is not a primary indicator of sediment impairment and its failure to meet the target when all of the primary indicators meet their respective targets is not indicative of a sediment problem. Three of the four macroinvertebrate samples for the segment did not meet the target; however two of the samples were close to the target and the sample from 10/16/2003 was collected using a method that the O/E model was not developed for and the information is of limited value. It is also important to note that the O/E model is not sediment specific and therefore not meeting the target does not necessarily indicate excessive sediment. Periphyton samples gave mixed results with two-thirds of the samples meeting the target. Although the biological results give a mixed signal with regards to possible

sediment impairment, they are not primary indicators. Because all of the primary indicators meet their respective targets, the biological data provide background information with respect to Fish Creek but do not determine whether or not there is a sediment impairment.

Timber harvest and unknown sources were originally identified as sediment sources to Fish Creek. Information collected by DEQ in 2008 at a representative site indicates that these sources are not contributing fine sediment to the segment in an amount that causes a failure to meet these targets (**Attachment A**). In addition, instream habitat targets are being met and bank erosion data (**Attachment A**) indicate that Fish Creek is in a stable state with the majority of sediment input coming from natural sources. The roads present and timber harvest occurring in the watershed appear to be managed such that any contribution of sediment and/or channel instability is minimal. Based on this evaluation Fish Creek is not impaired by either sedimentation/siltation or solids (suspended/bedload); Fish Creek will be removed from the 303(d) for these impairments and a TMDL will not be written. This change will be reflected on the 2016 Montana 303(d) List.

6.4.2.5 Haskill Creek (MT76P003_070)

Haskill Creek (MT76O003_070) has not been previously assessed by DEQ for any pollutant. The assessment unit spans 8.43 miles from Haskill Basin Pond to the Whitefish River through glacial till. Two tributaries of this segment (Second, and Third creeks) have water supply intakes for the City of Whitefish that are actively maintained (Water Consulting, Inc., 2003). Land use in the watershed consists primarily of forested timber lands with commercial (i.e., Whitefish Mountain Resort) and urban development, residential, and agriculture being smaller components; the upper portion of the watershed tends to be forested whereas the lower portion is dominated by agriculture (River Design Group, Inc., 2007). From the 1960s to the present, timber harvest, ski area development and road building has occurred in the watershed (Water Consulting, Inc., 2003). The hydrology of this watershed is such that spring runoff is influenced by rain-on-snow and rain-on snowmelt events (Water Consulting, Inc., 2003). High magnitude flood events occurred in this watershed in 1967, 1969, 1973, and 1995 as a result of high precipitation and snowpack and human activities in the headwaters (U.S. Department of Agriculture, Forest Service, Flathead National Forest, 1995). The watershed has been modified by channel straightening and vegetation removal (Water Consulting, Inc., 2003). Multiple evaluations have indicated sediment as a pollutant of concern, especially lower in the watershed (Water Consulting, Inc., 2003; River Design Group, 2004; Bollman, 2006).

Physical Condition and Sediment Sources

Water Consulting, Inc. (2003) inventoried fine sediment sources in the summer and fall of 2002. They found that modification of the Haskill Creek stream channel had caused an increase in fine sediment loading and channel instability, and a reduction in aquatic habitat quality and quantity. In addition they determined that medium- to high-risk sources of sediment were present throughout the watershed with those at higher elevations typically being associated with commercial and private development and those at lower elevations being associated with agriculture. Road crossings were not considered to be a significant source of sediment as best management practices were being implemented; however, Water Consulting, Inc. (2003) did identify three moderate to high risk crossings (one on Haskill Basin Road and two on First Creek) and made recommendations for fixing them. During this evaluation, excessive fine sediment (i.e., embeddedness of 50 – 100% and a pebble count with 63% fine sediment < 6.35 mm in First Creek) was observed in pool tails and riffles in headwater areas upstream of the segment of concern. Directly downstream of Haskill Basin Pond, Water Consulting, Inc. (2003) observed excessive sediment deposition and an aggraded channel with reduced sediment transport capacity. Further

downstream as Haskill Creek enters and flows across the valley, active streambank erosion was present and the channel was incised and had lost connectivity to the floodplain.

River Design Group (2004) gives a summary of the information found in Water Consulting, Inc. (2003), but also provides additional information regarding pollutant sources. River Design Group (2004) found that more than 95% of the effective contribution area for upland sediment to Haskill Creek came from commercial land use in the First Creek portion of the watershed; the majority of this area was associated with roads and native material parking lots. The three land uses with the greatest effective contribution area to instream channel sediment in this study were agriculture (37%), commercial (36%) and commercial forest (18%). It appears that First Creek typically contributes more fine sediment relative to other tributaries in the Haskill Creek watershed as indicated by Total Suspended Solids (TSS) data collected by the F.H. Stolze Land and Lumber Company from 1998 – 2003 and synoptic sampling by Water Consulting Inc. in 2003 (River Design Group, 2004).

Bollman (2006) evaluated macroinvertebrate samples collected throughout the Haskill Creek watershed. Samples indicated a gradient of water quality with the best being at the upstream sites. The two most downstream sites indicated fine sediment as potential pollutant affecting the macroinvertebrate community.

Substantial mitigation and restoration activities have occurred in the Haskill Creek watershed. Specific to the ski area, a basin is used to capture sediment at the base of Big Ravine; this effort requires removal of deposited sediment and ongoing maintenance (Water Consulting, Inc., 2003). Restoration work occurred on about 1,200 feet of Haskill Creek in 2005 with maintenance occurring in 2007 (River Design Group, 2008b) and post-monitoring data collection in 2008 (River Design Group, 2008a). An evaluation by (Grubb, 2014) indicated that the project appeared to be effective at stabilizing banks and reducing fine sediment loading. As of March, 2014, the US Forest Service has slated $7 million from the Forest Legacy Program to protect more than 3,000 acres in the Haskill Creek watershed from development (Priddy, 3/10/2014).

In 2008, DEQ collected sediment and habitat data at two sites in Haskill Creek (HASK-06 and HASK-13; **Figure 6-1**). HASK-06 was located in an area that experienced past logging including the removal of large cedar trees (**Attachment A**). The channel at this site appeared to be in good condition and in the process of recovery. The streambanks consisted primarily of gravel and most erosion was attributed to natural sources. A healthy riparian vegetation community consisting of fir, birch, alder, cottonwood, and red osier dogwood was present.

HASK-13 had little evidence of current land use impacts but was located downstream of several reaches with active agriculture and the stream channel appeared to be modified by beaver activity (**Attachment A**). There was some indication that floodplain grazing had occurred in the past and the channel was overwidened as a result; silt dominated the streambed. The streambanks consisted primarily of fine gravel and silt/clay; all observed erosion at this site was attributed to natural sources. The vegetative community consisted of a mix of shrubs, but reed canary grass may have been inhibiting shrub regeneration.

Comparison with Water Quality Targets

The existing physical data in comparison with the targets for Haskill Creek are summarized in **Table 6-10**. The bioassessment data are located in **Table 6-11**. Two of the bioassessment samples were collected at sites upstream of the segment of concern and help describe biological communities throughout the

watershed. All bolded cells are not meeting the target; depending on the target parameter, this may equate to being below or above the target value.

Table 6-10. Existing sediment-related data for Haskill Creek relative to targets

Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean Bankfull Width (feet)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)	Channel Form (median)			Instream Habitat	
					% <6mm[1]	% <2mm[1]	Pool % <6mm[1]	W/D Ratio[1]	Entrenchment Ratio	Riffle Stability Index	Residual Pool Depth (feet)[1]	Pools / Mile[1]
HASK-06	2008	23.2	B4	B4	11	6	**16**	17	1.7	**92**	2.1	42
HASK-13	2008	25.7	C5	C5	**94**	**91**	--	12	5.6	--	2.2	37

[1] Primary indicator used to determine sediment and habitat impairment (Kusnierz et al., 2013)

Table 6-11. Bioassessment data for Haskill Creek

Values that do not meet the target threshold (0.90 for O/E and 51% for periphyton) are in bold.

Station ID	Collection Date	Collection Method	O/E[1]	Periphyton
C09HSKLC01	8/20/2012	EMAP	--	**53%**
C09HSKLC02	8/20/2012	EMAP	--	50%
C09HSKLC03	8/20/2012	EMAP	--	37%
C09HSKLC04	8/21/2012	EMAP	--	48%
C09HSKLC05[1]	8/21/2012	EMAP	--	42%
C09HSKLC06[1]	8/21/2012	EMAP	--	42%

[1]Sites are located upstream of the segment of concern

Summary and TMDL Development Determination

For fine sediment, the riffle pebble count for HASK-13 fails the targets for both percent < 6 mm and < 2 mm. The pool grid toss target was exceeded at HASK-06. The channel form parameters met the target values with the exception of riffle stability index at HASK-06 which indicates an unstable streambed. Residual pool depth and pool frequency parameters met the target values at both sites. Although no macroinvertebrate samples were collected in 2012, samples collected by (Bollman, 2006) indicate sediment could be affecting the community at the two lowermost sites. Many of the periphyton samples collected in 2012 are near the target with the most downstream site exceeding the target.

Evaluations by Water Consulting, Inc. (2003) and River Design Group (2004) and data collected by DEQ in 2008 (**Attachment A**) indicate that commercial and agricultural activities and bank erosion are contributing fine sediment to the segment and that restoration and implementation of best management practices will reduce sediment input from these sources. Based on current land management practices that are contributing human sources of sediment, the active human-caused erosion observed, and the comparison of recent instream data to the targets, Haskill Creek is impaired for sediment and a TMDL will be written.

6.4.2.6 Logan Creek (MT76P001_030)

Logan Creek (MT76P001_030) is listed for sedimentation/siltation on the 2014 303(d) List. In addition, this segment is listed for physical substrate habitat alterations, which is a non-pollutant listing

commonly linked to sediment impairment. The stream was originally listed in 1988 because of excess sediment associated with silvicultural activities, streambank modification/stabilization, and forest roads. This segment of Logan Creek flows 21.16 miles from its headwaters to Tally Lake primarily through forested lands and fine soils.

Physical Condition and Sediment Sources

Road building and timber harvest in the upper portion of the Logan Creek watershed began in the 1970s with most timber harvest occurring since 1985 when the Flathead National Forest voluntarily committed to using BMPs (Stevens, 2003). Stevens (2003) noted that there was little evidence of riparian harvest in the upper watershed. The DEQ assessment file notes the observation of sediment clogging riffles and pools in a 2003 DEQ field assessment. In addition, the file contains a review of historical literature related to road building and timber harvest in the Logan Creek watershed and the decreased habitat quality and increased sediment loading that occurred as a result. Specifically, U.S. Department of Agriculture, Forest Service, Flathead National Forest (2001) noted that past activities in the watershed have increased sediment load and decreased channel stability and that upper Logan Creek (above Star Meadow) has fine sediment levels that may be greater than the historical range. In addition, U.S. Department of Agriculture, Forest Service Flathead National Forest (2004a) stated that the road system is the primary anthropogenic source of sediment to Logan Creek and that some of its tributaries are susceptible to accelerated bank erosion due to the soils present. Modeled sediment loading from roads in the watershed indicated that in the headwaters of Logan Creek sediment loading had increased 687% over the unmanaged condition (U.S. Department of Agriculture, Forest Service, Flathead National Forest, 2004a).

In July 2003, macroinvertebrate and periphyton samples were collected from three locations on Logan Creek within the sediment-impaired segment. Bollman (2003b) analyzed the macroinvertebrate samples and determined that they were representative of "undisturbed" conditions and that no "evidence of fine sediment deposition compromising instream habitats" was detected. The periphyton samples from this segment were interpreted by Bahls (2004) who stated that they "indicated minor stress but full support of aquatic life uses at all three sites." Bahls (2004) also suggested that the results of the upper two sites indicated "minor sedimentation." During September 2005, a single sample was collected from the sediment-impaired segment of Logan Creek. This sample suggested good water quality and "insignificant" sediment deposition (Bollman, 2006).

Reducing sediment loading to the Logan Creek watershed was a goal of the *Logan Creek Ecosystem Restoration Project* (U.S. Department of Agriculture, Forest Service, Flathead National Forest, 2004a; 2004b). Subsequent to the US Department of Agriculture record of decision for this project (U.S. Department of Agriculture, Forest Service, Flathead National Forest, 2004b) BMPs have been implemented on 155.5 miles of roads in the Logan Creek Drainage in association with timber sales (Guenthner, Mitch, personal communication, 2014[3]); **Appendix C**). In the Griffin Creek watershed (a tributary of Logan Creek), the USFS plans on implementing about 85 miles of road BMP improvements beginning this year (Guenthner, Mitch, personal communication, 2014[4]).

In 2008, DEQ collected sediment and habitat data at two sites in this segment of Logan Creek (LOGA-20 and LOGA-37; **Figure 6-1**). LOGA-20 was located upstream of Star Meadow in a spruce forest with minimal human impacts (**Attachment A**). However, evidence from past logging was observed. The

[3] Personal communication by e-mail between Paul Kusnierz (DEQ) and Mitch Guenther (USFS), 6/27/2014
[4] Personal communication by e-mail between Paul Kusnierz (DEQ) and Mitch Guenther (USFS), 10/6/2014

channel at this site appeared to have diverse habitat but sediment deposits were common and the channel appeared overwidened in areas. Streambanks consisted primarily of sand and clay and all observed erosion was attributed to natural sources. A diverse riparian vegetation community consisting of native species was present.

LOGA-37 was located about 1 mile upstream of Tally Lake; it had little evidence of current land use impacts on the channel but was located within 300 feet of an active road (**Attachment A**). The stream channel was boulder dominated and stable. No bank erosion was observed. The vegetative community was less diverse than that at LOGA-20 but no invasive species were observed.

Comparison with Water Quality Targets

The existing physical data in comparison with the targets for Logan Creek are summarized in **Table 6-12**. The bioassessment data are located in **Table 6-13**. All bolded cells are not meeting the target; depending on the target parameter, this may equate to being below or above the target value.

Table 6-12. Existing sediment-related data for Logan Creek relative to targets

Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean Bankfull Width (feet)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)	Channel Form (median)			Instream Habitat	
					% <6 mm[1]	% <2 mm[1]	Pool % <6 mm[1]	W/D Ratio[1]	Entrenchment Ratio	Riffle Stability Index	Residual Pool Depth (feet)[1]	Pools / Mile[1]
LOGA-20	2008	20.9	C4	C4	**31**	**20**	15	16	5	**--**	1.4	79
LOGA-37	2008	56.4	B3	B3	3	2	--	35	1.4	--	1.3	42

[1] Primary indicator used to determine sediment and habitat impairment (Kusnierz et al., 2013)

Table 6-13. Bioassessment data for Logan Creek

Values that do not meet the target threshold (0.90 for O/E and 51% for periphyton) are in bold.

Station ID	Collection Date	Collection Method	O/E	Periphyton
C09LOGNC01	7/8/2003	EMAP	--	32%
C09LOGNC02	7/8/2003	EMAP	--	24%
C09LOGNC03	7/8/2003	EMAP	--	29%

Summary and TMDL Development Determination

The riffle pebble count exceeded both targets at LOGA-20 and met both at LOGA-37. The grid toss target was met at LOGA-20, and all channel form and instream habitat targets were met targets at both sites. None of the biological samples indicate impairment.

Evaluation by DEQ and U.S. Department of Agriculture, Forest Service, Flathead National Forest (2004a) demonstrated that past management practices have contributed elevated levels of sediment to the stream channel. The physical data and observations made by DEQ in 2008 (**Table 6-12** and **Attachment A**) indicate that the effects of these past activities are still present despite implementation of roads BMPs and changes in timber harvest practices. It is possible that under the current management regime, as time passes, the fine sediment measurements will achieve target values. However, continued restoration and implementation of BMPs in the watershed should be implemented and maintained as

needed. Based on historical land management practices that may still be contributing human sources of sediment and the comparison of recent instream data to the targets, Logan Creek is impaired for sediment and a TMDL will be written.

6.4.2.7 Sheppard Creek (MT76P001_050)

Sheppard Creek (MT76P001_050) is a tributary of Logan Creek that is listed for sedimentation/siltation on the 2014 303(d) List. In addition, this segment is listed for alteration in streamside or littoral vegetative covers, which is a non-pollutant listing commonly linked to sediment impairment. It was originally listed for siltation in 1998 because of sediment impacts from agriculture, range land, and silviculture, but the impairment was removed in 2000 due to insufficient data. However, the impairment was re-listed in 2006 because of excess sediment associated with timber harvest, grazing in riparian or shoreline zones, and forest roads. Sheppard Creek flows 15.92 miles from its headwaters to its mouth at Griffin Creek. The upper 2.4 miles of Sheppard Creek contains a genetically pure population of westslope cutthroat trout and has been part of a US Forest service-led cutthroat trout conservation project since 2001 (Gardner, 2014).

Physical Condition and Sediment Sources

The DEQ assessment file states that in 1989, partially filled pools and embedded riffles were observed in the upper reaches of this section and the middle reaches commonly had bank erosion and fine sediment deposits. More recent observations indicate that the upper reaches have limited bank erosion, "somewhat embedded" substrate and a veneer of silt on pool substrates and in the channel margins. The assessment file also describes fine sediment increasing in the downstream direction with the most substantial disturbance to Sheppard Creek being in Star Meadows where habitat and vegetation have been altered by grazing and hay production that occurs up to the channel margins.

Macroinvertebrate samples collected in the 2004 indicated that at the uppermost site the community was indicative of an "unimpaired montane" while at the middle site there was the potential indication of sediment deposition and "water quality degradation and habitat disruption" at the most downstream site (Bollman, 2005). It should be noted that the most downstream site was in Star Meadows, which, in addition to being influenced by grazing and hay production also contains historic and current beaver activity.

As indicated in **Section 6.4.2.6**, reducing sediment loading to the Logan Creek watershed was a goal of the *Logan Creek Ecosystem Restoration Project* (U.S. Department of Agriculture, Forest Service, Flathead National Forest, 2004a; 2004b). Subsequent to the record of decision for this project (U.S. Department of Agriculture, Forest Service, Flathead National Forest, 2004b), BMPs have been implemented on 48.89 miles of roads in the Shepard Creek drainage in association with timber (Guenthner, Mitch, personal communication, 2014[5]; **Appendix C**). Since 2007, 75 miles of ditches and culverts have been cleaned, eight culverts have been upgraded in small tributaries, and upgraded aquatic organism passage culverts have been installed on Dunsire, Upper Sheppard, and Listle creeks (Kendall, Craig, personal communication, 2014[6].

In 2007 the Brush Creek fire burned the upper portion of the Sheppard Creek watershed and the US Forest Service proposed post-fire harvest of marketable wood products (U.S. Department of Agriculture, Forest Service, Flathead National Forest, Tally Lake Ranger District, 2008a). The Record of Decision (U.S.

[5] Personal communication by e-mail between Paul Kusnierz (DEQ) and Mitch Guenther (USFS), 6/27/2014
[6] Personal communication by e-mail between Paul Kusnierz (DEQ) and Craig Kendall (USFS), 9/30/2014

Department of Agriculture, Forest Service, Flathead National Forest, Tally Lake Ranger District, 2008b) for this action indicated that as part the implementation no new roads would be created, monitoring of wildlife, fish, soils, water, and vegetation would take place, and BMPs would be implemented to protect water quality. As part of BMP implementation BMPs will be monitored, evaluated, and maintained (U.S. Department of Agriculture, Forest Service, Flathead National Forest, Tally Lake Ranger District, 2008a).

In 2008, DEQ collected sediment and habitat data at two sites on Sheppard Creek (SHEP-18 and SHEP-25; **Figure 6-1**). In addition, two sites (SHEP-30 and SHEP-BUFFER3; **Figure 6-1**) were visited and observations were recorded. SHEP-18 was located about 3-4 miles below Sylvia Lake in a burned area (**Attachment A**). A forest road paralleled the stream, but it was not an obvious source of sediment. The channel at this site appeared to be well armored with large angular rock; pools were predominantly found in the upper portion of the site. LWD was causing scour. Streambanks consisted primarily of sand and clay and all observed erosion was attributed to natural sources. The riparian community had recently been completely burned. Standing dead trees were present along the stream. Alders were resprouting and riparian forbs and grasses were the most common vegetation.

SHEP-25 was also located in a burned area (**Attachment A**). The stream channel contained boulders and was well-armored with angular rock. Streambanks consisted primarily of sand and clay and all observed erosion was attributed to natural sources. The riparian community had recently been completely burned. However, riparian shrubs were regenerating and native forbs were dominant.

SHEP-30 was located in Star Meadow. The site appeared to be recovering from past grazing; there was little cow manure and no recent hoof-shear observed. The channel at the site was not wadeable (too deep) due to beaver activity. The stream bottom was mostly silt. Streambank erosion was present on outside bends. Riparian vegetation consisted of sedges and willows. At some locations within the site pasture/grass was present.

SHEP-BUFFER3 was also located in Star Meadow. Grazing impacts were observed where cattle had access to the stream; however, most of the stream was too incised for cattle to access. The stream channel was not wadeable in areas due to depth. As with SHEP-30, the stream bottom was mostly fine sediment, but large cobbles were also observed. The deep pools and sedimentation appeared to be the result of past beaver activity. Some high eroding banks were present, and some of these banks were being eroded by cattle use. Riparian vegetation was dominated by reed canary grass with shrubs being infrequent and heavily browsed.

Comparison with Water Quality Targets

The existing physical data in comparison with the targets for Sheppard Creek are summarized in **Table 6-14**. The bioassessment data are located in **Table 6-15**. All bolded cells are not meeting the target; depending on the target parameter, this may equate to being below or above the target value.

Table 6-14. Existing sediment-related data for Shepard Creek relative to targets

Values that do not meet the target are in bold.

Reach ID	Assessment Year	Mean Bankfull Width (feet)	Existing Stream Type	Potential Stream Type	Riffle Pebble Count (mean)		Grid Toss (mean)	Channel Form (median)			Instream Habitat	
					% <6 mm[1]	% <2 mm[1]	Pool % <6 mm[1]	W/D Ratio[1]	Entrenchment Ratio	Riffle Stability Index	Residual Pool Depth (feet)[1]	Pools / Mile[1]
SHEP-18	2008	18.8	C4b	C4b	16	6	8	14	2.7	--	1.1	74
SHEP-25	2008	23.7	C3	C3	8	3	10	17	3.4	--	1.4	48

[1] Primary indicator used to determine sediment and habitat impairment (Kusnierz et al., 2013)

Table 6-15. Bioassessment data for Sheppard Creek

Values that do not meet the target threshold (0.90 for O/E and 51% for periphyton) are in bold.

Station ID	Collection Date	Collection Method	O/E	Periphyton
C09SHEPC01	7/30/2004	KICK – EMAP	1.03[1]	21%
C09SHEPC02	8/1/2004	KICK – EMAP	**0.84**[1]	47%
C09SHEPC02	9/8/2006	EMAP	--	46%
C09SHEPC03	7/31/2004	JAB – EMAP	**0.35**[2]	**88%**
C09SHEPC04	8/14/2012	EMAP	--	**60%**
C09SHEPC05	8/14/2012	EMAP	--	41%
C09SHEPC06	8/14/2012	EMAP	--	**60%**
C09SHEPC07	8/15/2012	EMAP	--	42%
C09SHEPC07	7/17/2013	EMAP	--	20%

[1]This sample was collected using the "Kick" method, not the "MAC R 500" method, which the O/E model was developed for. Therefore, caution should be used when interpreting this data

[2]This sample was collected using the "Jab" method, not the "MAC R 500" method, which the O/E model was developed for. Therefore, caution should be used when interpreting this data

Summary and TMDL Development Determination

All physical data targets were met at SHEP-18 and SHEP-25. Because SHEP-30 and SHEP-BUFFER3 were not wadeable, no physical data was collected from those two sites. Biological samples yielded mixed results with one-third of the periphyton samples and two-thirds of the macroinvertebrate samples not meeting their respective targets.

The physical data and observations made by DEQ in 2008 (**Table 6-14** and **Attachment A**) indicate that Sheppard Creek does not appear to have a fine sediment problem in the upper sections. However, no data was collected at the two sites in Star Meadow and human-caused sources of bank erosion were observed at both assessment sites. Due to the current sediment listing, the lack of information for Sheppard Creek in Star Meadow, and the current land use in the area, Sheppard Creek will remain listed as impaired for sediment and a TMDL will be written.

6.4.2.8 Stillwater River (MT76P001_010)

The Stillwater River (MT76P001_010) is listed for sedimentation/siltation on the 2014 303(d) List. In addition, this segment is listed for alteration in streamside or littoral vegetative covers, which is a non-pollutant listing commonly linked to sediment impairment. It was originally listed in 1988 because of loss

of riparian habitat, site clearance (land development or redevelopment), and upstream sources. This segment of the Stillwater River flows 45.61 miles from Logan Creek to the mouth (Flathead River).

The Stillwater River from Logan Creek to Highway 93 is dominated by a low gradient channel with a pool/riffle ratio of 102 to 1, high banks, and fine sediment substrate (Ganser, 1981). Ganser (1981) performed an analysis of the Stillwater River in which he looked at human impacts to the river via aerial images and by floating the river. In this analysis Ganser (1981), indicated that Logan Creek contributed a large volume of sediment to the Stillwater River, 17% of Stillwater River banks were eroding, and that 55 livestock concentration areas were observed in the Stillwater River floodplain. Downstream of Highway 93 the Stillwater River transitions into a steeper gradient channel with a pool/riffle ratio of 1.4 to 1 and much less fine sediment. In 1979, in this portion of the segment, 8.2% of banks were eroding and 9.9% of the streambank was either rock rip rap or car bodies as rip rap (Ganser, 1981).

DEQ has not collected physical data from this portion of the Stillwater River. However, in September 2012, DEQ observed the Stillwater River by boat to help evaluate the sediment and alteration in stream-side or littoral vegetation covers listings. This float covered about 20 miles from Spring Prairie Road to Lawrence Park (**Figure 6-2**). In the section from Spring Prairie Road to West Reserve Drive, the river was entrenched with a substrate consisting of silt and clay making it a Rosgen F6 channel type, which "are very sensitive to disturbance and adjust rapidly to changes in flow regime and sediment supply from the watershed" (Rosgen, 1996). This area was sparsely populated and little evidence of livestock was observed near the channel. Eroding banks were observed periodically (**Figure 6-3**); these were typically at meander beds with most of this erosion being attributed to natural causes. Steep, densely vegetated banks were generally stable. Riparian vegetation consisted of large coniferous trees and woody shrub species, but also canary reed grass with some native grasses and sedges. Locations where riparian vegetation had been removed at some point in the past were limited, but this accelerated erosion in some instances (**Figure 6-4**). In the section from West Reserve Drive to Lawrence Park, the river was an entrenched Rosgen C channel type (Rosgen, 1996) with well-defined pool/riffle sequencing and point bars with a substrate dominated by cobble. Bank material in this section shifted from all clay to a layer of unconsolidated cobbles and gravel. Vegetation was cleared right up to the river edge in many places along the golf course, and bank instability was more common than in the upstream section. DEQ observed evidence of efforts to stabilize the banks in many locations along the golf course; this included coir fabric bank layering and willow plantings in a number of locations (**Figure 6-5**) and a few locations with riprap (**Figure 6-6**).

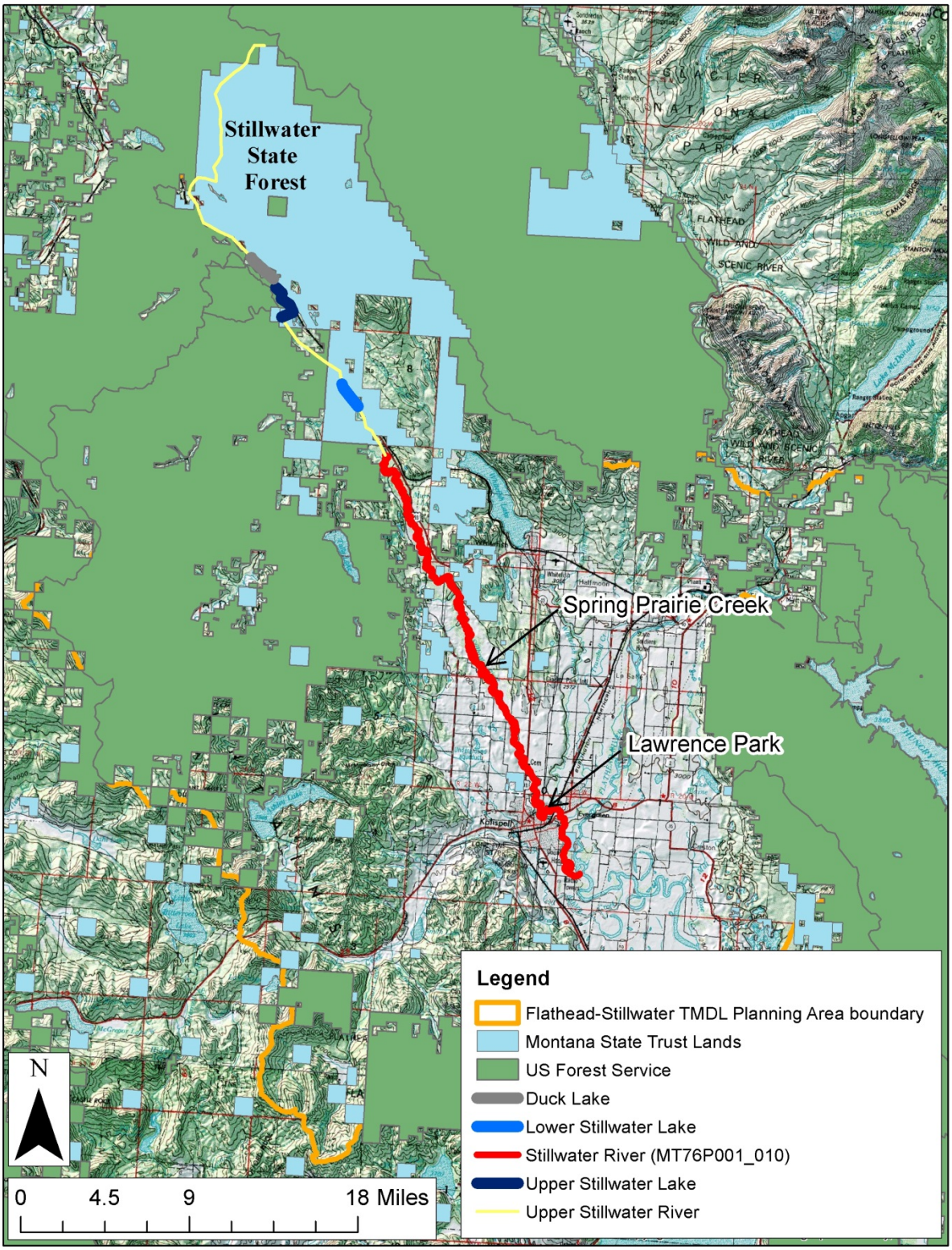


Figure 6-2. The Stillwater River near Kalispell, MT



Figure 6-3. Eroding banks on the Stillwater River

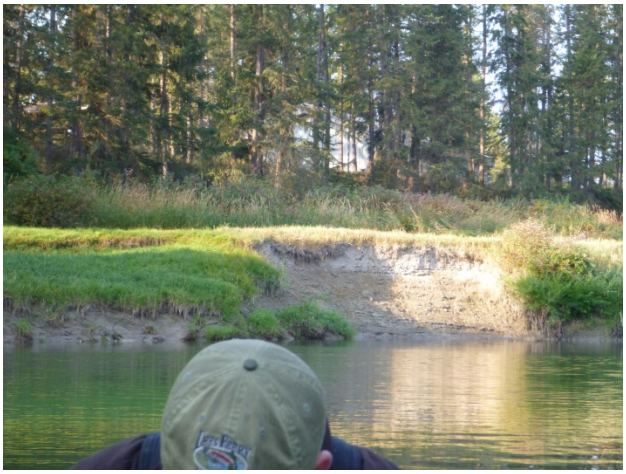


Figure 6-4. Eroding banks exacerbated by vegetation removal on the Stillwater River



Figure 6-5. Coir fabric and willow plantings on the Stillwater River



Figure 6-6. Rip rap on the Stillwater River

The Stillwater River upstream of the impaired segment flows predominantly through lands administered by the Stillwater State Forest and the US Forest Service (**Figure 6-2**). This area historically and currently is managed for timber harvest, and in some areas grazing. Bull trout and westslope cutthroat trout can be found in this part of the Stillwater River and its tributaries. McNeil cores samples, substrate scores, bull trout redd counts, and both bull trout and cutthroat trout population estimates have been recorded for this area since at least the early 1990s (River Design Group, Inc., 2003). Data collected in the upper Stillwater River indicate that substrate scores and McNeil core values remained relatively stable from 2001 to 2010 (Montana Department of Natural Resources and Conservation, 2005; 2011). BMPs are implemented by DNRC in the Stillwater River watershed as part of timber harvest projects. An example of work done recently by DNRC that benefits the Stillwater River is the Stillwater Road Improvement project where a culvert was replaced with a larger diameter pipe at stream grade on Campsite Creek and a drain dip was constructed adjacent to Hellroaring Creek so that water drained away from the stream (Montana Department of Natural Resources and Conservation, 2006b).

Timber harvest is occurring in the upper watershed and BMPs are being implemented to prevent excessive sediment loading. Upstream of the impaired segment of the Stillwater River, there are three lakes (Duck, Upper Stillwater, and Lower Stillwater; **Figure 6-2**) that, based on water quality sampling on May 20, 2014, appear to trap nearly the entire sediment load from the headwaters (**Table 6-16**).

Table 6-16. Synoptic sampling of the Stillwater River upstream and downstream of lakes in the system on 5/20/2014

Sampling Location	Latitude	Longitude	Turbidity (Nephelometric Turbidity Unit)	TSS (mg/L)	Suspended Sediment Concentration (mg/L)
Upstream of Duck Lake	48.62537	-114.68782	3.8	15.5	17.6
Downstream of Duck Lake	48.61039	-114.65850	0.8	2.5	2.0
Upstream of Upper Stillwater Lake	48.60405	-114.65656	1.6	5.5	6.2
Downstream of Upper Stillwater Lake/Upstream of Lower Stillwater Lake	48.56836	-114.63402	0.3	1.5	1.5
Downstream of Lower Stillwater Lake	48.53546	-114.57167	0.1	Not detected	1[(1)]

[(1)]Mean value of sample and duplicate

Logan Creek (**Figure 6-1**) is a major tributary to the listed segment of the Stillwater River and is also impaired by sediment (see **Section 6.4.2.6**). Logan Creek flows into Tally Lake downstream of much of the timber harvest in the watershed. Similar to the lakes on Stillwater River, Tally Lake likely acts as a sediment trap and any excessive sediment from the Logan Creek headwaters likely settles out before it can enter the Stillwater River.

Comparison with Water Quality Targets

DEQ has not collected physical data for this segment of the Stillwater River. Bioassessment data has been collected and are located in **Table 6-17**. All bolded cells are not meeting the target; depending on the target parameter, this may equate to being below or above the target value.

Table 6-17. Bioassessment data for the Stillwater River

Values that do not meet the target threshold (0.90 for O/E and 51% for periphyton) are in bold.

Station ID	Collection Date	Collection Method	O/E	Periphyton
C11STILR01	7/16/2012	MAC R 500	**0.20**	--
C11STILR02	7/16/2012	MAC R 500	**0.44**	--
C11STILR04	7/17/2012	MAC R 500	**0.29**	--
C11STILR05	7/17/2012	MAC R 500	**0.29**	--
C11STILR03	8/28/2012	EMAP	--	37%
C11STILR04	8/28/2012	EMAP	--	44%
C11STILR05	8/28/2012	EMAP	--	32%
C11STILR06	8/27/2012	EMAP	--	36%

This segment of the Stillwater River represents a unique case with regards to sediment assessment and the types of targets typically used by DEQ (**Table 6-2**). Much of the middle portion of the Stillwater River is an incised Rosgen F stream type that has the potential to both transport and store large sediment loads. The targets in **Table 6-2** are only applicable on the Stillwater River in locations where the channel qualifies as a Rosgen A, B, C, or E stream type. While Rosgen A, B, and E stream types are not likely in this segment of the Stillwater River, areas where there is a good potential for Rosgen C stream types include upstream of Twin Bridges Road and downstream of West Reserve Drive.

Summary and TMDL Development Determination

The observations made by DEQ in September 2012 identified bank erosion exacerbated by human impacts. Biological samples yielded mixed results with all of the macroinvertebrate samples failing to meet the target and all of the periphyton samples meeting the target. The presence of lakes on the Stillwater River and Logan Creek are likely limiting sediment loading to the impaired segment. This evidence considered with the observed bank erosion and silt/clay substrate of the stream bottom indicate that much of the sediment loading to this segment is natural and from within the channel itself. However, due to the current listing, the presence of human-caused sources, and the lack of physical data for the segment, this segment of the Stillwater River will remain listed for sediment and a TMDL will be written.

6.5 SOURCE ASSESSMENT AND QUANTIFICATION

This section summarizes the assessment approach, current sediment load estimates, and the determination of the allowable load for each source category. DEQ determines the allowable load by estimating the obtainable load reduction once all reasonable land, soil, and water conservation practices

have been implemented. The reduction forms the basis of the allocations and TMDLs provided in **Section 6-6**. This section focuses on four potentially significant sediment source categories and associated controllable human loading for each of these sediment source categories:

- streambank erosion
- upland erosion
- unpaved roads
- permitted point sources

EPA's guidance for developing sediment TMDLs states that the basic procedure for assessing sources includes compiling an inventory of all sediment sources to the waterbody. In addition, the guidance suggests using one or more methods to determine the relative magnitude of loading, focusing on the primary and controllable sources (U.S. Environmental Protection Agency, 1999b). Federal 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 code of federal regulation (CFR) 130.2(G)"}.

For each impaired waterbody segment, sediment loads from each source category were estimated using a Loading Simulation Program in C++ (LSPC) model for the Flathead Lake watershed. This model and the assumptions used when estimating sediment loading are described in Tetra Tech (2014b). The results of this model include annual loading of TSS (fine sediment) from different sediment sources and the percent contribution of each to the overall load. This output from the model represents the current conditions within each watershed. Although some sources such as bank erosion contribute a mix of sediment sizes, implementing BMPs that address TSS loading will also reduce larger sediment particles. The following sections describe 1) the percent contribution of sediment from various sources, 2) loading for specific sources, and 3) percent reductions to specific sources necessary to meet the TMDL.

6.5.1 Percent Sediment Contribution from Each Source Type

Figures 6-7 through **6-13** display sediment loading from various sources to the seven segments with TMDLs in this document. The predominant source of sediment is bank erosion; it is always ≥ 49%. The bank erosion category consists of all bank erosion regardless of it is caused by natural processes or human activities; a portion of bank erosion can always be attributed to natural sources. Upland erosion from natural background sources is always ≥ 12% of the load to the segments of concern and is the second largest contributor of sediment to all segments. Agriculture (upland source), unpaved roads, and timber harvest (upland source) are typically the third to fourth largest contributors of sediment, however they tend to contribute substantially less sediment with agriculture always being ≤ 20%, unpaved roads being ≤ 4%, and timber harvest being ≤ 2%. Urban areas contribute 14% of the sediment load in lower Ashley Creek and 7% in middle Ashley Creek, but ≤ 2% in all other segments. Impacts from forest fire contribute 4% of the annual sediment load in Sheppard Creek and ≤ 1% in the other segments.

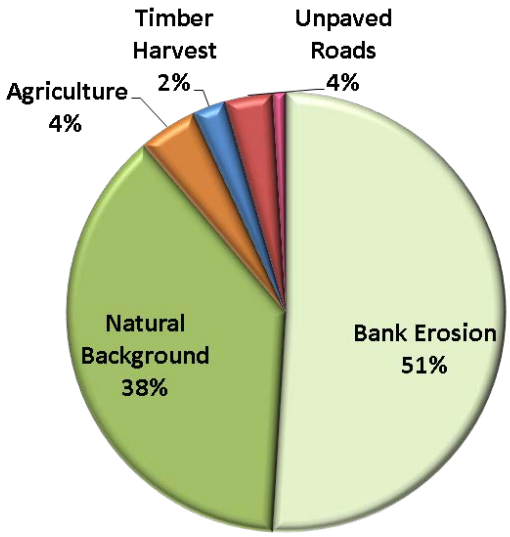


Figure 6-7. Percent contribution of sediment sources to upper Ashley Creek at the downstream end of the segment

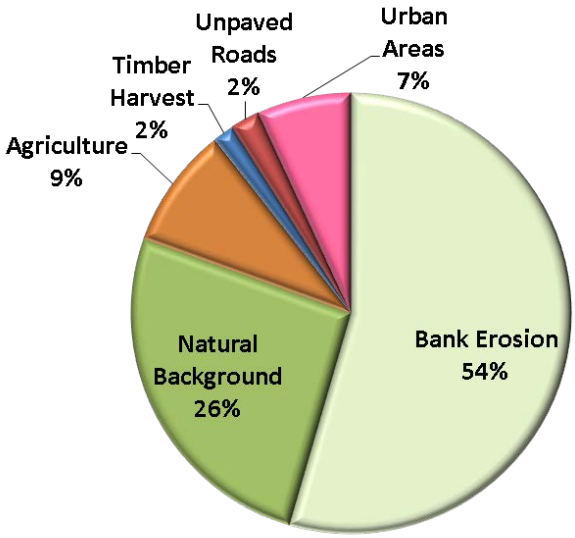


Figure 6-8. Percent contribution of sediment sources to middle Ashley Creek at the downstream end of the segment

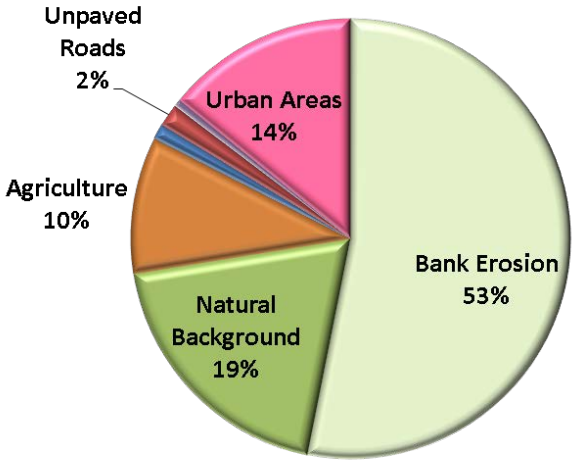


Figure 6-9. Percent contribution of sediment sources to lower Ashley Creek at the mouth (i.e., the entire Ashley Creek watershed)

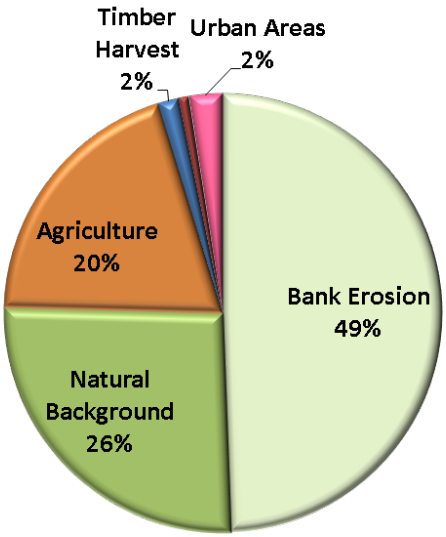


Figure 6-10. Percent contribution of sediment sources to the Haskill Creek watershed

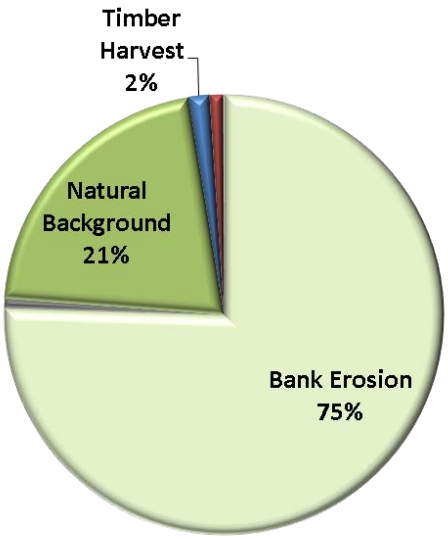


Figure 6-11. Percent contribution of sediment sources to the Logan Creek watershed

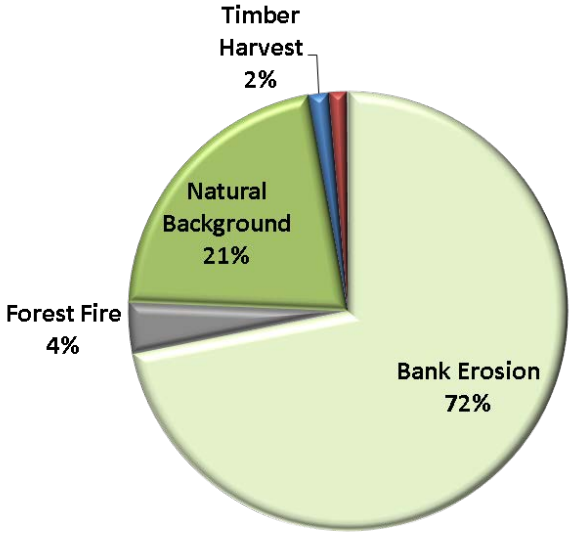


Figure 6-12. Percent contribution of sediment sources to the Sheppard Creek watershed

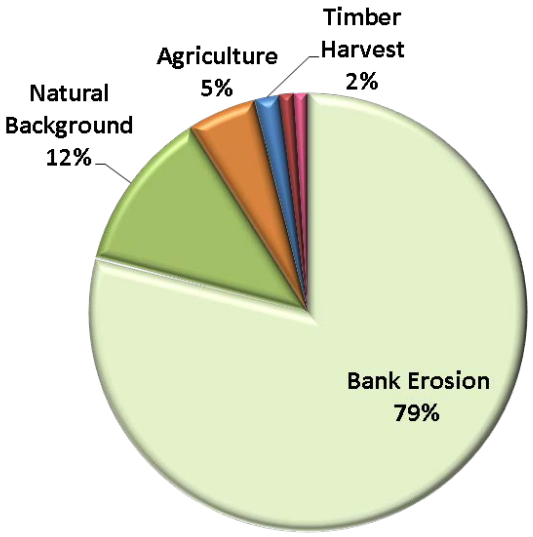


Figure 6-13. Percent contribution of sediment sources to the Stillwater River watershed

6.5.2 Eroding Streambank Sediment Assessment

Streambank erosion is a natural process typically dominated by slowly eroding streambanks. Human disturbances to riparian vegetation and health and/or stream hydrology can accelerate the natural erosion rate. This commonly occurs when streambanks shift from being well vegetated and/or armored (and commonly undercut) to being largely, or entirely, unvegetated with vertical banks. Eroding streambanks were explicitly estimated in the LSPC model for the Flathead Lake watershed. The output from the model represents the current conditions within each watershed. Detailed information regarding how streambank erosion was calculated in the LSPC model and applicable assumptions are in Tetra Tech (2014b). Information from the 2008 Flathead-Stillwater sediment and habitat field work (**Attachment A**) was used to describe controllable sources of bank erosion when observed.

Establishing the Total Allowable Load

To establish the total allowable load when controllable sources of bank erosion are present, a reduction must be applied to the existing load. In this case, the reduction for sediment loading from bank erosion was estimated as the percentage of banks at sites sampled within a segment in 2008 that were eroding due to non- "natural" (i.e., human-caused) sources (see **Attachment A** for erosion assessment details). The reduction was calculated as:

$$Bank\ erosion\ reduction = (E_{Non\text{-}nat}/E_{Tot})*100$$

Where:

E_{Tot} = *sum of the linear distance of eroding banks at all sites sampled within the segment*

$E_{Non\text{-}nat}$ = *sum of the linear distance of eroding banks at all sites sampled within the segment that are attributed to controllable non-natural sources*

Thus, the reduced load is intended to represent bank erosion caused by natural sources and human sources when best management practices are used.

A key assumption to establishing the allowable load for bank erosion in this manner is that the sampling sites are representative of the segment of concern. In the case of upper Ashley Creek, only one site was

sampled. This site was in an area dominated by agricultural land-use. An aerial analysis indicated that 56% of the 15.6 stream miles that comprise upper Ashley Creek adjacent to agricultural land-use with the remainder being forested. Bank erosion at the sampled site was 98% human-caused. To account for the 55% of the stream length that was in forest (and presumably dominated by natural erosion), the percent reduction for bank erosion in upper Ashley Creek was reduced via the following calculation:

98%*0.56 = 55% reduction to human-caused bank erosion to upper Ashley Creek

Sediment loading to the middle Ashley Creek segment consists of sediment from upper Ashley Creek as well as sediment internal to the segment. The percent reduction for this segment was calculated using the data from both upper Ashley Creek and middle Ashley Creek. In this case, the reduction for sites within middle Ashley Creek was 40% based on the human-caused erosion observed. To incorporate the reduction to the sediment load coming from upper Ashley Creek, the middle Ashley Creek reduction was calculated based on the proportion of each segment that ultimately contributed the load to middle Ashley Creek. Upper Ashley Creek is 52% of the linear distance of the two segments combined and middle Ashley Creek is 48%. The overall reduction for sediment loading to middle Ashley Creek was then calculated as:

(55%*0.52) + (40%*0.48) = 48% reduction to human-caused bank erosion loading to middle Ashley Creek

No bank erosion field data was collected for the lower Ashley Creek segment. The reduction to streambank erosion in this segment is 48%, based on the percent reduction for middle Ashley Creek.

Based on the source assessment, streambank erosion loads range from 255.2 tons per year in upper Ashley Creek to 12,240.6 tons per year in the Stillwater River (**Table 6-18**). Significant human-caused sources of streambank erosion include cropland and grazing practices. Depending on the watershed, DEQ estimated that implementing and maintaining riparian BMPs could decrease the human-caused level of streambank erosion by 7% to 55% within specific assessed reaches.

Table 6-18. Existing and reduced sediment loads from eroding streambanks in specific segments of the Flathead-Stillwater TPA

Segment	Estimated Existing Sediment Load (tons/year)	Percent Reduction (i.e., percent human-caused bank erosion)	Allowable Sediment Load with Riparian BMPs (tons/year)
Upper Ashley	255.2	55%	114.8
Middle Ashley	533.7	48%	277.5
Lower Ashley	736.8	48%[1]	388.1
Haskill	372.4	7%	346.3
Logan	2,264.5	0%	2,264.5
Sheppard	393.5	0%	393.5
Stillwater River	12,240.6	0%[2]	12,240.6

[1] No bank erosion field data was collected for this segment. The reduction is based on the percent reduction for middle Ashley Creek

[2] No bank erosion field data was collected for this segment. The reduction is based on field observations made by DEQ personnel in 2012. All controllable sources of bank erosion will need to have BMPs applied to achieve the TMDL and applicable load allocation

Note: Values were rounded to the nearest tenth; differences in loads presented in this table may not correspond to the identified percent reduction

6.5.3 Upland Erosion Assessment

Upland sediment is that which originates beyond the stream channel. The erosion rate of sediment from upland sources is influenced by land use and/or vegetative cover. Sediment loading from upland erosion was explicitly estimated in the LSPC model for the Flathead Lake watershed. The output from the model represents the current conditions within each watershed. Detailed information regarding how upland erosion was calculated in the LSPC model and applicable assumptions is in Tetra Tech (2014b). Human-caused upland erosion sources (e.g., agriculture, timber harvest, golf courses) are generally a small proportion of the overall sediment load to the segments of concern (**Figures 6-7** through **6-13)**. However, erosion from these sources can be controlled through the implementation and maintenance of BMPs.

Establishing the Total Allowable Load

The allowable load from upland erosion is based on a 50% reduction to loading from controllable human sources (agriculture and golf courses). This reduction is reasonable based on the sediment trapping efficiency of 53% to 98% documented by Liu (2008) for riparian buffers and the sediment reductions of 76% to 91% reported by Arora (1996) for filter strips. The previously mentioned studies can are summarized in Miller (2012), which provides a review of agricultural BMPs and potential reductions for various pollutants that can be achieved.

The Montana Streamside Management Zone (SMZ) Law (77-5-301 through 307 Montana Code Annotated (MCA)) prohibits specific timber harvest activities within 50 feet of any waterbody. As a result, loading from timber harvest is considered to be implemented with all applicable BMPs in place. Meeting the load allocation for upland erosion assumes that all BMPs are being implemented at timber harvest locations. If any controllable sources of upland erosion result from timber harvest activities, BMPs will be necessary to meet the upland erosion allocation. Meeting the load allocation for upland erosion also assumes that BMPs are in place for any other controllable sources of upland erosion that are not explicitly represented in the LSPC model.

Existing sediment loads from upland erosion range from 146.4 tons/year in the Logan Creek watershed to 3,066.8 tons/year in the Stillwater River watershed (**Table 6-19**). Existing sediment loads from the controllable human sources component of upland erosion range from 0 tons/year in the Sheppard Creek watershed to 149.5 tons/year in the Haskill Creek watershed (**Table 6-19**). A 50% reduction in controllable human sources results in allowable upland loads ranging from 146.4 tons/year in Sheppard Creek to 3,052.2 tons/year in the Stillwater River and overall percent reductions to upland loads from 0.01 to 20%.

Table 6-19. Existing and reduced sediment loads from upland erosion in specific segments of the Flathead-Stillwater TPA

Segment	Existing Delivered Upland Erosion Sediment Load (tons/year)	Existing Delivered Sediment Load from controllable human sources (tons/year)	Percent Reduction to controllable human Sources	Allowable Sediment Load from controllable human Sources (tons/year)	Allowable Sediment Load from Upland Erosion (tons/year)	Overall percent reduction to Upland Erosion
Upper Ashley	227.8	21.5	50%	10.8	217.1	5%
Middle Ashley	383.5	87.1	50%	43.6	340.0	11%
Lower Ashley	496.7	139.5	50%	69.8	427.0	14%
Haskill	375.7	149.5	50%	74.8	301.0	20%
Logan	705.9	0.1	50%	0.05	705.85	0.01%
Sheppard	146.4	0	50%	Not Applicable	146.4	0%
Stillwater River	3,066.8	786.0	50%	393.0	2,673.8	13%

Note: Values were rounded; differences in loads presented in this table may not correspond to the identified percent reduction

6.5.4 Unpaved Road Sediment Assessment

Roads located near stream channels can reduce stream function by degrading riparian vegetation, encroaching on the channel, and adding sediment. The degree of harm is determined by a number of factors including road type, construction specifications, drainage, soil type, topography, and precipitation, as well as the usage and maintenance of BMPs. Culverts and road crossing can be substantial sources of sediment when not installed properly and/or when not appropriately sized. Unpaved roads were identified as a potentially significant sediment source for this project area and were explicitly accounted for in the LSPC model. Failing culverts and road crossings were not explicitly modeled; as a result, meeting the allocations for unpaved road sediment assumes that such issues are addressed as they occur. Detailed information regarding how unpaved road sediment loading was calculated in the LSPC model and applicable assumptions are in Tetra Tech (2014b).

Establishing the Total Allowable Load

The allowable load from unpaved road is based on a 30% reduction to loading and is applied to each segment of concern. This reduction assumes that all BMPs are implemented and maintained. DEQ has performed road loading analyses in watersheds throughout western Montana. Reductions to road sediment range from 8% in Grave Creek (Montana Department of Environmental Quality et al., 2005) to 75% for the worst locations in the Ruby River watershed (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2006). Within the Flathead Lake watershed, a 40% reduction was applied to the Swan Lake watershed (Montana Department of Environmental Quality, 2004) and a 75% reduction in Coal Creek (U.S. Environmental Protection Agency et al., 2004). Northwest of the Flathead-Stillwater TPA, the Tobacco watershed has reductions ranging from 50% to 57% for road sediment loads (Montana Department of Environmental Quality, 2011c). A reduction of 30% to unpaved road sediment represents a value that is within the range used in other TMDLs in western Montana. The 30% reduction is near the low end of those used by DEQ in other western Montana watersheds and was chosen in recognition of the road BMP work being implemented by land managers (e.g., USFS, DNRC; **Section 6.4.2**) in the Flathead-Stillwater TPA. In the case of Logan and Sheppard creeks, the 30% reduction was applied only to unpaved roads in those

watersheds where the USFS has not recently implemented BMPs. In the Logan Creek watershed (including roads in the Sheppard Creek and Griffin Creek watersheds), BMPs have been applied to 155.49 of 443.32 road miles (35%), and in the Sheppard Creek watershed best management practices (BMPs) have been applied to 48.89 of 74.52 road miles (66%) (Guenthner, Mitch, personal communication, 2014[7]). The reduction values for unpaved roads can be changed (increased or decreased) if future analyses indicate this is necessary.

Based on the source assessment, the existing sediment load from unpaved roads ranges from 5.6 tons/year in the Haskill Creek watershed to 166.3 tons/year in the Stillwater River watershed (**Table 6-20**). A 30% reduction in sediment load from unpaved roads results in allowable loads ranging from 3.9 to 116.4 tons/year.

Table 6-20. Existing and reduced sediment loads from unpaved roads in specific segments of the Flathead-Stillwater TPA

Segment	Existing Delivered Sediment Load from Unpaved Roads (tons/year)	Percent Reduction to Unpaved Roads	Allowable Sediment Load from Unpaved Roads (tons/year)
Upper Ashley	17.7	30%	12.4
Middle Ashley	21.2	30%	14.8
Lower Ashley	23.2	30%	16.2
Haskill	5.6	30%	3.9
Logan	29.8	22%	23.3
Sheppard	7.1	13%	6.2
Stillwater River	166.3	30%	116.4

Note: Values were rounded to the nearest tenth; differences in loads presented in this table may not correspond to the identified percent reduction

6.5.5 Permitted Point Sources

As of June 10, 2014, the Flathead-Stillwater TPA had 20 Montana Pollutant Discharge Elimination System (MPDES) permitted point sources that could be contributing sediment to sediment-impaired watersheds (**Table B-2** of **Appendix B**). All of the permits fall within the Ashley Creek and Stillwater River watersheds. Nineteen of the permits are general permits; twelve are for construction stormwater, six are for industrial stormwater, and one is for a small Municipal Separate Storm Sewer System (MS4). One permit is an individual permit for the Kalispell Wastewater Treatment Plant (WWTP). To provide the required wasteload allocation (WLA) for permitted point sources, a source assessment was performed for these point sources. The source assessments for the Kalispell WWTP and small MS4 are based on the results of the LSPC model. The source assessments for the construction stormwater and industrial stormwater permits did not use the LSPC model and source assessment methods are described in **Sections 6.5.4.3** and **6.5.4.4** respectively. Because of the conditions set within all of the applicable permits, and the nature of sediment loading associated with these permits, the WLAs are not intended to add load limits to the permits; DEQ assumed that the WLAs will be met by adhering to the permit requirements.

[7] Personal communication by e-mail between Paul Kusnierz (DEQ) and Mitch Guenther (USFS) on 6/27/2014, 10/1/2014, and 10/6/2014

6.5.5.1 Kalispell Wastewater Treatment Plant (MT0021938)

The Kalispell WWTP is a modified Johannesburg treatment system that serves about 19,000 customers (Flathead City-County Health Department, 2009). It has a design capacity of 5.4 million gallons per day (mgd) and a single outfall that discharges to lower Ashley Creek. The facility has average monthly TSS limits of 10 mg/L concentration and 259 lb/day (0.13 tons/day). The permit for this facility has been administratively continued since 2013 and is being evaluated for renewal by DEQ. Additional background information regarding the Kalispell WWTP can be found in **Attachment B**.

Establishing the Total Allowable Load

The average (1/3/1993 – 12/27/2012) effluent TSS concentration from the WWTP was 2.48 mg/L (**Attachment B**), well below the permit limit of 10 mg/L. The LSPC model estimates that the Kalispell WWTP is contributing 6.7 tons TSS per year to lower Ashley Creek. Based on the permit limit of 0.13 tons/day (47.4 tons/year), the WWTP is currently meeting the permit requirements for TSS loading. The WLA for permit MT0021938 (47.4 tons/year) is based on the monthly average load limit and is seven times greater than the existing load.

6.5.5.2 Kalispell Small MS4 (MTR040005)

Stormwater within the city of Kalispell is regulated under the General Permit for Storm Water Discharge Associated with MS4 (MTR040000) and applies within the Kalispell city limits. The city is a co-permittee with the Montana Department of Transportation (MDT), and as such, this section addresses the MDT portion of the MS4 as well. This MS4 has 23 outfalls to the Stillwater River, 24 outfalls to middle Ashley Creek, and five outfalls to lower Ashley Creek (Figures 2 and 3 in **Attachment C**).

The permit does not include effluent limits, but does have a benchmark value of 125 mg/L TSS and requires the development and implementation of a stormwater management program (SWMP) to minimize sediment loading to surface waters. The SWMP must include six minimum control measures: (1) public education and outreach; (2) public involvement/participation; (3) detection and elimination of illicit discharge; (4) control of stormwater runoff from construction sites; (5) management of post-construction stormwater in new development and redevelopment; and (6) pollution prevention/good housekeeping. Additionally, the permit requires monitoring at two sites twice per year following storm events; one must represent a residential area and the other represent a commercial/industrial area (Figure 2 in **Attachment C**).

Using stormwater discharge monitoring data from 2007-2008 for two outfalls in the Kalispell MS4, summary statistics were calculated for the commercial/industrial sample location (average = 100 mg/L TSS; maximum = 167 mg/L TSS) and residential sample location (average = 392 mg/L TSS; maximum = 951 mg/L TSS). Note that stormwater TSS concentrations can vary depending on the size of the outfall's drainage area, the types of activities occurring, the BMPs that are installed, the rainfall volume, and time between storm events.

Establishing the Total Allowable Load

Because of the limited amount of information regarding stormwater BMPs currently in place within the MS4, no BMP scenario was run in the model. Instead, BMP effectiveness values reported from the International Storm Water BMP Database (Geosyntec Consultants, Inc. and Wright Water Engineers, Inc., 2011) will be used as the basis for the WLA. The database includes statistics for loading reduction efficiencies from a compilation of studies for a variety of BMPs. The BMPs include bioretention, bioswales, detention basins, filter strips, manufactured devices, media filters, porous pavement,

retention ponds, wetland basins, and wetland channels. The effectiveness range among different studies and practices are fairly tight. Studies were summarized by evaluating the 75th percentile, median, and 25th percentile concentration of influent and effluent. The quartiles for each percentile category ranged from a reduction efficiency of 53% to 76%. Using the median influent and effluent concentration, the average percent reduction among BMPs was 62%.

The LSPC model estimates that the Kalispell MS4 annually contributes 40.4 tons TSS to middle Ashley Creek, 122.4 tons TSS to Lower Ashley, and 43.4 tons to the Stillwater River (**Table 6-21**). The 2007-2008 monitoring data did exceed the TSS benchmark of 125 mg/L TSS. Because some BMPs are already in place within all land-use categories, the average percent reduction of 62% previously described will be used to approximate the reduction in loading that additional BMP implementation across all land-use categories could achieve and to determine the WLA.

Table 6-21. Sediment loading and reductions from the Kalispell small MS4

Segment	Existing Load (tons/year)	Percent Reduction	MS4 WLA (tons/year)
Middle Ashley	40.4	62%	15.4
Lower Ashley	122.4	62%	46.5
Stillwater River	43.4	62%	16.5

Note: Values were rounded to the nearest tenth; differences in loads presented in this table may not correspond to the identified percent reduction

As stated previously, the WLAs are not intended to add load limits to the permit. DEQ assumed that the WLAs will be met by adhering to the permit requirements. As identified in the permit, monitoring data should continue to be evaluated to assess BMP performance and help determine whether and where additional BMP implementation may be necessary.

6.5.5.3 Construction Storm Water Permits (MTR100000)

Because construction activities at any given site are temporary and relatively short term, 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 Storm Water Pollution Prevention Plan (SWPPP) that identifies the stormwater BMPs that will be in place during construction. Before a permit is terminated, disturbed areas must 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).

Establishing the Total Allowable Load

The permit files were reviewed to determine the amount of disturbed land associated with each permit. The estimated level of disturbance ranged from 1 to 49 acres (**Table B-2** in **Appendix B**). The permits are for a range of construction projects including road/highway, home, business, and stormwater improvements. The SWPPPs contain BMPs such as silt fencing, retention basins, fiber rolls, erosion control blankets, and vegetated buffers.

To estimate sediment loading from permitted construction sites without BMPs in place an approach similar to that in the “Tobacco Planning Area Sediment TMDLs and Framework Water Quality Improvement Plan” (Montana Department of Environmental Quality, 2011c) was used. For this

approach, the average existing annual erosion rate for all cropland land use types in the LSPC model (0.0721 tons/acre/year) was tripled to represent construction sites with some ground cover but inadequate BMP implementation, resulting in an erosion rate of 0.216 tons/acre/year. This value was then multiplied by the total disturbed acreage associated with construction storm water permits in each applicable watershed (**Table 6-22**).

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 EPA and the International Storm Water Best Management Practices Database (Geosyntec Consultants, Inc. and Wright Water Engineers, Inc., 2008; U.S. Environmental Protection Agency, 2009). The reduced loads (**Table 6-22**) will be used to set the WLAs for construction stormwater permits. Because following permit conditions meet the intent of the WLA for construction stormwater, any future permits within any watersheds with sediment TMDLs in the Flathead-Stillwater TPA will meet the TMDL by following all permit conditions, including the SWPPP.

Table 6-22 Sediment loading and reductions from permitted construction sites

Watershed	Average LSPC model loading rate* 3 (tons/acre/year)	Annual Disturbed Acres	Estimated load without adequate BMPs (tons/year)	Percent Reduction	BMP sediment load (tons/year)
Middle Ashley Creek	0.216	38	8.2	65%	2.9
Lower Ashley Creek	0.216	69[(1)]	14.9	65%	5.2
Stillwater River	0.216	114	24.6	65%	8.6

[(1)] Includes area in middle Ashley Creek

Note: Values were rounded to the nearest tenth; differences in loads presented in this table may not correspond to the identified percent reduction

6.5.5.4 Industrial Storm Water Permits (MTR000000)

There are currently six facilities that are regulated under the General Permit for Storm Water Discharges Associated with Industrial Activity (MTR000000) that could be contributing to segments of concern (**Table 6-23**). These permits regulate the direct discharge of stormwater draining the facility and its grounds. Under the stipulations of the permits, the facilities maintain an approved SWPPP. The SWPPP sets forth the procedures, methods, and equipment used to prevent the pollution of stormwater discharges. In addition, the SWPPP describes general practices used to reduce pollutants in stormwater discharges. The SWPPPs contain BMPs such as using conveyances that minimize contact between runoff and sediment and other pollutants and retention basins that allow sediment to settle and water to infiltrate into the ground.

Establishing the Total Allowable Load

At the six facilities with industrial storm water permits, the sites range in size from 6.3 – 310 acres with four being located in the Ashley Creek watershed and two in the Stillwater River watershed (**Table 6-23**). According to the general stormwater permit, the benchmark value for TSS is 100 mg/L; this means that the TSS concentration of runoff from the site should not exceed 100 mg/L if permit conditions are followed. The WLA for each facility was calculated using the area it encompasses, the average annual precipitation rate in Kalispell, MT, the benchmark value of 100 mg/L, and the following equation:

$$Load_{BMP}\ (tons/year) = Area_d * Precip_{aa} * Target_{TSS} * 0.00136$$

Where:

$Area_d$ = acres of disturbed land
$Precip_{aa}$ = 1.31 feet (Average annual precipitation in Kalispell, MT; http://www.wrcc.dri.edu/summary/Climsmnidwmt.html)
$Target_{TSS}$ = 100 mg/L
0.00136 = conversion factor

The WLAs are provided because it is a requirement for permitted point sources but is not intended to add load limits to the permit. DEQ assumed that the WLAs will be met by adhering to each permit's requirements, including the SWPPP.

Table 6-23 Sediment loading from permitted industrial sites

NPDES ID	Facility Name	Watershed	Facility Area (acres)	BMP Load (tons/year)
MTR000447	UPS - KALISPELL	Middle and Lower Ashley Creek	4.0	0.7
MTR000251	WISHER'S AUTO RECYCLING	Lower Ashley Creek	22.27	4.0
MTR000419	BUILDING MATERIALS HOLDING CORP. - BMC WEST TRUSS PLANT	Lower Ashley Creek	6.3	1.1
MTR000531	CITY OF KALISPELL WWTP	Lower Ashley Creek	17.04	3.0
MTR000465	GLACIER GOLD LLC	Stillwater River	38.0	6.8
MTR000476	FLATHEAD COUNTY SOLID WASTE DISTRICT	Stillwater River	310.0	55.2

6.5.6 Source Assessment Summary

Based on field observations, the LSPC model, and associated source assessment work, all assessed source categories represent controllable loads within the Flathead-Stillwater TPA. 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, because of 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 effects within each assessment category (e.g., bank erosion, upland erosion, roads). Results for each source assessment category provide an adequate tool to focus water quality restoration activities in the Flathead-Stillwater TPA; they indicate the relative contribution of sediment to different subwatersheds for each source category and the percent loading reductions that can be achieved with the implementation of improved management practices.

6.6 TMDL AND ALLOCATIONS

The sediment TMDLs for the Flathead-Stillwater TPA will be based on the percent reduction approach, discussed in **Section 4.0**. This approach will apply to the loading allocated among sources as well as to the TMDL for each waterbody. Each impaired segment's TMDL consists of any upstream allocations and an implicit margin of safety (further discussed in **Section 6.8**).

6.6.1 Application of Percent Reductions

Cover et al. (2008) observed a correlation between sediment supply and instream measurements of fine sediment in riffles and pools. DEQ assumes 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 attaining 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 it helps focus on implementing water BMPs versus focusing on uncertain loading values. TMDL allocations based on the percent reduction approach dot not preclude new roads, forestry, or other nonpoint source activities as long as those activities incorporate BMPs. However, a significant increase in nonpoint source activities should prompt an evaluation of cumulative impacts even with all BMPs in place.

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. The reduction is calculated by 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, Benjamin, personal communication 2006). Daily loads are provided in **Appendix D**.

6.6.2 Development of Sediment Allocations by Source Categories

The percent-reduction allocations are based on the implementation and maintenance of BMPs s for each major source type (e.g., streambank erosion, upland erosion, roads, and permitted point sources). These BMPs are discussed in **Section 9.0**. The reductions are reasonable 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 allocations for that location. For many nonpoint source activities, it may take several years to decades to achieve the full load reduction at the location of concern, even though full BMP implementation and maintenance 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 past 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 increase to sediment loading.

Progress toward TMDL and individual allocation achievement can be gaged by adhering to point source discharge permits, implementing and maintaining BMPs for nonpoint sources, and improving or attaining the water quality targets defined in **Section 6.4**. Any effort to calculate loads and percent reductions for comparison with 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.

6.6.2.1 Streambank Erosion

Streambank stability and erosion rates are closely linked to the health of the riparian zone. Reductions in sediment loading from bank erosion are expected to be achieved by applying and maintaining BMPs within the riparian zone. Sediment loads associated with bank erosion can be identified by separate source categories (e.g., transportation, grazing, natural); however, because of the inherent uncertainty in extrapolating this level of detail to the watershed scale, and also because of uncertainty regarding the effects of past land management activity, all sources of bank erosion were combined to express the TMDL and allocations.

DEQ acknowledges that the annual sediment loads are estimates based on data input to the LSPC model for the Flathead Lake watershed. The assignment of bank erosion loads to the various land uses is not definitive but was done to direct efforts to reduce the loads toward those causes that are likely having the biggest effect on the investigated streams. Ultimately, local land owners and managers are responsible for identifying the causes of bank erosion and for adopting practices to reduce bank erosion wherever practical.

6.6.2.2 Upland Erosion

The allocation to upland sources includes application and maintenance of BMPs to present land-use activities as well as recovery from past land-use influences, such as riparian timber harvest. No reductions were allocated to natural sources, which are a significant portion of all upland land-use categories. The percent reduction for human-caused upland erosion is applied to controllable human sources (agriculture and golf courses) of sediment and will be achieved via riparian improvements.

6.6.2.3 Roads

The allocation to roads can be met by incorporating and documenting that all road crossings with potential sediment delivery to streams have the appropriate BMPs in place and that they are being maintained. Routine maintenance of the BMPs is necessary to ensure that sediment loading remains consistent with the intent of the allocations. The allocation to roads also includes no loading from undersized, improperly installed, or inadequately maintained culverts. At a minimum, culverts should meet the 25-year event; however, for fish-bearing streams and streams with a high level of road and impervious surface development upstream, or for culvert sites with a large amount of fill, meeting the 100-year event is recommended. Although the allocation to roads does not preclude constructing new roads as long as that activity incorporates BMPs, a significant increase in road activity or density should prompt an evaluation of cumulative impacts even with all BMPs in place.

6.6.2.4 Permitted Point Sources

All WLAs are expected to be met by adhering to permit conditions and loads provided within this document are not intended to be incorporated into permit limits or added to permit conditions.

6.6.3 Allocations and TMDL for Each Segment

The following subsections present the existing quantified sediment loads, allocations, and TMDL for each waterbody (**Tables 6-24** through **6-30**).

6.6.3.1 Upper Ashley Creek (MT76O002_010)

Table 6-24. Sediment Source Assessment and Example Allocations and TMDL for upper Ashley Creek

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Streambank Erosion	255.2	114.8	55%
Upland Sediment Sources	227.8	217.1	5%[1]
Roads	17.7	12.4	30%
Total Sediment Load	**500.7**	**344.3**	**31%**

[1]Overall reduction to upland sediment sources; based on a 50% load reduction to controllable human sources
Note: Values were rounded to the nearest tenth; differences in loads presented in this table may not correspond to the identified percent reduction

6.6.3.2 Middle Ashley Creek (MT76O002_020)

Table 6-25. Sediment Source Assessment and Example Allocations and TMDL for middle Ashley Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Streambank Erosion		533.7	277.5	48%
Upland Sediment Sources		383.5	340.0	11%[1]
Roads		21.2	16.2	30%
Point Source	Kalispell Small MS4	40.4	15.4	62%
	Construction Stormwater (MTR100000)	2.9	2.9	0%
	MTR000447	0.7	0.7	0%
Total Sediment Load		**982.4**	**652.7**	**34%**

[1]Overall reduction to upland sediment sources; based on a 50% load reduction to controllable human sources
Note: Values were rounded to the nearest tenth; differences in loads presented in this table may not correspond to the identified percent reduction

6.6.3.3 Lower Ashley Creek (MT76O002_030)

Table 6-26. Sediment Source Assessment and Example Allocations and TMDL for lower Ashley Creek

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Streambank Erosion		736.8	383.1	48%[1]
Upland Sediment Sources		496.7	427.0	14%[2]
Roads		23.2	16.2	30%
Point Source	Kalispell WWTP	6.7	47.4	0%
	Kalispell Small MS4	122.4	46.5	62%
	Construction Stormwater (MTR100000)	5.2	5.2	0%
	MTR000447	0.7	0.7	0%
	MTR000251	4.0	4.0	0%
	MTR000419	1.1	1.1	0%
	MTR000531	3.0	3.0	0%
Total Sediment Load		**1,399.8**	**934.2**	**33%**

[1] No bank erosion field data was collected for this segment. The reduction is based on the percent reduction for middle Ashley Creek
[2]Overall reduction to upland sediment sources; based on a 50% load reduction to controllable human sources
Note: Values were rounded to the nearest tenth; differences in loads presented in this table may not correspond to the identified percent reduction

6.6.3.4 Haskill Creek (MT76P003_070)

Table 6-27. Sediment Source Assessment and Example Allocations and TMDL for Haskill Creek

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Streambank Erosion	372.4	346.3	7%
Upland Sediment Sources	375.7	301.0	20%[1]
Roads	5.6	3.9	30%
Total Sediment Load	**753.7**	**651.2**	**14%**

[1]Overall reduction to upland sediment sources; based on a 50% load reduction to controllable human sources
Note: Values were rounded to the nearest tenth; differences in loads presented in this table may not correspond to the identified percent reduction

6.6.3.5 Logan Creek (MT76P001_030)

Table 6-28. Sediment Source Assessment and Example Allocations and TMDL for Logan Creek

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Streambank Erosion	2,264.5	2,264.5	0%[1]
Upland Sediment Sources	705.9	705.85	0.01%[2]
Roads	29.8	23.3	22%
Total Sediment Load	**3,000.2**	**2,993.65**	**0.2%**

[1]No bank erosion field data was collected for the Star Meadow portion of the segment. All controllable sources of bank erosion will need to have BMPs applied to achieve the TMDL and applicable load allocation
[2]Overall reduction to upland sediment sources; based on a 50% load reduction to controllable human sources
Note: Values were rounded; differences in loads presented in this table may not correspond to the identified percent reduction

6.6.3.6 Sheppard Creek (MT76P001_050)

Table 6-29. Sediment Source Assessment, Allocations and TMDL for Sheppard Creek

Sediment Sources	Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Streambank Erosion	393.5	393.5	0%[1]
Upland Sediment Sources	146.4	146.4	0%[2]
Roads	7.1	6.2	13%
Total Sediment Load	**547.0**	**546.1**	**0.2%**

[1]No bank erosion field data was collected for the Star Meadow portion of the segment. All controllable sources of bank erosion will need to have BMPs applied to achieve the TMDL and applicable load allocation
[2]Overall reduction to upland sediment sources; based on a 50% load reduction to controllable human sources
Note: Values were rounded to the nearest tenth; differences in loads presented in this table may not correspond to the identified percent reduction

6.6.3.7 Stillwater River (MT76P001_010)

Table 6-30. Sediment Source Assessment and Example Allocations and TMDL for the Stillwater River

Sediment Sources		Current Estimated Load (Tons/Year)	Total Allowable Load (Tons/Year)	Load Allocations (% reduction)
Streambank Erosion		12,240.6	12,240.6	0%[1]
Upland Sediment Sources		3,066.8	2,673.8	13%[2]
Roads		166.3	116.4	30%
Point Source	Kalispell Small MS4	43.4	16.5	62%
	Construction Stormwater (MTR100000)	8.6	8.6	0%
	MTR000465	6.8	6.8	0%
	MTR000476	55.2	55.2	0%
Total Sediment Load		**15,587.7**	**15,117.9**	**3%**

[1] No bank erosion field data was collected for this segment. The reduction is based on observations made by DEQ personnel on a float of the Stillwater River in 2012. All controllable sources of bank erosion will need to have BMPs applied to achieve the TMDL and applicable load allocation

[2]Overall reduction to upland sediment sources; based on a 50% load reduction to controllable human sources

[3]Assuming that no storm event has occurred on a particular day

Note: Values were rounded to the nearest tenth; differences in loads presented in this table may not correspond to the identified percent reduction

6.7 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 Flathead-Stillwater sediment TMDLs.

6.7.1 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:

- The applicable narrative water quality standards (**Appendix A**) 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 runoff from snowmelt 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 project area. 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.

6.7.2 Margin of Safety

Natural systems are inherently complex. Any approach used to quantify or define the relationship between pollutant loading rates and the resulting water quality effects, 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 (MOS) 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, 1999a). 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; as discussed for each target parameter in **Section 6.4.1**, an effort was made to select achievable water quality targets, but in all cases, the most protective statistical approach was used. **Appendix A** contains additional details about statistical approaches used by DEQ.
- By developing TMDLs for streams that were close to meeting all target values. This approach addresses some of the uncertainty associated with sampling variability and site representativeness and recognizes that capabilities to reduce sediments exist throughout the watershed.
- Sediment impairment is typically identified based on excess fine sediment but the targets and TMDLs address both coarse and fine sediment delivery.
- By properly incorporating seasonality into target development, source assessments, and TMDL allocations (details provided in **Section 6.7.1**).
- By using an adaptive management approach to evaluate target attainment and allow for refinement of load allocations, targets, modeling assumptions, and restoration strategies to further reduce uncertainties associated with TMDL development (discussed in **Sections 6.8** and **10.0**).
- By using naturally occurring sediment loads as described in Administrative Rules of Montana (ARM) 17.30.602(17) (see **Appendix A**) 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.
- By developing TMDLs at the watershed scale to address 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.

6.8 Uncertainty 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

subject to periodic modification or adjustment as new information and relationships are better understood. Within the Flathead-Stillwater TPA, adaptive management for sediment TMDLs relies on continued monitoring of water quality and stream habitat conditions, continued assessment of effects from human activities and natural conditions, and continued assessment of how aquatic life and coldwater fishes respond to changes in water quality and stream habitat conditions.

As further monitoring and assessment is conducted, uncertainties with present assumptions and consideration may be mitigated via periodic revision or review of the assessment that occurred for this document. As noted in **Section 6.7.2**, adaptive management represents an important component of the implicit MOS. 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 (a) field data and target development and (b) 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.

6.8.1 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 in **Attachment A**. To control sampling variability and improve accuracy, the sampling was done by trained environmental professionals using a standard DEQ procedure developed to evaluate sediment loading (Montana Department of Environmental Quality, 2011a). This procedure defines specific methods for each parameter, including sampling location and frequency, to ensure proper representation and applicability of results. Before 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 **Attachment A**. 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 the appropriate sites were assessed and whether an adequate number of sites were evaluated for each waterbody. In addition, there is the uncertainty of the representativeness of collecting data from a single sampling season. These uncertainties are difficult to quantify and even more difficult to eliminate given resource limitations and occasional stream access issues.

Target Development

DEQ evaluated several data sets to ensure that the most representative information and statistic were used to develop each target parameter, consistent with the reference approach framework outlined in **Appendix A**. 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 recent sample data for the project area. These differences were acknowledged within the target development discussion and taken into consideration during target setting. For each target parameter, DEQ stratified the Flathead-Stillwater 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 comparisons.

The established targets are meant to apply under median conditions of natural background and natural disturbance. DEQ recognizes 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. Under these conditions the goal is to ensure that management activities do not significantly delay achievement of targets as compared to the time for natural recovery to occur.

Also, human activity should not significantly increase the magnitude of water quality effects from natural events. For example, extreme flood events can cause a naturally high level of sediment loading that could be further increased by a large number of road crossing or culvert failures.

Because sediment target values are based on 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 flexibility to refine targets as necessary to ensure resource protection and to adapt to new information concerning target achievability.

6.8.2 Source Assessments and Load Reduction Analyses

Each source of sediment has uncertainties associated with the accuracy and representativeness of the sediment load estimates and percent load reductions. For each source assessment, assumptions were made to evaluate sediment loading and potential reductions at the watershed scale. Because of these uncertainties, conclusions may not represent existing conditions and achievable reductions at all locations in the watershed. Uncertainties are discussed independently for the three major non-point source categories: bank erosion, upland erosion, and unpaved roads.

Bank Erosion

Bank erosion loads were estimated using the LSPC model for the Flathead Lake watershed. Assumptions and uncertainty associated with bank erosion loading can be found in Tetra Tech (2014b). Load reductions were determined using the percentage of eroding banks that were assigned to human sources during 2008 field visits (**Attachment A)**. Before the field 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 **Attachment A**. Because only one or two sites per segment of concern were evaluated for bank erosion, there is some uncertainty with regards to the accuracy of erosion attributed to human-causes at the watershed scale. For this reason, the loads are intended to provide a relative sense of the loading associated with bank erosion from human and natural sources for each watershed.

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 identifying sources at the stream segment scale using aerial photos

and also because of the heavy influence from past disturbances; it is extremely difficult to identify the level to which historical occurrences still affect 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 Flathead-Stillwater TPA. Evaluating bank erosion levels, particularly where BMPs 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 effect that bank erosion has on water quality throughout the Flathead-Stillwater TPA.

Upland Erosion

Professional modelers determined upland erosion loads by using the water quality model LSPC (Tetra Tech, Inc., 2014b). As with any model there is uncertainty in the model input parameters, including land use, land cover, slope, soil types, and assumptions regarding existing levels of BMP application. Thus, there is uncertainty regarding existing erosion prevention BMPs in a given watershed and the ability to reduce erosion with additional BMPs. Even with these uncertainties, the ability to reduce upland sediment erosion and delivery to nearby waterbodies, especially from agricultural sources, is well documented in the literature, and the estimated reductions are consistent with literature values for riparian buffers in agricultural settings.

Unpaved Roads

As described in Tetra Tech (2014b), sediment loading from roads was estimated using the LSPC model. The inputs to this model represent roads with typical BMPs in place and do not account for failing road crossings and culverts. It also does not account for roads that are poorly designed and/or not maintained. As such a 30% reduction was applied to unpaved roads in the watersheds for each of the segments of concern. The reductions to unpaved roads can by adjusted as part of adaptive management as detailed information becomes available. Meeting the allocations for sediment from roads requires that all BMPs are implemented and maintained and all failing road crossings and culverts are repaired and properly functioning.

7.0 TEMPERATURE TMDL COMPONENTS

This portion of the document focuses on temperature as an identified cause of water quality impairment in the Flathead-Stillwater Total Maximum Daily Load (TMDL) Planning Area (TPA). It describes: (1) the mechanisms by which temperature affects beneficial uses of streams; (2) the specific stream segments of concern; (3) information sources used for temperature total maximum daily load (TMDL) development; (4) temperature target development; (5) assessment of sources contributing to excess thermal loading; (6) example temperature total maximum daily loads (TMDLs) and allocations; (7) seasonality and margin of safety; and (8) uncertainty and adaptive management.

7.1 EFFECTS OF TEMPERATURE ON BENEFICIAL USES

Human influences that reduce stream shade, increase stream channel width, add heated water, or decrease the capacity of the stream to buffer incoming solar radiation all increase stream temperatures. Warmer temperatures can negatively affect aquatic life and fish that depend upon cool water for survival. Increased water temperature reduces dissolved oxygen and causes increased primary production via algal (Robarts and Zohary, 1987) and bacterial (Kaplan and Bott, 1989) growth that can exacerbate nutrient-related problems and lead to further reductions in dissolved oxygen. In addition, higher instream temperatures make fishes more prone to disease (Tops et al., 2006; Roth, 1972; Roberts, 1975). Coldwater fish species are more stressed in warmer water temperatures as these conditions increase metabolism and reduce the amount of available oxygen in the water. In turn, coldwater fish, and other aquatic species, may feed less frequently and use more energy to survive in thermal conditions above their tolerance range, sometimes creating lethal conditions for a percentage of the fish population. Also, elevated temperatures can boost the ability of non-native fish to outcompete native fish if the latter are less able to adapt to warmer water conditions (Bear et al., 2007a). These lower winter temperatures can lead to the formation of anchor and frazil ice, which can harm aquatic life by causing changes in movement patterns (Brown, 1999; Jakober et al., 1998), reducing available habitat, and inducing physiological stress (Brown et al., 1993). Addressing the issues associated with increased summer maximum temperatures will also address these potential winter problems. Assessing thermal effects upon a beneficial use is an important initial consideration when interpreting Montana's water quality standard (**Appendix A**) and subsequently developing temperature TMDLs.

7.2 STREAM SEGMENTS OF CONCERN

Three waterbody segments in the Flathead-Stillwater TPA appeared on the 2014 Montana impaired waters list as having temperature limiting a beneficial use: upper Ashley Creek from Ashley Lake to Smith Lake (MT76O002_010), lower Ashley Creek from Kalispell Airport Road to the mouth (MT76O002_030), and the Whitefish River from Whitefish Lake to the mouth (MT76P003_010) (**Figure 7-1**). Although middle Ashley Creek from Smith Lake to the Kalispell Airport Road (MT76O002_020) was not on the 2014 Montana impaired water list as having temperature limiting a beneficial use, it was included as part of this project. The data collected indicate that middle Ashley Creek (Ashley Creek from Smith Lake to Kalispell Airport Road; MT76O002_020) does have temperature limiting a beneficial use and it will appear in the 2016 Integrated Report (IR) as a result. A temperature TMDL will also be written for this segment. The three segments of Ashley Creek have three different use class designations; upper Ashley is B-1, lower Ashley is C-2, and middle Ashley Creek segment is B-2. The Whitefish River is designated B-2. Although there is a slight difference in standard language between B-1, B-2, and C-2

streams, the same temperature standards apply to all three class designations. That language describes a maximum allowable increase above naturally occurring temperature of 0.5 – 1.0°F, depending on the naturally occurring temperature. In addition to the temperature impairment, lower Ashley Creek is listed for alteration in streamside or littoral vegetative covers, which is a non-pollutant listing that can be linked to temperature impairment.

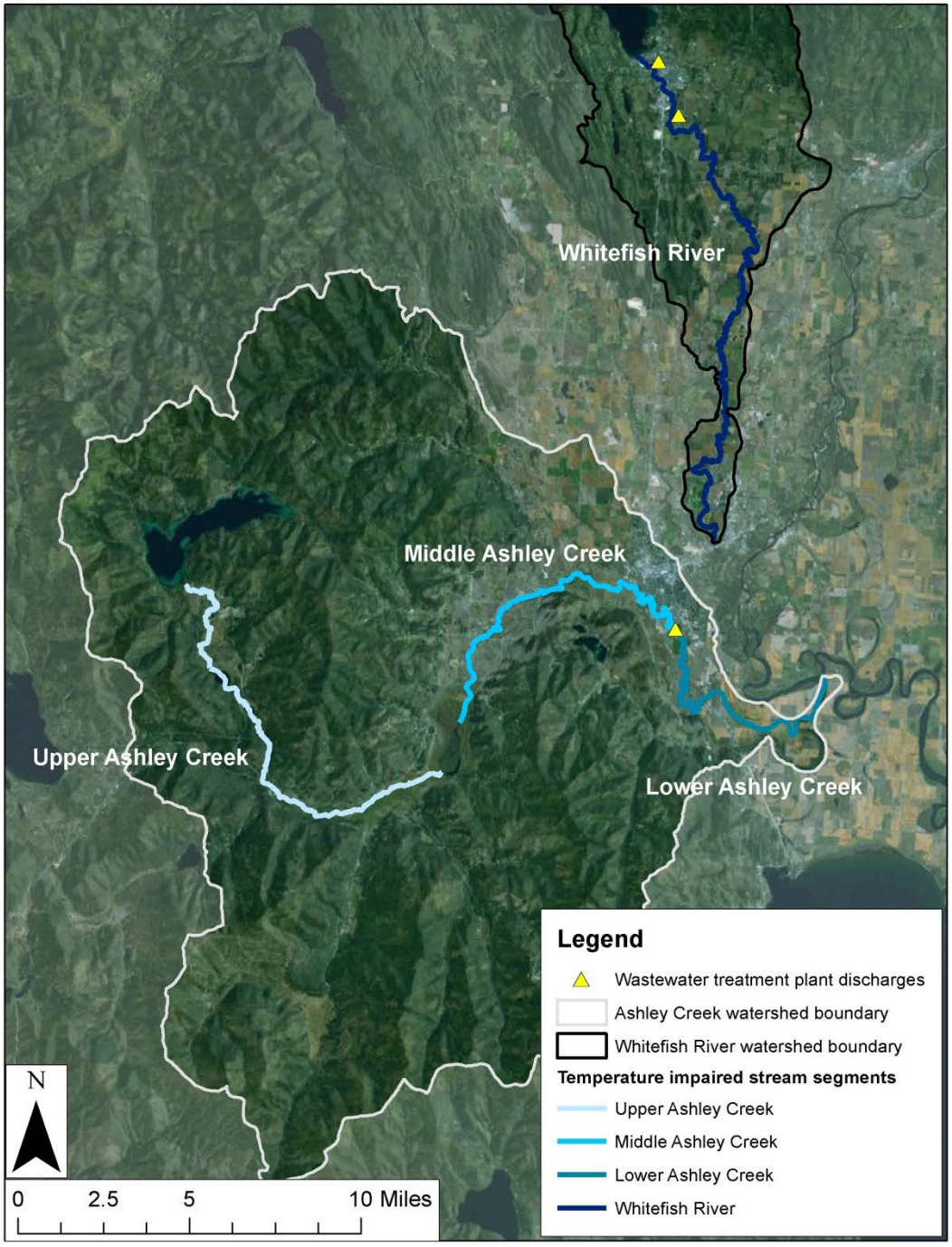


Figure 7-1. Ashley Creek and the Whitefish River watersheds and the four corresponding segments for which TMDLs are presented in this document

Although middle Ashley Creek was not included in the 2014 IR, it has been included here to maintain continuity and a full understanding of the Ashley Creek system. Results from the analysis indicate temperature conditions in middle Ashley Creek are above the standard, therefore temperature TMDLs are included for all three Ashley Creek segments. To help put sampling data into perspective and understand how elevated stream temperatures may affect aquatic life, information on fish presence in Ashley Creek and the Whitefish River and temperature preferences for the most sensitive species are described below.

7.2.1 Fish Presence and Temperatures of Concern

Because different fish species have varying optimal temperature ranges for survival and some are more sensitive than others to elevated stream temperatures, it is important to identify the fish species within each stream segment of concern.

7.2.1.1 Fish Presence in Ashley Creek

According to the Montana Fish, Wildlife, and Parks fisheries resource value ratings (determined by the species present and habitat quality, description at: http://fwp.mt.gov/fwpDoc.html?id=29756), Ashley Creek is considered "Substantial" (rating score 3) from river mile 15.9 to 41.7 (Lone Lake; upper Ashley Creek and middle Ashley Creek segments). Its score is one category lower at "Moderate" (rating score 4) for the reach of Ashley Creek from the mouth to river mile 15.9 (middle Ashley Creek and lower Ashley Creek segments).

Based on a query of the Montana Fisheries Information System (MFISH), brook trout, rainbow trout, and westslope cutthroat/rainbow trout hybrids, and mountain whitefish can all be found in Ashley Creek (**Table B-3** in **Appendix B**). Northern pike and yellow perch are other sport fish that can be found in this watershed. In addition, largescale sucker, longnose sucker, northern pike minnow, peamouth, redside slider, and sculpin are present.

7.2.1.2 Fish Presence in the Whitefish River

According to the Montana Fish, Wildlife, and Parks fisheries resource value ratings, Whitefish River is considered "Substantial" (rating score 3) from river mile 0 to 23.7.

Based on a query of MFISH, brook trout, bull trout, rainbow trout, westslope cutthroat trout, and mountain whitefish can all be found in the Whitefish River (**Table B-4** in **Appendix B**). Northern pike is another sport fish that can be found in this watershed. In addition, largescale sucker, longnose sucker, northern pike minnow, peamouth, redside slider, and slimy sculpin are present.

7.2.1.3 Temperature Levels of Concern

Special temperature considerations are warranted for westslope cutthroat trout, which are listed in Montana as a species of concern and occur within both the Ashley Creek and Whitefish River watersheds. Research by Bear et al. (2007b) found that westslope cutthroat maximum growth occurs around 56.5°F with an optimum growth range (based on 95% confidence intervals) from 50.5 – 62.6°F. Rainbow trout were found to have a similar optimum growth temperature; however, rainbow trout were predicted to grow better over a wider range of temperatures than cutthroat trout, with growth being significantly better at temperatures below 44.2° F and above 69.4°F, possibly allowing for increased competition with cutthroat trout in lower-elevation (warmer) streams.

The ultimate upper incipient lethal temperature (UUILT) is the temperature considered to be survivable by 50% of a population over a specified time period. Bear et al. (2007b) found the 60-day UUILT for westslope cutthroat trout to be 67.3°F and the 7-day UUILT to be 75.4°F. In contrast they observed that rainbow trout had a 60-day UUILT of 75.7°F and a 7-day UUILT of 78.8°F. The lethal, temperature dose for westslope cutthroat that will kill 10% of the population in a 24-hour period is 73.0°F (Liknes and Graham, 1988).

Bull trout require cold water to thrive and survive with maximum growth occurring around 55.8°F and an optimum growth range (based on 95% confidence intervals) from 51.6 – 59.7°F (Selong et al., 2001). Water temperatures important to bull trout for spawning, incubation, and rearing typically range from the upper 30s to low 50s Fahrenheit (U.S. Fish and Wildlife Service, 2002). As water temperatures increase, conditions become more adverse. Selong et al. (2001) found the 60-day UUILT to be 69.6°F and predicted the 7-day UUILT to be 74.3°F. The critical thermal maximum is the arithmetic mean of collected thermal points at which locomotor activity becomes disorganized such that the organism loses its ability to escape lethal conditions (Cowells and Bogert, 1944). According to Selong et al. (2001), the critical thermal maximum for bull trout is in the range of 76.6 – 84.0°F depending on age.

Bull trout are not known to regularly occupy either Ashley Creek or the Whitefish River, but their presence in the Flathead watershed does indicate that the potential exists. However, temperatures recorded in Ashley Creek and the Whitefish River during data collection associated with TMDL development suggest that bull trout presence, especially during summer months would be very unlikely. During the data collection period the 7-day average maximum temperatures at the 19 Ashley Creek sites ranged from 61.4 – 76.8°F and at the 10 Whitefish River sites ranged from 66.9 – 73.3°F (**Attachment EA** of **Appendix E**).

7.3 INFORMATION SOURCES AND DATA COLLECTION

As part of this TMDL project, Department of Environmental Quality (DEQ) used several information and data sources to analyze and assess the conditions in Ashley Creek and the Whitefish River:

- **DEQ Assessment Files:** These files contain information used to make the existing temperature impairment determinations.

- **Temperature Related Data collection:** Temperature, flow, riparian shade, and channel geometry data were collected from July – September 2008 to update impairment determinations, construct River and Stream Water Quality (QUAL2K) models, and assist with the development of temperature TMDLs.

Sample locations were generally such that they provided a comprehensive upstream to downstream view of stream temperature. The location of sample collection also allowed for analysis of potential source impacts (e.g., shade, irrigation influence, point sources). All data used in TMDL development were collected during July – September, the time of year when fish are likely to be the most stressed by thermal conditions. **Appendix E** contains detailed information regarding data collection and model use.

The data used for the analyses in this document can be obtained from the Montana Department of Environmental Quality's Water Quality Planning Bureau. Other water quality data from the watershed are publicly available through the Environmental Protection Agency's (EPA) STOrage and RETrieval database (STORET) and DEQ's EQuIS water quality databases.

As discussed in **Appendix E** and **Section 7.4.1**, Montana defines temperature impairment as occurring when human sources cause a certain degree of change over the water temperature that occurs as a result of natural sources and human sources that are implementing all reasonable land, soil, and water conservation practices. Because interpreting the standard is more complex than just comparing measured temperatures to the temperature levels of concern discussed in **Section 7.2.1.3**, a QUAL2K water quality model was used to determine if human sources are causing the allowable temperature change to be exceeded. Model details are presented in **Appendix E** but model summaries are provided in **Sections 7.6.1.1 and 7.6.2.1**. To assist with model development and assessment of temperature conditions in Ashley Creek and the Whitefish River, two other categories of data were needed:

- Geographic Information System (GIS) data layers
- Land-use information

7.3.1 DEQ Assessment Files

DEQ maintains assessment files that provide a summary of available water quality and other existing condition information, along with a justification for impairment determinations. This information was compiled from 1999 to 2006 for the four applicable waterbody segments. The following is a short review of the temperature impairment determinations DEQ has made.

7.3.1.1 Ashley Creek

Information about the three segments of Ashley Creek catalogued within the DEQ assessment files describes a variety of sources that indicate potential temperature impairment to aquatic life. A report about macroinvertebrate populations in Ashley Creek by Bollman (2003a) described assemblages between Ashley Lake and Smith Lake that suggest water quality may be affected by nutrients and warm temperatures. These same conclusions were made based on assemblages in the lower segment of Ashley Creek.

7.3.1.2 Whitefish River

Information about the Whitefish River catalogued within the DEQ assessment files references (Montana Department of Fish, Wildlife and Parks, Fisheries Division, 1996) which states, “Poor rearing and spawning success due to dewatering and high water temperatures.” Suggested improvements however were focused on tributary enhancement rather than mainstem improvements. The Montana Bulle Trout Scientific Group (1995) judged the Whitefish River as a low priority stream for restoration due to long-term degraded habitat conditions. The report also stated that the lack of bull trout in the Whitefish drainage is likely due in to the presence of non-native species with road building, logging, and subdivision development also contributing to the population decline.

7.3.2 Ashley Creek and Whitefish River TMDL Field Data Collection

DEQ’s methods for Ashley Creek and Whitefish River temperature TMDL development included a combination of characterizing water temperatures throughout the summer and collecting additional vegetation, channel width, shade, and streamflow data, which were used to model stream temperature. As described in **Attachment ED** of **Appendix E**, the QUAL2K temperature models were calibrated to existing flow, shade, and temperature conditions, with the ability to evaluate temperature impacts from differing riparian health (shade) and streamflow conditions. The following sections describe the data collected in Ashley Creek and the Whitefish River for temperature assessment.

7.3.2.1 Temperature Monitoring

Temperature monitoring was conducted in 2008 on Ashley Creek and the Whitefish River between mid-July and mid-September. The study examined stream temperatures during the period when streamflow tends to be the lowest and water temperatures the warmest and thus, when negative effects to the aquatic life beneficial use are likely most pronounced. Temperature monitoring consisted of placing temperature data loggers at 20 sites in the Ashley Creek watershed (17 on the mainstem and three on tributaries) and at 11 sites in the Whitefish River watershed (nine on the mainstem and two on tributaries). Temperature monitoring sites were selected to bracket stream reaches with similar hydrology, riparian vegetation type, valley type, stream aspect, and channel width. Temperature monitoring locations are shown in **Figures 7-2 and 7-3**; latitude and longitude coordinates for these sites can be found in **Attachment EA** of **Appendix E**. Temperature data can be obtained by contacting DEQ but are summarized within this document and **Appendix E**.

Data loggers were deployed in the Ashley Creek watershed between July 21st and 28th and retrieved between September 10th and 17th. Of the 20 temperature monitoring sites established, temperature data loggers were retrieved from 19 sites (one temperature data logger from the mainstem (ASHL-12) was not recovered). Maximum daily temperatures ranged from 62.2 – 79.8°F with 17 of 19 seasonal maximums being greater than 67°F. These maximum values occurred between July 26th and August 18th, with 15 out of 19 seasonal maximum temperatures occurring on August 17th (**Attachment EA** of **Appendix E**). The QUAL2K model for Ashley Creek indicated that it takes water 15 days to travel from Ashley Lake to the mouth; all scenarios were run for the August 4th-18th timeframe.

Data loggers were deployed in the Whitefish River watershed between July 18th and 21st and retrieved between September 11th and 15th. All of the data loggers were retrieved; however, there were no data for one site (WHTF-03, Haskill Creek) due to technical issues. Maximum daily temperatures ranged from 68.0 – 75.2°F and with 10 of 10 seasonal maximums being greater than 67°F. These maximum values occurred between July 26th and August 18th, with seven out of 10 seasonal maximum temperatures occurring on August 18th (**Attachment EA** of **Appendix E**). The QUAL2K model for the Whitefish River indicated that it takes water two days to travel from Whitefish Lake to the mouth; all scenarios were run for the August 17th-18th timeframe.

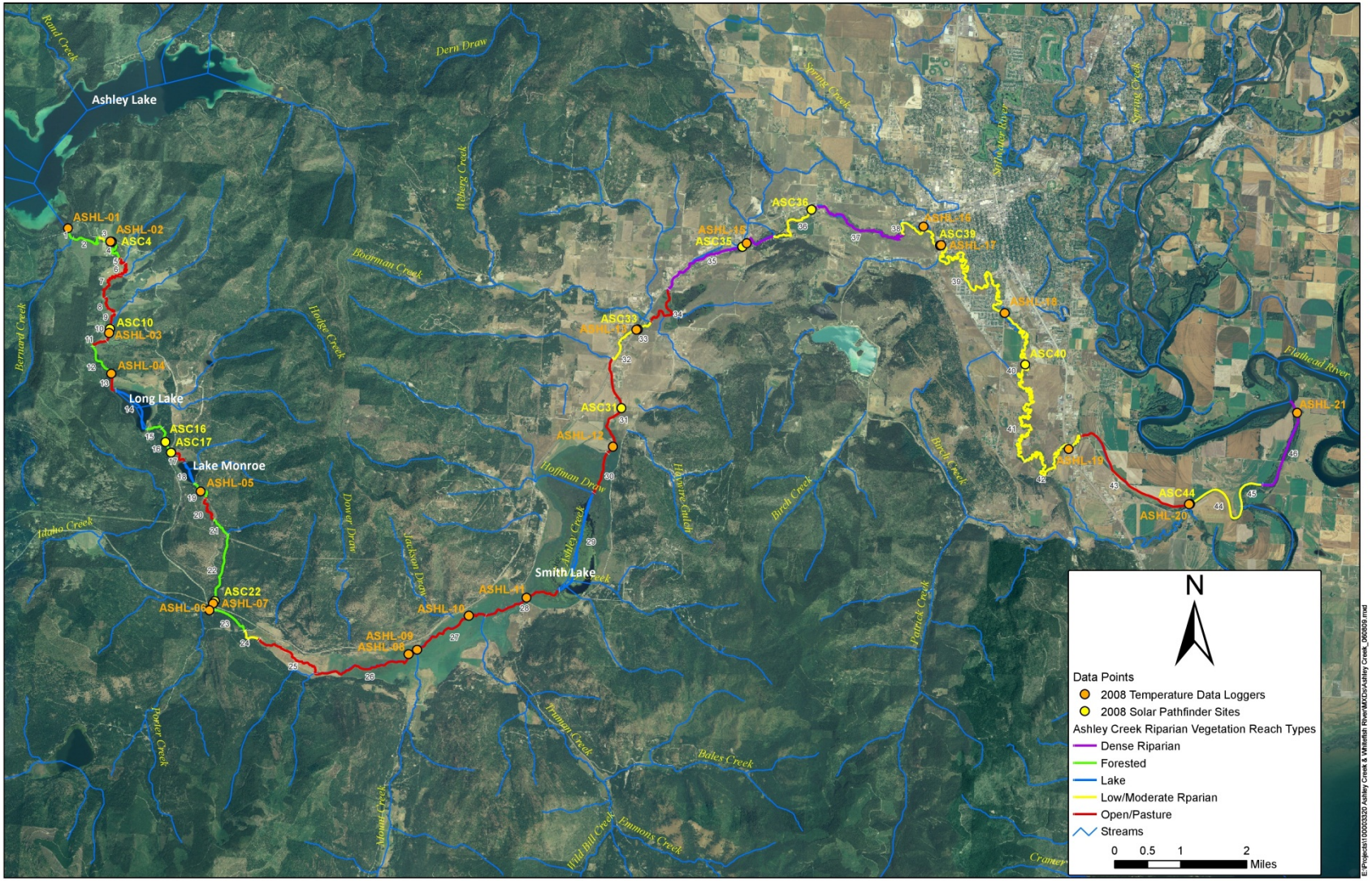


Figure 7-2. Temperature data logger and Solar Pathfinder sampling sites on Ashley Creek

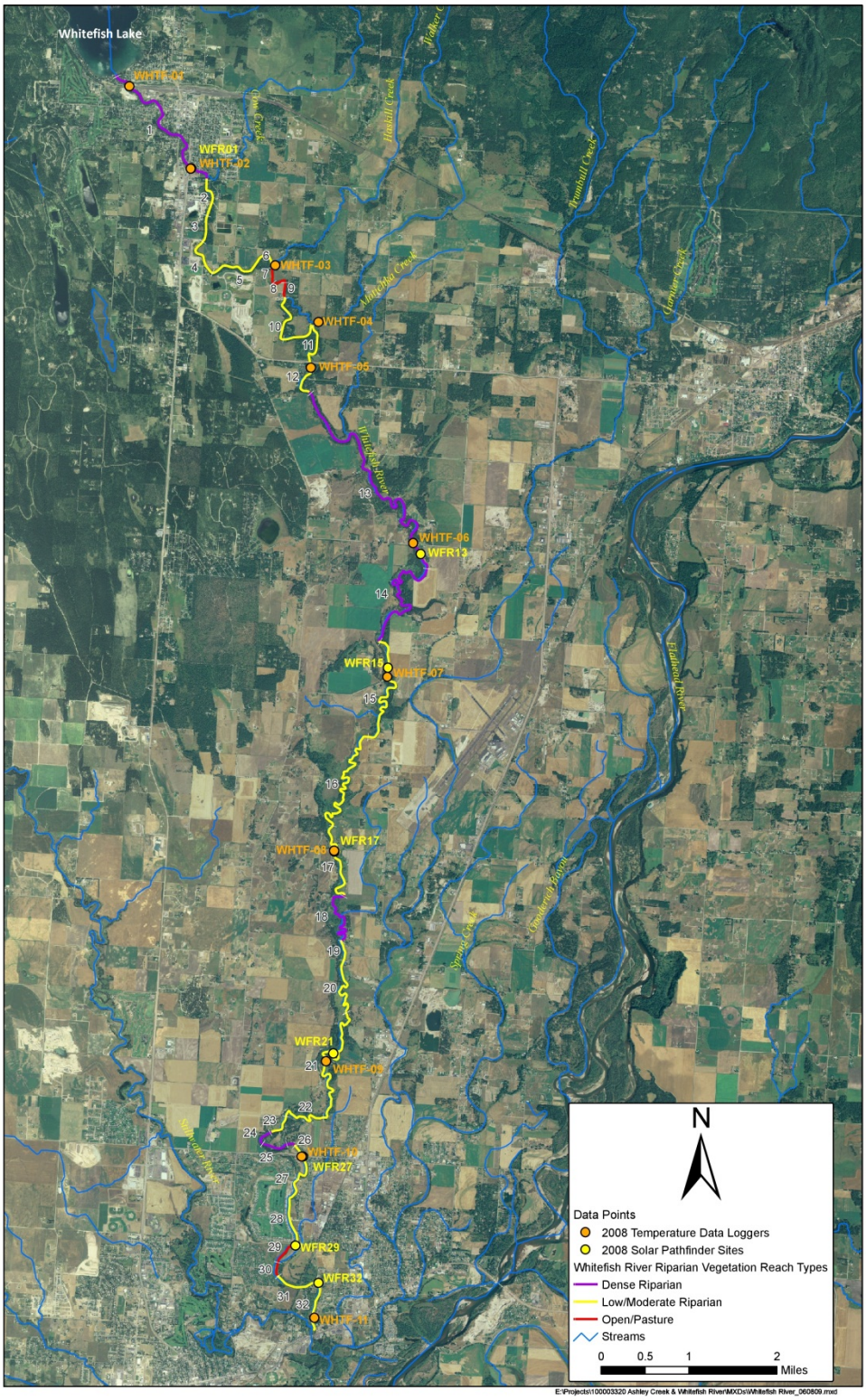


Figure 7-3. Temperature data logger and Solar Pathfinder sampling sites on the Whitefish River

7.3.2.2 Streamflow

Streamflow measurements were collected at 12 temperature monitoring locations in Ashley Creek and two temperature monitoring locations on tributary streams (**Table E2-2** in **Appendix E**) between August 15th and August 25th. Three of the Ashley Creek measurements were not used in the model due to slow velocity, dense aquatic vegetation growth, and poor comparison to United States Geological Survey (USGS) estimates (See **Section E2.2.1.2** in **Appendix E**).

Streamflow measurements were collected at five temperature monitoring locations in the Whitefish River and two temperature monitoring locations on tributary streams (**Table E2-3** in **Appendix E**) between August 11th and August 13th. One of the Whitefish River measurements was not used in the model because it appeared to over-estimate the actual streamflow (See **Section E2.2.1.2** in **Appendix E**).

7.3.2.3 Riparian Shading

Characterization of riparian shade was based on a combination of field data and aerial imagery analysis. A Solar Pathfinder was used to measure effective shade in 2008 at 12 locations on Ashley Creek (**Figure 7-2**) and eight locations on the Whitefish River (**Figure 7-3**). Effective shade is the percent reduction of incoming solar radiation that reaches the stream because of riparian vegetation and topography.

Before collecting field data, Ashley Creek was divided into 46 distinct reaches covering 44.6 miles based on the riparian vegetation type as observed in GIS using National Agricultural Imagery Program (NAIP) color aerial imagery from 2005 and high-resolution color orthophotographs from May 24th, 2004 (**Figure 7-2**). Riparian vegetation reach types included forested, dense riparian, low/moderate riparian and open/pasture. Forested areas were dominated by coniferous vegetation, while dense riparian areas had a mix of deciduous trees and shrubs. Low/moderate riparian areas were comprised primarily of deciduous shrubs and herbaceous vegetation. Each reach was reviewed using aerial imagery of the predominant riparian vegetation and assigned a vegetation type using best professional judgment.

Streamside shading was assessed at 12 sites along Ashley Creek and the average amount of shade within each riparian vegetation reach type was calculated (**Table E2-4** in **Appendix E**). For reaches in which shade measurements were performed, the result was applied directly to the entire reach. For reaches in which no shade measurement was performed, the riparian vegetation reach type average was applied. The complete riparian shading dataset is presented in **Attachment EB** of **Appendix E** and supplemental information for each assessed reach is presented in **Attachment EC** of **Appendix E**. Riparian vegetation reach types as determined through GIS analysis of aerial imagery are presented in **Figure 7-2** and **Attachment EF** of **Appendix E**, along with assumptions applied during the shade model scenario (see **Section E2.2.2.2** of **Appendix E**).

Prior to field data collection, the Whitefish River was divided into 32 distinct reaches covering 24.8 miles based on the riparian vegetation type as observed in GIS using NAIP color aerial imagery from 2005 and high-resolution color orthophotographs from May 24th, 2004 (**Figure 7-3**). Riparian vegetation reach types included dense riparian, low/moderate riparian and open/pasture. Dense riparian areas had a mix of deciduous trees and shrubs, while low/moderate riparian areas were comprised primarily of deciduous shrubs and herbaceous vegetation. Each reach was reviewed using aerial imagery of the predominant riparian vegetation and assigned a vegetation type using best professional judgment.

Streamside shading was assessed at eight sites along the Whitefish River and the average amount of shade within each riparian vegetation reach type was calculated (**Table E2-5** in **Appendix E**). For reaches

in which shade measurements were performed, the result was applied directly to the entire reach. For reaches in which no shade measurement was performed, the riparian vegetation reach type average was applied. The complete riparian shading dataset is presented in **Attachment EB** of **Appendix E** and supplemental information for each assessed reach is presented in **Attachment EC** of **Appendix E**. Riparian vegetation reach types as determined through GIS analysis of aerial imagery are presented in **Figure 7-3** and **Attachment EF** of **Appendix E**, along with assumptions applied during the shade model scenario (see **Section E2.2.3.2** of **Appendix E**).

7.3.2.4 Channel Geometry

Although not a direct measure of thermal effect on the stream, channel geometry can influence the rate of thermal loading. Wide, shallow streams transfer heat energy faster than narrow, deep streams. Therefore, channel geometry can be used to identify areas that may be destabilized, and may be more prone to rapid thermal loading, particularly in locations where shading is minimal.

Channel width (wetted and bankfull) was collected at each of the shade sites on Ashley Creek and the Whitefish River. While this data was incorporated into the QUAL2K model, field measurements and observations indicated the respective stream channels had appropriate widths and there was minimal potential to reduce them. Thus, a channel morphology modeling scenario was not applied to either Ashley Creek or the Whitefish River.

7.3.3 Other Information Sources

The following sections describe data used in the analysis of Ashley Creek and the Whitefish River from sources other than the DEQ.

7.3.3.1 USGS Gaging Station

USGS gaging station 12367800 on Ashley Creek was used to evaluate the flows measured at sites ASHL-17, ASHL-19, and ASHL-20. Station 12366080 on the Whitefish River was used to evaluate the flows measured at sites WHTF-07 and WHTF-08. Temperature was not collected throughout each day at these sites and therefore could not be used to validate temperature logger values.

7.3.3.2 Climatic Data

Climatic data inputs for the QUAL2K model were obtained from the Pacific Northwest Cooperative Agricultural Weather Network (AgriMet) site in Creston, Montana (http://www.usbr.gov/pn/agrimet/webaghrread.html) and included air temperature, dew point temperature and wind speed. The dew point temperature was adjusted by increasing the relative humidity by 15% based on local conditions within the stream corridor as measured in a similar assessment in the Big Hole River watershed (Flynn et al., 2008). In addition, cloud cover was assigned based on hourly measurements from the National Climatic Data Center at Kalispell Glacier Park International Airport.

7.4 WATER QUALITY TARGETS

The following section describes 1) the framework for interpreting Montana's temperature standard; 2) the selection of indicator parameters used as targets for TMDL development and how target values were developed; and 3) a summary of the temperature target values for Ashley Creek and the Whitefish River.

7.4.1 Framework for Interpreting Montana's Temperature Standard

Montana's water quality standard for temperature is narrative in that it specifies a maximum allowable increase above the naturally occurring temperature to protect fish and aquatic life. For waters classified as B-1 [Administrative Rules of Montana (ARM) 17.30.623(e)], B-2 [ARM 17.30.624(e)], and C-2 [ARM 17.30.627(e)] the maximum allowable increase over the naturally occurring temperature is 1°F when the naturally occurring temperature is less than 66°F. Within the naturally occurring temperature range of 66 – 66.5°F, the allowable increase cannot exceed 67°F. If the naturally occurring temperature is greater than 66.5°F the maximum allowable increase is 0.5°F. Under Montana water quality law, naturally occurring temperatures incorporate natural sources and human sources that are applying all reasonable land, soil, and water conservation practices. Naturally occurring temperatures can be estimated for a given set of conditions using QUAL2K or other modeling approaches, but because water temperature changes daily and seasonally, no single temperature value can be identified to represent standards attainment. Therefore, in addition to evaluating if human sources are causing the allowable temperature change to be exceeded, a suite of temperature TMDL targets were developed to translate the narrative temperature standard into measurable parameters that collectively represent attainment of applicable water quality standards at all times. The goal is to set the target values at levels that occur under naturally occurring conditions but are conservatively selected to incorporate an implicit margin of safety that helps account for uncertainty and natural variability.

For Ashley Creek and the Whitefish River, a model (QUAL2K) was used to estimate the extent of human influence on temperature by evaluating the temperature deviation when existing conditions of riparian health and associated shade, channel geometry, and streamflow were compared with naturally occurring conditions for these parameters. If the modeled temperature difference between the existing condition and the naturally occurring condition is greater than allowed by the water quality standard (i.e., 0.5 – 1.0°F, depending on the naturally occurring temperature), this verifies the existing temperature impairments for the Ashley Creek and Whitefish River segments.

7.4.2 Temperature Targets and Target Values

Naturally occurring temperatures can be estimated for a given set of conditions using QUAL2K or other modeling approaches. Because naturally occurring temperatures can significantly vary throughout the summer, as well as from year to year, the quantified temperature targets include those indicator parameters that influence temperature and can be linked to human causes. These indicator or target parameters include riparian health and associated shade, channel geometry, improved streamflow conditions where applicable, and allowable increases from Montana Pollutant Discharge Elimination System (MPDES) -permitted point sources.

Values are developed for each target parameter and are set at levels that result in attainment of Montana's temperature standard under all seasonal and yearly variability. The goal is to set most of the target values at levels that would contribute to naturally occurring temperature conditions, while ensuring that any variability from naturally occurring conditions is less than that allowed by the standard. The target values presented are protective of the use most sensitive to elevated temperatures, aquatic life; as such, the targets are protective of all designated uses for the applicable waterbody segments.

The primary temperature target is the allowable human-caused temperature change (i.e., 0.5 – 1.0°F, depending on the naturally occurring temperature), and the other targets are those parameters that influence temperature and can be linked to human causes. The other targets are for riparian canopy and

shade, channel bankfull width, instream discharge, and allowable temperature increase from point source discharges. All targets are described in more detail below.

7.4.2.1 Allowable Human-Caused Temperature Change

The target for allowable human-caused temperature change for Ashley Creek and the Whitefish River links directly to the numeric portion of Montana's temperature standard for B-1 [ARM 17.30.623(e)], B-2 [ARM 17.30.624(e)], and C-2 [ARM 17.30.627(e)] streams. When the naturally occurring temperature is less than 66°F, the maximum allowable increase is 1°F. Within the naturally occurring temperature range of 66 – 66.5°F, the allowable increase cannot exceed 67°F. When the naturally occurring temperature is greater than 66.5°F, the maximum allowable increase is 0.5°F. As stated above, naturally occurring temperatures incorporate natural sources, yet also include human sources that are applying all reasonable land, soil, and water conservation practices.

7.4.2.2 Riparian Canopy and Shade

Increased shading from riparian vegetation reduces sunlight hitting the stream and, thus, reduces heat load to the stream. Riparian vegetation also reduces near-stream wind speed and traps air against the water surface, which reduces heat exchange with the atmosphere. In addition, lack of established riparian areas can lead to bank instability, which could result in overwidened streams. Human influences affecting riparian canopy cover in the Ashley Creek and Whitefish River watersheds include present and historical agricultural activities, timber harvest, and some limited areas of recreational activity.

To help minimize the influence of upland activities on stream temperature, a riparian buffer close to 100 feet is commonly recommended (Ledwith, 1996; Knutson and Naef, 1997; Ellis, 2008). However, several studies have shown that most (85-90%) of the maximum shade potential is obtained within the first 50 feet (Brazier and Brown, 1973; Broderson, 1973; Steinblums et al., 1984) or 75 feet of the channel (CH2M, 2000; Castelle and Johnson, 2000; Christensen, 2000). The Natural Resources Conservation Service (NRCS) Conservation Practice Standard recommends a minimum buffer width of 35 feet, and also includes recommendations to use species with a medium or high shade value and to meet the minimum habitat requirements of aquatic species of concern (Natural Resources Conservation Service, 2011a; 2011b). Based on several literature sources finding that most shade is obtained within a buffer width of 50 feet and that 50 feet is the minimum buffer width for the Montana Streamside Management Zone (Montana Department of Natural Resources and Conservation, 2006a), the goal is a buffer width of at least 50 feet. The target does not apply to portions where the riparian zone is already at potential or is dominated by vegetation not likely to attain great heights at maturity (e.g., wetland shrub community).

DEQ uses a reference approach to define naturally occurring conditions for riparian health. 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 past and current land-use activities. The riparian canopy cover targets for the Ashley Creek and Whitefish River segments of concern are based on measurements made in the field from sites with good to moderate riparian conditions to represent potential reference conditions for the respective streams.

For Ashley Creek, the shade targets for riparian areas range from 7 – 80% effective shade. Specific shade target values are dependent on the reach, the potential vegetation type, and whether or not the reach was deemed to be meeting potential (**Attachment EF** of **Appendix E**).

For the Whitefish River the shade targets for riparian areas range from 47 – 59% effective shade. Specific shade target values are dependent on the reach and whether or not the reach was deemed to be meeting potential (**Attachment EF** of **Appendix E**).

Improvement in riparian health needs significant time before changes are visible. DEQ does not expect these targets to be met in the short-term; however, changes in land management practices and a commitment to those practices would need to be implemented to start meeting goals for temperature in Ashley Creek and the Whitefish River. DEQ recognizes that for a reach, target values may be lower or higher than the actual potential depending on the presence of roads and road crossings and the vegetation that can be established. An adaptive management approach should be used in concert with the effective shade target values to ensure that the true potential effective shade is realized for each reach and the portions thereof.

7.4.2.3 Channel Bankfull Width

A narrower channel with a lower width-to-depth ratio results in a smaller contact area with warm afternoon air and is slower to absorb heat (Poole and Berman, 2001). Also, a narrower channel increases the effectiveness of shading produced by the riparian canopy.

Channel dimensions were not altered in the QUAL2K model scenarios because field measurements and observations suggest there was minimal potential to reduce stream channel width in both Ashley Creek and the Whitefish River. However, a channel geometry target width will apply for all applicable waterbody segments. The width target is no increase in average bankfull width due to human-caused sources from the range of values observed in each segment during 2008 data collection. The target is not intended to be specific to every given point on the stream; the intent rather, is to maintain width values in their current condition throughout each segment. If specific locations have the potential to become narrower, improved vegetation in riparian areas will generally lead to gradual improvements in these width values over time. If deemed appropriate, active restoration techniques could be used to give the stream channel an appropriate width at these locations.

7.4.2.4 Instream Discharge (Streamflow Conditions)

Larger volumes of water take longer to heat up during the day. The volumetric heat capacity of a stream is reduced if water volumes are reduced. In the Ashley Creek watershed, streamflow reductions are largely attributed to irrigation diversions. Therefore, improvements in water diversion infrastructure and water use efficiencies may leave more in the stream, and it is presumed that voluntary actions by water users could increase instream flow volume.

To determine the effects of having instream discharge targets on Ashley Creek, a scenario was run to represent all shade targets being met and an improvement in irrigation and domestic water use efficiency that would result in reducing water withdrawals by 15% (i.e., leaving 15% of the currently withdrawn water in the stream). Reducing the identified irrigation withdrawal volume by 15% is considered to be minimal based on the efficiency estimates of (Howell and Stewart, 2003; Negri et al., 1989; Natural Resources Conservation Service, 1997; Osteen et al., 2012) for different irrigation practices and has been used in other DEQ TMDL documents (e.g., (Montana Department of Environmental Quality, 2008b; 2009; 2013). A second model was run to represent only all shade targets being met.

Table 7-1 shows the results for Ashley Creek from both models as compared to the current condition and the difference between the two scenarios (i.e., the change in temperature as a result of meeting a 15% reduction in irrigation withdrawal) (see **Sections E2.2.2.2** and **E2.2.2.6** in **Attachment E** for detailed model output). Increasing the instream flows in addition to meeting shade targets resulted in no change at four sites, smaller temperature reductions at seven sites (i.e., higher stream temperatures), and greater temperature reductions (i.e., lower stream temperatures) at five sites. The increases in temperature reduction were less than 0.05°F at four of the five sites and never greater than 0.21°F (less than the 0.5°F increase allowed by the standard at naturally occurring temperatures greater than 66.5°F). Because the increased instream flow resulting from 15% less irrigation water being diverted had little benefit to Ashley Creek temperatures, there will not be targets for instream discharge values.

Table 7-1. Temperature reduction from the Baseline Scenario using the Shade and 15% Reduction of Water Withdrawn for Irrigation Scenario and the Shade Scenario

Segment	Site	Baseline Scenario Temperature (°F) – Shade and 15% Reduction of Water Withdrawn for Irrigation Scenario Temperature (°F)	Baseline Scenario Temperature (°F) – Shade Scenario Temperature (°F)	Difference
Upper Ashley Creek	ASHL-01	0.00	0.00	0.00
	ASHL-02	0.58	0.58	0.00
	ASHL-03	10.82	10.81	0.00
	ASHL-04	9.32	9.32	0.01
	ASHL-05	0.91	0.91	0.00
	ASHL-06	0.34	0.68	-0.34
	ASHL-08	1.88	1.95	-0.07
	ASHL-10	1.30	1.37	-0.07
	ASHL-11	1.47	1.53	-0.06
Middle Ashley Creek	ASHL-13	5.12	5.15	-0.03
	ASHL-15	1.99	2.02	-0.03
	ASHL-17	5.34	5.44	-0.10
	ASHL-18	6.26	6.06	0.21
Lower Ashley Creek	ASHL-19	8.42	8.39	0.03
	ASHL-20	9.00	8.99	0.01
	ASHL-21	3.38	3.37	0.01

Per Montana's water quality law, TMDL development cannot be construed to divest, impair, or diminish any water right recognized pursuant to Title 85 (Montana Code Annotated Section 75-5-705), so any voluntary water savings and subsequent in-stream flow augmentation must be done in a way that protects water rights. However, water users in the Ashley Creek watershed are encouraged to work with the United States Department of Agriculture (USDA) Natural Resource Conservation Service, the Montana Department of Natural Resources and Conservation, the local conservation district, and other local land management agencies to review their irrigation systems, practices, and the variables that may affect overall irrigation efficiency (Negri and Brooks, 1990; Natural Resources Conservation Service, 1997). If warranted and practical, users may consider changes that increase in-stream flows, and/or reduce warmwater return flows in Ashley Creek.

No irrigation withdrawals or return flows were identified along the Whitefish River during the 2008 assessment (**Section E2.2.3.4** in **Appendix E**). As a result, the water consumptive use scenario was not explored and there are no targets for instream discharge values for the segment. If irrigation

withdrawals are identified during future monitoring, then target development will be assessed using methods similar to those used for Ashley Creek.

7.4.2.5 City of Kalispell Small Municipal Separate Storm Sewer System (MS4)

The City of Kalispell and Montana Department of Transportation are co-permittees to a municipal separate storm sewer system (MS4) permit (MTR040005) that has discharge outfalls to the Ashley Creek watershed (middle Ashley Creek, lower Ashley Creek, and Spring Creek) and the Whitefish River watershed (Whitefish River). The short duration, infrequency, and magnitude of storm events in Montana during the summer makes it likely that any increase in instream temperature due to MS4 discharges will be short-term and the result of the initial flush through the system (Kron et al., 2011). The target for the City of Kalispell MS4 permit will be to follow the minimum control measures provided in the MPDES permit authorization for permit MTR04005, or any subsequent permit renewals. As long as all best management plans (BMPs) are effectively implemented as described in the permit, discharge will be consistent with naturally occurring conditions.

7.4.2.6 Wastewater Treatment Plants

Wastewater treatment plants (WWTPs) may influence a stream's water temperature. The temperature TMDL target is performance based for WWTPs and other point source effluents. This target requirement states that these point sources shall not warm the stream individually or in combination by more than the allowable increase in temperature under Montana's temperature standard that applies to Ashley Creek and the Whitefish River. This translates to no more than a 1.0°F increase when the receiving water is cooler than 66.5°F, no increase above 67°F when the receiving water is 66 – 66.5°F and no more than a 0.5°F increase under conditions where the receiving water is greater than 66.5°F.

7.4.3 Target Values Summary

The allowable human-caused temperature change is the primary target that must be achieved to meet the standard. The primary target for both Ashley Creek and the Whitefish River is as follows:

- When the naturally occurring temperature is less than 66°F, the maximum allowable increase is 1°F.
- Within the naturally occurring temperature range of 66 – 66.5°F, the allowable increase cannot exceed 67°F.
- When the naturally occurring temperature is greater than 66.5°F, the maximum allowable increase is 0.5°F.

Alternatively, compliance with the temperature standard can be attained by meeting all temperature-influencing targets for shade, bankfull width, and allowable temperature increase from point sources (**Table 7-2**). In this approach, if all reasonable land, soil, and water conservation practices are installed or practiced, state standards are met.

Table 7-2. Temperature-influencing Targets for Ashley Creek and the Whitefish River

Ashley Creek	
Target Parameter	**Target Value**
Riparian Health - Shade[1]	A buffer with a minimum effective shade of: • 79% at sampling sites with the potential for forested riparian vegetation • 64% at sampling sites with the potential for dense riparian vegetation • 10% at sampling sites with the potential for open/pasture riparian vegetation
Channel Bankfull Width	No increase in average channel bankfull width due to human-caused sources from the range of values observed in each segment during data collection: • Upper Ashley Creek: 16 - 25 feet • Middle Ashley Creek: 24 - 42 feet • Lower Ashley Creek: 26 - 94 feet
City of Kalispell Small MS4	Follow the minimum control measures provided in the MPDES permit authorization for permit MTR04005, or any subsequent permit renewals.
Wastewater Treatment Plants	Individually or in combination no more than a 1.0°F increase when the receiving water is cooler than 66.5°F, no increase above 67°F when the receiving water is 66 – 66.5°F, and no more than a 0.5°F increase under conditions where the receiving water is greater than 66.5°F
Whitefish River	
Target Parameter	**Target Value**
Riparian Health - Shade[1]	A buffer with a minimum of 47% effective shade at a given sample site
Channel Bankfull Width	No increase in average channel bankfull width due to human-caused sources from the range of values observed during data collection: • 63 - 80 feet
City of Kalispell Small MS4	Follow the minimum control measures provided in the MPDES permit authorization for permit MTR04005, or any subsequent permit renewals.
Wastewater Treatment Plants	Individually or in combination no more than a 1.0°F increase when the receiving water is cooler than 66.5°F, no increase above 67°F when the receiving water is 66 – 66.5°F and no more than a 0.5°F increase under conditions where the receiving water is greater than 66.5°F

[1] The shade minimum does not apply to portions where the riparian zone is already at potential or is dominated by vegetation not likely to attain great heights at maturity (e.g., wetland shrub community).

7.5 Approach to Source Assessment, TMDLs, Allocations, and Reductions

This section provides the overall approach used for source assessment, TMDL development, allocations, and reductions. This approach was applied to each of the four stream segments.

7.5.1 Source Assessment Using QUAL2K Models

Source assessment for Ashley Creek and the Whitefish River largely involved QUAL2K temperature modeling. **Appendix E** contains information regarding model setup and the scenarios that were used for source assessment analysis. Four of these scenarios are discussed in detail within this document (Baseline, Shade, Shade with no Kalispell WWTP discharge, and Shade with Kalispell WWTP discharge at the naturally occurring stream temperature).

Water temperature, flow, channel dimension, and riparian shade data were incorporated in a QUAL2K water quality model to characterize existing temperature conditions and to evaluate differing land management scenarios for Ashley Creek and the Whitefish River (see **Appendix E** for details). The QUAL2K model was used to determine the extent that human-caused disturbances within the Ashley Creek and Whitefish River watersheds have increased the water temperature above the naturally occurring level. QUAL2K is a one-dimensional river and stream water quality model that assumes the channel is well-mixed vertically and laterally. The QUAL2K model uses steady state hydraulics that simulates non-uniform steady flow. Within the model, water temperatures are estimated based on climate data, riparian shading, and channel conditions. Each stream is segmented into reaches within the model that are assigned the same channel and shade characteristics. For much of this assessment, the QUAL2K model was used to evaluate maximum summer water temperatures in Ashley Creek and the Whitefish River.

7.5.1.1 QUAL2K Model Assumptions

The following is a summary of the significant assumptions used during the QUAL2K model development:

- Ashley Creek and the Whitefish River can be divided into distinct segments, each considered homogeneous for shade, flow, and channel geometry characteristics. Monitoring site locations were selected to be representative of segments of Ashley Creek and the Whitefish River.
- Stream meander and subsurface flow paths (both of which may affect depth-velocity and temperature) are inherently represented during the estimation of various parameters (e.g., stream slope and channel geometry) for each segment.
- Weather conditions at the AgriMet Creston station and the Kalispell Glacier International Airport are representative of local weather conditions along Ashley Creek and the Whitefish River.
- The effective shade targets are achievable and consistent with the definition of the naturally occurring condition.

Additional assumptions are described in **Attachment ED** of **Appendix E**.

7.5.2 Wastewater Treatment Plant Source Assessment

The Kalispell WWTP (MT0021938) discharges into lower Ashley Creek 13.05 miles from the mouth and has a design flow of 8.36 cfs. The Burlington Northern and Santa Fe (BNSF) Facility (MT0000019) discharges into the Whitefish River 24.05 miles from the mouth and has a design flow of 0.15 cfs. The Whitefish WWTP (MT0020184) discharges into the Whitefish River at 22.25 miles from the mouth and has a design flow of 2.79 cfs. A QUAL2K model and mixing equations are used to evaluate the effect of the Kalispell WWTP on temperature in Ashley Creek. Mixing equations are used to evaluate the effect of the BNSF Facility and the Whitefish WWTP on temperature in the Whitefish River. In all cases where mixing equations are used, DEQ is interpreting the water quality standard for temperature to allow for complete mixing between the discharge water and the receiving waterbody.

7.5.3 Ashley Creek and Whitefish River Temperature TMDLs

TMDLs are a measure of the maximum load of a pollutant a particular waterbody can receive and still maintain water quality standards (**Section 4.0**). A TMDL is the sum of wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources. A TMDL includes a margin of safety (MOS) to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving stream. Allocations represent the distribution of allowable load applied to those factors that influence loading to the stream. In the case of temperature, thermal loading is assessed.

Because temperature changes throughout the course of a day, the temperature TMDL is the thermal load, at an instantaneous moment, associated with the stream temperature when in compliance with Montana's water quality standards. As stated earlier, the temperature standard for Ashley Creek and the Whitefish River is defined as follows: the maximum allowable increase over the naturally occurring temperature is 1°F, when the naturally occurring temperature is less than 66°F; within the naturally occurring temperature range of 66 – 66.5°F, the allowable increase cannot exceed 67°F; if the naturally occurring temperature is greater than 66.5°F, the maximum allowable increase is 0.5°F. Montana's temperature standard for B-1, B-2, and C-2 classified waters, relative to naturally occurring temperatures, is depicted in **Figure 7-4**.

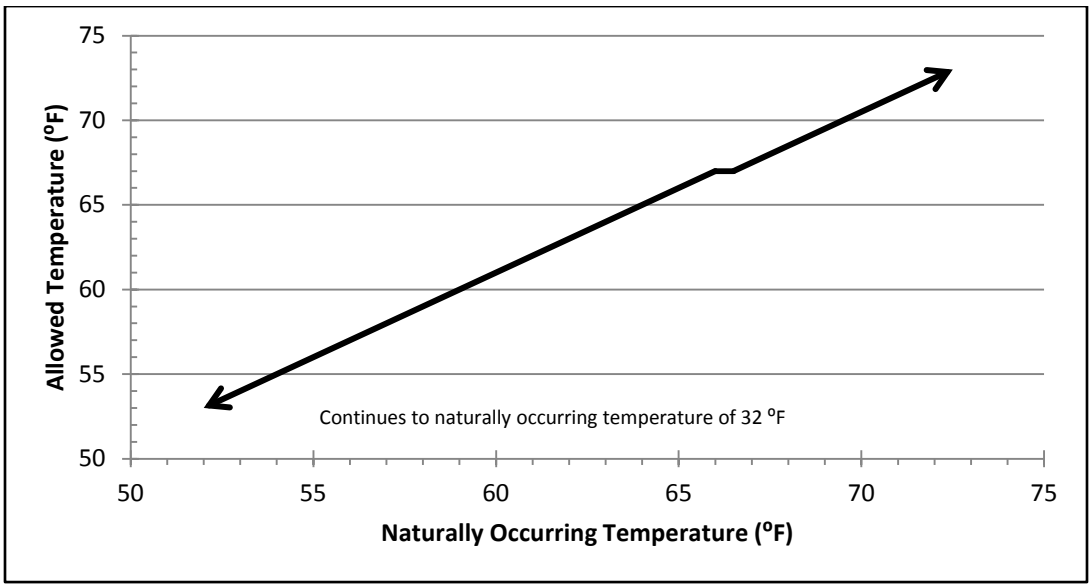


Figure 7-4. Instream Temperatures Allowed by Montana's B-1, B-2, and C-2 Classification Temperature Standards

An instantaneous load is computed by the second and applied at all times. The allowed temperature can be calculated using Montana's B-1, B-2, and C-2 classification standards and using a modeled, measured, or estimated naturally occurring instantaneous temperature. The allowable instantaneous total maximum load (per second) at any location in the waterbody is provided by **Equation 7-1**. This equates to the heat load (kcal/s) increase associated with the warming of the water from 32°F (i.e., water's freezing point) to the temperature that represents compliance with Montana's temperature standard, as determined from **Figure 7-4**.

Equation 7-1:

$$\mathbf{TMDL_{(instantaneous)} = ((T_{NO} + \Delta) - 32)*(5/9) * Q * 28.3}$$

Where:

T_{NO} = naturally occurring water temperature (°F)
Δ = allowable increase above naturally occurring temperature (°F)
Q = streamflow (cfs)
28.3 = conversion factor

The instantaneous load is the most appropriate expression for a temperature TMDL because water temperatures fluctuate throughout the day and an instantaneous load allows for evaluation of human-

caused thermal loading when fish are most distressed by elevated water temperatures and when human-caused thermal loading would have the most effect. Although EPA encourages TMDLs to be expressed in the most applicable timescale, it also requires TMDLs to be presented as daily loads (Grumbles, Benjamin, personal communication 2006). Any instantaneous TMDL calculated using **Equation 7-1**, which provides a load per second, can be converted to a daily load (kcal/day) by multiplying by 86,400 (i.e., the number of seconds in a day). Daily loads are provided for all example TMDLs and allocations in **Sections 7.6.1.3** and **7.6.2.3**.

Because calculation of the TMDL on any timescale relies on the identification of the naturally occurring condition, which fluctuates over time and within a stream, it generally requires a water quality model. However, the shade, width, and point source targets that will be met when all reasonable land, soil, and water conservation practices are applied fall under the definition of naturally occurring and are measurable components of meeting the TMDL and water quality standard. Meeting targets for effective shade, width, and point sources and applying all reasonable water conservation measures collectively provide an alternative method for meeting and evaluating the TMDL that more directly translates to implementation than an instantaneous or daily thermal load. Therefore, the targets provided in **Section 7.4.3** will serve as surrogates to the example numeric TMDLs and allocations in **Sections 7.6.1.3** and **7.6.2.3**.

7.5.4 Temperature TMDL Allocations, Wasteload Allocations, Existing Loads, and Reductions

As discussed in **Section 4.0**, the temperature TMDLs for applicable impaired waterbodies consist of the sum of the load allocations and wasteload allocations. For upper Ashley Creek and middle Ashley Creek, the TMDL consists of a single load allocation to all nonpoint sources, including natural background sources and an explicit MOS. For the upper and middle Ashley Creek segments, the load allocation for all nonpoint sources will be based on the naturally occurring temperature (**Equation 7-2**). This results in the entire temperature change allowed by the standard (0.5 – 1.0°F depending on the naturally occurring temperature) to be applied as an explicit MOS. Once the TMDL and load allocations (LA) have been calculated, the MOS (as a load) can be determined using **Equation 7-3**.

Equation 7-2:

$$LA_{(instantaneous)} = (T_{NO} - 32)*(5/9) * Q * 28.3$$

Where:

T_{NO} = *naturally occurring water temperature (°F)*
Q = *streamflow (cfs)*
28.3 = conversion factor

Equation 7-3:

$$TMDL_{(instantaneous)} = LA_{(instantaneous)} + MOS_{(instantaneous)}$$

Where:

$LA_{(instantaneous)}$ = *Composite Load Allocation to all nonpoint sources including natural background sources*
$MOS_{(instantaneous)}$ = *explicit margin of safety load based on the allowable increase above the naturally occurring temperature*

Allocations for lower Ashley Creek will consist of a composite load allocation for all nonpoint sources including natural background sources (**Equation 7-2**) and a wasteload allocation to the Kalispell WWTP.

In this case, the discharger appears to be causing a temperature change that is greater than allowed by the standard (see **Section 7.6.1.1.5**) and the WLA will be written to meet the standard using **Equation 7-4**. This segment of Ashley Creek will not be given an explicit MOS as the temperature change allowed by the standard will likely be used by the Kalispell WWTP. In the absence of an explicit MOS, an implicit MOS will be applied as described in **Section 7.7** and the TMDL for temperature in this waterbody segment is equal to the sum of the individual loads as follows:

Equation 7-4:

$$TMDL_{(instantaneous)} = LA_{(instantaneous)} + WLA_{(instantaneous)}$$

Where:

$LA_{(instantaneous)}$ = *Composite Load Allocation to all nonpoint sources including natural background sources*

$WLA_{(instantaneous)}$ = *Waste Load Allocation to the applicable point source*

Nonpoint sources in lower Ashley Creek are given a load allocation that is equal to the naturally occurring temperature (**Equation 7-2**). The WLA is given the entire increase above the naturally occurring temperature allowed by the water quality standard (0.5 – 1.0°F depending on the naturally occurring temperature). As such, the WLA for this segment is calculated using **Equation 7-4** as rearranged below:

$$WLA_{(instantaneous)} = TMDL_{(instantaneous)} - LA_{(instantaneous)}$$

In the case of the Whitefish River, the BNSF Whitefish Facility and the Whitefish WWTP do not appear to have a substantial effect on stream temperature (see **Sections 7.6.2.1.3** and **7.6.2.1.4**). The WLAs for these dischargers will be written based on the design flow of the facilities and a maximum temperature per **Equation 7-5**.

Equation 7-5:

$$WLA_{(instantaneous)} = (T_{max} - 32)*(5/9) * Q * 28.3$$

Where:

T_{max} = *maximum temperature of discharge (°F)*

Q = *design flow discharge in cubic feet per second*

28.3 = conversion factor

Allocations for the Whitefish River will consist of a composite load allocation for all nonpoint sources including natural background sources (**Equation 7-2**), wasteload allocations to the BNSF Facility and the Whitefish WWTP (**Equation 7-5**) and an explicit MOS consisting of the load remaining after the LA and WLAs are assigned (**Equation 7-6**). The WLAs were determined using the design flows, thus addressing future growth for these facilities. A portion of the explicit MOS may be reassigned as an allocation to address new discharges or additional increases in existing discharges if deemed necessary by DEQ. This would likely require a modification to the Whitefish temperature TMDL.

Equation 7-6:

$$TMDL_{(instantaneous)} = LA_{(instantaneous)} + WLA_{BNSF\,(instantaneous)} + WLA_{WHTFWWTP\,(instantaneous)} + MOS_{(instantaneous)}$$

Where:

$LA_{(instantaneous)}$ = Composite Load Allocation to all nonpoint sources including natural background sources
$WLA_{BNSF\ (instantaneous)}$ = Waste Load Allocation to the BNSF Facility
$WLA_{WHTFWWTP\ (instantaneous)}$ = Waste Load Allocation to the Whitefish WWTP
$MOS_{(instantaneous)}$ = explicit margin of safety consisting of the remaining load after the LA and WLAs are calculated

Per Montana state rule (ARM 17.30.637(2)), no wastes may be discharged such that the wastes, either alone or in combination with other wastes, will violate, or can reasonably be expected to violate, any of the standards. With reference to temperature this means that for WWTPs and other permitted dischargers, the discharge concentration must not change the water temperature more than allowed by the water quality standard. **Equations 7-4**, **7-5**, and **7-6**, are used to ensure that the development of the WLAs is consistent with the reasonable assurance approach defined within **Section 4.4**. WLAs will be modified based on a mass-balance approach if the status of assimilative capacity changes in the receiving water.

To provide an example estimate of the total existing loading from all sources combined, the following equation will be used:

Equation 7-7:

$$\textbf{Total Existing Load}_{(instantaneous)} = ((T_{meas}) - 32)*(5/9) * Q * 28.3$$

Where:

T_{meas} = measured or modeled existing water temperature (°F)
Q = streamflow (cfs)
28.3 = conversion factor

Reductions for both upper and middle Ashley Creek are calculated using the example LA (**Equation 7-2**) and the example existing load (**Equation 7-7**) using **Equation 7-8**. This was done because an explicit MOS was applied to the TMDLs in each of these segments.

Equation 7-8:

$$\textbf{Load Reduction} = ((\text{Existing Load} - LA) / \text{Existing Load})*100$$

No explicit MOS was applied to the TMDL for lower Ashley Creek. Therefore, the reduction is calculated using the example TMDL (**Equation 7-1**) and the example existing load (**Equation 7-7**) using **Equation 7-9**:

Equation 7-9:

$$\textbf{Load Reduction} = ((\text{Existing Load} - TMDL) / \text{Existing Load})*100$$

An explicit MOS was applied to the TMDL for the Whitefish River. The reduction for this segment is calculated using the example LA (**Equation 7-1**), WLAs (**Equation 7-5**) and the example existing load (**Equation 7-7**) using **Equation 7-10**:

Equation 7-10:

$$\textbf{Load Reduction} = ((\text{Existing Load} - (LA + WLA_{BNSF} + WLA_{WHTFWWTP})) / \text{Existing Load})*100$$

7.6 SOURCE ASSESSMENT, EXISTING CONDITIONS AND COMPARISON TO TARGETS, AND EXAMPLE TMDLS AND ALLOCATIONS FOR EACH STREAM

The below sections describe the most significant natural, non-permitted, and permitted sources of temperature in more detail; compare the existing conditions to targets; establish example TMDLs, load allocations, and wasteload allocations; provide existing temperature loading estimates for nonpoint and permitted point sources to temperature-impaired stream segments; and estimate reductions necessary to meet water quality targets for the following waterbody segments:

- Upper Ashley Creek (Ashley Lake to Smith Lake; MT76O002_010)
- Middle Ashley Creek (Smith Lake to Kalispell Airport Road; MT76O002_020)
- Lower Ashley Creek (Kalispell Airport Road to the mouth; MT76O002_030)
- Whitefish River (Whitefish Lake to the mouth; MT76P003_010)

Source assessments are presented for the whole stream, whereas existing conditions and comparison to targets, TMDLs, allocations, and reductions are presented for specific waterbody segments. Existing (baseline scenario) loads are used to estimate load reductions. The existing loads, TMDLs, allocations, and reductions provided in the following sections are examples based on specific instream and effluent temperature and discharge conditions. They are not intended to prescribe what the values should be at all times. The actual values for each vary depending on the naturally occurring water temperature and streamflow which vary by location and time. Use **Equation 7-1** in **Section 7.5.3** to determine the actual TMDL for a given naturally occurring temperature and flow.

7.6.1 Ashley Creek

7.6.1.1 Source Assessment

This section describes the nonpoint and point sources associated with elevated temperatures in Ashley Creek. QUAL2K model scenarios are used to describe the most substantial sources of elevated temperature and conditions under which the water quality standard for temperature are met.

7.6.1.1.1 Baseline Scenario (Existing Conditions)

The baseline scenario represents the existing conditions within Ashley Creek on August 18, 2008, which was determined to be the hottest period for water temperatures during the 2008 summer. To inform the model, this scenario used the measured field data to represent temperature, flow, and shade. When field data were unavailable, reasonable assumptions and extrapolation were used. The model was then run and compared with measured conditions. Hydraulic output in the model accurately reflected measured conditions, indicating that water routing and channel morphology were adequately calibrated. To assure consistency when evaluating the potential to reduce stream temperatures, subsequent model scenarios were compared with the existing-conditions results of the baseline model and not to the field-measured values.

Under the baseline scenario, maximum daily temperatures range from 66.2°F at ASHL-06 to 80.3°F at ASHL-13 (**Figure 7-5**). Temperatures are variable with a slight decrease in the downstream direction. The modeled maximum temperatures exhibit a pattern similar to the maximum measured values with an average error of 4.1% (**Figure 7-5**).

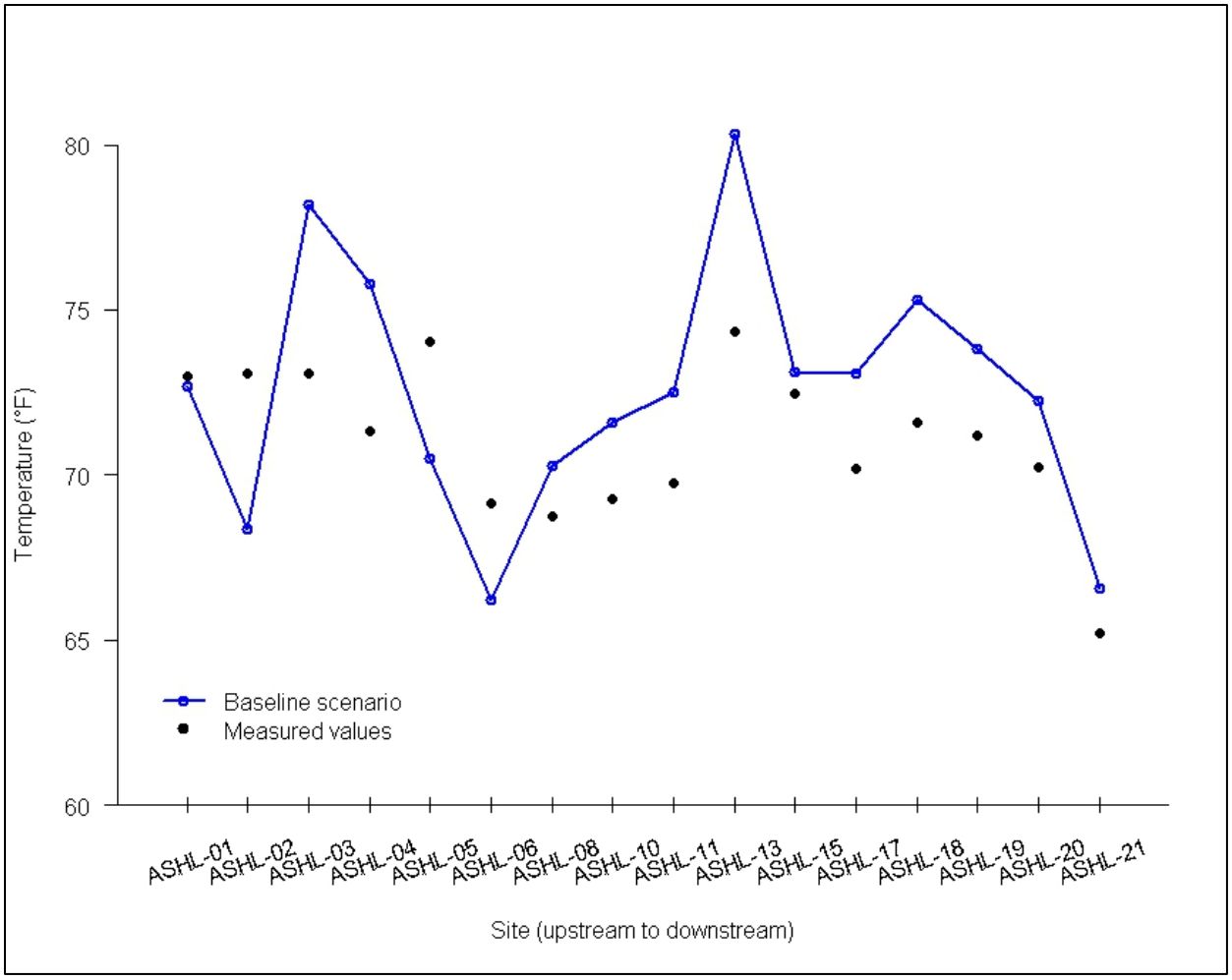


Figure 7-5. Maximum temperatures for measured data and the QUAL2K Baseline Scenario at Ashley Creek sampling sites

7.6.1.1.2 Shade Scenario

The shade scenario altered the model to represent the naturally occurring condition for shade based on field measured shade values and GIS analysis. In this scenario, the upper watershed was set to be forested except in locations that appeared to naturally be meadow environments, which were then set to be open/pasture. The lower reaches of Ashley Creek were set to be dense riparian vegetation as the reference condition. The input from the Kalispell WWTP was not adjusted in this scenario. For the shade scenario, a total of 10 reaches (3.8 miles) were altered to a forested vegetation type and 12 reaches (19.6 miles) were altered to a dense riparian vegetation type (**Table E2-6** in **Appendix E**). Thus, riparian shade density was increased along a total of 23.4 miles of Ashley Creek, which is 52% of the total length (44.7 miles). Percent effective shade for each category was based on the field assessed sites. The results of the shade scenario indicate that an increase in streamside shading along Ashley Creek would decrease stream temperatures from 0 – 10.81°F as compared to the current conditions with a decrease of at least 0.5°F at 15 of 16 sampling sites (**Figure 7-6**).

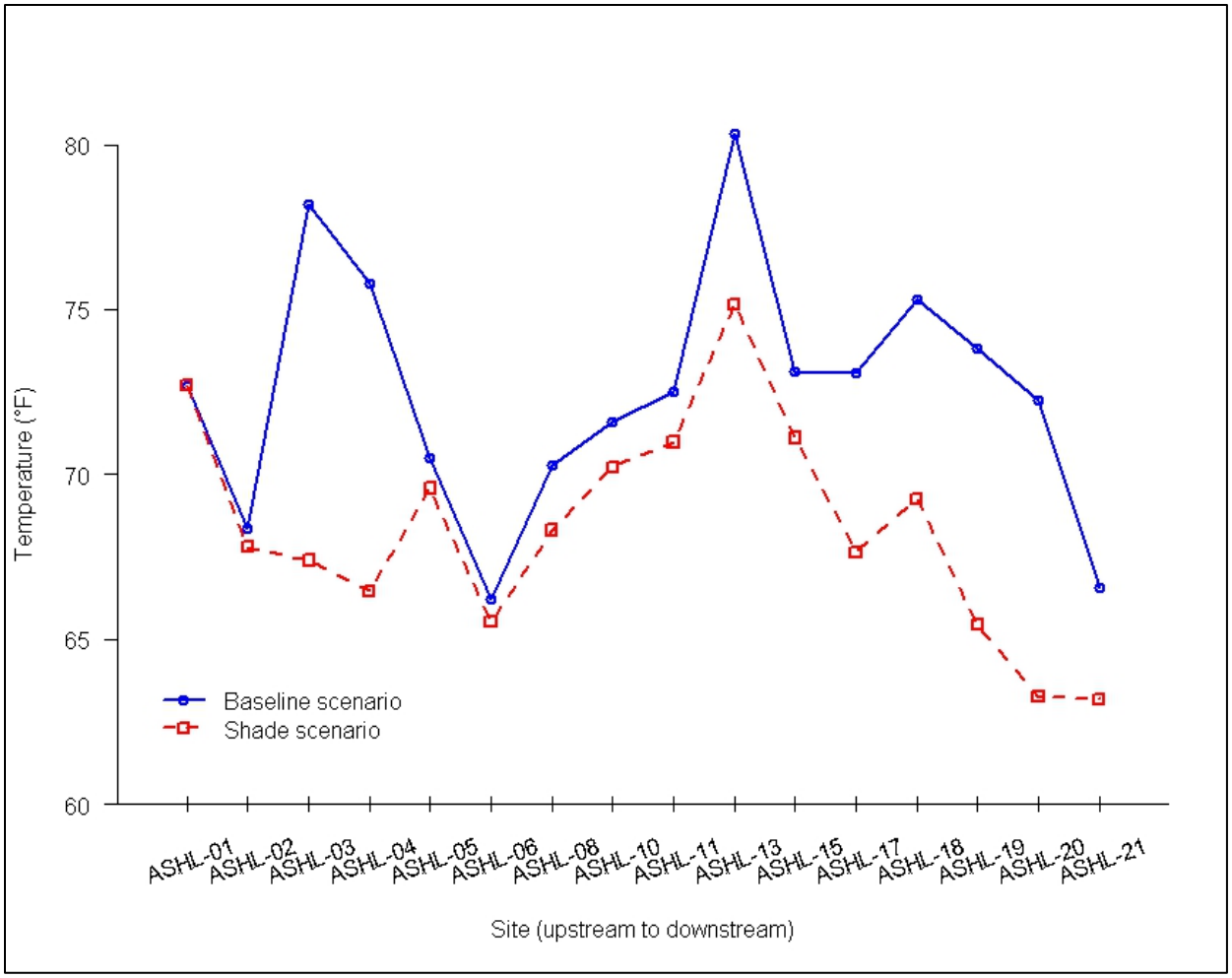


Figure 7-6. Maximum temperatures for QUAL2K Baseline and Shade scenarios at Ashley Creek sampling sites

7.6.1.1.3 Shade with no Kalispell WWTP discharge scenario

This scenario included the same alterations made to the model for the shade scenario but in this case the input of effluent discharge from the Kalispell WWTP was removed. This models the naturally occurring temperature of Ashley Creek from the WWTP location (13.05 miles from the mouth) downstream in the absence of the WWTP discharge (**Section E2.2.2.7** in **Appendix E**). This model resulted in an average naturally occurring temperature near the WWTP location (13.39 miles from the mouth) of 61.95°F (**Table E2-13** in **Appendix E**).

7.6.1.1.4 Shade with the Kalispell WWTP discharging at the naturally occurring stream temperature scenario

This scenario included the same alterations made to the model for the shade scenario but in this case the input of effluent from the Kalispell WWTP was set to the average naturally occurring instream temperature of 61.95°F (**Section 7.6.1.1.3**; **Section E2.2.2.7** in **Appendix E**) at the location of the Kalispell WWTP (13.05 miles from the mouth). To determine the approximate effect of the WWTP when all shade targets are met we can subtract the temperature values produced by this scenario from those produced by the shade scenario at the sites downstream of the WWTP. The WWTP discharging at the naturally occurring temperature decreases temperatures at the sites downstream from the effluent discharge

(**Figure 7-7**). Further evaluation of the effects of the Kalispell WWTP on Ashley Creek is found in **Section 7.6.1.1.5**.

The naturally occurring condition for water temperature results from implementing all reasonable land, soil, and water conservation practices as outlined in ARM 17.30.602. This condition identifies the naturally occurring temperature in waterbodies of interest and establishes the temperature increase that is allowable. In turn, this can be used to identify the impairment status of a waterbody and forms the basis for the allocations and temperature TMDLs in this document. Based on the results of the scenario comparisons, the shade scenario with the Kalispell WWTP discharging at the naturally occurring stream temperature represents the naturally occurring condition and there is the potential for substantial reductions in stream temperatures relative to the baseline (existing) condition.

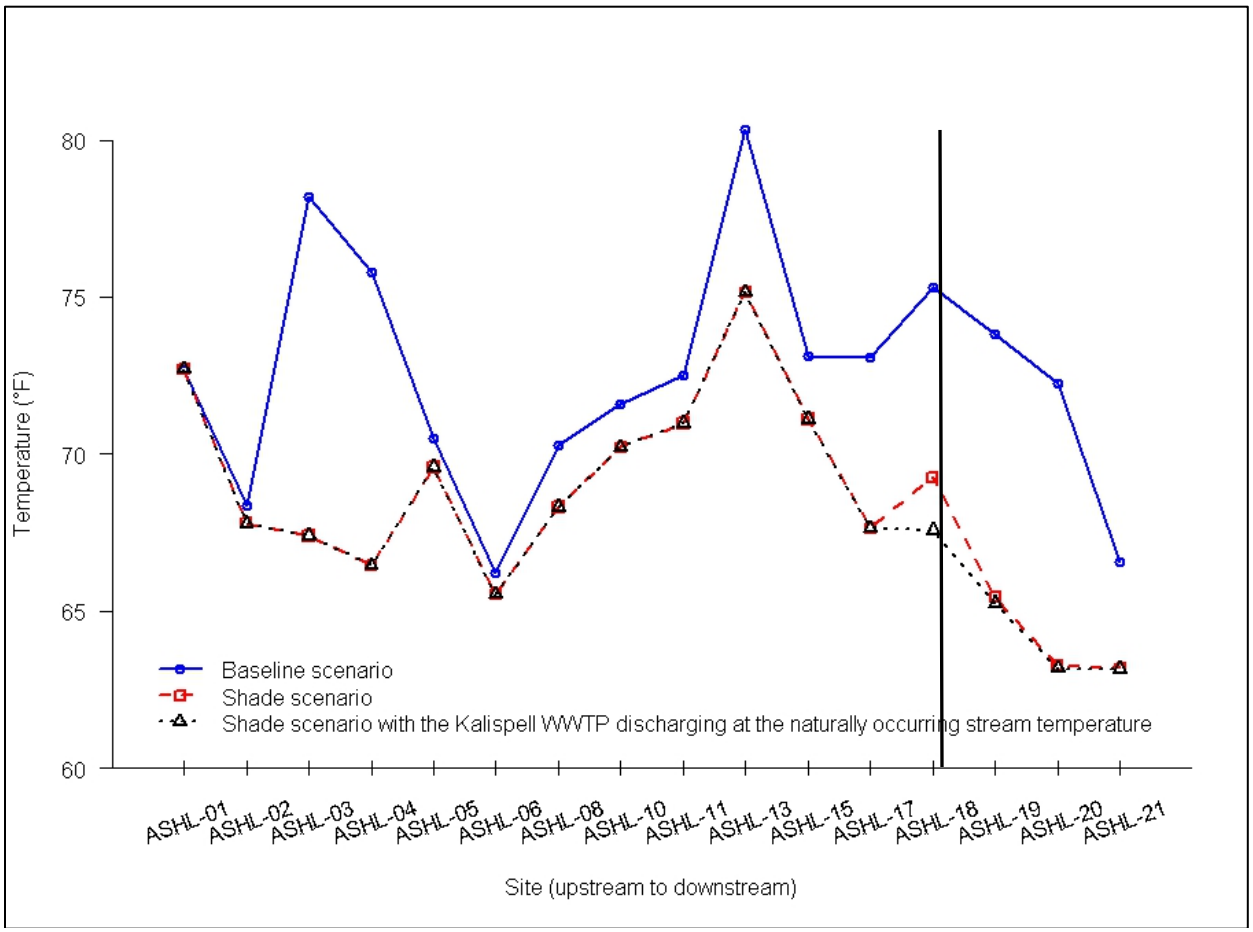


Figure 7-7. Maximum temperatures for QUAL2K Baseline, Shade scenarios, and Shade scenario with the Kalispell WWTP discharging at the average naturally occurring stream temperature at Ashley Creek sampling sites

The WWTP is located just downstream of site ASHL-18 in lower Ashley Creek (black vertical bar). However, the QUAL2K model was set up to incorporate ASHL-18 and the WWTP into the same reach. Therefore, effects from the WWTP are incorporated into the modeled temperature at ASHL-18

7.6.1.1.5 Kalispell WWTP (MT0021938) Point Source Discharge Assessment

The City of Kalispell WWTP discharges directly into Ashley Creek. To evaluate the temperature effects of the WWTP under the current condition, measured data were used. To determine the effects of the WWTP under the shade scenario the QUAL2K model was used.

An instantaneous thermal load (in kilocalories per second) can be calculated for the streamflow and WWTP discharge flows per **Equation 7-11** below. Note that this loading equation is applicable to water at a temperature greater than the freezing point of 32°F. The effects of the WWTP discharge can then be calculated by completely mixing the discharge water with the flow of Ashley Creek under differing conditions.

Equation 7-11:

$$\textbf{Relative Heat Load per unit time (kcal/s)} = ((T_{°F} - 32)*(5/9) * Q * 28.3$$

Where:

Relative Heat Load per unit time (kcal/s) = Heat Energy (kcal)/s
$T_{°F}$ *= Temperature in °F*
Q = Flow in cfs
28.3 = conversion factor

To examine the effects of the Kalispell WWTP on Ashley Creek, we calculated temperature changes for two different examples. The first uses the measured average August 2008 temperature (66.12°F) recorded by the temperature data logger at sampling site ASHL-18 upstream of the WWTP and is considered the measured existing conditions example. The second example uses the modeled average shade scenario temperature of 62.01°F upstream of the WWTP between ASHL-17 and ASHL-18 (15.25 mi from the mouth; **Table E2-13** in **Appendix E**) and is considered the shade scenario example. In this instance the shade scenario temperature is considered a naturally occurring temperature because the location is upstream of the WWTP influence and improving riparian shading is considered to be implementation of all reasonable land, soil, and water conservation practices. Both examples use an average measured August (2003 – 2012) effluent temperature of 68.18°F (**Table B-5** in **Appendix B**) and effluent discharge of 4.1 cfs (**Table B-6** in **Appendix B**) from the Kalispell WWTP and an average measured August (2007 – 2008) streamflow of 11.72 cfs in Ashley Creek downstream of the Kalispell WWTP; **Table B-7** in **Appendix B**). **Equation 7-11** and a basic mixing equation (**Equation 7-12**) were used to calculate the effects of the WWTP on instream temperatures in Ashley Creek.

Equation 7-12:

Heat load of downstream of point source =
Heat load from stream upstream of point source + Heat load from point source effluent

Equation 7-11 rewritten as:

$$T_{°F} = (9/5) * (\text{Relative Heat Load per unit time} / (Q * 28.3)) + 32$$

was used to convert the thermal load of Ashley Creek with the WWTP effluent back to a temperature.

Measured Existing Conditions Example:

For this example, the thermal load of Ashley Creek at ASHL-18 was:

$$((66.12°F – 32)*(5/9) * 7.62 \text{ cfs}^{(2)} * 28.3 = 4,088 \text{ kcal/s}$$

(2) 7.62 cfs is the flow at ASHL-18 based on the calculation of 11.72 cfs (**Appendix B**, **Table B-7**) at the gage downstream of the WWTP minus 4.1 cfs, the August 2003 – 2012 average effluent flow from the WWTP (**Appendix B**, **Table B-6**).

The thermal load of the WWTP was:

$$(68.18°F – 32) * (5/9) * 4.1 \text{ cfs} * 28.3 = 2,332 \text{ kcal/s}$$

The total thermal load of Ashley Creek below the WWTP would therefore be:

$$4,088 \text{ kcal/s} + 2,332 \text{ kcal/s} = 6,420 \text{ kcal/s}$$

And the water temperature would be:

$$(9/5) * (6,421 \text{ kcal/s}) / (11.72 \text{ cfs} * 28.3)) + 32 = 66.85°F$$

In this case, the WWTP causes an increase of 0.72°F (66.84°F – 66.12°F) in the temperature of Ashley Creek, less than the 0.88°F increase allowed by the standard if the naturally occurring temperature of Ashley Creek was 66.13°F.

Modeled Shade Scenario Example:
For this example, the thermal load of Ashley Creek between ASHL-17 and ASHL-18 was:

$$(62.01°F – 32) * (5/9) * 7.62 \text{ cfs} * 28.3 = 3,595 \text{ kcal/s}$$

The thermal load of the WWTP was:

$$(68.18°F – 32)*(5/9) * 4.1 \text{ cfs} * 28.3 = 2,332 \text{ kcal/s}$$

The total thermal load of Ashley Creek below the WWTP would therefore be:

$$3,595 \text{ kcal/s} + 2,332 \text{ kcal/s} = 5,927 \text{ kcal/s}$$

And the water temperature would be:

$$(9/5) * (5,927 \text{ kcal/s} / (11.72 \text{ cfs} * 28.3)) + 32 = 64.17°F$$

In this case, the WWTP causes an increase of 2.16°F (64.17°F – 62.01°F) in the temperature of Ashley Creek, which is greater than the 1.0°F increase allowed by the standard at the modeled naturally occurring temperature of 62.01°F.

The results of the two examples indicate that, all other variables remaining the same, as temperature in Ashley Creek upstream of the WWTP decreases, the WWTP has a greater warming effect on downstream temperatures. This means that as BMPs are put into place, shade is increased, and temperatures decrease, the WWTP will have a greater effect on the instream temperature. **Figure 7-8** displays the relationship between modeled Ashley Creek temperature and the effect of the WWTP on

temperature immediately downstream of the effluent discharge. It indicates that, with existing WWTP effluent discharge conditions of 4.1 cfs at 68.18°F, the WWTP causes the temperature standard to be exceeded when the stream temperature is below about 66°F and at about 66.5°F. When the stream temperature is greater than about 68°F, the WWTP has a cooling effect on Ashley Creek.

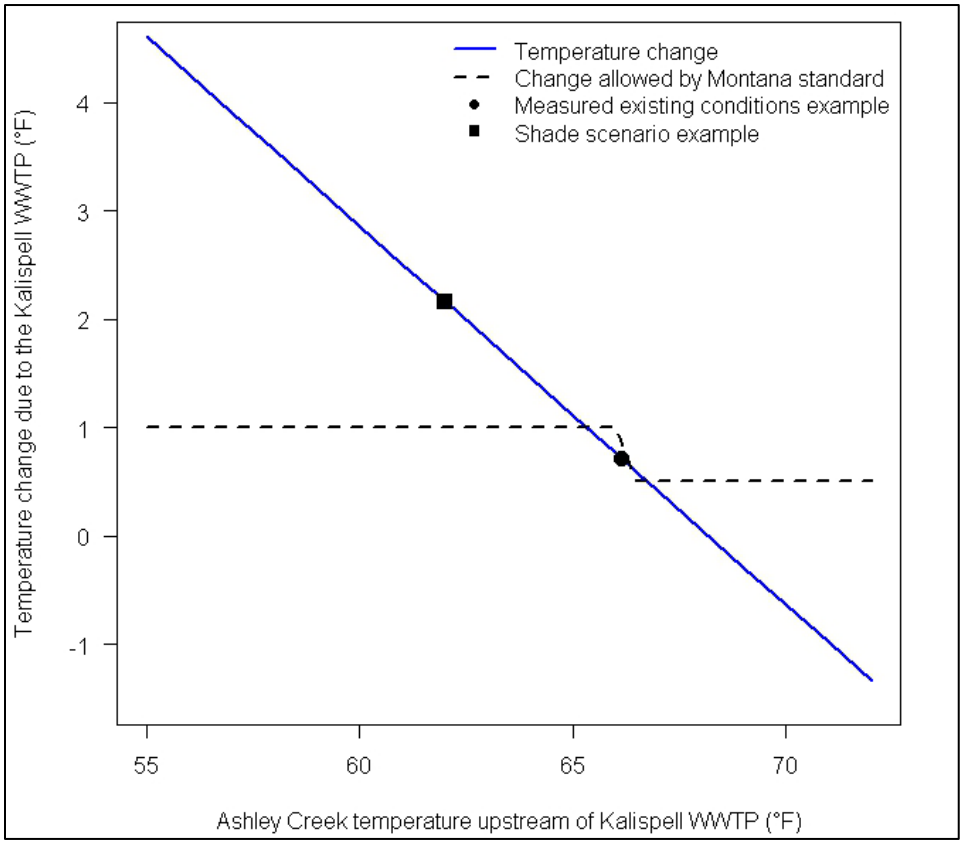


Figure 7-8. Temperature change in Ashley Creek at various stream temperatures caused by the Kalispell WWTP at a stream discharge of 7.62 cfs and a WWTP effluent discharge of 4.1 cfs at 68.18°F

The two examples outlined above (measured existing conditions and modeled shade scenario) and the temperature change due to the Kalispell WWTP plotted in **Figure 7-8** represent temperature change immediately downstream of the WWTP discharge point.

The QUAL2K model also indicates that the WWTP is increasing temperatures above what is described by the standard for a substantial distance downstream of the discharge point. As outlined in **Section 7.6.1.1.4**, the approximate effect of the WWTP when all shade targets are met can be determined by subtracting the temperature values produced by the shade with the Kalispell WWTP discharging at the naturally occurring stream temperature scenario from those produced by the shade scenario at locations downstream of the WWTP. When looking at the differences between these two scenarios, the WWTP (discharging 13.05 miles from the mouth) seems to be causing the standard to be exceeded at least 2.48 mi downstream of the effluent discharge when maximum temperatures are observed and 2.03 mi when minimum temperatures are observed (**Table 7-3**). The WWTP appears to increase temperature throughout the remainder of Ashley Creek, although the difference in temperature is not enough to exceed the standard.

Table 7-3. Comparison of differences in maximum and minimum temperatures on the hottest day of August between the shade scenario and the shade with the Kalispell WWTP (13.05 miles from the mouth) discharging at the average naturally occurring stream temperature (61.95°F) scenario at locations downstream of the effluent discharge

Differences that exceed the standard are in bold text

Distance from mouth (mi)	Modeled maximum temperature (°F)			Modeled minimum temperature (°F)		
	Shade scenario	Shade with WWTP effluent at naturally occurring stream temperature scenario	Difference	Shade scenario	Shade with WWTP effluent at naturally occurring stream temperature scenario	Difference
12.17	69.31	67.93	**1.38**	58.23	56.81	**1.43**
11.60	69.09	67.96	**1.13**	57.76	56.60	**1.16**
11.02	68.81	67.88	**0.92**	57.46	56.52	**0.94**
10.27	68.46	67.78	**0.68**	57.20	56.51	0.69
9.36	68.24	67.74	0.50	57.05	56.54	0.51
8.45	68.10	67.74	0.37	56.93	56.56	0.37
7.60	65.91	65.61	0.29	57.92	57.63	0.29
6.81	65.34	65.11	0.23	58.53	58.30	0.23
6.02	65.44	65.26	0.19	58.70	58.52	0.19
5.27	65.55	65.40	0.15	58.68	58.52	0.15
4.56	65.58	65.45	0.12	58.61	58.49	0.12
3.84	65.56	65.46	0.10	58.57	58.47	0.10
3.27	63.26	63.18	0.08	60.57	60.49	0.08
2.84	63.10	63.03	0.06	60.92	60.86	0.06
2.41	63.13	63.08	0.05	60.91	60.86	0.05
2.09	63.17	63.12	0.04	60.89	60.85	0.04
1.88	63.17	63.13	0.04	60.88	60.84	0.04
1.67	63.17	63.14	0.03	60.88	60.85	0.03
1.30	63.18	63.15	0.03	60.89	60.86	0.03
0.78	63.18	63.16	0.02	60.89	60.87	0.02
0.26	63.19	63.17	0.02	60.90	60.88	0.02
0.00	63.19	63.17	0.02	60.90	60.88	0.02

Table B-5 in **Appendix B** shows monthly average temperature data collected upstream of the Kalispell WWTP, in the effluent of the WWTP, and downstream of the WWTP. These values suggest that there are times when the WWTP is actually cooling Ashley Creek. Because there is evidence that the WWTP is warming Ashley Creek at some times and cooling it at others, it is important that a robust dataset of synoptic temperature samples collected in Ashley Creek directly upstream of the WWTP effluent discharge, from the effluent discharge, and directly downstream of the effluent discharge mixing zone be collected prior to temperature WLAs being incorporated into the MPDES permit for the Kalispell WWTP. These data will help determine if and when the WWTP is warming Ashley Creek such that the water quality standard for temperature is exceeded and when mitigation is warranted. Further discussion of such sampling can be found in **Section 7.6.3**.

7.6.1.2 Ashley Creek Existing Conditions and Comparison to Targets

To evaluate whether attainment of temperature targets has been met, the existing water quality conditions in the Ashley Creek waterbody segments are compared to the conditions when water quality targets are met. This is done using the QUAL2K model and different scenarios that represent the

implementation of all reasonable land, soil, and water conservation practices. This approach provides DEQ with updated impairment determinations used for TMDL development.

As part of the temperature analysis, aerial photographs were used to identify study reaches and provide broad classifications of potential riparian vegetation condition in three categories: Forested, dense riparian, and open/pasture. Sites were then analyzed in the field in a selected number of study reaches and average effective shade for those sites was assessed. For modeling purposes, the average of the results for sites in each category was then applied to the corresponding category for those reaches that were not sampled. For all Ashley Creek segments the average effective shade for the reach vegetation classifications are: 10% for open/pasture; 64% for dense riparian; and 79% for forested.

7.6.1.2.1 Upper Ashley Creek (Ashley Lake to Smith Lake)

The QUAL2K model results indicate that maximum naturally occurring summer temperatures ≥ 66.5°F occur at all upper Ashley Creek sites (ASHL-01 to ASHL-11; **Figure 7-7**), which means that when water temperatures are the warmest, the allowed increase above the naturally occurring temperature is 0.5°F (**Figure 7-4**). Temperature differences between maximum temperatures under the baseline condition and the naturally occurring condition (**Section 7.6.1.1.4**) range from 0 to 10.8°F and average 3.0°F (**Figure 7-9**). The allowed increase is being exceeded at all sites in upper Ashley Creek except ASHL-01.

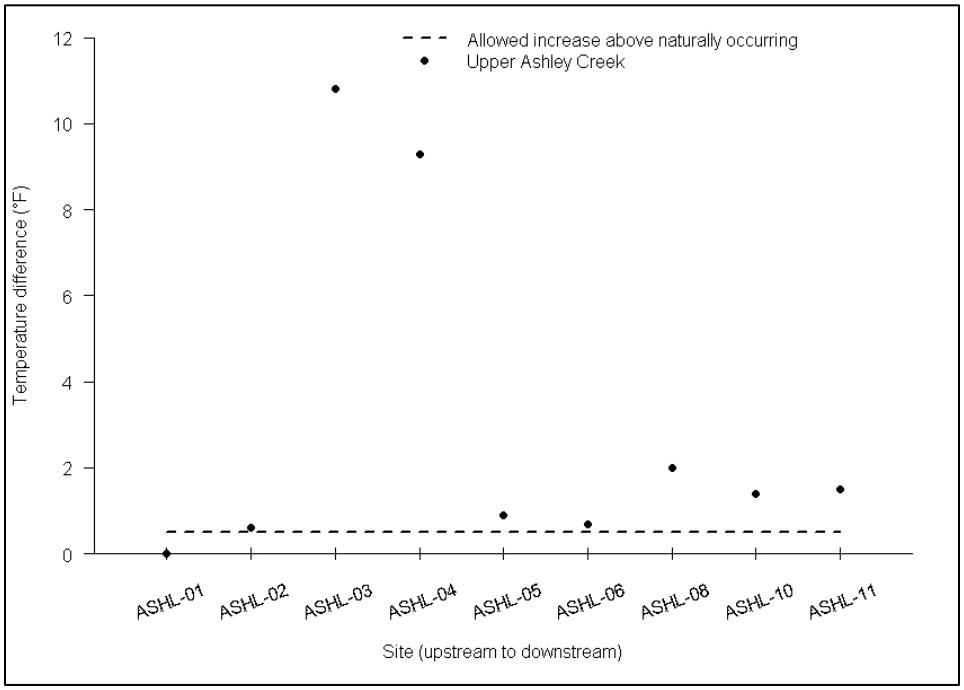


Figure 7-9. Difference between the baseline (existing) condition and the naturally occurring condition (implementation of all reasonable land, soil and water conservation practices) maximum temperatures at temperature data logger sites on upper Ashley Creek

Field vegetation classification data for upper Ashley Creek indicate that 57% of the segment is open/pasture, 3% is low/moderate riparian, and 32% is forested with the remainder being lake. The potential riparian vegetation for upper Ashley Creek consists of 56% forested and 36% open pasture. About 24% of the segment is below target for effective shade (**Attachment EF** in **Appendix E**).

As described in **Section 7.4.2.3**, the width target is included because wider streams, especially those with higher width-to-depth ratios absorb more solar energy than narrow, deep channels; therefore, overwidened streams will be more sensitive to thermal loading. Overall, the width of upper Ashley Creek appears to be in a healthy state and as such it meets the target. There may be specific locations that are substantially wider than is ideal. Such areas may be identified and incorporated as potential restoration locations in the Watershed Restoration Plan for Ashley Creek.

Summary and TMDL Development Determination

The human-influenced allowable temperature change target is being exceeded in upper Ashley Creek. Although width values are meeting the targets throughout the segment, riparian vegetation is generally under the shade target, which causes increases in temperature. This information supports the existing temperature impairment listing for upper Ashley Creek; a temperature TMDL has been developed for this segment (see **Section 7.6.1.3.1**).

7.6.1.2.2 Middle Ashley Creek (Smith Lake to Kalispell Airport Road)

The QUAL2K model results indicate that maximum naturally occurring summer temperatures ≥ 66.5°F occur at all middle Ashley Creek sites (ASHL-13 to ASHL-18; **Figure 7-7**), which means that when water temperatures are the warmest, the allowed increase above the naturally occurring temperature is 0.5°F (**Figure 7-4**). Temperature differences between maximum temperatures under the baseline condition and the naturally occurring condition (**Section 7.6.1.1.4**) range from 2.0 to 7.7°F and average 5.1°F (**Figure 7-10**). The allowed increase is being exceeded at all sites in middle Ashley Creek.

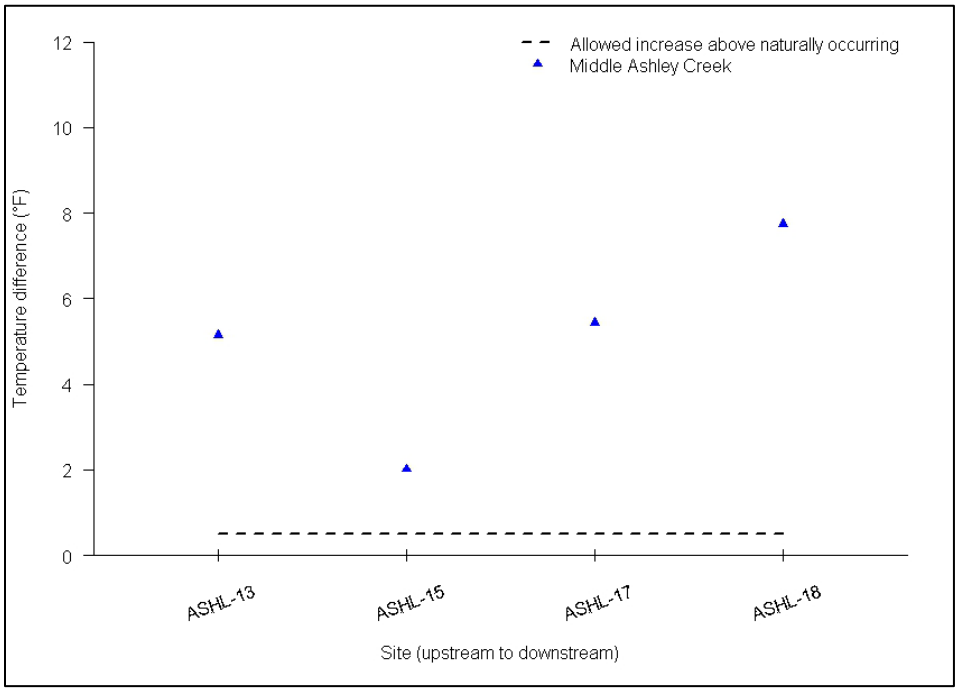


Figure 7-10. Difference between the baseline (existing) condition and the naturally occurring condition (implementation of all reasonable land, soil and water conservation practices) maximum temperatures at temperature data logger sites on middle Ashley Creek

Field vegetation classification data for middle Ashley Creek indicate that 22% of the segment is open/pasture, 52% is low/moderate riparian, and 26% is dense riparian. The potential riparian

vegetation for middle Ashley Creek consists of 16% open/pasture and 84% dense riparian. About 78% of the segment is below target for effective shade (**Attachment EF** in **Appendix E**).

As described in **Section 7.4.2.3**, the width target is included because wider streams, especially those with higher width-to-depth ratios absorb more solar energy than narrow, deep channels; therefore, overwidened streams will be more sensitive to thermal loading. Overall, the width of middle Ashley Creek appears to be in a healthy state and as such it meets the target. There may be specific locations that are substantially wider than is ideal. Such areas may be identified and incorporated as potential restoration locations in the Watershed Restoration Plan for Ashley Creek.

Summary and TMDL Development Determination

The human-influenced allowable temperature change target is being exceeded in middle Ashley Creek. Although width values are meeting the targets throughout the segment, riparian vegetation is generally under the shade target, which causes increases in temperature. This information supports the addition of a temperature impairment listing for middle Ashley Creek; a temperature TMDL has been developed for this segment (see **Section 7.6.1.3.2**).

7.6.1.2.3 Lower Ashley Creek (Kalispell Airport Road to the mouth)

The QUAL2K model results indicate that the maximum naturally occurring summer temperatures at the three lower Ashley Creek sites are ≤ 66.5°F (ASHL-19 to ASHL-21; **Figure 7-7**), which means that when water temperatures are the warmest, the allowed increase above the naturally occurring temperature is 1.0°F (**Figure 7-4**). Temperature differences between maximum temperatures under the baseline condition and the naturally occurring condition (**Section 7.6.1.1.4**) range from 3.4 to 9.1°F and average 7.0°F (**Figure 7-11**). The allowed increase is being exceeded at all sites in lower Ashley Creek.

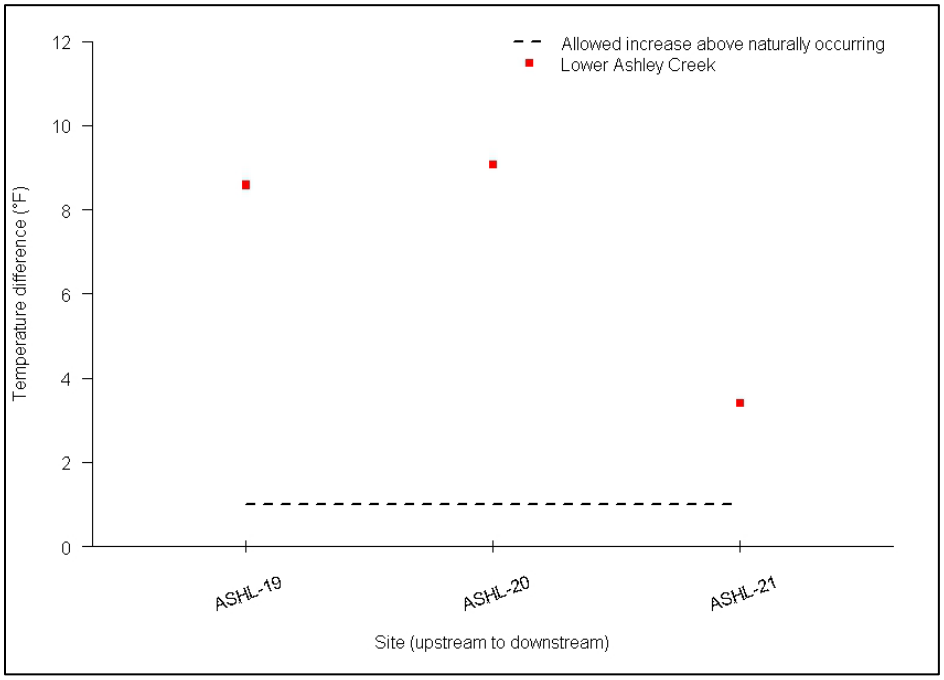


Figure 7-11. Difference between the baseline (existing) condition and the naturally occurring condition (implementation of all reasonable land, soil and water conservation practices) maximum temperatures at temperature data logger sites on lower Ashley Creek

Field vegetation classification data for lower Ashley Creek indicate that 17% of the segment is open/pasture, 70% is low/moderate riparian, and 13% is dense riparian. The potential riparian vegetation for lower Ashley Creek consists of 100% dense riparian. About 87% of the segment is below target for effective shade (**Attachment EF** in **Appendix E**).

As described in **Section 7.4.2.3**, the width target is included because wider streams, especially those with higher width-to-depth ratios absorb more solar energy than narrow, deep channels; therefore, overwidened streams will be more sensitive to thermal loading. Overall, the width of lower Ashley Creek appears to be in a healthy state and as such it meets the target. There may be specific locations that are substantially wider than is ideal. Such areas may be identified and incorporated as potential restoration locations in the Watershed Restoration Plan for Ashley Creek.

Point sources of thermal load to Ashley Creek are required to meet temperature discharges that are consistent with the appropriate water quality standards. The City of Kalispell WWTP discharge to lower Ashley Creek is not currently satisfying this target as evaluated in **Section 7.6.1.1.5**.

Summary and TMDL Development Determination

The human-influenced allowable temperature change target is being exceeded in lower Ashley Creek. Although width values are meeting the targets throughout the segment, riparian vegetation is generally under the shade target, which causes increases in temperature. In addition, the Kalispell WWTP is exceeding the target for point source discharges. This information supports the existing temperature impairment listing for lower Ashley Creek; a temperature TMDL has been developed for this segment (see **Section 7.6.1.3.3**).

7.6.1.3 Ashley Creek Example TMDLs and Allocations

7.6.1.3.1 Upper Ashley Creek (Ashley Lake to Smith Lake)

The example numeric temperature TMDL for upper Ashley Creek is based on **Equation 7-1** and the load allocation to nonpoint sources is based on **Equation 7-2**. An explicit MOS of 0.5 to1.0°F will be used in this waterbody segment depending on the naturally occurring temperature. The following example TMDL for upper Ashley Creek uses the flow measured at ASHL-06 on 8/15/08 (5.0 cfs) and the modeled shade scenario (i.e. naturally occurring) maximum temperature of 65.5°F. At this temperature the allowable increase above the naturally occurring temperature is 1.0°F based on the water quality standard for temperature [ARM 17.30.623(e)].

The example TMDL is therefore:

$$\mathbf{TMDL_{(instantaneous)} = ((65.5 + 1) - 32)*(5/9) * 5.0 * 28.3 = 2{,}712\ kcal/s}$$

Converted to a daily load the example TMDL is:

$$\mathbf{TMDL = 2{,}712\ kcal/s * 86{,}400\ s/day = 234{,}316{,}800\ kcal/day}$$

Equation 7-2 is the basis for the example composite load allocation for temperature. To continue with the example at a modeled naturally occurring maximum temperature of 65.5°F, flow of 5.0 cfs, and an explicit MOS of 1.0°F, this allocation is as follows:

$$\mathbf{LA_{(instantaneous)} = (65.5 - 32)*(5/9) * 5.0 * 28.3 = 2{,}633\ kcal/s}$$

Converted to a daily load the example LA is:

LA = 2,633 kcal/s * 86,400 s/day = 227,491,200 kcal/day

Using **Equation 7-3** the resulting explicit MOS at 5.0 cfs is:

$MOS_{(instantaneous)}$ = 2,712 kcal/s - 2,633 kcal/s = 79 kcal/s

Converted to a daily load the MOS is:

MOS = 79 kcal/s * 86,400 s/day = 6,825,600 kcal/day

The instantaneous existing load at ASHL-06 based on **Equation 7-7**, a modeled existing maximum temperature of 66.2°F, and flow of 5.0 cfs is:

Existing Load $_{(instantaneous)}$ = (66.2-32)*(5/9) * 5.0 * 28.3 = 2,689 kcal/s

The example temperature TMDL, LA, and MOS are summarized in **Table 7-4**. The targets in **Section 7.4.3** (**Table 7-3**) serve as surrogates to the numeric allocation. Meeting these targets will result in meeting the numeric allocation under all conditions including the example in **Table 7-4**. As demonstrated in **Table 7-5**, the existing temperature loading to upper Ashley Creek is greater than the LA to all nonpoint sources and a reduction is needed; implementation of BMPs is necessary to meet the water quality targets for temperature. The source assessment for the upper Ashley Creek watershed indicates that a lack of shade contributes the most human-caused temperature loading; load reductions should focus on allowing riparian vegetation to grow and decreasing activities that reduce shade. The 2% reduction to temperature loading that is needed to meet the LA for upper Ashley Creek equates to about 3.8 stream miles having riparian shade increased to the target of 79%. Overall, this means that riparian vegetation needs to be improved on 24% of upper Ashley Creek. Specific reaches that are not meeting the shade target are listed in **Attachment EF** of **Appendix E**. Meeting the LA for upper Ashley Creek may be achieved through a variety of water quality planning and implementation actions, which are addressed in **Section 9.0**.

Table 7-4. Upper Ashley Creek example instantaneous and daily TMDL, LA, and explicit MOS

Category	Instantaneous Load (kcal/s) / Temperature (°F)[1]	Daily Load (kcal/day)[1]
Composite LA	2,633 / 65.5°F	227,491,200
Explicit MOS	79 / 1.0°F	6,825,600
TMDL	2,712 / 66.5°F	234,316,800

[1] Based on a naturally occurring temperature of 65.5°F, flow of 5.0 cfs, and an explicit MOS of 1.0°F

Table 7-5. Upper Ashley Creek example reduction based on the modeled instantaneous existing condition and example LA and an explicit MOS

Category	Instantaneous Existing Load (kcal/s) / Temperature (°F)	LA (kcal/s) / Temperature (°F)	Percent Reduction Needed
Nonpoint Sources	2,689 / 66.2 °F	2,633 / 65.5°F	2%

7.6.1.3.2 Middle Ashley Creek (Smith Lake to Kalispell Airport Road)

The example numeric temperature TMDL for middle Ashley Creek is based on **Equation 7-1** and the load allocation to nonpoint sources is based on **Equation 7-2**. An explicit MOS of 0.5 to1.0°F will be used in

this waterbody segment depending on the naturally occurring temperature. The following example TMDL for middle Ashley Creek uses the flow measured at ASHL-17 on 8/19/08 (4.6 cfs) and the modeled shade scenario (i.e. naturally occurring) maximum temperature of 67.6°F. At this temperature the allowable increase above the naturally occurring temperature is 0.5°F based on the water quality standard for temperature [ARM 17.30.624(e)].

The example TMDL is therefore:

$$\textbf{TMDL}_{\text{(instantaneous)}} = ((67.6 + 0.5) - 32)*(5/9) * 4.6 * 28.3 = 2{,}611 \text{ kcal/s}$$

Converted to a daily load the example TMDL is:

$$\textbf{TMDL} = 2{,}611 \text{ kcal/s} * 86{,}400 \text{ s/day} = 225{,}590{,}400 \text{ kcal/day}$$

Equation 7-2 is the basis for the example composite load allocation for temperature. To continue with the example at a modeled naturally occurring maximum temperature of 67.6°F, flow of 4.6 cfs, and an explicit MOS of 0.5°F, this allocation is as follows:

$$\textit{LA}_{\text{(instantaneous)}} = (67.6 - 32) * (5/9) * 4.6 * 28.3 = 2{,}575 \text{ kcal/s}$$

Converted to a daily load the example LA is:

$$\textbf{LA} = 2{,}575 \text{ kcal/s} * 86{,}400 \text{ s/day} = 222{,}480{,}000 \text{ kcal/day}$$

Using **Equation 7-3** the resulting explicit MOS at 4.6 cfs is:

$$\textbf{MOS}_{\text{(instantaneous)}} = 2{,}611 \text{ kcal/s} - 2{,}575 \text{ kcal/s} = 36 \text{ kcal/s}$$

Converted to a daily load the MOS is:

$$\textbf{MOS} = 36 \text{ kcal/s} * 86{,}400 \text{ s/day} = 3{,}110{,}400 \text{ kcal/day}$$

The instantaneous existing load at ASHL-17 based on **Equation 7-7**, a flow of 4.6 cfs, and a modeled existing maximum temperature of 73.1°F is:

$$\textbf{Existing Load}_{\text{(instantaneous)}} = (73.1-32) * (5/9) * 4.6 * 28.3 = 2{,}972 \text{ kcal/s}$$

The example temperature TMDL, LA, and MOS are summarized in **Table 7-6**. The targets in **Section 7.4.3** (**Table 7-2**) serve as surrogates to the numeric allocation. Meeting these targets will result in meeting the numeric allocation under all conditions including the example in **Table 7-6**. As demonstrated in **Table 7-7**, the existing temperature loading to middle Ashley Creek is greater than the LA to all nonpoint sources and a reduction is needed; implementation of BMPs is necessary to meet the water quality targets for temperature. The source assessment for the middle Ashley Creek watershed indicates that a lack of shade contributes the most human-caused temperature loading; load reductions should focus on allowing riparian vegetation to grow and decreasing activities that reduce shade. The 13% reduction to temperature loading that is needed to meet the LA for middle Ashley Creek equates to about 10 stream miles having riparian shade increased to the target of 64% and 1.6 additional miles having shade increased to the target of 10%. Overall, 78% of middle Ashley Creek needs increased shade in addition

to the shade improvements needed on upper Ashley Creek. Specific reaches that are not meeting the shade targets are listed in **Attachment EF** of **Appendix E**. Meeting LA for middle Ashley Creek may be achieved through a variety of water quality planning and implementation actions, which are addressed in **Section 9.0**.

Table 7-6. Middle Ashley Creek example instantaneous and daily TMDL, LA, and explicit MOS

Category	Instantaneous Load (kcal/s) / Temperature (°F)[1]	Daily Load (kcal/day)
Composite LA	2,575 / 67.6°F	222,480,000
Explicit MOS	36 / 0.5°F	3,110,400
TMDL	2,611 / 68.1°F	225,590,400

[1] Based on a naturally occurring temperature of 67.6°F, flow of 4.6 cfs, and an explicit MOS of 0.5°F

Table 7-7. Middle Ashley Creek example reduction based on the modeled instantaneous existing condition and example LA with an explicit MOS

Category	Instantaneous Existing Load (kcal/s) / Temperature (°F)	LA (kcal/s) / Temperature (°F)	Percent Reduction Needed
Nonpoint sources	2,972 / 73.1°F	2,575 / 67.6°F	13%

The WLA for the City of Kalispell Small MS4 was not calculated as part of the example provided in **Tables 7-6** and **7-7**. This was done because storm events during summer occur infrequently and are generally short in duration (Kron et al., 2011). The target for the City of Kalispell Small MS4 in **Section 7.4.3, Table 7-2** serves as a surrogate WLA.

7.6.1.3.3 Lower Ashley Creek (Kalispell Airport Road to the mouth)

The example numeric temperature TMDL for lower Ashley Creek is based on **Equation 7-1** and the load allocation to nonpoint sources is based on **Equation 7-2**. An explicit MOS will not be used in this waterbody segment as it is expected that the Kalispell WWTP will use the entire temperature change above the naturally occurring temperature allowed by the water quality standard. The following example TMDL for lower Ashley Creek uses a flow of 11.72 cfs downstream of the WWTP and the modeled shade scenario (i.e. naturally occurring) average stream temperature of 62.01°F between ASHL-17 and ASHL-18 (15.25 mi from the mouth) used in the shade scenario example source assessment calculation for the Kalispell WWTP (**Section 7.6.1.1.5**). At this temperature the allowable increase above the naturally occurring temperature is 1.0°F based on the water quality standard for temperature [ARM 17.30.627(e)].

The example TMDL is therefore:

$$\mathbf{TMDL_{(instantaneous)} = ((62.01 + 1.0) - 32)*(5/9) * 11.72 * 28.3 = 5{,}714\ kcal/s}$$

Converted to a daily load the example TMDL is:

$$\mathbf{TMDL = 5{,}714\ kcal/s * 86{,}400\ s/day = 493{,}689{,}600\ kcal/day}$$

Equation 7-2 is the basis for the example composite load allocation for temperature. To continue with the example at the modeled naturally occurring average stream temperature of 62.01°F, a flow upstream of the WWTP of 7.62 cfs, and no explicit MOS this allocation is as follows:

$$\mathbf{\mathit{LA}_{(instantaneous)} = (62.01 - 32)*(5/9) * 7.62 * 28.3 = 3{,}595\ kcal/s}$$

Converted to a daily load the example LA is:

LA = 3,595 kcal/s * 86,400 s/day = 310,608,000 kcal/day

Using **Equation 7-4** the example WLA is:

$WLA_{(instantaneous)}$ = 5,714 kcal/s – 3,595 kcal/s = 2,119 kcal/s

Converted to a daily load the example WLA is:

WLA = 2,119 kcal/s * 86,400 s/day = 183,081,600 kcal/day

At a discharge of 4.1 cfs from the Kalispell WWTP, the WLA results in a temperature of 64.87°F per **Equation 7-11** and the calculation below:

WLA = (9/5) * ((2,119 kcal/s) / (4.1 cfs * 28.3)) + 32 = 64.87°F

The instantaneous existing load downstream of the WWTP based on **Equation 7-7**, a flow of 11.72 cfs, and a modeled baseline scenario average temperature of 68.61°F is:

Existing Load $_{(instantaneous)}$ = (68.61 - 32)*(5/9) * 11.72 * 28.3 = 6,746 kcal/s

The example temperature TMDL, LA, and WLA are summarized in **Table 7-8**. The targets in **Section 7.4.3** (**Table 7-2**) serve as surrogates to the numeric allocations. Meeting these targets will result in meeting the numeric allocations under all conditions including the examples in **Table 7-8**. As demonstrated in **Table 7-9**, the existing temperature loading to lower Ashley is greater than the sum of the LA for all nonpoint sources and the WLA for the Kalispell WWTP and a reduction is needed; implementation of BMPs is necessary to meet the water quality targets for temperature. The source assessment for the lower Ashley Creek watershed indicates that a lack of shade and the Kalispell WWTP contribute the most human-caused temperature loading. Load reductions should focus on allowing riparian vegetation to grow and decreasing activities that reduce shade. The temperature of the effluent from the Kalispell WWTP seems to be causing the delta allowed by the water quality standard for temperature to be exceeded during late July and August when stream temperatures tend to be the greatest and instream flow approaching the lowest. A process to evaluate and address this issue is outlined in **Section 7.6.3**. The 15% reduction to temperature loading that is needed to meet the LA for Lower Ashley Creek equates to about 10.9 stream miles (87% of lower Ashley Creek needs increased shade), having riparian shade increased to the target of 64% in addition to the shade improvements needed on upper Ashley Creek and middle Ashley Creek. Specific reaches that are not meeting the shade target are listed in **Attachment EF** of **Appendix E**. Meeting load allocations for lower Ashley Creek may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 9.0**. **Section 7.6.3** discusses the process by which the Kalispell WWTP can achieve the numeric WLA in **Table 7-8** and the surrogate WLA described in **Table 7-2**.

Table 7-8. Lower Ashley Creek example instantaneous and daily TMDL, LA, and WLA

Category	Instantaneous Load (kcal/s) / Temperature (°F)[1]	Daily Load (kcal/day)[1]
Composite LA	3,595 / 62.01°F	310,608,000
Kalispell WWTP WLA	2,119 / 64.87°F	183,081,600
TMDL	5,714 / 63.01°F	493,689,600

[1] Based on a naturally occurring temperature of 62.01°F, flow of 7.62 cfs above the Kalispell WWTP, flow of 4.1 cfs from the Kalispell WWTP , and no explicit MOS

Table 7-9. Lower Ashley Creek example reduction based on the modeled instantaneous existing condition and the example TMDL with no explicit MOS

Category	Instantaneous Existing Load (kcal/s) / Temperature (°F)	TMDL (kcal/s) / Temperature (°F)	Percent Reduction Needed
All Sources	6,746 / 68.61°F	5,714 / 63.01°F	15%

The WLA for the City of Kalispell Small MS4 was not calculated as part of the example provided in **Tables 7-8** and **7-9**. This was done because storm events during summer occur infrequently and are generally short in duration (Kron et al., 2011). The target for the City of Kalispell Small MS4 in **Section 7.4.3, Table 7-2** serves as a surrogate WLA.

7.6.2 Whitefish River

7.6.2.1 Source Assessment

This section describes the nonpoint and point sources associated with elevated temperatures in the Whitefish River. QUAL2K model scenarios are used to describe the most substantial sources of elevated temperature and conditions under which the water quality standard for temperature are met.

7.6.2.1.1 Baseline Scenario (Existing Conditions)

The baseline scenario represents the existing conditions within the Whitefish River on August 17, 2008, which was determined to be the hottest period for water temperatures during the 2008 summer. To inform the model, this scenario used the measured field data to represent temperature, flow, and shade. When field data were unavailable, reasonable assumptions and extrapolation were used. The model was then run and compared with measured conditions. Hydraulic output in the model accurately reflected measured conditions, indicating that water routing and channel morphology were adequately calibrated. To assure consistency when evaluating the potential to reduce stream temperatures, subsequent model scenarios were compared with the existing-conditions results of the baseline model and not to the field-measured values.

Under the baseline scenario, maximum daily temperatures range from 72.0°F at WHFS-08 to 74.8°F at WHFS-02 (**Figure 7-12**). Temperatures are stable with a slight decrease in the downstream direction. The modeled maximum temperatures exhibit a pattern similar to the maximum measured values with an average error of 1.4% (**Figure 7-12**).

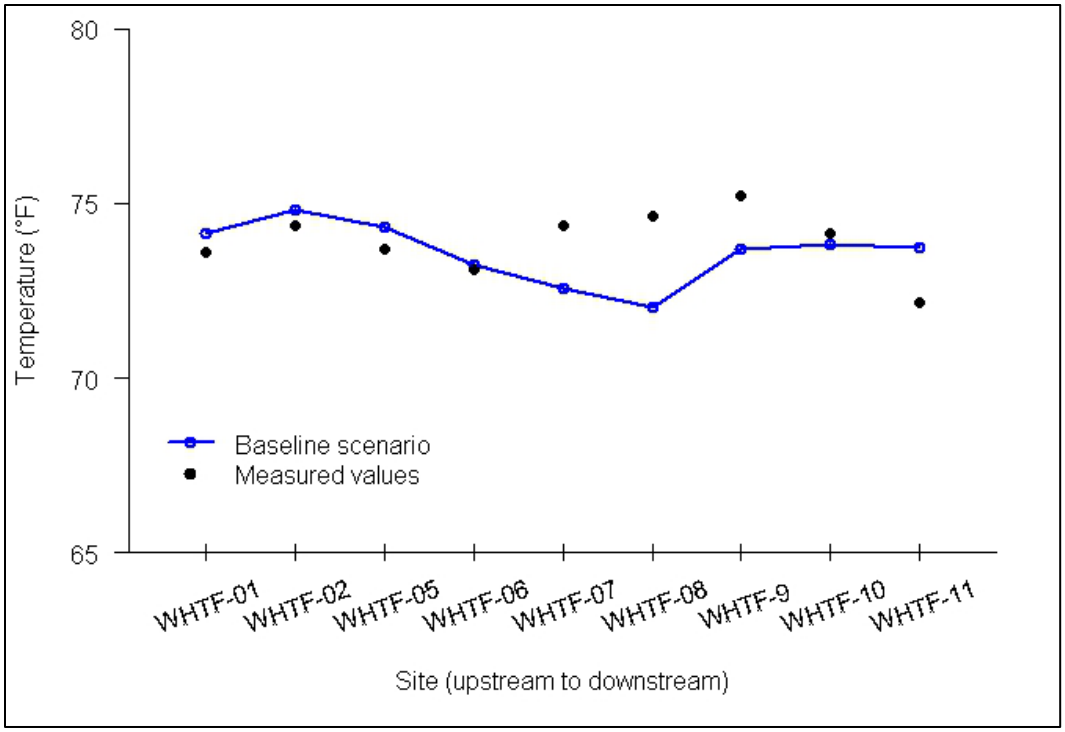


Figure 7-12. Maximum temperatures for measured data and the QUAL2K Baseline Scenario at Whitefish River sampling sites

7.6.2.1.2 Shade Scenario

The shade scenario altered the model to represent the naturally occurring condition based on field measured shade values and GIS analysis. In this scenario, the entire segment was set to be dense riparian vegetation (**Table E2-14** in **Appendix E**). Thus, riparian shade density was increased along a total of 16.2 miles of the Whitefish River, which is 65% of the total length (24.8 miles). Percent effective shade for the dense riparian vegetation category was based on the field assessed sites. The results of the shade scenario indicate that an increase in streamside shading along the Whitefish River would decrease stream temperatures from 0.14 to0.99°F as compared to the baseline scenario with a decrease of at least 0.5°F at 4 of 9 sampling sites (**Figure 7-13**).

The naturally occurring condition represents water temperatures resulting from implementing all reasonable land, soil, and water conservation practices as outlined in ARM 17.30.602. This condition identifies the naturally occurring temperature in waterbodies of interest and establishes the temperature increase that is allowable. In turn, this can be used to identify the impairment status of a waterbody and forms the basis for the allocations and temperature TMDLs in this document. For the Whitefish River, the shade scenario is considered the naturally occurring condition. Based on the results of the comparison between the baseline and shade scenarios, there is the potential for substantial reductions in stream temperatures relative to the baseline (existing) condition.

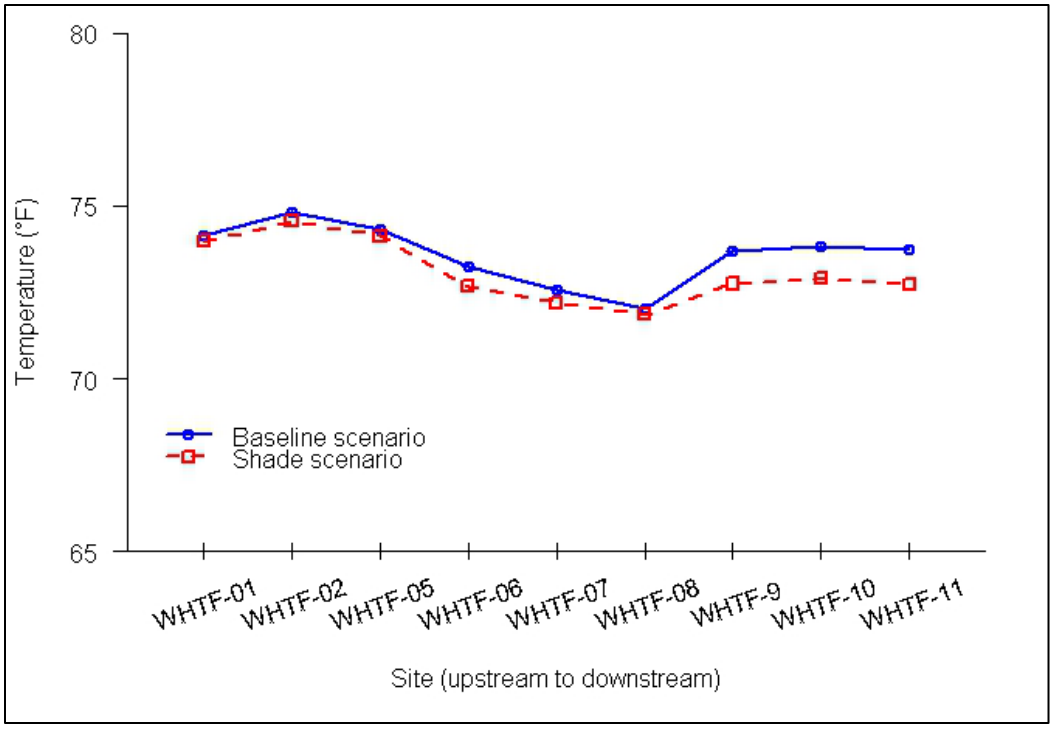


Figure 7-13. Maximum temperatures for QUAL2K Baseline and Shade scenarios at Whitefish River sampling sites

7.6.2.1.3 Burlington Northern Santa Fe Railway Whitefish Facility (MT0000019) Point Source Discharge Assessment

The BNSF Facility discharges directly into the Whitefish River. To evaluate the effects of temperature, an instantaneous thermal load (in kilocalories per second) can be calculated for the streamflow and BNSF facility discharge flows per **Equation 7-11**. Note that this loading equation is applicable to water at a temperature greater than the freezing point of 32°F. The effects of the BNSF facility discharge can then be calculated by completely mixing the discharge water with the flow of the Whitefish River under differing conditions.

To examine the effects of the BNSF Facility on the Whitefish River, we calculated temperature changes for two different examples. The first uses the average August 2008 temperature (66.94°F) measured by the temperature data logger at sampling site WHTF-01 upstream of the BNSF Facility and is considered the measured existing condition example. The second example uses the modeled average shade scenario temperature (70.38°F) at WHTF-01 and is called the modeled shade scenario example. The temperature value from the shade scenario example is greater than the measured existing conditions example temperature value because the model was constructed to examine source effects on the day of the month with the warmest stream temperatures. Both examples use the measured maximum August (2003 – 2012) effluent temperature of 76.80°F (**Table B-8** in **Appendix B**) and effluent design discharge of 0.15 cfs from the BNSF Facility and the measured average August (2008 – 2012) streamflow of 142.22 cfs in the Whitefish River at WHTF-01 (**Table B-9** in **Appendix B**). **Equation 7-11** and a basic mixing equation (**Equation 7-12**) were used to calculate the effects of the BNSF Facility on instream temperatures in the Whitefish River. **Equation 7-11** rewritten as:

$$T_{°F} = (9/5) * (\text{Relative Heat Load per unit time} / (Q * 28.3)) + 32$$

was used to convert the thermal load of Whitefish River with the BNSF Facility effluent back to a temperature.

Measured Existing Conditions Example:
For this example, the thermal load of the Whitefish River at WHTF-01 is:

(66.94 – 32) * (5/9) * 142.22 cfs * 28.3 = 78,125 kcal/s

The thermal load of the BNSF Facility is:

(76.8 – 32) * (5/9) * 0.15 cfs * 28.3 = 106 kcal/s

The total thermal load of the Whitefish River below the BNSF Facility would therefore be:

78,125 kcal/s + 106 kcal/s = 78,231 kcal/s

And the water temperature would be:

(9/5) * ((78,231 kcal/s) / (142.37 cfs * 28.3)) + 32 = 66.95°F

In this case, the BNSF Facility causes an increase of 0.01°F (66.95°F – 66.94°F) in the temperature of the Whitefish River, which is much less than the 0.5°F increase allowed by the standard at the modeled naturally occurring temperature of 66.94°F.

Modeled Shade Scenario Example:
For this example, the thermal load of the Whitefish River at WHTF-01 is:

(70.38°F – 32) * (5/9) * 142.22 cfs * 28.3 = 85,807 kcal/s

The thermal load of the BNSF Facility is:

(76.80°F – 32)*(5/9) * 0.15 cfs * 28.3 = 106 kcal/s

The total thermal load of the Whitefish River below the BNSF Facility would therefore be:

85,807 kcal/s + 106 kcal/s = 85,913 kcal/s

And the water temperature would be:

(9/5) * ((85,913 kcal/s) / (142.34 cfs * 28.3)) + 32 = 70.38°F

For this example, the BNSF Facility causes an unsubstantial increase (70.38°F – 70.38°F) in the naturally occurring average temperature of the Whitefish River.

Because the BNSF Facility discharges a small amount of effluent relative to the discharge of the Whitefish River, it has a negligible effect on instream temperatures below the effluent discharge. Maintaining operation of this BNSF facility at current levels would appear to cause no significant increase in Whitefish River temperatures.

7.6.2.1.4 Whitefish WWTP (MT0020184) Point Source Discharge Assessment

The City of Whitefish WWTP also discharges directly into the Whitefish River. To evaluate the effects of temperature, an instantaneous thermal load (in kilocalories per second) can be calculated for the streamflow and WWTP discharge flows per **Equation 7-11**. Note that this loading equation is applicable to water at a temperature greater than the freezing point of 32°F. The effects of the WWTP discharge can then be calculated by completely mixing the discharge water with the flow of the Whitefish River under differing conditions.

To examine the effects of the Whitefish WWTP on the Whitefish River, we calculated temperature changes for two different examples. The first uses the average August 2008 temperature (67.40°F) measured by the temperature data logger at sampling site WHTF-02 upstream of the WWTP and is considered the measured existing conditions example. The second example uses the average modeled shade scenario temperature (70.34°F) at WHTF-02 and is called the modeled shade scenario example. The temperature value from the shade scenario is greater than the current condition temperature value because the model was constructed to examine source effects on the day of the month with the warmest stream temperatures. Both examples use the measured maximum August (2003 – 2012) effluent temperature of 74.8°F (**Table B-10** in **Appendix B**) and effluent design discharge of 2.79 cfs from the WWTP and the measured average August (2008 – 2012) streamflow of 142.37 cfs (the flow downstream of the BNSF Facility; described in **Section 7.6.2.1.3**) in the Whitefish River at WHTF-02. **Equation 7-11** and a basic mixing equation (**Equation 7-12**) were used to calculate the effects of the WWTP on instream temperatures in Ashley Creek.

Measured Existing Conditions Example:
For this example, the thermal load of the Whitefish River at WHTF-02 was:

$$(67.40°F – 32) * (5/9) * 142.37 \text{ cfs} * 28.3 = 79{,}238 \text{ kcal/s}$$

The thermal load of the WWTP was:

$$(74.8°F – 32) * (5/9) * 2.79 \text{ cfs} * 28.3 = 1{,}877 \text{ kcal/s}$$

The total thermal load of the Whitefish River below the WWTP would therefore be:

$$79{,}238 \text{ kcal/s} + 1877 \text{ kcal/s} = 81{,}115 \text{ kcal/s}$$

And the water temperature would be:

$$(9/5) * ((81{,}115 \text{ kcal/s}) / (145.16\text{cfs} * 28.3)) + 32 = 67.54°F$$

In this case, the WWTP causes an increase of 0.14°F (67.54°F - 67.40°F) in the temperature of the Whitefish River, less than the 0.5°F increase allowed by the standard at the modeled naturally occurring temperature of 67.40°F.

Modeled Shade Scenario Example:
For this example, the thermal load of the Whitefish River at WHTF-02 was:

$$(70.34°F – 32) * (5/9) * 142.37 \text{ cfs} * 28.3 = 85{,}819 \text{ kcal/s}$$

The thermal load of the WWTP was:

(74.8°F – 32)*(5/9) * 2.79 cfs * 28.3 = 1877 kcal/s

The total thermal load of the Whitefish River below the WWTP would therefore be:

85,819 kcal/s + 1877 kcal/s = 87,696 kcal/s

And the water temperature would be:

(9/5) * ((87,698 kcal/s) / (145.16 cfs * 28.3)) + 32 = 70.40°F

In this case, the WWTP causes an increase of 0.06°F (70.40°F – 70.34°F) in the temperature of the Whitefish River. This value is well below the 0.5°F increase allowed by the standard at the naturally occurring average temperature of 70.34°F.

Because the Whitefish WWTP discharges a small amount of effluent relative to the discharge of the Whitefish River, it has a negligible effect on instream temperatures below the effluent discharge. Maintaining operation of this facility at current levels would appear to cause no significant increase in Whitefish River temperatures.

7.6.2.2 Whitefish River Existing Conditions and Comparison to Targets

To evaluate whether attainment of temperature targets has been met, the existing water quality conditions in the Whitefish River waterbody segment are compared to the conditions when water quality targets are met. This is done using the QUAL2K model and different scenarios that represent the implementation of all reasonable land, soil, and water conservation practices. This approach provides DEQ with updated impairment determinations used for TMDL development.

The QUAL2K model results indicate that maximum naturally occurring summer temperatures ≥ 66.5°F occur at all Whitefish River sites (**Figure 7-13**), which means that when water temperatures are the warmest, the allowed increase above the naturally occurring temperature is 0.5°F (**Figure 7-4**). Temperature differences between maximum temperatures under the baseline condition and the naturally occurring condition (**Section 7.6.2.1.2**) range from 0.1 to1.0°F and average 0.5°F (**Figure 7-14**). The allowed increase is being exceeded at four of the nine sites on the Whitefish River.

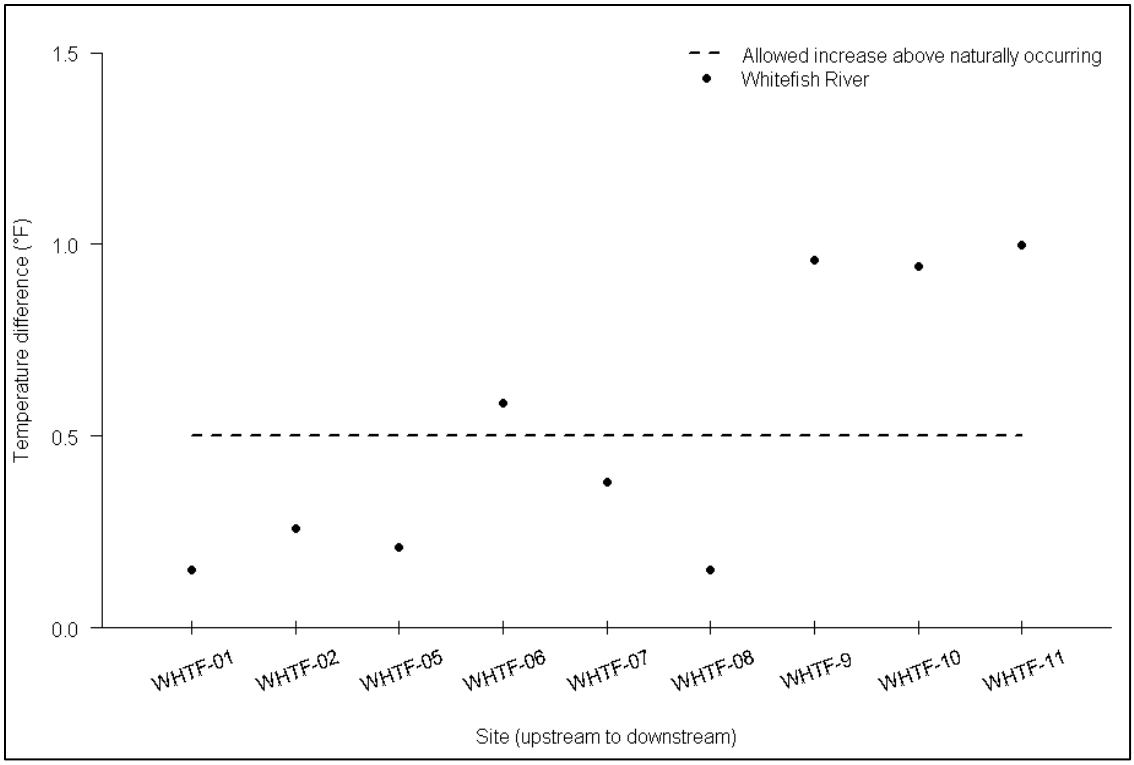


Figure 7-14. Difference between the baseline (existing) condition and the naturally occurring condition (implementation of all reasonable land, soil and water conservation practices) maximum temperatures at temperature data logger sites on the Whitefish River

Similar to Ashley Creek, aerial photographs were used to identify study reaches along the Whitefish River. From these, one broad classification of potential riparian vegetation condition was determined: dense riparian. Sites were then analyzed in the field in a selected number of study reaches and average effective shade for those sites was assessed. For modeling purposes, the average of the results for sites in the dense riparian category was then applied to those reaches that were not sampled. Average effective shade for the dense riparian vegetation classification is 47%. Field vegetation classification data for the Whitefish River indicate that 4% of the stream is open/pasture, 61% is low/moderate riparian, and 35% is dense riparian. The potential riparian vegetation for the Whitefish River consists of 100% dense riparian. About 66% of the stream (i.e., waterbody segment) is below target for effective shade (**Attachment EF** in **Appendix E**).

As described in **Section 7.4.2.3**, the width target is included because wider streams, especially those with higher width-to-depth ratios absorb thermal energy from the sun more efficiently than narrow, deep channels and therefore overwidened streams will be more sensitive to thermal loading. Overall, the width of the Whitefish River appears to be in a healthy state and as such it meets the target in all segments. There may be specific locations on the Whitefish River that are substantially wider than is ideal. Such areas may be identified and incorporated as potential restoration locations in the Watershed Restoration Plan for the Whitefish River.

Point sources of thermal load to the Whitefish River are required to meet temperature discharges that are consistent with the appropriate water quality standards. The Burlington Northern Santa Fe Railway Whitefish Facility (BNSF Facility; MT0000019) and Whitefish WWTP (MT0020184) discharges are currently satisfying this target as evaluated in **Sections 7.6.2.1.3** and **7.6.2.1.4**.

Summary and TMDL Development Determination
The human-influenced allowable temperature change target is being exceeded in the Whitefish River. Although width values are meeting the targets, the riparian vegetation is generally not meeting the shade target, which causes increases in temperature. This information supports the existing impairment listing for the Whitefish River. A temperature TMDL will be developed for this segment.

7.6.2.3 Whitefish River Example TMDL and Allocations

The example numeric temperature TMDL for the Whitefish River is based on **Equation 7-1** the load allocation to nonpoint sources is based on **Equation 7-2**. An explicit MOS will be based on the remaining temperature change allowed by the standard after the LA to nonpoint sources is calculated to meet the naturally occurring temperature and the WLAs are calculated based on the design flow of the facilities and the maximum August temperature of effluent discharge (2003 – 2012). The following example TMDL for the Whitefish River uses the flow measured at WHTF-11 on 8/13/08 (139 cfs) and the modeled shade scenario (i.e. naturally occurring) average temperature of 69.08°F. At this temperature the allowable increase above the naturally occurring temperature is 0.5°F based on the water quality standard for temperature [ARM 17.30.624(e)].

The example TMDL is therefore:

$$\mathbf{TMDL_{(instantaneous)} = ((69.08 + 0.5) - 32)*(5/9) * 139 * 28.3 = 82{,}127\ kcal/s}$$

Converted to a daily load the example TMDL is:

$$\mathbf{TMDL = 82{,}127\ kcal/s * 86{,}400\ s/day = 7{,}095{,}772{,}800\ kcal/day}$$

Equation 7-2 is the basis for the example composite load allocation for temperature. To continue with the example at a naturally occurring temperature of 69.08°F, flow of 136.06 cfs subtracting out the discharges from the BNSF Facility and the Whitefish WWTP, and an explicit MOS this allocation is as follows:

$$\mathbf{LA_{(instantaneous)} = (69.08- 32)*(5/9) * 136.06 * 28.3 = 79{,}320\ kcal/s}$$

Converted to a daily load the example LA is:

$$\mathbf{LA = 79{,}320\ kcal/s * 86{,}400\ s/day = 6{,}853{,}248{,}000\ kcal/day}$$

Equation 7-5 is the basis for the example WLAs for the BNSF Whitefish Facility and the Whitefish WWTP. For the BNSF Facility the design flow (0.15 cfs) and maximum August temperature (76.80°F) from the **Section 7.6.2.1.3** examples will be used. The WLA for the BNSF Facility is:

$$\mathbf{WLA_{BNSF\ (instantaneous)} = (76.80 - 32)*(5/9) * 0.15 * 28.3 = 106\ kcal/s}$$

Converted to a daily load the WLA is:

$$\mathbf{WLA_{BNSF} = 106\ kcal/s * 86{,}400\ s/day = 9{,}158{,}400\ kcal/day}$$

Using Equation 7-5, the design flow (2.79 cfs), and the maximum August temperature (73.4°F) from the **Section 7.6.2.1.4** examples, the WLA for the Whitefish WWTP is:

$$\mathbf{WLA_{WHTFWWTP\ (instantaneous)} = (74.8 - 32)*(5/9) * 2.79 * 28.3 = 1{,}877\ kcal/s}$$

Converted to a daily load the WLA is:

$$\mathbf{WLA_{WHTFWWTP} = 1{,}877\ kcal/s * 86{,}400\ s/day = 162{,}172{,}800\ kcal/day}$$

Using **Equation 7-6** the resulting explicit MOS at 139 cfs is:

$$\mathbf{MOS_{\ (instantaneous)} = 82{,}127\ kcal/s – 79{,}320\ kcal/s – 106\ kcal/s – 1{,}877\ kcal/s = 824\ kcal/s}$$

Converted to a daily load the MOS is:

$$\mathbf{MOS = 824\ kcal/s * 86{,}400\ s/day = 71{,}193{,}600\ kcal/day}$$

The instantaneous existing load at WHFT-11 based on **Equation 7-7**, a flow of 139 cfs, and a modeled existing average temperature of 69.7°F is:

$$\mathbf{Existing\ Load_{\ (instantaneous)} = (69.7\text{-}32)*(5/9) * 139 * 28.3 = 82{,}389\ kcal/s}$$

The example temperature TMDL, LA, WLAs, and MOS are summarized in **Table 7-10**. The targets in **Section 7.4.3** (**Table 7-2**) serve as surrogates to the numeric allocations. Meeting these targets will result in meeting the numeric allocations under all conditions including the examples in **Table 7-10**. As demonstrated in **Table 7-11**, the existing temperature loading to the Whitefish River is greater than the sum of the LA for all nonpoint sources and WLAs for the BNSF Whitefish Facility and the Whitefish WWTP and a reduction is needed; implementation of BMPs is necessary to meet the water quality targets for temperature. The source assessment for the Whitefish River watershed indicates that a lack of shade contributes the most human-caused temperature loading; load reductions should focus on allowing riparian vegetation to grow and reducing activities that reduce shade. The 1% reduction to temperature loading that is needed to meet the LA for the Whitefish River equates to about 16.5 stream miles having riparian shade increased to the target of 47%. Overall, this means that riparian vegetation needs to be improved on 66% of the Whitefish River. Specific reaches that are not meeting the shade target are listed in **Attachment EF** of **Appendix E**. Meeting load allocations for the Whitefish River may be achieved through a variety of water quality planning and implementation actions and is addressed in **Section 9.0**.

Table 7-10. Whitefish River example instantaneous and daily TMDL, LAs, WLAs, and explicit MOS

Category	Instantaneous Load (kcal/s) / Temperature (°F)[1]	Daily Load (kcal/day)[1]
Composite LA	79,320 / 69.08°F	6,853,248,000
BNSF Facility WLA	106 / 76.8°F	9,158,400
Whitefish WWTP WLA	1,877 / 74.8°F	162,172,800
Explicit MOS	824 / 0.38°F	71, 193,600
TMDL	82,127 / 69.58°F	7,095,772,800

[1] Based on a naturally occurring temperature of 69.08°F, flow of 139 cfs at WHTF-11, and an explicit MOS

Table 7-11. Whitefish River example reduction based on the modeled instantaneous existing condition and the example LA, WLAs, and explicit MOS

Category	Instantaneous Existing Load (kcal/s) / Temperature (°F)	LA + WLA_{BNSF} + $WLA_{WHTFWWTP}$ (kcal/s) / Temperature (°F)	Percent Reduction Needed
All Sources	82,389 / 69.7°F	81,303 / 69.2°F	1%

The WLA for the City of Kalispell Small MS4 was not calculated as part of the example provided in **Tables 7-10** and **7-11**. This was done because storm events during summer occur infrequently and are generally short in duration (Kron et al., 2011). The target for the City of Kalispell Small MS4 in **Section 7.4.3** (**Table 7-2**) serves as a surrogate WLA.

7.6.3 Achieving Temperature Allocations

Over time, riparian vegetation has been removed and riparian buffer width reduced along both Ashley Creek and the Whitefish River (**Figures 7-15** and **7-16**). In some locations though, riparian vegetation has been allowed to establish and grow, resulting in temperature-reducing shade (**Figure 7-17**). The historical photographs in **Figures 7-15** and **7-16** provide images of what riparian buffers could look like on Ashley Creek and the Whitefish River with the implementation of riparian BMPs.

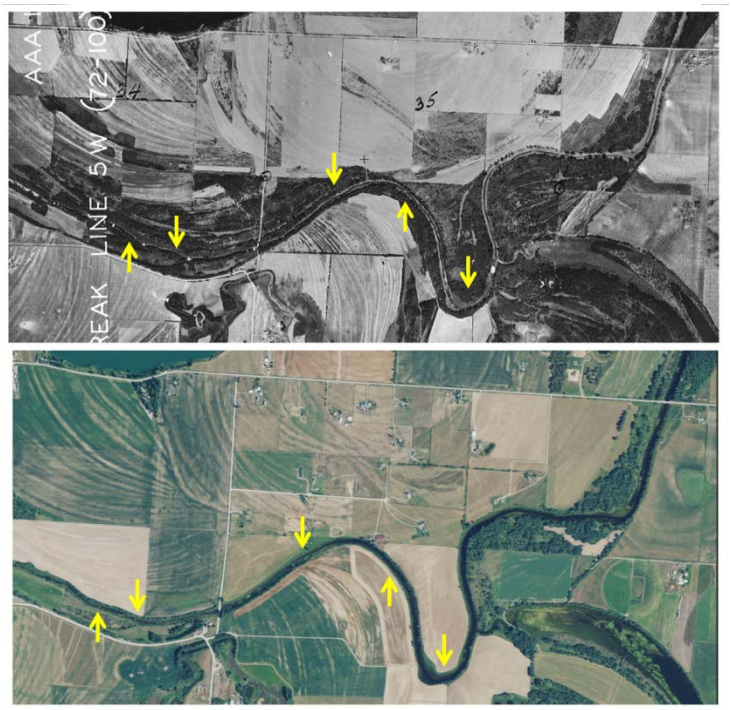


Figure 7-15. Aerial photographs of lower Ashley Creek near the mouth in 1937 (top image) and 2009 (bottom image)

Yellow arrows indicate areas where riparian vegetation has been removed and currently provides less shade than in the past

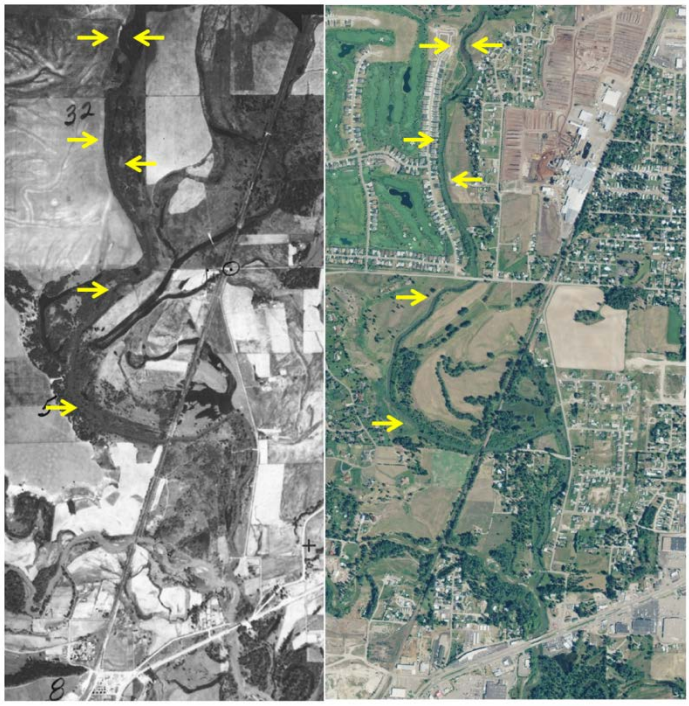


Figure 7-16. Aerial photographs of the Whitefish River near the mouth in 1938 (left image) and 2009 (right image)

Yellow arrows indicate areas where riparian vegetation has been removed and currently provides less shade than in the past



Figure 7-17. Aerial photographs of a portion of middle Ashley Creek in 1937 (top image) and 2009 (bottom image)
Yellow arrows indicate areas where riparian vegetation has grown and currently provides more shade than in the past

Riparian vegetation needs significant time before health improvements and increased shading can be seen. DEQ does not expect these targets to be met in the short-term; however, changes in land management practices and a commitment to BMPs would need to be implemented to start meeting goals for temperature in Ashley Creek and the Whitefish River. In addition, the targets and allocations presented represent the desired conditions that would be expected in most areas along a stream, but DEQ acknowledges that all sites may not be able to achieve them. For instance, some riparian areas may not be physically capable of achieving the desired effective shade target due to naturally occurring conditions. The targets and allocations are not intended to be specific to every given point on the stream; the intent, rather, is to achieve the TMDLs as a typical condition throughout the Ashley Creek and Whitefish River segments. Note that some areas may also be able to achieve conditions greater than the targets, and the management should strive for the best possible condition given all reasonable land, soil, and water conservation practices in all circumstances.

Achieving the Wasteload Allocation for the Kalispell WWTP

The WLA for the Kalispell WWTP may be difficult to achieve based on the limits of technology and/or cost to implement effluent cooling technology. The WLA in **Table 7-8** is an example for a specific set of conditions and is not intended to be a number in the Kalispell WWTP permit. The following approach will begin during the first permit cycle after the TMDL is approved by EPA and will end within 20 years

when all steps have been addressed. The actions outlined below will be written into the permit for the Kalispell WWTP. Meeting these permit requirements will meet the intent of the WLA.

First permit cycle (5 years):
STEP 1 – The City of Kalispell will collect additional data (3-5 years) to address the impacts of the Kalispell WWTP on Ashley Creek

- Place a temperature logger and a trutrack upstream of the WWTP and downstream of the WWTP below the mixing zone (defined by DEQ in consultation with the City of Kalispell), from July 1 – September 30 each year.
- Collect a flow measurement at the trutrack locations on the same day every other week using protocols approved by DEQ.
- Collect real-time (continuous) discharge and temperature data from the WWTP effluent before it enters Ashley Creek at a location approved by DEQ.

Second permit cycle (5 years):
STEP 2 (First 2 years of the permit cycle) – DEQ will analyze data

- Determine when the WWTP is causing the water quality standard for temperature to be exceeded and the magnitude and duration of any exceedances.
- Determine the effluent temperature (target) at which exceedances are eliminated or reduced to an acceptable level.

STEP 3 (Final 3 years of the permit cycle) – If warranted (per the results of STEP 2), the City of Kalispell will study the feasibility of achieving the target

- Identify and analyze the techniques available for achieving the temperature target in WWTP effluent.
- Cost/benefit analysis of each technique.
- Identify and analyze alternatives for reducing temperature in Ashley Creek (e.g., increasing instream flow upstream of the WWTP).

Third permit cycle (5 years):
STEP 4 – If warranted (per the results of STEP 3), the City of Kalispell will determine and outline an implementation plan deemed sensible by DEQ and put it in document format

- Using the information in STEPs 1 – 4 determine what sensible actions will be pursued by the Kalispell WWTP.
- Document 1) the actions that will be taken by the WWTP to improve water temperature in Ashley Creek downstream of the discharge to the extent it is affected by the discharge, 2) a timeline for implementation, and 3) monitoring that will occur.

Fourth permit cycle (5 years):
STEP 5 – If warranted (per the results of STEP 4), the City of Kalispell will implement the plan

- Follow through with the plan as documented in STEP 4.
- Achieve the final effluent limits.

DEQ will collaborate with the City of Kalispell to provide guidance on sampling, data analysis, determining an effective implementation plan, and if applicable, implementation of land, soil, and water conservation practices. This process is expected to occur over multiple years and multiple permit cycles.

7.7 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 (MOS) were applied during development of the Ashley Creek and Whitefish River temperature TMDLs.

Seasonality addresses the need to ensure year-round beneficial-use support. Seasonality is addressed for temperature in this TMDL document as follows:

- Temperature monitoring occurred during the summer and modeling simulated August, which is the warmest time of the year and when instream temperatures are most stressful to aquatic life.
- Effective shade for both Ashley Creek and the Whitefish River was based on the August solar path, which is typically the hottest month of the year.
- Although the maximum daily temperature was used for the source assessment and impairment characterization because it is mostly likely to stress aquatic life, sources affecting maximum stream temperatures can also alter daily minimum temperatures; restoration approaches will help to stabilize stream temperatures year round.
- Temperature exceedances occur mostly during the summer, but targets, TMDLs, and load allocations apply year round.

The MOS is included 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. The MOS is addressed in several ways for temperature as part of this document:

- Although there is an allowable increase from human sources beyond those applying all reasonable land, soil, and water conservation practices, the targets (and thus the allocations) for nonpoint sources are expressed (via an explicit MOS) so that all reasonable land, soil, and water conservation practices must be applied.
- Despite the limited amount of irrigation in the watershed and modest improvement in stream temperature that could be obtained by implementing conservation measures to leave additional water instream, the targets section (**7.4.2**) addresses consumptive use as a potential human source and recommends the use of all reasonable water conservation measures.
- Compliance with targets and refinement of load allocations are all based on an adaptive management approach (**Section 7.8**) that relies on future monitoring and assessment for updating planning and implementation efforts to ensure that temperatures are suitable to support all applicable beneficial uses.

7.8 UNCERTAINTY AND ADAPTIVE MANAGEMENT

Uncertainties in the accuracy of field data, source assessments, water quality models, loading calculations and other considerations are inherent when evaluating environmental variables for TMDL development. While uncertainties are an undeniable fact of TMDL development, mitigation, and reduction of uncertainty through adaptive management approaches are key components of ongoing TMDL implementation activities. Uncertainties, assumptions, and considerations are applied throughout this document and point to the need for refining analyses when needed.

The process of adaptive management is predicated on the premise that TMDLs, allocations, and their supporting analyses are not static, but are processes that are subject to periodic modification and

adjustment as new information and relationships are better understood. As further monitoring and assessment is conducted, uncertainties with present assumptions and consideration may be mitigated via periodic revision or review of the assessment that occurred for this document. As part of the adaptive management approach, changes in land and water management that affect temperature should be monitored. As implementation of restoration projects that reduce thermal input or new sources that increase thermal loading arise, monitoring should occur. Known changes in management should be the basis for building future monitoring plans to determine if the thermal conditions meet state standards.

Uncertainty was minimized during data collection because field data were collected following a sampling and analysis plan (Montana Department of Environmental Quality, 2008a) and adhering to DEQ sampling protocols (Montana Department of Environmental Quality, 2005b; 2005a). However, there was more uncertainty associated with the model than with the field data because assumptions had to be made to help simulate existing and naturally occurring conditions. Modeling assumptions are briefly described in **Section 7.5.1.1** but are further detailed within the model report in **Attachment ED** of **Appendix E**.

The TMDLs and allocations established in this section are meant to apply to recent conditions of natural background and natural disturbance (e.g., flood, wildfire, diseased vegetation). Under some periodic but extreme natural conditions, it may not be possible to satisfy all targets, loads, and allocations because of natural short-term affects to temperature. The goal is to ensure that management activities are undertaken to achieve loading approximate to the TMDLs within a reasonable time frame and to prevent significant long-term excess loading during recovery from significant natural events.

Any factors that increase water temperatures, including global climate change, could impact thermally sensitive fish species in Montana. The assessments and technical analysis for the temperature TMDLs considered a worst case scenario reflective of current weather conditions, which inherently accounts for any global climate change to date. Allocations to future changes in global climate are outside the scope of this project but could be considered during the adaptive management process if necessary.

Uncertainties in environmental assessments should not paralyze, but should point to the need for flexibility in our understanding of complex systems and to adjust our current thinking and future analysis. Implementation and monitoring recommendations presented in **Sections 9.0** and **10.0** provide a basic framework for reducing uncertainty and further understanding these issues.

8.0 NON-POLLUTANT IMPAIRMENTS, PREVIOUSLY COMPLETED TMDLS, AND FUTURE TMDL DEVELOPMENT

This section discusses non-pollutant impairments in the Flathead and Flathead – Stillwater Total Maximum Daily Load (TMDL) Planning Areas, previously completed TMDLs in the full Flathead Lake watershed, and impairments that will be addressed in future TMDL projects. This section is included for informational purposes to help with development of overall watershed management goals and objectives and prioritization of restoration projects in the broader Flathead Lake watershed.

8.1 NON-POLLUTANT IMPAIRMENTS

A waterbody may be on Montana's list of impaired waters, but does not require a TMDL if it is not impaired for a pollutant, such as sediment, temperature, a nutrient, or metal. Non-pollutant causes of impairment such as "alteration in streamside or littoral vegetative covers" do not require a TMDL. Non-pollutant causes of impairment are often associated with a pollutant cause of impairment; however in some cases, non-pollutant impairments are causing a deleterious effect on beneficial uses without a clearly defined quantitative measurement or direct linkage to a pollutant.

Department of Environmental Quality (DEQ) recognizes that non-pollutant impairments can limit a waterbody's ability to fully support all beneficial uses and these impairment causes are important to consider when improving water quality conditions in both individual streams, and the project area as a whole. **Table 8-1** shows the non-pollutant impairments for waterbodies in the both the Flathead – Stillwater TMDL Planning Area and the Flathead TMDL Planning Area on Montana's 2014 list of impaired waters. They are summarized in this section to increase awareness of the non-pollutant impairment definitions and typical sources, and should be considered during planning of watershed-scale restoration efforts. Non-pollutant impairments for the Flathead Headwaters, Big Creek, and Swan TMDL planning areas are not included in this section, as those impairments are associated with completed TMDL projects (**Section 8.4**), with the exception of a "other flow regime alterations" impairment for the South Fork of the Flathead River.

It is important to note that water quality issues are not limited to waterbodies with identified pollutant and non-pollutant impairments. In some cases, streams have not yet been reviewed through DEQ's water quality assessment process and do not appear on Montana's list of impaired waters even though they may not be fully supporting all of their beneficial uses.

Table 8-1. Waterbody Segments in the Flathead and Flathead – Stillwater TMDL Planning Areas with Non-Pollutant Impairments in the 2014 Water Quality Integrated Report

Waterbody and Location Description	Waterbody ID	Impairment Cause	Addressed by a TMDL(s) in this Document[1]
Ashley Creek, Ashley Lake to Smith Lake	MT76O002_010	Alteration in stream-side or littoral vegetative covers	Yes
		Chlorophyll-*a*	Yes
Ashley Creek, Smith Lake to Kalispell Airport Road	MT76O002_020	Low flow alterations	No

Table 8-1. Waterbody Segments in the Flathead and Flathead – Stillwater TMDL Planning Areas with Non-Pollutant Impairments in the 2014 Water Quality Integrated Report

Waterbody and Location Description	Waterbody ID	Impairment Cause	Addressed by a TMDL(s) in this Document[1]
Ashley Creek, Kalispell airport road to mouth (Flathead River)	MT76O002_030	Alteration in stream-side or littoral vegetative covers	Yes
		Chlorophyll-*a*	Yes
Lake Mary Ronan	MT76O004_020	Chlorophyll-*a*	No
Logan Creek, Headwaters to Tally Lake	MT76P001_030	Other flow regime alterations	Yes
		Physical substrate habitat alterations	Yes
Sheppard Creek, Headwaters to mouth (Griffin Creek)	MT76P001_050	Alteration in stream-side or littoral vegetative covers	Yes
Sinclair Creek, Headwaters to mouth (Sheppard Creek)	MT76P001-040	Low flow alterations	No
Spring Creek, Headwaters to mouth (Ashley Creek)	MT76O002_040	Alteration in stream-side or littoral vegetative covers	No
		Other flow regime alterations	No
		Physical substrate habitat alterations	No
Stillwater River, Logan Creek to mouth	MT76P001_010	Alteration in stream-side or littoral vegetative covers	Yes

[1] Habitat alteration impairments and flow regime alteration impairments are addressed by sediment and temperature TMDLs; chlorophyll-*a* impairments are addressed by nutrient TMDLs (**Table 1-1**)

8.2 NON-POLLUTANT IMPAIRMENT CAUSE DESCRIPTIONS

Non-pollutants are often used as a probable cause of impairment when available data at the time of a water quality assessment do not provide a direct, quantifiable linkage to a specific pollutant. In some cases, the pollutant and non-pollutant categories are linked and appear together in the list of impairment causes for a waterbody; however a non-pollutant impairment cause may appear independently of a pollutant cause. The following discussion provides some rationale for the application of the identified non-pollutant causes to a waterbody, and thereby provides additional insight into possible factors in need of additional investigation and potential restoration.

Alteration in Streamside or Littoral Vegetation Covers

"Alteration in streamside 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 streamside 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 straightening of the channel or 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 placer mine operations.

Chlorophyll-*a*

A chlorophyll-*a* impairment occurs when excess levels of chlorophyll-*a* or algae in the stream impairs aquatic life and/or primary contact recreation (Suplee et al., 2009). These high levels of chlorophyll-*a* or algae are caused by excess concentrations of nutrients in the stream, which increases algal biomass (Suplee and Sada de Suplee, 2011). Chlorophyll-*a* impairments are typically addressed by nutrient TMDLs.

Other Flow Regime Alterations

Flow alteration refers to a change in the flow characteristics of a waterbody relative to natural conditions. An impairment listing caused by other flow regime alterations could be associated with changes in runoff and streamflow due to activities such as urban development, road construction, or timber harvest. Changes in runoff are commonly linked to elevated peak flows, which can also cause excess sedimentation by increasing streambank erosion and channel scour. Road crossings, particularly where culverts are undersized or inadequately maintained, can also alter flows by causing water to back-up upstream of the culvert.

Low Flow Alterations

Streams are typically listed as impaired 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. Low flow conditions 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 requires monitoring and assessment to identify threatened or impaired waterbodies (Montana Code Annotated (MCA) 75-5-702) and to subsequently develop TMDLs for these waterbodies (MCA 75-5-703), the law also states that these requirements may not be construed to divest, impair, or diminish any legally-recognized water right (MCA 75-5-705). The identification of low flow alterations as a probable cause of impairment should not be construed to divest, impair, or diminish a water right. Instead, it should be considered an opportunity to characterize the impacts of flow alterations, and pursue solutions that can result in improved streamflows during critical periods, while at the same time ensuring no harm to water rights. These same considerations apply to flow related targets and allocations applied to temperature TMDLs in this document. It is up to local users, agencies, and entities to voluntarily improve instream flows through water and land management, which may include irrigation efficiency improvements and/or instream water leases, that result in reduced amounts of water diverted from streams.

8.3 MONITORING AND BEST MANAGEMENT PLANS (BMPS) FOR NON-POLLUTANT AFFECTED STREAMS

Table 8-1 above indicates whether the non-pollutant impairment causes are addressed by a nutrient, sediment, and/or temperature TMDL in this document. Habitat alteration impairments (i.e., alteration in streamside or littoral vegetative covers and physical substrate habitat alterations) and flow regime alteration impairments can be linked to sediment and/or temperature TMDL development for Ashley, Logan, and Sheppard creeks, and the Stillwater River. It is likely that meeting the sediment and

temperature TMDL targets (**Sections 6.4** and **7.4**) will also equate to addressing the habitat and other flow regime alteration impairment conditions in each of these streams. For streams with habitat alteration or other flow regime alteration impairments that do not have a sediment or temperature TMDL, meeting the sediment targets applied to streams of similar size will likely equate to addressing the habitat impairment condition for each stream.

The chlorophyll-*a* impairments for Ashley Creek are addressed by the total nitrogen and total phosphorus TMDLs contained in **Section 5.0** of this document. The chlorophyll-*a* impairment for Lake Mary Ronan will be addressed through future water quality restoration planning that could include additional monitoring and/or possible TMDL development if nutrient impairments are identified.

Streams with non-pollutant impairments should be considered when developing watershed management goals and plans and when prioritizing restoration projects. Additional sediment, nutrient, and/or temperature information should be collected where data is insufficient for pollutant impairment determinations and the linkage between probable cause, non-pollutant listing, and effects to the beneficial uses is 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 Flathead – Stillwater TMDL Planning Area with TMDLs in this document, and they are equally applicable to streams listed for the above non-pollutant impairment causes. The strategies also apply to the entire Flathead Lake and Flathead River watersheds.

8.4 PREVIOUSLY COMPLETED TMDLS

Table 8-2 below lists the waterbody segments in the Flathead Lake watershed that have completed TMDLs. A TMDL Implementation Evaluation has since been completed for Big Creek (Montana Department of Environmental Quality, unpublished 2010), determining that a reassessment of beneficial uses was needed. As a result of an updated water quality assessment, the "sedimentation/siltation" impairment cause was removed from the 303(d) List in 2012. However, Big Creek remains on the impaired waters list as not fully supporting aquatic life, with a probable cause of habitat alteration.

Phase I of nutrient TMDLs for Flathead Lake was completed in 2001, which provided a total nitrogen and total phosphorus load reduction goal and a prioritized nutrient management plan for Flathead Lake and the broader Flathead Basin. A phase II of the nutrient TMDL project for Flathead Lake will involve further refinement of the TMDL allocations provided in the 2001 document (Montana Department of Environmental Quality, 2001).

Table 8-2. TMDLs Previously Completed in the Flathead Lake Watershed

TMDL Planning Area	Waterbody & Location Description	Waterbody ID	Completed TMDL(s)	TMDL Document[1]
Big Creek	**Big Creek,** Headwaters to mouth (North Fork of the Flathead River)	MT76Q002_050	Sediment[2]	2003 "Watershed Restoration Plan for Big Creek, North Fork of the Flathead River"
Flathead Headwaters	**Coal Creek,** South Fork to mouth (North Fork Flathead)	MT76Q002_080	Sediment	2004 "Water Quality Assessment and TMDLs for the Flathead River Headwaters Planning Area, Montana"

Table 8-2. TMDLs Previously Completed in the Flathead Lake Watershed

TMDL Planning Area	Waterbody & Location Description	Waterbody ID	Completed TMDL(s)	TMDL Document[1]
Flathead Lake	**Flathead Lake**	MT76O003_010	Total Nitrogen, Total Phosphorus	2001 "Nutrient Management Plan & Total Maximum Daily Load for Flathead Lake, Montana"
Swan	**Goat Creek,** Headwaters to Squeezer Creek	MT76K003_031	Total Suspended Solids	2004 "Water Quality Protection Plan and TMDLs for the Swan Lake Watershed"
	Jim Creek, Headwaters to mouth (Swan River)	MT76K003_010	Sediment	
	Swan Lake	MT76K002_010	Total Nitrogen, Total Phosphorus, Sediment	

[1] These documents can be found on DEQ's website at: http://deq.mt.gov/wqinfo/TMDL/finalReports.mcpx
[2] The sedimentation/siltation cause of impairment for Big Creek was removed from the 303(d) List in 2012; however, Big Creek remains on the impaired waters list as not fully supporting aquatic life, with a probable cause of habitat alteration.

8.5 Future TMDL Development

There are metals, oil and grease, and polychlorinated biphenyl (PCB) impairments identified on the "2014 Water Quality Integrated Report" for streams and lakes in the Flathead Lake and Flathead – Stillwater TMDL planning areas (**Table 8-3**). These impairments were not part of this TMDL development project. DEQ currently has a separate, ongoing monitoring project to further evaluate most of the impairment causes in **Table 8-3**. These evaluations will help define future TMDL development requirements.

Table 8-3. Waterbodies in the Flathead and Flathead – Stillwater TMDL Planning Areas with Pollutant Impairments on the 2014 303(d) List Not Addressed in this Document

TMDL Planning Area	Waterbody & Location Description	Waterbody ID	Impairment Cause
Flathead - Stillwater	**Spring Creek**, Headwaters to mouth (Ashley Creek)	MT76O002_040	Arsenic
	Whitefish Lake	MT76P004_010	Mercury
			Polychlorinated biphenyls
	Whitefish River, Whitefish Lake to mouth (Stillwater River)	MT76P003_010	Oil and Grease
			PCB in Water Column
Flathead	**Flathead Lake**	MT76O003_010	Mercury
			Polychlorinated biphenyls

Additionally, total nitrogen and total phosphorus TMDLs were written for Flathead Lake in 2001 (**Table 8-2**) (Montana Department of Environmental Quality, 2001). A Phase II component of these TMDLs includes further refinement of the allocations provided within the 2001 document. This Phase II activity is part of a separate and ongoing TMDL project.

9.0 WATER QUALITY IMPROVEMENT PLAN

While certain land uses and human activities are identified as sources and causes of water quality impairment during total maximum daily load (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.

9.1 PURPOSE OF IMPROVEMENT STRATEGY

This section describes an overall strategy and specific on-the-ground measures designed to restore water quality beneficial uses and attain water quality standards in the Flathead-Stillwater TMDL Planning Area streams. The strategy includes general measures for reducing loading from identified nonpoint sources of pollutants.

This section should assist stakeholders in developing a watershed restoration plan (WRP) that will provide more detailed information about restoration goals within the Flathead-Stillwater TMDL Planning Area, and also in the broader Flathead Lake and Flathead River watersheds. The WRP may also encompass broader goals than the water quality improvement strategy outlined in this document. The intent of the WRP is to serve as a locally organized "road map" for watershed activities, prioritizing types of projects, sequences of projects, and funding sources towards achieving local watershed goals. Within the WRP, local stakeholders identify and prioritize streams, tasks, resources, and schedules for applying best management practices (BMPs). As restoration experiences and results are assessed through watershed monitoring, this strategy could be adapted and revised by stakeholders based on new information and ongoing improvements.

9.2 WATER QUALITY RESTORATION OBJECTIVE

The water quality restoration objective for the Flathead-Stillwater TMDL Planning Area is to reduce pollutant loads as identified throughout this document in order to meet the water quality standards and TMDL targets for full recovery of beneficial uses for all impaired streams. Meeting the TMDLs provided in this document will achieve this objective for all identified pollutant-impaired streams. Based on the assessment provided in this document, the TMDLs can be achieved through proper implementation of BMPs, and using the appropriate technology for treating wastewater. However; this section focuses on BMPs for nonpoint sources.

A WRP can provide a framework strategy for water quality restoration and monitoring in the Flathead - Stillwater TMDL Planning Area, 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. WRPs 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 Environmental Protection Agency (EPA) requires nine minimum elements for a WRP, summarized here:

1. Identification of the causes and sources of pollutants
2. Estimated load reductions expected based on implemented management measures
3. Description of needed nonpoint source management measures
4. Estimate of the amounts of technical and financial assistance needed
5. An information/education component
6. Schedule for implementing the nonpoint source management measures
7. Description of interim, measurable milestones
8. Set of criteria that can be used to determine whether loading reductions are being achieved over time
9. A monitoring component to evaluate effectiveness of the implementation efforts over time

This document provides, or can serve as an outline, for many of the required elements. Water quality goals for nutrients, sediment, and temperature pollutants are detailed in **Sections 5.0, 6.0,** and **7.0**, respectively. These goals include water quality targets as measures for long-term effectiveness monitoring. These targets specify satisfactory conditions to ensure protection and/or recovery of beneficial uses of waterbodies in the Flathead-Stillwater TMDL Planning Area. It is presumed that meeting all water quality targets will achieve the water quality goals for each impaired waterbody. **Section 10.0** identifies a general monitoring strategy and recommendations to track post-implementation water quality conditions and measure restoration successes.

9.3 Role of DEQ, Other Agencies, and Stakeholders

The Montana Department of Environmental Quality (DEQ) does not implement TMDL pollutant-reduction projects for nonpoint source activities, but may provide technical and financial assistance for stakeholders interested in improving their water quality. Successful implementation of TMDL pollutant-reduction projects requires collaboration among private landowners, land management agencies, and other stakeholders. DEQ will work with participants to use the TMDLs as a basis for developing locally-driven WRPs, administer funding specifically to help support water quality improvement and pollution prevention projects, and 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 work collaboratively with local and state agencies to achieve water quality restoration goals and to meet TMDL targets and load reductions. Specific stakeholders and agencies that will likely be vital to restoration efforts for streams discussed in this document include:

- Flathead Conservation District
- U.S. Environmental Protection Agency (EPA)
- U.S. Forest Service (USFS)
- Natural Resources and Conservation Service (NRCS)
- U.S. Fish & Wildlife Service (USFWS)
- U.S. Army Corp of Engineers
- Bureau of Reclamation
- Montana Department of Natural Resources and Conservation (DNRC)
- Montana Fish, Wildlife and Parks (FWP)

- Montana Department of Environmental Quality (DEQ)
- Montana Department of Transportation
- Montana Bureau of Mines and Geology
- Flathead Basin Commission
- Confederated Salish and Kootenai Tribes
- Flathead Lake Biological Station
- Flathead Lakers
- Haskill Basin Watershed Council
- Whitefish Lake Institute
- Plum Creek Timber Company
- Montana Trout Unlimited
- Local City and County Representatives
- Flathead Regional Wastewater Management Group

Other organizations and non-profits that may provide assistance through technical expertise, funding, educational outreach, or other means include:

- Montana Water Center (at Montana State University)
- University of Montana Watershed Health Clinic
- Montana Aquatic Resources Services
- Montana State University Extension Water Quality Program

9.4 RESTORATION APPROACHES BY POLLUTANT

TMDLs were completed for four waterbody segments for nutrients, seven waterbody segments for sediment, and four waterbody segments for temperature. Other streams in the planning area may be in need of restoration or pollutant reduction, but insufficient information about them precludes TMDL development at this time. The following sub-sections describe some generalized recommendations for implementing projects to achieve the TMDLs. Details specific to each stream, and therefore which of the following strategies may be most appropriate, are found within **Sections 5.0, 6.0,** and **7.0**.

In general, restoration activities can be separated into two categories: active and passive. Passive restoration allows natural succession to occur within an ecosystem by removing a source of disturbance. Fencing off riparian areas from cattle grazing is a good example of passive restoration. Active restoration, on the other hand involves accelerating natural processes or changing the trajectory of succession. For example, historic placer mining often resulted in the straightening of stream channels and piling of processed rock on the streambank. These impacts would take so long to recover passively that active restoration methods involving removal of waste rock and rerouting of the stream channel would likely be necessary to improve stream and water quality conditions. In general, passive restoration is preferable for nutrient, sediment, and temperature problems due to nonpoint sources because it is generally more cost effective, less labor intensive, and will not result in short term increase of pollutant loads as active restoration activities may. However, in some cases active restoration is the only feasible mechanism for achieving desired goals; these activities must be assessed on a case by case basis (Nature Education, 2013).

9.4.1 Nutrient Restoration Approach

The goal of the nutrient restoration strategy is to reduce nutrient input to Ashley Creek and other stream channels from nonpoint sources 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 agricultural areas. 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:

- The timing, frequency, and duration of near-stream grazing
- The spacing and exposure duration of on-stream watering locations
- Provision of off-stream watering areas to minimize near-stream damage and allow impoundment operations that minimize salt accumulations
- Active reseeding and rest rotation of locally damaged vegetation stands
- Improved management of irrigation systems
- Incorporation of streamside vegetation buffer to irrigated croplands and animal feeding areas

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 a comprehensive plan for farm and ranch operators. Sound planning combined with effective conservation BMPs should be sought whenever possible. Assistance from resource professionals from various local, state, and federal agencies or non-profit groups is widely available in Montana. The local United States Department of Agriculture (USDA) Service Center and county conservation district offices are geared to offer both planning and implementation assistance.

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 electricity. 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, particularly where excess phosphorus is a problem. Additional sediment-related BMPs are presented in **Section 9.5**.

9.4.2 Sediment Restoration Approach

The goal of the sediment restoration strategy is to limit the availability, transport, and delivery of excess sediment by a combination of minimizing sediment delivery, reducing the rate of runoff, and intercepting sediment transport. Monitoring data used to develop targets and determine impairments are described in **Section 6.0** and in **Attachment A**. Sediment restoration activities on impaired stream segments will help reduce the amount of fine sediment, reduce width/depth ratio, increase residual pool depth, increase pool frequency, increase riparian understory shrub cover, reduce impacts of human-caused sediment sources, and restore appropriate macroinvertebrate assemblages. These are indicators of successful restoration activities targeted toward sediment reduction and need to be considered together and within the context of stream potential in comparison to appropriate reference

sites. For example, pool frequency tends to decline as stream size increases; therefore, indicators for these parameters will vary. General targets for these indicators are summarized in **Table 6-2**.

Streamside riparian and wetland vegetation restoration and long term management are crucial to achieving the sediment TMDLs. Native streamside riparian and wetland vegetation provides root mass, which hold streambanks together. Suitable root mass density ultimately slows bank erosion. Riparian and wetland vegetation filters pollutants from upland runoff. Therefore, improving riparian and wetland vegetation will decrease bank erosion by improving streambank stability and will also reduce pollutant delivery from upland sources. Suspended sediment is also deposited more effectively in healthy riparian zones and wetland areas during flooding because water velocities slow in these areas enough for excess sediment to settle out. Restoration recommendations involve the promotion of riparian and wetland recovery through improved grazing and land management (including the timing and duration of grazing, the development of multi-pasture systems that include riparian pastures, and the development of off-site watering areas), application of timber harvest best management practices, floodplain and streambank stabilization, revegetation efforts, and instream channel and habitat restoration where necessary. Appropriate BMPs will differ by location and are recommended to be included and prioritized as part of a comprehensive watershed scale plan (e.g., WRP).

In areas where stormwater is accelerating sediment loading to streams, the sediment restoration strategy will be achieved by BMPs that promote infiltration of runoff and lessen its volume and the timing of delivery to surface water. Smart growth and low impact development are two closely related planning strategies that help reduce stormwater volume, slow its transport to surface waterbodies, and improve groundwater recharge.

Although unpaved 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 primarily include measures that divert water to 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. In addition, routine maintenance of unpaved roads (particularly near stream crossings) and proper sizing and maintenance of culverts, regardless of road use status, are crucial components to limiting sediment production from roads.

9.4.3 Temperature Restoration Approach

The goal of the temperature restoration approach is to reduce water temperatures where possible to be consistent with naturally occurring conditions. The most significant mechanism for reducing water temperature in both Ashley Creek and the Whitefish River is increasing riparian shade. On Ashley Creek, the Kalispell wastewater treatment plant (WWTP) also appears to be increasing temperatures and is addressed in **Section 6.6.3**. Other factors that will help are: maintaining conditions where Ashley Creek and the Whitefish River are currently meeting the targets and using water conservation measures to maximize water left in the stream.

Increases in shade can be accomplished through the restoration and protection of shade-providing vegetation within the riparian corridor. This type of vegetation can also have the added benefit of improving streambank stabilization to reduce bank erosion, slowing lateral river migration, and providing a buffer to prevent pollutants from upland sources from entering the stream. In some cases, this can be achieved by limiting the frequency and duration of livestock access to the riparian corridor,

or through other grazing related BMPs such as installing water gaps or off-site watering. Other areas may require planting, active bank restoration, and protection from browse to establish vegetation.

Both Ashley Creek and the Whitefish River appear to have appropriate bankfull width. However, there may be discreet locations where channel morphology could be improved. Recovery of stream channel morphology in most cases will occur slowly over time and follow the improvement of riparian condition, stabilization of streambanks, and reduction in overall sediment load. Stream size, project scale, and cost of restoration in most cases are limiting factors to applying this type of remedy.

Although there is no specific target for instream summer flow in either Ashley Creek or the Whitefish River, if increases in instream summer flows are possible, they can be achieved through a thorough investigation of water use practices and water conveyance infrastructure, and a willingness and ability of local water users to keep more water in the stream. This TMDL document cannot, nor is it intended to, prescribe limitations on individual water rights owners and users. Local water users should work collectively and with local, state, and federal resource management professionals to review water use options and available assistance programs.

The above approaches give only the broadest description of activities to help reduce water temperatures. The temperature assessments described in **Section 7.0** looked at possible scenarios based on limited information at the watershed scale. Those scenarios showed that improvements in stream temperatures can primarily be made by improvements to riparian shade. It is strongly encouraged that resource managers and land owners continue to work to identify all potential areas of improvement and develop projects and practices to reduce stream temperatures in Ashley Creek and the Whitefish River.

9.4.4 Non-Pollutant Restoration Approach

Although TMDL development is not required for non-pollutant causes of impairment, they are frequently linked to pollutants, and addressing non-pollutant causes is an important component of TMDL implementation. Non-pollutant impairment causes within the Flathead-Stillwater TMDL Planning Area (TPA) include alteration in streamside or littoral vegetative covers, physical substrate habitat alterations, other flow regime alterations, and low flow alterations, and are described in **Section 8.0**. 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 and nutrient inputs. Therefore, if restoration goals within the Flathead-Stillwater TMDL Planning Area are not also addressing non-pollutant impairments, additional non-pollutant related BMP implementation should be considered.

9.5 RESTORATION APPROACHES BY SOURCE

General management recommendations are outlined below for the major sources of human caused pollutant loads in the Flathead-Stillwater TMDL Planning Area: agricultural sources, riparian and wetland vegetation removal, beaver populations, roads, forestry and timber harvest, stormwater from construction sites, residential development, and roads. The effect of different sources can change seasonally and be dependent on the magnitude of storm/high flow events. Therefore, restoration activities 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.

Applying and maintaining BMPs is the core of the nonpoint source pollutant reduction strategy, but BMPs are only part of a watershed restoration strategy. It is important that future load increases are avoided by ensuring that new activities within the watershed incorporate all appropriate BMPs and that implementation and maintenance of those BMPs currently in place or in practice is continued. For each major source, BMPs will be most effective as part of a comprehensive 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 the appendices and attachments and summarized in **Sections 5.5, 6.5, and 7.5** 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. The WRP developed by local watershed groups and partners should contain more detailed information on restoration goals and specific management recommendations that may be required to address key pollutant sources. BMPs are usually identified as a first effort and further monitoring and evaluation of activities and outcomes, as part of an adaptive management approach will be used to determine if further restoration approaches are necessary to achieve water quality standards. Monitoring is an important part of the restoration process, and monitoring recommendations are outlined in **Section 10.0**.

In recognition that noxious weeds are a problem throughout Montana and may be associated with any of the following source categories, noxious weed control should be actively pursued whenever BMPs are being implemented.

9.5.1 Agriculture Sources

Reduction of pollutants from upland agricultural sources can be accomplished by limiting the amount of erodible soil, reducing the rate of runoff, and intercepting eroding soil and runoff before it enters a waterbody. The main BMP recommendations for the Flathead-Stillwater TMDL Planning Area are riparian buffers, wetland restoration, and vegetated filter strips, where appropriate. These methods reduce the rate of runoff, promote infiltration of the soil (instead of delivering runoff directly to the stream), and intercept pollutants. Filter strips and buffers are even more effective for reducing upland agricultural related sediment when used in conjunction with BMPs that reduce the availability of erodible soil such as conservation tillage, crop rotation, and strip-cropping. Additional BMP information, design standards and effectiveness, and details on the suggested BMPs can be obtained from your local USDA Agricultural Service Center and in Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012).

An additional benefit of reducing sediment input to the stream is a decrease in sediment-bound nutrients. Reductions in sediment loads may help address some nutrient related problems. Nutrient management considers the amount, source, placement, form, and timing of plant nutrients and soil amendments. Conservation plans should include the following information (NRCS Conservation Practice Standard 590 and 590-1, Nutrient Management (United States Department of Agriculture, Natural Resources Conservation Service, 2005):

- Field maps and soil maps
- Planned crop rotation or sequence
- Results of soil, water, plant, and organic materials sample analysis
- Realistic expected yields
- Sources of all nutrients to be applied
- A detailed nutrient budget

- Nutrient rates, form, timing, and application method to meet crop demands and soil quality concerns
- Location of environmentally sensitive areas, including streams, wetlands, springs, or other locations that deliver surface runoff to groundwater or surface water
- Guidelines for operation and maintenance

9.5.1.1 Grazing

Grazing has the potential to increase sediment and nutrient loads, as well as stream temperatures (by altering channel width and riparian vegetation), but these effects can be mitigated with appropriate management. Development of riparian grazing management plans should be a goal for any landowner who operates livestock and does not currently have such plans. Private land owners may be assisted by state, county, federal, and local conservation groups to establish and implement appropriate grazing management plans. Note that riparian grazing management does not necessarily eliminate all grazing in riparian corridors. In some areas however, a more limited management strategy may be necessary for a period of time in order to accelerate reestablishment of a riparian community with the most desirable species composition and structure.

Every livestock grazing operation should have a grazing management plan. The NRCS Prescribed Grazing Conservation Practice Standard (Code 528) recommends the plan include the following elements (Natural Resource Conservation Service, 2010):

- A map of the operation showing fields, riparian and wetland areas, winter feeding areas, water sources, animal shelters, etc.
- The number and type of livestock
- Realistic estimates of forage needs and forage availability
- The size and productivity of each grazing unit (pasture/field/allotment)
- The duration and time of grazing
- Practices that will prevent overgrazing and allow for appropriate regrowth
- Practices that will protect riparian and wetland areas and associated water quality
- Procedures for monitoring forage use on an ongoing basis
- Development plan for off-site watering areas

Reducing grazing pressure in riparian and wetland areas and improving forage stand health are the two keys to preventing nonpoint source pollution from grazing. Grazing operations should use some or all of the following practices:

- Minimizing or preventing livestock grazing in riparian and wetland areas
- Providing off-stream watering facilities or using low-impact water gaps to prevent ‘loafing’ in wet areas
- Managing riparian pastures separately from upland pastures
- Installing salt licks, feeding stations, and shelter fences in areas that prevent ‘loafing’ in riparian areas and help distribute animals
- Replanting trodden down banks and riparian and wetland areas with native vegetation (this should always be coupled with a reduction in grazing pressure)
- Rotational grazing or intensive pasture management that takes season, frequency, and duration into consideration

The following resources provide guidance to help prevent pollution and maximize productivity from grazing operations:

- Plum Creek Timber Company's Native Fish Habitat Conservation Plan (http://www.plumcreek.com/Environment/nbspSustainableForestrySFI/nbspSFIImplementation/HabitatConservationPlans/tabid/153/Default.aspx)
- USDA, Natural Resources Conservation Service
  The office serving Flathead County is located in Kalispell (find your local USDA Agricultural Service Center listed in your phone directory or on the Internet at www.nrcs.usda.gov)
- Montana State University Extension Service (www.extn.msu.montana.edu)
- DEQ Watershed Protection Section (Nonpoint Source Program): Nonpoint Source Management Plan (http://deq.mt.gov/wqinfo/nonpoint/NonpointSourceProgram.mcpx)

The key strategy of the recommended grazing BMPs is to develop and maintain healthy riparian and wetland vegetation and minimize disturbance of the streambank and channel. The primary recommended BMPs for the Flathead-Stillwater TMDL Planning Area are limiting livestock access to streams and stabilizing the stream at access points, providing off-site watering sources when and where appropriate, planting native stabilizing vegetation along streambanks, and establishing and maintaining riparian buffers. Although bank revegetation is a preferred BMP, in some instances bank stabilization may be necessary prior to planting vegetation.

9.5.1.2 Cropland

The primary strategy of the recommended cropland BMPs is to reduce sediment 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 Flathead-Stillwater TMDL Planning Area are vegetated filter strips 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% for the filter strips and 50% for the buffers (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012). 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. Additional BMPs and details on the suggested BMPs can be obtained from NRCS and in Appendix A of Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012).

9.5.1.3 Water Management and Irrigation

Flow alteration and dewatering are commonly considered water quantity rather than water quality issues. However, changes to streamflow 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). In addition to the BMPs recommended in Appendix A of Montana's Nonpoint Source (NPS) Management Plan (Montana Department of Environmental Quality, 2012c), 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 (Montana Code Annotated (MCA) 75-5-705).

Irrigation management is a critical component of attaining both coldwater fishery conservation and TMDL goals. Understanding irrigation water, groundwater, and surface water interactions is an important part of understanding how irrigation practices will affect streamflow during specific seasons. 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.

Some irrigation practices in western Montana are based on flood irrigation methods. Occasionally head gates and ditches leak, which can decrease the amount of water in diversion flows. The following recommended activities could potentially result in notable water savings:

- Install upgraded head gates for more exact control of diversion flow and to minimize leakage when not in operation
- Develop more efficient means to supply water to livestock
- Determine necessary diversion flows and timeframes that would reduce over watering and improve forage quality and production
- Where appropriate, redesign or reconfigure irrigation systems
- Upgrade ditches (including possible lining, if appropriate) to increase ditch conveyance efficiency

Some water from spring and early summer flood irrigation likely returns as cool groundwater to the streams during the heat of the summer. These critical areas could be identified so that they can be preserved as flood irrigation areas. Other irrigated areas which do not contribute to summer groundwater returns to the river should be identified as areas where year round irrigation efficiencies could be more beneficial than seasonal management practices. Winter baseflow should also be considered during these investigations.

9.5.1.4 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 nonpoint source 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 Montana State University (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 and 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.

9.5.1.5 Small Acreages

The number of small acreages is 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, 2012c) or the MSU extension website at: http://animalrangeextension.montana.edu/articles/NatResourc/main-smallacre-links.htm.

9.5.2 Riparian Areas, Wetlands, and Floodplains

Healthy and functioning riparian areas, wetlands, and floodplains are critical for wildlife habitat, groundwater recharge, reducing the severity of floods and upland and streambank erosion, and filtering pollutants from runoff. The performance of these functions is dependent on the connectivity of riparian areas, wetlands, and floodplains to both the stream channel and upland areas. Human activities affecting the quality of these transitional habitats or their connectivity can alter their performance and greatly affect the transport of water, sediments, and contaminants (e.g., channelization, increased stream power, bank erosion, and habitat loss or degradation). Therefore, restoring, maintaining, and protecting riparian areas, wetlands, and floodplains within the watershed should be a priority of TMDL implementation in the Flathead-Stillwater TMDL Planning Area, and the Flathead River watershed as a whole.

Reduction of riparian and wetland vegetative cover by various land management activities is a principal cause of water quality and habitat degradation in watersheds throughout Montana. Although implementation and maintenance of passive BMPs that allow riparian and wetland vegetation to recover at natural rates is typically the most cost-effective approach, active restoration (i.e., plantings) may be necessary in some instances. The primary advantage of riparian and wetland plantings is that installation can be accomplished with minimum impact to the stream channel, existing vegetation, and private property. Weed management should also be a dynamic component of managing riparian areas.

Factors influencing the appropriate riparian and wetland restoration would include severity of degradation, site-potential for various species, and availability of local sources for native transplant materials. In general, riparian and wetland plantings would promote establishment of functioning stands of native species. The following recommended restoration measures would allow for stabilization of the soil, decrease sediment delivery to the stream, and increase absorption of nutrients from overland runoff:

- Harvesting and transplanting locally available sod mats with an existing dense root mass provides immediate promotion of bank stability and filtering nutrients and sediments
- Seeding with native graminoids (grasses and sedges) and forbs is a low cost activity at locations where lower bank shear stresses would be unlikely to cause erosion
- Willow sprigging expedites vegetative recovery, but involves harvest of dormant willow stakes from local sources
- Transplanting mature native shrubs, particularly willows (*Salix* sp.), provides rapid restoration of instream habitat and water quality through overhead cover and stream shading, as well as uptake of nutrients

Note: Before transplanting *Salix* from one location to another it is important to determine the exact species so that we do not propagate the spread of non-native species. There are several non-native willow species that are similar to our native species and commonly present in Montana watersheds.

In addition to the benefits described above, it should be noted that in some cases, wetlands act as areas of shallow subsurface groundwater recharge and/or storage areas. The captured water via wetlands is then generally discharged to the stream later in the season and contributes to the maintenance of base flows and stream temperatures. Restoring ditched or drained wetlands can have a substantial effect on the quantity, temperature, and timing of water returning to a stream, as well as the pollutant filtering capacity that improved riparian and wetlands provide.

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. As discussed above, passive riparian restoration is preferable, but in areas where stream channels are unnaturally unstable or streambanks are eroding excessively, additional active restoration approaches, such as channel design, woody debris and log vanes, bank sloping, seeding, and shrub planting may be desired to speed up the rate of recovery. Bank stabilization using natural channel design techniques can provide both bank stability and aquatic habitat potential. The primary recommended structures include natural or “natural-like” structures, such as large woody debris jams. These natural arrays can be constructed to emulate historical debris assemblages that were introduced to the channel by the adjacent cottonwood-dominated riparian

community types. When used together, woody debris jams and straight log vanes can benefit the stream and fishery by improving bank stability, reducing bank erosion rates, adding protection to fillslopes and/or embankments, reducing near-bank shear stress, and enhancing aquatic habitat and lateral channel margin complexity.

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. Limit threats to infrastructure by reducing floodplain development through local land use planning initiatives.

9.5.3 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 un-incised 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.

9.5.4 Roads

Unpaved roads contribute sediment (as well as nutrients and other pollutants) to streams in the Flathead-Stillwater TMDL Planning Area. The road sediment reductions in this document represent an estimation of the sediment load that will remain once appropriate road BMPs are applied and maintained 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, 2012c). 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

9.5.4.1 Culverts and Fish Passage

Undersized and improperly installed and maintained culverts can be a substantial source of sediment to streams, and a barrier to fish and other aquatic organisms. There are many factors associated with culvert failure and it is difficult to estimate the true at-risk load. The allocation strategy for culverts is that, regardless of road use status, there should be no loading from culverts as a result of being undersized, improperly installed, or inadequately maintained. It is recommended that 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. Each culvert that is deemed a 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.

9.5.4.2 Traction Sand

Severe winter weather and mountainous roads in the Flathead-Stillwater TMDL Planning Area will require the continued use of relatively large quantities of traction sand. Even so, 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:

- Use a snow blower to directionally place snow and traction sand on cut/fillslopes 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 Montana Department of Transportation 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

9.5.5 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 Montana Code Annotated (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 (e.g., 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 and nutrient (especially forms bound to sediments) load allocations. On USFS Lands, Inland Native Fish Strategy (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). The Native Fish Habitat Conservation Plan developed by Plum Creek Timber includes a riparian management section that supplements the SMZ riparian buffer rules to help Plum Creek minimizes impacts from timber harvest in riparian areas. It includes specific commitments to leave more trees in locations that provide the maximum benefit, such as channel migration zones and provide for an additional caution area outside of the SMZ.

In addition to the BMPs identified above, effects that timber harvest may have on yearly streamflow levels, such as peak flow, should be considered. Timber harvest plans should evaluate the potential for cumulative effects on water yield and peak flow increases and implement BMPs to reduce sediment and nutrients loading. Finally, noxious weed control should be actively pursued in all harvest areas.

9.5.6 Storm Water 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 Storm Water General Permit for Construction Activities. A Storm Water Pollution Prevention Plan (SWPPP) must be developed and submitted to obtain a permit. A SWPPP identifies pollutants of concern (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 wasteload allocations 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 (U.S. Environmental Protection Agency, 2009).

9.5.7 Residential/Urban Development

There are multiple sources and pathways of pollution to consider in residential and urban areas. Destruction of riparian areas, pollutants from both functioning and failing septic systems, and stormwater generated from impervious areas and construction sites are discussed below.

9.5.7.1 Riparian Degradation

Residential development adjacent to streams can affect the amount and health of riparian vegetation, the amount of large woody debris available in the stream, and might result in placement of riprap on streambanks (see **Section 10.5.5**). As discussed in Riparian Areas, Wetlands, and Floodplains in **Section 9.5.2** above, substantially degraded riparian areas do not effectively filter pollutants from upland runoff. Riparian areas that have been converted to lawns or small acreage pastures for domestic livestock may suffer from increased contributions of nutrients, sediment, and bacteria, as well as increased summer stream temperatures, increased channel erosion, and greater damage to property from flooding (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012). Of consideration, conservation easements can be a viable alternative to subdividing land, reducing residential development, and can be facilitated through several organizations such as The Nature Conservancy, the Trust for Public Land, and FWP. Further information on conservation easements and other landowner programs can be obtained from FWP (http://fwp.mt.gov/fishAndWildlife/habitat/wildlife/programs/landownersGuide.html).

DEQ encourages the consideration of adopting local zoning or regulations that protect the functions of floodplains and riparian and wetland areas where future growth may occur. Requirements for protecting native vegetation riparian buffers can be an effective mechanism for maintaining or improving stream health. Local outreach activities to inform new residential property owners of the effects of riparian degradation may also prevent such activities from occurring, including providing information on: appropriate fertilizer application rates to lawns and gardens, regular septic system maintenance, preserving existing riparian vegetation, native vegetation for landscaping, maintaining a buffer to protect riparian and wetland areas, and practices to reduce the amount of stormwater originating from developed property. Montana's Nonpoint Source Management Plan contains suggested BMPs to address the effects of residential and urban development, and also contains an appendix of setback regulations that have been adopted by various cities and counties in Montana (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012). Planning guides and informational publications related to wetlands and native plant species in Montana can be found on DEQ's Wetlands Conservation website at: http://deq.mt.gov/wqinfo/Wetlands/default.mcpx.

9.5.7.2 Septic

BMPs for septic systems include regular inspection and cleaning and repair of leaking or otherwise malfunctioning systems. As large acreages are subdivided into smaller lots, the number of septic systems

will increase. Plans for development of lands within the Flathead-Stillwater TMDL Planning Area should consider the effects of additional septic systems to watersheds and consider ways of minimizing septic impacts to water quality such as installing type II systems to decrease nitrogen loading, installing systems further away from streams to allow for more nutrients attenuation, connecting to an existing WWTP, and/or constructing new WWTPs to connect multiple wastewater systems.

9.5.7.3 Urban Area Stormwater

Buildings and other impervious surfaces associated with land development prevent water from infiltrating into the ground and can alter watershed hydrology and transport built-up pollutants into nearby waterbodies. An important component to effectively managing stormwater is comprehensive planning that integrates land and infrastructure management. Smart growth and low impact development are two closely related planning strategies that help reduce stormwater volume, slow its transport to surface waterbodies, and improve groundwater recharge. Smart growth emphasizes structuring development to preserve open space, reduce the use of impervious surfaces, and improve water detention so more precipitation can be retained on the landscape before runoff occurs. Low impact development mimics natural processes of water storage and infiltration and can limit the harmful effects that increased percentages of impervious surface have on surface waters. Both concepts focus on applying simple, non-structural, and low cost methods to treat stormwater on the landscape and they can be used to retrofit existing development and also applied to new development.

Starting in 2012, Montana's MS4 general permit requires that to the extent practicable, new development or redevelopment projects greater than one acre implement low impact development practices that "infiltrate, evapotranspire, or capture for reuse the runoff generated from the first 0.5 inches of rainfall from a 24-hour storm preceded by 48 hours of no measurable precipitation." Generally, newer developments in the watershed have better BMP implementation than older developments, and although planning for future development and retrofitting older developments with better levels of treatment are important, consistent maintenance and effectiveness evaluation of new and recently implemented stormwater BMPs is also an important component of effective stormwater management and TMDL implementation. Examples of low impact development and smart growth practices include drain chains, rain barrels, vegetated swales, sidewalk storage, permeable pavers, native landscaping, reducing parking areas, and mixed-use development. Parking lot drainage into a swale and a mixed use development are shown in **Figure 9-1**. Additional information about smart growth and low impact development can be found in Montana's Nonpoint Source Management Plan (Montana Department of Environmental Quality, 2012c) and at the EPA's website (www.epa.gov/nps/lid; www.epa.gov/dced).




Figure 9-1. Stormwater BMPs: Parking lot designed to drain into a swale and a mixed use development

9.5.8 Nonpoint Source Pollution Education

Because most nonpoint source pollution (NPS) is generated by individuals, a key factor in reducing NPS is increasing public awareness through education. Local watershed groups can provide educational opportunities to both students and adults through water quality workshops and informational meetings. Continued education is key to ongoing understanding of water quality issues in the Flathead-Stillwater TMDL Planning Area, and the Flathead River watershed as a whole, and to the support for implementation and restorative activities.

9.6 Potential Funding and Technical Assistance Sources

Prioritization and funding of restoration or water quality improvement projects is integral to maintaining restoration activities and monitoring project successes and failures. Several government agencies and also a few non-governmental organizations fund or can provide assistance with watershed or water quality improvement projects or wetlands restoration projects. Below is a brief summary of potential funding sources and organizations to assist with TMDL implementation. Note that some programs or funding sources summarized below may be discontinued in the future, and new sources of funding could possibly become available. Be sure to inquire with these agencies and organizations for the most current information.

In addition to the information presented below, 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, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012) and information regarding additional funding opportunities can be found at http://www.epa.gov/nps/funding.html.

9.6.1 Section 319 Nonpoint Source Grant Program

DEQ issues a call for proposals every year to award Section 319 grant funds administered under the federal Clean Water Act. The primary goal of the 319 program is to restore water quality in waterbodies whose beneficial uses are impaired by nonpoint source pollution and whose water quality does not meet state standards. 319 funds are distributed competitively to support the most effective and highest priority projects. In order to receive funding, projects must directly implement a DEQ-accepted

watershed restoration plan and funds may either be used for the education and outreach component of the WRP or for implementing restoration projects. The recommended range for 319 funds per project proposal is $10,000 to $30,000 for education and outreach activities and $50,000 to $300,000 for implementation projects. All funding has a 40% cost share requirement, and projects must be administered through a governmental entity such as a conservation district or county, or a nonprofit organization. For information about past grant awards and how to apply, please visit http://deq.mt.gov/wqinfo/nonpoint/319GrantInfo.mcpx.

9.6.2 Future Fisheries Improvement Program

The Future Fisheries grant program is administered by FWP and offers funding for 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 Flathead-Stillwater TMDL Planning Area include restoring streambanks, improving fish passage, and restoring/protecting spawning habitats. For additional information about the program and how to apply, please visit http://fwp.mt.gov/fishAndWildlife/habitat/fish/futureFisheries/.

9.6.3 Renewable Resource Project Planning Grants

The DNRC administers watershed grants to pay for contracted costs associated with the development of a watershed assessment. Grant are available for a maximum of $75,000 per project. Eligible applicants include conservation districts and irrigation districts, among many others. For additional information about the program and how to apply, please visit http://dnrc.mt.gov/cardd/ResourceDevelopment/ProjectPlanningGrants.asp.

9.6.4 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. For additional information about the program and how to apply, please visit http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/.

9.6.5 Montana Partners for Fish and Wildlife

Montana Partners for Fish and Wildlife is a program under the U.S. Fish & Wildlife Service that assists private landowners to restore wetlands and riparian habitat by offering technical and financial assistance. For additional information about the program and to find your local contact for the Flathead River watershed, please visit: http://www.fws.gov/mountain-prairie/pfw/montana/.

9.6.6 Wetland Reserve Easements

The NRCS provides technical and financial assistance to private landowners and Indian tribes to restore, enhance, and protect wetlands through permanent easements, 30 year easements, or term easements. Land eligible for these easements includes farmed or converted wetland that can be successfully and

cost-effectively restored. For additional information about the program and how to apply, please visit http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/easements/acep/.

9.6.7 Montana Wetland Council

The Montana Wetland Council is an active network of diverse interests that works cooperatively to conserve and restore Montana's wetland and riparian ecosystems. Please visit their website to find dates and locations of upcoming meetings, wetland program contacts, and additional information on potential grants and funding opportunities: http://deq.mt.gov/wqinfo/wetlands/wetlandscouncil.mcpx.

9.6.8 Montana Natural Heritage Program

The Montana Natural Heritage Program is a valuable resource for restoration and implementation information including maps. Wetlands and riparian areas are one of the 14 themes in the Montana Spatial Data Infrastructure. The Montana Wetland and Riparian Mapping Center (found at: http://mtnhp.org/nwi/) is creating a statewide digital wetland and riparian layer as a resource for management, planning, and restoration efforts.

9.6.9 Montana Aquatic Resources Services, Inc.

Montana Aquatic Resources Services, Inc. (MARS) is a nonprofit organization focused on restoring and protecting Montana's rivers, streams and wetlands. MARS identifies and implements stream, lake, and wetland restoration projects, collaborating with private landowners, local watershed groups and conservation districts, state and federal agencies, and tribes. For additional information about the program, please visit http://montanaaquaticresources.org/.

10.0 MONITORING STRATEGY AND ADAPTIVE MANAGEMENT

The monitoring strategies discussed in this section are an important component of watershed restoration, and a requirement of total maximum daily load (TMDL) implementation under the Montana Water Quality Act (Montana Code Annotated (MCA) 75-5-703(7)), and the foundation of the adaptive management approach. Water quality targets and allocations presented in this document are based on available data at the time of analysis. The scale of the watershed analysis, coupled with constraints on time and resources, often result in necessary compromises that include estimations, extrapolation, and a level of uncertainty in TMDLs. The margin of safety (MOS) (**Section 4.4**) 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, the amount of reduction of instream pollutants (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 strategy presented in this section provides a starting point for the development of more detailed 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 the water quality improvement goals outlined in this document. Funding for future monitoring is uncertain and can vary with economic and political changes. Prioritizing monitoring activities depends on funding opportunities and stakeholder priorities for restoration. Once restoration measures have been implemented for a waterbody with an approved TMDL and given time to take effect, Department of Environmental Quality (DEQ) will conduct a formal evaluation of the waterbody's impairment status and whether TMDL targets and water quality standards are being met.

The objectives for future monitoring in the Flathead-Stillwater TMDL Planning Area (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, contacts, and any effectiveness evaluation should be compiled about each project. Information about all restoration projects along with tracking overall extent of best management plans (BMP) implementation and maintenance should be compiled in one location for the entire watershed.

For nutrients, 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, and temperature, which was evaluated using a water quality model, loading reductions and BMP effectiveness may be estimated using the approaches used within this document. However, tracking BMP implementation, maintenance, and project-related measurements will likely be most practical for sediment and temperature. 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, the Montana Department of Environmental Quality (DEQ) will conduct a TMDL Implementation Evaluation (TIE). During this process, DEQ compiles recent data, conducts monitoring (if necessary), may compare data to water quality targets (typically a subset for sediment), summarizes BMP implementation since TMDL development, and evaluates data 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 removed from the 303(d) list. 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.

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 TMDL implementation evaluation. 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 Nutrients

Water quality sampling for nutrients were distributed spatially along an assessment unit in order to best delineate nutrient sources. Additional sampling will help refine nutrient source assessment and loading dynamics.

For those watershed groups and/or government agencies that monitor water quality, it is recommended that the same analytical procedures and reporting limits are used in order that water quality data may be compared to TMDL targets (**Table 10-1**). In addition, stream discharge should be measured at time of sampling. Field procedures for sample collection and discharge monitoring can be found in DEQ's Field Procedures Manual (Montana Department of Environmental Quality, 2012e) at: http://deq.mt.gov/wqinfo/qaprogram/sops.mcpx.

Table 10-1. DEQ Nutrient Monitoring Parameter Requirements

Parameter	Preferred Method	Alternate Method	Required Reporting Limit (µg/L)	Holding Time (days)	Bottle	Preservative
Total Persulfate Nitrogen	A4500-NC	A4500-N B	40	28	250mL HDPE	≤ 6°C (7d HT); Freeze (28d HT)
Total Phosphorus as P	EPA-365.1	A4500-P F	3			H2S04, ≤ 6°C or Freeze
Nitrate-Nitrite as N	EPA-353.2	A4500-N03 F	10			

DEQ-required analytical methods and reporting limits may change in the future (e.g., become more stringent); consult with DEQ prior to monitoring in order to ensure you use the most current methods.
HT = holding time, HDPE = high-density polyethylene

It will be important to continually assess nutrient sources in a watershed with changing land uses and/or new Montana Pollutant Discharge Elimination System (MPDES) permitted discharges to surface waters. As discussed in **Sections 5.5.3.8** and **5.8**, there is uncertainty regarding the source of nutrients in the area around and upstream of Smith Lake. As discussed in **Section 5.8.2**, Ashley Creek and Spring Creek appear to be unique within the region with Ashley Creek having in-channel wetland complexes and lakes, and Spring Creek originating from a low-elevation spring as opposed to a mountainous headwater region. Additional monitoring should focus on defining the delivered nutrient load to upper Ashley Creek in the Smith Lake area. This includes synoptic high- and low-flow monitoring in Ashley Creek and its tributaries. This data, in conjunction with the LSPC model, could be used to better define natural background nutrient levels and evaluate the appropriateness of site-specific criteria. If site-specific criteria are developed for Ashley Creek and/or Spring Creek, TMDL targets could be adjusted accordingly.

Additional monitoring should also be conducted to better understand the linkage of Dissolved Oxygen (DO) to nutrients in Ashley Creek. Multi-day diel studies would help to define the extent of the DO problem and to define the magnitude of DO concentrations.

10.3.2 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 measurements

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, and areas with a high background sediment load; macroinvertebrate studies; McNeil core sediment samples; and fish population surveys and redd counts.

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 Flathead National Forest, ongoing PIBO monitoring can provide critical insight into the extent of recovery from past practices via comparisons between reference and managed sites.

10.3.3 Temperature

Habitat and shade sampling for temperature was distributed spatially along an assessment unit in order to best delineate shade condition. The information used for the QUAL2K temperature model (**Appendix E**) can help inform restoration planning and serve as the baseline to compare against in any analyses that track changes in riparian vegetation and shade along Ashley Creek and the Whitefish River.

10.4 SOURCE ASSESSMENT REFINEMENT

In many cases, the level of detail provided by the source assessments only provides broad source categories need reduced pollutant loads. Strengthening source assessments for each of the pollutants may include more thorough sampling or field surveys of source categories and are described in this section. To refine source assessment of impaired waterbodies in the Flathead-Stillwater TPA, resources could be used to focus on identifying the most significant source areas within each impaired stream's watershed to determine where implementation will be most effective.

10.4.1 Nutrients

The following could help strengthen nutrients source assessment and may better characterize where restoration activities should be focused within a watershed:

- More data to characterize background conditions,

- Better understanding of septic contributions,
- Better understanding of nutrient concentrations and spatial variability in groundwater,
- Detailed understanding of fertilization practices within the watershed,
- 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,
- Synoptic sampling at locations upstream, within, and downstream of all lakes and wetland complexes in upper Ashley Creek and all tributaries to this segment.

10.4.2 Sediment

Evaluation of the following could help strengthen sediment source assessment and may better characterize where restoration activities should be focused within a watershed:

- Eroding bank sources and sediment and habitat data collection (included potential stream type) in upper Ashley Creek,
- Eroding bank sources and sediment and habitat data collection in lower Ashley Creek,
- Eroding bank sources and sediment and habitat data collection (included potential stream type) in Haskill Creek,
- Eroding bank sources and sediment and habitat data collection in the upper and Star Meadow portions of Logan Creek,
- Eroding bank sources and sediment and habitat data collection in the Star Meadow portion of Sheppard Creek,
- Sources and loading rates of eroding banks on the Stillwater River from Logan Creek to Kalispell, and
- Sediment and habitat data collection in B and C stream-type reaches of the Stillwater River.

10.4.3 Temperature

The following could help strengthen temperature source assessment and may better characterize where restoration activities should be focused within a watershed:

- Further characterization of tributaries to the stream segments where TMDLs are provided within this document,
- Analysis of current irrigation practices in the Ashley Creek watershed including the quantity, temperature, and timing of water withdrawn and returned,
- Temperature monitoring of urban runoff, and
- As mentioned in **Section 7.6.3**, a detailed evaluation of the effects of the Kalispell wastewater treatment plant (WWTP) on temperatures in lower Ashley Creek.

11.0 STAKEHOLDER AND PUBLIC PARTICIPATION

Stakeholder and public involvement is a component of total maximum daily load (TMDL) planning supported by U.S. Environmental Protection Agency (EPA) guidelines and required by Montana state law (Montana Code Annotated (Montana Code Annotated (MCA) 75-5-703 and 75-5-704) which directs the Department of Environmental Quality (DEQ) to consult with a watershed advisory group 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 for this project in the Flathead-Stillwater TMDL Planning Area, and for development of a water quality model for the entire Flathead Lake watershed.

11.1 PARTICIPANTS AND ROLES

This project was a collaborative effort between Montana DEQ and the U.S. EPA. Throughout completion of the Flathead-Stillwater nutrient, sediment, and temperature TMDLs, DEQ and EPA worked to keep stakeholders apprised of project status and solicited input from a TMDL watershed advisory group. A description of the participants and their roles in the development of the TMDLs in this document is contained below.

Montana Department of Environmental Quality
Montana state law (MCA 75-5-703) directs DEQ to develop all necessary TMDLs. DEQ provided resources toward completion of these 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.

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 support for the Flathead-Stillwater TMDLs was provided by the EPA Regional Office in Helena, MT, including funding; project planning; data collection, analysis, and hydrologic modeling; communicating and coordinating with the Flathead TMDL Watershed Advisory Group and other stakeholders; document development; and providing technical review.

Conservation Districts
DEQ and EPA consulted with both the Flathead and Lake Conservation Districts during development of the TMDLs in this document, which included opportunities to provide comment during the various stages of TMDL development and an opportunity for participation in the watershed advisory and technical advisory groups described below.

Flathead TMDL Watershed Advisory Group
The Flathead TMDL Watershed Advisory Group consisted of selected resource professionals who possess a familiarity with water quality issues and processes in the Flathead Lake watershed, and representatives of applicable interest groups. All members were solicited to participate and work with DEQ in an advisory capacity per Montana state law (75-5-703 and 704). DEQ, in collaboration with EPA,

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; timber industry representatives; state and federal land management agencies, tribal representatives; and representatives of fishing, recreation, and tourism interests. The advisory group also included the Flathead Basin Commission, additional state and federal agency professionals, local action groups, and stakeholders 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 and EPA 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.

Communication with advisory group members was conducted through a series of group meetings, conference calls, and e-mails. Draft documents, project status updates, and meeting agendas and presentations were made available both via e-mail and through DEQ's website for TMDL development projects (http://montanatmdlflathead.pbworks.com). Opportunities for review and comment were provided for participants at varying stages of TMDL development, including a two-week review and comment period for a draft version of this TMDL document prior to the public comment period. Members' comments were incorporated into this version of the draft document. The draft TMDLs were also presented to and discussed with the group at a meeting in Kalispell, MT in September 2014.

Flathead Technical Advisory Group

A technical advisory group was created for this project to help develop the Flathead Lake watershed model. The group was composed of local resource professionals, hydrologists, ecologists, and scientists; Montana collegiate professors and research scientists; and local, state, and federal water quality modelers. The group met in a series of in-person meetings and conference calls from 2011 to 2014. Members were asked to provide input on the Flathead Lake watershed's characteristics and pollutant sources, review model inputs, and review model calibration results. Model technical reports, model results, and technical advisory group presentations were made available on DEQ's website for TMDL development projects (http://montanatmdlflathead.pbworks.com).

11.2 RESPONSE TO PUBLIC COMMENTS

Upon completion of a 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 public comment, and DEQ addresses and responds to all formal public comments.

The formal public comment period for the "Flathead-Stillwater Planning Area Nutrient, Sediment, and Temperature TMDLs and Water Quality Improvement Plan" was initiated on October 10, 2014 and closed on November 12, 2014. Electronic copies of the draft document were made available at the Big Fork, Columbia Falls, Kalispell, Missoula, Polson, and Whitefish public libraries and at the State Library in Helena, MT. Electronic copies of the final document are also available at these libraries.

A public informational meeting was held in Kalispell, MT on October 30, 2014. DEQ and EPA provided an overview of the document, answered questions, and solicited public input and comment on the TMDLs

in this document. The announcement of both the public comment period and the public meeting was distributed to the Flathead TMDL watershed and technical advisory groups, which included the Flathead and Lake conservation districts; the Statewide TMDL Advisory Group; and other identified interested parties via e-mail. Notice of the public comment period and public meeting was posted on the DEQ webpage and DEQ wiki for TMDL development projects, and also advertised in the Daily Interlake, Missoulian, Bigfork Eagle, Flathead Beacon, Hungry Horse News, and Whitefish Pilot newspapers.

Several public comments were received and responses are included in **Appendix F**. Original comment letters and submissions are held on file at DEQ and may be viewed upon request.

12.0 REFERENCES

Andrews, Edmund D. and James 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.

Archer, Eric K., Rebecca A. Scully, Richard Henderson, Brett P. Roper, and Jeremiah D. Heitke. 2012. Effectiveness Monitoring for Streams and Riparian Areas: Sampling Protocol for Stream Channel Attributes. Logan, UT: PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program. http://www.fs.fed.us/biology/fishecology/new.html#pibo_reports.

Arora, K., Steven K. Mickelson, James L. Baker, Dennis Tierney, and C. J. Peters. 1996. Herbicide Retention by Vegetative Buffer Strips From Runoff Under Natural Rainfall. *Transactions of the American Society of Agricultural Engineers.* 39: 2155-2162.

Atkins. 2012. Swan Lake TMDL Planning Area Road Sediment Assessment Results. Condon, MT: Prepared for the Swan Ecosystem Center.

Bahls, Loren L. 2004. Biological Integrity of Logan Creek (Flathead-Stillwater TMDL Planning Area) Based on the Structure and Composition of the Benthic Algae Community. Helena, MT: Hannaea.

Baigun, Claudio R. M. 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, Christopher W. 2004. Effects of Beaver Impoundments on Stream Water Quality and Floodplain Vegetation in the Inner Coastal Plain of North Carolina. M.S. Greenville, NC: East Carolina University.

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. EPA 910-R-99-014.

Bear, Elizabeth A., Thomas E. McMahon, and Alexander V. Zale. 2007a. Comparative Thermal Requirements of Westslope Cutthroat Trout and Rainbow Trout: Implications for Species Interactions and Development of Thermal Protection Standards. *Transactions of the American Fisheries Society.* 136: 1113-1121.

-----. 2007b. Comparative Thermal Requirements of Westslope Cutthroat Trout and Rainbow Trout: Implications for Species Interactions and Development of Thermal Protection Standards. *Transactions of the American Fisheries Society.* 136: 1113-1121.

Bengeyfield, Pete. 2004. Beaverhead-Deerlodge National Forest Stream Morphology Data. Unpublished.

Bicknell, Brian R., J.C.Imhoff, Jr. J.L.Kittle, T.H.Jobes, and Jr. A.S.Donigian. 2004. HSPF Version 12 User's Manual. Mountain View, CA: Aqua Terra Consultants.

Bilby, Robert E. and Jack 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.

Bjornn, Ted C. and Dudley 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.

Bollman, Wease. 2003a. A Biological Assessment of Stream Sites in the Ashley Creek Drainage: Flathead County, Montana. Helena, MT: Rhithron Biological Associates.

-----. 2003b. A Biological Assessment of Stream Sites on Logan Creek: Flathead National Forest, Flathead County, Montana. Missoula, MT: Rhithron Associates, Inc.

-----. 2004. A Biological Assessment of a Site on Fish Creek Flathead County, Montana: TMDL-C11 October 16, 2003. Missoula, MT: Rhithron Associates, Inc.

-----. 2005. A Biological Assessment of Sites in the Flathead River Watershed: Flathead County, Montana: Project TMDL-C09, July-August 2004. Missoula, MT: Rhithron Associates, Inc.

-----. 2006. A Biological Assessment of Sites on Haskill and Logan Creeks: Flathead County, Montana. Missoula, MT: Rhithron Associates, Inc. Project RDG05JF.

Bonneau, Joseph L. 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(5): 783-790.

Brazier, Jon R. and G. W. Brown. 1973. Buffer Strips for Stream Temperature Control. Oregon State University, School of Forestry, Forest Research Laboratory. Research Paper 15.

Broderson, J. M. 1973. Sizing Buffer Strips to Maintain Water Quality. Seattle, WA: University of Washington.

Brown, R. S. 1999. Fall and Early Winter Movements of Cutthroat Trout, Oncorhynchus Clarki, in Relation to Water Temperature and Ice Conditions in Dutch Creek, Alberta. *Environmental Biology of Fishes.* 55: 359-368.

Brown, R. S., S. S. Stanislawski, and W. C. Mackay. 1993. The Effects of Frazil Ice on Fish. In: Prowse, T. D. (ed.). Proceedings of the Workshop of Environmental Aspects of River Ice. Saskatoon, Saskatchewan: National Hydrology Research Institute; 261-278.

Bryce, Sandra A., Gregg 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.

Castelle, Andrew J. and Alan W. Johnson. 2000. Riparian Vegetation Effectiveness. Research National Park, NC: National Council for Air and Stream Improvement. Technical Bulletin No. 799.

Center for Watershed Protection. 2007. National Pollutant Removel Performance Database: Version 3. Ellicott City, MD.

CH2M. 2000. Review of the Scientific Foundations of the Forests and Fish Plan. Washington Forest Protection Association. www.wfpa.org.

Christensen, D. 2000. Protection of Riparian Ecosystems: A Review of Best Available Science. Jefferson County Health Department.

Coats, R., L. Collins, Joan L. Florsheim, and D. Kaufman. 1985. Channel Change, Sediment Transport, and Fish Habitat in a Coastal Stream: Effects of an Extreme Event. *Environmental Management.* 9: 35-48.

Cover, Matthew R., Christine 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.

Cowells, R. B. and C. M. Bogert. 1944. A Preliminary Study of the Thermal Requirements of Desert Reptiles. *Bulletin of the American Museum of Natural History.* 83: 265-296.

Crawford, Norman H. and R. K. Linsley. 1966. Digital Simulation in Hydrology Stanford Watershed Model 4.

Cross, David and Loren Everest. 1995. Fish Habitat Attributes of Reference and Managed Watersheds With Special Reference to the Location of Bull Charr (Salvalinus Confluentus) Spawning Sites in the Upper Spokane River Ecosystem, Northern Idaho. *Fish Habitat Relationships Technical Bulletin.* 17: 1-7.

Ellis, Janet H. 2008. Scientific Recommendations on the Size of Stream Vegetated Buffers Needed to Protect Fish and Aquatic Habitat. Helena, MT: Montana Audubon. The Need for Stream Vegetated Buffers: What Does the Science Say?

Ensign, Scott H. and Martin W. Doyle. 2006. Nutrient Spiraling in Streams and River Networks. *Journal of Geophysical Research.* 111(G04009)

Feldman, David and Benjamin Jessup. 2012. The Proper Use and Interpretation of the Montana Observed/Expected (O/E) Models. Helena, MT: Montana Dept. of Environmental Quality.

Flathead City-County Health Department. 2009. Flathead County Wastewater Study. Kalispell, MT: Flathead City-County Health Dept., Environmental Health.

Flynn, Kyle F., Darrin Kron, and Marcus Granger. 2008. Modeling Streamflow and Water Temperature in the Big Hole River, Montana - 2006. Helena, MT: Montana Dept. of Environmental Quality, Water Quality Planning Bureau, Watershed Modeling Program. TMDL Technical Report DMS-2008-03.

Fudge, Thomas S., Kerry G. Wautier, Robert E. Evans, and Vince P. Palace. 2008. Effect of Different Levels of Fine-Sediment Loading on the Escapement Success of Rainbow Trout Fry From Artificial Redds. *North American Journal of Fisheries Management.* 28: 758-765.

Ganser, Thomas J. 1981. Stillwater River Natural Resources and Physical Features Inventory. Bozeman, MT: United States Department of Agriculture, Soil Conservation Service.

Gardner, B. 2014. Sheppard Creek Cutthroat Trout Conservation Project Status Report After 12 Years of Brook Trout Suppression. Flathead National Forest, Tally Lake Ranger District: U.S. Forest Service.

Geosyntec Consultants, Inc. 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.

-----. 2011. Internationational Stormwater Best Management Practices Database Pollutant Category Summary: Solids (TSS, TDS, and Turbidity). www.bmpdatabase.org.

Grubb, C. 2014. Project Effectiveness Report. Helena, MT: Montana Dept. of Environmental Quality.

Grumbles, Benjamin. 2006. Letter From Benjamin Grumbles, US EPA, to All EPA Regions Regarding Daily Load Development. U.S. Environmental Protection Agency.

Heckenberger, Brian. 2009. Personal Communication. Kusnierz, Lisa. Accessed 5/2009.

Hirschman, D., K Collins, and T. Schueler. 2008. Technical Memorandum: The Runoff Reduction Method. Ellicott City, MD: Center for Watershed Protection and the Chesapeake Stormwater Network.

Howell, Terry A. and B. A. Stewart. 2003. "Irrigation Efficiency," in *Encyclopedia of Water Science*, (New York, NY: Marcel Dekker): 467-472.

Irving, John S. and Ted C. Bjornn. 1984. Effects of Substrate Size Composition on Survival of Kokanee Salmon and Cutthroat and Rainbow Trout Embryos. Idaho Cooperative Fishery Research Unit, College of Forestry, Wildlife, and Range Sciences, University of Idaho. Technical Report No. 84-6.

Jakober, Michael J., Thomas E. McMahon, Russell F. Thurow, and Christopher C. Clancy. 1998. Role of Stream Ice on Fall and Winter Movements and Habitat Use by Bull Trout and Cutthroat Trout in Montana Headwater Streams. *Transactions of the American Fisheries Society.* 127: 223-235.

Kaplan, Louis A. and Thomas L. Bott. 1989. Diel Fluctuations in Bacterial Activity on Streambed Substrata During Vernal Algal Blooms: Effects of Temperature, Water Chemistry, and Habitat. *Limnology and Oceanography.* 34(4): 718-733.

Kappesser, Gary B. 2002. A Riffle Stability Index to Evaluate Sediment Loading to Streams. *Journal of the American Water Resources Association.* 38(4): 1069-1081.

King, K. W., J. C. Balogh, K. L. Hughes, and R. D. Harmel. 2007. Nutrient Load Generated by Storm Event Runoff From a Golf Course. *Journal of Environmental Quality.* 36: 1021-1030.

Knighton, David. 1998. Fluvial Forms and Processes: A New Perspective, New York, New York: John Wiley and Sons Inc.

Knutson, K. Lea and Virginia L. Naef. 1997. Management Recommendations for Washington's Priority Habitats: Riparian. Olympia, WA: Washington Department of Fish and Wildlife (WDFW).

Kramer, Richard P., Brian W. Riggers, and Kenneth R. Furrow. 1993. Basinwide Methodolgoy: Stream Habitat Inventory Methodology. Missoula, MT: USDA Forest Service.

Kron, Darrin, Erik Makus, and Eric Sivers. 2011. Bitterroot River TMDL Planning Area Missoula MS4 Temperature and Thermal Loading Assessment. Helena, MT: Montana Dept. of Environmental Quality.

Kusnierz, Paul, Andy Welch, and Darrin Kron. 2013. The Montana Department of Environmental Quality Sediment Assessment Method: Considerations, Physical and Biological Parameters, and Decision Making. Helena, MT: Montana Dept. of Environmental Quality.

Ledwith, Tyler S. 1996. The Effects of Buffer Strip Width on Air Temperature and Relative Humidity in a Stream Riparian Zone. *Watershed Council Networker.* Summer 1996

Liknes, George Alton and Patrick J. Graham. 1988. Westslope Cutthroat Trout in Montana: Life History, Status, and Management. In: American Fisheries Society Symposium. American Fisheries Society Symposium. [Place unknown]: American Fisheries Society; 53-60.

Liu, X., X. Zhang, and M. Zhang. 2008. Major Factors Influencing the Efficacy of Vegetated Buffers on Sediment Trapping: a Review and Analysis. *Journal of Environmental Quality.* 37: 1667-1674.

MacDonald, J. S., Cher A. King, and Herb Herunter. 2010. Sediment and Salmon: The Role of Spawning Sockeye Salmon in Annual Bed Load Transport Characteristics in Small, Interior Streams of British Columbia. *Transactions of the American Fisheries Society.* 140(3): 758-767.

MacDonald, Lee H., Alan W. Smart, and Robert C. Wissmar. 1991. Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska. Seattle, WA: U.S. Environmental Protection Agency. EPA 910/9-91-001.

May, Christine L. and Danny C. Lee. 2004. The Relationships Among in-Channel Sediment Storage, Pool Depth, and Summer Survival of Juvenile Salmonids in Oregon Coast Range Streams. *North American Journal of Fisheries Management.* 24: 761-744.

McNeil, William J. and Warren H. Ahnell. 1964. Success of Pink Salmon Spawning Relative to Size of Spawning Bed Materials. Washington D.C.: U.S. Fish and Wildlife Service. Special Scientific Report—Fisheries No. 469. http://www.krisweb.com/biblio/gen_usfws_mcneiletal_1964.pdf .

Meals, Donald W., Steven A. Dressing, and Thomas E. Davenport. 2010. Lag Time in Water Quality Response to Best Management Practices: A Review. *Journal of Environmental Quality.* 39: 85-96.

Mebane, Christopher A. 2001. Testing Bioassessment Metrics: Macroinvertebrate, Sculpin, and Salmonid Responses to Stream Habitat, Sediment and Metals. *Environmental Monitoring & Assessment.* 67(3): 293-322.

Miller, T. P., J. R. Peterson, C. F. Lenhart, and Y. Nomura. 2012. The Agricultural BMP Handbook for Minnesota. St. Paul, MN: Minnesota Dept. of Agriculture.

Montana Bull Trout Scientific Group. 1995. Flathead River Drainage: Bull Trout Status Report (Including Flathead Lake, the North and Middle Forks of the Flathead River, and the Stillwater and Whitefish Rivers). Helena, MT: The Montana Bull Trout Scientific Group.

Montana Department of Agriculture and U.S. Department of Agriculture, National Agricultural Statistics Service. 2012. Montana 2012 Agricultural Statistics: 2010-2011 County Estimates. Helena, MT: USDA, NASS, Montana Field Office. XLIX. http://www.nass.usda.gov/Statistics_by_State/Montana/Publications/Annual_Statistical_Bulletin/2012/2012_Bulletin.pdf:

Montana Department of Environmental Qualit. 2009. Middle and Lower Big Hole Planning Area TMDLs and Water Quality Improvement Plan. Helena, MT: Montana Dept. of Environmental Quality. M03-TMDL-02A.

Montana Department of Environmental Quality. 2001. Nutrient Management Plan and Total Daily Maximum Load for Flathead Lake, Montana. Helena, MT: Montana Department of Environmental Quality.

-----. 2004. Swan River Planning Area Water Quality and Habitat Restoration Plan and TMDL for Sediment. Helena, MT: Montana Department of Environmental Quality (MDEQ).

-----. 2005a. Temperature Data Logger Protocols Standard Operating Procedure. WQPBWQM-006, Rev. 1. http://www.deq.mt.gov/wqinfo/QAProgram/PDF/SOPs/WQPBWQM-006.pdf.

-----. 2005b. Water Quality Planning Bureau Field Procedures Manual for Water Quality Assessment Monitoring WQPBWQM-020. http://www.deq.state.mt.us/wqinfo/QAProgram/SOP%20WQPBWQM-020.pdf:

-----. 2008a. Flathead-Stillwater TMDL Planning Area Temperature and Instantaneous Flow Monitoring Sampling and Analysis Plan. Helena, MT: Montana Dept. of Environmental Quality.

-----. 2008b. Middle Blackfoot-Nevada Creek Total Maximum Daily Loads and Water Quality Improvement Plan: Sediment, Nutrient, Trace Metal and Temperature TMDLs. Helena, MT: Montana Dept. of Environmental Quality, Water Quality Planning Bureau.

-----. 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.

-----. 2010. Big Creek Sediment TMDL Implementation Evaluation - Water Quality Assessment Report. Unpublished work.

-----. 2011a. Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments. Helena, MT: Montana Department of Environmental Quality.

-----. 2011b. Periphyton Standard Operating Procedure. Helena, MT: Montana Department of Environmental Quality. WQPVWQM-010. http://deq.mt.gov/wqinfo/qaprogram/sops.mcpx. Accessed 8/5/2014b.

-----. 2011c. Tobacco Planning Area Sediment TMDLs and Framework Water Quality Improvement Plan: Final. Helena, MT: Montana Department of Environmental Quality. K01-TMDL-03aF.

-----. 2012a. Circular DEQ-7: Montana Numeric Water Quality Standards. Helena, MT: Montana Department of Environmental Quality. http://deq.mt.gov/wqinfo/Circulars.mcpx. Accessed 1/15/2013a.

-----. 2012b. Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments. Helena, MT: Montana Department of Environmental Quality.

-----. 2012c. Montana Nonpoint Source Management Plan. Helena, MT: Montana Department of Environmental Quality.

-----. 2012d. Sample Collection, Sorting, Taxonomic Identification, and Analysis of Benthic Macroinvertebrate Communities Standard Operating Procedure. MT Department of Environmental Quality. WQPBWQM-009. http://deq.mt.gov/wqinfo/qaprogram/sops.mcpx. Accessed 8/5/2014d.

-----. 2012e. Water Quality Planning Bureau Field Procedures Manual for Water Quality Assessment Monitoring, Version 3.0. Helena, MT: Montana Department of Environmental Quality.

-----. 2013. Sediment, Nutrients, and Temperature TMDLs and Water Quality Improvement Plans for the Boulder-Elkhorn Planning Area. Helena, MT: Montana Dept. of Environmental Quality.

-----. 2014a. Base Numeric Nutrient Standards Implementation Guidance. Version 1.0. Helena, MT.

-----. 2014b. Circular DEQ-12A. Montana Base Numeric Nutrient Standards. http://deq.mt.gov/wqinfo/Circulars.mcpx. Accessed 8/5/2014b.

-----. 2014c. Circular DEQ-12B. Nutrient Standards Variances. http://deq.mt.gov/wqinfo/Circulars.mcpx. Accessed 8/5/2014c.

-----. 2014d. Clean Water Act Information Center. Helena, MT: Montana Department of Environmental Quality. http://deq.mt.gov/wqinfo/CWAIC/default.mcpx. Accessed 4/17/2014d.

Montana Department of Environmental Quality, Kootenai River Network, and River Design Group. 2005. Grave Creek Watershed Water Quality and Habitat Restoration Plan and Sediment Total Maximum Daily Loads. Helena, MT: Montana Department of Environmental Quality.

Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Region 8. 2011. Little Blackfoot River Watershed TMDLs and Framework Water Quality Improvement Plan: Final. Helena, MT: Montana Department of Environmental Quality. C01-TMDL-03A-F.

Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau. 2006. Ruby River Watershed Total Maximum Daily Loads and Framework for a Water Quality Restoration Plan. Montana Department of Environmental Quality.

-----. 2011. Water Quality Assessment Method. Helena, MT: Montana Department of Environmental Quality. Revision 3.0.

-----. 2012. Montana's Nonpoint Source Management Plan. Helena, MT: Montana Department of Environmental Quality, Water Quality Planning Bureau, Watershed Protection Section. WQPBWPSTR-005.

-----. 2014. Montana 2014 Final Water Quality Integrated Report. Helena, MT: Montana Department of Environmental Quality. WQPBIMTSTR-009d.

Montana Department of Fish, Wildlife and Parks, Fisheries Division. 1996. Future Fisheries Improvement Program Report to 1997 Legislature and Fish, Wildlife and Parks Commission: July 1, 1995 to December 4, 1996. Helena, MT: Montana Department Fish, Wildlife and Parks.

Montana Department of Natural Resources and Conservation. 2005. State Forest Land Management Plan: Implementation Monitoring Report. Helena, MT: Montana Dept. of Natural Resources and Conservation.

-----. 2006a. Montana Guide to the Streamside Management Zone Law & Rules. Helena, MT: Montana Department of Natural Resources and Conservation. http://dnrc.mt.gov/forestry/assistance/practices/documents/smz.pdf. Accessed 3/27/2014a.

-----. 2006b. Stillwater Road Improvement Attachment B. Helena, MT: Montana Dept. of Natural Resources and Conservation.

-----. 2011. State Forest Land Management Plan: Implementation Monitoring Report. Montana Dept. of Natural Resources and Conservation.

Montana State University Extension Service. 2001. Water Quality BMPs for Montana Forests. Bozeman, MT: MSU Extension Publications.

Montgomery, David R. and John M. Buffington. 1997. Channel-Reach Morphology in Mountain Drainage Basins. *Bulletin of the Geological Society of America.* 109(5)

Muhlfeld, Clint C., David H. Bennett, and Brian L. Marotz. 2001. Fall and Winter Habitat Use and Movement by Columbia River Redband Trout in a Small Stream in Montana. *North American Journal of Fisheries Management.* 21(1)

Multi-Resolution Land Characteristics Consortium. 2006. National Land Cover Dataset 2006. http://www.mrlc.gov/nlcd2006.php.

Natural Resource Conservation Service. 2010. Natural Resources Conservation Service Conservation Practice Standard : Prescribed Grazing (Ac), Code 528. http://efotg.sc.egov.usda.gov/references/public/NE/NE528.pdf.

Natural Resources Conservation Service. 1995. Animal Manure Management. RCA Issue Brief #7. U.S. Department of Agriculture, Natural Resourves Conservation Service.

-----. 1997. National Engineering Handbook Irrigation Guide, Vol. Part 652, Washington, D.C.: Natural Resources 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. MT: NRCS. http://efotg.sc.egov.usda.gov/references/public/mt/391_standard_june_2011.pdf. Accessed 11/7/11 A.D.b.

Nature Education. 2013. The Nature Education Knowledge Project: Restoration Ecology. http://www.nature.com/scitable/knowledge/library/restoration-ecology-13339059.

Negri, Donald and D. H. Brooks. 1990. Determinants of Irrigation Technology Choice. *Western Journal of Agricultural Economics.* 15: 213-223.

Negri, Donald, John J Hanchar, and U.S. Department of Agriculture, Economic Research Service. 1989. Water Conservation Through Irrigation Technology. Washington, D.C.: Economic Research Service. AIB-576.

Nielson, Jennifer L., Thomas E. Lisle, and Vicki Ozaki. 1994. Thermally Stratified Pools and Their Use by Steelhead in Northern California Streams. *Transactions of the American Fisheries Society.* 123(4): 613-626.

Nolan, K. M. and D. C. Marron. 1985. Contrast in Stream-Channel Response to Major Storms in Two Mountainous Areas of California. *Geology.* 13: 135-138.

-----. 1988. "Stream Channel Response to the Storm," in *Landslides, Floods, and Marine Effects of the Storm of January 3-5, 1982, in the San Francisco Bay Region, California*, S.D.Ellen and G.F.Wieczorek, U.S. Geological Survey Professional Paper 1434 ed., 245-264.

Osteen, C., J. Gottlieb, and U. Vasavada. 2012. Agricultural Resources and Environmental Indicators. Washington, D.C.: United States Department of Agriculture, Economic Research Service. EIB-98.

Parker, Gary S. and Peter C. Klingeman. 1982. On Why Gravel Bed Streams Are Paved. *Water Resources Research.* 18: 1409-1423.

PBS&J. 2006. Whitefish River TMDL Planning Area Watershed Characterization Report. Helena, MT: Montana Department of Environmental Quality.

Poole, Geoffrey C. and Cara H. Berman. 2001. An Ecological Perspective on In-Stream Temperature: Natural Heat Dynamics and Mechanisms of Human-Caused Thermal Degradation. *Environmental Management.* 276(6): 787-802.

Priddy, M. 3/10/2014. Haskill Basin Project Ranked As Top Priority in Budget. *Flathead Beacon*, 3/11/2014

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 No. 159.

Relyea, Christina, G. Wayne Minshall, and Robert J. Danehy. 2000. Stream Insects As Bioindicators of Fine Sediment. In: Watershed 2000. Water Environment Federation Specialty Conference. Boise, ID: Idaho State University.

River Design Group. 2004. Haskill Creek Pollutant Source Assessment and Water Quality Restoration Plan. Kalispell, MT: Haskill Basin Watershed Council Flathead Conservation District. DEQ Contract #202070; Project # RDG-03-007.

-----. 2007a. Haskill Creek TMDL Planning Area Watershed Characterization - Final. Helena, MT: Montana Department of Environmental Quality.

-----. 2007b. Stillwater River TMDL Planning Area Watershed Characterizations. Helena, MT: Montana Department of Environmental Quality.

-----. 2008a. Haskill Creek Bank Stabilization Project: 2008 Post Runoff Monitoring Report. Whitefish, MT: River Design Group, Inc. DEQ Contract #207039.

-----. 2008b. Haskill Creek Bank Stabilization Project: As-Build Monitoring Report - Final. Whitefish, MT: River Design Group, Inc. DEQ Contract #207039.

River Design Group, Inc. 2003. Revised Phase 1 Total Maximum Daily Load Report for the Stillwater River, Northwest Montana. Whitefish, MT: **River Design Group, Inc.**

-----. 2007. Final Haskill Creek TMDL Planning Area Watershed Characterization. Whitefish, MT: River Design Group,Inc.

Robarts, R. D. and T. Zohary. 1987. Temperature Effects on Photosynthetic Capacity, Respiration, and Growth Rates Aof Bloom-Forming Cyanobacteria. *New Zealand Journal of Marine and Freshwater Research.* 21(3): 391-399.

Roberts, R. J. 1975. "The Effects of Temperature on Diseases and Their Histopathological Manifestations in Fish," in *The Pathology of Fishes*, Ribelin, W. E. and Migaki, G., Ch. 20, (Madison, WI: The University of Wisconsin Press): 477-496.

Rosgen, David L. 1996. Applied River Morphology, Pagosa Springs, CO: Wildland Hydrology.

Roth, R. R. 1972. Some Factors Contributing to the Development of Fungus Infection in Freshwater Fish. *Journal of Wildlife Diseases.* 8(1): 24-28.

Rowe, Mike, Don A. Essig, and Benjamin K. Jessup. 2003. Guide to Selection of Sediment Targets for Use in Idaho TMDLs. Pocatello, ID: Idaho Department of Environmental Quality.

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. General Technical Report RMRS-GTR-128.

Selong, Jason H., Thomas E. McMahon, Alexander V. Zale, and Frederic T. Barrows. 2001. Effect of Temperature on Growth and Survival of Bull Trout, With Application of an Improved Method for Determining Thermal Tolerance in Fishes. *Transactions of the American Fisheries Society.* 130: 1026-1037.

Shepard, Bradley B., Stephen A. Leathe, Thomas M. Weaver, and Michael D. Enk. 1984. Monitoring Levels of Fine Sediment Within Tributaries to Flathead Lake, and Impacts of Fine Sediment on Bull Trout Recruitment. In: Wild Trout III, Proceedings of the Symposium. Sept. 24, 1984. Yellowstone National Park, MT: Wild Trout III.

State of Montana. 2014. Administrative Rules of Montana (ARM) 17.30.623 - B-1 Classification Standards. http://mtrules.org/gateway/ruleno.asp?RN=17%2E30%2E623. Accessed 4/28/2014.

Steinblums, Ivars J., Henry A. Froehlich, and Joseph K. Lyons. 1984. Designing Stable Buffer Strips for Stream Protection. *Journal of Forestry.* 82(1): 49-52.

Stevens, Rick. 2003. Logan Creek Water Quality and Aquatic Life/Fisheries Status Report. Whitefish, MT: Flathead National Forest.

Strahler, A. N. 1952. Hypsometric (Area-Altitude) Analysis of Erosional Topography. *Geological Society of America Bulletin.* 63: 1117-1142.

Sugden, Brian and Scott W. Woods. 2007. Sediment Production From Forest Roads in Western Montana. *Journal of American Water Resources Association.* 43: 193-206.

Sullivan, S. M. P. and Mary 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, Michael W. 2013. Technical Memorandum: Benchmark for Nitrate + Nitrite in Assessing Ambient Surface Water. McCarthy, Mindy and Eric Urban.

Suplee, Michael W. and Rosie 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. WQPMASTR-01.

Suplee, Michael W. and Vicki Watson. 2013. Scientific and Technical Basis of the Numeric Nutrient Criteria for Montana's Wadeable Streams and Rivers—Update 1. Helena, MT: Montana Department of Environmental Quality.

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, Kenwyn B., Mary E. Power, Jonathan M. Levine, and Camille McNeely. 2004. How Fine Sediment in Riverbeds Impairs Growth and Survival of Juvenile Salmonids. *Ecological Applications.* 14(4): 969-974.

Teply, Mark E. 2010a. Diatom Biocriteria for Montana Streams. Lacey, WA: Cramer Fish Sciences.

-----. 2010b. Interpretation of Periphyton Samples From Montana Streams. Lacey, WA: Cramer Fish Sciences.

Tetra Tech. 2012. Flathead Lake Basin Modeling Approach and Quality Assurance Plan. Final QAPP 342, Revision 5. Montana Office. Jackson, WY.: Prepared by Tetra Tech, Inc. for U.S. EPA.

Tetra Tech, Inc. 2014a. Ashley Creek Watershed Charaterization. Helena, MT: Montana Department of Environmental Quality.

-----. 2014b. Modeling Hydrology, Sediment, and Nutrients in the Flathead Lake Basin. Jackson, WY: Tetra Tech, Inc. Prepared for U.S. EPA, Region 8, Montana Office.

Tops, S., W Lockwood, and B. Okamura. 2006. Temperature-Driven Proliferation of Tetracapsuloides Bryosalmonae in Bryozoan Hosts Portends Salmonid Declines. *Diseases of Aquatic Organisms.* 70(3): 227-236.

U.S. Department of Agriculture and U.S. Environmental Protection Agency. 1999. Unified National Strategy for Animal Feeding Operations.

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. Department of Agriculture, Forest Service, Flathead National Forest. 1995. Big Mountain Ski and Summer Resort Final – Environmental Impact Statement. Kalispell, MT: USDA Forest Service, Flathead National Forest.

-----. 2001. Logan Geographic Unit: Summary of Findings From the Ecosystem Analysis at the Watershed Scale. Flathead County, MT: Flathead National Forest - Tally Lake Ranger District.

-----. 2004a. Logan Creek Ecosystem Restoration Project: Final Environmental Impact Statement. Kalispell, MT: Flathead National Forest.

-----. 2004b. Record of Decision for the Logan Creek Ecosystem Restoration Project. Flathead County, MT: Flathead National Forest, Tally Lake Ranger District.

U.S. Department of Agriculture, Forest Service, Flathead National Forest, Tally Lake Ranger District. 2008a. Sheppard Creek Post-Fire Project: Final Environmental Impact Statement. Kalispell, MT: U.S. Department of Agriculture, Forest Service, Flathead National Forest, Tally Lake Ranger District.

-----. 2008b. Sheppard Creek Post-Fire Project: Record of Decision. Kalispell, MT: U.S. Department of Agriculture, Forest Service, Flathead National Forest, Tally Lake Ranger District.

U.S. Environmental Protection Agency. 1999a. Protocol for Developing Nutrient TMDLs. Washington, D.C.: Office of Water, U.S. Environmental Protection Agency. EPA 841-B-99-007.

-----. 1999b. Protocol for Developing Sediment TMDLs. Washington, D.C.: Office of Water, United States Environmental Protection Agency. EPA 841-B-99-004.

-----. 2002. Memorandum: Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs. U.S. Environmental Protection Agency.

-----. 2009. Preliminary Data Summary of Urban Stormwater Best Management Practices. 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. EPA-820-S-10-001.

U.S. Environmental Protection Agency, Tetra Tech, Inc., Ron F. Steg, Jason Gildea, Tina Laidlaw, and Donna Pridmore. 2004. Water Quality Assessment and TMDLs for the Flathead River Headwaters Planning Area, Montana. Kalispell, MT: Flathead National Forest.

U.S. Fish and Wildlife Service. 2002. Bull Trout (Salvelinus Confluentus) Draft Recovery Plan. Portland, OR: U.S. Fish and Wildlife Service.

United States Department of Agriculture, Natural Resources Conservation Service. 2005. Natural Resources Conservation Service Conservation Practice Standard: Nutrient Management (Acre), Code 590. http://efotg.sc.egov.usda.gov/references/public/wi/590.pdf. Accessed 3/31/2014.

United States Environmental Protection Agency. 2010. Summary of Road Network in the the Flathead Lake Basin - Public Review Draft. Helena, MT: Prepared by Tetrat Tech for U.S. EPA, Region 8, Montana Operations Office.

Valett, H. M., Chelsea L. Crenshaw, and Paul F. Wagner. 2002. Stream Nutrient Uptake, Forest Succession, and Biogeochemical Theory. *Ecology.* 83: 2888-2901.

Water Consulting, Inc. 2003. Haskill Creek Watershed Assessment. Whitefish, MT: Water Consulting, Inc.

Watershed Consulting, LLC. 2002. Ashley Creek Watershed Assessment. Whitefish, MT: Watershed Consulting, LLC.

-----. 2009. Flathead-Stillwater TMDL Planning Area Sediment and Habitat Assessment: Summary Report. Helena, MT: Montana DEQ. DEQ Contract # 205037-TO9.

Weaver, Thomas M. and John J. Fraley. 1991. Fisheries Habitat and Fish Populations in Flathead Basin Forest Practices Water Quality and Fisheries Cooperative Program. Kalispell, MT: Flahead Basin Commission.

Wendt, Alan R. 2011. Flathead Valley Agricultural Impacts Report. Kalispell, MT: Alan Wendt. DEQ Contract #209077.

Winter, Jennifer G. and Peter J. Dillon. 2006. Export of Nutrients From Golf Courses on the Precambrian Shield. *Environmental Pollution.* 141(550): 554.

Wolman, M. G. 1954. A Method of Sampling Coarse River-Bed Material. *Transactions of the American Geophysical Union.* 35(6): 951-956.

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/.

Zimmerman, Andre E. and Michel Lapointe. 2005. Intergranular Flow Velocity Through Salmonid Redds: Sensitivity to Fines Infiltration From Low Density Sediment Transport Events. *River Research and Applications.* 21(8): 865-881.

Zweig, Leanna D. and Charles F. Rabeni. 2001. Biomonitoring for Deposited Sediment Using Benthic Invertebrates: A Test on Four Missouri Streams. *Journal of the North American Benthological Society.* 20(4): 643-657.

APPENDIX A - 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 A-2
A1.0 TMDL Development Requirements A-3
A2.0 Applicable Water Quality Standards A-4
A2.1 Classification and Beneficial Uses A-4
A2.2 Standards A-6
A2.2.1 Sediment Standards A-7
A2.2.2 Nutrient Standards A-8
A2.2.3 Dissolved Oxygen Standards A-8
A2.2.4 Temperature Standards A-9
A3.0 Reference Conditions A-9
A3.1 Reference Conditions as Defined in DEQ's Standard Operating Procedure for Water Quality Assessment A-9
A3.2 Use of Statistics for Developing Reference Values or Ranges A-11
A4.0 References A-14

LIST OF TABLES

Table A2-1. Montana Surface Water Classifications and Designated Beneficial Uses A-5
Table A2-2. Applicable Rules for Sediment Related Pollutants A-7
Table A2-3. Numeric Nutrient Criteria for the Northern Rockies Ecoregion A-8
Table A2-4. Human Health Standards for Nitrogen for the State of Montana A-8
Table A2-5. Dissolved Oxygen Water Quality Criteria A-9

LIST OF FIGURES

Figure A3-1. Boxplot Example for Reference Data A-12
Figure A3-2. Boxplot example for the use of all data to set targets A-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 (U.S.)
HHC	Human Health Criteria
MCA	Montana Code Annotated
MCL	Maximum Contaminant Level
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UAA	Use Attainability Analysis
WQA	Water Quality Act
WQS	Water Quality Standards

A1.0 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 Attachment 1 of Montana's Water Quality Integrated Report (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2012).

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. None of the waterbodies being addressed within the scope of this document are listed as threatened.

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.

A2.0 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 5.0**, **6.0**, and **7.0**. Pollutants addressed in this framework water quality improvement plan include sediment, nutrients, temperature, and metals. This section provides a summary of the applicable water quality standards for these pollutants.

A2.1 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**. In 2003, Montana added four classes: D, E, F, and G. These classes include ephemeral

streams (E-1 and E-2), ditches (D-1 and D-2), seasonal or semi-permanent lakes and ponds (E-3, E-4, E-5) and waters with low or sporadic flow (F-1). Waterbodies within the Flathead-Stillwater TMDL Planning Area addressed in this document are classified as A-1, B-1, B-2, and C-2 (see **Section 3.1** and **Table 3-1** in the main document for individual stream classifications).

Table A2-1. Montana Surface Water Classifications and Designated Beneficial Uses

Classification	Designated Uses
A-CLOSED:	Waters classified A-Closed are to be maintained suitable for drinking, culinary and food processing purposes after simple disinfection.
A-1:	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:	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:	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:	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:	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:	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:	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:	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.
D-1:	Waters classified D-1 are to be maintained suitable for agricultural purposes and secondary contact recreation.
D-2:	Waters classified D-2 are to be maintained suitable for agricultural purposes and secondary contact recreation. Because of conditions resulting from low flow regulations, maintenance of the ditch, or geomorphologic and riparian habitat conditions, quality is marginally suitable for aquatic life.
E-1:	Waters classified E-1 are to be maintained suitable for agricultural purposes, secondary contact recreation, and wildlife.
E-2:	Waters classified E-2 are to be maintained suitable for agricultural purposes, secondary contact recreation, and wildlife. Because of habitat, low flow, hydro-geomorphic, and other physical conditions, waters are marginally suitable for aquatic life.
E-3:	Waters classified E-3 are to be maintained suitable for agricultural purposes, secondary contact recreation, and wildlife.

Table A2-1. Montana Surface Water Classifications and Designated Beneficial Uses

Classification	Designated Uses
E-4:	Waters classified E-4 are to be maintained suitable for aquatic life, agricultural purposes, secondary contact recreation, and wildlife.
E-5:	Waters classified E-5 are to be maintained suitable for agricultural purposes, secondary contact recreation, saline-tolerant aquatic life, and wildlife.
F-1:	Waters classified F-1 are to be maintained suitable for secondary contact recreation, wildlife, and aquatic life, not including fish.
G-1:	Waters classified G-1 are to be maintained suitable for watering wildlife and livestock; aquatic life, not including fish; secondary contact recreation; marginally suitable for irrigation after treatment or with mitigation measures.

A2.2 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 Numeric Water Quality Standards(Montana Department of Environmental Quality, 2012) , and the Department Circular DEQ-12A, Montana Base Numeric Nutrient Standards (Montana Department of Environmental Quality, 2014). 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 Flathead-Stillwater TMDL Planning Area 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.

A2.2.1 Sediment Standards

Sediment (i.e., coarse and fine bed sediment) and suspended sediment are addressed via the narrative criteria identified in **Table A2-2**. 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 A2-2**).

Table A2-2. Applicable Rules for Sediment Related Pollutants

Rule(s)	Standard or Definition
17.30.622(3), 623(2), 624(2), 627(2)	No person may violate the following specific water quality standards for waters classified [A-1, B-1, B-2, C-2]:
17.30.622(3)(f) [A-1], 17.30.623(2)(f) [B-1], 17.30.624(2)(f) [B-2], 17.30.627(2)(f) [C-2]	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.
17.30.622(3)(d) [A-1 classification]	No increase above naturally occurring turbidity or suspended sediment is allowed except at permitted in 75-5-318, MCA. Note: 75-5-318, MCA allows for short term variances linked to construction activities, etc.
17.30.623(2)(d) [B-1 classification]	The maximum allowable increase above naturally occurring turbidity is five nephelometric turbidity units except at permitted in 75-5-318, MCA. Note: 75-5-318, MCA allows for short term variances linked to construction activities, etc.
17.30.624(2)(e) [B-2], 17.30.627(2)(d) [C-2]	The maximum allowable increase above naturally occurring turbidity is 10 nephelometric turbidity units except as permitted in 75-5-318, MCA.
17.30.637(1) (a & d) [applies to all streams discussed in this document]	State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will: (a) settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines; … and (d) create concentrations or combinations of materials that are toxic or harmful to human, animal, plant, or aquatic life.
17.30.602	DEFINITIONS
	"Sediment" means solid material settled from suspension in a liquid; mineral or organic solid material that is being transported or has been moved from its site of origin by air, water, or ice and has come to rest on the earth's surface, either above or below sea level; or inorganic or organic particles originating from weathering, chemical precipitation, or biological activity.
	"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. Conditions resulting from the reasonable operations of dams in existence as of July 1, 1971, are natural.

Table A2-2. Applicable Rules for Sediment Related Pollutants

Rule(s)	Standard or Definition
	"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.

A2.2.2 Nutrient Standards

The numeric standards applicable to nutrients in Montana are contained in the Department Circular DEQ-12A (Montana Department of Environmental Quality, 2014). The nutrient criteria within this document are for total nitrogen (TN) and total phosphorus (TP) based on the Level III ecoregion in which a stream is located (Suplee and Watson, 2013). For the Northern Rockies Level III Ecoregion, water quality criteria for TN and TP are presented in **Table A2-3**. These criteria are growing season, or summer, values applied from July 1st through September 30th. Additionally, numeric human health standards exist for nitrogen (**Table A2-4**), but the criteria in **Table A2-3** are 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 A2-3. Numeric Nutrient Criteria for the Northern Rockies Ecoregion

Parameter	Target Value
Total Nitrogen (TN)	≤ 0.275 mg/L
Total Phosphorus (TP)	≤ 0.025 mg/L

Table A2-4. 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.

A2.2.3 Dissolved Oxygen Standards

The water quality standards for dissolved oxygen are numeric and differ based on the waterbody classification and the life stage of aquatic organisms that may be affected (**Table A2-5**). The water quality standards for dissolved oxygen in A-1, B-1, B-2, C-1, and C-2 waters can be found in ARM 17.30.622, 17.30.623, 17.30.624, 17.30.626, 17.30.627, respectively, and in B-3 and C-3 stream classifications in ARM 17.30.625 and 17.30.629 respectively.

Table A2-5. Dissolved Oxygen Water Quality Criteria

	Standards for Waters Classified A-1, B-1, B-2, C-1, and C-2		Standards for Waters Classified B-3, C-3, and I	
	Early Life Stages[1,2]	Other Life Stages	Early Life Stages[2]	Other Life Stages
30 Day Mean	N/A[3]	6.5	N/A[3]	5.5
7 Day Mean	9.5 (6.5)	N/A[3]	6.0	N/A[3]
7 Day Mean Minimum	N/A[3]	5.0	N/A[3]	4.0
1 Day Minimum[4]	8.0 (5.0)	4.0	5.0	3.0

[1] These are water column concentrations recommended to achieve the required inter-gravel dissolved oxygen concentrations shown in parentheses. For species that have early life stages exposed directly to the water column, the figures in parentheses apply.
[2] Includes all embryonic and larval stages and all juvenile forms of fish to 30-days following hatching.
[3] N/A (Not Applicable).
[4] All minima should be considered as instantaneous concentrations to be achieved at all times.

A2.2.4 Temperature Standards

Montana's temperature standards were originally developed to address situations associated with point source discharges, making them somewhat awkward to apply when dealing with primarily nonpoint source issues. In practical terms, the temperature standards address a maximum allowable increase above "naturally occurring" temperatures to protect the existing temperature regime for fish and aquatic life. Additionally, Montana's temperature standards address the maximum allowable decrease or rate at which cooling temperature changes (below naturally occurring) can occur to avoid fish and aquatic life temperature shock.

For waters classified as B-1 (ARM 17.30.623(e)), B-2 (ARM 17.30.624(e)), and C-2 (ARM 17.30.627(e)): A 1° F maximum increase above naturally occurring water temperature is allowed within the range 32° F to 66° F; within the naturally occurring range of 66° F to 66.5^{o} F, no discharge is allowed which will cause the water temperature to exceed 67° F; and where the naturally occurring water temperature is 66.5^{o} F or greater, the maximum allowable increase in water temperature is 0.5^{o} F. A 2° F per-hour maximum decrease below naturally occurring water temperature is above 55° F. A 2° F maximum decrease below naturally occurring water temperature is allowed within the range of 55° F to 32° F.

A3.0 Reference Conditions

A3.1 Reference Conditions as Defined in DEQ's Standard Operating Procedure for Water Quality Assessment

DEQ uses the reference condition to evaluate compliance with many of the narrative WQS (Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau, 2011). 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 pre-settlement 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.

A3.2 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 A3-1 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.

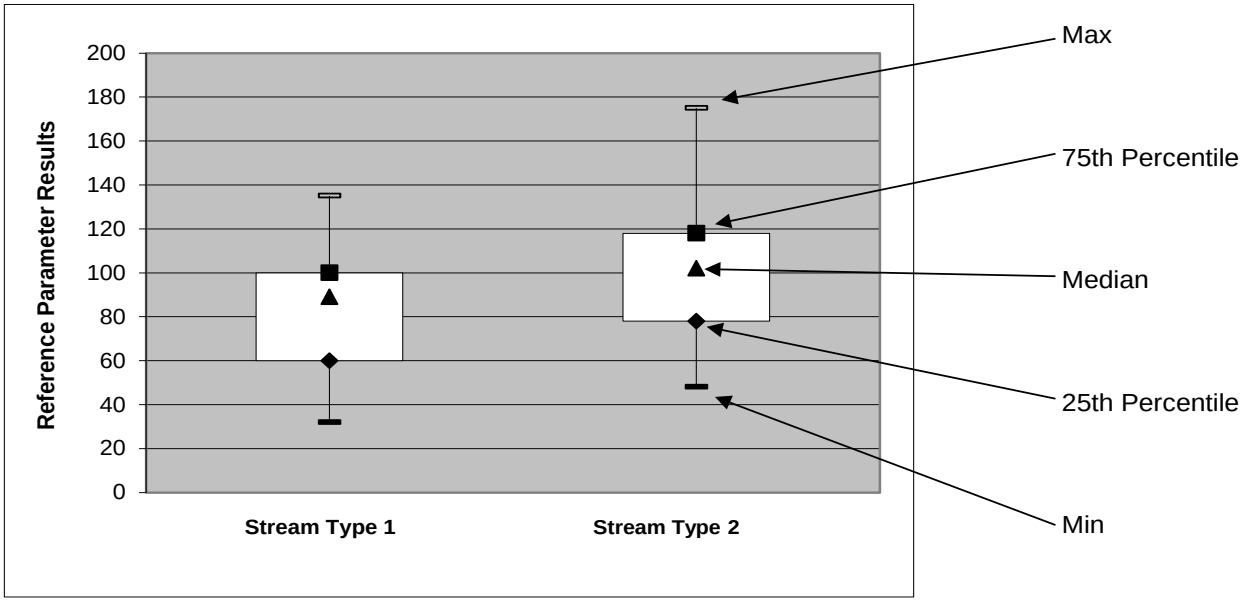


Figure A3-1. Boxplot Example for Reference Data

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% 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% 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 A2-2**. In other words, if not meeting the reference range is not expected to negatively impact aquatic life, coldwater 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% to 75% of the results from the whole data distribution represent questionable water quality. **Figure A3-2** is an example statistical distribution of an entire dataset where lower values represent better water quality (and reference data are limited). In **Figure A3-2**, the median and 25th percentiles of all data 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 may be lower using this approach, and you may need to rely more on adaptive management as part of TMDL implementation.

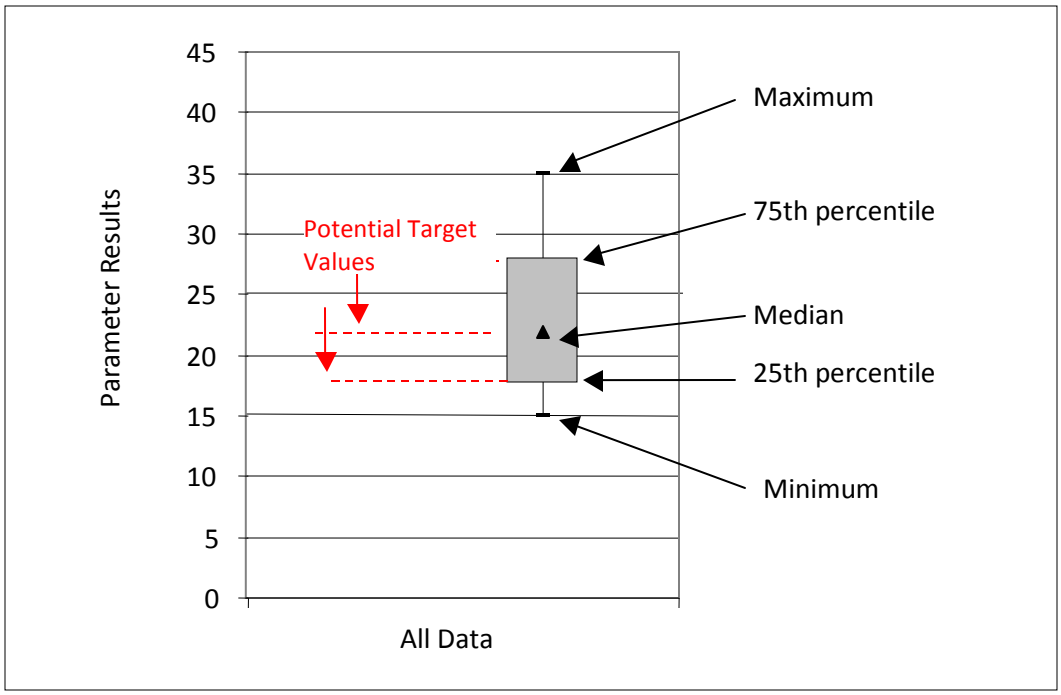


Figure A3-2. Boxplot example for the use of all data to set targets

A4.0 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, D.C.: U.S. Environmental Protection Agency. 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, Vol. 49, Amsterdam, The Netherlands: Elsevier Science Publishers B.V.

Montana Department of Environmental Quality. 2012. Circular DEQ-7: Montana Numeric Water Quality Standards. Helena, MT: Montana Department of Environmental Quality. http://deq.mt.gov/wqinfo/Circulars.mcpx. Accessed 1/15/2013.

-----. 2014. Circular DEQ-12A. Montana Base Numeric Nutrient Standards. http://deq.mt.gov/wqinfo/Circulars.mcpx. Accessed 8/5/2014.

Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau. 2011. Water Quality Assessment Method. Helena, MT: Montana Department of Environmental Quality. Revision 3.0.

-----. 2012. Montana 2012 Final Water Quality Integrated Report. Helena, MT: Montana Department of Environmental Quality, Planning, Prevention and Assistance Division, Water Quality Planning Bureau. WQPBIMTSR-004f.

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. and Vicki Watson. 2013. Scientific and Technical Basis of the Numeric Nutrient Criteria for Montana's Wadeable Streams and Rivers—Update 1. Helena, MT: Montana Department of Environmental Quality.

APPENDIX B - CHEMISTRY, FLOW, FISH DISTRIBUTION, AND PERMITTED POINT SOURCES DATA FOR THE FLATHEAD – STILLWATER TMDL PLANNING AREA

Table B-1. Recent Surface Water Nutrients, Chlorophyll-*a*, and Flow Data, Ashley Creek Watershed

Organization ID	Waterbody Name	Site ID	Latitude	Longitude	Collection Date	Flow (cfs)	NN (mg/L)	TN (mg/L)	TP (mg/L)	Chl-*a* (mg/m2)
MTWTRSHD_WQX	Ashley Creek (lower)	AC-9	48.164417	-114.301967	7/24/2003	6.2	2.56	3.91	0.079	-
MTWTRSHD_WQX	Ashley Creek (lower)	AC-9	48.164417	-114.301967	9/17/2003	7.67	3.93	5	0.068	-
MTWTRSHD_WQX	Ashley Creek (lower)	AC-9	48.164417	-114.301967	9/21/2004	11.66	2.26	3.13	0.062	-
MTWTRSHD_WQX	Ashley Creek (lower)	AC-9	48.164417	-114.301967	6/30/2005	49.82	0.74	1.52	0.074	-
MTWTRSHD_WQX	Ashley Creek (lower)	AC-9	48.164417	-114.301967	7/13/2005	-	0.94	1.72	0.069	-
MTWTRSHD_WQX	Ashley Creek (lower)	AC-9	48.164417	-114.301967	7/27/2005	13.48	2	3.33	0.074	-
MTWTRSHD_WQX	Ashley Creek (lower)	AC-9	48.164417	-114.301967	8/10/2005	9.58	2.98	3.87	0.055	-
MTWTRSHD_WQX	Ashley Creek (lower)	AC-9	48.164417	-114.301967	8/31/2005	7.5	3.77	5.11	0.087	-
MTWTRSHD_WQX	Ashley Creek (lower)	AC-9	48.164417	-114.301967	7/5/2004	27.83	-	-	-	-
MTWTRSHD_WQX	Ashley Creek (lower)	AC-9	48.164417	-114.301967	9/21/2005	10.87	2.87	C 4.7	0.037	69
MDEQ_WQ_WQX	Ashley Creek (lower)	C11AHLYC01	48.1464	-114.27334	8/2/2004	E 0-	0.69	1.69	0.075	-
MDEQ_WQ_WQX	Ashley Creek (lower)	C11AHLYC01	48.1464	-114.27334	7/30/2008	20.702	-	-	0.036	-
MDEQ_WQ_WQX	Ashley Creek (lower)	C11AHLYC01	48.1464	-114.27334	8/13/2008	5.985	-	-	0.034	-
MDEQ_WQ_WQX	Ashley Creek (lower)	C11AHLYC01	48.1464	-114.27334	9/6/2008	4.18-	-	-	0.019	-
MDEQ_WQ_WQX	Ashley Creek (lower)	C11AHLYC01	48.1464	-114.27334	10/1/2008	2.81	-	-	0.021	-
MDEQ_WQ_WQX	Ashley Creek (lower)	C11AHLYC02	48.16434	-114.29966	8/2/2004	E 5	1.91	2.81	0.086	-
MDEQ_WQ_WQX	Ashley Creek (lower)	C11AHLYC03	48.17543	-114.30929	8/2/2004	E 3	0.03	0.83	0.057	-
USGS	Ashley Creek (lower)	12367800	48.16384648	-114.3012402	7/13/2007	21	-	-	-	-
USGS	Ashley Creek (lower)	12367800	48.16384648	-114.3012402	7/16/2007	17	-	-	0.075	-
USGS	Ashley Creek (lower)	12367800	48.16384648	-114.3012402	8/6/2007	11	-	-	0.042	-
USGS	Ashley Creek (lower)	12367800	48.16384648	-114.3012402	8/7/2007	9.2	-	-	-	-
USGS	Ashley Creek (lower)	12367800	48.16384648	-114.3012402	9/19/2007	11	-	-	-	-
USGS	Ashley Creek (lower)	12367800	48.16384648	-114.3012402	7/14/2008	46	-	-	0.043	-
USGS	Ashley Creek (lower)	12367800	48.16384648	-114.3012402	8/26/2008	13	-	-	0.089	-
USGS	Ashley Creek (lower)	12367800	48.16384648	-114.3012402	8/29/2008	8.8	-	-	-	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-5	48.14945	-114.433	7/24/2003	6.48 t-	< 0.01	0.805	0.037	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-5	48.14945	-114.433	9/17/2003	4.43 t	< 0.01	1.055	0.025	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-5	48.14945	-114.433	7/5/2004	23.15 t	< 0.01	0.795	0.024	-

Table B-1. Recent Surface Water Nutrients, Chlorophyll-*a*, and Flow Data, Ashley Creek Watershed

Organization ID	Waterbody Name	Site ID	Latitude	Longitude	Collection Date	Flow (cfs)	NN (mg/L)	TN (mg/L)	TP (mg/L)	Chl-*a* (mg/m2)
MTWTRSHD_WQX	Ashley Creek (middle)	AC-5	48.14945	-114.433	9/21/2004	6.93 t	< 0.01	0.735	0.018	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-5	48.14945	-114.433	6/30/2005	34.58	< 0.01	0.665	0.035	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-5	48.14945	-114.433	7/13/2005	-	< 0.01	0.745	0.034	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-5	48.14945	-114.433	7/27/2005	12.90 t	< 0.01	0.745	0.032	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-5	48.14945	-114.433	8/10/2005	7.62 t	< 0.01	0.865	0.029	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-5	48.14945	-114.433	8/31/2005	7.50 t	< 0.01	0.935	0.025	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-5	48.14945	-114.433	9/21/2005	10.49 t	< 0.01	C 1.7	0.019	57
MTWTRSHD_WQX	Ashley Creek (middle)	AC-6	48.18218	-114.412	7/24/2003	5.52 t	< 0.01	0.725	0.04	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-6	48.18218	-114.412	9/17/2003	4.33 tt	0.01	1.08	0.028	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-6	48.18218	-114.412	7/5/2004	24.88 t	< 0.01	0.845	0.03	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-6	48.18218	-114.412	9/21/2004	12.74 t	< 0.01	0.605	0.018	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-6	48.18218	-114.412	6/30/2005	41.71 t	< 0.01	0.755	0.04	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-6	48.18218	-114.412	7/13/2005	-	< 0.01	0.605	0.037	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-6	48.18218	-114.412	7/27/2005	11.34 t	< 0.01	0.755	0.034	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-6	48.18218	-114.412	8/10/2005	7.17 t	0.01	0.825	0.028	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-6	48.18218	-114.412	8/31/2005	8.73 t	< 0.01	0.825	0.025	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-6	48.18218	-114.412	9/21/2005	13.28 t	< 0.01	C 1.7	0.025	49
MTWTRSHD_WQX	Ashley Creek (middle)	AC-7	48.19518	-114.373	7/24/2003	4.15 t	0.01	0.71	0.044	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-7	48.19518	-114.373	9/17/2003	5.37 t	0.01	0.91	0.022	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-7	48.19518	-114.373	7/5/2004	25.51 t	< 0.01	0.945	0.032	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-7	48.19518	-114.373	9/21/2004	10.91 t	< 0.01	0.595	0.022	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-7	48.19518	-114.373	6/30/2005	40.46 t	< 0.01	0.755	0.039	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-7	48.19518	-114.373	7/13/2005	-	< 0.01	0.805	0.039	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-7	48.19518	-114.373	7/27/2005	14.16 t	0.01	0.585	0.039	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-7	48.19518	-114.373	9/21/2005	10.53 t	< 0.01	C 1.7	0.021	50
MTWTRSHD_WQX	Ashley Creek (middle)	AC-8	48.18235	-114.323	7/24/2003	3.13 t	< 0.01	0.665	0.059	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-8	48.18235	-114.323	9/17/2003	2.00 t	< 0.01	0.885	0.033	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-8	48.18235	-114.323	7/5/2004	18.84 t	< 0.01	0.795	0.035	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-8	48.18235	-114.323	9/21/2004	-	0.07	0.565	0.034	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-8	48.18235	-114.323	6/30/2005	46.36 t	< 0.01	0.795	0.047	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-8	48.18235	-114.323	7/13/2005		< 0.01	0.695	0.055	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-8	48.18235	-114.323	7/27/2005	10.14 t	< 0.01	0.845	0.039	-

Table B-1. Recent Surface Water Nutrients, Chlorophyll-*a*, and Flow Data, Ashley Creek Watershed

Organization ID	Waterbody Name	Site ID	Latitude	Longitude	Collection Date	Flow (cfs)	NN (mg/L)	TN (mg/L)	TP (mg/L)	Chl-*a* (mg/m2)
MTWTRSHD_WQX	Ashley Creek (middle)	AC-8	48.18235	-114.323	8/10/2005	4.02 t	< 0.01	0.725	0.05	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-8	48.18235	-114.323	8/31/2005	3.12 t	< 0.01	0.755	0.032	-
MTWTRSHD_WQX	Ashley Creek (middle)	AC-8	48.18235	-114.323	9/21/2005	-	< 0.01	C 1.5	0.025	11
MDEQ_WQ_WQX	Ashley Creek (middle)	C11AHLYC04	48.1467	-114.436	7/3/2007	24.390 t	-	-	0.017	-
MDEQ_WQ_WQX	Ashley Creek (middle)	C11AHLYC04	48.1467	-114.436	8/1/2007	4.247 t	-	-	< 0.001	-
MDEQ_WQ_WQX	Ashley Creek (middle)	C11AHLYC04	48.1467	-114.436	9/19/2007	2.553 t	-	-	0.026	-
MDEQ_WQ_WQX	Ashley Creek (middle)	C11AHLYC05	48.1493	-114.433	5/7/2008	-	-	-	0.015	-
MDEQ_WQ_WQX	Ashley Creek (middle)	C11AHLYC05	48.1493	-114.433	7/2/2008	54.17 t	-	-	0.02	-
MDEQ_WQ_WQX	Ashley Creek (middle)	C11AHLYC05	48.1493	-114.433	7/14/2008	36.68 t	-	-	0.015	-
MDEQ_WQ_WQX	Ashley Creek (middle)	C11AHLYC05	48.1493	-114.433	7/28/2008	14.296 t	-	-	0.015	-
MDEQ_WQ_WQX	Ashley Creek (middle)	C11AHLYC05	48.1493	-114.433	8/13/2008	3.984 t	-	-	0.017	-
MDEQ_WQ_WQX	Ashley Creek (middle)	C11AHLYC05	48.1493	-114.433	9/5/2008	0.06 t	-	-	0.017	-
MDEQ_WQ_WQX	Ashley Creek (middle)	C11AHLYC05	48.1493	-114.433	10/1/2008	-	-	-	0.02	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-1	48.18005	-114.618	7/24/2003	10.18	< 0.01	0.285	0.017	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-1	48.18005	-114.618	9/17/2003	4.31	< 0.01	0.305	0.009	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-1	48.18005	-114.618	7/5/2004	7.67	< 0.01	0.445	0.008	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-1	48.18005	-114.618	9/21/2004	12.19	< 0.01	0.055	0.01	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-1	48.18005	-114.618	6/30/2005	5.83	< 0.01	0.115	0.017	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-1	48.18005	-114.618	7/13/2005	-	< 0.01	0.115	0.011	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-1	48.18005	-114.618	7/27/2005	12.36	< 0.01	0.115	0.012	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-1	48.18005	-114.618	8/10/2005	8.25	< 0.01	0.355	0.011	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-1	48.18005	-114.618	8/31/2005	7.79	< 0.01	0.265	0.01	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-1	48.18005	-114.618	9/21/2005	6.46	< 0.01	C 1.5	0.011	43
MTWTRSHD_WQX	Ashley Creek (upper)	AC-2	48.16775	-114.604	7/24/2003	13.25	< 0.01	0.055	0.015	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-2	48.16775	-114.604	9/17/2003	5.58	< 0.01	0.255	0.009	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-2	48.16775	-114.604	7/5/2004	8.48	< 0.01	0.465	0.011	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-2	48.16775	-114.604	9/21/2004	6.31	< 0.01	0.055	0.008	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-2	48.16775	-114.604	6/30/2005	5.33	< 0.01	0.225	0.018	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-2	48.16775	-114.604	7/13/2005	-	< 0.01	0.115	0.014	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-2	48.16775	-114.604	7/27/2005	12.36	< 0.01	0.115	0.012	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-2	48.16775	-114.604	8/10/2005	7.52	< 0.01	0.345	0.011	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-2	48.16775	-114.604	8/31/2005	7.78	< 0.01	0.265	0.01	-

Table B-1. Recent Surface Water Nutrients, Chlorophyll-*a*, and Flow Data, Ashley Creek Watershed

Organization ID	Waterbody Name	Site ID	Latitude	Longitude	Collection Date	Flow (cfs)	NN (mg/L)	TN (mg/L)	TP (mg/L)	Chl-*a* (mg/m2)
MTWTRSHD_WQX	Ashley Creek (upper)	AC-2	48.16775	-114.604	9/21/2005	6.34	< 0.01	C 1.4	0.009	34
MTWTRSHD_WQX	Ashley Creek (upper)	AC-3	48.10033	-114.562	7/24/2003	7.33	0.02	0.07	0.017	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-3	48.10033	-114.562	9/17/2003	5.4	0.01	0.45	0.024	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-3	48.10033	-114.562	7/5/2004	-	< 0.01	0.049	0.013	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-3	48.10033	-114.562	9/21/2004	7.67	< 0.01	0.275	0.012	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-3	48.10033	-114.562	6/30/2005	10.82	0.01	0.29	0.021	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-3	48.10033	-114.562	7/13/2005	-	< 0.01	0.285	0.016	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-3	48.10033	-114.562	7/27/2005	11.86	0.01	0.37	0.016	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-3	48.10033	-114.562	8/10/2005	7.32	0.03	0.27	0.014	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-3	48.10033	-114.562	8/31/2005	6.9	< 0.01	0.385	0.017	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-3	48.10033	-114.562	7/5/2004	12.65	-	-	-	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-3	48.10033	-114.562	9/21/2005	7.5	< 0.01	C 1.4	0.009	74
MTWTRSHD_WQX	Ashley Creek (upper)	AC-4	48.1055	-114.459	7/24/2003	-	< 0.01	0.255	0.032	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-4	48.1055	-114.459	9/17/2003	-	< 0.01	0.375	0.03	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-4	48.1055	-114.459	7/5/2004	-	< 0.01	0.565	0.03	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-4	48.1055	-114.459	9/21/2004	-	< 0.01	0.325	0.017	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-4	48.1055	-114.459	6/30/2005	-	< 0.01	0.385	0.048	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-4	48.1055	-114.459	7/13/2005	-	< 0.01	-	0.028	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-4	48.1055	-114.459	7/27/2005	-	< 0.01	0.335	0.025	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-4	48.1055	-114.459	8/10/2005	-	< 0.01	0.335	0.023	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-4	48.1055	-114.459	8/31/2005	-	< 0.01	0.365	0.018	-
MTWTRSHD_WQX	Ashley Creek (upper)	AC-4	48.1055	-114.459	9/21/2005	-	< 0.01	C 1.3	0.015	-
MDEQ_WQ_WQX	Spring Creek	C11SPRGC01	48.2059	-114.35	7/18/2012	7.67	0.43	0.43	0.007	-
MDEQ_WQ_WQX	Spring Creek	C11SPRGC01	48.2059	-114.35	9/17/2012	6.5	0.39	0.47	< 0.003	-
MDEQ_WQ_WQX	Spring Creek	C11SPRGC01	48.2059	-114.35	6/6/2012	7.81	-	-	-	-
MDEQ_WQ_WQX	Spring Creek	C11SPRGC02	48.2191	-114.37	7/18/2012	8.11	0.35	0.52	0.006	-
MDEQ_WQ_WQX	Spring Creek	C11SPRGC02	48.2191	-114.37	9/18/2012	6.85	0.47	0.52	0.004	-
MDEQ_WQ_WQX	Spring Creek	C11SPRGC30	48.19832	-114.331	8/15/2005	E 1.5	-	-	-	-
MDEQ_WQ_WQX	Spring Creek	C11SPRGC30	48.19832	-114.331	8/8/2007	-	0.164	0.25	0.02	-
MDEQ_WQ_WQX	Spring Creek	C11SPRGC30	48.19832	-114.331	7/17/2012	E 8	0.34	0.36	0.014	-
MDEQ_WQ_WQX	Spring Creek	C11SPRGC30	48.19832	-114.331	9/17/2012	6.79	0.47	0.63	0.009	-
MDEQ_WQ_WQX	Spring Creek	C11SPRGC30	48.19832	-114.331	8/15/2005	-	< 0.01	C 0.5	0.037	-
MDEQ_WQ_WQX	Spring Creek	C11SPRGC31	48.22517	-114.383	8/15/2005	E 1	-	-	-	-

Table B-1. Recent Surface Water Nutrients, Chlorophyll-*a*, and Flow Data, Ashley Creek Watershed

Organization ID	Waterbody Name	Site ID	Latitude	Longitude	Collection Date	Flow (cfs)	NN (mg/L)	TN (mg/L)	TP (mg/L)	Chl-*a* (mg/m2)
MDEQ_WQ_WQX	Spring Creek	C11SPRGC31	48.22517	-114.383	7/18/2012	E 8	0.62	0.66	0.005	-
MDEQ_WQ_WQX	Spring Creek	C11SPRGC31	48.22517	-114.383	9/18/2012	E 3	EXC	EXC	< 0.003	-
MDEQ_WQ_WQX	Spring Creek	C11SPRGC31	48.22517	-114.383	8/15/2005	-	0.81	C 1.3	0.079	-
MTWTRSHD_WQX	Spring Creek	SPC01	48.21975	-114.373	9/9/2005	0.85	0.02	C 0.6	0.005	18
MTWTRSHD_WQX	Spring Creek	SPC02	48.20611	-114.351	9/9/2005	0.51	< 0.01	C 0.6	0.012	20-
MTWTRSHD_WQX	Spring Creek	SPC03	48.19973	-114.336	9/9/2005	E 0.5	< 0.01	C 0.8	0.012	10
MTWTRSHD_WQX	Spring Creek	SPC03	48.19973	-114.336	9/9/2005	-	-0.43	C 1.3	-	-

NN = Nitrate + Nitrite, TN = Total Nitrogen, TP = Total Phosphorus, Chl-*a* = chlorophyll *a*
Duplicate flows at AC-1, AC-2, AC-3, and AC-9 from 9/21/2005 that are in the water quality assessment records (DEQ 2014b) were excluded from this table.
TN was calculated as the summation of TKN and NN for all "AC-" sites for this project, unless noted otherwise (i.e., TKN and NN are reported in STORET but not TN).
C = TN concentration is a calculated value and is reported as such in STORET.
E = An estimated flow value.
EXC = DEQ excluded these result values from the water quality assessment record (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2014)
t = Flow record was included in STORET but was excluded from the water quality assessment record (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2014).
tt = Flow record was included in STORET (as 433 cfs) but was excluded from the water quality assessment record (Montana Department of Environmental Quality, Water Quality Planning Bureau, 2014). It is assumed to be 4.33 cfs.

Table B-2. Permitted Point Sources with Possible Sediment Contribution to Sediment-Impaired Watersheds

NPDES ID	Facility Name	Latitude	Longitude	Permit Type	Expiration	Discharge To	Project Size
MT0021938	CITY OF KALISPELL WWTP	48.17472	-114.30611	NPDES Individual Permit	8/31/2013	ASHLEY CREEK	N/A
MTR000251	WISHER'S AUTO RECYCLING	48.167778	-114.310278	MPDES Storm Water - Industrial Activity	1/31/2018	ASHLEY CREEK	22.27
MTR000419	BUILDING MATERIALS HOLDING CORP. - BMC WEST TRUSS PLANT	48.118889	-114.253611	MPDES Storm Water - Industrial Activity	1/31/2018	ASHLEY CREEK	6.3
MTR000447	UPS - KALISPELL	48.211667	-114.329444	MPDES Storm Water - Industrial Activity	1/31/2018	SPRING CREEK	4.0

Table B-2. Permitted Point Sources with Possible Sediment Contribution to Sediment-Impaired Watersheds

NPDES ID	Facility Name	Latitude	Longitude	Permit Type	Expiration	Discharge To	Project Size
MTR000465	GLACIER GOLD LLC	48.532694	-114.572639	MPDES Storm Water - Industrial Activity	1/31/2018	STILLWATER RIVER & LOWER STILLWATER LAKE	38
MTR000476	FLATHEAD COUNTY SOLID WASTE DISTRICT	48.322222	-114.341667	MPDES Storm Water - Industrial Activity	1/31/2018	STILLWATER RIVER	310
MTR000531	CITY OF KALISPELL WWTP	48.17472	-114.30611	MPDES Storm Water - Industrial Activity	1/31/2018	ASHLEY CREEK	17.04
MTR040005	CITY OF KALISPELL SMALL MS-4	48.19967	-114.3132	MPDES Storm Water - Small MS4 (Municipal Separate Storm Sewer System)	12/31/2014	FLATHEAD RIVER, ASHLEY CREEK	N/A
MTR102686	TKD SPRING PRAIRIE DEVEL THREE SPRING PRAIRIECENTER PHASE III	48.238944	-114.332611	MPDES Storm Water - Construction Activity General Permit	12/31/2017	STILLWATER RIVER	24
MTR103414	WHITEFISH HILLS FOREST SUBDIVISION	48.345556	-114.365278	MPDES Storm Water - Construction Activity General Permit	12/31/2017	BLANCHARD LAKE AND STILLWATER RIVER	19
MTR103908	MDOT - KALISPELL BYPASS US 93 BIKEPATH CONNECTION	48.14975	-114.2925	MPDES Storm Water - Construction Activity General Permit	12/31/2017	ASHLEY CREEK	9
MTR104432	MONTANA DEPT OF NATURAL RESOURCES - SPRING PRAIRIE FUTURE DEVEL	48.23639	-114.34198	MPDES Storm Water - Construction Activity General Permit	12/31/2017	STORMWATER SYSTEM	9
MTR105030	KRAMER ENTERPRISES - SONJU INDUSTRIAL FACILITY	48.2554	-114.3313	MPDES Storm Water - Construction Activity General Permit	12/31/2017	STILLWATER RIVER	2
MTR105102	LASALLE SAND & GRAVEL - FLATHEAD CO SWD OLNEY GREEN BOX CONTAINER SITE	48.49306	-114.52417	MPDES Storm Water - Construction Activity General Permit	12/31/2017	STILLWATER RIVER	3
MTR105146	SCHELLINGER CONSTRUCTION - KBP RESERVE LOOP TO US 93	48.2329	-114.3462	MPDES Storm Water - Construction Activity General Permit	12/31/2017	DETENTION POND TO STILLWATER R	49

Table B-2. Permitted Point Sources with Possible Sediment Contribution to Sediment-Impaired Watersheds

NPDES ID	Facility Name	Latitude	Longitude	Permit Type	Expiration	Discharge To	Project Size
MTR105263	NELCON INC - TOWN PUMP - KALISPELL NO 5	48.163027	-114.28973	MPDES Storm Water - Construction Activity General Permit	12/31/2017	ASHLEY CREEK	22
MTR105284	SCHELLINGER CONSTRUCTION - THE WILLOWS STORMWATER IMPROVEMENTS PROJ	48.175123	-114.283294	MPDES Storm Water - Construction Activity General Permit	12/31/2017	STILLWATER RIVER	1
MTR105434	LHC INC - KBP THREE MILE DRIVE	48.21132	-114.34599	MPDES Storm Water - Construction Activity General Permit	12/31/2017	SPRING CREEK	15
MTR105492	TOM GARWIN - GARWIN STILLWATER RESIDENCE	48.384861	-114.448472	MPDES Storm Water - Construction Activity General Permit	12/31/2017	STILLWATER RIVER	7
MTR105578	WILLOW CREEK SUBDIVISION	48.187083	-114.341167	MPDES Storm Water - Construction Activity General Permit	12/31/2017	TRIBUTARY OF ASHLEY CREEK	23

N/A = not applicable

Table B-3. MFISH Fish Presence Data for Ashley Creek

Species	Begin Mile	End Mile	Abundance	Origin
Brook Trout	0	25.3	Rare	Introduced
	26.9	29.5	Abundant	
	29.5	35.4	Abundant	
Largescale Sucker	0	25.3	Rare	Native
Longnose Sucker	0	25.3	Abundant	Native
	26.9	41.7	Common	
Mountain Whitefish	0	15.9	Rare	Native
	15.9	25.3	Common	
	26.9	29.5	Rare	
	29.5	41.7	Rare	
Northern Pike	26.9	36.8	Common	Introduced
	37.6	41.7	Rare	

Table B-3. MFISH Fish Presence Data for Ashley Creek

Species	Begin Mile	End Mile	Abundance	Origin
Northern Pike Minnow	0	25.3	Abundant	Native
	26.9	41.7	Common	
Peamouth	0	25.3	Abundant	Native
	26.9	41.7	Rare	
Rainbow Trout	0	15.9	Rare	Introduced
	15.9	25.3	Common	
	26.9	35.4	Common	
Redside Shiner	0	25.3	Abundant	Native
	26.9	41.7	Rare	
Sculpin	26.9	28.2	Common	Native
	29.5	41.7	Unknown	
Slimy Sculpin	15.9	25.3	Abundant	Native
	28.2	29.5	Common	
Westslope X Rainbow Trout	20	47	Common	Introduced
Yellow Perch	0	25.3	Common	Introduced
	26.9	29.5	Common	
	29.5	41.7	Rare	

Table B-4. MFISH Fish Presence Data for the Whitefish River

Species	Begin Mile	End Mile	Abundance	Origin
Brook Trout	0	23.7	Rare	Introduced
Bull Trout	0	23.7	Unknown	Native
Largescale Sucker	0	23.7	Abundant	Native
Longnose Sucker	0	23.7	Abundant	Native
Mountain Whitefish	0	19.4	Common	Native
	19.4	22.1	Rare	
	22.1	23.7	Rare	
Northern Pike	0	23.7	Common	Introduced
Northern Pike Minnow	0	19.4	Abundant	Native
	19.4	23.7	Common	
Peamouth	0	19.4	Abundant	Native
	19.4	23.7	Common	
Rainbow Trout	0	23.7	Rare	Introduced
Redside Shiner	0	23.7	Common	Native

Table B-4. MFISH Fish Presence Data for the Whitefish River

Species	Begin Mile	End Mile	Abundance	Origin
Slimy Sculpin	0	23.7	Unknown	Native
Westslope Cutthroat Trout	0	29.3	Rare	Native

Table B-5. Kalispell WWTP Effluent and Ashley Creek Upstream and Downstream of the Kalispell WWTP Temperature Data August 2003 – 2012

NPDES ID	Facility Name	Location	Parameter	Monitoring Location	Statistic	DMR Value (°C) [1]	DMR Value (°F) [1]	Monitoring Period
MT0021938	CITY OF KALISPELL WWTP	ASHLEY CK - UPSTREAM STATION	Temperature	Upstream Monitoring	30 Day Average	24	75.2	8/1/2003 - 8/31/2003
MT0021938	CITY OF KALISPELL WWTP	WASTEWATER TREATMENT PLANT	Temperature	Effluent Gross	30 Day Average	21.8	71.24	8/1/2003 - 8/31/2003
MT0021938	CITY OF KALISPELL WWTP	ASHLEY CK DOWNSTREAM STATION	Temperature	Downstream Monitoring	30 Day Average	23.6	74.48	8/1/2003 - 8/31/2003
MT0021938	CITY OF KALISPELL WWTP	ASHLEY CK - UPSTREAM STATION	Temperature	Upstream Monitoring	30 Day Average	21.2	70.16	8/1/2004 - 8/31/2004
MT0021938	CITY OF KALISPELL WWTP	WASTEWATER TREATMENT PLANT	Temperature	Effluent Gross	30 Day Average	20	68	8/1/2004 - 8/31/2004
MT0021938	CITY OF KALISPELL WWTP	ASHLEY CK DOWNSTREAM STATION	Temperature	Downstream Monitoring	30 Day Average	20.9	69.62	8/1/2004 - 8/31/2004
MT0021938	CITY OF KALISPELL WWTP	ASHLEY CK - UPSTREAM STATION	Temperature	Upstream Monitoring	30 Day Average	19.8	67.64	8/1/2005 - 8/31/2005
MT0021938	CITY OF KALISPELL WWTP	WASTEWATER TREATMENT PLANT	Temperature	Effluent Gross	30 Day Average	20	68	8/1/2005 - 8/31/2005
MT0021938	CITY OF KALISPELL WWTP	ASHLEY CK DOWNSTREAM STATION	Temperature	Downstream Monitoring	30 Day Average	20.6	69.08	8/1/2005 - 8/31/2005
MT0021938	CITY OF KALISPELL WWTP	ASHLEY CK - UPSTREAM STATION	Temperature	Upstream Monitoring	30 Day Average	18.3	64.94	8/1/2006 - 8/31/2006
MT0021938	CITY OF KALISPELL WWTP	WASTEWATER TREATMENT PLANT	Temperature	Effluent Gross	30 Day Average	20	68	8/1/2006 - 8/31/2006
MT0021938	CITY OF KALISPELL WWTP	ASHLEY CK DOWNSTREAM STATION	Temperature	Downstream Monitoring	30 Day Average	19.3	66.74	8/1/2006 - 8/31/2006
MT0021938	CITY OF KALISPELL WWTP	ASHLEY CK - UPSTREAM STATION	Temperature	Upstream Monitoring	30 Day Average	20.5	68.9	8/1/2007 - 8/31/2007
MT0021938	CITY OF KALISPELL WWTP	WASTEWATER TREATMENT PLANT	Temperature	Effluent Gross	30 Day Average	20.2	68.36	8/1/2007 - 8/31/2007

Table B-5. Kalispell WWTP Effluent and Ashley Creek Upstream and Downstream of the Kalispell WWTP Temperature Data August 2003 – 2012

NPDES ID	Facility Name	Location	Parameter	Monitoring Location	Statistic	DMR Value (°C) [1]	DMR Value (°F) [1]	Monitoring Period
MT0021938	CITY OF KALISPELL WWTP	ASHLEY CK DOWNSTREAM STATION	Temperature	Downstream Monitoring	30 Day Average	21	69.8	8/1/2007 - 8/31/2007
MT0021938	CITY OF KALISPELL WWTP	ASHLEY CK - UPSTREAM STATION	Temperature	Upstream Monitoring	30 Day Average	21.1	69.98	8/1/2008 - 8/31/2008
MT0021938	CITY OF KALISPELL WWTP	WASTEWATER TREATMENT PLANT	Temperature	Effluent Gross	30 Day Average	20.1	68.18	8/1/2008 - 8/31/2008
MT0021938	CITY OF KALISPELL WWTP	ASHLEY CK DOWNSTREAM STATION	Temperature	Downstream Monitoring	30 Day Average	21.6	70.88	8/1/2008 - 8/31/2008
MT0021938	CITY OF KALISPELL WWTP	WASTEWATER TREATMENT PLANT	Temperature	Effluent Gross	30 Day Average	20	68	8/1/2009 - 8/31/2009
MT0021938	CITY OF KALISPELL WWTP	WASTEWATER TREATMENT PLANT	Temperature	Effluent Gross	30 Day Average	19.5	67.1	8/1/2010 - 8/31/2010
MT0021938	CITY OF KALISPELL WWTP	WASTEWATER TREATMENT PLANT	Temperature	Effluent Gross	30 Day Average	19.3	66.74	8/1/2011 - 8/31/2011
MT0021938	CITY OF KALISPELL WWTP	WASTEWATER TREATMENT PLANT	Temperature	Effluent Gross	30 Day Average	19.9	67.82	8/1/2012 - 8/31/2012
"ASHLEY CK - UPSTREAM STATION" Average = 69.44°F, "WASTEWATER TREATMENT PLANT" Average = 68.18°F, "ASHLEY CK DOWNSTREAM STATION" Average = 70.16°F								

[1] DMR = discharge monitoring report

Table B-6. Kalispell WWTP Effluent Flow Data August 2003 – 2012

NPDES ID	Facility Name	Location	Parameter	Monitoring Location	Statistic	DMR Value (mgd)[1]	DMR Value (cfs) [1]	Monitoring Period
MT0021938	CITY OF KALISPELL WWTP	WASTEWATER TREATMENT PLANT	Flow	Effluent Gross	30 Day Average	2.538	3.93	8/1/2003 - 8/31/2003
MT0021938	CITY OF KALISPELL WWTP	WASTEWATER TREATMENT PLANT	Flow	Effluent Gross	30 Day Average	2.678	4.14	8/1/2004 - 8/31/2004
MT0021938	CITY OF KALISPELL WWTP	WASTEWATER TREATMENT PLANT	Flow	Effluent Gross	30 Day Average	2.765	4.28	8/1/2005 - 8/31/2005
MT0021938	CITY OF KALISPELL WWTP	WASTEWATER TREATMENT PLANT	Flow	Effluent Gross	30 Day Average	2.854	4.42	8/1/2006 - 8/31/2006

Table B-6. Kalispell WWTP Effluent Flow Data August 2003 – 2012

NPDES ID	Facility Name	Location	Parameter	Monitoring Location	Statistic	DMR Value (mgd)[1]	DMR Value (cfs)[1]	Monitoring Period
MT0021938	CITY OF KALISPELL WWTP	WASTEWATER TREATMENT PLANT	Flow	Effluent Gross	30 Day Average	2.857	4.42	8/1/2007 - 8/31/2007
MT0021938	CITY OF KALISPELL WWTP	WASTEWATER TREATMENT PLANT	Flow	Effluent Gross	30 Day Average	2.723	4.21	8/1/2008 - 8/31/2008
MT0021938	CITY OF KALISPELL WWTP	WASTEWATER TREATMENT PLANT	Flow	Effluent Gross	30 Day Average	2.6	4.02	8/1/2009 - 8/31/2009
MT0021938	CITY OF KALISPELL WWTP	WASTEWATER TREATMENT PLANT	Flow	Effluent Gross	30 Day Average	2.601	4.02	8/1/2010 - 8/31/2010
MT0021938	CITY OF KALISPELL WWTP	WASTEWATER TREATMENT PLANT	Flow	Effluent Gross	30 Day Average	2.617	4.05	8/1/2011 - 8/31/2011
MT0021938	CITY OF KALISPELL WWTP	WASTEWATER TREATMENT PLANT	Flow	Effluent Gross	30 Day Average	2.222	3.44	8/1/2012 - 8/31/2013
"WASTEWATER TREATMENT PLANT" Average = 4.1 cfs								

[1] DMR = discharge monitoring report

Table B-7. USGS August 2007-2008 Discharge Data for Station 12367800 Ashley Creek at Kalispell, MT (downstream of the Kalispell WWTP)

Date	Daily Average (cfs)	Date	Daily Average (cfs)	Date	Daily Average (cfs)
8/1/2007	14	8/22/2007	9.9	8/12/2008	14
8/2/2007	13	8/23/2007	9.8	8/13/2008	13
8/3/2007	13	8/24/2007	9.7	8/14/2008	12
8/4/2007	12	8/25/2007	9.6	8/15/2008	13
8/5/2007	11	8/26/2007	9.6	8/16/2008	12
8/6/2007	11	8/27/2007	9.7	8/17/2008	12
8/7/2007	11	8/28/2007	9.7	8/18/2008	11
8/8/2007	10	8/29/2007	9.8	8/19/2008	9.5
8/9/2007	10	8/30/2007	9.7	8/20/2008	10
8/10/2007	10	8/31/2007	9.7	8/21/2008	11
8/11/2007	9.9	8/1/2008	23	8/22/2008	10
8/12/2007	9.6	8/2/2008	21	8/23/2008	10
8/13/2007	9.7	8/3/2008	20	8/24/2008	10
8/14/2007	9.8	8/4/2008	19	8/25/2008	9.4
8/15/2007	9.7	8/5/2008	19	8/26/2008	13
8/16/2007	9.5	8/6/2008	18	8/27/2008	9

Table B-7. USGS August 2007-2008 Discharge Data for Station 12367800 Ashley Creek at Kalispell, MT (downstream of the Kalispell WWTP)

Date	Daily Average (cfs)	Date	Daily Average (cfs)	Date	Daily Average (cfs)
8/17/2007	9.5	8/7/2008	17	8/28/2008	8.6
8/18/2007	9.5	8/8/2008	15	8/29/2008	9.8
8/19/2007	9.3	8/9/2008	15	8/30/2008	8.8
8/20/2007	9.2	8/10/2008	14	8/31/2008	8.2
8/21/2007	9.5	8/11/2008	14	**Average = 11.72 cfs**	

Table B-8. Burlington Northern Santa Fe Railway Whitefish Facility effluent temperature data August 2003 – 2012

NPDES ID	Permit Name	Parameter	Monitoring Period	Value
MT0000019	Burlington Northern Santa Fe Railway	Daily Maximum Temperature (°F)	8/1/2003 – 8/31/2003	74
MT0000019	Burlington Northern Santa Fe Railway	Daily Maximum Temperature (°F)	8/1/2004 – 8/31/2004	72
MT0000019	Burlington Northern Santa Fe Railway	Daily Maximum Temperature (°F)	8/1/2005 – 8/31/2005	72
MT0000019	Burlington Northern Santa Fe Railway	Daily Maximum Temperature (°F)	8/1/2006 – 8/31/2006	70
MT0000019	Burlington Northern Santa Fe Railway	Daily Maximum Temperature (°F)	8/1/2008 – 8/31/2008	69.8
MT0000019	Burlington Northern Santa Fe Railway	Daily Maximum Temperature (°F)	8/1/2009 – 8/31/2009	77
MT0000019	Burlington Northern Santa Fe Railway	Daily Maximum Temperature (°F)	8/1/2010 – 8/31/2010	68
MT0000019	Burlington Northern Santa Fe Railway	Daily Maximum Temperature (°F)	8/1/2012 – 8/31/2012	76.8
Burlington Northern Santa Fe Railway Maximum = 76.8°F				

Table B-9. Calculating Average Flow for August 2008 – 2012 at WHTF-01

Description	Value
Average discharge for August 2008 – 2012 at USGS station 12366080	169.66 cfs
Average discharge at USGS station 12366080 on 8/12/08	139.1 cfs
Discharge measured at WHTF-01 on 8/12/08	116.6 cfs
Proportion of USGS station 12366080 discharge at WHTF-01 on 8/12/08	0.84
Average discharge for August 2008 – 2012 at WHTF-01 (169.66 cfs * 0.84)	**142.22 cfs**

Table B-10. Whitefish WWTP Effluent Temperature Data August 2008 – 2012

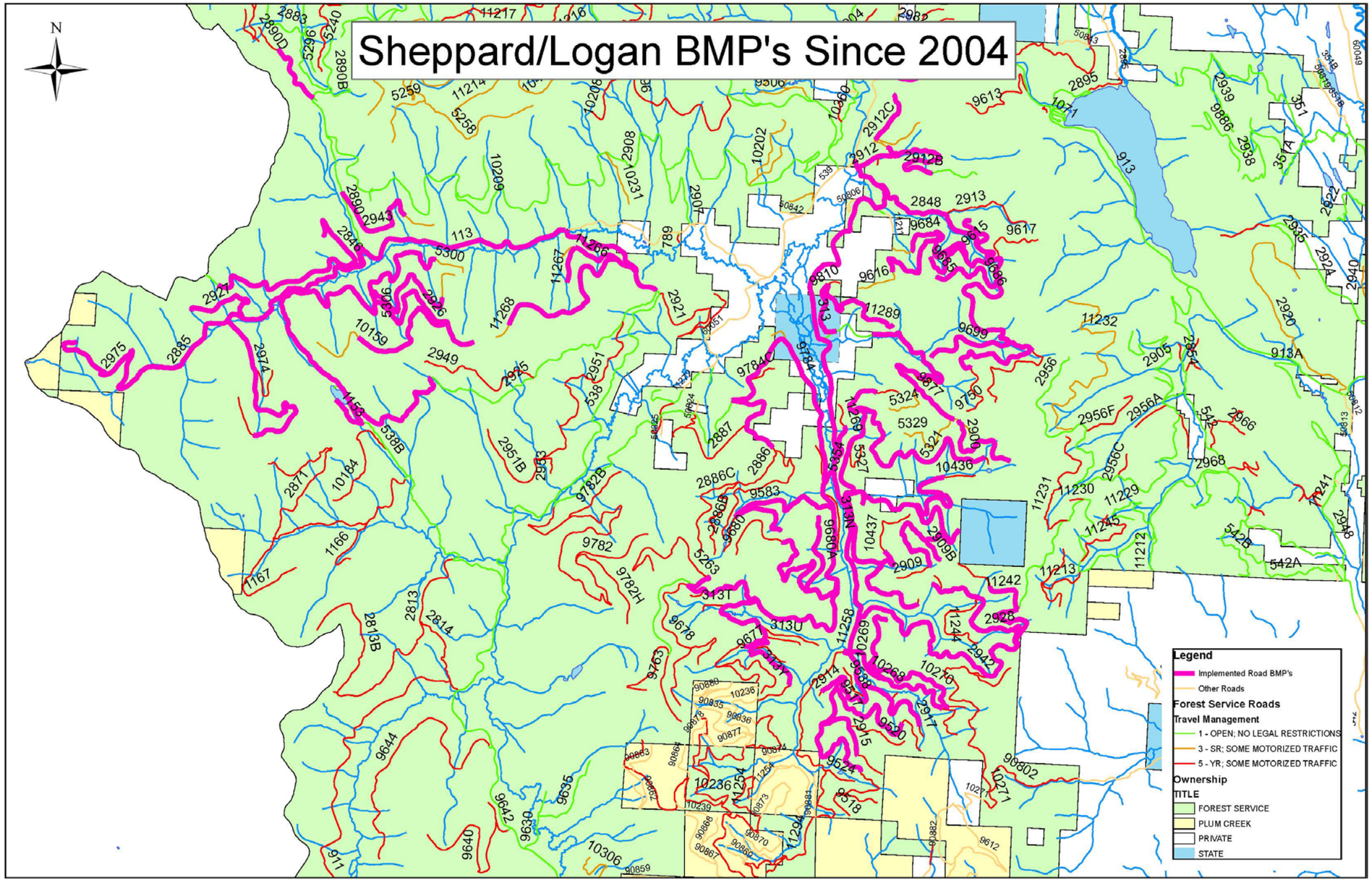
NPDES ID	Permit Name	Parameter Description	Monitoring Period	Value
MT0020184	City of Whitefish	Daily Maximum Temperature (°F)	8/1/2008 – 8/31/2008	72
MT0020184	City of Whitefish	Daily Maximum Temperature (°F)	8/1/2009 – 8/31/2009	74.8
MT0020184	City of Whitefish	Daily Maximum Temperature (°F)	8/1/2010 – 8/31/2010	73.2
MT0020184	City of Whitefish	Daily Maximum Temperature (°F)	8/1/2011 – 8/31/2011	73
MT0020184	City of Whitefish	Daily Maximum Temperature (°F)	8/1/2012 – 8/31/2012	73
City of Whitefish Maximum = 74.8°F				

REFERENCES

Montana Department of Environmental Quality, Water Quality Planning Bureau. 2014. 2013 Water Quality Assessment Records. Accessed 5/1/2014.

APPENDIX C – SHEPPARD/LOGAN ROAD BMPS SINCE 2004

Map provided by Mitch Guenther, Flathead National Forest



APPENDIX D - SEDIMENT TOTAL MAXIMUM DAILY LOADS

D1.0 SEDIMENT

D1.1 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.

D1.2 APPROACH

The preferred approach for calculating daily sediment loads is to use a nearby water quality gage with a long-term dataset for flow and suspended sediment. Within the Flathead-Stillwater TPA, there is one USGS gage station with an extensive discharge dataset for a stream segment with a TMDL in this document. Since sediment loading in the Flathead-Stillwater TPA is associated with nonpoint sources and stormwater related point sources, the hydrograph is assumed to be a reasonable surrogate for sediment loading to streams (i.e. peak contributions during periods of runoff and high flow). Therefore, mean daily discharge values from seven years of record (2006-2013) at the gage on the Stillwater River at Lawrence Park, Kalispell, MT (#12365700) were used to provide the bases for calculating daily sediment values for TMDLs in the Flathead-Stillwater TPA.

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 D-1**). For each TMDL, the daily load can be calculated by multiplying the daily percentages in **Table D-1** by the total average annual load associated with the TMDL percent reductions in **Section 6.6.3** of the main document (**Table D-3** in this appendix). For instance, the total allowable annual sediment load for the Stillwater River is 15,117.9 tons. To determine the TMDL for January 1, 15,117.9 tons is multiplied by 0.06% which provides a daily load for the Stillwater River on January 1st of 9.1 tons. To conserve resources, this appendix contains the daily loads for the Stillwater River as an example (**Table D-2** and **Figure D-1**). Daily loads for all other TMDLs can be calculated by multiplying the percentages in **Table D-1** by the values in **Table D-3**. 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 6.6.3** of the main document to the daily load.

Table D-1. USGS Stream Gage 12365700 (Stillwater River at Lawrence Park, Kalispell, MT) - Percent of mean annual discharge based on mean daily discharge values for each date of record (calculation period 2006-10-01 → 2013-09-30)

Day of month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.06%	0.06%	0.06%	0.20%	0.72%	0.92%	0.62%	0.19%	0.10%	0.08%	0.09%	0.08%
2	0.06%	0.06%	0.06%	0.22%	0.71%	0.90%	0.59%	0.18%	0.10%	0.08%	0.09%	0.08%
3	0.06%	0.06%	0.07%	0.24%	0.70%	0.89%	0.58%	0.18%	0.09%	0.08%	0.10%	0.08%
4	0.06%	0.06%	0.07%	0.27%	0.68%	0.89%	0.56%	0.18%	0.09%	0.08%	0.10%	0.08%
5	0.07%	0.06%	0.07%	0.29%	0.69%	0.89%	0.54%	0.18%	0.09%	0.08%	0.09%	0.08%
6	0.07%	0.06%	0.07%	0.31%	0.69%	0.89%	0.51%	0.17%	0.09%	0.08%	0.09%	0.08%
7	0.07%	0.06%	0.07%	0.33%	0.72%	0.89%	0.49%	0.17%	0.09%	0.08%	0.09%	0.09%
8	0.06%	0.06%	0.07%	0.34%	0.74%	0.89%	0.46%	0.16%	0.09%	0.08%	0.09%	0.08%
9	0.06%	0.06%	0.07%	0.35%	0.77%	0.90%	0.44%	0.16%	0.09%	0.09%	0.09%	0.09%
10	0.06%	0.06%	0.08%	0.35%	0.80%	0.92%	0.42%	0.15%	0.09%	0.09%	0.09%	0.08%
11	0.06%	0.06%	0.08%	0.36%	0.82%	0.94%	0.40%	0.15%	0.09%	0.08%	0.09%	0.08%
12	0.06%	0.06%	0.09%	0.37%	0.84%	0.94%	0.38%	0.14%	0.09%	0.08%	0.09%	0.08%
13	0.06%	0.06%	0.09%	0.38%	0.86%	0.92%	0.36%	0.14%	0.09%	0.08%	0.09%	0.08%
14	0.06%	0.06%	0.10%	0.41%	0.90%	0.88%	0.35%	0.14%	0.09%	0.08%	0.09%	0.08%
15	0.06%	0.06%	0.10%	0.43%	0.95%	0.84%	0.35%	0.14%	0.08%	0.08%	0.09%	0.08%
16	0.06%	0.06%	0.10%	0.45%	0.99%	0.82%	0.34%	0.14%	0.08%	0.08%	0.09%	0.07%
17	0.06%	0.06%	0.11%	0.45%	1.04%	0.80%	0.33%	0.13%	0.08%	0.08%	0.09%	0.07%
18	0.06%	0.06%	0.12%	0.46%	1.10%	0.79%	0.32%	0.13%	0.08%	0.09%	0.09%	0.07%
19	0.06%	0.06%	0.12%	0.46%	1.15%	0.78%	0.31%	0.13%	0.08%	0.08%	0.09%	0.07%
20	0.06%	0.05%	0.12%	0.47%	1.16%	0.80%	0.30%	0.12%	0.09%	0.08%	0.09%	0.07%
21	0.06%	0.05%	0.13%	0.48%	1.18%	0.82%	0.29%	0.12%	0.09%	0.08%	0.08%	0.07%
22	0.06%	0.06%	0.14%	0.50%	1.19%	0.82%	0.27%	0.12%	0.09%	0.08%	0.09%	0.07%
23	0.06%	0.06%	0.14%	0.53%	1.18%	0.81%	0.27%	0.11%	0.09%	0.09%	0.08%	0.07%
24	0.06%	0.06%	0.15%	0.56%	1.15%	0.80%	0.26%	0.11%	0.09%	0.09%	0.08%	0.07%
25	0.06%	0.05%	0.15%	0.59%	1.12%	0.78%	0.25%	0.11%	0.09%	0.09%	0.08%	0.07%
26	0.06%	0.05%	0.16%	0.63%	1.09%	0.76%	0.24%	0.10%	0.09%	0.09%	0.08%	0.07%
27	0.06%	0.06%	0.17%	0.67%	1.04%	0.74%	0.23%	0.10%	0.09%	0.09%	0.08%	0.07%
28	0.06%	0.06%	0.18%	0.70%	1.01%	0.71%	0.22%	0.10%	0.09%	0.09%	0.08%	0.07%
29	0.06%		0.19%	0.71%	0.99%	0.68%	0.21%	0.10%	0.09%	0.09%	0.08%	0.07%
30	0.06%		0.19%	0.73%	0.97%	0.64%	0.20%	0.10%	0.09%	0.09%	0.08%	0.07%
31	0.06%		0.19%		0.94%		0.20%	0.10%		0.09%		0.06%

Table D-2. Daily TMDL for the Stillwater River in tons

Day of month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	9.3	8.7	9.6	31.4	112.4	143.0	95.6	29.7	15.1	12.3	14.5	13.0
2	9.2	9.0	9.9	34.3	110.8	140.6	91.9	28.6	14.9	12.2	14.7	13.1
3	9.1	8.7	10.2	37.8	108.1	138.3	89.8	28.4	14.7	12.4	14.8	12.9
4	9.3	9.3	10.6	41.8	106.2	138.3	86.7	28.1	14.4	12.4	14.8	12.6
5	10.4	9.6	11.5	45.0	106.6	138.3	83.3	27.3	14.3	12.5	14.7	12.6
6	10.2	9.8	11.1	48.3	107.8	138.3	79.2	26.6	14.3	12.8	14.7	12.5
7	10.3	9.6	11.3	51.0	111.2	138.3	75.4	26.0	14.3	13.0	14.5	13.2
8	10.0	9.1	11.2	52.3	115.3	138.3	72.0	25.1	14.3	13.1	14.5	13.1
9	10.0	8.7	11.1	54.4	119.3	139.4	68.5	24.1	14.2	13.2	14.5	13.2
10	9.8	8.6	12.4	54.9	124.1	143.0	65.5	23.4	14.3	13.2	14.4	13.0
11	9.3	8.7	13.1	55.7	127.6	146.5	62.4	23.0	14.2	13.1	14.3	12.6
12	9.0	9.2	14.3	56.8	130.0	146.5	59.1	22.3	13.9	13.0	14.3	12.8
13	9.3	9.1	14.4	59.7	133.5	143.0	56.2	21.7	13.6	13.0	14.5	12.8
14	9.3	9.3	14.8	63.1	139.4	137.1	54.4	21.6	13.5	13.0	14.7	12.4
15	9.6	9.3	15.2	67.2	147.7	131.2	53.8	21.5	13.0	12.9	14.7	11.8
16	9.6	9.0	15.8	69.2	153.6	127.6	52.9	21.0	12.8	13.0	14.2	11.0
17	9.1	9.0	17.4	70.0	161.9	124.1	51.5	20.6	12.6	13.0	14.2	11.0
18	9.6	8.9	18.7	70.8	171.3	122.9	50.2	20.1	12.8	13.2	13.8	10.5
19	9.1	8.7	18.9	71.6	178.4	121.7	48.7	19.5	13.0	13.1	13.4	10.8
20	8.9	8.4	19.0	72.3	180.8	124.1	46.6	18.9	13.2	13.0	13.4	10.6
21	9.2	8.5	20.1	74.2	183.2	127.6	44.3	18.4	13.5	13.0	13.1	10.5
22	9.1	8.6	21.4	78.1	184.3	127.6	42.5	18.1	13.6	13.1	13.4	10.4
23	8.9	8.9	22.3	82.1	183.2	126.4	41.4	17.7	13.7	13.2	13.0	10.5
24	8.9	8.7	23.0	86.5	178.4	124.1	40.4	17.1	13.8	13.5	12.9	10.9
25	9.2	8.5	23.8	92.2	173.7	121.7	38.8	16.5	13.8	13.6	12.4	10.9
26	9.2	8.4	24.7	98.2	169.0	118.2	37.1	16.3	14.1	13.6	13.0	10.9
27	9.2	8.9	26.8	103.6	161.9	114.3	35.8	16.1	13.9	13.7	12.9	10.4
28	9.1	9.1	28.6	108.0	157.2	110.1	34.1	15.8	13.7	13.8	12.8	10.4
29	9.1		29.3	111.1	153.6	105.2	33.0	15.6	13.5	13.9	13.0	10.5
30	8.9		29.4	112.8	150.1	100.2	31.3	15.6	13.2	14.1	12.6	10.2
31	8.9		30.1		146.5		30.4	15.4		14.3		9.6

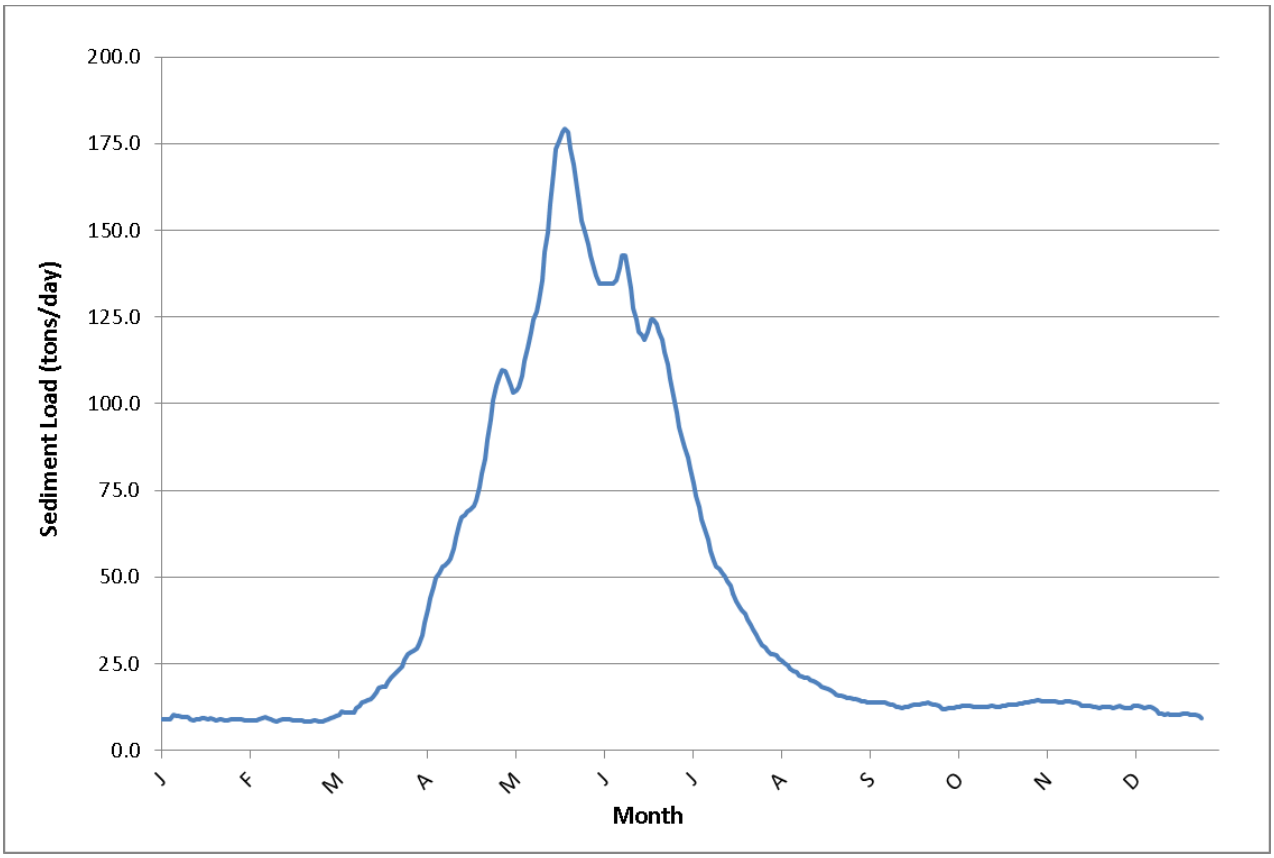


Figure D-1. Total maximum daily load for sediment in the Stillwater River

Table D-3. TMDLs expressed as an average annual load that can be used in conjunction with the values in Table D-1 to compute daily loads

Stream segment	Waterbody ID	TMDL expressed as average annual load (tons/year)
Ashley Creek, Ashley Lake to Smith Lake	MT76O002_010	344.3
Ashley Creek, Smith Lake to Kalispell Airport Road	MT76O002_020	652.7
Ashley Creek, Kalispell airport road to mouth (Flathead River)	MT76O002_030	934.2
Haskill Creek, Haskill Basin Pond to mouth (Whitefish River)	MT76P003_070	651.2
Logan Creek, headwaters to mouth (Tally Lake)	MT76P001_030	2,993.65
Sheppard Creek, headwaters to mouth (Griffin Creek)	MT76P001_050	546.1
Stillwater River, Logan Creek to mouth	MT76P001_010	15,117.9

APPENDIX E – QUAL2K STREAM TEMPERATURE MODELING FOR ASHLEY CREEK AND THE WHITEFISH RIVER

TABLE OF CONTENTS

E1.0 Introduction E-3
E1.1 Montana Water Quality Standards E-3
E1.2 Temperature Thresholds E-4
E2.0 Temperature Assessment E-4
E2.1 Field Data Collection E-4
E2.1.1 Temperature Measurements E-4
E2.1.2 Streamflow Measurements E-4
E2.1.3 Riparian Shading E-5
E2.2 QUAL2K Model E-5
E2.2.1 Data Sources and Model Assumptions E-6
E2.2.2 Ashley Creek Model Scenarios E-10
E2.2.3 Whitefish River Model Scenarios E-21
E2.3 Modeled Temperatures Relative to Montana Standards E-23
E2.3.1 Ashley Creek E-23
E2.3.2 Whitefish River E-24
E3.0 Conclusions E-24
E4.0 References E-25
Attachment EA – 2008 Temperature Data Summary E-27
Attachment EB – Solar Pathfinder Hourly Shade Measurements E-28
Attachment EC – Solar Pathfinder Supplemental Field Data E-32
Attachment ED – QUAL2K Model Calibration Inputs E-34
Ashley Creek Model Calibration Inputs E-34
Whitefish River Model Calibration Inputs E-36
Attachment EE – Monitoring Site and Riparian Vegetation Reach Type Maps E-38
Attachment EF – Riparian Vegetation Reach Types E-41
Attachment EG – Hydrologic Balance E-43

LIST OF TABLES

Table E1-1. Temperature Impairments in the Flathead-Stillwater TPA E-3

Table E2-1. Conversion Table °C to °F E-6
Table E2-2. Streamflow Data for Ashley Creek E-7
Table E2-3. Streamflow Data for the Whitefish River E-8
Table E2-4. Ashley Creek Riparian Vegetation Reach Type Average Hourly Shade Conditions E-9
Table E2-5. Whitefish River Riparian Vegetation Reach Type Average Hourly Shade Conditions E-9
Table E2-6. Ashley Creek Existing Conditions and Shade Scenario Riparian Vegetation Reach Types E-11
Table E2-7. Ashley Creek QUAL2K Shade Scenario E-12
Table E2-8. Ashley Creek QUAL2K Water Consumptive Use Scenario E-13
Table E2-9. Ashley Creek QUAL2K Shade and water consumptive use scenario E-15
Table E2-10. Ashley Creek QUAL2K Shade and 15% reduction of water withdrawn for irrigation scenario E-16
Table E2-11. Temperature change from the Baseline (existing) condition scenario using the Shade and 15% Reduction of Water Withdrawn for Irrigation and Shade model scenarios E-17
Table E2-12. Ashley Creek QUAL2K Shade with no Kalispell WWTP discharge scenario E-18
Table E2-13. Ashley Creek QUAL2K Shade with the Kalispell WWTP discharging at the naturally occurring stream temperature scenario E-20
Table E2-14. Whitefish River Existing Conditions and Shade Scenario Riparian Vegetation Reach Types E-22
Table E2-15. Whitefish River QUAL2K Shade Scenario (maximum temperatures shown) E-23
Table E2-16. Ashley Creek Temperatures Relative to Montana's Water Quality Standards E-23
Table E2-17. Whitefish River Temperatures Relative to Montana's Water Quality Standards E-24

LIST OF FIGURES

Figure E2-1. Ashley Creek QUAL2K Baseline (Existing Conditions) Scenario (maximum temperatures shown) E-11
Figure E2-2. Ashley Creek QUAL2K Shade Scenario (maximum temperatures shown) E-12
Figure E2-3. Ashley Creek QUAL2K Water Consumptive Use Scenario (maximum temperatures shown) E-13
Figure E2-4. Ashley Creek QUAL2K Shade and water consumptive use scenario (maximum temperatures shown) E-14
Figure E2-5. Ashley Creek QUAL2K Shade and 15% reduction of water withdrawn for irrigation scenario (maximum temperatures shown) E-16
Figure E2-6. Ashley Creek QUAL2K Shade with no Kalispell WWTP discharge scenario (maximum temperatures shown) E-18
Figure E2-7. Ashley Creek QUAL2K Shade with the Kalispell WWTP discharging at the naturally occurring stream temperature scenario (maximum temperatures shown) E-20
Figure E2-8. Whitefish River QUAL2K Baseline (Existing Conditions) Scenario (maximum temperatures shown) E-21
Figure E2-9. Whitefish River QUAL2K Shade Scenario (maximum temperatures shown) E-22

E1.0 INTRODUCTION

Temperature impairments were assessed within Ashley Creek and the Whitefish River using a combination of instream temperature measurements, riparian shading assessments, mid-summer streamflow measurements, and modeling. The Ashley Creek and Whitefish River temperature assessment was conducted to aid in the development of total maximum daily loads (TMDLs) for temperature impaired stream segments in the Flathead-Stillwater TMDL Planning Area (TPA) (**Table E1-1**). Data collected during this assessment were used in the QUAL2K model to assess the influence of shading and streamflow on stream temperatures in Ashley Creek and the Whitefish River. The results of this assessment were compared to Montana's water quality standards for temperature to evaluate beneficial-use support and potential restoration strategies.

Table E1-1. Temperature Impairments in the Flathead-Stillwater TPA

Name	Waterbody ID	Length (miles)	Use Class	Location	Temperature Impairment
Ashley Creek	MT76O002_010	14.8	B-1	from Ashley Lake to Smith Lake	yes
Ashley Creek	MT76O002_020	13.4	B-2	from Smith Lake to bridge crossing on Kalispell airport road	no
Ashley Creek	MT76O002_030	11.8	C-2	from bridge crossing on Kalispell airport road to the confluence with the Flathead River	yes
Whitefish River	MT76P003_010	23.7	B-2	from Whitefish Lake to the confluence with the Stillwater River	yes

E1.1 MONTANA WATER QUALITY STANDARDS

Montana's water quality standard for temperature addresses a maximum allowable increase above the "naturally occurring" temperature to protect the existing thermal regime for fish and aquatic life. Among other uses, Ashley Creek and the Whitefish River are to be maintained suitable for the growth and propagation (for B-1 waters) or marginal propagation (for B-2 and C-2 waters) of salmonid fishes and associated aquatic life, waterfowl and furbearers. For waters classified as B-1, B-2 and C-2, the associated standard specific to temperature is as follows: "A 1°F maximum increase above naturally occurring water temperature is allowed within the range of 32°F to 66°F; within the naturally occurring range of 66°F to 66.5°F, no discharge is allowed which will cause the water temperature to exceed 67°F; and where the naturally occurring water temperature is 66.5°F or greater, the maximum allowable increase in water temperature is 0.5°F. A 2°F per-hour maximum decrease below naturally occurring water temperature is allowed when the water temperature is above 55°F. A 2°F maximum decrease below naturally occurring water temperature is allowed within the range of 55°F to 32°F." [ARM 17.30.623(2e), ARM 17.30.624(2e) and ARM 17.30.627(2e)]. Temperature monitoring and modeling indicated that naturally occurring stream temperatures in Ashley Creek and the Whitefish River are likely

greater than 66.5°F during portions of the summer months. Thus, the maximum allowable increase due to unmitigated human causes is likely to be 0.5°F during the hottest part of the summer.

E1.2 TEMPERATURE THRESHOLDS

Special temperature considerations are warranted for the westslope cutthroat trout, which is listed by the State of Montana as a species of concern (Carlson, 2001). Research by (Bear et al., 2007) found that the upper incipient lethal temperature (UILT) for westslope cutthroat trout was 67°F, while the UILT for rainbow trout was 76°F. The UILT is the temperature that is considered to be survivable indefinitely by 50 percent of the population (Lohr, 1996). Although these temperature thresholds are used as a reference that likely causes impact to fish, they are not targeted temperatures and are not directly related to Montana's water quality standards.

E2.0 TEMPERATURE ASSESSMENT

The Ashley Creek and Whitefish River temperature assessment was performed in order to identify existing conditions and to determine if human caused disturbances have led to increased stream water temperatures. This assessment utilized field data and computer modeling to assess stream temperatures in relation to Montana's water quality standards.

E2.1 FIELD DATA COLLECTION

Field data used in this assessment were collected during the 2008 summer field season and included temperature measurements, streamflow measurements, and an assessment of riparian shading along Ashley Creek, the Whitefish River and selected tributary streams. Field methods are described in *Flathead Stillwater TMDL Planning Area Temperature and Instantaneous Flow Monitoring Sampling and Analysis Plan* (Montana Department of Environmental Quality, 2008).

E2.1.1 Temperature Measurements

Temperature monitoring was conducted on Ashley Creek and the Whitefish River between late-July and mid-September in 2008. The study timeframe examined stream temperatures during the period when streamflows tend to be lowest, water temperatures are warmest, and negative effects to the aquatic life beneficial use are likely most pronounced. Temperature monitoring consisted of placing temperature data logging devices at 20 sites in the Ashley Creek watershed and 11 sites in the Whitefish River watershed. Temperature monitoring sites were selected to bracket stream reaches with similar hydrology, riparian vegetation type, valley type, stream aspect, and channel width so that the temperature data collected during this assessment could be utilized in the QUAL2K model. A summary of temperature data is presented in **Attachment A**.

E2.1.2 Streamflow Measurements

Streamflow was measured at 14 sites in the Ashley Creek watershed and seven sites in the Whitefish River watershed during mid-August. Streamflow data collected during this assessment were used in the QUAL2K model to help determine if instream temperatures exceed Montana standards.

E2.1.3 Riparian Shading

Riparian shading was assessed at 12 sites along Ashley Creek and eight sites along the Whitefish River using a Solar Pathfinder, which measures the amount of shade at a site in one-hour intervals between 6 a.m. and 6 p.m. The Solar Pathfinder was utilized to assess riparian shading using the August template for the path of the sun. Shade was measured at three locations over a 200-foot reach at each site. In addition to the Solar Pathfinder readings, the following measurements were performed at each site for which riparian shading was assessed:

- Stream azimuth
- Bankfull width
- Wetted width
- Dominant tree species

Riparian shading data were used to assess existing and potential riparian shading conditions relative to the level of anthropogenic disturbance at a site. Measurements obtained with the Solar Pathfinder were used in the QUAL2K model to help determine if instream temperatures exceed Montana standards. Solar Pathfinder hourly shade measurements are presented in **Attachment B** and supplemental field data are presented in **Attachment C**.

E2.2 QUAL2K MODEL

The QUAL2K model was used to determine if human caused disturbances within the watersheds have increased the water temperature above the "naturally occurring" level and, if so, to what degree. The QUAL2K model is available at: http://www.epa.gov/ATHENS/wwqtsc/html/qual2k.html. Stream temperature, riparian shading and streamflow data collected in the summer of 2008 were used to calibrate the QUAL2K model for existing conditions. The potential to reduce stream temperatures was then modeled based on up to seven scenarios, including:

- Baseline (existing) scenario
- Shade scenario
- Water consumptive use scenario (only for Ashley Creek)
- Shade and water consumptive use scenario (only for Ashley Creek)
- Shade and 15% reduction of water withdrawn for irrigation scenario (only for Ashley Creek)
- Shade with no Kalispell wastewater treatment plant (WWTP) discharge present scenario (only for Ashley Creek)
- Shade with Kalispell WWTP discharge at the average naturally occurring stream temperature (only for Ashley Creek)

The QUAL2K model inputs and outputs are based on the metric system; results are presented in °F. Temperature values in °C are converted to °F using the equation:

$$°F = °C * 9/5 + 32$$

For comparison, conversion values between °C and °F are included in **Table E2-1**.

Table E2-1. Conversion Table °C to °F

°C	°F		°C	°F		°C	°F
1	33.8		11	51.8		21	69.8
2	35.6		12	53.6		22	71.6
3	37.4		13	55.4		23	73.4
4	39.2		14	57.2		24	75.2
5	41.0		15	59.0		25	77.0
6	42.8		16	60.8		26	78.8
7	44.6		17	62.6		27	80.6
8	46.4		18	64.4		28	82.4
9	48.2		19	66.2		29	84.2
10	50.0		20	68.0		30	86.0

E2.2.1 Data Sources and Model Assumptions

Data sources and model assumptions made during this assessment are described within the following sections. A more detailed discussion on specific model inputs for each data entry tab of the QUAL2K model is presented in **Attachment D**.

E2.2.1.1 Temperature Data

Temperature data collected in both Ashley Creek and the Whitefish River during the summer of 2008 were applied in the QUAL2K model.

Ashley Creek

Temperature data loggers were placed at 20 sites in the Ashley Creek watershed during the summer of 2008, including 17 mainstem locations and three tributaries (**Attachment E**). Data loggers were deployed between July 21st and 28th and retrieved between September 10th and 17th. One mainstem temperature data logger was lost (ASHL-12) resulting in temperature data for 16 Ashley Creek sites and three tributary sites.

The maximum daily temperature data were reviewed for all sites in the Ashley Creek watershed to identify the warmest day of the season. Maximum daily temperatures occurred between July 26th and August 18th, with 15 out of 19 seasonal maximum temperatures occurring on August 17th (**Attachment A**). Model results for Ashley Creek indicate a 15 day travel time and the QUAL2K model for Ashley Creek was run for the August 4th – 18th timeframe.

Whitefish River

Temperature data loggers were placed at 11 sites in the Whitefish River watershed, including nine mainstem locations and two tributaries (**Attachment E**). Data loggers were deployed between July 18th and 21st and retrieved between September 11th and 15th.

The maximum daily temperature data were reviewed for all sites in the Whitefish River watershed to identify the warmest day of the season. Maximum daily temperatures occurred between July 26th and August 18th, with seven out of 10 seasonal maximum temperatures occurring on August 18th (**Attachment A**). Model results indicate a two-day travel time in the Whitefish River and the QUAL2K model for the Whitefish River was run for the August 17th – 18th timeframe.

E2.2.1.2 Streamflow Data

Streamflow data collected in both Ashley Creek and the Whitefish River during the summer of 2008 were applied in the QUAL2K model.

Ashley Creek

Streamflow measurements were collected at 12 sites on Ashley Creek and two sites on tributary streams, including Porter Creek and Spring Creek (**Table E2-2, Attachment E**). Streamflow measurements on Ashley Creek were collected between August 15th and August 25th. Nine streamflow measurements were applied in the QUAL2K model from the mainstem of Ashley Creek along with both tributary streamflow measurements. Three mainstem flow measurements from Ashley Creek (ASHL-11, ASHL-19 and ASHL-20) were discarded because the data were collected in very slow moving portions of the stream where there was dense of aquatic vegetation, which may have reduced the accuracy of the velocity measurement. Several of the velocity readings at each of these sites were below 0.05 feet per second. According to the Marsh McBirney guidelines, velocities less than 0.05 feet per second are subject to error and may provide inaccurate readings (Marsh-McBirney, 1990).

In order to validate DEQ measurements, streamflow data collected during the 2008 temperature project were compared with streamflow measurements performed by the USGS at gaging station 12367800, which is located approximately 1.2 miles downstream of the Kalispell WWTP. The USGS water quality information serves as a useful and dependable validating tool as it is generated from a scientifically respected source that provides reviewed and published information. Upstream of the WWTP (ASHL-17) a flow of 4.6 cfs was measured during this project on August 19th, while the average discharge from the wastewater treatment plant in August of 2008 was 4.2 cfs. This hydrologic balance of 8.8 cfs compares well with the USGS estimate on August 19th of 9.5 cfs. Since there are no known water withdrawals downstream of the wastewater treatment plant, the 2008 temperature project measured values of 5.6 cfs and 5.9 cfs from sites ASHL-19 and ASHL-20, respectively, were determined to be in error and therefore discarded.

Table E2-2. Streamflow Data for Ashley Creek

Temperature Data Logger Site	Stream	Date	Streamflow (cfs)	Streamflow (cms)
ASHL-01	Ashley Creek	8/15/08	7.2	0.2024
ASHL-02	Ashley Creek	8/15/08	10.3	0.2920
ASHL-03	Ashley Creek	8/15/08	6.9	0.1955
ASHL-04	Ashley Creek	8/18/08	6.3	0.1792
ASHL-05	Ashley Creek	8/19/08	7.3	0.2055
ASHL-06	Ashley Creek	8/15/08	5.0	0.1416
ASHL-07	Porter Creek	8/25/08	2.9	0.0827
ASHL-11	Ashley Creek	8/22/08	11.9*	0.3370
ASHL-13	Ashley Creek	8/19/08	3.7	0.1042
ASHL-15	Ashley Creek	8/18/08	4.2	0.1175
ASHL-16	Spring Creek	8/19/08	2.4	0.0670
ASHL-17	Ashley Creek	8/19/08	4.6	0.1306
ASHL-19	Ashley Creek	8/21/08	5.6*	0.1578
ASHL-20	Ashley Creek	8/22/08	5.9*	0.1657

* Streamflow measurement discarded.

Whitefish River

Streamflow measurements were collected at five sites on the Whitefish River and two tributary streams, including Haskill Creek and Walker Creek (**Table E2-3, Attachment E**). Streamflow measurements in the Whitefish River were collected between August 11th and August 13th. Four streamflow measurements for the Whitefish River were applied in the QUAL2K model along with both tributary streamflow measurements. The streamflow measurement from WHTF-08 was discarded since it appeared to over-estimate the actual streamflow. Site WHTF-07 was located at the USGS gaging station 12366080. A mean daily streamflow measurement of 135 cfs at the USGS gaging station correlated well with the measured value of 133.7 cfs at WHTF-07 on August 13th, however as there were no significant tributary inputs identified for the 3.5 miles between WHTF-07 and WHTF-08, no significant increase in flow would be expected and therefore the WHTF-08 measurement was assumed to be in error.

Table E2-3. Streamflow Data for the Whitefish River

Temperature Data Logger Site	Stream	Date	Streamflow (cfs)	Streamflow (cms)
WHTF-01	Whitefish River	8/12/08	116.6	3.2918
WHTF-03	Haskill Creek	8/11/08	3.6	0.1004
WHTF-04	Walker Creek	8/11/08	0.6	0.0158
WHTF-06	Whitefish River	8/12/08	126.1	3.5590
WHTF-07	Whitefish River	8/13/08	133.7	3.7738
WHTF-08	Whitefish River	8/13/08	145.0*	4.0946
WHTF-11	Whitefish River	8/13/08	139.0	3.9226

* Streamflow measurement discarded.

E2.2.1.3 Streamside Shading

Streamside shading data collected in both Ashley Creek and the Whitefish River during the summer of 2008 were applied in the QUAL2K model.

Ashley Creek

Prior to field data collection, Ashley Creek was divided into 46 distinct reaches covering 44.6 miles based on the riparian vegetation type as observed in GIS using National Agricultural Imagery Program (NAIP) color aerial imagery from 2005, along with high-resolution color orthophotographs from May 24th, 2004 (**Attachment E**). Riparian vegetation reach types included forested, dense riparian, low/moderate riparian and open/pasture. Forested areas were dominated by coniferous vegetation, while dense riparian areas had a mix of deciduous trees and shrubs. Low/moderate riparian areas were comprised primarily of deciduous shrubs and herbaceous vegetation. Each reach was reviewed using aerial imagery of the predominant riparian vegetation and assigned a vegetation type using best professional judgment.

Streamside shading was assessed at 12 sites along Ashley Creek and the average amount of shade within each riparian vegetation reach type was calculated (**Table E2-4**). For reaches in which shade measurements were performed, the result was applied directly to the entire reach. For reaches in which no shade measurement was performed, the riparian vegetation reach type average was applied. The complete riparian shading dataset is presented in **Attachment B** and supplemental information for each assessed reach is presented in **Attachment C**. Riparian vegetation reach types as determined through GIS analysis of aerial imagery are presented in **Attachments E** and **F**, along with assumptions applied during the shade model scenario (see **Section E2.2.2.2**).

Table E2-4. Ashley Creek Riparian Vegetation Reach Type Average Hourly Shade Conditions

Riparian Vegetation Reach Type	Morning (AM)						Afternoon (PM)						Average Daily Shade
	6-7	7-8	8-9	9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	5-6	
Forested	100%	100%	93%	76%	40%	50%	49%	77%	78%	89%	96%	100%	79%
Dense Riparian	89%	80%	75%	70%	64%	47%	53%	25%	33%	42%	93%	100%	64%
Low/Moderate Riparian	61%	34%	23%	14%	14%	10%	13%	11%	11%	12%	32%	58%	25%
Open/Pasture	30%	2%	0%	0%	0%	0%	0%	0%	0%	3%	18%	63%	10%

Whitefish River

Prior to field data collection, the Whitefish River was divided into 32 distinct reaches covering 24.8 miles based on the riparian vegetation type as observed in GIS using National Agricultural Imagery Program (NAIP) color aerial imagery from 2005, along with high-resolution color orthophotographs from May 24th, 2004 (**Attachment E**). Riparian vegetation reach types included dense riparian, low/moderate riparian and open/pasture. Dense riparian areas had a mix of deciduous trees and shrubs, while low/moderate riparian areas were comprised primarily of deciduous shrubs and herbaceous vegetation. Each reach was reviewed using aerial imagery of the predominant riparian vegetation and assigned a vegetation type using best professional judgment.

Streamside shading was assessed at eight sites along the Whitefish River and the average amount of shade within each riparian vegetation reach type was calculated (**Table E2-5**). For reaches in which shade measurements were performed, the result was applied directly to the entire reach. For reaches in which no shade measurement was performed, the riparian vegetation reach type average was applied. The complete riparian shading dataset is presented in **Attachment B** and supplemental information for each assessed reach is presented in **Attachment C**. Riparian vegetation reach types as determined through GIS analysis of aerial imagery are presented in **Attachments E** and **F**, along with assumptions applied during the shade model scenario (see **Section E2.2.3.2**).

Table E2-5. Whitefish River Riparian Vegetation Reach Type Average Hourly Shade Conditions

Riparian Vegetation Reach Type	Morning (AM)						Afternoon (PM)						Average Daily Shade
	6-7	7-8	8-9	9-10	10-11	11-12	12-1	1-2	2-3	3-4	4-5	5-6	
Dense Riparian	93%	70%	42%	42%	38%	20%	10%	13%	28%	39%	70%	94%	47%
Low/Moderate Riparian	72%	44%	26%	15%	10%	5%	7%	9%	27%	62%	76%	91%	37%
Open/Pasture	41%	22%	19%	11%	7%	4%	0%	0%	8%	11%	20%	22%	14%

E2.2.1.4 Climatic Data

Climatic data inputs for the QUAL2K model were obtained from the Pacific Northwest Cooperative Agricultural Weather Network (AgriMet) site in Creston, Montana (http://www.usbr.gov/pn/agrimet/webaghrread.html) and included air temperature, dew point temperature and wind speed. The dew point temperature was adjusted by increasing the relative humidity by 15% based on local conditions within the stream corridor as measured in a similar assessment in the Big Hole River watershed (Flynn et al., 2008). In addition, cloud cover was assigned based on hourly measurements from the National Climatic Data Center (NCDC) at Kalispell Glacier Park International Airport.

E2.2.1.5 Hydrologic Balance

To evaluate tributary inflows, WWTP discharges, and irrigation water withdrawals along Ashley Creek and the Whitefish River, a hydrologic balance was created. Basic assumptions applied when developing the hydrologic balance include:

Streamflows were balanced at the outlet of each reach in which a data logger was located and flows were measured. Along Ashley Creek, streamflows were also balanced at the inlet and outlet of each of the three lakes that the streamflows through.

Where unmeasured tributaries were present in a reach, increases in streamflow were entirely attributed to the tributary inflows. When no tributaries were present, inputs were assumed to be either groundwater upwelling or un-identified surface water discharges.

Wastewater treatment plant discharges were estimated based on mean monthly data for August of 2008 obtained from the Montana DEQ Water Protection Bureau.

Decreases in streamflow were considered to be due to irrigation withdrawals, except when no irrigated agriculture was evident in the aerial imagery, in which case streamflow losses were considered due to either groundwater losses or evapotranspiration.

A detailed hydrologic balance for Ashley Creek and the Whitefish River is presented in **Attachment G**.

E2.2.2 Ashley Creek Model Scenarios

Seven model scenarios were examined for Ashley Creek; they include: 1) baseline (existing conditions), 2) shade, 3) water consumptive use, 4) shade and water consumptive use, 5) shade and 15% reduction of water withdrawn for irrigation, 6) shade with no Kalispell WWTP discharge present, and 7) shade with Kalispell WWTP discharge at the naturally occurring stream temperature. A channel morphology scenario is described in **Section E2.2.2.8**, but due to limited potential for improvement was not applied to the assessment.

E2.2.2.1 Baseline (Existing Conditions) Scenario

Once the calibration steps were performed, the QUAL2K model was run for the baseline scenario, which is intended to represent the existing conditions in Ashley Creek. This model run utilized all measured field data, with the assumptions described in **Section E2.2.1**. Hydraulic output in the model accurately reflected measured conditions, indicating that water routing and channel morphology were adequately calibrated. The modeled maximum temperatures exhibit a pattern similar to the maximum measured values with an average error of 4.1% (**Figure E2-1)**. Subsequent model scenarios were compared to the results of the baseline model and not to the field measured values to assure consistency when evaluating the potential to reduce stream temperatures.

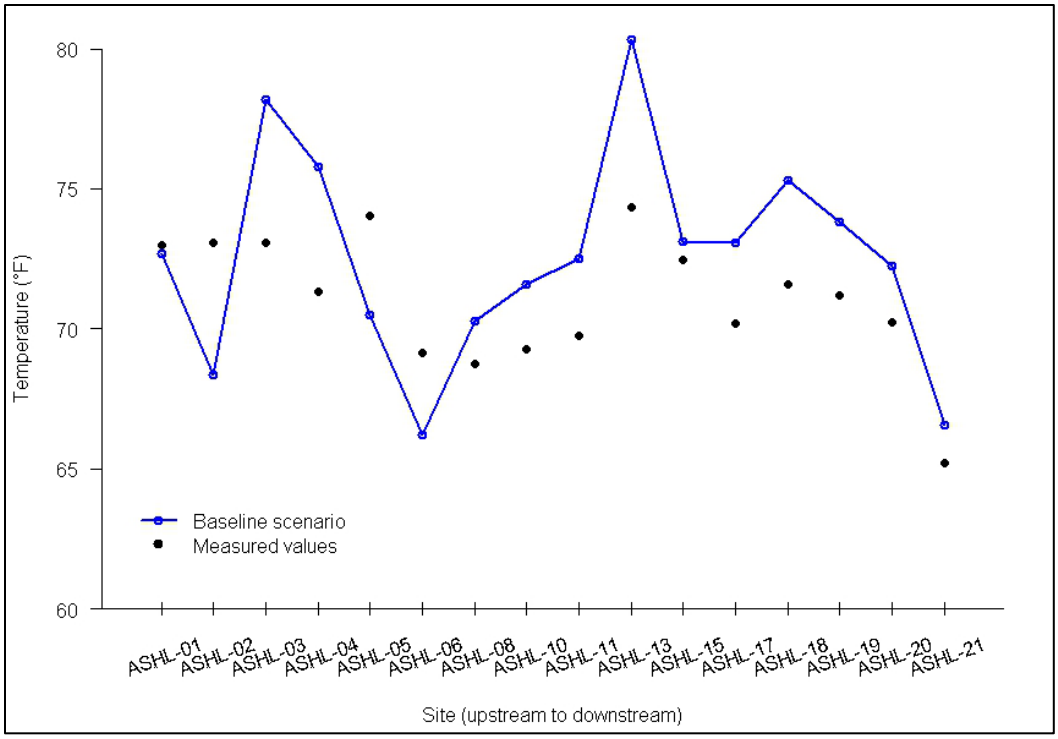


Figure E2-1. Ashley Creek QUAL2K Baseline (Existing Conditions) Scenario (maximum temperatures shown)

E2.2.2.2 Shade Scenario

In the shade scenario, areas with presently diminished shade conditions were changed to a reference condition based on field measured shade values and GIS analysis. The input from the Kalispell WWTP was not adjusted from the baseline scenario. In this scenario, it was determined that the watershed upstream of Smith Lake would naturally be forested except in reaches that appeared to occur in natural meadow environments, where the natural condition was considered to be "open/pasture." Most of the reaches of Ashley Creek downstream of Smith Lake were determined to have dense riparian vegetation as the reference condition with the two reaches having the potential for "open/pasture." For the shade scenario, a total of 10 reaches (3.8 miles) were altered to a forested vegetation type and 12 reaches (19.6 miles) were altered to a dense riparian vegetation type (**Table E2-6**). Thus, riparian shade density was increased along a total of 23.4 miles of Ashley Creek, which is 52% of the total length (44.7 miles). Reference shade values were developed based on riparian vegetation reach type average hourly shade values (see **Table E2-4**). An evaluation of existing shade and potential shade as assigned in the shade scenario is presented for each reach in **Attachment F**.

Table E2-6. Ashley Creek Existing Conditions and Shade Scenario Riparian Vegetation Reach Types

Riparian Vegetation Reach Type	Baseline (Existing Conditions) Scenario		Shade Scenario*	
	Number of Reaches	Length (Miles)	Number of Reaches	Length (Miles)
Forested	10	5.0	20	8.8
Dense Riparian	3	5.4	15	25.0
Low/Moderate Riparian	12	17.0	0	0.0
Open/Pasture	18	14.4	8	8.0
Lake	3	2.9	3	2.9

* Applied in all scenarios that incorporate the Shade Scenario.

The results of the shade scenario indicate that an increase in streamside shading along Ashley Creek would lead to a decrease in stream water temperature of 0 – 10.81°F (**Figure E2-2**; **Table E2-7**).

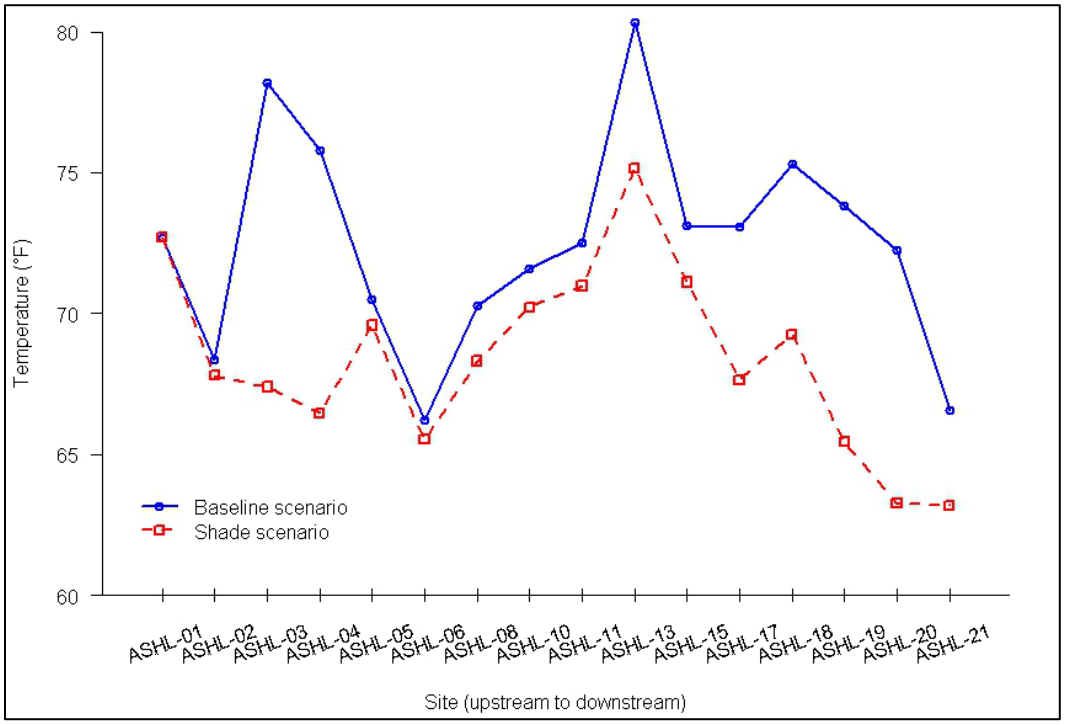


Figure E2-2. Ashley Creek QUAL2K Shade Scenario (maximum temperatures shown)

Table E2-7. Ashley Creek QUAL2K Shade Scenario

Data Logger Site	Distance (mi)	QUAL2K Baseline Scenario Maximum Temperature (°F)	QUAL2K Shade Scenario Maximum Temperature (°F)	Departure from Baseline Scenario Model (°F)
ASHL-01	44.63	72.70	72.70	0.00
ASHL-02	43.71	68.38	67.80	**0.58**
ASHL-03	41.41	78.21	67.40	**10.81**
ASHL-04	40.51	75.78	66.46	**9.32**
ASHL-05	37.66	70.49	69.58	**0.91**
ASHL-06	35.69	66.22	65.54	**0.68**
ASHL-08	31.93	70.26	68.32	**1.95**
ASHL-10	30.53	71.59	70.22	**1.37**
ASHL-11	29.65	72.51	70.98	**1.53**
ASHL-13	24.36	80.31	75.16	**5.15**
ASHL-15	21.40	73.13	71.11	**2.02**
ASHL-17	17.11	73.09	67.65	**5.44**
ASHL-18	13.39	75.31	69.26	**6.06**
ASHL-19	6.02	73.84	65.44	**8.39**
ASHL-20	3.27	72.25	63.26	**8.99**
ASHL-21	0.26	66.56	63.19	**3.37**

Bolded values indicate that the model scenario predicts a potential decrease in temperature greater than 0.5°F.

E2.2.2.3 Water Consumptive Use Scenario

The water consumptive use scenario describes the thermal effect of irrigation and domestic water uses on water temperatures in Ashley Creek. This scenario was modeled by removing existing water diversions from the study reach as identified in the hydrologic balance (**Attachment G**). The current modeling effort included irrigation withdrawals identified in seven reaches: ASH5, ASH9, ASH11, ASH13, ASH25, ASH31 and ASH37. Additional irrigation withdrawals not identified through field measurements in 2008 may be present, but were not accounted for in this modeling exercise. This scenario indicated that increased streamflows would lead to a decrease in water temperatures in Ashley Creek (**Figure E2-3**; **Table E2-8**). Due to a lack of measurements of irrigation withdrawals throughout the system, the results of the water consumptive use scenario should be interpreted with caution. If more detailed flow data for the irrigation network become available, this scenario may need to be reevaluated.

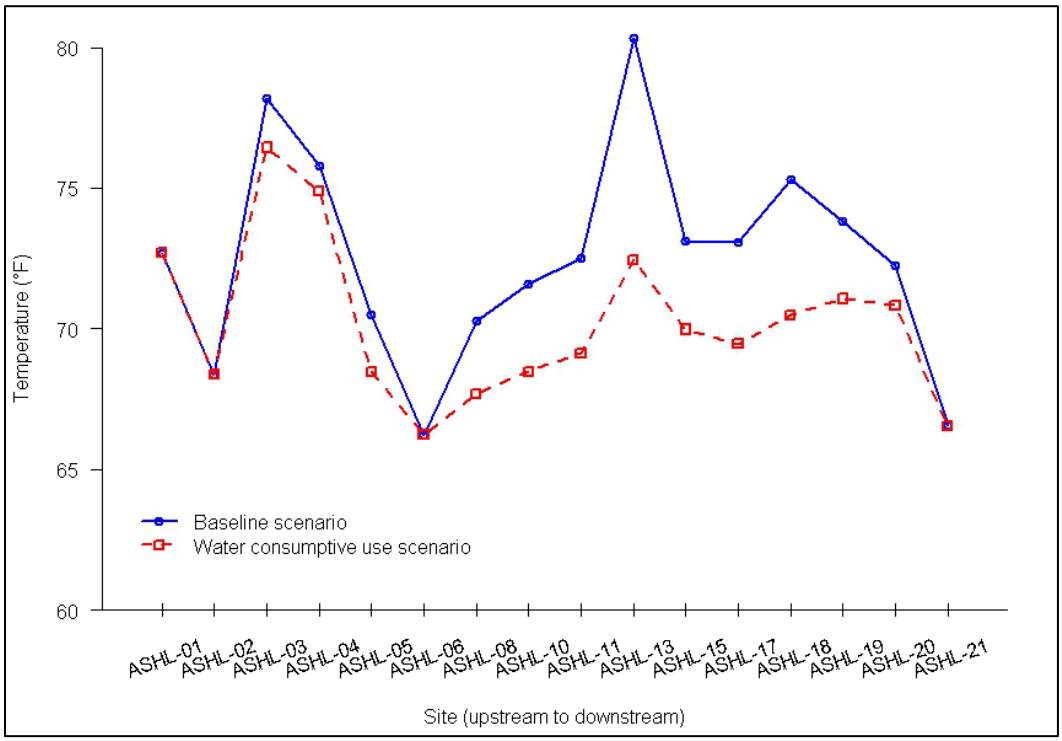


Figure E2-3. Ashley Creek QUAL2K Water Consumptive Use Scenario (maximum temperatures shown)

Table E2-8. Ashley Creek QUAL2K Water Consumptive Use Scenario

Data Logger Site	Distance (mi)	QUAL2K Baseline Scenario Maximum Temperature (°F)	QUAL2K Water Consumptive Use Scenario Maximum Temperature (°F)	Departure from Baseline Scenario Model (°F)
ASHL-01	44.63	72.70	72.70	0.00
ASHL-02	43.71	68.38	68.38	0.00
ASHL-03	41.41	78.21	76.44	**1.77**
ASHL-04	40.51	75.78	74.89	**0.89**
ASHL-05	37.66	70.49	68.48	**2.01**
ASHL-06	35.69	66.22	66.22	0.00
ASHL-08	31.93	70.26	67.68	**2.58**
ASHL-10	30.53	71.59	68.48	**3.12**
ASHL-11	29.65	72.51	69.12	**3.39**
ASHL-13	24.36	80.31	72.46	**7.86**

Table E2-8. Ashley Creek QUAL2K Water Consumptive Use Scenario

Data Logger Site	Distance (mi)	QUAL2K Baseline Scenario Maximum Temperature (°F)	QUAL2K Water Consumptive Use Scenario Maximum Temperature (°F)	Departure from Baseline Scenario Model (°F)
ASHL-15	21.40	73.13	69.98	**3.15**
ASHL-17	17.11	73.09	69.47	**3.62**
ASHL-18	13.39	75.31	70.48	**4.84**
ASHL-19	6.02	73.84	71.07	**2.77**
ASHL-20	3.27	72.25	70.83	**1.42**
ASHL-21	0.26	66.56	66.53	0.03

Bolded values indicate that the model scenario predicts a potential decrease in temperature greater than 0.5°F.

E2.2.2.4 Shade and Water Consumptive Use Scenario

The shade and water consumptive use scenario reflects the temperature regime that would be expected absent of the influence of man on nonpoint sources. Factors applied in the shade scenario (reference shade) and the water consumptive use scenario (no irrigation withdrawals) were applied to run this scenario. The results of this scenario indicate stream temperatures would naturally be lower than the existing condition along much of Ashley Creek (**Figure E2-4**; **Table E2-9**).

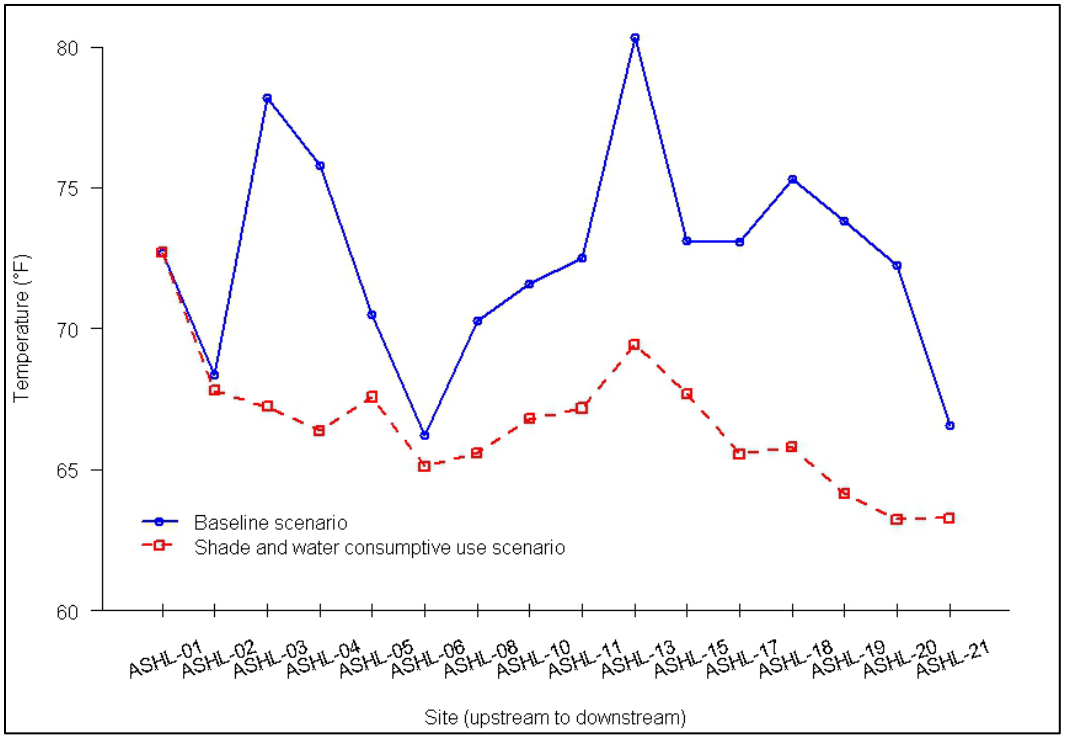


Figure E2-4. Ashley Creek QUAL2K Shade and water consumptive use scenario (maximum temperatures shown)

Table E2-9. Ashley Creek QUAL2K Shade and water consumptive use scenario

Data Logger Site	Distance (mi)	QUAL2K Baseline Scenario Maximum Temperature (°F)	QUAL2K Shade and Water Consumptive Use Scenario Maximum Temperature (°F)	Departure from Baseline Scenario Model (°F)
ASHL-01	44.63	72.70	72.70	0.00
ASHL-02	43.71	68.38	67.80	**0.58**
ASHL-03	41.41	78.21	67.23	**10.98**
ASHL-04	40.51	75.78	66.38	**9.39**
ASHL-05	37.66	70.49	67.57	**2.92**
ASHL-06	35.69	66.22	65.12	**1.10**
ASHL-08	31.93	70.26	65.58	**4.68**
ASHL-10	30.53	71.59	66.79	**4.80**
ASHL-11	29.65	72.51	67.18	**5.33**
ASHL-13	24.36	80.31	69.44	**10.87**
ASHL-15	21.40	73.13	67.69	**5.44**
ASHL-17	17.11	73.09	65.54	**7.55**
ASHL-18	13.39	75.31	65.79	**9.52**
ASHL-19	6.02	73.84	64.16	**9.68**
ASHL-20	3.27	72.25	63.23	**9.02**
ASHL-21	0.26	66.56	63.28	**3.28**

Bolded values indicate that the model scenario predicts a potential decrease in temperature greater than 0.5°F.

E2.2.2.5 Shade and 15% Reduction of Water Withdrawn for Irrigation Scenario

The Shade and 15% reduction of water withdrawn for irrigation scenario defines water temperature conditions resulting from the implementation of BMPs that would allow the shade condition to improve to potential and a 15% reduction in water withdrawal for irrigation (i.e., leaving 15% of the currently withdrawn water in the stream). This scenario included the shade scenario (reference shade) along with a 15% decrease in withdrawal from Ashley Creek attained through irrigation and domestic water use efficiency. This was estimated by reducing the seven identified irrigation withdrawals by 15%. Reducing the identified irrigation withdrawal volume by 15% is considered to be minimal based on the efficiency estimates of (Howell and Stewart, 2003) (Negri et al., 1989) (Natural Resources Conservation Service, 1997), and (Osteen et al., 2012) for different irrigation practices. Based on this scenario, it appears there is the potential for a reduction in instream temperatures relative to the baseline scenario (**Figure E2-5**; **Table E2-10**).

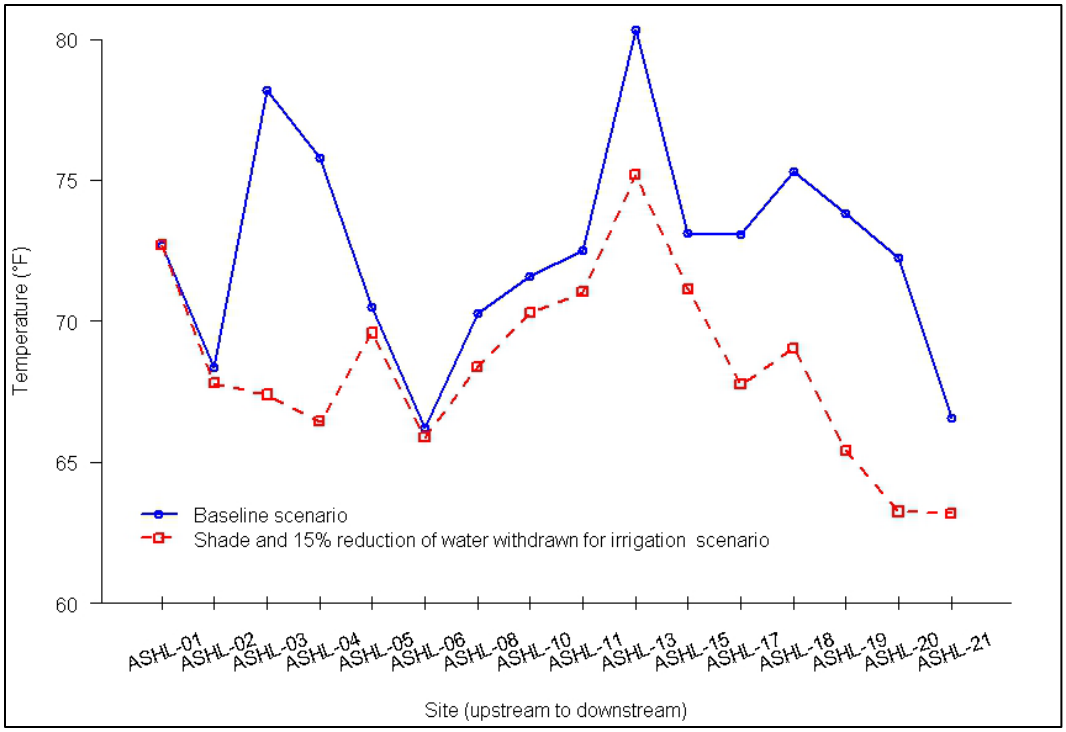


Figure E2-5. Ashley Creek QUAL2K Shade and 15% reduction of water withdrawn for irrigation scenario (maximum temperatures shown)

Table E2-10. Ashley Creek QUAL2K Shade and 15% reduction of water withdrawn for irrigation scenario

Data Logger Site	Distance (mi)	QUAL2K Baseline Scenario Maximum Temperature (°F)	QUAL2K Shade and 15% Reduction of Water Withdrawn for Irrigation Scenario Maximum Temperature (°F)	Departure from Baseline Scenario Model (°F)
ASHL-01	44.63	72.70	72.70	0.00
ASHL-02	43.71	68.38	67.80	**0.58**
ASHL-03	41.41	78.21	67.39	**10.82**
ASHL-04	40.51	75.78	66.45	**9.32**
ASHL-05	37.66	70.49	69.58	**0.91**
ASHL-06	35.69	66.22	65.88	0.34
ASHL-08	31.93	70.26	68.38	**1.88**
ASHL-10	30.53	71.59	70.29	**1.30**
ASHL-11	29.65	72.51	71.04	**1.47**
ASHL-13	24.36	80.31	75.19	**5.12**
ASHL-15	21.40	73.13	71.14	**1.99**
ASHL-17	17.11	73.09	67.75	**5.34**
ASHL-18	13.39	75.31	69.05	**6.26**
ASHL-19	6.02	73.84	65.42	**8.42**
ASHL-20	3.27	72.25	63.25	**9.00**
ASHL-21	0.26	66.56	63.18	**3.38**

Bolded values indicate that the model scenario predicts a potential decrease in temperature greater than 0.5°F.

The added benefit of keeping 15% of the water diverted in the stream appears to be limited when compared to the shade scenario alone (**Table E2-11**). Increasing the instream flows in addition to meeting shade targets resulted in no change at four sites, a decrease in temperature reduction (i.e., increased temperature) at seven sites, and an increase in temperature reduction (i.e., decreased temperature) at five sites. The increases in temperature reduction were less than 0.05°F at four of the five sites.

Table E2-11. Temperature change from the Baseline (existing) condition scenario using the Shade and 15% Reduction of Water Withdrawn for Irrigation and Shade model scenarios

Site	Baseline Scenario Temperature (°F) – Shade and 15% Reduction of Water Withdrawn for Irrigation Scenario Temperature (°F)	Baseline Scenario Temperature (°F) – Shade Scenario Temperature (°F)	Difference
ASHL-01	0.00	0.00	0.00
ASHL-02	0.58	0.58	0.00
ASHL-03	10.82	10.81	0.00
ASHL-04	9.32	9.32	0.01
ASHL-05	0.91	0.91	0.00
ASHL-06	0.34	0.68	-0.34
ASHL-08	1.88	1.95	-0.07
ASHL-10	1.30	1.37	-0.07
ASHL-11	1.47	1.53	-0.06
ASHL-13	5.12	5.15	-0.03
ASHL-15	1.99	2.02	-0.03
ASHL-17	5.34	5.44	-0.10
ASHL-18	6.26	6.06	0.21
ASHL-19	8.42	8.39	0.03
ASHL-20	9.00	8.99	0.01
ASHL-21	3.38	3.37	0.01

E2.2.2.6 Shade with no Kalispell WWTP Discharge Scenario

This scenario included the same alterations made to the model for the shade scenario but in this case the input of effluent discharge from the Kalispell WWTP was removed. This models the naturally occurring temperature of Ashley Creek from the WWTP location (13.05 miles from the mouth) downstream in the absence of the WWTP discharge (**Figure E2-6**; **Table E2-12**). This model resulted in an average naturally occurring temperature near the WWTP location (13.39 miles from the mouth) of 61.95°F (**Table E2-13**).

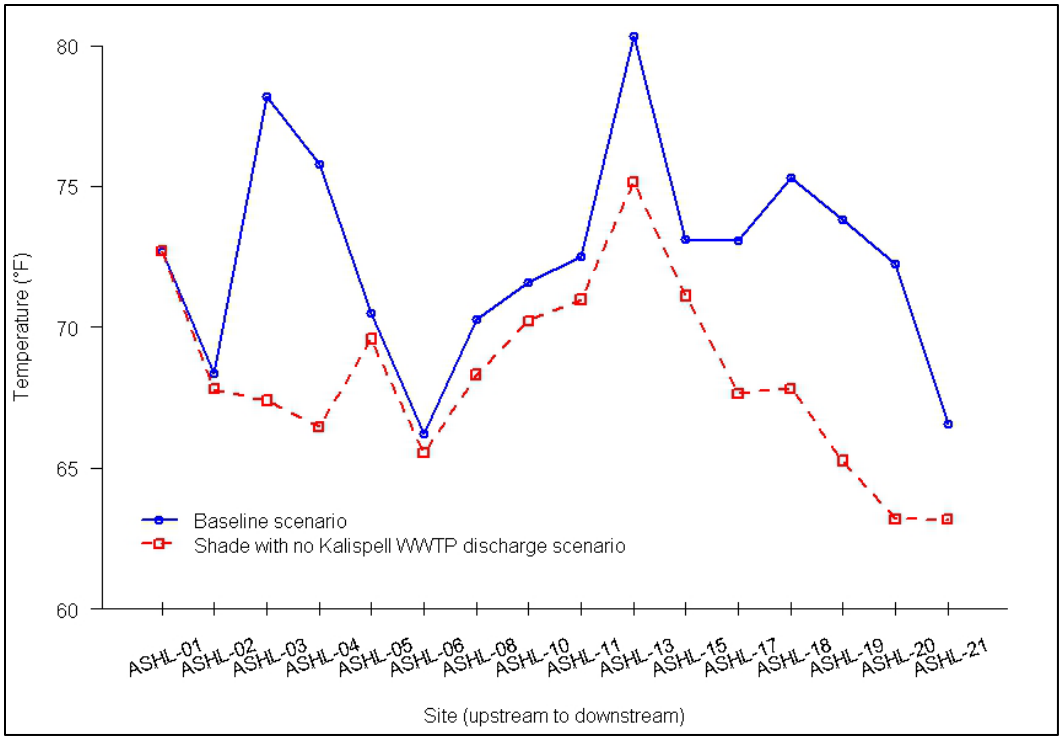


Figure E2-6. Ashley Creek QUAL2K Shade with no Kalispell WWTP discharge scenario (maximum temperatures shown)

Table E2-12. Ashley Creek QUAL2K Shade with no Kalispell WWTP discharge scenario

Data Logger Site	Distance (mi)	QUAL2K Baseline Scenario Maximum Temperature (°F)	QUAL2K Shade with no Kalispell WWTP discharge Scenario Maximum Temperature (°F)	Departure from Baseline Scenario Model (°F)
ASHL-01	44.63	72.70	72.70	0.00
ASHL-02	43.71	68.38	67.80	**0.58**
ASHL-03	41.41	78.21	67.40	**10.81**
ASHL-04	40.51	75.78	66.46	**9.32**
ASHL-05	37.66	70.49	69.58	**0.91**
ASHL-06	35.69	66.22	65.54	**0.68**
ASHL-08	31.93	70.26	68.32	**1.95**
ASHL-10	30.53	71.59	70.22	**1.37**
ASHL-11	29.65	72.51	70.98	**1.53**
ASHL-13	24.36	80.31	75.16	**5.15**
ASHL-15	21.40	73.13	71.11	**2.02**
ASHL-17	17.11	73.09	67.65	**5.44**
ASHL-18	13.39	75.31	67.82	**7.49**
ASHL-19	6.02	73.84	65.26	**8.58**
ASHL-20	3.27	72.25	63.18	**9.07**
ASHL-21	0.26	66.56	63.17	**3.40**

Bolded values indicate that the model scenario predicts a potential decrease in temperature greater than 0.5°F.

Table E2-13. Average Temperatures (°F) from the Shade with no Kalispell WWTP Discharge Scenario downstream of ASHL-17

Model Reach	Data Logger Site	Distance (mi)	QUAL2K Shade with no Kalispell WWTP Discharge Scenario Average Temperature (°F)
ASC39	**ASHL-17**	17.11	62.07
ASC39		15.25	**62.01**
ASC39	**ASHL-18**	13.39	**61.95**
ASC40		12.17	61.95
ASC40		11.60	61.94
ASC40		11.02	61.94
ASC41		10.27	61.93
ASC41		9.36	61.93
ASC41		8.45	61.92
ASC42		7.60	61.94
ASC42		6.81	61.97
ASC42	**ASHL-19**	6.02	61.99
ASC43		5.27	62.00
ASC43		4.56	62.01
ASC43		3.84	62.02
ASC44	**ASHL-20**	3.27	62.04
ASC44		2.84	62.07
ASC44		2.41	62.06
ASC45		2.09	62.07
ASC45		1.88	62.08
ASC45		1.67	62.09
ASC46		1.30	62.10
ASC46		0.78	62.12
ASC46	**ASHL-21**	0.26	62.13
Terminus		0.00	62.13

Bolded temperature values were used for other analyses in the main document and in Section E2.2.2.7

E2.2.2.7 Shade with the Kalispell WWTP Discharging at the Naturally Occurring Stream Temperature Scenario

This scenario included the same alterations made to the model for the shade scenario but in this case the input of effluent from the Kalispell WWTP was set to the average naturally occurring stream temperature of 61.95°F (based on the shade scenario with no Kalispell WWTP discharge; **Section E2.2.2.6; Table E2-13**). Based on this scenario, it appears there is the potential for a reduction of instream temperatures relative to the baseline scenario (**Figure E2-7**; **Table E2-14**).

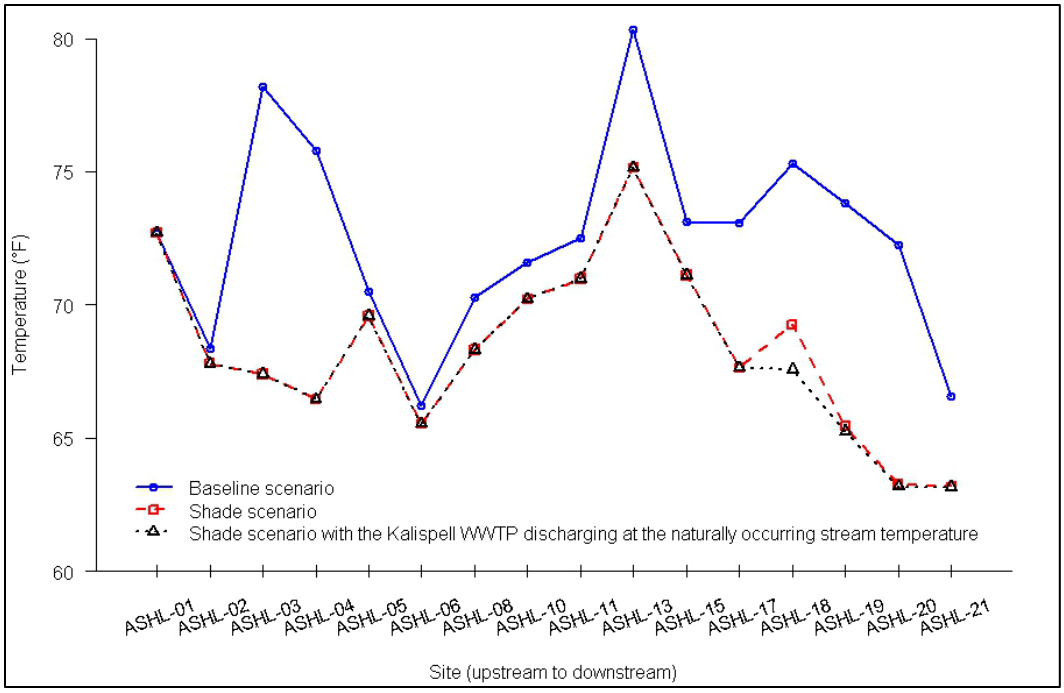


Figure E2-7. Ashley Creek QUAL2K Shade with the Kalispell WWTP discharging at the naturally occurring stream temperature scenario (maximum temperatures shown)

Table E2-14. Ashley Creek QUAL2K Shade with the Kalispell WWTP discharging at the naturally occurring stream temperature scenario

Data Logger Site	Distance (mi)	QUAL2K Baseline Scenario Maximum Temperature (°F)	QUAL2K Shade with the Kalispell WWTP Discharging at the Naturally Occurring Stream Temperature Scenario Maximum Temperature (°F)	Departure from Baseline Scenario Model (°F)
ASHL-01	44.63	72.70	72.70	0.00
ASHL-02	43.71	68.38	67.80	**0.58**
ASHL-03	41.41	78.21	67.40	**10.81**
ASHL-04	40.51	75.78	66.46	**9.32**
ASHL-05	37.66	70.49	69.58	**0.91**
ASHL-06	35.69	66.22	65.54	**0.68**
ASHL-08	31.93	70.26	68.32	**1.95**
ASHL-10	30.53	71.59	70.22	**1.37**
ASHL-11	29.65	72.51	70.98	**1.53**
ASHL-13	24.36	80.31	75.16	**5.15**
ASHL-15	21.40	73.13	71.11	**2.02**
ASHL-17	17.11	73.09	67.65	**5.44**
ASHL-18	13.39	75.31	67.57	**7.74**
ASHL-19	6.02	73.84	65.26	**8.58**
ASHL-20	3.27	72.25	63.18	**9.07**
ASHL-21	0.26	66.56	63.17	**3.39**

Bolded values indicate that the model scenario predicts a potential decrease in temperature greater than 0.5°F.

E2.2.2.8 Channel Morphology Scenario

When applying the QUAL2K model in temperature assessments, a channel morphology scenario that examines the influence of channel overwidening is often applied. However, field measurements and observations suggest there was minimal potential to reduce stream channel width. Thus, the channel morphology modeling scenario was not applied to the Ashley Creek temperature assessment.

E2.2.3 Whitefish River Model Scenarios

Two model scenarios were examined for the Whitefish River: 1) baseline (existing conditions) scenario and 2) shade scenario. A channel morphology scenario is described in **Section E2.2.3.3**, but due to limited potential for improvement was not applied to the assessment. A water consumptive use scenario is described in **Section E2.2.3.4**, but no irrigation diversions or return flows were observed on the Whitefish River in 2008 and this scenario was not applied to the assessment.

E2.2.3.1 Baseline Scenario

Once the calibration steps were performed, the QUAL2K model was run for the baseline scenario, which is intended to represent existing conditions in the Whitefish River. This model run utilized all measured field data, with the assumptions described in **Section E2.2.1** of this document. Hydraulic output in the model accurately reflected measured conditions, indicating that water routing and channel morphology were adequately calibrated. The modeled maximum temperatures exhibit a pattern similar to the maximum measured values with an average error of 1.4% (**Figure E2-8**). Subsequent model scenarios were compared to the results of the baseline model and not to the field measured values to assure consistency when evaluating the potential to reduce stream temperatures.

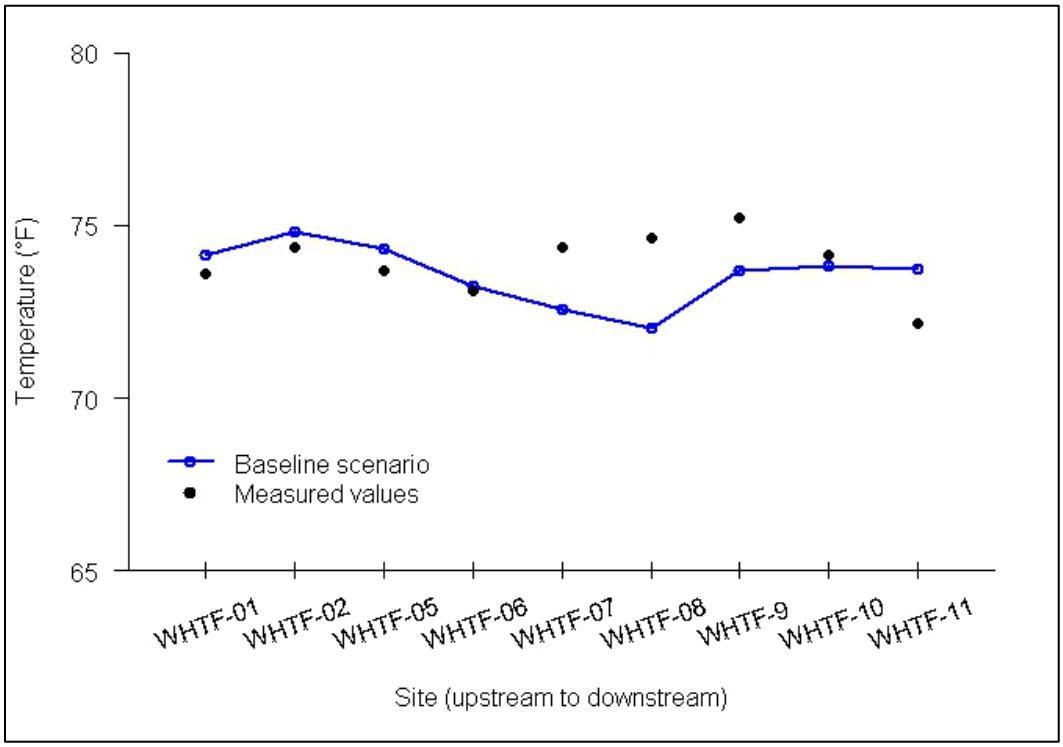


Figure E2-8. Whitefish River QUAL2K Baseline (Existing Conditions) Scenario (maximum temperatures shown)

E2.2.3.2 Shade Scenario

In the shade scenario, areas with presently diminished shade conditions were changed to a reference condition based on field measured shade values and GIS analysis. In this scenario, it was determined that the entire length of the Whitefish River would be lined by dense riparian vegetation. A total of 25 reaches (16.2 miles) were altered to a dense riparian vegetation type (**Table E2-15**). Thus, riparian shade density was increased along a total of 16.2 miles of the Whitefish River, which is 65% of the total length (24.8 miles). Dense riparian vegetation reference shade values were developed based on the reach type average hourly shade values (see **Table E2-5**). An evaluation of existing shade and potential shade as assigned in the shade scenario is presented for each reach in **Attachment F**.

Table E2-15. Whitefish River Existing Conditions and Shade Scenario Riparian Vegetation Reach Types

Riparian Vegetation Reach Type	Baseline (Existing Conditions) Scenario		Shade Scenario	
	Number of Reaches	Length (Miles)	Number of Reaches	Length (Miles)
Dense Riparian	7	8.6	32	24.8
Low/Moderate Riparian	20	15.2	0	0.0
Open/Pasture	5	1.0	0	0.0

The results of the shade scenario indicate that an increase in streamside shading along the Whitefish River would lead to a decrease in stream water temperatures (**Figure E2-9**; **Table E2-16**). In the absence of changes that could be made to channel morphology and water consumptive use (**Sections E2.2.3.3** and **E2.2.3.4**) this scenario represents implementation of all reasonable land, soil, and water conservation practices and thus the naturally occurring condition.

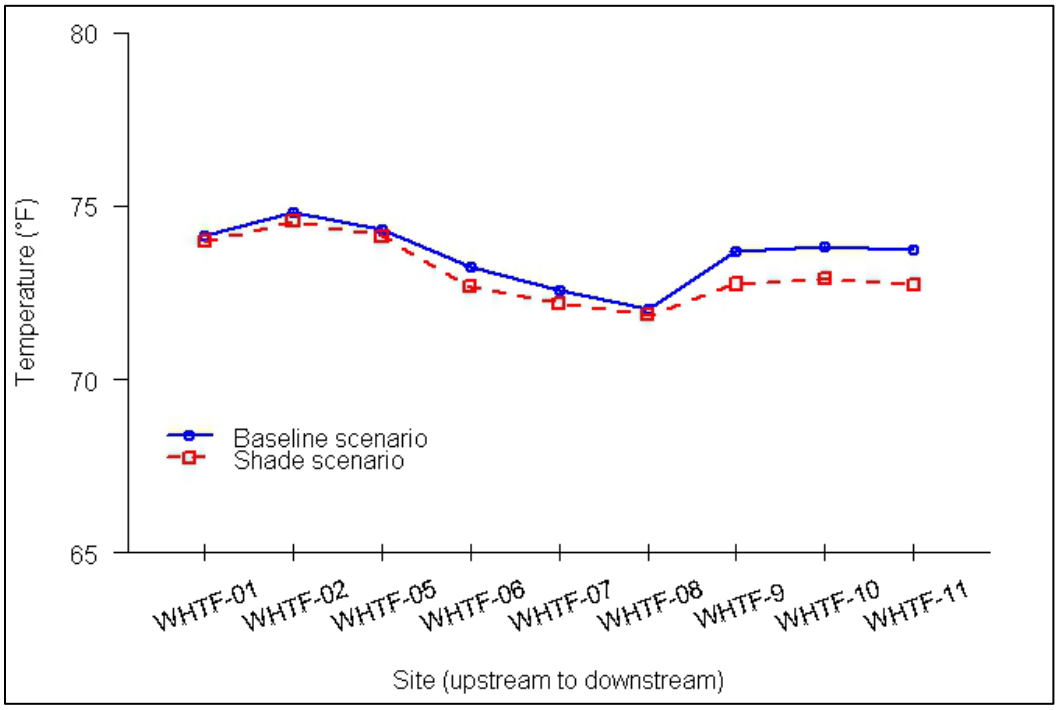


Figure E2-9. Whitefish River QUAL2K Shade Scenario (maximum temperatures shown)

Table E2-16. Whitefish River QUAL2K Shade Scenario (maximum temperatures shown)

Data Logger Site	Distance (mi)	QUAL2K Baseline Scenario Maximum Temperature (°F)	QUAL2K Shade Scenario Maximum Temperature (°F)	Departure from Baseline Scenario Model (°F)
WHTF-01	24.48	74.13	73.98	0.15
WHTF-02	23.20	74.81	74.55	0.26
WHTF-05	18.70	74.34	74.12	0.21
WHTF-06	15.48	73.26	72.67	**0.58**
WHTF-07	12.81	72.57	72.19	0.38
WHTF-08	8.97	72.02	71.87	0.15
WHTF-09	5.36	73.70	72.75	**0.96**
WHTF-10	2.82	73.84	72.90	**0.94**
WHTF-11	0.10	73.73	72.73	**1.00**

Bolded values indicate that the model scenario predicts a potential decrease in temperature greater than 0.5°F.

E2.2.3.3 Channel Morphology Scenario

When applying the QUAL2K model in temperature assessments, a channel morphology scenario that examines the influence of channel overwidening is often applied. However, field measurements and observations suggest there was minimal potential to reduce stream channel width. Thus, the channel morphology modeling scenario was not applied to the Whitefish River temperature assessment.

E2.2.3.4 Water Consumptive Use Scenario

No irrigation withdrawals or return flows were identified along the Whitefish River based on measurements made during this assessment. Thus, the water consumptive use scenario was not explored. However, if additional information becomes available regarding irrigation withdrawals and return flows, this scenario may need to be reevaluated.

E2.3 MODELED TEMPERATURES RELATIVE TO MONTANA STANDARDS

Comparing the baseline scenario with the naturally occurring scenario for both Ashley Creek and the Whitefish River indicated that the water quality standard for temperature is exceeded in both waterbodies.

E2.3.1 Ashley Creek

The shade with the Kalispell WWTP discharging at the naturally occurring stream temperature scenario (naturally occurring) indicated that maximum water temperatures of 63.17 – 75.16°F can be expected in Ashley Creek. Thus, the maximum allowable increase due to unmitigated human causes at these temperatures is 0.5 – 1.0°F. Based on the QUAL2K model results, the standard was exceeded at 14 out of 16 temperature monitoring sites in 2008 (**Table E2-17**). Model scenarios indicate that an increase in shade, an increase in streamflow, and a decrease in the Kalispell WWTP effluent temperature would help reduce water temperatures in Ashley Creek.

Table E2-17. Ashley Creek Temperatures Relative to Montana's Water Quality Standards

Data Logger Site	Distance (mi)	QUAL2K Baseline Scenario Maximum Temperature (°F)	QUAL2K Shade with the Kalispell WWTP Discharging at the Naturally Occurring Stream Temperature Scenario Maximum Temperature (°F)	Temperature Change allowed by the Standard (°F)	Modeled Temperature Change (°F)
ASHL-01	25.73	72.70	72.70	0.50	0.00
ASHL-02	25.17	68.38	67.80	0.50	**0.58**
ASHL-03	23.40	78.21	67.40	0.50	**10.81**

Table E2-17. Ashley Creek Temperatures Relative to Montana's Water Quality Standards

Data Logger Site	Distance (mi)	QUAL2K Baseline Scenario Maximum Temperature (°F)	QUAL2K Shade with the Kalispell WWTP Discharging at the Naturally Occurring Stream Temperature Scenario Maximum Temperature (°F)	Temperature Change allowed by the Standard (°F)	Modeled Temperature Change (°F)
ASHL-04	22.18	75.78	66.46	0.54	**9.32**
ASHL-05	19.84	70.49	69.58	0.50	**0.91**
ASHL-06	18.97	66.22	65.54	1.00	0.68
ASHL-08	18.42	70.26	68.32	0.50	**1.95**
ASHL-10	15.14	71.59	70.22	0.50	**1.37**
ASHL-11	13.30	72.51	70.98	0.50	**1.53**
ASHL-13	10.63	80.31	75.16	0.50	**5.15**
ASHL-15	8.32	73.13	71.11	0.50	**2.02**
ASHL-17	3.74	73.09	67.65	0.50	**5.44**
ASHL-18	2.03	76.00	67.57	0.50	**8.43**
ASHL-19	0.16	73.90	65.26	1.00	**8.64**
ASHL-20	0.00	72.27	63.18	1.00	**9.09**
ASHL-21	0.00	66.56	63.17	1.00	**3.39**

Bolded values indicate that the water quality standard is being exceeded.

E2.3.2 Whitefish River

The shade scenario (naturally occurring) indicated that maximum water temperatures of 71.87 – 74.55°F can be expected in the Whitefish River. Thus, the maximum allowable increase due to unmitigated human causes at these temperatures is 0.5°F. Based on the QUAL2K model results, the standard was exceeded at four out of nine temperature monitoring sites in 2008 (**Table E2-18**). Model scenarios indicate that an increase in shade would help reduce water temperatures in the Whitefish River.

Table E2-18. Whitefish River Temperatures Relative to Montana's Water Quality Standards

Data Logger Site	Distance (mi)	QUAL2K Baseline Scenario Maximum Temperature (°F)	QUAL2K Shade Scenario Maximum Temperature (°F)	Temperature Change Allowed by the Standard (°F)	Modeled Temperature Change (°F)
WHTF-01	14.42	74.13	73.98	0.50	0.15
WHTF-02	11.62	74.81	74.55	0.50	0.26
WHTF-05	9.62	74.34	74.12	0.50	0.21
WHTF-06	7.96	73.26	72.67	0.50	**0.58**
WHTF-07	5.57	72.57	72.19	0.50	0.38
WHTF-08	3.33	72.02	71.87	0.50	0.15
WHTF-09	1.75	73.70	72.75	0.50	**0.96**
WHTF-10	0.06	73.84	72.90	0.50	**0.94**
WHTF-11	0.00	73.73	72.73	0.50	**1.00**

Bolded values indicate that the model scenario predicts a potential decrease in temperature greater than 0.5°F.

E3.0 CONCLUSIONS

Major findings and restoration recommendations include:

- Temperature data collected in 2008 and the results of this QUAL2K modeling effort suggest that Ashley Creek and the Whitefish River fail to meet Montana's standard for temperature during low flow periods in the middle of summer.

- In Ashley Creek, modeling indicated that increased shading along 23.4 miles of Ashley Creek (52%) would lead to a decrease of instream temperatures. Decreasing the temperature of effluent being discharged from the Kalispell WWTP and increased instream flow would lead to additional decreases in water temperatures.

- In the Whitefish River, modeling indicated that increased shading along 16.2 miles (65%) would lead to a decrease in water temperatures.

Limitations of this study include a lack of detailed flow measurements for tributary streams and the irrigation network, as well as the reliance on a simplified hydrologic balance based on limited data points, including a basic analysis of the interaction between Ashley Creek and the three lakes it flows through: Lone, Monroe (between ASHL-04 and ASHL-05) and Smith (between ASHL-11 and ASHL-12). Thus, the results of this assessment may need to be reevaluated as additional information becomes available.

E4.0 REFERENCES

Bear, Elizabeth A., Thomas E. McMahon, and Alexander V. Zale. 2007. Comparative Thermal Requirements of Westslope Cutthroat Trout and Rainbow Trout: Implications for Species Interactions and Development of Thermal Protection Standards. *Transactions of the American Fisheries Society.* 136: 1113-1121.

Carlson, John. 2001. Montana Animal Species of Special Concern. Helena, MT: Montana Fish, Wildlife, and Parks.

Flynn, Kyle F., Darrin Kron, and Marcus Granger. 2008. Modeling Streamflow and Water Temperature in the Big Hole River, Montana - 2006. Helena, MT: Montana Dept. of Environmental Quality, Water Quality Planning Bureau, Watershed Modeling Program. TMDL Technical Report DMS-2008-03.

Howell, Terry A. and B. A. Stewart. 2003. "Irrigation Efficiency," in *Encyclopedia of Water Science*, (New York, NY: Marcel Dekker): 467-472.

Lohr, S. C. P. A. B. C. M. K. a. W. P. D. 1996. High-Temperature Tolerances of Fluvial Arctic Grayling and Comparison With Summer River Temperatures of the Big Hole River, Montana. *Transactions of the American Fisheries Society.* 125: 933-939.

Marsh-McBirney, Inc. 1990. Model 2000 Installation and Operations Manual. Frederick, MD: **Marsh-McBirney, Inc.**

Montana Department of Environmental Quality. 2008. Flathead-Stillwater TMDL Planning Area Temperature and Instantaneous Flow Monitoring Sampling and Analysis Plan. Helena, MT: Montana Dept. of Environmental Quality.

Natural Resources Conservation Service. 1997. National Engineering Handbook Irrigation Guide, Vol. Part 652, Washington, D.C.: Natural Resources Conservation Service.

Negri, Donald, John J Hanchar, and U.S. Department of Agriculture, Economic Research Service. 1989. Water Conservation Through Irrigation Technology. Washington, D.C.: Economic Research Service. AIB-576.

Osteen, C., J. Gottlieb, and U. Vasavada. 2012. Agricultural Resources and Environmental Indicators. Washington, D.C.: United States Department of Agriculture, Economic Research Service. EIB-98.

ATTACHMENT EA – 2008 TEMPERATURE DATA SUMMARY

Summary Temperature Data for Ashley Creek and Whitefish River Temperature Logger Sites

Site Name	Lat	Long	Start Date	Stop Date	Seasonal Maximum		Seasonal Minimum		Seasonal Max ΔT		7-Day averages				Days >50 F	Days >59 F	Days >70 F	Hours >50 F	Hours >59 F	Hours >70 F	Warmest day of 7-day max			Agency
					Date	Value	Date	Value	Date	Value	Date	Maximum	Minimum	Δ T							Date	Maximum	Minimum	
ASHL-01	48.1049	114.3704	07/23/08	09/10/08	08/17/08	75.6	09/10/08	45.5	09/10/08	27.9	07/27/08	73.7	67.4	6.3	50	50	28	1198.0	1071.5	316.5	07/27/08	75.2	68.9	DEQ
ASHL-02	48.1041	114.3613	07/23/08	09/10/08	08/17/08	76.5	09/10/08	46.5	09/10/08	26.9	07/27/08	73.9	63.9	10.0	50	48	29	1199.0	962.0	186.5	07/27/08	75.5	65.4	DEQ
ASHL-03	48.0929	114.3607	07/23/08	09/09/08	08/17/08	76.3	09/08/08	50.0	08/04/08	15.0	07/26/08	73.9	61.7	12.2	49	46	24	1174.0	872.5	179.0	07/26/08	76.0	62.6	DEQ
ASHL-04	48.0857	114.3602	07/23/08	09/15/08	08/17/08	74.6	09/08/08	49.6	08/04/08	13.5	07/26/08	72.3	61.4	10.8	55	49	18	1317.0	885.5	148.0	07/26/08	74.6	62.3	DEQ
ASHL-05	48.0728	114.3907	07/23/08	09/16/08	08/17/08	76.2	09/11/08	56.3	08/04/08	10.1	07/28/08	74.9	66.5	8.4	56	56	31	1343.5	1195.0	302.5	07/25/08	75.5	65.7	DEQ
ASHL-06	48.06	114.3344	07/23/08	09/09/08	08/17/08	72.8	09/08/08	49.6	08/05/08	11.8	08/16/08	70.2	61.0	9.3	49	44	10	1173.0	837.5	72.0	08/17/08	72.8	62.5	DEQ
ASHL-07	48.0555	114.3348	07/23/08	09/09/08	07/26/08	62.2	09/06/08	47.6	08/29/08	8.1	07/26/08	61.4	55.1	6.3	49	23	0	1081.0	169.0	0.0	07/26/08	62.2	55.7	DEQ
ASHL-08	48.0527	114.2951	07/23/08	09/15/08	08/17/08	72.5	09/02/08	51.9	08/04/08	8.9	08/17/08	70.2	63.9	6.3	55	41	8	1319.5	867.5	52.5	08/17/08	72.5	66.0	DEQ
ASHL-09	48.0534	114.294	07/23/08	09/15/08	08/18/08	72.8	09/02/08	51.8	08/14/08	8.1	08/17/08	70.4	64.0	6.4	55	43	8	1319.5	896.0	61.5	08/17/08	72.8	65.7	DEQ
ASHL-18	48.1029	114.1832	07/23/08	09/15/08	08/17/08	76.4	09/08/08	53.2	08/29/08	9.7	08/17/08	73.3	66.2	7.1	55	54	21	1319.5	1038.0	199.0	08/17/08	76.4	67.7	DEQ
ASHL-10	48.0604	114.2842	07/24/08	09/15/08	08/17/08	72.8	09/02/08	52.7	07/25/08	8.8	07/27/08	70.6	64.1	6.5	54	39	12	1295.5	870.5	78.0	07/26/08	72.8	64.9	DEQ
ASHL-11	48.0621	114.2735	07/23/08	09/15/08	08/17/08	73.7	09/02/08	52.7	08/04/08	7.5	08/17/08	71.8	65.8	6.0	55	45	13	1319.5	915.0	86.0	08/17/08	73.7	67.5	DEQ
ASHL-13	48.0958	114.2546	07/23/08	09/09/08	08/17/08	79.8	09/08/08	50.0	08/23/08	16.8	08/16/08	76.8	64.1	12.7	49	48	30	1175.5	936.5	200.0	08/17/08	79.8	65.2	DEQ
ASHL-15	48.1112	114.2342	07/23/08	09/09/08	08/17/08	76.5	09/08/08	49.6	08/16/08	13.0	08/16/08	73.9	63.1	10.8	49	46	23	1173.0	875.0	175.0	08/17/08	76.5	64.0	DEQ
ASHL-16	48.1133	114.2014	07/29/08	09/16/08	08/17/08	66.9	09/02/08	48.8	08/06/08	6.9	08/17/08	65.1	59.8	5.3	50	29	0	1167.0	502.0	0.0	08/17/08	66.9	61.1	DEQ
ASHL-17	48.112	114.1952	07/29/08	09/10/08	08/17/08	73.1	09/08/08	50.5	08/06/08	11.1	08/07/08	70.9	62.6	8.3	44	32	13	1055.5	663.0	84.5	08/09/08	72.8	65.4	DEQ
ASHL-19	48.0845	114.1707	07/23/08	09/15/08	08/17/08	73.9	09/02/08	55.1	08/06/08	7.1	07/27/08	72.4	67.7	4.7	55	49	20	1319.5	1013.0	236.0	07/28/08	73.6	67.9	DEQ
ASHL-20	48.0807	114.1441	07/22/08	09/11/08	07/26/08	73.3	09/06/08	57.6	07/25/08	5.1	07/27/08	72.7	69.6	3.2	52	52	20	1247.5	1197.5	345.5	07/26/08	73.3	69.7	DEQ
ASHL-21	48.0924	114.124	07/22/08	09/15/08	07/27/08	69.7	09/15/08	56.8	07/22/08	7.5	07/27/08	69.3	66.2	3.1	56	56	0	1343.5	1177.5	0.0	07/27/08	69.7	64.2	DEQ
WHTF-01	48.414	114.351	07/19/08	09/11/08	08/18/08	73.7	09/11/08	57.1	08/05/08	8.5	08/16/08	72.4	67.4	5.0	55	55	26	1319.5	1292.5	145.0	08/18/08	73.7	68.4	DEQ
WHTF-02	48.2404	114.2004	07/19/08	09/11/08	08/18/08	74.4	09/11/08	54.4	09/11/08	7.6	08/16/08	72.9	67.2	5.7	55	55	27	1319.5	1244.0	206.0	08/17/08	74.4	67.5	DEQ
WHTF-04	48.2238	114.1802	07/22/08	09/14/08	07/26/08	68.0	09/14/08	46.0	07/25/08	9.2	07/25/08	66.9	59.8	7.1	55	36	0	1245.5	622.5	0.0	07/26/08	68.0	59.6	DEQ
WHTF-05	48.2211	114.1807	07/22/08	09/14/08	08/18/08	73.7	09/14/08	56.3	07/25/08	7.1	08/16/08	72.6	67.7	4.9	55	55	26	1319.5	1243.0	244.5	08/17/08	73.7	68.6	DEQ
WHTF-06	48.2031	114.1626	07/22/08	09/11/08	08/18/08	73.3	09/11/08	57.8	08/29/08	4.3	08/17/08	71.7	69.0	2.7	52	52	17	1247.5	1205.0	209.0	08/18/08	73.3	70.8	DEQ
WHTF-07	48.3197	114.2784	07/22/08	09/10/08	08/18/08	74.5	09/02/08	56.8	08/24/08	5.5	08/17/08	72.8	68.1	4.7	51	51	22	1223.5	1153.0	228.0	08/18/08	74.5	69.4	DEQ
WHTF-08	48.2907	114.2889	07/22/08	09/10/08	08/18/08	74.6	09/08/08	54.4	08/05/08	9.1	08/16/08	72.8	65.7	7.1	51	51	19	1223.5	1041.5	169.5	08/17/08	74.6	66.6	DEQ
WHTF-09	48.1522	114.1716	07/22/08	09/10/08	08/18/08	75.2	09/08/08	53.4	08/05/08	11.2	08/16/08	73.3	64.8	8.5	51	51	26	1223.5	1040.5	219.5	08/17/08	75.2	65.6	DEQ
WHTF-10	48.1424	114.1732	07/22/08	09/10/08	08/17/08	74.3	09/08/08	53.8	08/05/08	11.1	07/28/08	72.9	64.1	8.8	51	51	25	1223.5	1028.0	187.0	07/26/08	74.3	64.8	DEQ
WHTF-11	48.125	114.1712	07/22/08	09/10/08	07/26/08	73.2	09/02/08	54.4	07/25/08	9.4	07/27/08	71.9	64.4	7.5	51	49	17	1223.5	993.5	112.5	07/26/08	73.2	64.6	DEQ

ATTACHMENT EB – SOLAR PATHFINDER HOURLY SHADE MEASUREMENTS

Reach	Section	6-7am	7-8am	8-9am	9-10am	10-11am	11-12pm	12-1pm	1-2pm	2-3pm	3-4pm	4-5pm	5-6pm	TOTAL
	Potential	***3***	***5***	***8***	***10***	***12***	***12***	***12***	***12***	***10***	***8***	***5***	***3***	
ASC4-1	Transect 1	3	5	7	10	9	10	8	10	2	8	5	3	80
ASC4-2	Transect 2	3	5	8	8	1	8	4	10	9	8	5	3	72
ASC4-3	Transect 3	3	5	8	8	1	1	9	12	10	7	3	3	70
ASC4	**Average %**	**100%**	**100%**	**96%**	**87%**	**31%**	**53%**	**58%**	**89%**	**70%**	**96%**	**87%**	**100%**	***80%***
ASC10-1	Transect 1	3	1	0	0	0	0	0	0	0	0	1	3	8
ASC10-2	Transect 2	2	0	0	0	0	0	0	0	0	0	2	3	7
ASC10-3	Transect 3	1	0	0	0	0	0	0	0	0	0	3	3	7
ASC10	**Average %**	**67%**	**7%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**40%**	**100%**	***18%***
ASC16-1	Transect 1	3	5	8	2	0	7	12	6	9	8	5	3	68
ASC16-2	Transect 2	3	5	7	6	6	8	10	12	10	8	5	3	83
ASC16-3	Transect 3	3	5	7	7	0	0	0	10	10	8	5	3	58
ASC16	**Average %**	**100%**	**100%**	**92%**	**50%**	**17%**	**42%**	**61%**	**78%**	**97%**	**100%**	**100%**	**100%**	***78%***
ASC17-1	Transect 1	0	0	0	0	0	0	0	0	0	0	0	1	1
ASC17-2	Transect 2	0	0	0	0	0	0	0	0	0	2	2	3	7
ASC17-3	Transect 3	1	0	0	0	0	0	0	0	0	0	0	1	2
ASC17	**Average %**	**11%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**8%**	**13%**	**56%**	***7%***
ASC22-1	Transect 1	3	5	7	8	11	11	0	4	10	8	5	3	75
ASC22-2	Transect 2	3	5	7	9	9	0	4	10	10	8	5	3	73
ASC22-3	Transect 3	3	5	8	10	6	9	6	9	0	1	5	3	65
ASC22	**Average %**	**100%**	**100%**	**92%**	**90%**	**72%**	**56%**	**28%**	**64%**	**67%**	**71%**	**100%**	**100%**	***78%***
ASC31-1C	Transect 1 - center	2	0	0	0	0	0	0	0	0	0	0	0	2
ASC31-1L	Transect 1 - left	0	0	0	0	0	0	0	0	0	0	0	1	1
ASC31-1R	Transect 1 - right	0	0	0	0	0	0	0	0	0	0	0	1	1
ASC31-2C	Transect 2 - center	0	0	0	0	0	0	0	0	0	0	0	0	0
ASC31-2L	Transect 2 - left	0	0	0	0	0	0	0	0	0	0	0	2	2
ASC31-2R	Transect 2 - right	0	0	0	0	0	0	0	0	0	0	0	3	3
ASC31-3C	Transect 3 - center	0	0	0	0	0	0	0	0	0	0	0	0	0
ASC31-3L	Transect 3 - left	0	0	0	0	0	0	0	0	0	0	0	2	2
ASC31-3R	Transect 3 - right	1	0	0	0	0	0	0	0	0	0	0	0	1
ASC31	**Average %**	**11%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**33%**	***4%***
ASC33-1C	Transect 1 - center	0	0	0	0	0	0	0	0	0	0	2	3	5
ASC33-1L	Transect 1 - left	1	0	0	0	0	0	0	0	1	8	5	3	18
ASC33-1R	Transect 1 - right	0	0	0	0	0	0	0	0	0	0	0	1	1
ASC33-2C	Transect 2 - center	1	0	0	0	0	0	0	0	0	0	0	1	2
ASC33-2L	Transect 2 - left	3	1	0	0	0	0	0	0	0	0	0	1	5
ASC33-2R	Transect 2 - right	0	0	0	0	0	0	0	0	1	2	3	3	9
ASC33-3C	Transect 3 - center	3	5	2	0	0	0	0	0	0	0	1	3	14
ASC33-3L	Transect 3 - left	3	2	0	0	0	0	0	0	0	0	3	3	11
ASC33-3R	Transect 3 - right	3	5	7	9	5	4	1	0	0	0	0	0	34
ASC33	**Average %**	**52%**	**29%**	**13%**	**10%**	**5%**	**4%**	**1%**	**0%**	**2%**	**14%**	**31%**	**67%**	***19%***
ASC35-1	Transect 1	2	3	7	7	6	7	10	4	0	2	4	3	55
ASC35-2	Transect 2	3	5	5	6	5	1	4	3	0	1	5	3	41
ASC35-3	Transect 3	3	4	6	8	12	9	5	2	10	7	5	3	74
ASC35	**Average %**	**89%**	**80%**	**75%**	**70%**	**64%**	**47%**	**53%**	**25%**	**33%**	**42%**	**93%**	**100%**	***64%***
ASC36-1	Transect 1	1	0	0	0	0	0	0	5	10	8	5	3	32

Reach	Section	6-7am	7-8am	8-9am	9-10am	10-11am	11-12pm	12-1pm	1-2pm	2-3pm	3-4pm	4-5pm	5-6pm	TOTAL
	Potential	***3***	***5***	***8***	***10***	***12***	***12***	***12***	***12***	***10***	***8***	***5***	***3***	
ASC36-2	Transect 2	0	0	0	0	0	0	0	0	0	0	0	2	2
ASC36-3	Transect 3	3	3	5	10	10	2	11	5	0	0	0	0	49
ASC36	**Average %**	**44%**	**20%**	**21%**	**33%**	**28%**	**6%**	**31%**	**28%**	**33%**	**33%**	**33%**	**56%**	***30%***
ASC39-1C	Transect 1 - center	2	0	0	0	9	7	0	0	0	0	0	0	18
ASC39-1L	Transect 1 - left	2	0	0	0	0	0	0	0	0	0	0	3	5
ASC39-1R	Transect 1 - right	3	5	7	10	10	11	11	4	3	0	0	0	64
ASC39-2C	Transect 2 - center	1	0	0	0	0	3	4	0	0	0	0	0	8
ASC39-2L	Transect 2 - left	3	2	0	0	0	0	0	0	0	0	0	0	5
ASC39-2R	Transect 2 - right	1	1	5	8	10	12	12	12	10	6	2	0	79
ASC39-3C	Transect 3 - center	3	1	0	0	0	0	0	0	0	0	0	1	5
ASC39	**Average %**	**71%**	**26%**	**21%**	**26%**	**35%**	**39%**	**32%**	**19%**	**19%**	**11%**	**6%**	**19%**	***27%***
ASC40-1	Transect 1	2	0	0	0	0	0	0	0	0	0	2	3	7
ASC40-2	Transect 2	3	5	6	0	0	0	0	0	0	0	5	3	22
ASC40-3	Transect 3	3	2	0	0	0	0	0	0	0	0	4	3	12
ASC40	**Average %**	**89%**	**47%**	**25%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**73%**	**100%**	***28%***
ASC44-1C	Transect 1 - center	1	0	0	0	0	0	0	0	0	0	0	1	2
ASC44-1L	Transect 1 - left	1	0	0	0	0	0	0	0	0	1	5	3	10
ASC44-1R	Transect 1 - right	2	5	6	0	4	2	1	7	1	0	0	1	29
ASC44-2C	Transect 2 - center	2	4	4	0	0	0	0	0	0	0	0	1	11
ASC44-2L	Transect 2 - left	0	1	0	0	0	0	0	0	0	0	0	1	2
ASC44-2R	Transect 2 - right	3	5	6	0	0	0	0	0	0	0	0	2	16
ASC44	**Average %**	**50%**	**50%**	**33%**	**0%**	**6%**	**3%**	**1%**	**10%**	**2%**	**2%**	**17%**	**50%**	***19%***

Reach	Section	6-7am	7-8am	8-9am	9-10am	10-11am	11-12pm	12-1pm	1-2pm	2-3pm	3-4pm	4-5pm	5-6pm	TOTAL
	Potential	***3***	***5***	***8***	***10***	***12***	***12***	***12***	***12***	***10***	***8***	***5***	***3***	
WFR1-1C	Transect 1 - center	3	3	0	0	0	0	0	0	0	0	1	3	10
WFR1-1L	Transect 1 - left	2	4	6	9	4	0	0	0	0	0	0	1	26
WFR1-1R	Transect 1 - right	2	0	0	0	0	0	0	0	8	2	1	3	16
WFR1-2C	Transect 2 - center	3	2	0	0	0	0	0	0	0	0	2	3	10
WFR1-2L	Transect 2 - left	2	3	8	8	1	0	0	0	0	0	0	2	24
WFR1-2R	Transect 2 - right	2	0	0	1	12	12	11	6	10	7	4	3	68
WFR1-3C	Transect 3 - center	3	5	0	0	0	0	0	0	0	0	4	3	15
WFR1-3L	Transect 3 - left	3	5	1	1	0	0	0	0	0	0	4	3	17
WFR1-3R	Transect 3 - right	3	1	0	1	11	11	10	10	8	7	5	3	70
WFR1	**Average %**	**85%**	**51%**	**21%**	**22%**	**26%**	**21%**	**19%**	**15%**	**29%**	**22%**	**47%**	**89%**	**37%**
WFR13-1C	Transect 1 - center	3	5	6	4	0	0	0	0	8	7	5	3	41
WFR13-1L	Transect 1 - left	3	5	8	10	11	1	0	0	4	4	5	3	54
WFR13-1R	Transect 1 - right	3	4	5	1	0	0	0	11	7	8	5	3	47
WFR13-2C	Transect 2 - center	3	5	7	9	7	0	0	0	0	4	5	3	43
WFR13-2L	Transect 2 - left	3	5	8	9	7	8	0	0	0	3	5	3	51
WFR13-2R	Transect 2 - right	3	3	3	1	0	0	0	0	5	6	5	3	29
WFR13-3C	Transect 3 - center	3	4	1	8	11	1	0	0	0	3	4	3	38
WFR13-3L	Transect 3 - left	3	5	6	5	11	11	0	0	0	2	3	3	49
WFR13-3R	Transect 3 - right	3	4	1	9	7	0	0	0	0	3	5	3	35
WFR13	**Average %**	**100%**	**89%**	**63%**	**62%**	**50%**	**19%**	**0%**	**10%**	**27%**	**56%**	**93%**	**100%**	**56%**
WFR15-1C	Transect 1 - center	3	4	3	0	0	0	0	6	9	8	5	3	41
WFR15-1L	Transect 1 - left	3	5	7	10	10	0	0	0	7	7	5	3	57
WFR15-1R	Transect 1 - right	3	5	0	0	0	10	12	12	5	8	5	3	63

Reach	Section	6-7am	7-8am	8-9am	9-10am	10-11am	11-12pm	12-1pm	1-2pm	2-3pm	3-4pm	4-5pm	5-6pm	TOTAL
	Potential	***3***	***5***	***8***	***10***	***12***	***12***	***12***	***12***	***10***	***8***	***5***	***3***	
WFR15-2C	Transect 2 - center	2	5	8	8	0	0	0	0	1	7	5	3	39
WFR15-2L	Transect 2 - left	3	4	8	10	12	0	0	0	0	8	5	3	53
WFR15-2R	Transect 2 - right	3	5	8	2	0	0	0	0	6	8	5	3	40
WFR15-3C	Transect 3 - center	3	5	6	0	0	0	0	2	4	6	5	3	34
WFR15-3L	Transect 3 - left	3	5	8	10	5	0	0	0	0	5	5	3	44
WFR15-3R	Transect 3 - right	2	4	0	0	0	5	10	2	2	7	5	3	40
WFR15	**Average %**	**93%**	**93%**	**67%**	**44%**	**25%**	**14%**	**20%**	**20%**	**38%**	**89%**	**100%**	**100%**	**59%**
WFR17-1C	Transect 1 - center	0	0	0	0	0	0	0	4	9	7	5	3	28
WFR17-1L	Transect 1 - left	0	0	0	0	0	0	0	0	0	5	5	3	13
WFR17-1R	Transect 1 - right	0	0	0	0	0	0	0	10	9	8	5	3	35
WFR17-2C	Transect 2 - center	0	0	0	0	0	0	0	0	0	6	5	3	14
WFR17-2L	Transect 2 - left	3	0	0	0	0	0	0	0	0	6	5	3	17
WFR17-2R	Transect 2 - right	0	0	0	0	0	0	0	0	4	8	5	3	20
WFR17-3C	Transect 3 - center	3	0	0	0	0	0	0	0	1	6	5	3	18
WFR17-3L	Transect 3 - left	1	2	0	0	0	0	0	0	0	3	5	3	14
WFR17-3R	Transect 3 - right	2	0	0	0	0	0	0	0	3	6	5	3	19
WFR17	**Average %**	**33%**	**4%**	**0%**	**0%**	**0%**	**0%**	**0%**	**13%**	**29%**	**76%**	**100%**	**100%**	**30%**
WFR21-1C	Transect 1 - center	0	0	1	1	0	0	0	0	0	0	5	3	10
WFR21-1L	Transect 1 - left	1	4	8	4	10	0	0	0	0	0	1	3	31
WFR21-1R	Transect 1 - right	0	0	0	0	0	0	0	0	1	8	4	3	16
WFR21-2C	Transect 2 - center	3	5	4	0	0	0	0	0	3	8	5	3	31
WFR21-2L	Transect 2 - left	3	5	5	0	0	0	0	0	0	0	4	3	20
WFR21-2R	Transect 2 - right	3	3	0	0	0	0	0	0	0	8	5	3	22
WFR21-3C	Transect 3 - center	3	1	0	0	0	0	0	0	0	0	0	1	5
WFR21-3L	Transect 3 - left	3	0	0	6	10	2	0	0	0	0	0	2	23
WFR21-3R	Transect 3 - right	3	2	0	0	0	0	0	0	0	0	0	3	8
WFR21	**Average %**	**70%**	**44%**	**25%**	**12%**	**19%**	**2%**	**0%**	**0%**	**4%**	**33%**	**53%**	**89%**	**29%**
WFR27-1C	Transect 1 - center	3	2	0	0	0	0	0	0	10	7	5	2	29
WFR27-1L	Transect 1 - left	3	5	8	8	0	0	0	0	4	8	4	0	40
WFR27-1R	Transect 1 - right	2	0	0	0	0	0	0	8	10	7	5	3	35
WFR27-2C	Transect 2 - center	3	4	4	0	0	0	0	0	6	2	5	3	27
WFR27-2L	Transect 2 - left	3	5	0	0	0	0	0	0	1	5	2	3	19
WFR27-2R	Transect 2 - right	3	1	3	0	0	0	0	0	5	8	4	3	27
WFR27-3C	Transect 3 - center	3	2	0	0	0	0	10	0	3	7	4	3	32
WFR27-3L	Transect 3 - left	3	0	0	0	0	11	5	5	5	7	4	3	43
WFR27-3R	Transect 3 - right	3	5	8	10	6	0	0	1	0	8	2	2	45
WFR27	**Average %**	**96%**	**53%**	**32%**	**20%**	**6%**	**10%**	**14%**	**13%**	**49%**	**82%**	**78%**	**81%**	**45%**
WFR29-1C	Transect 1 - center	2	0	0	0	0	0	0	0	0	0	0	0	2
WFR29-1L	Transect 1 - left	3	5	7	4	0	0	0	0	0	0	0	0	19
WFR29-1R	Transect 1 - right	1	0	0	0	0	0	0	0	0	0	0	3	4
WFR29-2C	Transect 2 - center	1	0	0	0	0	0	0	0	0	0	0	0	1
WFR29-2L	Transect 2 - left	3	5	7	5	6	3	0	0	0	0	0	0	29
WFR29-2R	Transect 2 - right	1	0	0	0	0	0	0	0	0	1	5	2	9
WFR29-3C	Transect 3 - center	0	0	0	0	0	0	0	0	0	0	0	0	0
WFR29-3L	Transect 3 - left	0	0	0	1	2	1	0	0	7	7	4	1	23
WFR29-3R	Transect 3 - right	0	0	0	0	0	0	0	0	0	0	0	0	0
WFR29	**Average %**	**41%**	**22%**	**19%**	**11%**	**7%**	**4%**	**0%**	**0%**	**8%**	**11%**	**20%**	**22%**	**14%**
WFR32-1C	Transect 1 - center	2	0	0	0	0	0	0	0	0	0	0	3	5

Reach	Section	6-7am	7-8am	8-9am	9-10am	10-11am	11-12pm	12-1pm	1-2pm	2-3pm	3-4pm	4-5pm	5-6pm	TOTAL
	Potential	***3***	***5***	***8***	***10***	***12***	***12***	***12***	***12***	***10***	***8***	***5***	***3***	
WFR32-1L	Transect 1 - left	1	0	0	0	0	0	0	0	0	0	0	2	3
WFR32-1R	Transect 1 - right	1	0	1	0	0	0	0	0	9	7	5	3	26
WFR32-2C	Transect 2 - center	3	0	0	0	0	0	0	0	0	0	4	3	10
WFR32-2L	Transect 2 - left	3	5	0	0	0	0	0	0	0	0	0	2	10
WFR32-2R	Transect 2 - right	1	0	0	0	0	0	0	0	0	5	5	3	14
WFR32-3C	Transect 3 - center	3	1	0	0	0	0	0	0	0	0	2	3	9
WFR32-3L	Transect 3 - left	2	5	4	0	0	0	0	0	0	0	0	1	12
WFR32-3R	Transect 3 - right	2	0	0	0	0	0	0	0	4	8	5	3	22
WFR32	**Average %**	**67%**	**24%**	**7%**	**0%**	**0%**	**0%**	**0%**	**0%**	**14%**	**28%**	**47%**	**85%**	**23%**

ATTACHMENT EC – SOLAR PATHFINDER SUPPLEMENTAL FIELD DATA

Temperature Data Logger Site	Reach	GIS Riparian Vegetation Reach Type	Site Description	Average Daily Shade	GIS Reach Scale Aspect	Azimuth			Bankfull Width (Feet)			Average Bankfull Width (Feet)	Wetted Width (Feet)			Average Wetted Width (Feet)
						1	2	3	1	2	3		1	2	3	
ASHL-02	ASC4	Forested	Dense shrubs with cottonwoods and conifers at potential shade conditions. Minor road encroachment along river left to the north.	80%	-45	320	120	60		22.0	25.4	24		19.4	16.5	18
ASHL-03	ASC10	Open/Pasture	Likely straightened reach with fields on both sides and tall grass along the channel margin.	18%	0	170	170	170	15.0	17.2	16.3	16	14.4	16.1	13.5	15
none	ASC16	Forested	Somewhat meandering with alders and conifers, grazing may have led to slight channel overwidening.	78%	-45	100	10	40	23.7	24.8	29.0	26	19.6	19.7	24.9	21
none	ASC17	Open/Pasture	Meadow area upstream of lake, cattails and grasses. Probably close to potential, though there were signs of grazing.	7%	-45	190		100	31.0	27.3	28.0	29	21.5	22.2	24.7	23
ASHL-06	ASC22	Forested	Dense shrubs with cottonwoods and conifers at potential shade conditions.	78%	45	20	10	335	18.5	23.3	19.1	20	13.8	17.8	14.1	15
none	ASC31	Open/Pasture	Through fields, downstream of lake outlet, with tall grass along the channel margin and grazing along river left.	4%	0	0	10	10	28	31	35	31	24	25	31	27
ASHL-13	ASC33	Low/Moderate Riparian	Grass and shrubs along overwidened reach with historic and on-ongoing semi-urban impacts.	19%	45	100	90	140	43	45	39	42	23	28	32	28
ASHL-15	ASC35	Dense Riparian	Dense shrubs with cottonwoods and conifers, as well as topographic shading from hillslope.	64%	45	140	140	160	41	29	27	32	23	24	21	23
none	ASC36	Low/Moderate Riparian	Lawns extend to channel margin, along with riprap. Dispersed large deciduous trees.	30%	45	180	160	160	23	22	26	24	15	18	21	18
none	ASC39	Low/Moderate Riparian	Entrenched reach in urban setting with shrubs and grass.	27%	-45	100	100	100	36	30	27	31	30	26	19	25
none	ASC40	Low/Moderate Riparian	Entrenched reach in urban/rural residential setting with shrubs and grass. Downstream of USGS gage.	28%	0	20	340	60	32	25	23	26	29	22	19	23
ASHL-20	ASC44	Low/Moderate Riparian	Dense shrubs and deciduous trees along right bank and field along left bank. Slough-like channel conditions.	19%	90	140	140		*97*	*90*		*94*	*67*	*66*		*67*

Italics denote width estimates made using GIS.

Temperature Data Logger Site	Reach	GIS Riparian Vegetation Reach Type	Site Description	Average Daily Shade	GIS Reach Scale Aspect	Azimuth			Bankfull Width (Feet)			Average Bankfull Width (Feet)	Wetted Width (Feet)			Average Wetted Width (Feet)
						1	2	3	1	2	3		1	2	3	
WHTF-02	WFR1	Dense Riparian	Entrenched channel with dense deciduous trees along both banks.	37%	-45	80	80	80	80.2	72.5	70.5	74	70.5	61.6	59.1	64
WHTF-06	WFR13	Dense Riparian	Conifers and shrubs. Likely at potential.	56%	-45	20	20	20	51.1	65.3	72.2	63	48.6	58.2	51.1	53
WHTF-07	WFR15	Low/Moderate Riparian	Conifers and large deciduous trees, with understory shrubs. Likely at potential. Single band of trees along river left provide excellent shade.	59%	0	30	30	30	64.5	72.0	92.7	76	59.1	56.9	72.7	63
WHTF-08	WFR17	Low/Moderate Riparian	Conifers and shrubs with hillslope/topographic shading along river right.	30%	0	50	40	30	68.6	71.4	99.1	80	61.8	69.6	76.7	69
WHTF-09	WFR21	Low/Moderate Riparian	Conifers and shrubs, with interspersed cottonwoods. Perhaps historic loss of sinuosity.	29%	0	10		350	92.3	54.4	66.2	71	76.1	50.5	55.5	61
WHTF-10	WFR27	Low/Moderate Riparian	Conifers, deciduous trees and shrubs in residential setting.	45%	-45		60	60	65	70	68	68	61	60	62	61
none	WFR29	Open/Pasture	Shrubs and grass. Residential and horse pasture.	14%	-45	320	320	300	65	70	66	67	59	61	62	61
WHTF-11	WFR32	Low/Moderate Riparian	Shrubs and sparse deciduous trees in urban setting.	23%	90	60	60	40	63	60	59	61	49	53	53	52

ATTACHMENT ED – QUAL2K MODEL CALIBRATION INPUTS

ASHLEY CREEK MODEL CALIBRATION INPUTS

1. QUAL2K

- 15 days, August 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18

2. Headwater

- Temperatures and flow for ASHL-01 used to simulate outflow from lake
- Rating curve coefficients based on mean velocity and mean depth measurements with an exponent of zero based on measurements in ASHL-01

3. Downstream

- No prescribed downstream boundary

4. Reach

- 46 reaches based on vegetation and aspect derived from GIS analysis of aerial imagery
- Three reaches flow through lakes: 14, 18 and 29
- Rating curve coefficients based on mean velocity and mean depth measurements with an exponent of zero, applied to each reach based on data from measured site within reach, extrapolated to un-assessed reaches based on proximal measurement and review of aerial imagery
- Depth and velocity coefficients for reaches that flow through lakes were estimated based on measured values in slow moving slough-like conditions
- Depth coefficients were manipulated in the application of the water use scenario and the natural condition scenario in order to keep the width constant for the majority of the reaches

5. Reach Rates

- N/A

6. Air Temperature

- Averaged over 15 days from AgriMet Creston station

7. Due Point Temperature

- Averaged over 15 days from AgriMet Creston station
- Increased relative humidity data by 15% based on Big Hole assessment

8. Wind Speed

- Averaged over 15 days from AgriMet Creston station

9. Cloud Cover

- Averaged over 15 days from NCDC station at Kalispell Glacier Park International Airport

10. Shade

- Solar pathfinder measurements were assigned to the reach in which they were located

- Average solar pathfinder values were assigned to reaches in which no measurement was performed, averages based on vegetation type as assessed in GIS: forested, dense riparian, low/moderate riparian, open/pasture
- 0% shade was assigned for the three "lake" reaches – 14, 18, 29

11. Rates

- No adjustment to standard model assumptions

12. Light and Heat

- Utilized sediment thermal thickness of 10 cm and sediment thermal diffusivity of 0.005 cm^2/s

13. Diffuse Sources

- Irrigation loss at six sites based on observed agriculture and decrease in streamflow between temperature data logger sites
- Loss due to groundwater aquifer or evapotranspiration at one site where no agriculture was observed, based on decrease in streamflow between temperature data logger sites
- Hydro balance performed at each streamflow measurement site and above/below each lake
- Appears that lowermost portion of creek is a backwater slough of the Flathead River and there may be extensive hyporheic interactions which were not accounted for in the model

14. Point Sources

- 22 identified tributaries based on 1:100,000 NHD layer, 2 with flow measurements (tribs 8 and 20), 5 flows estimated based on hydro balance (tribs 1, 5, 17, 18, 22), no flow assigned to 15 tribs, some noted as dry during field visits
- Tributary temperatures based on Spring Creek measurement (ASHL-16) since Porter Creek (ASHL-07) had cool water and actually appeared to be a spring creek
- 3 temperature measurements on tributary streams, ASHL-09 discarded since no flow measurement performed and hydro balance did not indicate an increase in streamflow
- Baseline Kalispell WWTP discharge based on average flow (0.119 m^3/s or 4.2 cfs)/temperature (20.1°C or 68.18°F) for August 2008
- Discharge for Kalispell WWTP when discharging at the naturally occurring stream temperature based on average flow for August 2003 – 2012 (0.116 m^3/s or 4.1 cfs).

15. Hydraulics Data

- 9 streamflow measurements, discarded additional flow measurement of 11.9 cfs from ASHL-11, also discarded the two lowermost streamflow measurements from sites ASHL-19 and ASHL-20

16. Temperature Data

- 16 temperature measurements on Ashley Creek, averaged over 15 days

WHITEFISH RIVER MODEL CALIBRATION INPUTS

1. QUAL2K
- 2 days, August 17-18

2. Headwater
- Temperatures and flow for WHTF-01 used to simulate outflow from lake
- Rating curve coefficients based on mean velocity and mean depth measurements from 5 sites measured in 2008, raised to the 0 exponent

3. Downstream
- No prescribed downstream boundary

4. Reach
- 32 reaches based on vegetation and aspect derived from GIS analysis of aerial imagery
- Rating curve coefficients based on mean velocity and mean depth measurements from 5 sites measured in 2008, raised to the 0 exponent

5. Reach Rates
- N/A

6. Air Temperature
- Averaged over 2 days from AgriMet Creston station

7. Due Point Temperature
- Averaged over 2 days from AgriMet Creston station
- Increased relative humidity data by 15% based on Big Hole measurements

8. Wind Speed
- Averaged over 2 days from AgriMet Creston station

9. Cloud Cover
- Averaged over 2 days from NCDC station at Kalispell Glacier Park International Airport

10. Shade
- Solar pathfinder measurements were assigned to the reach in which they were located
- Average solar pathfinder values were assigned to reaches in which no measurement was performed, averages based on vegetation type as assessed in GIS: dense riparian, low/moderate riparian, open/pasture

11. Rates
- No adjustment to standard model assumptions

12. Light and Heat
- Utilized sediment thermal thickness of 10 cm and sediment thermal diffusivity of 0.005 cm^2/s

13. Diffuse Sources

- Surface water inputs within 2 reaches (14 and 16-29) based on hydro balance, modeled at 17.25 °C based on mean temperature of WHTF-04 (Walker Creek)

14. Point Sources

- 7 tributaries, 2 with flow measurements, 5 flows estimated based on hydro balance
- Tributary temperatures all based on measurement from WHTF-04 (Walker Creek)
- 1 WWTP discharge based on average flow (0.0372 m^3/s or 1.3 cfs)/temperature (22.2°C or 71.96°F) for August 2008

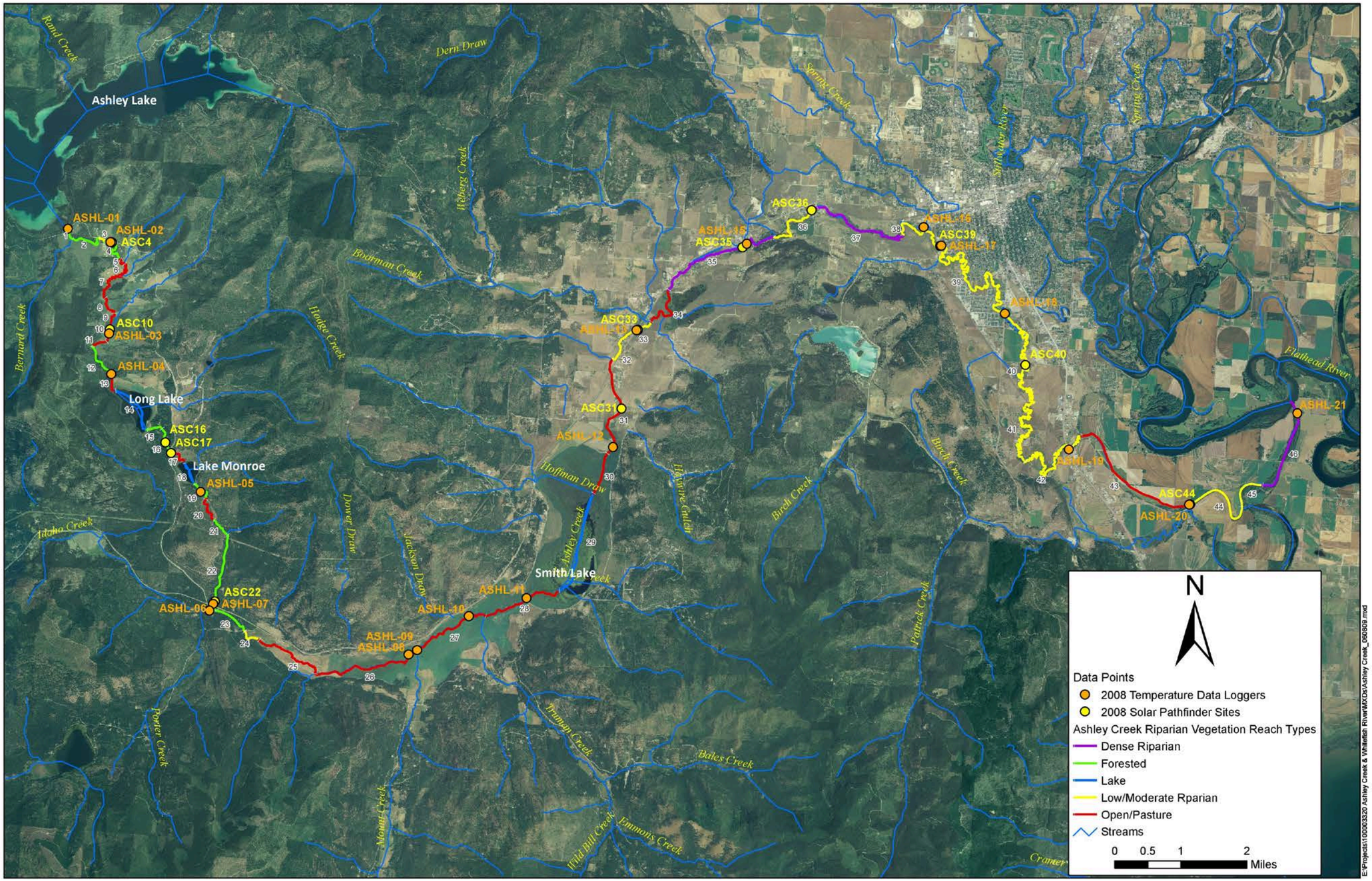
15. Hydraulics Data

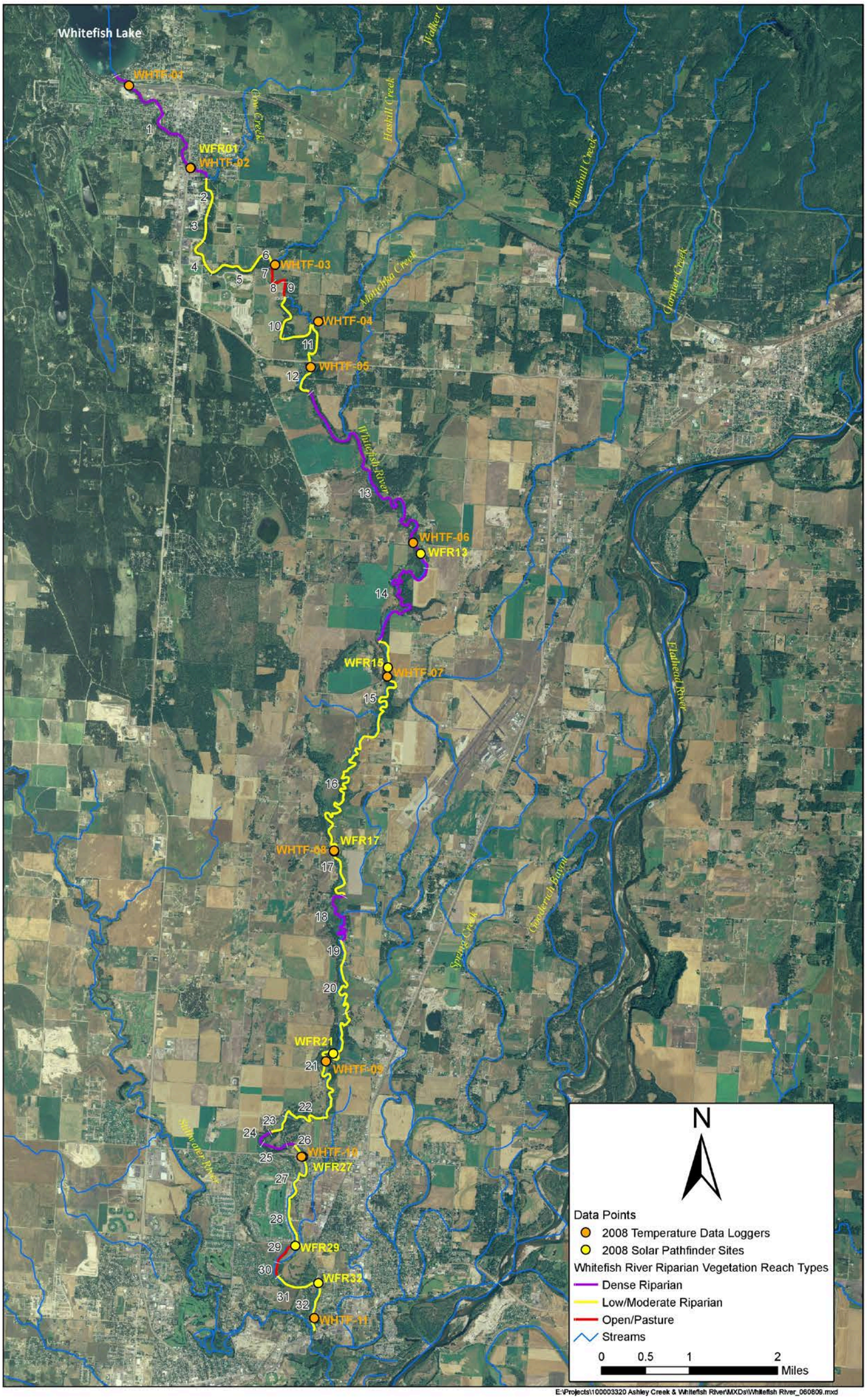
- 4 streamflow measurements, discarded additional measurement of 145 cfs from WHTF-08

16. Temperature Data

- 9 temperature measurements, averaged over 2 days

ATTACHMENT EE – MONITORING SITE AND RIPARIAN VEGETATION REACH TYPE MAPS


Ashley Lake
Long Lake
Lake Monroe
Smith Lake
ASHL-01
ASHL-02
ASC4
ASC10
ASHL-03
ASHL-04
ASC16
ASC17
ASHL-05
ASC22
ASHL-06
ASHL-07
ASHL-08
ASHL-09
ASHL-10
ASHL-11
ASHL-12
ASC31
ASC33
ASHL-13
ASHL-15
ASC35
ASC36
ASHL-16
ASC39
ASHL-17
ASHL-18
ASC40
ASHL-19
ASC44
ASHL-20
ASHL-21
Rand Creek
Dern Draw
Weberg Creek
Boorman Creek
Hodge Creek
Bernard Creek
Idaho Creek
Dower Draw
Jackson Draw
Hoffman Draw
Ashley Creek
Hayware Gulch
Birch Creek
Spring Creek
Stillwater River
Flathead River
Patrick Creek
Porter Creek
Truman Creek
Bales Creek
Mount Creek
Wild Bill Creek
Emmons Creek
Cramer
N
Data Points
2008 Temperature Data Loggers
2008 Solar Pathfinder Sites
Ashley Creek Riparian Vegetation Reach Types
Dense Riparian
Forested
Lake
Low/Moderate Rparian
Open/Pasture
Streams
0 0.5 1 2
Miles


Whitefish Lake
WHTF-01
WFR01
WHTF-02
WHTF-03
WHTF-04
WHTF-05
WHTF-06
WFR13
WFR15
WHTF-07
WFR17
WHTF-08
WHTF-09
WHTF-10
WFR27
WFR29
WFR32
WHTF-11
Ashley Creek
Haskill Creek
Walker Creek
Trumbull Creek
Monchka Creek
Garnier Creek
Whitefish River
Flathead River
Spring Creek
Goodrich Bayou
Stillwater River
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
N
Data Points
2008 Temperature Data Loggers
2008 Solar Pathfinder Sites
Whitefish River Riparian Vegetation Reach Types
Dense Riparian
Low/Moderate Riparian
Open/Pasture
Streams
0
0.5
1
2
Miles
E:\Projects\100003320 Ashley Creek & Whitefish River\MXDs\Whitefish River_060809.mxd

ATTACHMENT EF – RIPARIAN VEGETATION REACH TYPES

Stream	Length (km)	Length (mi)	Reach	Existing Riparian Vegetation Type	Field Assessment Performed	Potential Riparian Vegetation Type	Currently Meeting Potential Shade Conditions	Existing Conditions Scenario (assigned based on field data and reach type averages)	Shade Scenario
upper Ashley Creek	0.31	0.19	1	forested	no	forested	yes	79%	79%
upper Ashley Creek	0.89	0.55	2	forested	no	forested	yes	79%	79%
upper Ashley Creek	0.19	0.12	3	low/moderate riparian	no	forested	no	25%	79%
upper Ashley Creek	0.90	0.56	4	forested	yes	forested	yes	80%	80%
upper Ashley Creek	0.23	0.14	5	open/pasture	no	forested	no	10%	79%
upper Ashley Creek	0.54	0.34	6	open/pasture	no	forested	no	10%	79%
upper Ashley Creek	1.09	0.68	7	open/pasture	no	forested	no	10%	79%
upper Ashley Creek	0.56	0.35	8	open/pasture	no	forested	no	10%	79%
upper Ashley Creek	0.33	0.20	9	open/pasture	no	forested	no	10%	79%
upper Ashley Creek	0.43	0.27	10	open/pasture	yes	forested	no	18%	79%
upper Ashley Creek	0.40	0.25	11	open/pasture	no	forested	no	10%	79%
upper Ashley Creek	0.98	0.61	12	forested	no	forested	yes	79%	79%
upper Ashley Creek	0.47	0.29	13	open/pasture	no	open/pasture	yes	10%	10%
upper Ashley Creek	1.39	0.86	14	lake	no			0%	0%
upper Ashley Creek	0.37	0.23	15	forested	no	forested	yes	79%	79%
upper Ashley Creek	0.66	0.41	16	forested	yes	forested	yes	78%	78%
upper Ashley Creek	0.67	0.42	17	open/pasture	yes	open/pasture	yes	7%	7%
upper Ashley Creek	0.59	0.37	18	lake	no			0%	0%
upper Ashley Creek	0.56	0.35	19	forested	no	forested	yes	79%	79%
upper Ashley Creek	0.75	0.47	20	open/pasture	no	open/pasture	yes	10%	10%
upper Ashley Creek	0.52	0.32	21	forested	no	forested	yes	79%	79%
upper Ashley Creek	1.95	1.21	22	forested	yes	forested	yes	78%	78%
upper Ashley Creek	0.94	0.58	23	forested	no	forested	yes	79%	79%
upper Ashley Creek	0.50	0.31	24	low/moderate riparian	no	forested	no	25%	79%
upper Ashley Creek	1.84	1.14	25	open/pasture	no	forested	no	10%	79%
upper Ashley Creek	2.94	1.83	26	open/pasture	no	open/pasture	yes	10%	10%
upper Ashley Creek	2.13	1.32	27	open/pasture	no	open/pasture	yes	10%	10%
upper Ashley Creek	2.11	1.31	28	open/pasture	no	open/pasture	yes	10%	10%
Smith Lake	2.64	1.64	29	lake	no			0%	0%
middle Ashley Creek	1.05	0.65	30	open/pasture	no	open/pasture	yes	10%	10%
middle Ashley Creek	2.72	1.69	31	open/pasture	yes	open/pasture	no	4%	10%
middle Ashley Creek	0.54	0.34	32	low/moderate riparian	no	dense riparian	no	25%	64%
middle Ashley Creek	0.99	0.62	33	low/moderate riparian	yes	dense riparian	no	19%	64%
middle Ashley Creek	1.49	0.93	34	open/pasture	no	dense riparian	no	10%	64%
middle Ashley Creek	3.33	2.07	35	dense riparian	yes	dense riparian	yes	64%	64%
middle Ashley Creek	1.71	1.06	36	low/moderate riparian	yes	dense riparian	no	30%	64%
middle Ashley Creek	2.83	1.76	37	dense riparian	no	dense riparian	yes	64%	64%
middle Ashley Creek	0.32	0.20	38	low/moderate riparian	no	dense riparian	no	25%	64%
middle Ashley Creek	8.97	5.57	39	low/moderate riparian	yes	dense riparian	no	27%	64%
lower Ashley Creek	2.79	1.73	40	low/moderate riparian	yes	dense riparian	no	28%	64%
lower Ashley Creek	4.40	2.73	41	low/moderate riparian	no	dense riparian	no	25%	64%
lower Ashley Creek	3.81	2.36	42	low/moderate riparian	no	dense riparian	no	25%	64%
lower Ashley Creek	3.45	2.14	43	open/pasture	no	dense riparian	no	10%	64%
lower Ashley Creek	2.09	1.30	44	low/moderate riparian	yes	dense riparian	no	19%	64%
lower Ashley Creek	1.00	0.62	45	low/moderate riparian	no	dense riparian	no	25%	64%
lower Ashley Creek	2.52	1.57	46	dense riparian	no	dense riparian	yes	64%	64%

Stream	Length (km)	Length (mi)	Reach	Existing Riparian Vegetation Type	Field Assessment Performed	Potential Riparian Vegetation Type	Currently Meeting Potential Shade Conditions	Existing Conditions Scenario (assigned based on field data and reach type averages)	Shade Scenario
Whitefish River	3.09	1.92	1	dense riparian	yes	dense riparian	no	37%	47%
Whitefish River	0.73	0.45	2	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	0.49	0.31	3	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	0.76	0.48	4	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	1.23	0.76	5	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	0.24	0.15	6	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	0.30	0.19	7	open/pasture	no	dense riparian	no	14%	47%
Whitefish River	0.26	0.16	8	open/pasture	no	dense riparian	no	14%	47%
Whitefish River	0.30	0.19	9	open/pasture	no	dense riparian	no	14%	47%
Whitefish River	0.93	0.58	10	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	0.69	0.43	11	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	1.57	0.97	12	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	5.28	3.28	13	dense riparian	yes	dense riparian	yes	56%	56%
Whitefish River	2.98	1.85	14	dense riparian	no	dense riparian	yes	47%	47%
Whitefish River	2.60	1.62	15	low/moderate riparian	yes	dense riparian	yes	59%	59%
Whitefish River	3.07	1.91	16	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	1.89	1.17	17	low/moderate riparian	yes	dense riparian	no	30%	47%
Whitefish River	1.56	0.97	18	dense riparian	no	dense riparian	yes	47%	47%
Whitefish River	0.37	0.23	19	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	1.39	0.86	20	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	3.08	1.91	21	low/moderate riparian	yes	dense riparian	no	29%	47%
Whitefish River	0.96	0.60	22	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	0.47	0.29	23	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	0.31	0.19	24	dense riparian	no	dense riparian	yes	47%	47%
Whitefish River	0.48	0.30	25	dense riparian	no	dense riparian	yes	47%	47%
Whitefish River	0.18	0.11	26	dense riparian	no	dense riparian	yes	47%	47%
Whitefish River	0.81	0.50	27	low/moderate riparian	yes	dense riparian	no	45%	47%
Whitefish River	1.33	0.82	28	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	0.50	0.31	29	open/pasture	yes	dense riparian	no	14%	47%
Whitefish River	0.27	0.17	30	open/pasture	no	dense riparian	no	14%	47%
Whitefish River	0.84	0.52	31	low/moderate riparian	no	dense riparian	no	37%	47%
Whitefish River	0.93	0.58	32	low/moderate riparian	yes	dense riparian	no	23%	47%

ATTACHMENT EG – HYDROLOGIC BALANCE

Reach	Hydrologic Balance (cms)		Notes
1	0.2024	ASHL-01	outlet of Ashley Lake
	0.2024	**flow at outlet of 1**	
2	0.0895	trib 1	Bernard Creek
3			
4	0.2920	ASHL-02	
	0.2920	**flow at outlet of 4**	
5	0.0482	irrigation loss	start of irrigated agriculture, loss of 50% of decrease in flow between ASHL-02 and ASHL-03
6		trib 2	irrigated agriculture
7		trib 3	irrigated agriculture
8			irrigated agriculture
9	0.0482	irrigation loss	loss of 50% of decrease in flow between ASHL-02 and ASHL-03
10		trib 4	irrigated agriculture
	0.1955	ASHL-03	
	0.1955	**flow at outlet of 10**	
11	0.0082	irrigation loss	loss of 50% of decrease in flow between ASHL-03 and ASHL-04
12			
13	0.0082	irrigation loss	loss of 50% of decrease in flow between ASHL-03 and ASHL-04
	0.1792	ASHL-04	
	0.1792	**flow at outlet of 13**	flow into Lone Lake
14	0.0264	trib 5	Lone Lake, lake reach, Hodge Creek flows into lake
	0.2055	**flow at outlet of 14**	
15			
16			
17	**0.2055**	**flow at outlet of 17**	
18		trib 6	Monroe Lake, lake reach, unnamed streamflows into lake
	0.2055	**flow at outlet of 18**	
19	0.2055	ASHL-05	downstream of lake
	0.2055	**flow at outlet of 19**	
20	0.0639	groundwater loss	or evapotranspiration, flows through wet meadow
21			
22		trib 7	
	0.1416	ASHL-06	
	0.1416	**flow at outlet of 22**	
23	0.0827	ASHL-07, trib 8	Porter (Idaho) Creek
	0.2243	**flow at outlet of 23**	combined flow of ASHL-06 and ASHL-07
24			
25	0.0601	irrigation loss	loss of 50% of decrease in flow (0.601 cms) between combined ASHL-06/07 and ASHL-13
26		trib 9	
27		trib 10	Mount Creek, ASHL-09 identified as "ditch entering Ashley Cr", no flow measurement, data not applied
28		trib 11	Truman Creek
		ASHL-11	flow measurement discarded, slough-like conditions
	0.1643	**flow at outlet of 28**	
29		trib 12, trib 13	Smith Lake, lake reach, two un-named streams flow into lake
	0.1643	**flow at outlet of 29**	

Reach	Hydrologic Balance (cms)		Notes
30		trib 14	Hoffman Draw
31	0.0601	irrigation loss	loss of 50% of decrease in flow between combined ASHL-06/07 and ASHL-13
32		trib 15	
33	0.1042	ASHL-13	USGS gaging station 12367500 (1930-1974)
	0.1042	**flow at outlet of 33**	
34		trib 16	Boorman Creek, reported dry during site visit
	0.0067	trib 17	one half of difference in flow
	0.0067	trib 18	one half of difference in flow
	0.1175	ASHL-15	
	0.1175	**flow at outlet of 35**	
36		trib 19	
37	0.0539	irrigation loss	
38			
39	0.0670	ASHL-16, trib 20	Spring Creek
	0.1306	ASHL-17	
	0.1306	flow d/s of ASHL-17	
	0.1190		WWTP input (2.723mgd/4.214cfs)(station 21.0)
	0.2496	**flow at outlet of 39**	
40		trib 21	flow of 9.5 cfs at USGS 12367800 on 8/19/08, based on measured flow of 8.83cfs on 8/29/08
41			
42		ASHL-19	flow measurement discarded, slough-like conditions
43			
44		ASHL-20	flow measurement discarded, slough-like conditions
45	0.0270	trib 22	Patrick Creek connected or an oxbow
46	**0.2766**	**flow at mouth**	

Reach	Hydrologic Balance (cms)		Notes
1	3.2918	WHTF-01	outlet of Whitefish Lake
	3.2918	**flow at outlet of 1**	
2	0.0569	trib 1	Cow Creek, est. based on WHTF-01+03 and WHTF-06, split with Motichka Cr.
3	0.0372	WWTP	WWTP input (0.851mgd/1.317cfs)(station 35.8)
4			
5			
7	0.1004	WHTF-03, trib 2	Haskill Creek - temperature data logger did not work
	3.4863	**flow at outlet of 7**	
8			
9			
10	0.0158	WHTF-04, trib 3	Walker Creek
	3.5021	**flow at outlet of 10**	
11			
12			
13	0.0569	trib 4	Motchika, est. based on WHTF-01+03 and WHTF-06, split with Cow Cr.
	3.5590	WHTF-06	
	3.5590	**flow at outlet of 13**	
14	0.1579	surface water gain	majority of reach between WHTF-06 and WHTF-07 is irrigated agriculture, but no ditch outlets were observed in aerial imagery, so assumed to be an unidentified surface water input
15	3.7738	WHTF-07	at USGS gage mean daily flow on 8/13 was 135 cfs (3.8111 cms)
	0.0569	trib 5	unnamed small tributary, same flow as Cow/Motichka
	3.7738	**flow at outlet of 15**	
16	0.0350	surface water gain	added between reach 16 (station 18.445) and reach 29 (station 2.540)
17			
18	0.0569	trib 6	unnamed small tributary, same flow as Cow/Motichka
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30	0.0569	trib 7	unnamed small tributary, same flow as Cow/Motichka
31			
32	3.9226	WHTF-11	
	3.9226	**flow at outlet of 32**	approximately 60 yards upstream of confluence with Stillwater

APPENDIX F – RESPONSE TO PUBLIC COMMENTS

As described in **Section 11.2**, the formal public comment period for the Flathead-Stillwater Planning Area Nutrients, Sediment, and Temperature TMDLs extended from October 10, 2014 to November 12, 2014. Formal written comments were received from three organizations and a municipality. DEQ evaluates all comments and related information to ensure no critical information was excluded from the document. Particularly for stakeholders selected to help advise the TMDL development process, early and active involvement and feedback with DEQ enhances the ability for collaboration and dialogue about the process. All commenters were involved in the stakeholder advisory group for the project.

Excerpts of the public comments received are organized by category, with most comments pertaining to a specific pollutant (i.e., nutrients, sediment, and temperature). The original comment letters are located in the project files at DEQ and may be reviewed upon request. Responses follow each comment, and because this project was a joint effort between DEQ and the EPA Region 8 Montana Office, the responses were jointly prepared.

F1.0 GENERAL COMMENTS

Comment 1.1: We think the level of communication with watershed stakeholders during the development of this TMDL was commendable. The periodic meetings of the TAG and WAG, and use of the Flathead Wiki website all served to ensure that everyone was in the loop.

> **Response 1.1:** Thank you for the positive feedback. DEQ has sought to keep stakeholders informed of work progress throughout the TMDL development process. We appreciate the time and information stakeholders have contributed to this project and believe that the final document has been improved as a result.

Comment 1.2: In Section 4.5, Par. 1, the document states that nonpoint source reductions "...*are primarily implemented through voluntary measures*." Actually, a key control mechanism for nonpoint forestry sources is the regulatory Streamside Management Zone (SMZ) Act of 1991. This law regulates forestry along hundreds of miles of perennial and intermittent streams in the watersheds covered by these TMDLs. Because of this, I recommend that the text be revised to state that nonpoint source reductions "…*are implemented through a combination of voluntary and regulatory measures*."

> **Response 1.2:** We agree with your comment and the importance of the SMZ law in addressing nonpoint source pollution. The text within **Section 4.5** has been modified per your suggestion.

Comment 1.3: Due to Ashley Creek's impairments (naturally and human caused alike) and the lower flows the WWTP will always have a challenge meeting Water Quality Standards for Ashley Creek. What are DEQ's thoughts about relocating Kalispell's outfall to the Flathead River? Would MDEQ consider viewing the non-degradation requirements on a basin-wide basis or would non-degradation criteria apply in the new outfall location?

> **Response 1.3:** DEQ supports the evaluation of alternate discharge options. Any discharge to the Flathead River would require consideration of non-degradation, which could be influenced by the discharge location to Flathead River (i.e., upstream or downstream of the Ashley Creek

confluence with the Flathead River). Although this alternative discharge approach addresses the Ashley Creek WLA requirements, the nutrient loading from the City of Kalispell WWTP will still be a potential concern for Flathead Lake. Therefore, it is difficult to endorse this alternative discharge location until the Flathead Lake Phase II nutrient wasteload allocations are developed for the Kalispell WWTP.

Comment 1.4: The TMDLs do not identify what nonpoint source load reductions are necessary to attain water quality standards. Instead they estimate what load reductions might be achieved if BMPs were applied in impaired segments. This is probably the best that can be done given the nature of nonpoint sources. However, to be effective, this approach requires that further assessments be done as BMPs are implemented and that additional BMPs be applied when found necessary – then "adaptive management." In order to be complete, the TMDLs should specify in detail follow-up monitoring and assessment that must be done to determine needed changes to the TMDLs. This would be very helpful for defining monitoring and assessment strategies for the watershed. We encourage you to include this information in the final TMDLs.

Response 1.4: As you stated, an effective adaptive management approach requires monitoring after BMPs are in place and any restoration work completed to determine if water quality targets are being achieved, water quality is improving, or if revisions to water quality goals are necessary. **Sections 10.3** and **10.4** outline suggested monitoring to expand knowledge of existing water quality conditions, to refine source assessments, and to provide nutrient, sediment, and temperature data for possible future impairment status evaluations. These document sections specify the most useful parameters to be collected during future monitoring efforts and provide suggested monitoring locations. DEQ does not specify exact locations where restoration projects would be beneficial or where specific BMPs should be implemented; these decisions are best left to the local stakeholders and landowners, based on stakeholder-determined priorities, landowner interest, and available funding. DEQ will again perform water quality assessments where there have been sufficient activities to warrant an evaluation of current stream conditions. Through this process, we may find that a TMDL(s) should be adjusted or simply that additional time is needed to achieve water quality goals. However, DEQ does not provide a specific list of BMPs or where they should be implemented, as nonpoint source protection measures are not legally required for most activities. Flexible decision-making by stakeholders is part of the adaptive management approach.

Comment 1.5: Implementation of the TMDLs for nonpoint sources is left to other government agencies and local stakeholders. The document would be much more useful to them if, for each impaired segment, there was a clear summary of what BMPs are needed and where they should be applied. Please include such a summary in the final TMDLs document.

Response 1.5: The source assessment information provided in the nutrients, sediment, and temperature sections of the document (**Sections 5.5, 5.6, 6.5**, and **7.6**) provides detailed information on pollutant sources, and **Section 9.4** provides restoration approaches applicable to each of the source categories. As explained above in response to **Comment 1.4**, decisions on where to conduct these restoration measures and apply BMPs are best determined by stakeholders.

Comment 1.6: Information about the relationships among the TMDLs for sediment, nutrients and temperature for the same stream segments would be useful since the implementation of the

recommended BMPs will often address multiple impairments. An integrated summary of needed BMPs for each source would be very helpful for planning an implementation strategy.

> **Response 1.6:** Although this is not an EPA-required TMDL approvability item, DEQ agrees that it would be ideal to provide this type of detailed information in the TMDL document. However, staff resources are limited. These types of planning steps should be incorporated during development and implementation of a watershed restoration plan (see **Section 9.2** for additional information). As noted above in response to **Comment 1.5**, **Section 9.4** provides BMPs and restoration approaches for source categories.

Comment 1.7: Section 9 of the TMDL document is very well done and will be useful to stakeholders in implementation of the TMDLs through watershed restoration planning. It would also be very helpful if DEQ would identify what it is prepared to do to help implement TMDLs in the watershed.

> **Response 1.7:** Thank you for the positive feedback. Although point source pollutant reduction efforts are driven by discharge permit requirements, nonpoint source pollution reduction efforts are largely voluntary. DEQ does not conduct nonpoint source pollution reduction projects; however, DEQ staff is available to assist stakeholders with their project planning and implementation efforts. As outlined in **Section 9.3**, DEQ may provide the following resources and assistance:
>
> - Review of and technical feedback on draft watershed restoration plan(s)
> - Assistance with applying for DEQ 319 funding for restoration projects, education and outreach projects, and volunteer monitoring (see **Section 9.6**)
> - Review of sampling and analysis plans for sampling design and objectives, completeness, and required sampling procedures and analytical methods
> - Training for volunteer monitors on DEQ's field and sampling procedures and methods, data quality assurance and control, record keeping, and data reporting
> - Advisory role for watershed groups or other organizations and entities undertaking watershed planning efforts and developing restoration plans/projects

F2.0 NUTRIENTS COMMENTS

Comment 2.1: Section 5.4.2. In this section, nutrient targets are developed for Nitrate, TN, TP, Chl-a, Ash-Free dry weight, and HBI. It is unclear why with EPA's pending adoption of TN and TP standards in Montana, that six nutrient "targets" are needed. Most of these are captured in DEQs Nutrient Assessment Method, and are subject to change over time as new information becomes available. I recommend that the targets are simply the standards for TN and TP. Going beyond that to list a whole host of other related parameters would only seem to confuse future re-assessment.

> **Response 2.1:** DEQ evaluates nitrate-nitrite concentrations for impairment using an approach consistent with the evaluation of TN and TP. The rationale for this is articulated in the main technical support document for the numeric nutrient standards (see page 1-4 of Suplee and Watson, 2013). Consumption of nutrients by algae in surface waters, referred to as nutrient uptake, makes it inappropriate to only focus on TN, TP or nitrate-nitrite concentrations when trying to determine water quality impairment for nutrients. Chl-*a* provides a measure of the algal uptake, which can otherwise mask elevated nutrient concentrations, and Ash-free dry weight (mass) provides a measure of excess Chl-*a* after die-off. The addition of targets such as

periphyton and HBI help with impairment determinations under conditions when more information is desired due to a higher level of impairment uncertainty. Though these targets/measures can be subject to change over time as pointed out in the comment, the DEQ thinks that it is important to provide the full suite of targets that were applied toward nutrient impairment determinations identified within this document. Through a continuous improvement process, DEQ will routinely evaluate nutrient and other pollutant assessment methods and may update them as more tools and information become available and as the science improves. Any future assessments would apply the updated or revised method. Language has been added to **Section 5.4.3** to acknowledge the potential for assessment method refinement which could result in the application of refined targets for future assessments.

Comment 2.2: Section 5.4.3.1. It is unclear why DEQ is recommending that upper Ashley Creek remain listed for Chlorophyll-a, when the stream segment meets the state guideline of 120 mg/m2 for Chl-A, and passes the assessment method (See Table 5-4). Text in this section states that perhaps high chl-a levels were "missed." If this is DEQ's logic – which has been repeated in numerous TMDLs across western Montana - that the sampling protocol is not sufficient to capture chl-a values in streams, then perhaps this is not warranted as a water quality target. There is further confusion because Middle Ashley Creek is not listed for Chl-a as an impairment, even though the mean chl-a value is the same as for Upper Ashley (50 mg/m2). Per DEQ's logic, shouldn't Middle Ashley be listed as impaired for Chl-a also? DEQ should adhere to its current assessment method and delist Upper Ashley for this pollution metric.

Response 2.2: DEQ believes that focusing on TN, TP and nitrate-nitrite for the purpose of controlling nutrient loads will address the potential for Chl–*a* problems since this represents a response variable to elevated levels of TN, TP and/or nitrate-nitrite. Many of the Chl-*a* impairment cause determinations were made prior to the application of the 120 mg/m2 target value, as is the case for the upper and lower segments of Ashley Creek. Because of the limited amount of Chl-*a* data collected for assessment purposes, DEQ has decided to retain historical Chl-*a* impairment determinations whenever there is also a determination that the waterbody segment is impaired for nutrient concentration parameters of TN, TP and/or nitrate-nitrite. This approach applies even if there were no recent values greater than 120 mg/m2. Alternatively, Chl-*a* is not identified as a new impairment cause unless it exceeds the 120 mg/m2 value, which is the situation for the middle segment of Ashley Creek. Once a waterbody segment is no longer considered impaired for all three of the nutrient concentration parameters, then Chl-*a* will be removed as an impairment cause since Chl-*a* (and ash free dry mass) must both be at acceptable levels prior to concluding that there are no TN, TP or nitrate-nitrite impairment causes.

Comment 2.3: We greatly appreciate DEQ's efforts to refine the Ashley Creek nutrient TMDLs to better account for the complexities posed by the Smith Lake Area wetland complex. While I suspect that the nutrient criteria adopted by Montana might not be physically attainable in Ashley Creek, the efforts made to adjust the modeling to factor in the wetland complex effect serves as a reasonable starting point. We hope that DEQ – in cooperation with the Basin Commission and others – undertakes the necessary scientific investigations to improve our understanding of nutrient dynamics in the Ashley Lake watershed, and any need for site specific nutrient standards. I do note that DEQ discusses the possible need for a site-specific nutrient standard in **Section 5.8.2** of the draft document.

Response 2.3: DEQ recognizes that there is uncertainty regarding the applicability of the nutrient criteria used to develop the nutrient TMDLs for Ashley Creek. DEQ will continue to work

with stakeholders to investigate nutrient loading and the applicability of the nutrient criteria for the Northern Rockies ecoregion to Ashley Creek.

Comment 2.4: Section 10 – Monitoring and Adaptive Management. I suggest that some of the language in the nutrient section regarding Ashley Creek and the Smith Lake area wetland be brought forward into this section. This includes the question of whether the Northern Rockies ecoregion nutrient standards are attainable in Ashley Creek. Also, if DEQ modelers have specific suggestions on what next steps should be taken to better understand nutrient dynamics in the drainage, that could be captured in this section.

Response 2.4: In recognition of this comment, we have added language to **Section 10.3.1** that reiterates the uncertainty regarding the applicability of the Northern Rockies nutrient criteria to Ashley Creek. In **Section 10.4.1** we have added language describing the need for: "Synoptic sampling at locations upstream, within, and downstream of all lakes and wetland complexes in upper Ashley Creek and all tributaries to this segment."

Comment 2.5: Upon development of the Flathead lake TMDL, will the same variance process be utilized in Circular 12B, or will the City have a lb/day load associated with the lake?

Response 2.5: DEQ intends to develop numeric nutrient standards for Flathead Lake prior to completion of the Phase II nutrient allocations for Flathead Lake. When lake standards are adopted, the Flathead Lake numeric standards will incorporate a variance process for point source discharges consistent with the adopted variance process in Circular 12-B and with the new variance rules which will soon be published in ARM 17.30 subchapter 6. This would then provide a template for staged WLA implementation consistent with the approach used for the Ashley Creek nutrient TMDLs. The need for staged WLA implementation could ultimately be a separate determination for each individual WLA within the Flathead Lake Phase II TMDL, taking into consideration the location within the watershed and existing discharge characteristics. During Phase II TMDL development, DEQ will determine if the Flathead Lake WLAs will be based on discharge concentration limits, discharge load limits, or some combination of both.

Comment 2.6: Why is MDT's MS4 permit not addressed in the TMDLs?

Response 2.6: The LSPC model was set up to produce output explicitly from the geographic area included within the boundaries of the City of Kalispell Small MS4 (MTR040005), to which the City of Kalispell and Montana Department of Transportation are co-permittees. This language has been added to **Section 5.5.3.7** to acknowledge that the MDT is an MS4 co-permittee with the City of Kalispell. Additional language has also been added to several locations throughout the document (e.g., **Section 5.6.3.3.1**) to clarify that both the City of Kalispell and MDT are responsible for MS4 WLA implementation.

Comment 2.7: Suggest also adding an estimate for Stormwater related loads from Flathead County. Evergreen is a high density area in the county, immediate adjacent to the city, but has not recourse for development.

Response 2.7: Most of the stormwater sources in the Ashley Creek and Spring Creek watersheds fall within the Kalispell/MDT MS4 permit area. The Evergreen area is outside of the Ashley Creek watershed, and is not applicable to the analysis at this time. However, future assessments at the

Flathead Lake watershed scale could include loads for stormwater sources that occur outside of the MS4 area (such as Whitefish, Columbia Falls, Evergreen, etc.)

Comment 2.8: It is disappointing that after considerable effort and resources were expended on developing a world class model for the Flathead watershed, it is used only to estimate current loadings. Why wasn't the model also used to predict the effects of the proposed point and nonpoint source load reductions on the attainment of water quality targets/standards along the length of Ashley Creek?

Response 2.8: The model was used for its primary intended purpose, that is to provide reasonable estimations of pollutant loading from identified source areas to inform the TMDL. Model scenarios were thus, not required to complete TMDLs for Ashley Creek. The model, however, could be used to inform implementation plans and strategies in the future.

Comment 2.9: We strongly recommend that the TMDLs include load allocations for each nonpoint source. The composite load allocation approach will require that allocations to each nonpoint source be made at the local level. This is unrealistic. There is no incentive for stakeholders associated with any source to step up and assume responsibility for a share of a composite load allocation nor is it required by either law or regulation. In our view, restoration planning and BMPs implementation is very unlikely to occur with the composite load allocation approach. We believe the TMDLs must include allocations to specific sources in order to have any hope of implementation.

Response 2.9: The use of a composite allocation approach provides stakeholders with the opportunity to develop a customized restoration approach to achieve the TMDLs. A single TMDL can be achieved via different combinations of reductions. For example, if a TMDL is 10 lbs/day nitrogen and the existing load is 14 lbs/ day and 3 lbs are from fertilizer, 3 lbs are from grazing, and 2 lbs are from roads, fertilizer could be reduced by 1.5 lbs, grazing by 1.5 lbs, and roads by 1 lb. Alternatively, fertilizer could be reduced by 2 lbs, grazing by 1.25 lbs, and roads by 0.75 lb. Although, DEQ does not provide allocations to specific nonpoint nutrient sources, the source assessments for Ashley Creek and Spring Creek contain pie charts that detail the relative contribution of specific nonpoint and point sources. These charts can inform stakeholders during the process of developing a watershed restoration plan and determining which sources to address and to what extent they need to be reduced to achieve the TMDLs. The TMDL document provides a framework for stakeholders to develop a watershed restoration plan and DEQ believes that using a composite allocation approach provides flexibility for stakeholders in developing an effective plan.

Comment 2.10: We are pleased that on Page 5-64, a statement is made that the TMDL for Ashley Creek may not be enough to protect Flathead Lake. The statement should be broadened to include the possibility that TMDLs may be needed for other tributaries to protect Flathead Lake. A commitment needs to be made for when the Flathead Lake TMDL will be completed. We are also pleased that you recognize that an annual loading to the lake may also need to be established.

Response 2.10: We have broadened **Section 5.9** to include the following language: *In addition to Ashley Creek and Spring Creek, Flathead Lake Phase II TMDL allocations would also be applied to other tributaries throughout the Flathead Lake watershed. There are several approaches that could be used for setting these allocations. This could include allocations to multiple pollutant sources within a specific tributary, or application of load reductions to specific pollutant sources*

types across multiple tributaries. Note that tributary allocations can be developed for a downstream lake's TMDL without writing a TMDL specific to each tributary.

As stated in the above language, Flathead Lake TMDL allocations applicable to tributaries can be accomplished without writing TMDLs for each tributary. DEQ normally writes TMDLs for impaired waterbodies, and recently updated assessments and a review of water quality data throughout the watershed suggests that Ashley Creek and Spring Creek may be the only tributaries to Flathead Lake with nutrient impairment causes. DEQ is committed to completion of the Flathead Lake Phase II TMDL project and is in the process of defining the individual tasks and corresponding time frames for this work.

Comment 2.11: We strongly object to a statement made repeatedly in the TMDL document that "a staged WLA implementation via the variance process is justified" for the Kalispell Waste Water Treatment Plant (WWTP). No justification is provided. This determination should not be made in the TMDL.

Response 2.11: It is not the intent of the TMDL document to make the variance determination for the City of Kalispell's wastewater discharge. Instead, the TMDL document allows for staged WLA implementation via the variance process. The determination regarding variance applicability will be made outside the TMDL document during MPDES permit renewal. If the variance can be justified, then WLA implementation will be staged consistent with the DEQ MPDES permit and variance requirements. Allowing this type of staged WLA implementation consistent with Montana law and DEQ's permitting is logical, and **Sections 5.6.1.1**, **5.6.4.3.1** and **5.6.4.4.1** provide ample justification for staged implementation.

Within **Section 5.6.1.1**, language has been added (in underline here) to clarify that the final variance determination is outside the TMDL document: *"If the variance is granted, the city of Kalispell will have 20 years from the time they receive the variance to meet the numeric nutrient standards."* Also, in **Sections 5.6.4.3.1** and **5.6.4.4.1** similar language modifications are applied as follows (in underline and cross-out here using **Section 5.6.4.3.1** language): "*Yet, a 95% reduction is still required to meet the WLA concentration, thus justifying a staged WLA implementation if a ~~via the~~ variance is granted ~~process…~~".*

Comment 2.12: Perhaps the most troubling aspect of the nutrient TMDLs is the way requirements are established for point sources. The so-called waste load allocation for the Kalispell WWTP is not an allocation of load at all. The TMDL proposes that limitations in the NPDES permit for the WWTP based on a concentration at the end of its discharge pipe equal to the water quality standard for Ashley Creek would constitute a waste load allocation. This is not a legitimate approach. In effect it allows an unlimited nutrient load to be discharged to Ashley Creek from the Kalispell WWTP. It also shifts the entire burden for increased loading caused by growth to nonpoint sources (which are totally unregulated). This burden of controlling loading from future growth should be allocated among both point and nonpoint sources. This approach also fails to recognize that Flathead Lake is downstream of Ashley Creek. The quality of Flathead Lake is significantly impacted by nutrient loadings. The TMDL must establish maximum allowable nutrient loads for both point and nonpoint sources.

Response 2.12: The Kalispell WLA can be defined as a load using Equation 4 within **Section 5.6.1.1**. **Figure 5-4** provides an example curve for TP showing that the load can be determined for any WWTP discharge. The text below **Figure 5-4** states: "*For the purpose of setting MPDES*

discharge permit conditions, Equation 4 is always satisfied if the discharge concentration is equal to or less than the target concentration during the applicable time period (in this case, the summer growing season). Therefore, the permit WLA can be satisfied by applying a concentration-based requirement on the discharge as opposed to establishing a load. If a concentration-based approach is not used for MPDES permit integration, then the WLA should be based on the target concentration multiplied by the existing WWTP discharge flow (as opposed to the design flow). Using a concentration-based approach does not result in a load cap and can be used to simplify MPDES permit development." This language allows for either a load based or concentration based approach to setting permit requirements for the WLA. Applying a concentration based approach is practical because the load from a WWTP discharge cannot measured directly, it is instead calculated by multiplying the measured WWTP discharge flow by the measured WWTP discharge concentration. It does not matter what load comes from the WWTP since meeting the target concentration ensures protection of Ashley Creek, with the WWTP discharge flow providing the downstream dilution capacity.

By setting a concentration that is equal to the target, this approach addresses both present and future loading from the WWTP and it is done in a manner that is independent of existing and future upstream nonpoint source loading. No burden is shifted to upstream nonpoint sources. The upstream nonpoint source are addressed within composite nutrient load allocations which are set to satisfy the applicable TMDL target in all upstream segments and reaches of Ashley Creek. They are applicable to existing and future loading from all the nonpoint sources covered by each composite allocation. One advantage to using a concentration based approach is that it can help accommodate future sewering of septic systems. This is because the septic load, once transferred through the Kalispell WWTP, will be treated to meet target concentrations. An arbitrary load limit could hinder this type of water quality improvement.

We do acknowledge that a load limit may ultimately be required for the Kalispell WWTP for the purpose of future Flathead Lake TMDL development. That is outside the scope of this TMDL document since the Kalispell WLAs are written only for protection of Ashley Creek at this time. This is discussed in **Section 5.9**.

F3.0 SEDIMENT COMMENTS

Comment 3.1: Section 6.4.2.4. We are pleased that Fish Creek was found to be meeting physical and biological targets, and is no longer impaired for sediment. We collaborated with the Flathead National Forest on a road sediment inventory several years ago in the watershed, which supports DEQs findings.

Response 3.1: Thank you for your comment.

Comment 3.2: 6.5.4.2 Kalispell Small MS4, Establishing the Total Allowable load. Please provide the numbers, equations, and calculations used to determine Kalispell's determined contributions to upper and lower Ashley Creek and the Stillwater River?

Response 3.2: The Kalispell Small MS4 does not contribute to upper Ashley Creek. The contribution of sediment to middle and lower Ashley Creek and the Stillwater River were calculated by the Flathead Lake LSPC model. Information describing how these values were calculated is contained within the model report.

Comment 3.3: Please add a sentence in 6.5.4.2 indicating the w ide variability in stormwater samples. The paragraph presents the data without proper context.

> **Response 3.3:** A sentence describing the potential variability of TSS values in stormwater samples has been added.

Comment 3.4: Why is MDT's MS4 permit not addressed in the sediment TMDL?

> **Response 3.4:** **Section 6.5.5.2** states that MDT is a co-permittee to the Kalispell Small MS4 and as such the sediment TMDLs do address MDT's contribution to the MS4.

Comment 3.5: NOTE: Sections of this comment have been removed while retaining the key points.

While BMPs may be effective in limiting sediment to streams from roads they have limitations. First and foremost is regularly maintaining BMPs on roads. For the most part the Flathead National Forest and Dept. of Natural Resources and Conservation apply BMPs when they have a timber sale and need the roads for hauling. So when there is no logging going on, most roads are not maintained to BMP standards.

The Flathead National Forest has 3,519 miles of roads and had a road operation and maintenance budget of approximately $895,000 for fiscal years 2012 and 2013. However, the estimated funding needed to maintain roads to standard is approximately $1,300,000 annually. (Note that not all of this goes directly to road maintenance). The Flathead prioritizes road maintenance funds for roads open to public travel to administration and high use recreation sites.

In the Flathead's Draft Travel Analysis Report ~3,465 roads were slated to remain on the landscape because they are identified as "likely needed for future use"; 55 miles of road were identified as "likely not needed for future use"; 2,051 miles of roads that remain will be classified Maintenance Level 1.

Maintenance Level 1 roads allow use as a motorized trail and do not require that culverts be removed. It does place an emphasis on maintaining drainage facilities and runoff patterns. (Guidelines for Road Maintenance Levels, 7700-Transportation Management 1177 1811-SDTDC, June 2012, page 37) However, it is unclear how that can be accomplished when "planned road deterioration may occur" and motorized vehicles can be allowed to cause rutting and erosion.

So for the Flathead National Forest the majority of their roads will be in a maintenance category that does not require BMPs or that culverts be removed to protect water quality. Furthermore, in the draft Travel Analysis Report they didn't even raise the question of whether water quality and fish habitat would be protected.

The Flathead plans to keep all the current road system in the Sheppard and Logan Creek watersheds. The sediment TMDL cannot rely on the application of BMPs or maintenance of culverts for Forest Service roads unless it is a mandatory, non-discretionary term of the TMDL in order to protect and restore beneficial uses.

Also, appendix C shows roads that had BMPs applied in the Sheppard Creek watershed since 2004. This map is pretty meaningless since BMPs need to be continually maintained so roads that had BMPs applied ten years ago are probably not effective now.

DNRC's Northwest Land Office has 1,669 miles of roads of which 363 miles are in the Stillwater Block. DNRC assesses roads in the Stillwater Block every 5 years; other roads on scattered sections are not always inventoried every 5 years. (Habitat Conservation Plan Final Environmental Impact Statement 2010) This strategy does not seem to comply with the TMDL's reliance on maintaining BMPs.

Forest roads cause unacceptable impacts to water quality, fish habitat, secure wildlife habitat and native plants. The Sullivan Creek landslide (in the Hungry Horse reservoir area) is the most recent illustration of why it is dangerous to leave roads without adequate drainage features, maintenance and monitoring. The sediment TMDL needs a mechanism to ensure that the Forest Service and DNRC actually apply and maintain BMPs and either maintain or remove culverts on closed roads – otherwise beneficial uses will not be restored.

> **Response 3.5:** DEQ concurs that in addition to implementing BMPs, maintaining them is essential to achieving TMDLs. In recognition of this we have mentioned maintaining BMPs on pages 6-45, 6-46, and 9-7, as you have pointed out in your comment, as well as on page 9-5. We have also added language indicating the need for BMP maintenance on pages 6-45, 6-46, 6-53, 9-7, 9-12, and 10-2 to make it clear that both implementation and maintenance of BMPs are necessary to achieve the TMDLs within the document. In reference to your concern regarding culvert removal and maintenance, the words "regardless of road use status" have been added to sentences on pages 9-5 and 9-14. The language in the document now conveys that culverts should be properly sized, installed, and maintained regardless of how a road is used and managed. While DEQ provides specific actions that can be performed to decrease pollutant loading to impaired stream segments and encourages land managers to develop and implement forest plans consistent with TMDL allocations, the TMDL document does not give DEQ or EPA the authority to require these BMPs for nonpoint sources.

F4.0 TEMPERATURE COMMENTS

Comment 4.1: Section 7.6. If I understand this section correctly, the TMDL for temperature for the Whitefish River is calling for a 0.5^{o}F decrease in stream temperature. What concerns me is that the model error as demonstrated in the calibration is greater than 0.5^{o}F in the lower reaches of the River. This does not appear to make any sense – encumbering landowners and the local community to take steps to decrease stream temperature to such a trivial amount when it is within the model error.

> **Response 4.1:** The 1.4% model error described in **Section 7.6** is between the observed temperatures measured in the Whitefish River in 2008 and the baseline scenario (i.e., the model error is the observed temperature minus the simulated temperature). It is not a measurement of the error between the baseline and shade model scenarios. These two model scenarios (and not baseline versus observed data) were used to determine the temperature differences due to shading and whether the water quality standard for temperature is being exceeded. For this reason, the model error has little influence on the determination of whether the standard is being met.

The observed data used to construct and test the model (instream temperature measurements, riparian shading assessments, and flow measurements), was also used to determine that the Whitefish River has temperatures greater than 66.5°F in the summer and that it has been impacted to some degree by human sources due to reduction of streamside shading. The shade conditions used in the shade scenario were based on measurements made at locations on the Whitefish River where shade appears to be at potential. Although the accuracy of measured shade values and the application of them to other areas that are not currently meeting the potential for shade represent potential factors that can introduce model scenario uncertainty, DEQ is confident in the shade values used for both the baseline and shade models. If future sampling indicates that the potential for shade is less than, or greater than, that used in the current shade scenario, it could be adjusted accordingly and the impairment status re-evaluated.

Comment 4.2: Smith Lake is mislabeled on E-26.

Response 4.2: The map has been changed and now correctly identifies Smith Lake.

Comment 4.3: Section 7.4.2.5 … The following sentences don't make sense in relationship to temperature BMPs. *The target for the City of Kalispell MS4 permit will be to follow the minimum control measures provided in the MPDES permit authorization for permit MTR04005, or any update runoff reduction or initial flush stormwater capture control measures in subsequent permit renewals. Renewed permits must contain initial flush mitigation measure. As long as all BMPs are effectively implemented as described in the permit, discharge will be consistent with naturally occurring conditions.*

Initial flush BMPs don't correlate or mitigate temperature controls, the following sentences are recommended for substitutions. *The target for the City of Kalispell MS4 permit will be to follow the minimum control measures in the MPDES permit authorization for permit MTR04005. As long as all BMPs are effectively implemented as described in the permit, discharge will be consistent with naturally occurring conditions.*

Response 4.3: The language has been removed as suggested with "or any subsequent renewals" retained and now appears as: *The target for the City of Kalispell MS4 permit will be to follow the minimum control measures provided in the MPDES permit authorization for permit MTR04005, or any subsequent permit renewals. As long as all BMPs are effectively implemented as described in the permit, discharge will be consistent with naturally occurring conditions.*

Comment 4.4: Table 7-2 City of Kalispell Small MS4 Target Value for Ashley Creek and Whitefish River. Same comment as above, remove the following: *or any update runoff reduction or initial flush stormwater capture control measures in subsequent permit renewals. Renewed permits must contain initial flush mitigation measure.*

Response 4.4: The language has been edited and now appears as: *Follow the minimum control measures provided in the MPDES permit authorization for permit MTR04005, or any subsequent permit renewals.*

Comment 4.5: 7.6.1.1.3 Shade with no Kalispell WWTP Discharge Scenario. Please provide the numbers used to calculate the 61.95 average. From the graphs and table in appendix E, only maximums are provided which makes referencing material used for the calculation confusing.

Response 4.5: The 61.95°F value is the average temperature at 13.39 miles from the mouth of Ashley Creek (at the approximate location of the Kalispell WWTP) calculated by the QUAL2K model with all portions of Ashley Creek meeting the potential shade values listed in the "Shade Scenario" column of **Attachment EF** of **Appendix E** and the Kalispell WWTP discharge removed as a model input (i.e., the "Shade with no Kalispell WWTP Discharge Scenario"). **Table E2-13** has been added to **Appendix E** and lists the average temperatures for locations from ASHL-17 (17.11 miles from the mouth) to the mouth of Ashley Creek.

Comment 4.6: 7.6.1.1.5 Kalispell WWTP Point Source Assessment. Please provide the numbers used to calculate the 62.01 average. From the graphs and table in appendix E, only maximums are provided which makes referencing material used for the calculation confusing.

Response 4.6: The 62.01°F value is the average temperature at 15.25 miles from the mouth of Ashley Creek (upstream of the Kalispell WWTP and between ASHL-17 and ASHL-18) calculated by the QUAL2K model with all portions of Ashley Creek meeting the potential shade values listed in the "Shade Scenario" column of **Attachment EF** of **Appendix E** and the Kalispell WWTP discharge removed as a model input (i.e., the "Shade with no Kalispell WWTP Discharge Scenario"). **Table E2-13** has been added to **Appendix E** and lists the average temperatures for locations from ASHL-17 (17.11 miles from the mouth) to the mouth of Ashley Creek.

Comment 4.7: Because there is evidence, as provided in the report, that at times the Kalispell WWTP is not exceeding the narrative temperature standard, and will only exceed the standards when the modeled shade scenario upstream of the WWTP discharge is about 66 to 66.5 degrees; with that being established a WLA should not be implemented until such time as the WWTP discharge effects the stream temperature enough to exceed the narrative standard. Since the WWTP is currently the only contributor regulated by a permit, it would place an unwarranted requirement on the municipality to meet a modeled standard that may not be achieved due to no regulatory control on the non-point source contributors. Therefore, it is unreasonable to place a WLA onto the City before the upstream reaches are meeting the shade scenario (natural background) temperatures, and should be stated as such in the report.

Response 4.7: There is evidence that there may be times when the Kalispell WWTP is not causing the standard to be exceeded; however, **Figure 7-8** demonstrates that the WWTP has the potential to exceed the standard when the Ashley Creek temperature is around 66.5°F and when it is below about 66°F. Temperature data collected by DEQ in 2008 shows that on August 1 the temperature at ASHL-18 (upstream of the WWTP) ranged from 62.75 – 68.26°F. On this particular day, during about 13 hours the temperature was below 66°F and during an additional hour the temperature was 66.52°F. This means that during more than half of this particular day there was the potential that the WWTP could be causing the standard to be exceeded using *existing temperatures* (i.e., not accounting for any cooling that may result from upstream shade improvements. Even if shade could not be improved on Ashley Creek there would still be the potential for the WWTP to cause the standard to be exceeded. The goal of the sampling and analysis described in **Section 7.6.3** "Achieving Temperature Allocations" is to determine exactly when the standard is being exceeded. At this time we believe that the data collected as outlined in **Section 7.6.3** and mixing calculations will be sufficient to determine when the standard is being exceeded and additional modeling will not be necessary.

Comment 4.8: The City of Kalispell would like MDEQ to consider a development of a variance process for temperature similar to the nutrient variance for situations like this discharge; where temperature standards are only exceeded for a limited distance downstream of a discharge and exceeds the standard for minimal parts of the day and year.

> **Response 4.8:** The staged approach described in **Section 7.6.3** is intended to emulate a process that is similar to the intent of the nutrient variance process.

Comment 4.9: Do the narrative standards meet the intent of beneficial use for Ashley Creek? Can DEQ perform a more scientifically valid site specific study to assess and determine the natural background temperature for Ashley Creek?

> **Response 4.9:** Because the standard for temperature is narrative there is room for the interpretation of the naturally occurring temperature. For this reason we developed the staged implementation process and adaptive approach described in **Section 7.6.3**.

Comment 4.10: Would MDEQ write the temperature WLA going into the City WWTP permit? Or could the City propose alternative ways to mitigate its effect on temperature in Ashley Creek? See comment 12, below.

> **Response 4.10:** The WLA in **Table 7-8** is an example for a specific set of conditions and is not intended to be a number in the WWTP permit. The actions outlined in **Section 7.6.3** will be written into the permit in lieu of a discreet WLA value. Meeting these permit requirements will meet the intent of the WLA. As written in **Section 7.6.3,** DEQ will allow up to 20 years to meet the WLA. If appropriate, mitigation could be part of the staged implementation.

Comment 4.11: MDEQ should consider the addition of a benefit to cost analysis of meet the proposed Temperature WLA.

> **Response 4.11:** A benefit to cost analysis has already been incorporated into STEP 3 of the staged implementation process described **in Section 7.6.3**. The word “benefit” has added to the section for clarity.

Comment 4.12: Did the modelling performed for the shading scenarios accurately reflect the temperature decrease. Are there inputs that ca n be evaluated that would generate an increase in the temperature for the shaded scenarios?

> **Response 4.12:** Given the field data collected in 2008, we believe that the modelling performed for the shade scenario accurately reflects the temperature decrease. If in the future, we determine that the shade targets cannot be achieved in some locations, then the temperature decrease would be less than described under the current shade scenario. However, if we determine that greater shade values can be achieve then a larger temperature decrease would occur.

Comment 4.13: MDEQ has developed this temperature allocation and model based on one software package and a limited dataset. We would like MDEQ to consider alternative ways to better understand

Response 4.13: DEQ is open to consider other models. However, QUAL2K has been well-studied, is used around the world to model water quality, and is recommended by EPA for TMDL development. In addition to the QUAL2K model, mixing equations were used (with limited data as you point out) to demonstrate the potential effect of the WWTP on temperature in lower Ashley Creek under varying conditions. The synoptic data collected in Step 1 of the staged process will facilitate DEQ performing a robust analysis of the WWTP effect on lower Ashley Creek temperature via mixing equations in Step 2. The staged process outlined in **Section 7.6.3** does allow for DEQ to consider 1) additional methods for data analysis and 2) how the standard is to be applied in this specific situation.

Comment 4.14: Achieving the Waste load Allocation for the Kalispell WWTP. Achieving the step requirements is more practicable to achieve and plan for if it is associated with the permit cycles. Below is a recommended layout for achieving the step implementation.

- First permit cycle (5yrs) -Step 1data collection
  - Bullet 3. Real-time discharge is already being recorded at the WWTP, however collecting rea l-time data *just* before it enters into Ash ley Creek will provide multiple challenges, due to the physical location of the discharge pipe. Because of the layout of the pipe, we suggest removal of the word *just* from the sentence, and allow the installation at a more practical location suggested by Kalispell and approved by DEQ.
- Next permit cycle (5yrs)- Step 2 and 3 can be achieved
  - Please explain the intent of the second bullet in step 2, and who is responsible to determine the target for exceedance for elimination or reductions. What will the target be based from? Will modelling need to be performed to update the scenarios, and if so is DEQ able to perform the task.
- Next permit cycle (5yrs)- Step 4 can be achieved.
  - Document the actions that will be taken by the WWTP to improve water temperature in Ashley Creek *downstream of the discharge to the extent it was affected by the discharge*, timeline for implementation, and monitoring that will occur. By adding *downstream of the discharge* it defines the area of mitigations for step 4 second bullet. As written, it could be assumed the WWTP would be looking at all of Ashley Creek.
  - It should be stated that if the analysis proves the WWTP discharge is not creating an exceedance of the temperature standard at current temperatures, implementation to mitigate to natural modeled shade scenarios temperatures will only be required at such time as the upstream temperature are constantly meeting the shade scenario targets.
- Next permit cycle (5yrs)- Step 5 implement the plan; It should be stated that Step 5 should only be implemented if warranted.

Response 4.14: In general, DEQ agrees with your suggestions and we have made the appropriate changes to **Section 7.6.3**. The section now states the permit cycle during which each step will be completed as well as clarification as to whether the City of Kalispell or DEQ will be responsible for specific tasks.

Comment 4.15: 7.8 Uncertainty and Adaptive Management. It's stated, "As further monitoring and assessment is conducted, uncertainties with present assumption and consideration may be mitigated via periodic revision or review of the assessment that occurred for this document." Adaptive management techniques are a great management tool when utilized and acted upon. What guarantees will DEQ enact to ensure they will be reviewing this temperature TMDL, allocations, and supporting analysis that are

subject for periodic modifications and adjustments as new information and relationships are understood?

> **Response 4.15**: The role of DEQ in reviewing the temperature TMDL and associated WLA for lower Ashley Creek and performing supporting analyses will be written into the permit for the Kalispell WWTP as described in **Section 7.6.3**.

Comment 4.16: Why is MDT's MS4 permit not addressed in the Temperature TMDL?

> **Response 4.16**: In **Section 7.4.2.5** we acknowledge that MDT is a co-applicant (changed to "co-permittee" in the document) to permit MTR040005. As such, MDT's contribution to the Kalispell Small MS4 is addressed by the temperature TMDL.

Comment 4.17: No mention is made in the TMDLs of the relationship between temperature and increased biological activity, e.g., production of algae. We recommend addressing this in the TMDL document.

> **Response 4.17**: Language describing how increased temperature can affect primary production and dissolved oxygen content has been added to **Section 7.1**.

Comment 4.18: On Page 7-11, the statement is made that the targets include an implicit margin of safety (MOS). Why, then, do some of the TMDL calculations include the use of an explicit MOS and some do not, e.g., Lower Ashley Creek?

> **Response 4.18**: An explicit MOS was used on both upper and middle Ashley to ensure that the temperature of Ashley Creek will be at naturally occurring when all reasonable land, soil, and water conservation practices are applied and shade potential is achieved along all of Ashley Creek. By doing this, the temperature increase allowed by the water quality standard is reserved for use by the Kalispell WWTP in lower Ashley Creek. An explicit MOS was used in the Whitefish River temperature TMDL in recognition that the point sources are currently using only a small portion of the temperature increase allowed by the water quality standard and that our goal is for reaching the shade potential for riparian vegetation along the entire Whitefish River.

Comment 4.19: In Section 7.4.2.2, information is provided on the recommended width of a riparian buffer. Why wasn't a 75 foot buffer chosen as suggested by at least one of the references cited?

> **Response 4.19**: The 50 ft buffer was recommended as a minimum because that is the distance that appears to give the greatest benefit to water quality given the trade-offs to landowners that might graze or raise crops on their land. While increasing the width does increase the overall effectiveness of the buffer, the benefit per foot of buffer is decreased. DEQ supports any landowner that wants to implement riparian buffers and encourages them to use the widest buffer that they are comfortable with.

Comment 4.20: How was shade potential determined (Section 7.4.2.2)? The locations where there is "no potential" to achieve shade targets should be identified.

> **Response 4.20**: Shade potential was determined using field data collected from each of the streams and best professional judgment by environmental science professionals familiar with

riparian vegetation and its potential for growth when BMPs are applied and maintained. DEQ solicited stakeholder feedback regarding the temperature modeling and shade potential values incorporated into the models throughout the TMDL development process. The first draft of the model report was posted to the project website on 10/13/2011 and a new draft version of the model report was posted to the project website on 5/20/2014 with a notice of the update also being posted on the "Announcements and Updates" section on the project outreach page. The final QUAL2K model report was posted to the project website on 7/15/2014 and an email was sent to watershed advisory group members on 7/16/2014 notifying them of this action. The locations where there is "no potential" are locations where the riparian vegetation is already meeting its potential for producing shade; these locations could be healthy areas where there is lots of shade or an area where there is a road directly adjacent to the channel and there is nowhere for vegetation to grow. These locations are identified in **Attachment EF** of **Appendix E** and contain "yes" in the column labeled "Currently Meeting Potential Shade Conditions."

Comment 4.21: What limits the potential to reduce stream channel width? Do these conditions exist throughout the watershed?

Response 4.21: Stream discharge and hydrograph, topography, and channel type affect the width of a stream. Reducing the width of a stream can cause it to become deeper and/or faster and if the width is reduced too much can cause detrimental effects to the stream channel such as downcutting and excessive bank erosion. Site visits on Ashley Creek and the Whitefish River indicated that these streams are overall at the appropriate width. Aerial photos corroborate this finding. However, there may be some locations on either of these streams where localized overwidening is present; these locations could be targeted for restoration that would give the stream channel an appropriate width. Passive restoration via improved vegetation was suggested in **Section 7.4.2.3** of the draft document. Additional language has been added to this section mentioning active restoration to reduce stream width.

Comment 4.22: Does groundwater withdrawal have an effect on stream temperature? If so, is there a way to incorporate this variable into the TMDL determination?

Response 4.22: Groundwater withdrawal could have an impact on stream temperatures especially if it resulted in less cool water contributing to the discharge of a stream. The effects of existing groundwater quantity on instream temperature were incorporated into the QUAL2K models via the measured flow data used to construct the model and the temperature data used to calibrate the model. Water (and thus temperature) inputs and losses due to groundwater movement could be explicitly incorporated into the QUAL2K model and as such could be incorporated into the TMDL. However, gaining an understanding of the groundwater dynamics could require extensive research and was not considered given the time and resources available for this project. Groundwater studies could be incorporated into the watershed restoration plan for Ashley Creek and/or the Whitefish River if stakeholders deem this information to be of interest. As part of the adaptive management approach, new groundwater information could be used to further refine the temperature TMDLs.

Comment 4.23: Why is the shade target for the Whitefish River so much less than that for Ashley Creek (Table 7-2)?

Response 4.23: The shade targets for both the Whitefish River and Ashley Creek are the average shade values measured at sites that were deemed to be meeting potential for a given vegetation type. How much shade a stream receives from vegetation is a function of the type of vegetation, the height it can achieve, and the width of the stream. The Whitefish River tends to be wider than Ashley Creek (**Attachment EC** in **Appendix E**) and thus will receive less shade even if the same vegetation type and height are present on both streams.

Comment 4.24: In the last paragraph of page 7-20, the statement is made that the WLA was determined using design flows, thus addressing future growth. We believe this to be a legitimate way of providing for future growth. Why wasn't the same approach used in the nutrient TMDLs?

Response 4.24: The design flow was not used for the nutrient TMDLs because there are specific numeric criteria for nutrients. The goal for nutrients is to achieve these concentration values in the effluent discharge (see the response to Comment 2.12). However, design flows are used during staged implementation of the nutrient TMDLs which incorporates the nutrient variance process (Department Circular DEQ-12). Once the WWTP discharge concentration is equal to or less than the target concentration, then application of design flow is unnecessary since no matter what volume of flow is being discharged, it will not be causing or contributing to impairment. The standard for temperature is narrative and therefore provides for different options when calculating the wasteload allocation depending on the temperature and volume of effluent discharged and the temperature and volume of the stream discharge. Because the two point sources that discharge to the Whitefish River have so little effluent relative to the discharge of the Whitefish River, and even when they are discharging at their maximum temperature they do not seem to substantially affect the temperature in the Whitefish River, we opted to calculate the wasteload allocation using the design flow.

Comment 4.25: On page 7-21, it says that no explicit MOS was applied to the TMDL for the Kalispell WWTP. Why? How does this satisfy the provision of the Clean Water Act that requires a MOS?

Response 4.25: No explicit MOS was applied to the TMDL for lower Ashley Creek (which includes the Kalispell WWTP wasteload allocation) to allow for the Kalispell WWTP to use the entire temperature change allowed by the water quality standard. The TMDL for lower Ashley Creek has an implicit MOS incorporated into it. As described in **Section 7.7**, the implicit MOS for lower Ashley Creek includes the adaptive management approach that relies on future data collection and analysis to evaluate the effectiveness of targets and TMDL implementation and the recommendation that all reasonable water conservation measures be implemented to increase instream flow. Improving water quality via water management and irrigation practices are discussed in **Section 9.5.1.3**.

Comment 4.26: In Section 7.6 it says that the TMDL varies depending on specific temperature and "discharge conditions." We assume that "discharge conditions" means stream flow. It would be inappropriate to use WWTP discharge flows. This should be clarified.

Response 4.26: The "discharge conditions" in **Section 7.6** refer to both those of the stream and point source effluent and were used to calculate example TMDLs, allocations, and reductions. Language has been added on pages 7-22 and 7-28 to clarify this. You are correct that the TMDL is calculated based on the instream flow and temperature (see Equation 7-1). However, if a

point source enters a stream upstream of where the TMDL is calculated, the flow from that point source is part of the instream flow. Point source effluent flow and temperature are used to determine specific effects on instream temperature relative to the water quality standard and calculate existing loading, wasteload allocations, and reductions.

Comment 4.27: In the last paragraph, it is stated that the Kalispell WWTP will have 20 years to comply with the temperature TMDL for Lower Ashley Creek. It is not appropriate to include a point source compliance schedule in a TMDL, especially without the development and negotiation of a detailed schedule. The compliance schedule should be determined in the NPDES permit and variance process with an opportunity for public comment. No basis for a 20-year schedule is provided.

Response 4.27: The temperature wasteload allocation for the Kalispell WWTP is expected to be achieved through a staged implementation process. The variance process is currently applied to nutrients per state law. In developing staged implementation for the temperature WLA, the variance process concept as well as EPA guidance on staged TMDL implementation were both taken into consideration. The 20 years given in this document is the same amount of time given to the WWTP to achieve the nutrient wasteload allocations via the variance process. DEQ TMDL program personnel worked closely with both DEQ Permitting and representatives from the City of Kalispell toward the development of this staged implementation and an appropriate compliance schedule. In the final document (**Section 7.6.3**), we have incorporated permit cycles in the staged approach and the 20 year time period corresponds to four permit cycles. Public comments regarding the TMDLs were accepted during the October 10 – November 12, 2014 comment period. Implementation of the TMDL in the permit can be commented on during subsequent permit public comment periods.

ATTACHMENT A - FLATHEAD-STILLWATER TMDL PLANNING AREA SEDIMENT AND HABITAT ASSESSMENT SUMMARY REPORT

Flathead-Stillwater TMDL Planning Area
Sediment and Habitat Assessment
Summary Report



Prepared by:
Watershed Consulting, LLC
P.O. Box 1701
Kalispell, MT 59903

Submitted to:
Montana DEQ
1520 E. Sixth Avenue
Helena, MT 59620

March 15, 2009

TABLE OF CONTENTS

Table of Contents i
List of Figures iii
List of Tables iv
List of Appendices vi
1.0 Introduction 1
2.0 Aerial Assessment Reach Stratification 5
2.1 Methods 5
2.1.1 Stream Reaches and Reach Types 5
2.1.2 Sub-Reaches 8
3.0 Sediment and Habitat Dataset Review 9
3.1 Field Methodology 9
3.1.1 Survey Site Delineation 10
3.1.2 Field Determination of Bankfull 10
3.1.3 Channel Cross-sections 10
3.1.4 Channel Bed Morphology 12
3.1.5 Riparian Greenline Assessment 14
3.1.6 Streambank Erosion Assessment 15
3.1.7 Water Surface Slope 15
3.1.8 Field Notes 15
3.1.9 Quality Assurance/Control 15
3.2 Assessment Variables and Summary Statistics 16
3.2.1 Width/Depth Ratio 16
3.2.2 Entrenchment Ratio 18
3.2.3 Riffle Pebble Count: Substrate Fines (<2mm) 20
3.2.4 Riffle Pebble Count: Substrate Fines (<6mm) 22
3.2.5 Riffle Grid Toss: Substrate Fines (<6mm) 23
3.2.6 Pool Residual Depth (Reach mean value) 25
3.2.7 Pool Frequency (Count per 1000 ft) 26
3.2.8 Large Woody Debris (Frequency per 1000 ft) 28
3.2.9 Greenline Inventory: Percent Understory Shrub Cover 29
3.2.10 Greenline Inventory: Percent Bare Ground 31
3.3 Overview of Sampled Reaches 32
3.3.1 Reach Type CR-0-2-U 32
3.3.2 Reach Type CR-2-2-U 33
3.3.3 Reach Type CR-2-4-U 34
3.3.4 Reach Type NR-0-2-U 35
3.3.5 Reach Type NR-0-3-U 36
3.3.6 Reach Type NR-0-4-U 38
3.3.7 Reach Type NR-2-2-U 40
3.3.8 Reach Type NR-2-3-U 41
3.3.9 Reach Type NR-2-4-U 42
3.3.10 Reach Type NR-4-1-U 42
3.4 Data Summary: Sampled Reach Comparisons 43
3.4.1 Width/Depth Ratio 44
3.4.2 Entrenchment Ratio 45

3.4.3 Riffle Pebble Count (Substrate <2mm) 46
3.4.4 Riffle Pebble Count (Substrate <6mm) 47
3.4.5 Riffle Grid Toss (Substrate <6mm) 48
3.4.6 Percent Understory Shrub Cover 49
3.4.7 Percent Bare Ground 50
4.0 Streambank Erosion Source Assessment 51
4.1 Overview 51
4.2 Field Measurement of BEHI 52
4.3 Index Calculations 52
4.4 Retreat Rate 53
4.5 Bank Erosion Sediment Loading 53
4.6 BEHI Results 53
4.6.1. Reach EFSC-12 54
4.6.2. Reach STIL-12 55
4.6.3 Reach WFSC-08 56
4.6.4 Reach STIL-19 57
4.6.5 Reach STIL-23 58
4.6.6 Reach EFSC-15 59
4.6.7 Reach HASK-13 60
4.6.8 Reach LOGA-20 61
4.6.9 Reach SHEP-25 62
4.6.10 Reach WFSC-18 63
4.6.11 Reach ASHL-19 64
4.6.12 Reach ASHL-25 65
4.6.13 Reach ASHL-29 66
4.6.14 Reach LOGA-45 67
4.6.15 Reach STIL-33 68
4.6.16 Reach EFSC-16 69
4.6.17 Reach SHEP-18 69
4.6.18 Reach HASK-06 70
4.6.19 Reach LOGA-37 72
4.6.20 Reach FISH-05 72
4.7 Data Summary 73
4.7.1 Reach Type CR-0-2-U 74
4.7.2 Reach Type CR-2-2-U 74
4.7.3 Reach Type CR-2-4-U 74
4.7.4 Reach Type NR-0-2-U 75
4.7.5 Reach Type NR-0-3-U 75
4.7.6 Reach Type NR-0-4-U 75
4.7.7 Reach Type NR-2-2-U 76
4.7.8 Reach Type NR-2-3-U 76
4.7.9 Reach Type NR-2-4-U 76
4.7.10 Reach Type NR-4-1-U 77
4.7.11 Average Loads for all Reach Types 77
References 78

LIST OF FIGURES

Figure 1-1. Reaches surveyed in the Flathead-Stillwater TPA during the 2008 assessment..... 4
Figure 3-1. Width/Depth Ratio Segregated by Reach Type 18
Figure 3-2. Entrenchment Ratio Segregated by Reach Type..... 19
Figure 3-3. Riffle Pebble Count: Substrate Fines (<2mm) Segregated by Reach Type 21
Figure 3-4. Riffle Pebble Count: Substrate Fines (<6mm) Segregated by Reach Type 22
Figure 3-5. Riffle Grid Toss: Substrate Fines (<6mm) Segregated by Reach Type..... 24
Figure 3-6. Mean Residual Pool Depths Segregated by Reach Type 25
Figure 3-7. Pool Frequency Segregated by Reach Type..... 27
Figure 3-8. Large Woody Debris Segregated by Reach Type 28
Figure 3-9. Percent Understory Shrub Cover Segregated by Reach Type 30
Figure 3-10. Percent Bare Ground Segregated by Reach Type 31
Figure 3-11. Typical stream conditions in EFSC-12 Reach. 32
Figure 3-12. Typical stream conditions in STIL-12 Reach. 33
Figure 3-13. Typical stream conditions in WFSC-08 Reach. 34
Figure 3-14. Typical stream conditions in STIL-19 Reach. 34
Figure 3-15. Typical stream conditions in STIL-23 Reach. 35
Figure 3-16. Typical stream conditions in EFSC-15 Reach. 35
Figure 3-17. Typical stream conditions in HASK-13 Reach. 36
Figure 3-18. Typical stream conditions in LOGA-20 Reach. 36
Figure 3-19. Typical stream conditions in SHEP-25 Reach. 37
Figure 3-20. Typical stream conditions in WFSC-18 Reach. 37
Figure 3-21. Typical stream conditions in ASHL-19 Reach. 38
Figure 3-22. Typical stream conditions in ASHL-25 Reach. 38
Figure 3-23. Typical stream conditions in ASHL-29 Reach. 39
Figure 3-24. Typical stream conditions in LOGA-45 Reach. 39
Figure 3-25. Typical stream conditions in STIL-33 Reach. 40
Figure 3-26. Typical stream conditions in EFSC-16 Reach. 40
Figure 3-27. Typical stream conditions in SHEP-18 Reach. 41
Figure 3-28. Typical stream conditions in HASK-06 Reach. 41
Figure 3-29. Typical stream conditions in LOGA-37 Reach. 42
Figure 3-30. Typical stream conditions in FISH-05 Reach. 43
Figure 3-31. Width/Depth Ratio Segregated by Reach 44
Figure 3-32. Entrenchment Ratio Segregated by Reach..... 45
Figure 3-33. Riffle Pebble Count: Substrate Fines (<2mm) Segregated by Reach 46
Figure 3-34. Riffle Pebble Count: Substrate Fines (<6mm) Segregated by Reach 47
Figure 3-35. Riffle Grid Toss: Substrate Fines (<6mm) Segregated by Reach..... 48
Figure 3-36. Percent Understory Shrub Cover Segregated by Reach..... 49
Figure 3-37. Percent Bare Ground Segregated by Reach 50
Figure 4-1. Typical streambank conditions in EFSC-12 Reach 54
Figure 4-2. Typical streambank conditions in STIL-12 Reach..... 55
Figure 4-3. Typical streambank conditions in WFSC-08 Reach 56
Figure 4-4. Typical streambank conditions in STIL-19 Reach..... 57
Figure 4-5. Typical streambank conditions in STIL-23 Reach..... 58
Figure 4-6. Typical streambank conditions in EFSC-15 Reach 59

Figure 4-7. Typical streambank conditions in HASK-13 Reach 60
Figure 4-8. Typical streambank conditions in LOGA-20 Reach 61
Figure 4-9. Typical streambank conditions in SHEP-25 Reach 62
Figure 4-10. Typical streambank conditions in WFSC-18 Reach 63
Figure 4-11. Typical streambank conditions in ASHL-19 Reach. 64
Figure 4-12. Typical streambank conditions in ASHL-25 Reach. 65
Figure 4-13. Typical streambank conditions in ASHL-29 Reach. 66
Figure 4-14. Typical streambank conditions in LOGA-45 Reach 67
Figure 4-15. Typical streambank conditions in STIL-33 Reach. 68
Figure 4-16. Typical streambank conditions in EFSC-16 Reach 69
Figure 4-17. Typical streambank conditions in SHEP-18 Reach 70
Figure 4-18. Typical streambank conditions in HASK-06 Reach 71
Figure 4-19. Typical streambank conditions in LOGA-37 Reach 72
Figure 4-20. Typical streambank conditions in FISH-05 Reach. 73

LIST OF TABLES

Table 1-1. Tributaries in the FS-TPA, stream class, and 2006 impairment source description and impairment cause. 1
Table 2-1. Possible Level III Ecoregion, Valley Gradient, Strahler Stream Order, and Confinement Combinations. 6
Table 2-2. Level III Ecoregion, Valley Gradient, Strahler Stream Order and Confinement Combinations Identified in Aerial Assessments 7
Table 2-3. Sampled Sub-reaches in project area sorted by reach type 9
Table 3-1. Summary of Width/Depth Ratio Statistics by Reach Type. 18
Table 3-2. Summary of Entrenchment Ratio Statistics by Reach Type. 20
Table 3-3. Summary of Riffle Pebble Count: Substrate Fines (<2mm) Statistics by Reach Type. 21
Table 3-4. Summary of Riffle Pebble Count: Substrate Fines (<6mm) Statistics by Reach Type. 23
Table 3-5. Summary of Riffle Grid Toss: Substrate Fines (<6mm) Statistics by Reach Type..... 24
Table 3-6. Summary of Mean Residual Pool Depth Statistics by Reach Type. 26
Table 3-7. Summary of Pool Frequency Statistics by Reach Type. 27
Table 3-8. Summary of Large Woody Debris (LWD) Statistics by Reach Type. 29
Table 3-9. Summary of Understory Shrub Cover Statistics by Reach Type. 30
Table 3-10. Summary of Bare Ground Statistics by Reach Type 32
Table 3-11. Summary of Width/Depth Ratio Statistics by Reach 44
Table 3-12. Summary of Entrenchment Ratio Statistics Segregated by Reach 45
Table 3-13. Summary of Riffle Pebble Count: Substrate Fines (<2mm) Statistics Segregated by Reach. 46
Table 3-14. Summary of Riffle Pebble Count: Substrate Fines (<6mm) Statistics Segregated by Reach. 47
Table 3-15. Summary of Riffle Grid Toss: Substrate Fines (<6mm) Statistics Segregated by Reach. 48
Table 3-16. Summary of Understory Shrub Cover Statistics Segregated by Reach 49
Table 3-17. Summary of Bare Ground Statistics Segregated by Reach 50

Table 4-1. BEHI score and rating matrix (Rosgen 1996) 51
Table 4-2. BEHI score and rating following bank materials adjustment 52
Table 4-3. BEHI and Near Bank Stress categories and rate of streambank retreat (ft/yr) 53
Table 4-4. BEHI statistics for EFSC-12 Reach 54
Table 4-5. Load Sources for EFSC-12 Reach 54
Table 4-6. BEHI statistics for STIL-12 Reach 55
Table 4-7. Load Sources for STIL-12 Reach 55
Table 4-8. BEHI statistics for WFSC-08 Reach 56
Table 4-9. Load Sources for WFSC-08 Reach 56
Table 4-10. BEHI statistics for STIL-19 Reach 57
Table 4-11. Load Sources for STIL-19 Reach 57
Table 4-12. BEHI statistics for STIL-23 Reach 58
Table 4-13. Load Sources for STIL-23 Reach 58
Table 4-14. BEHI statistics for EFSC-15 Reach 59
Table 4-15. Load Sources for EFSC-15 Reach 59
Table 4-16. BEHI statistics for HASK-13 Reach 60
Table 4-17. Load Sources for HASK-13 Reach 60
Table 4-18. BEHI statistics for LOGA-20 Reach 61
Table 4-19. Load Sources for LOGA-20 Reach 61
Table 4-20. BEHI statistics for SHEP-25 Reach 62
Table 4-21. Load Sources for SHEP-25 Reach 62
Table 4-22. BEHI statistics for WFSC-18 Reach 63
Table 4-23. Load Sources for WFSC-18 Reach 63
Table 4-24. BEHI statistics for ASHL-19 Reach 64
Table 4-25. Load Sources for ASHL-19 Reach 65
Table 4-26. BEHI statistics for ASHL-25 Reach 65
Table 4-27. Load Sources for ASHL-25 Reach 66
Table 4-28. BEHI statistics for ASHL-29 Reach 66
Table 4-29. Load Sources for ASHL-29 Reach 67
Table 4-30. BEHI statistics for LOGA-45 Reach 67
Table 4-31. BEHI statistics for STIL-33 Reach 68
Table 4-32. Load Sources for STIL-33 Reach 68
Table 4-33. BEHI statistics for EFSC-16 Reach 69
Table 4-34. BEHI statistics for SHEP-18 Reach 70
Table 4-35. Load Sources for SHEP-18 Reach 70
Table 4-36. BEHI statistics for HASK-06 Reach 71
Table 4-37. Load Sources for HASK-06 Reach 71
Table 4-38. BEHI statistics for LOGA-37 Reach 72
Table 4-39. BEHI statistics for FISH-05 Reach 73
Table 4-40. Load Sources for FISH-05 Reach 73
Table 4-41. Sediment Load Data CR-0-2-U Reach Type 74
Table 4-42. Sediment Load Data CR-2-2-U Reach Type 74
Table 4-43. Sediment Load Data CR-2-4-U Reach Type 74
Table 4-44. Sediment Load Data NR-0-2-U Reach Type 75
Table 4-45. Sediment Load Data NR-0-3-U Reach Type 75
Table 4-46. Sediment Load Data NR-0-4-U Reach Type 75

Table 4-47. Sediment Load Data NR-2-2-U Reach Type..... 76
Table 4-48. Sediment Load Data NR-2-3-U Reach Type..... 76
Table 4-49. Sediment Load Data NR-2-4-U Reach Type..... 76
Table 4-50. Sediment Load Data NR-4-1-U Reach Type..... 77
Table 4-51. Summarized BEHI Sediment Loads for all Reaches..... 77

LIST OF APPENDICES

Appendix A: Field Forms

Appendix B: Assessment Notes Summary

Appendix C: Field Data (CD Format)

1.0 INTRODUCTION

The Flathead-Stillwater Total Maximum Daily Load Planning Area (FS-TPA) is located entirely in Flathead County in Northwestern Montana and includes the entire Stillwater River fourth level HUC watershed. The TPA comprises the northwestern area of the larger Flathead Lake Basin and is generally defined by the Salish Mountains to the East and the Whitefish Range to the West. These ranges cradle the narrow valley carved by the south-flowing Flathead River, which empties into Flathead Lake. The Ashley Creek and Stillwater River drainages, the main feeder streams of the Flathead River in the FS-TPA, comprise approximately 239 square miles (DEQ 2001). Much of the higher elevations on either side of the valley north of the Whitefish and Kalispell urban areas are within the Flathead National Forest.

Primary land use of the Flathead Basin is evergreen forest in the higher elevations, where timber harvest levels have declined significantly over the last 15 years. Grazing and agricultural activities have expanded in recent decades in the lower foothills dominated by grasslands. The Stillwater/Whitefish sub-basin contains a fast-growing urban area, whose population, according to 2000 census data, grew by 20% in the last decade and 42% since 1980 (DEQ 2001). Networks of public access dirt roads are abundant in the mountainous reaches, with moderate to high levels of vehicle traffic for recreational purposes in summer months. Higher elevation lakes such as Tally, Ashley and Smith are popular among local residents and tourists.

The FS-TPA encompasses six tributary watersheds that are included on the 2006 State of Montana's 303(d) list for sediment impacts and habitat limitations. Haskill Creek, which is not listed on the 2006 list, is also included for investigation in this study. Studied streams, their stream classes and the cause and source of the 2006 listing are provided in Table 1-1 (DEQ 2008a).

Table 1-1. Tributaries in the FS-TPA, stream class, and 2006 impairment source description and impairment cause.

Listed Stream Segment	Class	Source Description	Cause
Ashley Creek- Ashley Lake to Smith Lake	B-1	Channelization, Crop Production (Crop Land or Dry Land), Grazing in Riparian or Shoreline Zones, Loss of Riparian Habitat, Source unknown	Alteration in stream-side or littoral vegetative covers, Chlorophyll-a, Dissolved Oxygen, Phosphorous, Sedimentation/Siltation, Water Temperature, Total Kjehldahl Nitrogen
Ashley Creek- Smith Lake to Bridge on Kalispell Airport Road	B-2	Agriculture	Low flow alterations
Ashley Creek- Bridge on Kalispell Airport Road to Flathead River	C-2	Discharges from municipal separate storm sewer systems, Irrigated crop production,	Alteration in stream-side or littoral vegetative covers, chlorophyll-a,

		Municipal point source discharges, Natural sources, Upstream source,	Nitrate/Nitrite, Nitrogen (total), Dissolved Oxygen, Phosphorous, Water temperature, Total Kjehldahl Nitrogen
East Fork Swift Creek	A-1	Silviculture Activities, Streambank Modifications/Destabilization	Low flow alterations, Physical substrate habitat alterations
Haskill Creek- Basin pond to Whitefish River	A-1	No previous assessments	No previous assessments
Haskill Creek- Headwaters to Basin pond	A-1	Insufficient data- no previous assessments	Insufficient data- no previous assessments
Logan Creek- above Tally Lake	B-1	Silviculture Activities, Streambank Modifications/Destabilization, Forest Roads,	Other flow regime alterations, Physical substrate habitat alterations, Sedimentation/Siltation
Sheppard Creek	B-1	Crop production, Grazing in riparian or shoreline zones, Silviculture harvesting, Forest roads	Alterations in stream-side or littoral vegetative covers, Nitrate/Nitrite, Phosphorous, Sedimentation/Siltation
Stillwater River- Logan Creek to mouth	B-2	Loss of Riparian Habitat, Site Clearance (Land Development or Redevelopment), Source unknown	Alterations in stream-side or littoral vegetative covers, Nitrates, Phosphorous, Sedimentation/Siltation
West Fork Swift Creek	A-1	Silviculture activities, Highway/Road/Bridge runoff (Non-construction related)	Alterations in stream-side or littoral vegetative covers, Low flow alterations, Sedimentation/Siltation

Data has been periodically collected in the FS-TPA in support of TMDL development over the past few years. In 2008, a more comprehensive and consistent effort was conducted to gather information specific to sediment, morphology and habitat data. Watershed Consulting (WSC) was contracted by Montana DEQ to assist in the assessments and analysis of sediment and habitat conditions as they influence aquatic life beneficial uses in the SF-TPA.

Assessment began by stratifying streams in the area by key geomorphic characteristics to develop unique reach categories that could be applied in comparative analysis across watersheds. Stratification enables comparison between observed and expected values for sediment and habitat parameters, and supports quantification of the effects of anthropogenic influences. Water bodies were divided into reaches and sub-reaches based on aerial photo interpretation, landscape

conditions, and land-use factors. This preliminary stratification work was completed in summer 2008. The details of the stratification are provided in Section 2.

Following the initial stratification, representative sub-reaches were chosen by DEQ for data collection. WSC conducted a two day sampling reach verification reconnaissance with the DEQ on July 31 and August 1, 2008. Site surveys at the selected sub-reaches were conducted from September 3 to 16, 2008 and encompassed a total approximately 21 stream miles. Surveyed reaches are mapped in Figure 1-1. Watershed Consulting and DEQ personnel recorded bank erosion data and vegetation and channel characteristics. These data were analyzed in December 2008 and January 2009, resulting in full descriptions of sediment and habitat conditions for all of the surveyed reaches. Details of the field study are included in Sections 3 and 4.



Figure 1-1. Reaches surveyed in the Flathead-Stillwater TPA during the 2008 assessment.

2.0 AERIAL ASSESSMENT REACH STRATIFICATION

2.1 Methods

An aerial assessment of streams in the SF-TPA was conducted using ESRI ArcGIS 9 and 2005 color aerial imagery. Other relevant geographic data layers were acquired from the U.S. Geological Survey (USGS), the U.S. Environmental Protection Agency (USEPA) and the Montana State National Resource Information System (MT NRIS) database. Additional layers include the following data sets:

- Ecoregion (USEPA)
- Scanned and Rectified Topographic Maps, 1:24,000 (USGS)
- National Hydrography Dataset Lakes and Streams (USGS)
- 2005 National Aerial Image Program (NAIP – NRIS)

GIS data layers were used to stratify streams into reaches based on landscape and land-use factors. The stream reach stratification methodology applied in this study is described in *Watershed Stratification Methodology for TMDL Sediment and Habitat Investigations* (DEQ 2008a), with additional background information provided in *White Paper: A Watershed Stratification Approach for TMDL Sediment and Habitat Impairment Verification* (DEQ 2008b).

2.1.1 Stream Reaches and Reach Types

The sediment and habitat assessment study was conducted for the following streams and stream segments:

- Ashley Creek- Ashley Lake to Smith Lake
- Ashley Creek- Smith Lake to Bridge on Kalispell Airport Road
- Ashley Creek- Bridge on Kalispell Airport Road to Flathead River
- East Fork Swift Creek
- Haskill Creek- Basin pond to Whitefish River
- Haskill Creek- Headwaters to Basin pond
- Logan Creek- above Tally Lake
- Sheppard Creek
- Stillwater River- Logan Creek to mouth
- West Fork Swift Creek

The aerial photograph reach stratification methodology involves dividing a **stream segment** (see Table 1.1) into distinct **stream reaches** based on four landscape factors:

- Level IV Ecoregion
- Valley gradient
- Strahler stream order
- Valley confinement

Each individual combination of the four stream reach factors will be referred to as a "**reach type**" in this report.

Reach Type - Unique combination of Ecoregion, gradient, Strahler stream order, and confinement

Reach types were described using the following naming convention:

Level III Ecoregion – Valley Gradient – Strahler Stream Order – Confinement

The following identifiers were applied for each of the four factors:

- Level III Ecoregion:
  NR = Northern Rockies
  CR = Canadian Rockies

- Valley Gradient:
  0 = 0-<2%
  2 = 2-<4%
  4 = 4-10%
  10 = >10%

- Strahler Stream Order:
  1 = first order
  2 = second order
  3 = third order
  4 = fourth order

- Confinement:
  U = unconfined
  C = confined

Thus, a stream reach identified as NR-0-3-U is a low gradient (0-<2%), 3rd order, unconfined stream in the Northern Rockies Level III Ecoregion. Possible reach type combinations based on the Level III Ecoregion identified in the SF-TPA are presented in Table 2-1.

Table 2-1. Possible Level III Ecoregion, Valley Gradient,

Strahler Stream Order, and Confinement Combinations.			
Ecoregion III	**Valley Gradient**	**Strahler Stream Order**	**Confinement**
Northern Rockies	> 10 %	1	Unconfined
	4 - 10 %	2	Confined
	2 - < 4 %	3	
	< 2 %	4	

Stratification was completed by DEQ for listed stream segments throughout the FS-TPA in 2008. A listing of the stream reach types determined from the landscape factors listed above is provided in Table 2-2. The column *number of monitoring sites* refers to the survey sites assessed by Watershed Consulting.

Table 2-2. Level III Ecoregion, Valley Gradient, Strahler Stream Order and Confinement Combinations Identified in Aerial Assessments

Level III Ecoregion	Valley Gradient	Strahler Stream Order	Confine-ment	Reach Type	Level IV Ecoregion Codes	Number of Reaches	Number of Monitoring Sites
Canadian Rockies	0 - <2%	2	U	CR-0-2-U	41c	3	1
		3	U	CR-0-3-U	41c	2	0
		4	U	CR-0-4-U	41c	2	0
	2% - 4%	1	C	CR-2-1-C	41c	1	0
		2	U	CR-2-2-U	41b, c	7	2
		3	U	CR-2-3-U	41b, c	4	0
		4	U	CR-2-4-U	41b, c	6	2
		4	C	CR-2-4-C	41c	1	0
	4% - 10%	1	U	CR-4-1-U	41c	4	0
		1	C	CR-4-1-C	41c	2	0
		2	U	CR-4-2-U	41b, c	5	0
		3	U	CR-4-3-U	41b	2	0
	>10%	1	U	CR-10-1-U	41c	12	0
		1	C	CR-10-1-C	41c	4	0
		2	U	CR-10-2-U	41c	1	0
		2	C	CR-10-2-C	41c	1	0
Northern	0 - <2%	1	U	NR-0-1-U	15c	2	0

Rockies		2	U	NR-0-2-U	15c, l, t	26	1
		3	U	NR-0-3-U	15c, l, t	58	3
		4	U	NR-0-4-U	15c, l, t	71	5
		5	U	NR-0-5-U	15c, t	33	0
	2% - 4%	1	U	NR-2-1-U	15l	2	0
		2	U	NR-2-2-U	15l, t	18	2
		3	U	NR-2-3-U	15c, l, t	19	1
		4	U	NR-2-4-U	15l, t	15	1
		4	C	NR-2-4-C	15t	1	0
	4% - 10%	1	U	NR-4-1-U	15l	18	1
		2	U	NR-4-2-U	15l, t	14	0
		3	U	NR-4-3-U	15l, t	2	0
		3	C	NR-4-3-C	15l, t	3	0
	>10%	1	U	NR-10-1-U	15l, t	11	0
		2	U	NR-10-2-U	15l, t	4	0
		3	U	NR-10-3-U	15l	1	0
		3	C	NR-10-3-C	15l	1	0

Note that the Northern Rockies Level III Ecoregion contains 3 Level IV Ecoregions in the SF-TPA:

- 15t- Stillwater-Swan Wooded Valley
- 15c- Flathead Valley
- 15l- Salish Mountains

For the reach type analysis, reach types in the Canadian Rockies Level III Ecoregion are within one of two Level IV Ecoregions (USEPA 2002):

- 41c- Western Canadian Rockies
- 41b- Crestal Alpine-Subalpine

2.1.2 Sub-Reaches

In addition to classifying stream reaches into **reach types**, stream segments were divided based on the surrounding vegetation, gradient and land-use/land cover characteristics as observed in the

2005 color aerial imagery using ArcGIS. These sub-reaches are defined by a stream acronym and a number, assigned in ascending numerical order from upstream to downstream, and referred to in this report as a **Reach ID**. Changes in Level IV Ecoregions are captured by these sub-reaches, as no Reach ID extends across two Level IV Ecoregions.

Survey sites were chosen to represent the range of landscape characteristics and land use/land cover influences existing in the TPA. Table 2-3 lists the **Reach IDs** for assessed reaches within the project area.

Table 2-3. Sampled Sub-reaches in project area sorted by reach type

Level III Ecoregion	Reach Type	Reach ID	Number Sampled
Canadian Rockies	CR-0-2-U	EFSC-12	1
	CR-2-2-U	STIL-12; WFSC-08	2
	CR-2-4-U	STIL-19; STIL-23	2
Northern Rockies	NR-0-2-U	EFSC-15	1
	NR-0-3-U	HASK-13; LOGA-20; SHEP-25; WFSC-18	4
	NR-0-4-U	ASHL-19; ASHL-25; ASHL-29; LOGA-45; STIL-33	5
	NR-2-2-U	EFSC-16; SHEP-18	2
	NR-2-3-U	HASK-06	1
	NR-2-4-U	LOGA-37	1
	NR-4-1-U	FISH-05	1

The result of the aerial stratification methodology is a series of stream reaches and sub-reaches delineated by landscape and land-use factors. The overall objective of such stratification is to improve the potential for comparison of stream reaches with similar landscape factors (i.e. their degree of impairment, approximate loads under natural conditions, perceived and actual contributions from agriculture, mining, development, etc.) and to maintain continuity in data collection. Ultimately, such a methodology will aid the state in its overall objectives for managing and monitoring streams over large and diverse areas.

3.0 SEDIMENT AND HABITAT DATASET REVIEW

3.1 Field Methodology

In this section the various field methodologies used for this study are described. Methods follow standard DEQ protocols for sediment and habitat assessment, as presented in the document,

"Longitudinal Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments" (DEQ 2008c). All field forms used in the study are standard forms used by DEQ for sediment and habitat assessments. These forms are included in Appendix A. On-site training in field methodologies and field forms was conducted by DEQ for the entire assessment team during the first two days of the assessment period (see section 3.1.9). For most survey sites a minimum of 5 team members were present, which were always divided into 3 teams, referred to as the "Greenline," "Substrate," and "Cross-Section" teams in this section. The teams worked independently moving upstream through the survey site and in a pre-established order so as to create the least possible in-stream disturbance.

3.1.1 Survey Site Delineation

Stream survey sites were delineated beginning at riffle crests at the downstream ends of reaches. Survey sites were measured upstream at pre-determined lengths based on the bankfull width at the selected downstream riffle. Survey lengths of 500' were used for bankfull widths less than 10'; lengths of 1000' were used for bankfull widths between 10' and 50'; lengths of 1500' were used for bankfull widths between 50' and 60'; and lengths of 2000' were used for bankfull widths greater than 60'. Each survey site was divided into 5 equally sized study cells. For each site, the field team leader identified the appropriate downstream riffle crest to begin a reach. Where no riffles were present or the stream was dry, the field team leader identified the appropriate starting point.

The GPS location of the downstream end of the survey site was recorded on the **Sediment and Habitat Assessment Site Information Form**.

Digital photographs were taken at both upstream and downstream ends of the survey site, looking both upstream and downstream. Photo numbers and a brief description were recorded in the **Photo Log**.

3.1.2 Field Determination of Bankfull

All members of the field crew (except for the "Greenline" team member) participated in determining the bankfull elevation prior to breaking into their respective teams.

Bankful indicators used included scour lines, changes in vegetation types, tops of point bars, changes in slope, changes in particle size and distribution, stained rocks and inundation features. Multiple locations and indicators were examined, and bankfull elevation estimates and their corresponding indicators were recorded in the **Bankfull Elevation and Slope Assessment Field Form** by the field team leader. Final determination of the appropriate bankfull elevation was determined by the team leader, and informed by the team experience and notes from the field form.

3.1.3 Channel Cross-sections

The "Cross Section team" was composed of two members of the assessment crew, who also performed pebble counts (3.1.4.6) riffle stability index (3.1.4.7) and riffle grid tosses (3.1.4.4).

Channel cross-section measurements were performed at the first riffle in each cell using a line level and a measuring rod and recorded in the **Channel Cross-section Field Form**.

Cross-sections were conducted in each cell containing a riffle feature. In the case that riffles were present in only 1 or 2 cells, but those cells contained multiple riffles, additional cross-sections were performed at the most downstream unmeasured riffle, such that a minimum of three cross-sections were conducted. If only 1 or 2 riffles were present in the entire reach, they were measured. In no cases of this assessment was the stream devoid of riffles.

To begin, the cross-section team placed a bank pin at the pre-determined bankfull elevation (using bankfull indicators as guides) on the right and left banks. A measuring tape was strung perpendicular to the stream channel at the most "well-defined" portion of the riffle and tied to the bank pins.

Where mid-channel bars or other features or crossings were present in the channel which prevented a "clean" line across the channel, protocol provided in section 2.3 of the "Longitudinal Field Methodology" document were followed (DEQ 2008c).

Depth measurements at bankfull were collected to a tenth of a foot across the channel at regular intervals. These intervals varied depending on channel width, following protocol in item 15, section 2.3 of the "Longitudinal Field Methodology" document (DEQ 2008c). Thalweg depth was recorded at the deepest point of the channel independent of the regularly spaced intervals.

From the recorded data, the following were calculated for each cross-section:

Mean depth = sum of depth measurements / number of depth measurements (exclude the RBF and LBF measurements, unless they are greater than zero, such as when there is a vertical bank)

Cross-sectional area = bankfull width x mean bankfull depth

Width/depth ratio = bankfull width / mean bankfull depth

Entrenchment ratio = floodprone width / bankfull width.

In the case that cross-sectional areas determined from different cross-sections varied greatly, a cross-section was re-strung and measured again. In some cases, major alterations in stream features caused these discrepancies, which were noted in the field form.

The floodprone elevation was determined by multiplying the maximum depth value by 2. The floodprone width was then determined by stringing a tape from the bankfull channel margin on both right and left banks until the tape (pulled tight and "flat") touched ground at the floodprone elevation. The total floodprone width was calculated by adding the bankfull channel width to the distances on either end of the channel to the floodprone elevation. When dense vegetation or other features prevented a direct line of tape from being strung, investigators determined the floodprone width using a range finder and Best Professional Judgment.

GPS coordinates for each cross-section were recorded. Photos were taken upstream and downstream of the cross section from the middle of the channel. A photo was also taken across the channel, showing the tape across the stream.

3.1.4 Channel Bed Morphology

A variety of channel bed morphology features was measured and recorded by the "Substrate" team, which usually consisted of two team members, and included the field team leader. The length of the survey site occupied by pools and riffles was identified and recorded in the **Pools, Riffles and Large Woody Debris Field Form.** Beginning from the downstream end of the survey site, the upstream and downstream stations of "dominant" riffle and pool stream features were recorded. Features were considered "dominant" when occupying over 50% of the stream width. Pools and riffles were measured from head crest or riffle crest, respectively, until the end of that feature (defined as the tail crest for pools).

Runs and glides were not recorded in the field form. Stream features were identified per standard field method criteria (DEQ 2008c).

3.1.4.1 Residual Pool Depth

At all pools encountered, a residual pool depth measurement was taken. Backwater pools were not measured. Measured pools were recorded at each "station" (distance in feet) of occurrence, beginning at the downstream end (station 0) of the survey site. The depth of the pool tail crest (see DEQ 2008c) at its deepest point was measured. No pool tail crest depth was recorded for dammed pools (see 3.1.4.2).

The maximum depth of each pool was also recorded. In the case of dry channels, readings were taken from channel bed surface to bankfull height.

3.1.4.2 Pool Habitat Quality

Qualitative assessments of each pool feature were undertaken and recorded in the **Pools, Riffles and Large Woody Debris Field Form** as follows:

1. Pool types were determined to be either Scour **(S)** or Dammed **(D)**.

2. Pool size was relative to bankfull channel width was recorded as Small **(S)**, Medium **(M)**, or Large **(L)**. Small pools were defined as those <1/3 of the bankfull channel; medium pools were >1/3 and <2/3 of the bankfull channel; and large pools were determined to be those >2/3 of the bankfull channel or >20 feet wide.

3. Pool formative features were recorded as either Lateral Scours **(LS)**, Plunge **(P)**, Boulder **(B)**, or Woody Debris **(W)**.

4. The primary pool cover type was recorded using the following codes:

V = Overhanging Vegetation
D = Depth
U = Undercut
B = Boulder
W = Woody Debris
N = No apparent cover

5. When undercut banks were present, their depths were measured to a tenth of a foot by inserting a measuring rod horizontally into the undercut bank.

3.1.4.3 Fine Sediment in Pool Tail-outs

A measurement of the percent of fine sediment in pool tail outs was taken using the grid toss method at the first and second scour pool of each cell. Grid toss readings were focused in those pool tail gravels that appeared to be suitable or potentially suitable for trout spawning.

Measurements were taken within the "arc" just upstream of the pool tail crest, following the methodology in section 2.8 of the field methods document (DEQ 2008c). Three measurements were taken across the channel with specific attention given to measurements in gravels determined to be of appropriate size for salmonid spawning. The potential for spawning was recorded as Yes **(Y)**, No **(N)**, or Unclear **(?)** at each measurement site.

3.1.4.4 Fine Sediment in Riffles

Using the same grid toss method as used in pools by the "Substrate" team (section 3.1.4.3), measurements of fine sediment in riffles were recorded by the "Cross Section" team. Grid tosses were performed in the same general location but before the pebble counts (section 3.1.4.6) and to avoid disturbances to fine sediments. These measurements were recorded in the **Riffle Pebble Count Field Form.**

3.1.4.5 Woody Debris Quantification

The amount of large woody debris (LWD) was recorded by the "Substrate" team along the entire assessment reach in the **Pools, Riffles and Large Woody Debris Field Form**. Large pieces of woody debris located within the bankfull channel and which were relatively stable as to influence channel form were counted as either single, aggregate or willow bunch. Further description of these categories is provided in section 2.10 of the field assessment protocols (DEQ 2008c).

3.1.4.6 Riffle Pebble Count

One Wolman pebble count (Wolman 1954) was performed by the "Cross Section" team at the first riffle encountered in cells 1, 3 and 5 as the team progressed upstream, providing a minimum of 300 particle sizes measured within each assessment reach. These measurements were recorded in the **Riffle Pebble Count Field Form**. Particle sizes were measured along their

intermediate length axis (*b-axis*) and results were grouped into size categories. The team progressed from bankfull to bankfull using the "heel to toe" method, measuring particle size at the tip of the boot at each step. More specific details of the pebble count methodology and protocol followed in cases where riffles were not encountered in the designated cells can be found in section 2.11 of the field methods document provided to the team prior to field assessment efforts (DEQ 2008c).

3.1.4.7 Riffle Stability Index

In streams that had developed point bars, a riffle stability index was performed to determine the average size of the largest recently deposited particle. This information was recorded in the **Riffle Pebble Count Field Form**.

For streams in which gravel bars were present, a total of 3 stability index measurements were conducted, which consisted of intermediate axis (*b-axis*) measurements of 15 particles determined to be among the largest size group to be recently deposited and which occur on over 10% of the point bar. During post-field data processing, the riffle stability index was calculated as the geometric mean of the survey site dataset.

3.1.5 Riparian Greenline Assessment

After the entire survey length was strung by the "greenline" team member, an assessment of riparian vegetation cover was performed. The greenline, which is located at approximately the bankfull channel margin, was walked by the "greenline" team member, who noted the general vegetation community type of the groundcover, and understory and overstory on both banks. Vegetation types were recorded at 10-foot intervals and were entered in the **Riparian Greenline Field Form**.

The ground cover vegetation (<1.5 foot tall) was described using the following categories:

W = Wetland vegetation, such as sedges and rushes
G = Grasses or forbs, rose, snowberry (vegetation lacking binding root structure)
B = Bare/disturbed ground
R = Rock, when a large cobble or bolder is encountered
RR = Riprap

The understory (1.5 to 15 feet tall) and overstory (>15 feet tall) vegetation was described using the following categories:

C = Coniferous
D = Deciduous, riparian shrubs and trees with sufficient rooting mass and depth to provide protection to the streambanks
M = mixed coniferous and deciduous

At 50-foot intervals, a riparian buffer width was estimated on either side of the bank. This width corresponded to the belt of vegetation buffering the stream from adjacent land uses. Upon conclusion of the greenline measurements, the total numbers of each type of vegetation were tallied.

3.1.6 Streambank Erosion Assessment

An assessment of all actively/visually eroding and slowly eroding/undercut/vegetated streambanks was conducted along each survey site. This assessment consisted of the Bank Erosion Hazard Index (BEHI; see Section 4) and Near Bank Stress estimation which are used to quantify sediment loads from bank erosion. All streambank measurements were recorded in the **Streambank Erosion Field Form** and **Additional Streambank Erosion Measurements Form.** Further information related to the streambank erosion assessment methodology and results is included in Section 4.

3.1.7 Water Surface Slope

Three water surface slope measurements were estimated using a clinometer and recorded in the **Elevation & Water Surface Slope Field Form** at each survey site. Two crew members, usually part of the "Cross Section" team stood at the water's surface in a riffle or similar stream feature and at a distance from each other with a direct line-of-sight.

3.1.8 Field Notes

At the completion of data collection at each survey site, field notes were collected by the field leader with inputs from the entire field team. The following four categories contributed to field notes, which served to provide an overall context for the condition of the stream channel relative to surrounding and historical uses:

- Description of human impacts and their severity
- Description of stream channel conditions
- Description of streambank erosion conditions
- Description of riparian vegetation conditions

3.1.9 Quality Assurance/Control

Two days of on-site training were held to familiarize the entire crew with all the field forms and procedures. The field team leader and most experienced crew members led the separate teams during these first two days. At the conclusion of the first days' training, all field forms were reviewed for completeness and accuracy.

To ensure the highest quality data collection, several protocols were followed at every site visit. Equipment checks were done every morning and field maps were reviewed with drivers before approaching the site. Field forms were distributed and double-checked before teams left the vehicles to the survey sites. Any questions that arose from field teams were brought to the

attention of the field team leader until doubts and questions were resolved to the leaders' satisfaction.

3.2 Assessment Variables and Summary Statistics

Erosion and sediment transport and deposition are natural functions of stream channels. Sediment deposition is needed to build streambanks and floodplains. Regular flooding allows sediment deposition to build floodplain soils and 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 erosion is taking place due to altered channel morphology or riparian vegetation, excess sediment is transported through the channel and may be deposited in critical aquatic habitat areas not naturally characterized by high levels of fine sediment.

Excessive sediment deposition may alter aquatic habitat quality and channel morphology by reducing pool depths, covering natural stream substrate, causing channel aggradation, altering shear stress on streambanks, or resulting in altered floodplain deposition patterns. Excess sediment often has detrimental effects on habitat for aquatic organisms. High suspended sediment levels reduce light penetration, which may cause a decline in primary production. As a result, aquatic invertebrate communities may also decline, in turn resulting in a decline in fish populations. Deposited particles may also obscure sources of food, habitat, hiding places, and nesting sites for invertebrates.

Excess sediment may also impair biological processes of individual aquatic organisms. When present in high levels, sediment may clog the gills of fish and cause other abrasive damage. High levels of benthic fine sediment can also impair reproductive success of fish. Fine sediment deposition reduces availability of suitable spawning habitat for salmonid fishes and can smother eggs or hatchlings. An accumulation of benthic fine sediment reduces the flow of water through gravels harboring salmonid eggs, hindering emergence of newly hatched fish, depleting oxygen supply to embryos, and causing metabolic wastes to accumulate around embryos, resulting in higher mortality rates (Armour and others 1991).

This sediment and habitat assessment focuses on environmental variables that are related to aquatic habitat condition and sediment supply in stream systems. The evaluated habitat and sediment variables are described below in the following subsections, in which results from field assessments are also presented. Results for each variable include a comparison among reach types and individual sites.

3.2.1 Width/Depth Ratio

Width/depth ratio is defined as the channel width at bankfull height divided by the mean bankfull depth (Rosgen 1996). 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 in 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"

Width/depth ratio is one of several standard measurements used to classify stream channels (Rosgen 1996), making it a useful variable for comparing conditions on reaches within the same stream type. Comparison of observed and expected width/depth ratio is a useful indicator of channel overwidening and aggradation, which are often linked to excess streambank erosion or acute or chronic erosion from sources upstream of the study reach. Channels that are overwidened often are associated with excess sediment deposition and streambank erosion, contain shallower, warmer water, and provide fewer deepwater habitat refugia for fish.

Width/depth data can be compared to guideline threshold values from previous studies to indicate if width/depth ratios observed on reaches in the FSTPA are greater than those expected for minimally impacted channels. Results exceeding the guideline values may indicate overwidening. A general threshold value for width/depth ratio is 23 for Rosgen B type channels and 30 for C channels. These values represent an average of target values used in previous TMDL assessments in northwest Montana. All study reaches fall within the range of B and C channel types and include Bc and Cb channels.

3.2.1.1 Reach Type Comparison

Width/depth ratio measured in the study reaches is plotted by reach type in Figure 3-1. Summary statistics for width/depth ratio of reach types are included in Table 3-1 following the box plot.

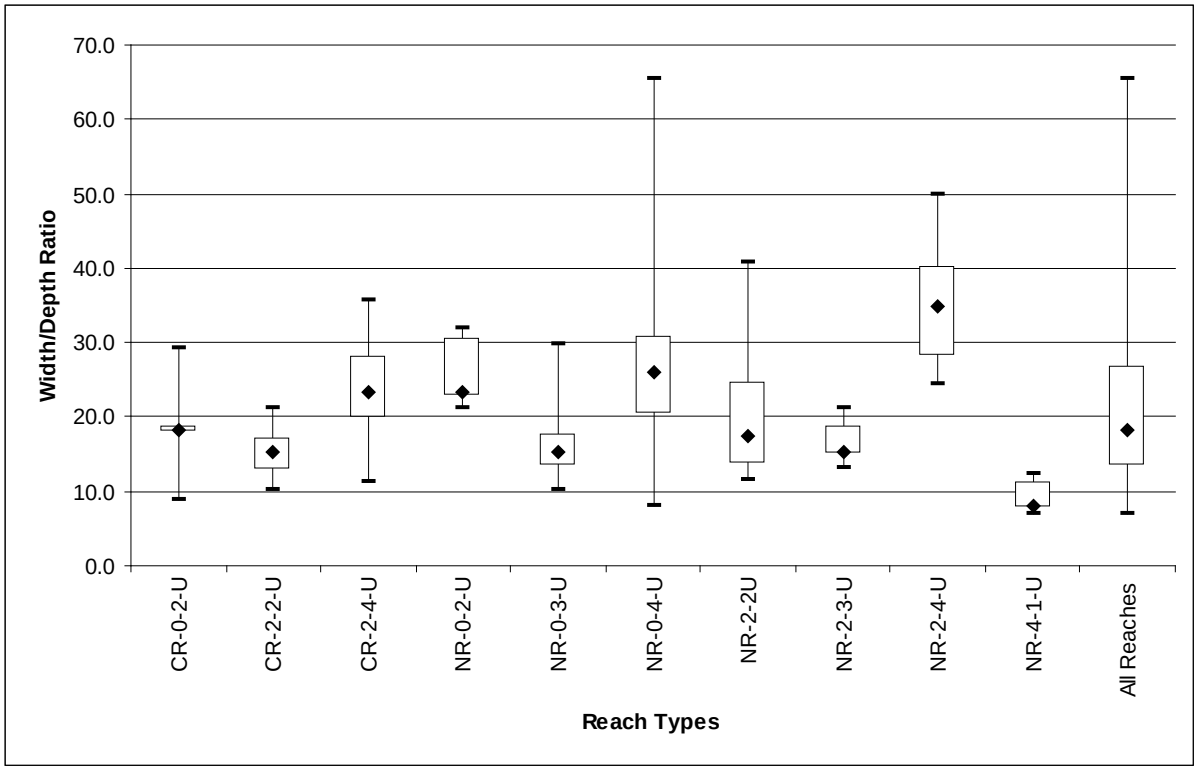


Figure 3-1. Width/Depth Ratio Segregated by Reach Type

Table 3-1. Summary of Width/Depth Ratio Statistics by Reach Type.

	Reach Types										
Statistic	**CR-0-2-U**	**CR-2-2-U**	**CR-2-4-U**	**NR-0-2-U**	**NR-0-3-U**	**NR-0-4-U**	**NR-2-2U**	**NR-2-3-U**	**NR-2-4-U**	**NR-4-1-U**	**All Reaches**
Number of Reaches	1	2	2	1	4	5	2	1	1	1	20
Sample Size	5	10	10	5	19	23	10	5	5	5	97
Minimum	8.9	10.3	11.2	21.3	10.3	8.0	11.6	13.0	24.3	6.9	6.9
25th Percentile	17.9	12.8	19.7	22.7	13.3	20.4	13.8	15.1	28.2	7.7	13.3
Median	18.3	15.4	23.2	23.4	15.4	26.0	17.6	15.4	34.8	8.0	18.3
75th Percentile	18.8	17.1	28.2	30.5	17.6	30.7	24.7	18.9	40.1	11.4	26.9
Maximum	29.1	21.2	35.8	32.0	29.9	65.4	40.8	21.2	49.8	12.2	65.4

3.2.2 Entrenchment Ratio

Stream entrenchment ratio is equal to the floodprone width divided by the bankfull width (Rosgen 1996). Entrenchment ratio is used to help determine if a stream shows departure from its natural stream type. It is an indicator of stream incisement, and therefore indicates how easily a stream can access its floodplain. Streams are often incised due to detrimental land management 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 high flow periods. Greater scouring energy in incised channels results in higher sediment loads derived from eroding banks. If the stream is not actively degrading (downcutting), the sources of human caused incisement are historic in nature and may not currently be present, although sediment loading may continue to occur. Entrenchment ratio is an important measure of channel condition as it relates to sediment loading and habitat condition, due to the long-lasting impacts of incisement and large potential for sediment loading in incised channels.

An expected entrenchment ratio for reaches classified as B channels falls within the range of 1.4-2.2, although an entrenchment ratio as low as 1.2 and as high as 2.4 is not outside the realm of expected channel dimensions. C channels, including Cb channels, generally have entrenchment ratios of greater than 2.2 (Rosgen 1996).

3.2.2.1 Reach Type Comparison

Entrenchment ratio measured in the study reaches is plotted by reach type in Figure 3-2. Summary statistics for entrenchment ratio of reach types are included in Table 3-2 following the box plot.

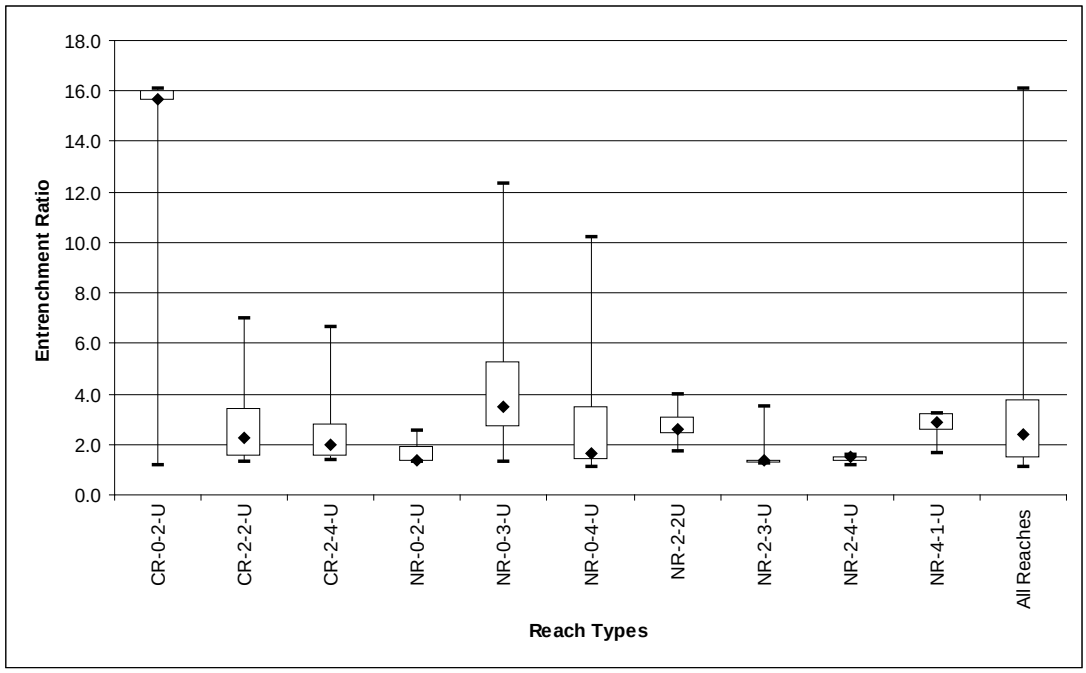


Figure 3-2. Entrenchment Ratio Segregated by Reach Type

Table 3-2. Summary of Entrenchment Ratio Statistics by Reach Type.

	Reach Types										
Statistic	**CR-0-2-U**	**CR-2-2-U**	**CR-2-4-U**	**NR-0-2-U**	**NR-0-3-U**	**NR-0-4-U**	**NR-2-2U**	**NR-2-3-U**	**NR-2-4-U**	**NR-4-1-U**	**All Reaches**
Number of Reaches	1	2	2	1	4	5	2	1	1	1	20
Sample Size	5	10	10	5	19	23	9	5	5	5	96
Minimum	1.2	1.3	1.4	1.3	1.3	1.1	1.7	1.2	1.1	1.6	1.1
25th Percentile	15.6	1.5	1.5	1.3	2.7	1.4	2.4	1.2	1.3	2.5	1.4
Median	15.7	2.3	2.0	1.4	3.5	1.6	2.6	1.4	1.5	2.9	2.4
75th Percentile	16.0	3.4	2.8	1.9	5.2	3.5	3.1	1.4	1.5	3.2	3.8
Maximum	16.1	7.0	6.6	2.5	12.3	10.2	4.0	3.5	1.6	3.2	16.1

3.2.3 Riffle Pebble Count: Substrate Fines (<2mm)

Percent surface fines provide a good measure of the siltation occurring in a river system and serve as an indicator of stream bottom aquatic habitat. Although it is difficult to correlate percent surface fines with loading in mass per time directly, the Clean Water Act allows "other applicable measures" for the development of TMDL water quality restoration plans. Percent surface fines have been used successfully in other TMDLs in western Montana addressing sediment related to stream bottom deposits, siltation, and aquatic life uses.

Surface fine sediment measured in the Wolman (1954) pebble count is one indicator of aquatic habitat condition and can indicate excessive sediment loading. Studies have shown that increased substrate fine materials less than 2mm can adversely affect embryo development success by limiting the amount of oxygen needed for development (Meehan 1991). As well, the TMDL for the Flathead Headwaters cites recent work completed in the Boise National Forest in Idaho, which showed a strong correlation between the health of macroinvertebrate communities and percent surface fines defined as all particles less than two millimeters.

Other studies in western Montana have set a threshold value for percent fine substrate (<2mm) at 15% to 20%. The guideline values used in these studies were based on best available conditions and empirical equations developed by Weaver and Fraley (1991). Surface fine sediment is difficult to measure with a great degree of precision using the Wolman pebble count method. To be conservative, any of the study reaches displaying greater than 15% fine sediment <2mm diameter in riffles may indicate an impact to fisheries or aquatic life.

3.2.3.1 Reach Type Comparison

Riffle pebble count (<2mm) measured in the study reaches is plotted by reach type in Figure 3-3. Summary statistics for riffle pebble count (<2mm) of reach types are included in Table 3-3 following the box plot.

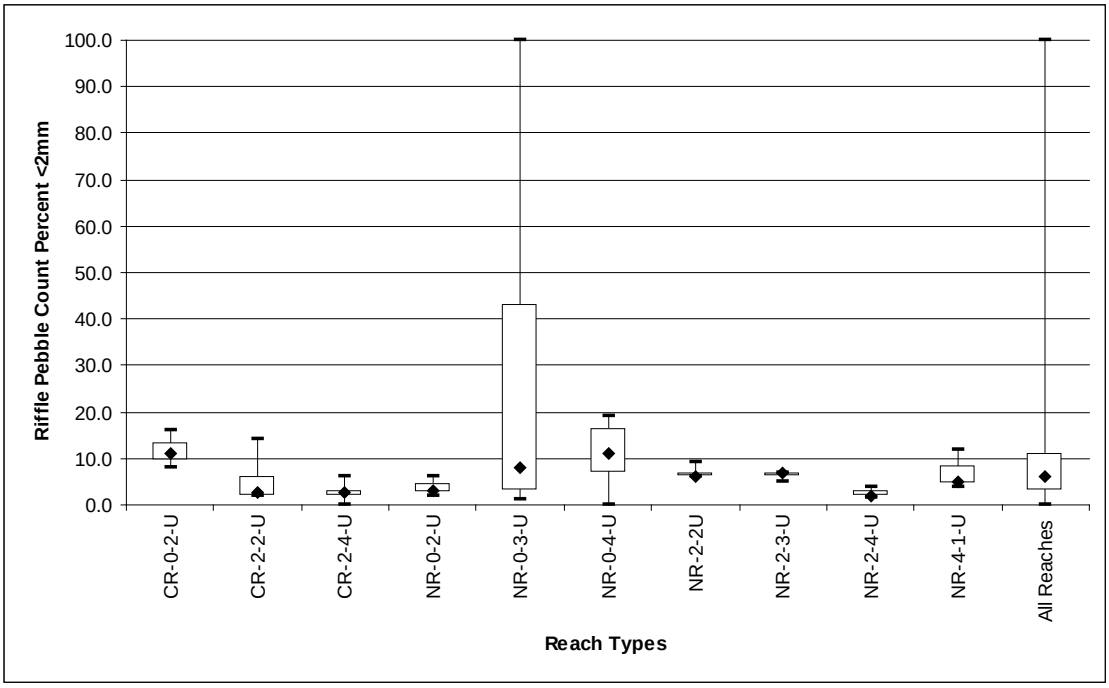


Figure 3-3. Riffle Pebble Count: Substrate Fines (<2mm) Segregated by Reach Type

Table 3-3. Summary of Riffle Pebble Count: Substrate Fines (<2mm) Statistics by Reach Type.

	Reach Types										
Statistic	**CR-0-2-U**	**CR-2-2-U**	**CR-2-4-U**	**NR-0-2-U**	**NR-0-3-U**	**NR-0-4-U**	**NR-2-2U**	**NR-2-3-U**	**NR-2-4-U**	**NR-4-1-U**	**All Reaches**
Number of Reaches	1	2	2	1	4	5	2	1	1	1	20
Sample Size	3	6	6	3	12	15	6	3	3	3	60
Minimum	8.0	2.0	0.0	2.0	1.0	0.0	6.0	5.0	1.7	4.0	0.0
25th Percentile	9.5	2.0	2.0	2.5	3.0	7.0	6.0	6.0	1.8	4.5	3.0
Median	11.0	2.5	2.5	3.0	7.8	11.0	6.0	7.0	2.0	5.0	6.0
75th Percentile	13.5	6.0	3.0	4.5	43.0	16.5	6.8	7.0	3.0	8.5	11.0
Maximum	16.0	14.0	6.0	6.0	100.0	19.0	9.0	7.0	4.0	12.0	100.0

3.2.4 Riffle Pebble Count: Substrate Fines (<6mm)

As with surface fine sediment smaller than 2mm diameter, an accumulation of surface fine sediment less than 6mm diameter may indicate excess sedimentation. The size distribution of substrate material in the streambed is also indicative of habitat quality for salmonid spawning and incubation. Excess surface fine substrate smaller than 6.35 mm may have detrimental impacts on aquatic habitat. Weaver and Fraley (1991) observed a significant inverse relationship between the percentage of material less than 6.35 mm and the emergence success of westslope cutthroat trout and bull trout.

Previous assessments in western Montana specify a wide range of target values for fine sediment less than 6 mm in diameter. Values vary by stream type and specific sampling method. For this assessment a guideline threshold value for fine sediment <6mm in riffles is 20%, which represents an average value of the guideline values used in previous studies.

3.2.4.1 Reach Type Comparison

Riffle pebble count (<6mm) measured in the study reaches is plotted by reach type in Figure 3-4. Summary statistics for riffle pebble count (<6mm) of reach types are included in Table 3-4 following the box plot.

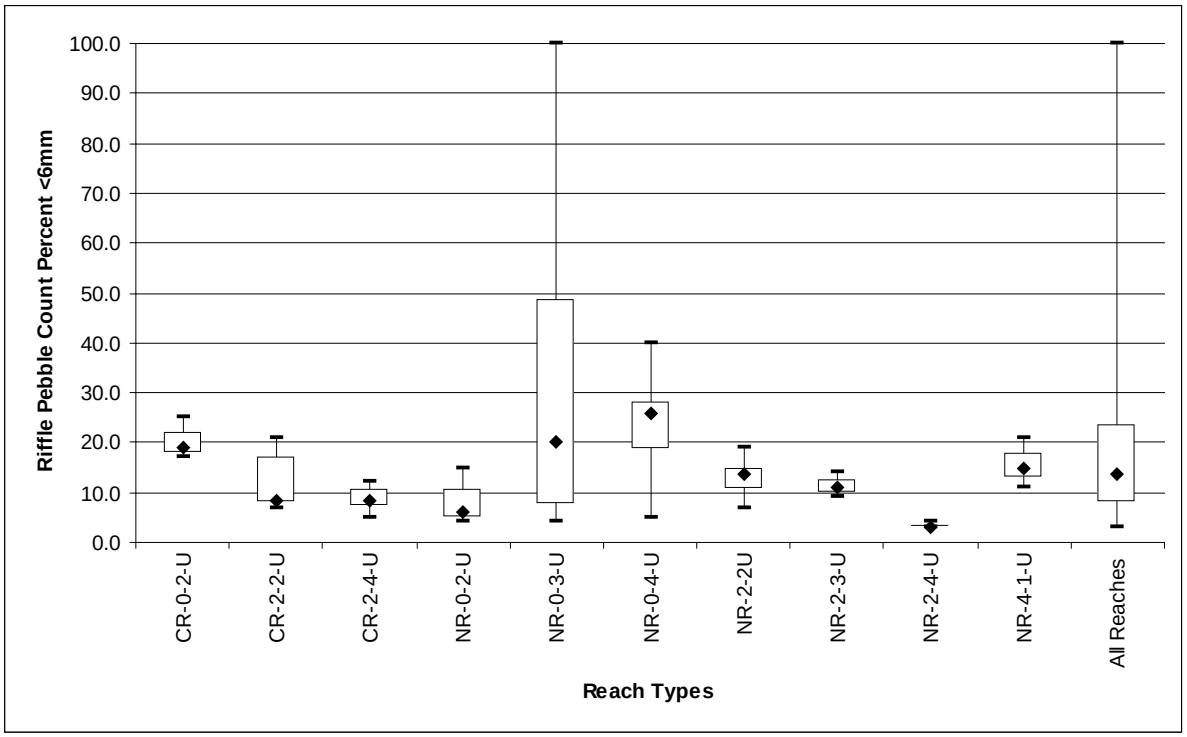


Figure 3-4. Riffle Pebble Count: Substrate Fines (<6mm) Segregated by Reach Type

Table 3-4. Summary of Riffle Pebble Count: Substrate Fines (<6mm) Statistics by Reach Type.

	Reach Types										
Statistic	**CR-0-2-U**	**CR-2-2-U**	**CR-2-4-U**	**NR-0-2-U**	**NR-0-3-U**	**NR-0-4-U**	**NR-2-2U**	**NR-2-3-U**	**NR-2-4-U**	**NR-4-1-U**	**All Reaches**
Number of Reaches	1	2	2	1	4	5	2	1	1	1	20
Sample Size	3	6	6	3	12	15	6	3	3	3	60
Minimum	17.0	7.0	5.0	4.0	4.0	5.0	7.0	9.0	3.0	11.0	3.0
25th Percentile	18.0	8.0	7.3	5.0	7.8	18.5	10.8	10.0	3.0	13.0	8.0
Median	19.0	8.5	8.5	6.0	20.0	26.0	13.5	11.0	3.0	15.0	13.5
75th Percentile	22.0	17.3	10.5	10.5	48.5	28.0	14.8	12.5	3.5	18.0	23.5
Maximum	25.0	21.0	12.0	15.0	100.0	40.0	19.0	14.0	4.0	21.0	100.0

3.2.5 Riffle Grid Toss: Substrate Fines (<6mm)

The wire grid toss is a standard procedure frequently used in aquatic habitat assessment. This method provides a more precise (repeatable) measurement of surface fine sediment than the broader survey approach of the Wolman pebble count. This measurement does not cover the entire channel width, as in the Wolman pebble count, but rather provides a more thorough measurement of surface fines in a subsample of the cross-section.

Previous assessments in western Montana specify a wide range of target values for fine sediment less than 6 mm in diameter. Values vary by stream type and specific sampling method. For this assessment a guideline threshold value for fine sediment <6mm in riffles is 20%, which represents an average value of the guideline values used in previous studies.

3.2.5.1 Reach Type Comparison

Riffle grid toss (fines<6mm) measured in the study reaches is plotted by reach type in Figure 3-5. Summary statistics for riffle grid toss results by reach type are included in Table 3-5 following the box plot.

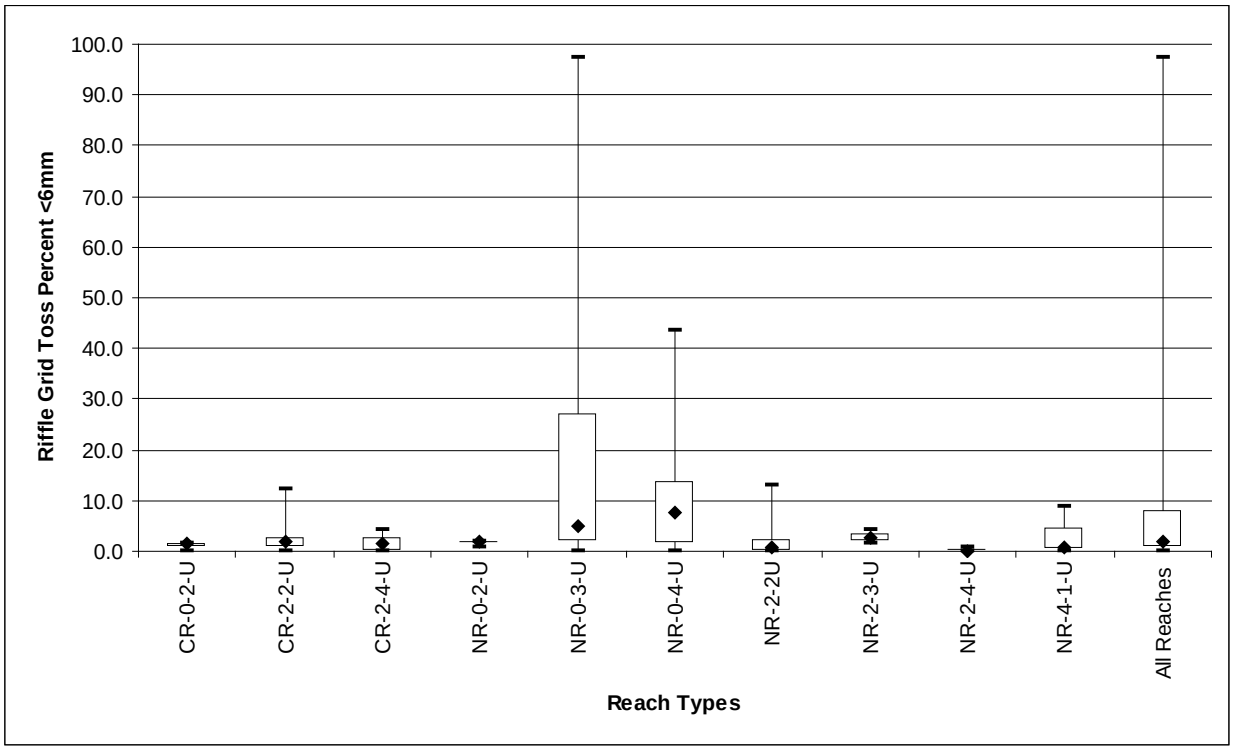


Figure 3-5. Riffle Grid Toss: Substrate Fines (<6mm) Segregated by Reach Type

Table 3-5. Summary of Riffle Grid Toss: Substrate Fines (<6mm) Statistics by Reach Type.

	Reach Types										
Statistic	**CR-0-2-U**	**CR-2-2-U**	**CR-2-4-U**	**NR-0-2-U**	**NR-0-3-U**	**NR-0-4-U**	**NR-2-2U**	**NR-2-3-U**	**NR-2-4-U**	**NR-4-1-U**	**All Reaches**
Number of Reaches	1	2	2	1	4	5	2	1	1	1	20
Sample Size	3	6	6	3	12	15	6	3	3	3	60
Minimum	0.0	0.0	0.0	0.7	0.0	0.0	0.0	1.4	0.0	0.0	0.0
25th Percentile	0.7	0.9	0.2	1.4	2.0	1.4	0.2	2.1	0.0	0.4	0.7
Median	1.4	2.1	1.4	2.0	5.1	7.5	0.7	2.7	0.0	0.7	2.0
75th Percentile	1.4	2.7	2.5	2.0	27.2	13.6	2.2	3.4	0.4	4.8	7.8
Maximum	1.4	12.2	4.1	2.0	97.3	43.5	12.9	4.1	0.7	8.8	97.3

3.2.6 Pool Residual Depth (Reach mean value)

Residual pool depth, defined as the difference between pool maximum depth and 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. Pool residual depth is also an indirect measurement of sediment inputs to listed streams. An increase in sediment loading would be expected to cause pools to fill, thus decreasing residual pool depth over time.

Previous assessments in western Montana specify target values for pool residual depth ranging from 1.5 ft to an average of 3 ft. Few individual pool depths exceeded 3 feet in the assessment reaches in this study, even in minimally impacted reaches, and most reaches had an average residual pool depth of less than 1.2 ft. Due to the stream sizes for most of the streams in the FS-TPA, a guideline value of 1.5 ft for mean residual pool depth appears to be the more suitable metric when examining these results.

3.2.6.1 Reach Type Comparison

Reach mean residual pool depth measured in the study reaches is plotted by reach type in Figure 3-6. Summary statistics for residual pool depth results by reach type are included in Table 3-6 following the box plot.

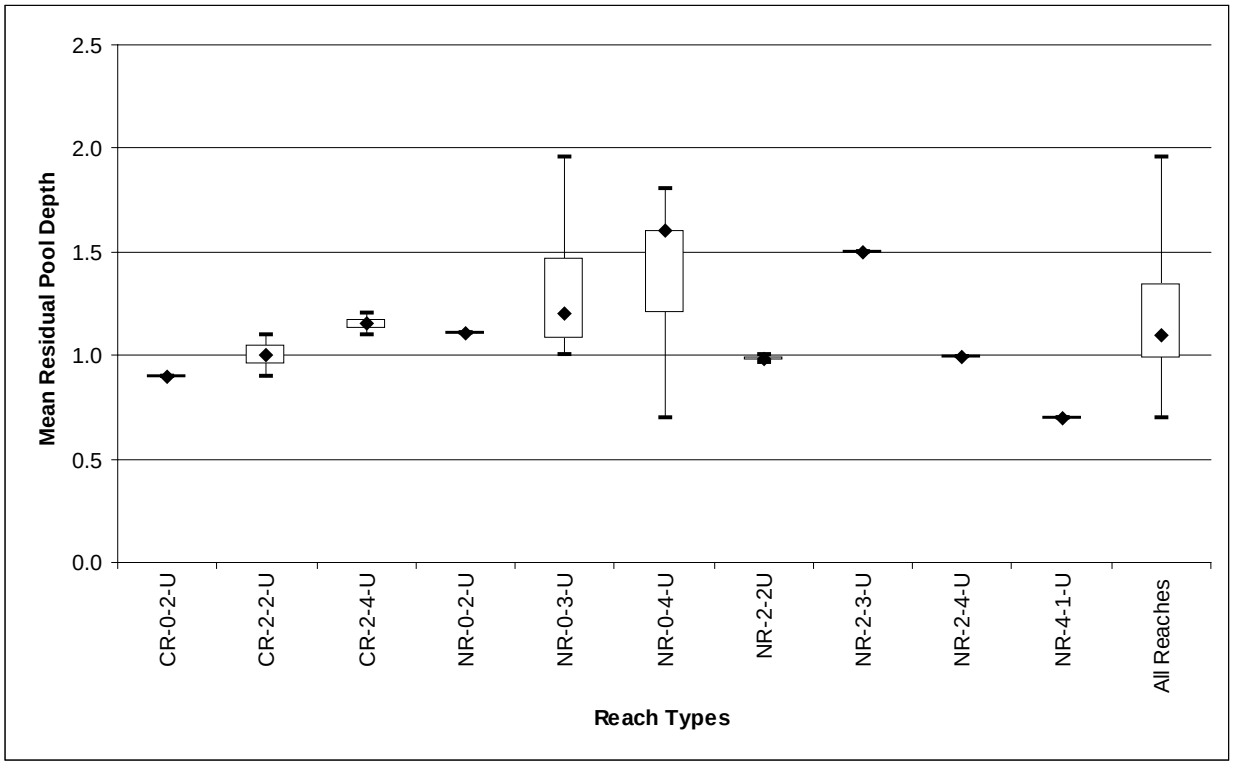


Figure 3-6. Mean Residual Pool Depths Segregated by Reach Type

Table 3-6. Summary of Mean Residual Pool Depth Statistics by Reach Type.

	Reach Types										
Statistic	**CR-0-2-U**	**CR-2-2-U**	**CR-2-4-U**	**NR-0-2-U**	**NR-0-3-U**	**NR-0-4-U**	**NR-2-2U**	**NR-2-3-U**	**NR-2-4-U**	**NR-4-1-U**	**All Reaches**
Number of Reaches	1	2	2	1	4	5	2	1	1	1	20
Sample Size	1	2	2	1	4	5	2	1	1	1	20
Minimum	0.9	0.9	1.1	1.1	1.0	0.7	1.0	1.5	1.0	0.7	0.7
25th Percentile	0.9	1.0	1.1	1.1	1.1	1.2	1.0	1.5	1.0	0.7	1.0
Median	0.9	1.0	1.2	1.1	1.2	1.6	1.0	1.5	1.0	0.7	1.1
75th Percentile	0.9	1.1	1.2	1.1	1.5	1.6	1.0	1.5	1.0	0.7	1.4
Maximum	0.9	1.1	1.2	1.1	2.0	1.8	1.0	1.5	1.0	0.7	2.0

3.2.7 Pool Frequency (Count per 1000 ft)

Pool frequency is a measure of the availability of pool habitat 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 affected adversely by riparian habitat degradation resulting in a reduced supply of large woody debris or scouring from stable root masses in streambanks.

Previous assessments from western Montana have specified pool frequency target values that vary according to channel wetted width, and in some cases by stream order and Rosgen type. Average wetted width on assessed stream reaches in the FSTPA was approximately 25 ft. A target value of 47 pools per mile, or approximately 9 pools per thousand feet, was used in previous studies for reaches with a specified wetted width of 25 ft. Although wetted widths differ among the assessed reaches in the FSTPA, reaches with a pool frequency much below 9 pools/1000 ft may have reduced aquatic habitat quality.

3.2.7.1 Reach Type Comparison

Pool frequency measured in the study reaches is plotted by reach type in Figure 3-7. Summary statistics for pool frequency by reach type are included in Table 3-7 following the box plot.

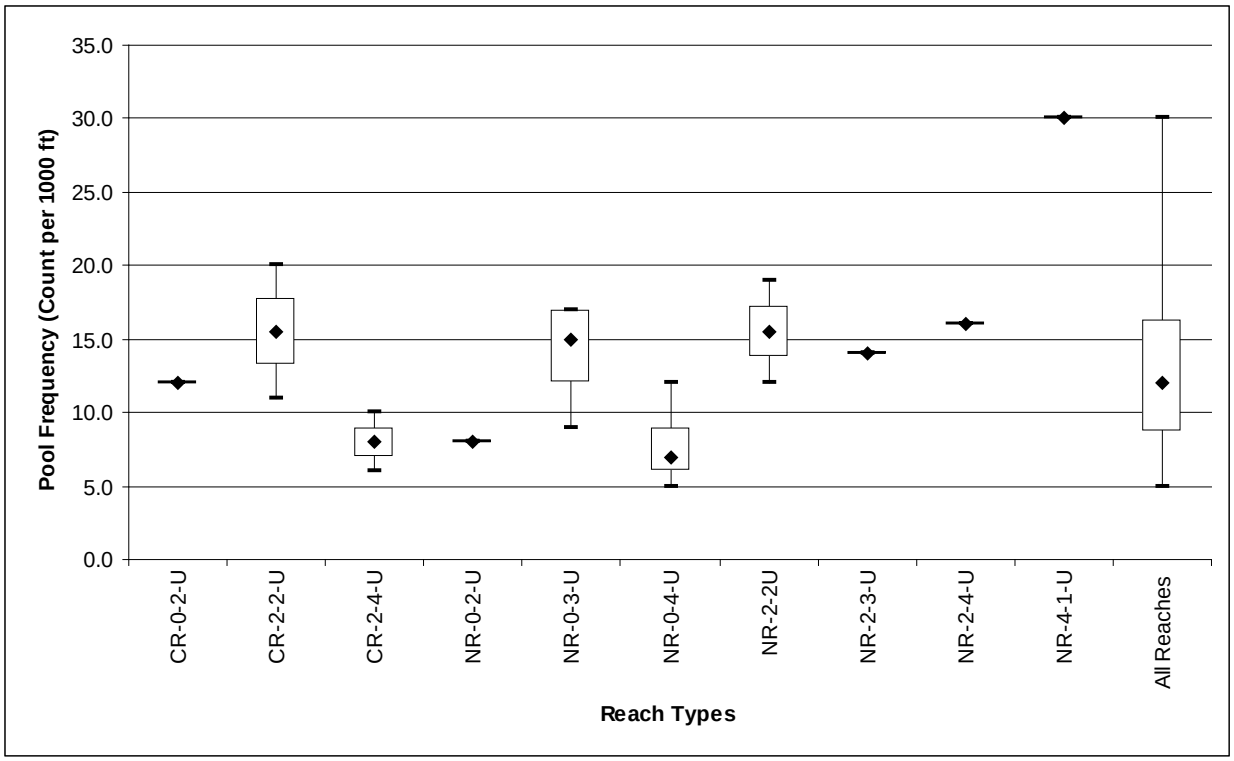


Figure 3-7. Pool Frequency Segregated by Reach Type

Table 3-7. Summary of Pool Frequency Statistics by Reach Type.

	Reach Types										
Statistic	**CR-0-2-U**	**CR-2-2-U**	**CR-2-4-U**	**NR-0-2-U**	**NR-0-3-U**	**NR-0-4-U**	**NR-2-2U**	**NR-2-3-U**	**NR-2-4-U**	**NR-4-1-U**	**All Reaches**
Number of Reaches	1	2	2	1	4	5	2	1	1	1	20
Sample Size	1	2	2	1	4	5	2	1	1	1	20
Minimum	12.0	11.0	6.0	8.0	9.0	5.0	12.0	14.0	16.0	30.0	5.0
25th Percentile	12.0	13.3	7.0	8.0	12.0	6.0	13.8	14.0	16.0	30.0	8.8
Median	12.0	15.5	8.0	8.0	15.0	7.0	15.5	14.0	16.0	30.0	12.0
75th Percentile	12.0	17.8	9.0	8.0	17.0	9.0	17.3	14.0	16.0	30.0	16.3
Maximum	12.0	20.0	10.0	8.0	17.0	12.0	19.0	14.0	16.0	30.0	30.0

3.2.8 Large Woody Debris (Frequency per 1000 ft)

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. Large woody debris 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). Large woody debris frequency can be measured and compared to reference reaches or literature values to determine whether more or less LWD is present than would be expected under optimal conditions. Too high or too low an LWD frequency may indicate riparian habitat impairment or upstream influences on habitat quality.

Target values for LWD span a broad range of values, even for streams of similar size. A guideline value of approximately 150 pieces of LWD per mile, or approximately 28 pieces of LWD per 1000 ft, represents an average of target values from other studies with similar average reach width. Results for LWD should be interpreted with caution, as the guideline value for this parameter is tied to a high degree of variability due to land use, vegetative community, and soils among other factors.

3.2.8.1 Reach Type Comparison

Large woody debris frequency measured in the study reaches is plotted by reach type in Figure 3-8. Summary statistics for large woody debris frequency by reach type are included in Table 3-8 following the box plot.

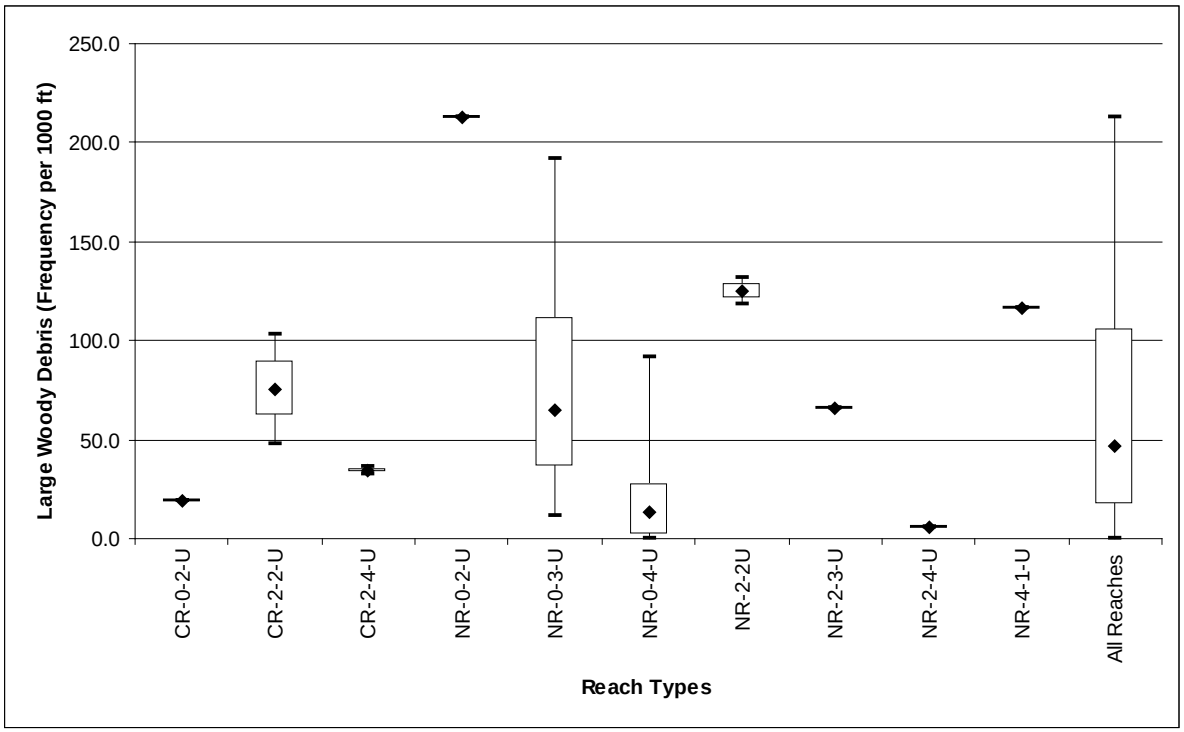


Figure 3-8. Large Woody Debris Segregated by Reach Type

Table 3-8. Summary of Large Woody Debris (LWD) Statistics by Reach Type.

	Reach Types										
Statistic	**CR-0-2-U**	**CR-2-2-U**	**CR-2-4-U**	**NR-0-2-U**	**NR-0-3-U**	**NR-0-4-U**	**NR-2-2U**	**NR-2-3-U**	**NR-2-4-U**	**NR-4-1-U**	**All Reaches**
Number of Reaches	1	2	2	1	4	5	2	1	1	1	20
Sample Size	1	2	2	1	4	5	2	1	1	1	20
Minimum	19.0	48.0	32.0	213.0	11.0	0.0	118.0	66.0	6.0	116.0	0.0
25th Percentile	19.0	61.8	33.0	213.0	36.5	2.0	121.5	66.0	6.0	116.0	17.5
Median	19.0	75.5	34.0	213.0	65.0	13.0	125.0	66.0	6.0	116.0	46.5
75th Percentile	19.0	89.3	35.0	213.0	111.8	28.0	128.5	66.0	6.0	116.0	106.3
Maximum	19.0	103.0	36.0	213.0	192.0	92.0	132.0	66.0	6.0	116.0	213.0

3.2.9 Greenline Inventory: Percent 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 main food source for fish. Organic inputs from shrubs, such as leaves and small twigs, provide food for aquatic macroinvertebrates, which are an important food source for fish.

Targets for streambank shrub cover and resulting streambank stability generally fall within the range of 75% to 85%, based on previous studies in Montana and Canada. Study reaches with lower than 75% shrub cover may be prone to excessive streambank erosion or have excessive streambank instability. It is important to keep in mind that understory shrub cover from study reaches may be low due to dense overstory canopy cover and competition from overstory canopy species, as in spruce-dominated reaches on smaller streams.

3.2.9.1 Reach Type Comparison

Percent understory shrub cover measured in the study reaches is plotted by reach type in Figure 3-9. Summary statistics for percent understory shrub cover by reach type are included in Table 3-9 following the box plot.

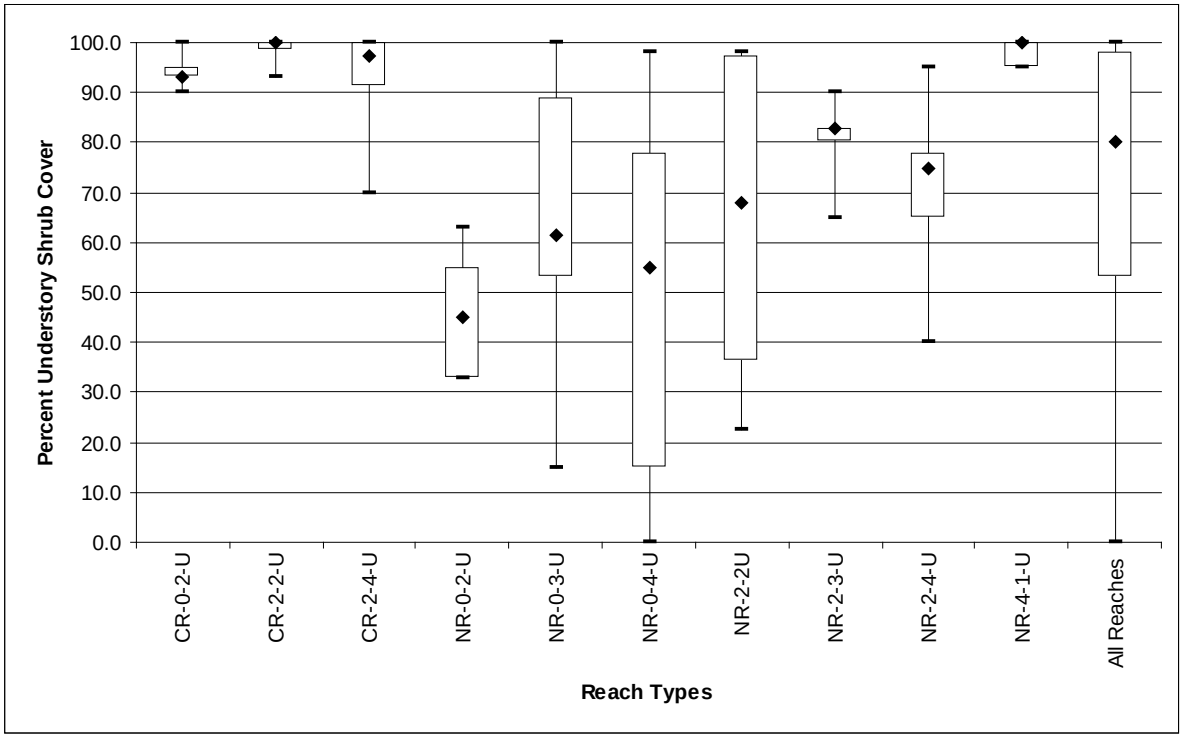


Figure 3-9. Percent Understory Shrub Cover Segregated by Reach Type

Table 3-9. Summary of Understory Shrub Cover Statistics by Reach Type.

	Reach Types										
Statistic	**CR-0-2-U**	**CR-2-2-U**	**CR-2-4-U**	**NR-0-2-U**	**NR-0-3-U**	**NR-0-4-U**	**NR-2-2U**	**NR-2-3-U**	**NR-2-4-U**	**NR-4-1-U**	**All Reaches**
Number of Reaches	1	2	2	1	4	5	2	1	1	1	20
Sample Size	5	10	10	5	20	25	10	5	5	5	100
Minimum	90.0	93.0	70.0	33.0	15.0	0.0	22.5	65.0	40.0	95.0	0.0
25th Percentile	93.0	98.5	91.3	33.0	53.0	15.0	36.3	80.0	65.0	95.0	53.0
Median	93.0	100.0	97.5	45.0	61.5	55.0	67.8	83.0	75.0	100.0	80.0
75th Percentile	95.0	100.0	100.0	55.0	88.8	78.0	97.3	83.0	78.0	100.0	98.0
Maximum	100.0	100.0	100.0	63.0	100.0	98.0	98.0	90.0	95.0	100.0	100.0

3.2.10 Greenline Inventory: Percent 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 was observed, leaving bare soil exposed. 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. Sediment can wash in from unprotected areas due to snowmelt, storm runoff, or 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.

Natural levels of bare ground can vary according to the riparian site type or habitat type, and by the landscape setting of the stream reach. For the purposes of this assessment, a general guideline value of greater than or equal to 10% bare ground is assigned to indicate a potential reduced riparian habitat quality or lowered filtering capacity.

3.2.10.1 Reach Type Comparison

Percent bare ground measured in the study reaches is plotted by reach type in Figure 3-10. Summary statistics for percent bare ground by reach type are included in Table 3-10 following the box plot.

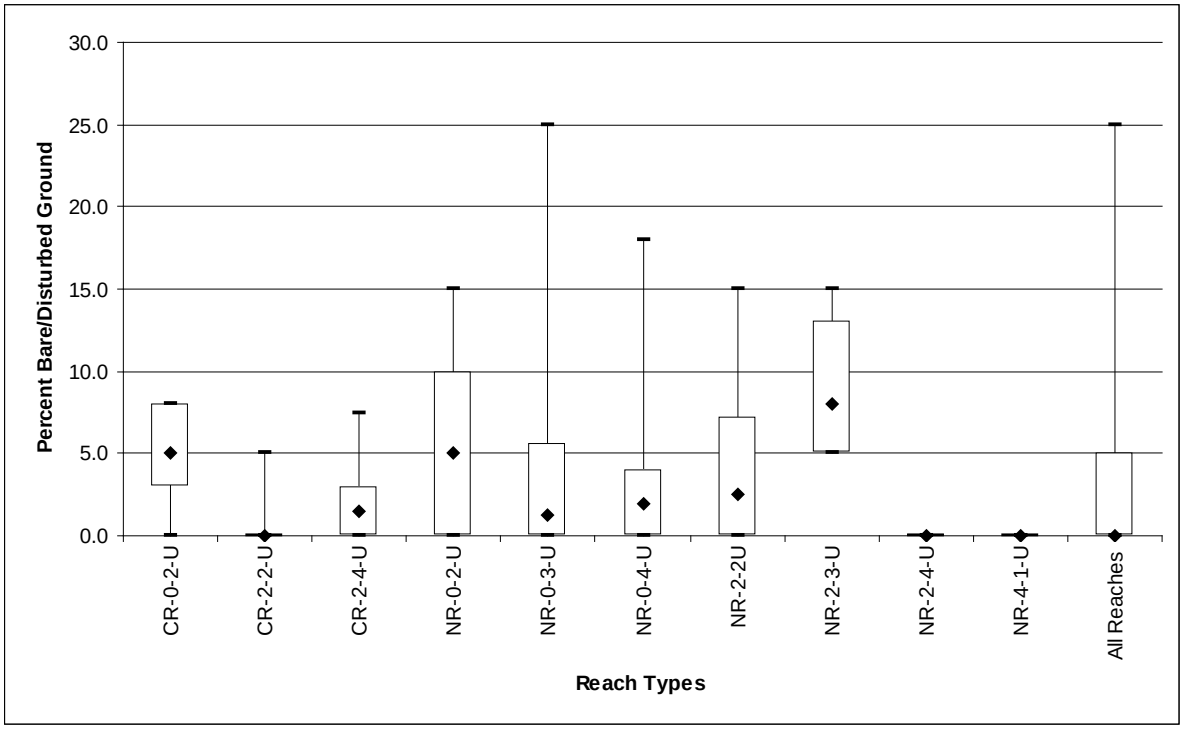


Figure 3-10. Percent Bare Ground Segregated by Reach Type

Table 3-10. Summary of Bare Ground Statistics by Reach Type

	Reach Types										
Statistic	**CR-0-2-U**	**CR-2-2-U**	**CR-2-4-U**	**NR-0-2-U**	**NR-0-3-U**	**NR-0-4-U**	**NR-2-2U**	**NR-2-3-U**	**NR-2-4-U**	**NR-4-1-U**	**All Reaches**
Number of Reaches	1	2	2	1	4	5	2	1	1	1	20
Sample Size	5	10	10	5	20	25	10	5	5	5	100
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0
25th Percentile	3.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0
Median	5.0	0.0	1.5	5.0	1.3	2.0	2.5	8.0	0.0	0.0	0.0
75th Percentile	8.0	0.0	3.0	10.0	5.6	4.0	7.3	13.0	0.0	0.0	5.0
Maximum	8.0	5.0	7.5	15.0	25.0	18.0	15.0	15.0	0.0	0.0	25.0

3.3 Overview of Sampled Reaches

This section describes the reach types and specific assessment reaches sampled in 2008. Each reach type description is followed by general descriptions of conditions in each assessment reach within that type. Assessment reaches are mapped in Fig. 1-1, Section 1. Reach conditions pertaining to habitat condition and sediment sources are summarized in Table B-1, Appendix B (Stream notes summary).

3.3.1 Reach Type CR-0-2-U

This reach type is within the Canadian Rockies Ecoregion (USEPA 2002) and is characterized by a stream gradient of 0% to 2%. Reaches in this type are on second-order streams (Strahler 1952) within an unconfined valley.

3.3.1.1 Reach EFSC-12



Figure 3-11. Typical stream conditions in EFSC-12 Reach.

Reach EFSC-12 is the only reach within the CR-0-2-U reach type. The reach, classified as a Rosgen C4b stream type (Rosgen 1996) is on the East Fork of Swift Creek above Upper Whitefish Lake. Vegetation outside the riparian area is dominated by mature conifer forest and grass. Past logging activity (50+ years prior) likely caused shifts in stream morphology and stability, particularly at the lower ends of the reach, though good shrub cover and some conifers along banks have stabilized the channel. There is a small amount of visible bank erosion attributed to de-stabilized banks of non-natural origin, mostly at the downstream ends of the reach. The streambed is dominated by coarse gravels and at the time of the survey was mostly dry. In high water, deep pools and wide riffle sections would be present.

3.3.2 Reach Type CR-2-2-U

This reach type is within the Canadian Rockies Level III Ecoregion (USEPA. 2002) and is characterized by stream gradients of 2% to 4% on second-order streams (Strahler 1952) and within an unconfined valley.

3.3.2.1 Reach STIL-12



Figure 3-12. Typical stream conditions in STIL-12 Reach.

Reach STIL-12 is on the Stillwater River in an area dominated by mature conifers (spruce, subalpine fir) on both banks. The riparian communities along the banks are diverse and vigorous, with dense root masses contributing to good bank stability. Bank erosion is minimal and primarily of natural cause. The stream is a C4b Rosgen stream type (Rosgen 1996) with a coarse gravel substrate. Spawning gravels are common, as is large woody debris. Pools are infrequent and shallow.

3.3.2.2 Reach WFSC-08



Figure 3-13. Typical stream conditions in WFSC-08 Reach.

Reach WFSC-08 of the West Fork of Swift Creek is classified as a B4 Rosgen stream type and is dominated by mature conifer forest. Historic logging activity in the drainage is not currently impacting the stream. Understory shrub growth is vigorous. The substrate is medium to coarse gravel, with larger gravels having potentially been deposited recently. Spawning gravels are present. Large woody debris is present, but not abundant.

3.3.3 Reach Type CR-2-4-U

This reach type is within the Canadian Rockies third level Ecoregion. Streams monitored in this Reach Type are in both Crestal Alpine-Subalpine and Western Canadian Rockies fourth level Ecoregions, both characterized by a stream gradient of 2% to 4%, on fourth-order streams (Strahler 1952) and within an unconfined valley.

3.3.3.1 Reach STIL-19



Figure 3-14. Typical stream conditions in STIL-19 Reach.

Reach STIL-19 of the Stillwater River is surrounded by coniferous forest. The reach is a Rosgen C3b stream type within the Crestal Alpine-Subalpine fourth level Ecoregion. Due to past logging around and upstream of the reach, the channel shows signs of adjustment, with some

natural bank scours, and a low diversity and presence of large woody debris and pools. Channel substrate is dominated by large gravels to small cobbles and spawning gravels are marginal. There is good shrub diversity and cover in the riparian area, and the surrounding floodplain forest is young.

3.3.3.2 Reach STIL-23

Reach STIL-23 is surrounded by mature mid-seral forest and shrub land. The reach is classified as a B4 stream type in the Western Canadian Rockies fourth level Ecoregion. The reach shows some signs of active adjustment to historic logging activity. Most bank erosion is occurring slowly and influence by natural cycles and high-flow events. Large gravels are the dominant substrate and spawning gravels are present in most cells. Pools and large woody debris are not abundant.



Figure 3-15. Typical stream conditions in STIL-23 Reach.

3.3.4 Reach Type NR-0-2-U

This reach type is within the Northern Rockies level three Ecoregion (USEPA 2002) and is characterized by a stream gradient of 0% to 2%, on second-order streams and within an unconfined valley. There is only one assessment reach in this reach type.

3.3.4.1 Reach EFSC-15



Figure 3-16. Typical stream conditions in EFSC-15 Reach.

Reach EFSC-15 is on the East Fork of Swift Creek in the Stillwater-Swan Wooded Valley fourth-level Ecoregion. It is a B4 Rosgen stream type and is surrounded by mature conifers. Land use impacts to the stream are negligible. Erosion is minimal and the channel is mostly stable, with large amounts of woody debris in the stream. The substrate is predominantly large gravels, of which some are suitable for spawning.

3.3.5 Reach Type NR-0-3-U

This reach type is within the Northern Rockies third level Ecoregion and characterized by a stream gradient of <2% on third-order streams and within an unconfined valley.

3.3.5.1 Reach HASK-13



Figure 3-17. Typical stream conditions in HASK-13 Reach.

The HASK-13 stream reach on Haskill Creek is within the Flathead Valley fourth level Ecoregion. It is a Rosgen C5 stream type with low sinuosity. The riparian vegetation is dominated by invasive grass species and provides a very limited supply of large woody debris. Beaver activity has influenced the stream historically but less so in the last few years. The substrate type is predominantly sand with naturally silted conditions due to beaver. Upstream agricultural activity does not appear to affect habitat conditions in this reach noticeably.

3.3.5.2 Reach LOGA-20



Figure 3-18. Typical stream conditions in LOGA-20 Reach.

The LOGA-20 reach is on Logan Creek in the Salish Mountain fourth level Ecoregion. It is a C4 Rosgen stream type characterized by a low sinuosity and dominated by mature spruce forest. Signs of light recreational use were observed. Large woody debris is present in the stream, although the riparian area is dominated by shrubs. This reach displays a diversity of aquatic habitat. The substrate type is small to medium gravels with some siltation. There is limited spawning habitat.

3.3.5.3 Reach SHEP-25



Figure 3-19. Typical stream conditions in SHEP-25 Reach.

The SHEP-25 reach is on Sheppard Creek within a mature conifer forest in the Salish Mountain level four Ecoregion (USEPA 2002). The reach is classified as a C3 Rosgen Stream type. Cobble substrates are dominant with few gravels suitable for spawning. The stream is well-armored and streambank erosion is infrequent. Large woody debris is present throughout the stream. Fire consumed this area in 2007, and forbs and shrub regrowth currently dominate the riparian area and adjacent uplands.

3.3.5.4 Reach WFSC-18



Figure 3-20. Typical stream conditions in WFSC-18 Reach.

Reach WFSC-18 is within the Stillwater-Swan Wooded Valley level four Ecoregion. It is classified as a C4b Rosgen stream type. No past human impacts are apparent, and this stream reach possesses some of the best available conditions within the study reaches. The riparian shrub community has good vigor and condition, and the channel is stable throughout this reach.

3.3.6 Reach Type NR-0-4-U

This reach type is in the Northern Rockies level three Ecoregion, and is characterized by fourth order streams with a 0-2% stream gradient and within an unconfined valley. Five of the reaches selected for assessment are in this reach type.

3.3.6.1 Reach ASHL-19



Figure 3-21. Typical stream conditions in ASHL-19 Reach.

This reach is in the Salish Mountains level four Ecoregion. Agricultural crops and grazing are the dominant land uses along this reach. It is a B4 Rosgen stream type with a low slope. The stream is incised and has unstable banks trampled by cattle in some areas. Small gravels are dominant and provide ample spawning substrate. Woody debris is very limited, as the riparian area is predominantly introduced grasses and forbs with minimal overstory canopy and understory shrub cover. Sediment loading from actively eroding banks is notable.

3.3.6.2 Reach ASHL-25



Figure 3-22. Typical stream conditions in ASHL-25 Reach.

The ASHL-25 reach is on Ashley Creek in the Flathead Valley fourth level Ecoregion. It is classified a C4 Rosgen stream type. Shrubs are the dominant vegetation and medium-sized gravels the dominant substrate. The stream has been channelized due to its urban setting, confined between housing developments and a highway. The substrate is small to medium gravels. Recent beaver activity is evident in the reach. Introduced riparian species and garbage are common in this reach.

3.3.6.3 Reach ASHL-29



Figure 3-23. Typical stream conditions in ASHL-29 Reach.

This reach, ASHL-29, is in the Flathead Valley fourth level Ecoregion. This reach of Ashley Creek is classified as a B4c Rosgen stream type. The stream energy has been altered from both natural and historic land use causes. Rip-rap in the channel indicates historic manipulation of the channel. Grasses and shrubs are the dominant vegetation. The substrate is small gravels. Erosion is not severe but is widespread.

3.3.6.4 Reach LOGA-45



Figure 3-24. Typical stream conditions in LOGA-45 Reach.

This reach of Logan Creek is in the Stillwater-Swan Wooded Valley fourth level Ecoregion and is a B3 Rosgen stream type. Mature conifers line the riparian areas of this reach. There has been

recent and historic logging in the watershed. Riparian shrub cover is good and the channel is stable and well-armored. The cobble substrate has few pools or large woody debris.

3.3.6.5 Reach STIL-33



Figure 3-25. Typical stream conditions in STIL-33 Reach.

This reach of the Stillwater River is in the Stillwater-Swan Wooded Valley fourth level Ecoregion. It is classified as B4c Rosgen stream type and is dominated by mature conifers. Large stumps in the floodplain indicate historic logging. The stream is highly embedded and fine sediment is common throughout the small gravel- dominated substrate. Vigorous riparian shrubs and some exotic grasses on banks are present.

3.3.7 Reach Type NR-2-2-U

This reach type is in the Northern Rockies level three Ecoregion, characterized by a 2-4% stream gradient for second order streams (Strahler 1952) and within an unconfined valley.

3.3.7.1 Reach EFSC-16



Figure 3-26. Typical stream conditions in EFSC-16 Reach.

This reach is in the Stillwater-Swan Wooded Valley fourth level Ecoregion. It is a C4 Rosgen stream type with well-defined pools and excellent riparian vegetation. The substrate is medium

to large gravels. This stream reach is an example of best available conditions among the assessed reaches.

3.3.7.2 Reach SHEP-18



Figure 3-27. Typical stream conditions in SHEP-18 Reach.

Reach SHEP-18 is within the Salish Mountains fourth level Ecoregion. Described as a C4b Rosgen stream type, it runs through an area that was completely burned in 2007. Forbs are dominant and woody debris is common in the stream. Substrate is predominantly gravel, and larger substrate creates deep but infrequent pools.

3.3.8 Reach Type NR-2-3-U

This reach type is in the Northern Rockies level three Ecoregion, characterized by a 2-4% stream gradient for third order streams and within an unconfined valley. There is one stream reach in this stream type.

3.3.8.1 Reach HASK-06



Figure 3-28. Typical stream conditions in HASK-06 Reach.

This reach is on Haskill Creek within the Stillwater-Swan Wooded Valley fourth level Ecoregion. The reach is characterized as a B4 Rosgen stream type with low sinuosity. The

channel is stable but is recovering from dramatic changes to the riparian area and large woody debris supply due to historic removal of large cedar trees. Some riparian clearing and an old road bed are present but not impacting the stream noticeably. The understory is naturally sparse.

3.3.9 Reach Type NR-2-4-U

This reach type is in the Northern Rockies level three Ecoregion, characterized by a 2-4% stream gradient for fourth order streams and within an unconfined valley. There is one stream reach in this stream type.

3.3.9.1 Reach LOGA-37



Figure 3-29. Typical stream conditions in LOGA-37 Reach.

This reach of Logan Creek is within the Stillwater-Swan Wooded Valley fourth level Ecoregion and is classified as a B3 Rosgen stream type. Streambanks are stable and channel has few pools or large woody debris. The dominant substrate is cobbles. Wildlife browse of the riparian vegetation is moderate.

3.3.10 Reach Type NR-4-1-U

This reach type is in the Northern Rockies level three Ecoregion, characterized by a 4-10% stream gradient for first order streams and within an unconfined valley. There is one stream reach in this stream type.

3.3.10.1 Reach FISH-05

This reach of Fish Creek is within the Salish Mountains fourth level Ecoregion and is classified as an A4 Rosgen stream type. The reach is generally characteristic of Rosgen A-type streams but is not as entrenched. There is infrequent spawning habitat in the gravel substrate, and a light surface of silt is common. There is minimal land use impact on the stream, potentially some from roads upstream of the reach and slight reduction in canopy cover due to timber harvest outside the riparian corridor.



Figure 3-30. Typical stream conditions in FISH-05 Reach.

3.4 Data Summary: Sampled Reach Comparisons

Assessment results are compared among all reaches in the following sections. The results summary in the following section includes box plot charts comparing results from each study reach for each study variable. Summary statistics among reaches for each variable are presented in tables following the box plots. Variables tallied reach wide that are not measured separately among cells in study reaches are not plotted by reach. These variables are Mean Residual Pool Depth, Pool Frequency, and Large Woody Debris.

3.4.1 Width/Depth Ratio

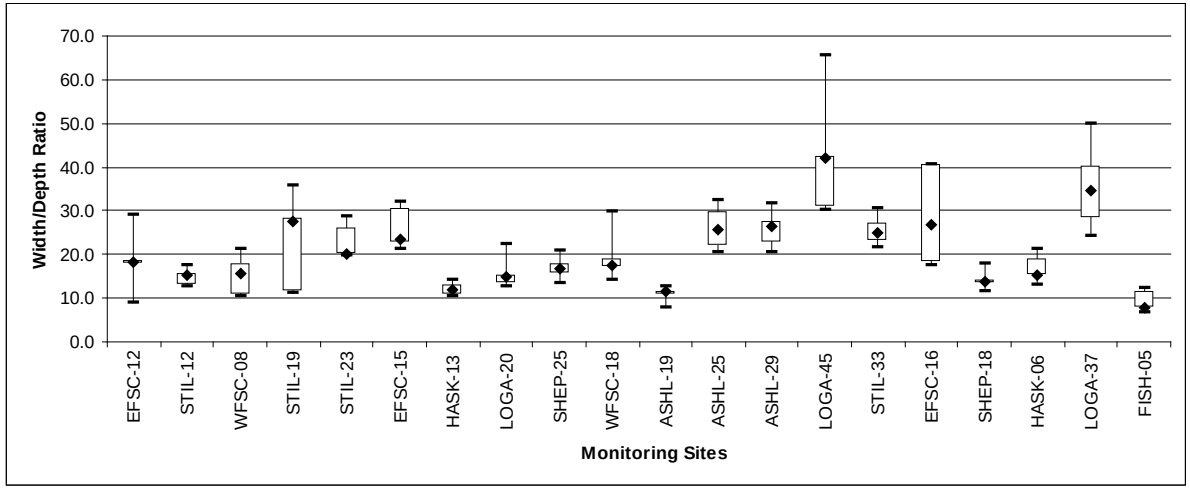


Figure 3-31. Width/Depth Ratio Segregated by Reach

Table 3-11. Summary of Width/Depth Ratio Statistics by Reach

Statistic	Reaches																			
Reach Type	CR-0-2-U	CR-2-2-U		CR-2-4-U		NR-0-2-U	NR-0-3-U				NR-0-4-U					NR-2-2-U		NR-2-3-U	NR-2-4-U	NR-4-1-U
Reach	EFSC-12	STIL-12	WFSC-08	STIL-19	STIL-23	EFSC-15	HASK-13	LOGA-20	SHEP-25	WFSC-18	ASHL-19	ASHL-25	ASHL-29	LOGA-45	STIL-33	EFSC-16	SHEP-18	HASK-06	LOGA-37	FISH-05
Sample Size	5	5	5	5	5	5	4	5	5	5	5	4	5	5	4	5	5	5	5	5
Minimum	8.9	12.7	10.3	11.2	19.6	21.3	10.3	12.7	13.3	14.3	8.0	20.3	20.5	30.1	21.4	17.4	11.6	13.0	24.3	6.9
25th Percentile	17.9	12.9	10.8	11.5	20.2	22.7	10.7	13.3	15.5	17.1	10.9	21.8	22.8	31.0	23.1	18.1	13.3	15.1	28.2	7.7
Median	18.3	15.2	15.5	27.5	20.3	23.4	11.8	15.0	16.9	17.4	11.4	25.5	26.6	42.1	24.8	26.9	13.7	15.4	34.8	8.0
75th Percentile	18.8	15.7	17.9	28.4	26.2	30.5	13.1	15.4	17.9	19.1	11.5	29.7	27.5	42.3	27.1	40.8	14.0	18.9	40.1	11.4
Maximum	29.1	17.5	21.2	35.8	28.5	32.0	14.2	22.2	20.7	29.9	12.6	32.4	31.7	65.4	30.5	40.8	17.7	21.2	49.8	12.2

3.4.2 Entrenchment Ratio

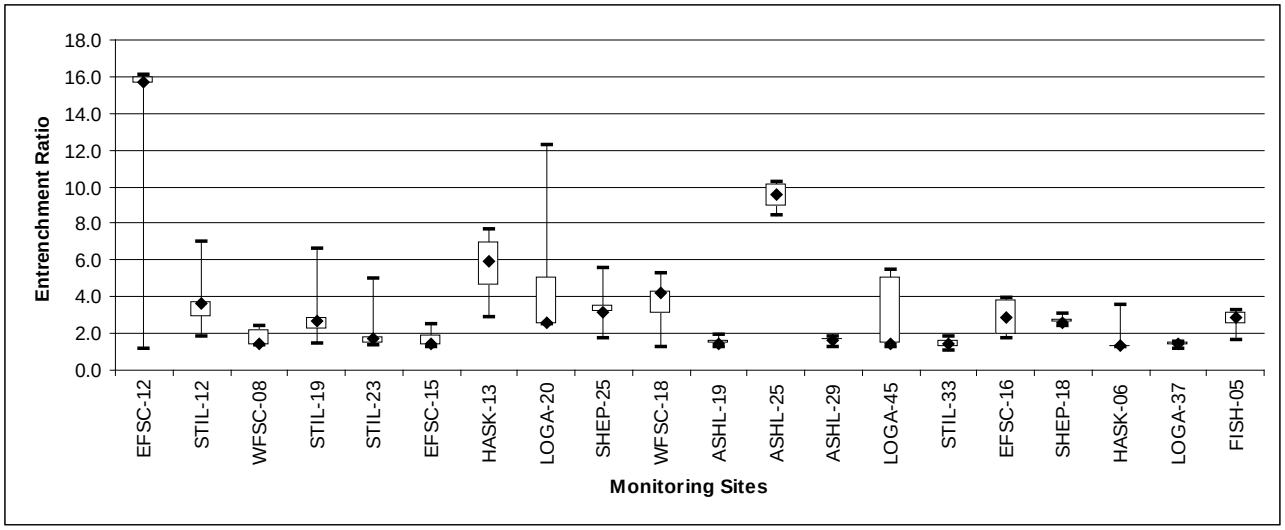


Figure 3-32. Entrenchment Ratio Segregated by Reach

Table 3-12. Summary of Entrenchment Ratio Statistics Segregated by Reach

Statistic	Reaches																			
Reach Type	CR-0-2-U	CR-2-2-U		CR-2-4-U		NR-0-2-U	NR-0-3-U				NR-0-4-U					NR-2-2-U		NR-2-3-U	NR-2-4-U	NR-4-1-U
Reach	EFSC-12	STIL-12	WFSC-08	STIL-19	STIL-23	EFSC-15	HASK-13	LOGA-20	SHEP-25	WFSC-18	ASHL-19	ASHL-25	ASHL-29	LOGA-45	STIL-33	EFSC-16	SHEP-18	HASK-06	LOGA-37	FISH-05
Sample Size	5	5	5	5	5	5	4	5	5	5	5	4	5	5	4	4	5	5	5	5
Minimum	1.2	1.9	1.3	1.4	1.4	1.3	2.8	2.5	1.8	1.3	1.2	8.4	1.2	1.3	1.1	1.7	2.4	1.2	1.1	1.6
25th Percentile	15.6	2.9	1.3	2.2	1.4	1.3	4.6	2.5	3.1	3.0	1.4	8.9	1.6	1.4	1.2	1.9	2.5	1.2	1.3	2.5
Median	15.7	3.6	1.4	2.7	1.7	1.4	6.0	2.6	3.2	4.2	1.4	9.6	1.7	1.4	1.4	2.9	2.6	1.4	1.5	2.9
75th Percentile	16.0	3.8	2.2	2.9	1.8	1.9	7.0	5.0	3.5	4.4	1.6	10.1	1.7	5.1	1.6	3.8	2.8	1.4	1.5	3.2
Maximum	16.1	7.0	2.4	6.6	5.0	2.5	7.7	12.3	5.6	5.3	1.9	10.2	1.8	5.5	1.9	4.0	3.1	3.5	1.6	3.2

3.4.3 Riffle Pebble Count (Substrate <2mm)

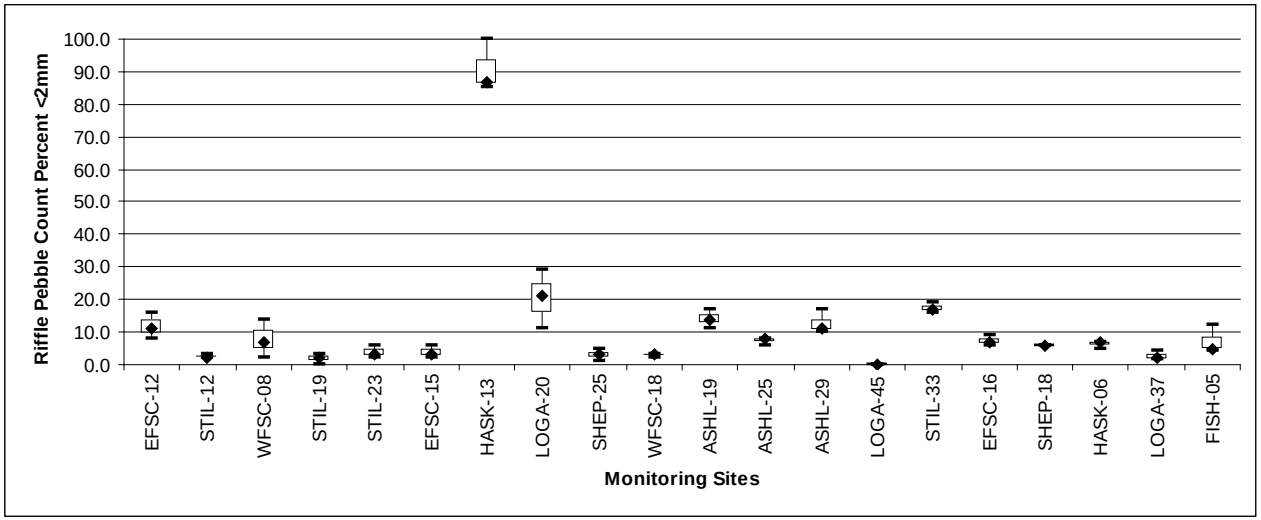


Figure 3-33. Riffle Pebble Count: Substrate Fines (<2mm) Segregated by Reach

Table 3-13. Summary of Riffle Pebble Count: Substrate Fines (<2mm) Statistics Segregated by Reach

Statistic	Reaches																			
Reach Type	CR-0-2-U	CR-2-2-U		CR-2-4-U		NR-0-2-U	NR-0-3-U				NR-0-4-U					NR-2-2-U		NR-2-3-U	NR-2-4-U	NR-4-1-U
Reach	EFSC-12	STIL-12	WFSC-08	STIL-19	STIL-23	EFSC-15	HASK-13	LOGA-20	SHEP-25	WFSC-18	ASHL-19	ASHL-25	ASHL-29	LOGA-45	STIL-33	EFSC-16	SHEP-18	HASK-06	LOGA-37	FISH-05
Sample Size	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Minimum	8.0	2.0	2.0	0.0	2.0	2.0	85.0	11.0	1.0	2.0	11.0	6.0	10.0	0.0	16.0	6.0	6.0	5.0	1.7	4.0
25th Percentile	9.5	2.0	4.5	1.0	2.5	2.5	86.0	16.0	2.0	2.5	12.5	7.0	10.5	0.0	16.5	6.5	6.0	6.0	1.8	4.5
Median	11.0	2.0	7.0	2.0	3.0	3.0	87.0	21.0	3.0	3.0	14.0	8.0	11.0	0.0	17.0	7.0	6.0	7.0	2.0	5.0
75th Percentile	13.5	2.5	10.5	2.5	4.5	4.5	93.5	25.0	3.8	3.0	15.5	8.0	14.0	0.0	18.0	8.0	6.0	7.0	3.0	8.5
Maximum	16.0	3.0	14.0	3.0	6.0	6.0	100.0	29.0	4.7	3.0	17.0	8.0	17.0	0.0	19.0	9.0	6.0	7.0	4.0	12.0

3.4.4 Riffle Pebble Count (Substrate <6mm)

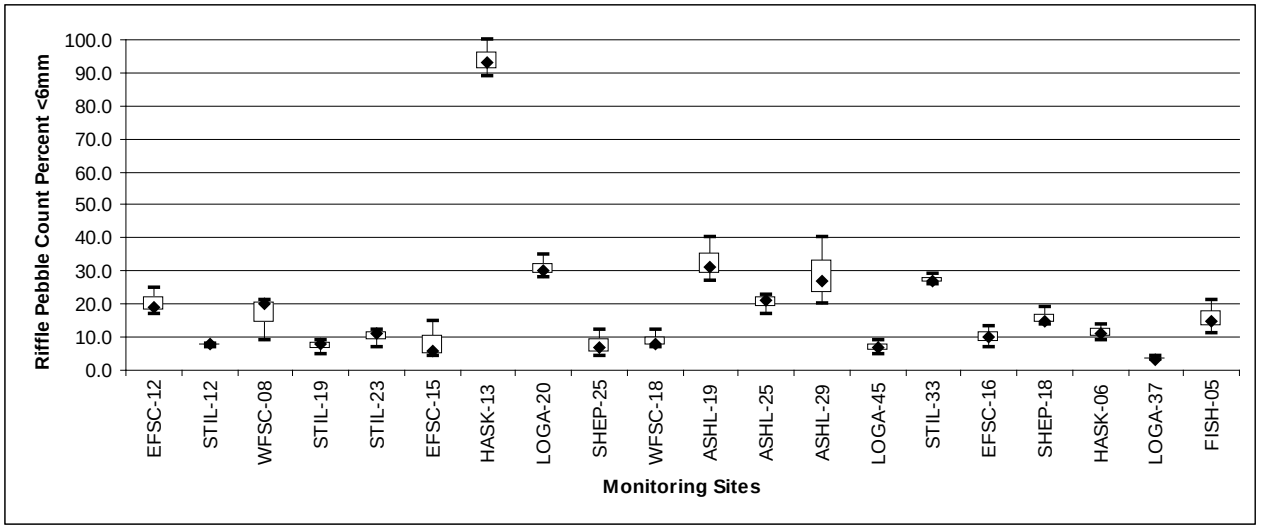


Figure 3-34. Riffle Pebble Count: Substrate Fines (<6mm) Segregated by Reach

Table 3-14. Summary of Riffle Pebble Count: Substrate Fines (<6mm) Statistics Segregated by Reach

Statistic	Reaches																			
Reach Type	CR-0-2-U	CR-2-2-U		CR-2-4-U		NR-0-2-U	NR-0-3-U				NR-0-4-U					NR-2-2-U		NR-2-3-U	NR-2-4-U	NR-4-1-U
Reach	EFSC-12	STIL-12	WFSC-08	STIL-19	STIL-23	EFSC-15	HASK-13	LOGA-20	SHEP-25	WFSC-18	ASHL-19	ASHL-25	ASHL-29	LOGA-45	STIL-33	EFSC-16	SHEP-18	HASK-06	LOGA-37	FISH-05
Sample Size	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Minimum	17.0	7.0	9.0	5.0	7.0	4.0	89.0	28.0	4.0	7.0	27.0	17.0	20.0	5.0	26.0	7.0	14.0	9.0	3.0	11.0
25th Percentile	18.0	7.5	14.5	6.5	9.0	5.0	91.0	29.0	5.5	7.5	29.0	19.0	23.5	6.0	26.5	8.5	14.5	10.0	3.0	13.0
Median	19.0	8.0	20.0	8.0	11.0	6.0	93.0	30.0	7.0	8.0	31.0	21.0	27.0	7.0	27.0	10.0	15.0	11.0	3.0	15.0
75th Percentile	22.0	8.0	20.5	8.5	11.5	10.5	96.5	32.5	9.5	10.0	35.5	22.0	33.5	8.0	28.0	11.5	17.0	12.5	3.5	18.0
Maximum	25.0	8.0	21.0	9.0	12.0	15.0	100.0	35.0	12.0	12.0	40.0	23.0	40.0	9.0	29.0	13.0	19.0	14.0	4.0	21.0

3.4.5 Riffle Grid Toss (Substrate <6mm)

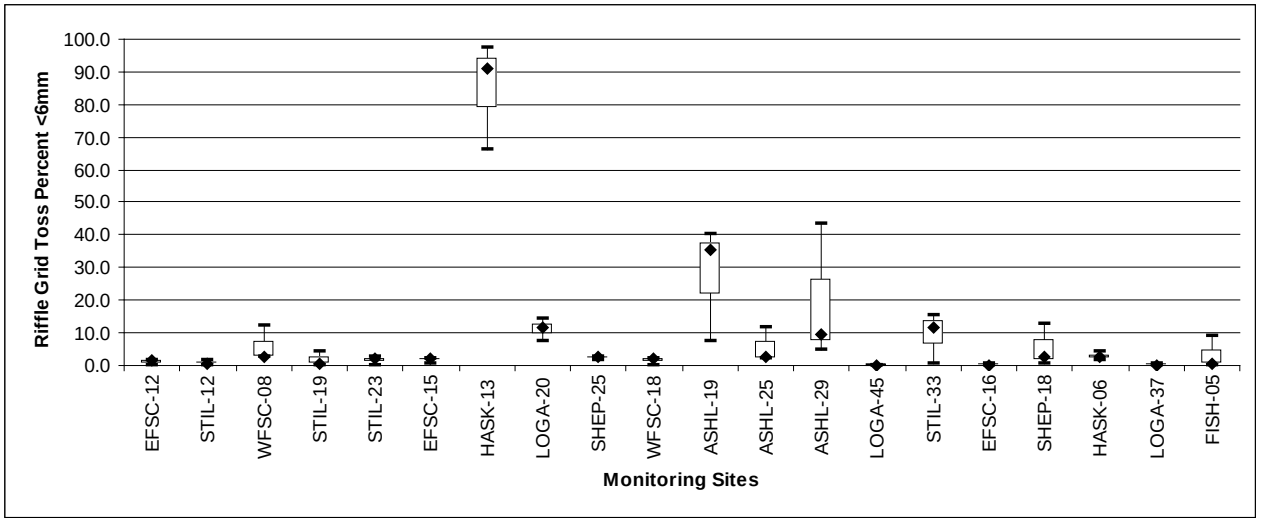


Figure 3-35. Riffle Grid Toss: Substrate Fines (<6mm) Segregated by Reach

Table 3-15. Summary of Riffle Grid Toss: Substrate Fines (<6mm) Statistics Segregated by Reach

Statistic	Reaches																			
Reach Type	CR-0-2-U	CR-2-2-U		CR-2-4-U		NR-0-2-U	NR-0-3-U				NR-0-4-U					NR-2-2-U		NR-2-3-U	NR-2-4-U	NR-4-1-U
Reach	EFSC-12	STIL-12	WFSC-08	STIL-19	STIL-23	EFSC-15	HASK-13	LOGA-20	SHEP-25	WFSC-18	ASHL-19	ASHL-25	ASHL-29	LOGA-45	STIL-33	EFSC-16	SHEP-18	HASK-06	LOGA-37	FISH-05
Sample Size	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Minimum	0.0	0.0	2.7	0.0	0.0	0.7	66.0	7.5	1.4	0.0	7.5	2.0	4.8	0.0	0.7	0.0	0.7	1.4	0.0	0.0
25th Percentile	0.7	0.4	2.7	0.4	1.0	1.4	78.6	9.6	2.1	1.0	21.5	2.4	7.2	0.0	6.2	0.0	1.7	2.1	0.0	0.4
Median	1.4	0.7	2.7	0.7	2.0	2.0	91.2	11.6	2.7	2.0	35.4	2.7	9.5	0.0	11.6	0.0	2.7	2.7	0.0	0.7
75th Percentile	1.4	1.1	7.5	2.4	2.4	2.0	94.3	13.0	2.7	2.0	37.8	7.2	26.5	0.0	13.6	0.3	7.8	3.4	0.4	4.8
Maximum	1.4	1.4	12.2	4.1	2.7	2.0	97.3	14.3	2.7	2.0	40.1	11.6	43.5	0.0	15.6	0.7	12.9	4.1	0.7	8.8

3.4.6 Percent Understory Shrub Cover

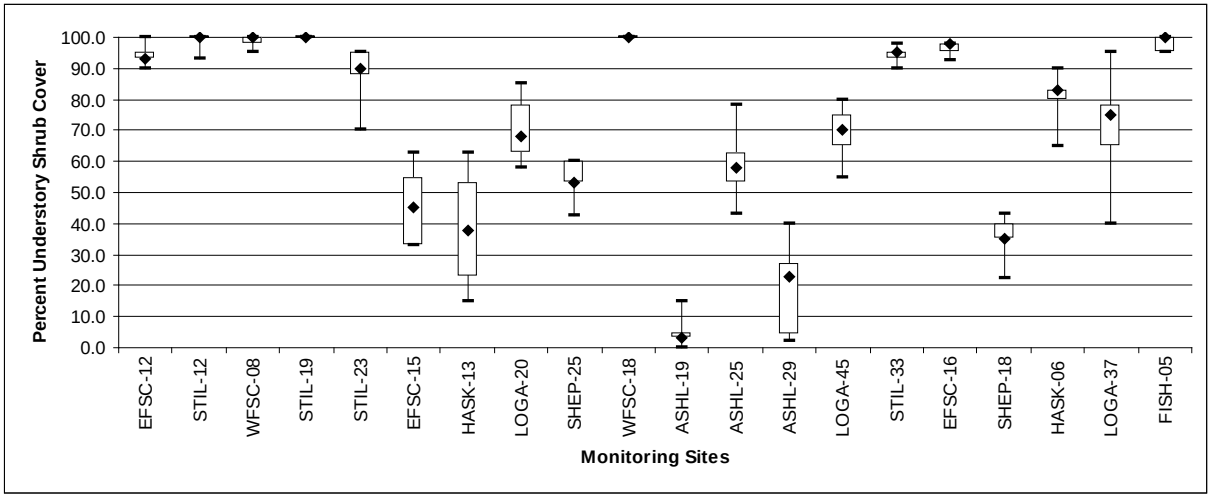


Figure 3-36. Percent Understory Shrub Cover Segregated by Reach

Table 3-16. Summary of Understory Shrub Cover Statistics Segregated by Reach

Statistic	Reaches																			
Reach Type	CR-0-2-U	CR-2-2-U		CR-2-4-U		NR-0-2-U	NR-0-3-U				NR-0-4-U					NR-2-2-U		NR-2-3-U	NR-2-4-U	NR-4-1-U
Reach	EFSC-12	STIL-12	WFSC-08	STIL-19	STIL-23	EFSC-15	HASK-13	LOGA-20	SHEP-25	WFSC-18	ASHL-19	ASHL-25	ASHL-29	LOGA-45	STIL-33	EFSC-16	SHEP-18	HASK-06	LOGA-37	FISH-05
Sample Size	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Minimum	90.0	93.0	95.0	100.0	70.0	33.0	15.0	58.0	42.5	100.0	0.0	43.0	2.0	55.0	90.0	92.5	22.5	65.0	40.0	95.0
25th Percentile	93.0	100.0	98.0	100.0	88.0	33.0	23.0	63.0	53.0	100.0	3.0	53.0	4.0	65.0	93.0	95.0	35.0	80.0	65.0	95.0
Median	93.0	100.0	100.0	100.0	90.0	45.0	38.0	68.0	53.0	100.0	3.0	58.0	23.0	70.0	95.0	98.0	35.0	83.0	75.0	100.0
75th Percentile	95.0	100.0	100.0	100.0	95.0	55.0	53.0	78.0	60.0	100.0	5.0	63.0	27.0	75.0	95.0	98.0	40.0	83.0	78.0	100.0
Maximum	100.0	100.0	100.0	100.0	95.0	63.0	63.0	85.0	60.0	100.0	15.0	78.0	40.0	80.0	98.0	98.0	43.0	90.0	95.0	100.0

3.4.7 Percent Bare Ground

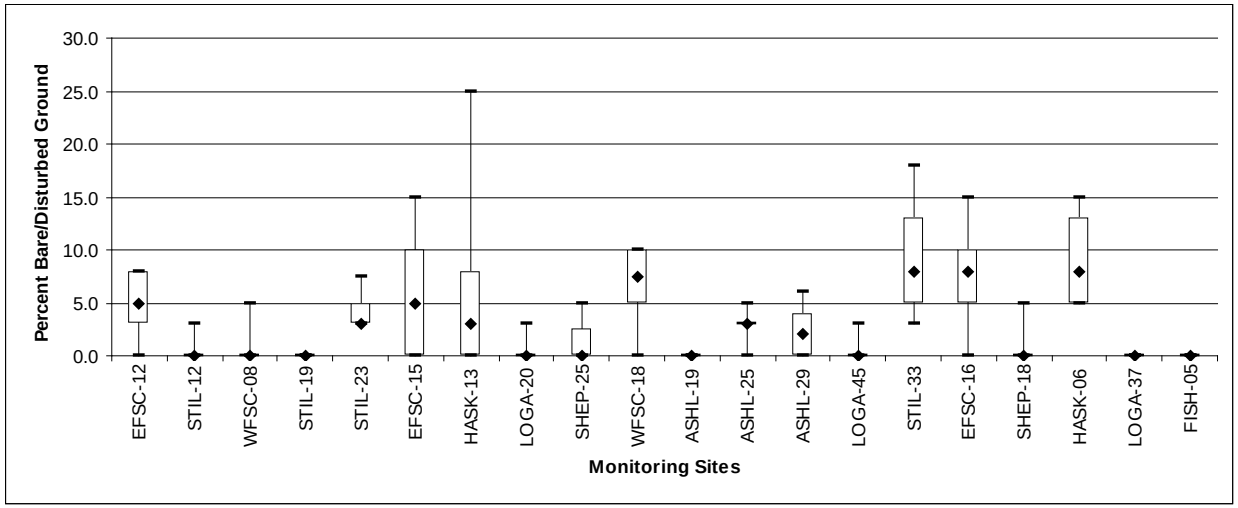


Figure 3-37. Percent Bare Ground Segregated by Reach

Table 3-17. Summary of Bare Ground Statistics Segregated by Reach

Statistic	Reaches																			
Reach Type	CR-0-2-U	CR-2-2-U		CR-2-4-U		NR-0-2-U	NR-0-3-U				NR-0-4-U					NR-2-2-U		NR-2-3-U	NR-2-4-U	NR-4-1-U
Reach	EFSC-12	STIL-12	WFSC-08	STIL-19	STIL-23	EFSC-15	HASK-13	LOGA-20	SHEP-25	WFSC-18	ASHL-19	ASHL-25	ASHL-29	LOGA-45	STIL-33	EFSC-16	SHEP-18	HASK-06	LOGA-37	FISH-05
Sample Size	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Minimum	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	5.0	0.0	0.0
25th Percentile	3.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	5.0	0.0	3.0	0.0	0.0	5.0	5.0	0.0	5.0	0.0	0.0
Median	5.0	0.0	0.0	0.0	3.0	5.0	3.0	0.0	0.0	7.5	0.0	3.0	2.0	0.0	8.0	8.0	0.0	8.0	0.0	0.0
75th Percentile	8.0	0.0	0.0	0.0	5.0	10.0	8.0	0.0	2.5	10.0	0.0	3.0	4.0	0.0	13.0	10.0	0.0	13.0	0.0	0.0
Maximum	8.0	3.0	5.0	0.0	7.5	15.0	25.0	3.0	5.0	10.0	0.0	5.0	6.0	3.0	18.0	15.0	5.0	15.0	0.0	0.0

4.0 STREAMBANK EROSION SOURCE ASSESSMENT

4.1 Overview

For each monitoring reach selected in the aerial photo assessment, measurements were collected to calculate the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS), in accordance with the Watershed Assessment of River Stability and Sediment Supply guidelines (Rosgen 2006). These measurements were used in conjunction with streambank length and erosion source notes to determine sediment loads per 1,000 feet of channel within each surveyed reach.

The BEHI procedure integrates multiple factors which have a direct impact on streambank stability, including the following parameters.

- Ratio of streambank height to bankfull stage.
- Ratio of riparian vegetation rooting depth to streambank height.
- Degree of rooting density.
- Composition of streambank materials.
- Streambank angle.
- Bank material stratigraphy.
- Bank surface protection afforded by woody debris and vegetation.

The BEHI index incorporates these seven variables into a numerical reach score that is used to rank streambank erosion potential on a scale ranging from very low to extreme (Table 4-1). Several sites within each assessment reach were evaluated for streambank integrity. The number of sites evaluated within each reach was based upon the variability of streambank conditions within the reach. Selected sites provided a representative sample of streambank conditions throughout the reach.

Table 4-1. BEHI score and rating matrix (Rosgen 1996)

Parameter		Very Low	Low	Moderate	High	Very High	Extrem
Bank Height Ratio	Value	1.0 – 1.1	1.11 – 1.19	1.2 – 1.5	1.6 – 2.0	2.1 – 2.8	> 2.8
	Index	1.0 – 1.9	2.0 – 3.9	4.0 – 5.9	6.0 – 7.9	8.0 – 9.0	10
Root Depth Ratio	Value	1.0 – 0.9	0.89 – 0.5	0.49 – 0.3	0.29 – 0.15	0.14 – 0.05	<0.05
	Index	1.0 – 1.9	2.0 – 3.9	4.0 – 5.9	6.0 – 7.9	8.0 – 9.0	10
Weighted Root Density	Value	100 – 80	79 – 55	54 – 30	29 – 15	14 – 5	<5
	Index	1.0 – 1.9	2.0 – 3.9	4.0 – 5.9	6.0 – 7.9	8.0 – 9.0	10
Bank Angle	Value	0 – 20	21 – 60	61 – 80	81 – 90	91 – 119	>119
	Index	1.0 – 1.9	2.0 – 3.9	4.0 – 5.9	6.0 – 7.9	8.0 – 9.0	10
Surface Protection	Value	100 – 80	79 – 55	54 – 30	29 – 15	14 – 10	<10
	Index	1.0 – 1.9	2.0 – 3.9	4.0 – 5.9	6.0 – 7.9	8.0 – 9.0	10

After evaluating the core bank integrity parameters describe in Table 1, bank material composition factors are considered. Depending upon bank materials, BEHI score is adjusted up or down (Rosgen 1996). Banks comprised of bedrock, boulders and cobble had very low erosion potential. Banks composed of cobble and/or gravel with a high fraction of sand had increased erosion potential. Stratified banks containing layers of unstable material also displayed greater

erosion potential. After adjusting the core BEHI score for bank material composition factors, a final BEHI score and rating is derived (Table 4-2).

Table 4-2. BEHI score and rating following bank materials adjustment

Rating	Very Low	Low	Moderate	High	Very High	Extreme
Score	5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

4.2 Field Measurement of BEHI

Within each sub-reach, eroding streambanks were identified and supporting BEHI measurements recorded. Measurements were completed for the following metrics:

- Bank condition including actively eroding, slowly eroding, undercut, or vegetated banks
- Bank height
- Bankfull height
- Root depth
- Root density
- Bank angle
- Surface protection
- Material adjustments
- Bankfull mean depth
- Near bank maximum depth
- Stationing
- Mean height
- Bank composition (size classes)
- Hoof shear presence
- Sources of streambank instability (percentage)

In addition to these measurements, photos were taken facing each streambank from a location perpendicular and a location upstream of the streambank. Photos were labeled according to the streambank site and position of the photograph.

4.3 Index Calculations

To calculate the BEHI rating for each eroding streambank, the following parameters were used:

- Bank height/bankfull height
- Root depth/bank height
- Weighted root density
- Bank density
- Surface protection

Each parameter is matched to a corresponding index value, derived from statistical relations for sedimentary/metamorphic geologic substrata (Rosgen 1996; 2001). Index values are summarized to create an overall BEHI rating number, which is then converted into a categorical rating (Very Low, Low, Moderate, High, Very High or Extreme).

To calculate the NBS rating for each bank, the following relationship is used:

NBS = Near Bank Maximum Bankfull Depth (ft) / Bankfull Mean Depth (ft)

As with the BEHI ratings, the resulting NBS value corresponds to a categorical rating.

4.4 Retreat Rate

The BEHI and NBS categorical ratings were matched to derive the average retreat rate of each streambank (ft/yr) (Table 4-3).

Table 4-3. BEHI and Near Bank Stress categories and rate of streambank retreat (ft/yr)

	Near Bank Stress					
BEHI	Very Low	Low	Moderate	High	Very High	Extreme
Very Low	NA	NA	NA	NA	NA	NA
Low	0.02	0.04	0.07	0.16	0.32	0.67
Moderate	0.09	0.15	0.25	0.42	0.70	1.16
High-Very High	0.17	0.25	0.38	0.58	0.87	1.32
Extreme	0.16	0.42	1.07	2.75	7.03	17.97

4.5 Bank Erosion Sediment Loading

The mass eroded (tons/yr) from each streambank is calculated using the following equation:

Mass eroded = Streambank Length (ft)* Mean Streambank Height (ft) * Retreat Rate (ft/yr)

Mass eroded per each streambank is then filtered into two categories (actively eroding versus slowly eroding, undercut, or vegetated banks). The resulting values for sediment loading due to streambank erosion are multiplied by the percentage attributed to each streambank instability source, then summarized or averaged over the entire length of eroding streambanks for the reach, to derive loads contributed by each source of streambank instability.

4.6 BEHI Results

The following sections provide the BEHI results by reach categories. Each reach category has two accompanying data tables. Reaches are organized by reach type. Summary tables for each reach type are included in Section 4.7.

4.6.1. Reach EFSC-12

The EFSC-12 stream reach is within a valley that has experienced historic logging. Due to some resulting stream instability from historic activities, 16.1% are unstable and actively eroding. Overall stream conditions, however, are natural and the channel is stable. The riparian community is diverse and recruitment is good, limiting the amount of erosion. Typical reach photographs are included in Figure 4-1. BEHI results for Reach EFSC-12 are included in Table 4-4 and Table 4-5.



Figure 4-1. Typical streambank conditions in EFSC-12 Reach

Table 4-4. BEHI statistics for EFSC-12 Reach

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
EFSC-12	9/04/2008	Active	35.7	322	16.1	47.0	47.0
		Slow	29.8	32	1.6	2.1	2.1
		Total	32.8	354	17.7	49.1	49.1

Table 4-5. Load Sources for EFSC-12 Reach

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silvi-culture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
EFSC-12	9/04/2008	Active	0.0	0.0	0.0	0.0	0.0	0.0	87.1	12.9
EFSC-12	9/04/2008	Slow	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
EFSC-12	9/04/2008	Total	0.0	0.0	0.0	0.0	0.0	0.0	87.7	12.3

4.6.2. Reach STIL-12

Reach STIL-12 is in a forested setting with dense riparian vegetation providing bank stabilizing rootmass. Streambanks are generally stable with some slowly-eroding undercut banks located along meander outcurves and constrictions. Typical reach photographs are included in Figure 4-2. BEHI results for Reach STIL-12 are included in Table 4-6 and Table 4-7.



Figure 4-2. Typical streambank conditions in STIL-12 Reach

Table 4-6. BEHI statistics for STIL-12 Reach

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
STIL-12	9/07/2008	Active	N/A	0	0.0	0.0	0.0
		Slow	12.8	52	2.6	0.2	0.2
		Total	12.8	52	2.6	0.2	0.2

Table 4-7. Load Sources for STIL-12 Reach

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silvi-culture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
STIL-12	9/07/2008	Active	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
STIL-12	9/07/2008	Slow	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
STIL-12	9/07/2008	Total	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0

4.6.3 Reach WFSC-08

Erosion in this stream reach is natural in cause and infrequent, occurring along 106' of the total reach length, or 5.6%. The limited extent of bank erosion does include some actively eroding banks. Some historic logging and road beds present may have caused some bank instability and subsequent erosion, but the riparian community is vigorous and regenerating well. Typical reach photographs are included in Figure 4-3. BEHI results for Reach WFSC-08 are included in Table 4-8 and Table 4-9.



Figure 4-3. Typical streambank conditions in WFSC-08 Reach

Table 4-8. BEHI statistics for WFSC-08 Reach

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
WFSC-08	9/08/2008	Active	N/A	0	0.0	0.0	0.0
		Slow	12.8	52	2.6	0.2	0.2
		Total	12.8	52	2.6	0.2	0.2

Table 4-9. Load Sources for WFSC-08 Reach

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silvi-culture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
WFSC-08	9/08/2008	Active	0.0	0.0	0.0	0.0	0.0	0.0	96.2	3.8
WFSC-08	9/08/2008	Slow	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
WFSC-08	9/08/2008	Total	0.0	0.0	0.0	0.0	0.0	0.0	96.3	3.7

4.6.4 Reach STIL-19

Reach STIL-19 showed erosion along 16.6% of the total bank length. Field notes indicate frequent bank scour and signs of channel adjustment from past upstream logging, albeit occurring within a natural stream channel with good shrub diversity and cover. The floodplain forest is considered to be young and emerging. Typical reach photographs are included in Figure 4-4. BEHI results for Reach STIL-19 are included in Table 4-10 and Table 4-11.



Figure 4-4. Typical streambank conditions in STIL-19 Reach

Table 4-10. BEHI statistics for STIL-19 Reach

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
STIL-19	9/07/2008	Active	38.3	146	7.3	15.2	15.2
		Slow	23.0	187	9.4	5.3	5.3
		Total	30.7	333	16.65	20.5	20.5

Table 4-11. Load Sources for STIL-19 Reach

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silvi-culture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
STIL-19	9/07/2008	Active	0.0	0.0	0.0	0.0	0.0	0.0	50.0	50.0
STIL-19	9/07/2008	Slow	0.0	0.0	0.0	0.0	0.0	0.0	93.9	6.1
STIL-19	9/07/2008	Total	0.0	0.0	0.0	0.0	0.0	0.0	59.7	40.3

4.6.5 Reach STIL-23

The STIL-23 reach is within a valley that has experienced historic logging. These past silvicultural activities have destabilized some banks and account for an estimated 10% of the active erosion along the channel. Total sediment contribution to the stream is 24.5 tons/year, attributed primarily to natural causes. The upstream end of this reach shows some signs of adjustment. Typical reach photographs are included in Figure 4-5. BEHI results for Reach STIL-23 are included in Table 4-12 and Table 4-13.



Figure 4-5. Typical streambank conditions in STIL-23 Reach

Table 4-12. BEHI statistics for STIL-23 Reach

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
STIL-23	9/25/2008	Active	27.9	80	4.0	18.1	18.1
		Slow	27.1	331	16.6	6.4	6.4
		Total	27.5	411	20.6	24.5	24.5

Table 4-13. Load Sources for STIL-23 Reach

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silvi-culture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
STIL-23	9/25/2008	Active	0.0	0.0	0.0	0.0	10.0	0.0	90.0	0.0
STIL-23	9/25/2008	Slow	0.0	0.0	0.0	0.0	0.4	0.0	99.6	0.0
STIL-23	9/25/2008	Total	0.0	0.0	0.0	0.0	6.7	0.0	93.3	0.0

4.6.6 Reach EFSC-15

Reach EFSC-15 is within a valley where human impacts are negligible. No active bank erosion was noted and slow streambank erosion is occurring on 9.4% of the reach, totaling 4 tons of sediment/year per 1000 ft. Typical reach photographs are included in Figure 4-6. BEHI results for Reach EFSC-15 are included in Table 4-14 and Table 4-15.



Figure 4-6. Typical streambank conditions in EFSC-15 Reach

Table 4-14. BEHI statistics for EFSC-15 Reach

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
EFSC-15	9/05/2008	Active	N/A	0	0.0	0.0	0.0
		Slow	26.7	188	9.4	4.0	4.0
		Total	26.7	188	9.4	4.0	4.0

Table 4-15. Load Sources for EFSC-15 Reach

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silvi-culture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
EFSC-15	9/05/2008	Active	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EFSC-15	9/05/2008	Slow	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
EFSC-15	9/05/2008	Total	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0

4.6.7 Reach HASK-13

Reach HASK-13 is downstream of agricultural land, but shows minimal impacts from immediate land uses. A total of 26.9 tons of sediment/year are deposited to the stream, primarily from a few areas, totaling 120 feet of streambank, where active erosion is visible (see Figure 4-7, right). Some beaver activity contributes sediment to the stream. Typical reach photographs are included in Figure 4-7. BEHI results for Reach HASK-13 are included in Table 4-16 and Table 4-17.



Figure 4-7. Typical streambank conditions in HASK-13 Reach

Table 4-16. BEHI statistics for HASK-13 Reach

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
HASK-13	9/03/2008	Active	38.8	120	6.0	19.7	19.7
		Slow	32.4	226	11.3	7.2	7.2
		Total	35.6	346	17.3	26.9	26.9

Table 4-17. Load Sources for HASK-13 Reach

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silvi-culture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
HASK-13	9/03/2008	Active	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
HASK-13	9/03/2008	Slow	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
HASK-13	9/03/2008	Total	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0

4.6.8 Reach LOGA-20

The LOGA-20 reach is within a spruce forest valley with minimal human impacts. A total of 218 feet of the reach is eroding, two-thirds of which is naturally occurring slow erosion (see Figure 4-8, left). The riparian community is diverse and well established. Typical reach photographs are included in Figure 4-8. BEHI results for Reach LOGA-20 are included in Table 4-18 and Table 4-19.



Figure 4-8. Typical streambank conditions in LOGA-20 Reach

Table 4-18. BEHI statistics for LOGA-20 Reach

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
LOGA-20	9/08/2008	Active	36.9	72	3.6	5.6	5.6
		Slow	30.6	146	7.3	6.7	6.7
		Total	33.8	218	10.9	12.3	12.3

Table 4-19. Load Sources for LOGA-20 Reach

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silvi-culture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
LOGA-20	9/08/2008	Active	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
LOGA-20	9/08/2008	Slow	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
LOGA-20	9/08/2008	Total	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0

4.6.9 Reach SHEP-25

The SHEP-25 reach is within a burned area which has seen past and present upstream logging. Mature riparian tree species are all burned and banks are dominated by fast-growing forbs and shrubs. The well-armored banks allow for some slow, naturally caused erosion, totaling 6.2 tons/year per 1000 ft. The riparian community is diverse and well established. Typical reach photographs are included in Figure 4-9. BEHI results for Reach SHEP-25 are included in Table 4-20 and Table 4-21.



Figure 4-9. Typical streambank conditions in SHEP-25 Reach

Table 4-20. BEHI statistics for SHEP-25 Reach

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
SHEP-25	9/09/2008	Active	N/A	0	0.0	0.0	0.0
		Slow	29.2	169	8.5	6.2	6.2
		Total	29.2	169	8.5	6.2	6.2

Table 4-21. Load Sources for SHEP-25 Reach

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silvi-culture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
SHEP-25	9/09/2008	Active	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SHEP-25	9/09/2008	Slow	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
SHEP-25	9/09/2008	Total	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0

4.6.10 Reach WFSC-18

The WFSC-18 reach is an example of best available conditions among the sample size of this project. Less than 2% of the streambanks show active or slow erosion, totaling 1.7 tons/year. The riparian is dominated by well-established shrubs and surrounded by a mature conifer forest. Typical reach photographs are included in Figure 4-10. BEHI results for Reach WFSC-18 are included in Table 4-22 and Table 4-23.



Figure 4-10. Typical streambank conditions in WFSC-18 Reach

Table 4-22. BEHI statistics for WFSC-18 Reach

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
WFSC-18	9/06/2008	Active	30.8	22	1.1	1.5	1.5
		Slow	29.6	11	0.6	0.2	0.2
		Total	30.2	33	1.7	1.7	1.7

Table 4-23. Load Sources for WFSC-18 Reach

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silvi-culture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
WFSC-18	9/06/2008	Active	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
WFSC-18	9/06/2008	Slow	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
WFSC-18	9/06/2008	Total	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0

4.6.11 Reach ASHL-19

The ASHL-19 reach is within a pasture area used for grazing cattle and hay. Steep streambanks are the major deterrent for cattle being in the stream, whose banks contribute 101.5 tons of sediment to the stream per year. Most of the erosion is characterized as slowly eroding and is attributed equally (49.2%) to the surrounding grazing and crop land uses. Bank trampling, shrub and tree removal, stream incisement and introduced species are all present in this reach. Typical reach photographs are included in Figure 4-11. BEHI results for Reach ASHL-19 are included in Table 4-24 and Table 4-25.

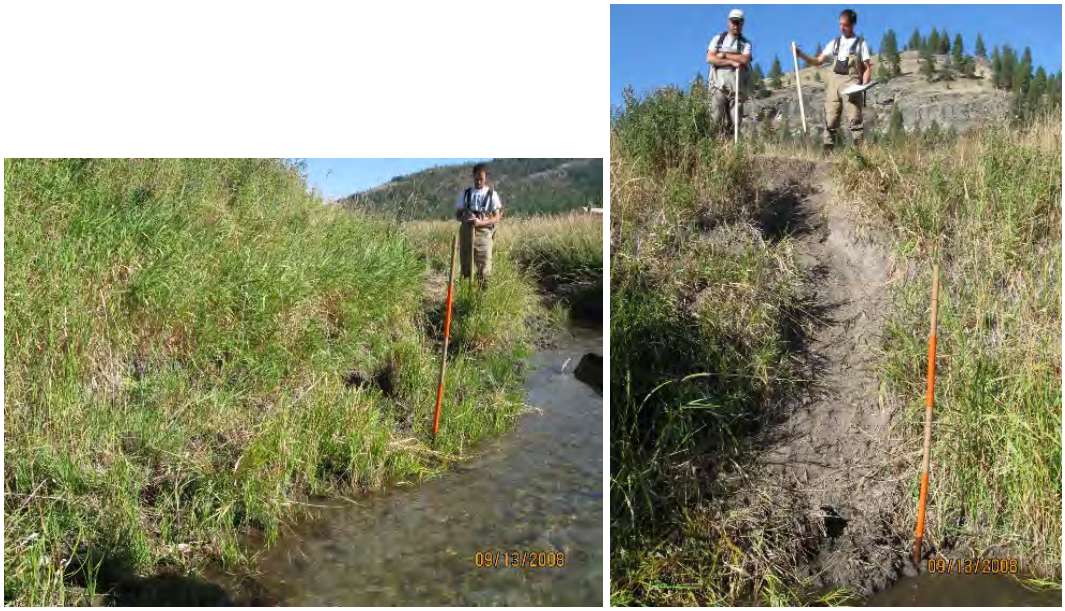


Figure 4-11. Typical streambank conditions in ASHL-19 Reach.

Table 4-24. BEHI statistics for ASHL-19 Reach

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
ASHL-19	9/13/2008	Active	34.9	152	7.6	4.4	4.4
		Slow	33.3	417	20.9	97.1	97.1
		Total	34.1	569	28.5	101.5	101.5

Table 4-25. Load Sources for ASHL-19 Reach

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silvi-culture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
ASHL-19	9/13/2008	Active	0.0	96.7	0.0	0.0	0.0	0.0	3.3	0.0
ASHL-19	9/13/2008	Slow	0.0	49.2	49.2	0.0	0.0	0.0	1.7	0.0
ASHL-19	9/13/2008	Total	0.0	51.3	47.1	0.0	0.0	0.0	1.8	0.0

4.6.12 Reach ASHL-25

The ASHL-25 stream reach is within an urban setting. There is a bridge crossing at the upstream end and the reach has been channelized and confined. Streambank erosion is limited to some slowly eroding banks along 14.5% of the reach. Some beaver activity influences sediment loading but the predominant causes of sediment loading are natural. Typical reach photographs are included in Figure 4-12. BEHI results for Reach ASHL-25 are included in Table 4-26 and Table 4-27.



Figure 4-12. Typical streambank conditions in ASHL-25 Reach

Table 4-26. BEHI statistics for ASHL-25 Reach

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
ASHL-25	9/09/2008	Active	N/A	0	0.0	0.0	0.0
		Slow	42.9	290	14.5	16.9	16.9
		Total	42.9	290	14.5	16.9	16.9

Table 4-27. Load Sources for ASHL-25 Reach

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silvi-culture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
ASHL-25	9/09/2008	Active	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ASHL-25	9/09/2008	Slow	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
ASHL-25	9/09/2008	Total	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0

4.6.13 Reach ASHL-29

Streambank erosion in this stream reach is low but widespread, covering 29.4% of the streams total bank length. Riparian grazing and cropland are the surrounding land uses, causing over 50% of the total sediment contribution to the stream, which approaches 35 tons/year. Typical reach photographs are included in Figure 4-13. BEHI results for Reach ASHL-29 are included in Table 4-28 and Table 4-29.



Figure 4-13. Typical streambank conditions in ASHL-29 Reach

Table 4-28. BEHI statistics for ASHL-29 Reach

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
ASHL-29	9/14/2008	Active	31.1	588	29.4	34.9	34.9
		Slow	N/A	0	0.0	0.0	0.0
		Total	31.1	588	29.4	34.9	34.9

Table 4-29. Load Sources for ASHL-29 Reach

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silvi-culture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
ASHL-29	9/14/2008	Active	0.0	29.8	29.8	0.0	0.0	0.0	40.4	0.0
ASHL-29	9/14/2008	Slow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ASHL-29	9/14/2008	Total	0.0	29.8	29.8	0.0	0.0	0.0	40.4	0.0

4.6.14 Reach LOGA-45

The LOGA-45 stream reach is within a stable and well-armored stream channel. There was no observed erosion in this stream reach. Typical reach photographs are included in Figure 4-14. BEHI results for Reach LOGA-45 are included in Table 4-30.



Figure 4-14. Typical streambank conditions in LOGA-45 Reach

Table 4-30. BEHI statistics for LOGA-45 Reach

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
LOGA-45	9/14/2008	Active					
		Slow		Well-armored banks - no erosion			
		Total					

4.6.15 Reach STIL-33

The STIL-33 reach is within a highly embedded channel in an area that was previously logged. Riparian shrubs and some exotic grasses dominate the streambank vegetation, providing some streambank stability. Over half of the streambank length within the reach shows signs of slow erosion. Most erosion is from low undercut banks, which in total contribute 78.2 tons of sediment/year to the channel. Typical reach photographs are included in Figure 4-15. BEHI results for Reach STIL-33 are included in Table 4-31 and Table 4-32.

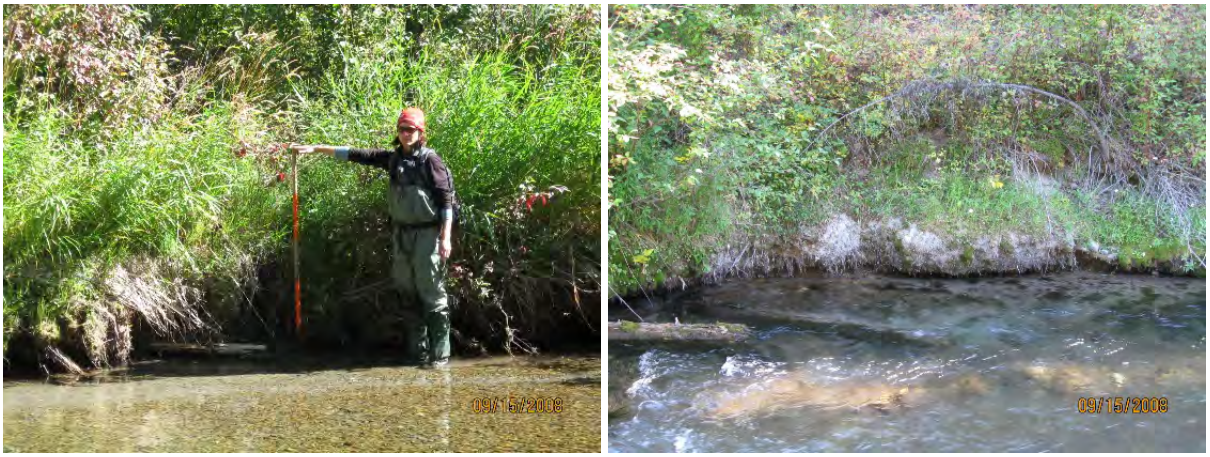


Figure 4-15. Typical streambank conditions in STIL-33 Reach

Table 4-31. BEHI statistics for STIL-33 Reach

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
STIL-33	9/15/2008	Active	N/A	0	0.0	0.0	0.0
		Slow	33.3	1026	51.3	78.2	78.2
		Total	33.3	1026	51.3	78.2	78.2

Table 4-32. Load Sources for STIL-33 Reach

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silvi-culture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
STIL-33	9/15/2008	Active	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
STIL-33	9/15/2008	Slow	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
STIL-33	9/15/2008	Total	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0

4.6.16 Reach EFSC-16

The EFSC-16 reach is an example of the best available conditions among the streams sampled. No visible erosion was noted in this reach. Typical reach photographs are included in Figure 4-16. BEHI results for Reach EFSC-16 are included in Table 4-33.



Figure 4-16. Typical streambank conditions in EFSC-16 Reach

Table 4-33. BEHI statistics for EFSC-16 Reach

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
EFSC-16	9/05/2008	Active					
		Slow		Well-armored banks - no erosion			
		Total					

4.6.17 Reach SHEP-18

This stream reach is within a burned valley, whose riparian vegetation has been reduced due to fire. Shrub roots are still intact and shrubs are resprouting. Well-armored banks provide for a stable channel, which shows mostly low and slowly eroding banks. All erosion, totaling 10 tons/year, is natural in cause in this reach. Typical reach photographs are included in Figure 4-17. BEHI results for Reach SHEP-18 are included in Table 4-34 and Table 4-35.





Figure 4-17. Typical streambank conditions in SHEP-18 Reach

Table 4-34. BEHI statistics for SHEP-18 Reach

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
SHEP-18	9/09/2008	Active	27.7	69	3.5	4.2	4.2
		Slow	32.8	104	5.2	5.8	5.8
		Total	30.3	173	8.7	10.0	10.0

Table 4-35. Load Sources for SHEP-18 Reach

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silvi-culture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
SHEP-18	9/09/2008	Active	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
SHEP-18	9/09/2008	Slow	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
SHEP-18	9/09/2008	Total	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0

4.6.18 Reach HASK-06

Historic large cedar removal in the floodplain buffering the HASK-06 stream reach has caused some instability in the channel. The natural but sparse understory has dense root masses that stabilize the banks. One area of human-caused erosion from an old road bed is qualified as "other" and accounts for 20% of the total load of 6.6 tons/year for this reach. Typical reach

photographs are included in Figure 4-18. BEHI results for Reach HASK-06 are included in Table 4-36 and Table 4-37.



Figure 4-18. Typical streambank conditions in HASK-06 Reach

Table 4-36. BEHI statistics for HASK-06 Reach

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
HASK-06	9/04/2008	Active	23.1	177	8.9	6.6	6.6
		Slow	N/A	0	0.0	0.0	0.0
		Total	23.1	177	8.9	6.6	6.6

Table 4-37. Load Sources for HASK-06 Reach

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silvi-culture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
HASK-06	9/04/2008	Active	0.0	0.0	0.0	0.0	0.0	0.0	79.9	20.1
HASK-06	9/04/2008	Slow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HASK-06	9/04/2008	Total	0.0	0.0	0.0	0.0	0.0	0.0	79.9	20.1

4.6.19 Reach LOGA-37

The LOGA-37 reach shows no visible erosion. Banks are naturally well-armored with large rock. Healthy riparian communities are present throughout the reach and there are no notable anthropogenic influences on the channel. Typical reach photographs are included in Figure 4-19. BEHI results for Reach LOGA-37 are included in Table 4-38.



Figure 4-19. Typical streambank conditions in LOGA-37 Reach

Table 4-38. BEHI statistics for LOGA-37 Reach

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
LOGA-37	9/08/2008	Active					
		Slow		Well-armored banks - no erosion			
		Total					

4.6.20 Reach FISH-05

Stream reach FISH-05 shows a total sediment load of 2.6 tons/year per 1000 ft, a low level when seen in comparison to the best available reaches (although Rosgen stream types and other factors differ). Examples of some of the slowly eroding banks present in the stream are shown in Figure 4-20. Typical reach photographs are included in Figure 4-20. BEHI results for Reach FISH-05 are included in Table 4-39 and Table 4-340.



Figure 4-20. Typical streambank conditions in FISH-05 Reach.

Table 4-39. BEHI statistics for FISH-05 Reach

Reach ID	Date	Erosion Rate	Mean BEHI Score	Length of Eroding Bank (Feet)	% of Reach with Eroding Bank	Reach Sediment Load (Tons/Year)	Total Sediment Load per 1000 Feet (Tons/Year)
FISH-05	9/13/2008	Active	N/A	0	0.0	0.0	0.0
		Slow	33.3	46	4.6	1.3	2.6
		Total	33.3	46	4.6	1.3	2.6

Table 4-40. Load Sources for FISH-05 Reach

Reach ID	Date	Erosion Rate	Trans-portation Load (%)	Riparian Grazing Load (%)	Crop-land Load (%)	Mining Load (%)	Silvi-culture Load (%)	Irrigation Load (%)	Natural Load (%)	"Other Load" (%)
FISH-05	9/13/2008	Active	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FISH-05	9/13/2008	Slow	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
FISH-05	9/13/2008	Total	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0

4.7 Data Summary

The following section details the findings of the BEHI investigations for each reach type. Summary tables in this section present the reach sediment load by category (actively eroding or slowly eroding) and the dominant influence (anthropogenic or natural). Erosion was considered to be anthropogenic if <75% of visible bank erosion was attributed to natural conditions. Across

all reaches, anthropogenic loads averaged twice as much as natural load. Reaches STIL-12, EFSC-16 and WFSC-18 were determined to have the most natural erosion conditions of all reaches.

4.7.1 Reach Type CR-0-2-U

The one stream reach in this reach type showed streambank erosion from natural sources.

Table 4-41. Sediment Load Data CR-0-2-U Reach Type

	Reach Sediment Load (tons per 1000')			Dominant Influence*	
Reach ID	**Actively Eroding**	**Slowly Eroding**	**Total**	**Anthropogenic**	**Natural**
EFSC-12	47.0	2.1	49.1		X
Reach Category Avg. Load	47.0	2.1	49.1	0.0	49.1

4.7.2 Reach Type CR-2-2-U

Streams in this reach type showed only natural causes of erosion, with an average load of 9.6 tons/1000 ft. The WFSC-08 reach contributed significantly more sediment than the STIL-12 reach, which represents some of the best available conditions of the assessed reaches.

Table 4-42. Sediment Load Data CR-2-2-U Reach Type

	Reach Sediment Load (tons per 1000')			Predominant Influence	
Reach ID	**Actively Eroding**	**Slowly Eroding**	**Total**	**Anthropogenic**	**Natural**
STIL-12	0.0	0.2	0.2		X
WFSC-08	18.8	0.1	18.9		X
Reach Category Avg. Load	9.4	0.2	9.6	0.0	9.6

4.7.3 Reach Type CR-2-4-U

The two streams in this reach showed similar total erosion rates, from a variety of sources.

Table 4-43. Sediment Load Data CR-2-4-U Reach Type

	Reach Sediment Load (tons per 1000')			Predominant Influence	
Reach ID	**Actively Eroding**	**Slowly Eroding**	**Total**	**Anthropogenic**	**Natural**
STIL-19	15.2	5.3	20.5	X	
STIL-23	18.1	6.4	24.5		X
Reach Category Avg. Load	16.65	5.85	22.5	20.5	24.5

4.7.4 Reach Type NR-0-2-U

The one stream in this reach type shows minimal amounts of erosion, caused by natural stream and riparian processes.

Table 4-44. Sediment Load Data NR-0-2-U Reach Type

	Reach Sediment Load (tons per 1000')			Predominant Influence	
Reach ID	**Actively Eroding**	**Slowly Eroding**	**Total**	**Anthropogenic**	**Natural**
EFSC-15	0.0	4.0	4.0		X
Reach Category Avg. Load	0.0	4.0	4.0	0.0	4.0

4.7.5 Reach Type NR-0-3-U

Streams in this reach type have an average sediment loading of 11.8 tons/year per 1000 ft of stream. All active and slow erosion in this stream reach type is from natural causes.

Table 4-45. Sediment Load Data NR-0-3-U Reach Type

	Reach Sediment Load (tons per 1000')			Predominant Influence	
Reach ID	**Actively Eroding**	**Slowly Eroding**	**Total**	**Anthropogenic**	**Natural**
HASK-13	19.7	7.2	26.9		X
LOGA-20	5.6	6.7	12.3		X
SHEP-25	0.0	6.2	6.2		X
WFSC-18	1.5	0.2	1.7		X
Reach Category Avg. Load	6.7	5.1	11.8	0.0	11.8

4.7.6 Reach Type NR-0-4-U

There are 5 streams within the NR-0-4-U reach type, which show erosion rates ranging from 0 to 101.5 tons/year. The reach type average is 46.3 tons/year/1000 ft, with two of the stream reaches predominantly influenced by anthropogenic sources.

Table 4-46. Sediment Load Data NR-0-4-U Reach Type

	Reach Sediment Load (tons per 1000')			Predominant Influence	
Reach ID	**Actively Eroding**	**Slowly Eroding**	**Total**	**Anthropogenic**	**Natural**
ASHL-19	4.4	97.1	101.5	X	
ASHL-25	0.0	16.9	16.9		X
ASHL-29	34.9	0.0	34.9	X	
LOGA-45	0.0	0.0	0.0		X
STIL-33	0.0	78.2	78.2		X
Reach Category Avg. Load	7.86	38.44	46.3	68.2	31.7

4.7.7 Reach Type NR-2-2-U

The two streams in this reach type show only natural causes of bank erosion.

Table 4-47. Sediment Load Data NR-2-2-U Reach Type

	Reach Sediment Load (tons per 1000')			Predominant Influence	
Reach ID	**Actively Eroding**	**Slowly Eroding**	**Total**	**Anthropogenic**	**Natural**
EFSC-16	0.0	0.0	0.0		X
SHEP-18	4.2	5.8	10.0		X
Reach Category Avg. Load	2.1	2.9	5.0	0.0	5.0

4.7.8 Reach Type NR-2-3-U

This reach type has one stream segment, which is influenced from natural sources. Erosion is minimal in this reach.

Table 4-48. Sediment Load Data NR-2-3-U Reach Type

	Reach Sediment Load (tons per 1000')			Predominant Influence	
Reach ID	**Actively Eroding**	**Slowly Eroding**	**Total**	**Anthropogenic**	**Natural**
HASK-06	6.6	0.0	6.6		X
Reach Category Avg. Load	6.6	0.0	6.6	0.0	6.6

4.7.9 Reach Type NR-2-4-U

The one stream reach within this stream type shows no erosion.

Table 4-49. Sediment Load Data NR-2-4-U Reach Type

	Reach Sediment Load (tons per 1000')			Predominant Influence	
Reach ID	**Actively Eroding**	**Slowly Eroding**	**Total**	**Anthropogenic**	**Natural**
LOGA-37	0.0	0.0	0.0		X
Reach Category Avg. Load	0.0	0.0	0.0	0.0	0.0

4.7.10 Reach Type NR-4-1-U

The one stream reach within this reach type is in a natural setting with only mild anthropogenic influence from harvest upslope and upstream road crossings. Bank erosion is low and described in the following section.

Table 4-50. Sediment Load Data NR-4-1-U Reach Type

	Reach Sediment Load (tons per 1000')			Predominant Influence	
Reach ID	**Actively Eroding**	**Slowly Eroding**	**Total**	**Anthropogenic**	**Natural**
FISH-05	0.0	2.6	2.6		X
Reach Category Avg. Load	0.0	2.6	2.6	0.0	2.6

4.7.11 Average Loads for all Reach Types

Table 4-51. Summarized BEHI Sediment Loads for all Reaches

	Reach Sediment Load (tons per 1000')		
	Actively Eroding	**Slowly Eroding**	**Total**
Avg. Load	9.6	6.1	15.7
Predominantly Anthropogenic Avg. Load	18.2	34.1	39.2
Predominantly Natural Avg. Load	7.1	8.0	16.1

Spreadsheets with complete data for the BEHI assessment are included on the CD data appendix, Appendix C.

REFERENCES

Armour, C. L., D. A. Duff, and W. Elmore. 1991. The effects of livestock grazing on riparian and stream ecosystems. Fisheries 16:7-11.

Bilby, R. and J.W. Ward. 1989. Changes in characteristics and function of woody debris with increasing size of streams in western Washington. Transactions of the American Fisheries Society 118:368-378.

DEQ. 2001. Nutrient Management Plan and Total Maximum Daily Load for Flathead Lake, Montana. Available at Montana DEQ, Helena, MT.

DEQ (Montana Department of Environmental Quality). 2008. Clean Water Act Information Center (CWAIC). Montana Department of Environmental Quality. Available at: http://cwaic.mt.gov (Accessed January, 2009).

_____2008a. Watershed Stratification Methodology for TMDL Sediment and Habitat Investigations. Available at Montana DEQ, Helena, MT.

_____2008b. A Watershed Stratification Approach for TMDL Sediment and Habitat Impairment Verification. White paper available at Montana DEQ, Helena, MT.

_____2008c. Longitudinal field methodology for the assessment of TMDL sediment and habitat impairments. Montana DEQ, Helena.

Dunne, T. and L.B. Leopold. 1978. Water in Environmental Planning. W.H. Freeman and Company, New York.

Meehan, W.R., ed. 1991. Influences of forest and rangeland management on salmonid fishes and their habitats. Special Publication 19. American Fisheries Society, Bethesda, MD. 751 p.

Rosgen, D. L. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, CO.

Rosgen, D. L. 2001. A Practical Method of Computing Streambank Erosion Rate, Federal Interagency Sediment (FISC) Conference 2001, Reno, NV, March, 2001, http://www.wildlandhydrology.com/

Rosgen, D. L. 2006. Watershed Assessment of River Stability and Sediment Supply (WARSSS). Wildland Hydrology, Fort Collins, CO.

Strahler, A. N. (1952). Hypsometric (area altitude) analysis of erosional topology. Geological Society of America Bulletin, 63, 1117 - 1142.

United States Environmental Protection Agency (USEPA). 2002. Description of the level III and level IV ecoregions of Montana. Accessed at State of Montana Natural Resource Information System (NRIS); http://nris.mt.gov/gis/gisdatalib/gisDataList.aspx.

Weaver, T. and Fraley, J., 1991. Fisheries Habitat and Fish Populations, Flathead Basin Forest Practices Water Quality and Fisheries Cooperative Program - Final Report. Flathead Basin Commission,Kalispell, MT. pp. 53- 68.

Wolman, M.G., 1954, A method of sampling coarse river-bed material: Trans. Am. Geophys. Union, v. 35, p. 951-956.

Woods, Alan J., Omernik, James, M., Nesser, John A., Shelden, J., and Azevedo, Sandra H., 1999, Ecoregions of Montana (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,500,000).

ATTACHMENT B - SUMMARY OF PERMITTED POINT SOURCES IN THE FLATHEAD LAKE BASIN



Summary of Permitted Point Sources in the Flathead Lake Basin

June 27, 2013

Public Review Draft

U.S. Environmental Protection Agency
Montana Operations Office
10 West 15th Street, Suite 3200
Helena, MT 59601

Revision History

Document Name	Revision	Release Date	Revisions
Summary of Permitted Point Sources in the Flathead Lake Basin – Stakeholder Review Draft	1.0	July 21, 2011	Draft sent to public entities that contributed data and information to the report.
Summary of Permitted Point Sources in the Flathead Lake Basin – Stakeholder Review Draft	2.0	September 28, 2011	Incorporated comments from stakeholders.
Summary of Permitted Point Sources in the Flathead Lake Basin – Stakeholder Review Draft	3.0	June 27, 2013	Updated with data through 2012. Reorganized by permit type.

CONTENTS

Executive Summary vii
1.0 Introduction 1
2.0 Individual MPDES Permits 5
2.1 Burlington Northern Whitefish Facility (MT0000019) 6
2.2 Columbia Falls WWTP (MT0020036) 9
2.3 Whitefish WWTP (MT0020184) 18
2.4 Bigfork Water and Sewer District WWTF (MT0020397) 28
2.5 Polson WWTP (MT0020559) 37
2.6 Kalispell WWTP (MT0021938) 42
2.7 Hungry Horse Dam WWTP (MT0022578) 51
2.8 Yellow Bay WWTP (Flathead Lake Biological Station) (MT0023388) 54
2.9 Columbia Falls Aluminum Co (MT0030066) 60
2.10 Whitefish WTP (MT0030414) 65
2.11 Lake McDonald (Glacier National Park) WWTP (MT0030601) 68
2.12 Donald G. Abbey House (MT0030651) 72
2.13 John Collins Pool House (MT0031658) 74
2.14 BNSF Railway KRY Site Petroleum Cleanup (MT0031739) 76
2.15 Comparing Nutrient Loads of Individual MPDES Permitees 78
2.16 Trends in Annual Nutrient Loads for the largest, continuously discharging facilities 81
3.0 MGWPCS Permits 85
3.1 Meadow Gold Dairy (MTX000066) 86
3.2 Plum Creek Manufacturing Facility (MTX000092) 88
3.3 Stampede Packing Company (MTX000100) 91
3.4 International RV LLC (MTX000120) 93
3.5 Glacier Ranch Subdivision (MTX000164) 95
3.6 Kootenai Lodge/Lake County Water & Sewer District (MTX000188) 97
3.7 Hungry Horse Wastewater Treatment Plant (MTX000193) 100
3.8 Cove Creek Ridge Subdivision (MTX000199) 102
3.9 Point of Pines Wastewater Treatment System (MTX000214) 104
3.10 Glacier International Airport Rental Car Facility Car Wash (MTX000220) 106
4.0 Non-Stormwater General MPDES Permits 108
4.1 Tutvedt Farms (MTG010253) 110
4.2 Creston National Fish Hatchery (MTG130007) 112
4.3 Flathead Lake Salmon Hatchery (MTG130014) 114
5.0 Stormwater General MPDES Permits 116
6.0 Montana Permits 117
6.1 Section 308 Permits 117
6.2 Section 318 Permits 117
7.0 Facilities that Do Not Need Permit Coverage 118
7.1 Unpermitted Facilities 118
7.2 Elmo 119
7.3 Lakeside/Somers 121
8.0 Data Gaps 124
9.0 References 125

Tables

Table 1. Individually permitted point sources in the Flathead Lake basin viii
Table 2. Summary of the types of permits in the Flathead Lake basin 1
Table 3. Facilities covered by individual MPDES permits with total phosphorus limits 2
Table 4. Facilities covered by individual MPDES permits with total nitrogen limits 3
Table 5. Facilities covered by individual MPDES permits with TSS limits 4
Table 6. Individual MPDES permits in the Flathead Lake basin 5
Table 7. Burlington Northern Whitefish Facility final permit limits 8
Table 8. Burlington Northern Whitefish Facility data summary 8
Table 9. Columbia Falls WWTP final permit limits 12
Table 10. Columbia Falls WWTP data summary for outfall 001 13
Table 11. Whitefish WWTP final permit limits 21
Table 12. Whitefish WWTP data summary 22
Table 13. Bigfork Water and Sewer District WWTF permit limits 31
Table 14. Bigfork Water and Sewer District WWTF data summary 31
Table 15. Polson WWTP permit limits 39
Table 16. Polson WWTP data summary 39
Table 17. Kalispell WWTP permit limits 45
Table 18. Kalispell WWTP data summary 46
Table 19. Hungry Horse Dam WWTP permit limits 53
Table 20. Hungry Horse Dam WWTP data summary 53
Table 21. Yellow Bay WWTP permit limits 56
Table 22. Yellow Bay WWTP data summary 56
Table 23. Columbia Falls Aluminum Company permit limits for outfalls 002, 003, and 004 62
Table 24. Columbia Falls Aluminum Company permit limits for outfall 005 62
Table 25. Columbia Falls Aluminum Company data summary ..... **Error! Bookmark not defined.**
Table 26. Whitefish WTP permit limits 67
Table 27. Whitefish WTP flow (cfs) data summary 67
Table 28. Lake McDonald WWTP permit limits 71
Table 29. Lake McDonald WWTP data summary 71
Table 30. Donald G. Abbey house data summary 72
Table 31. John Collins pool house data summary 74
Table 32. MGWPCS permits in the Flathead Lake basin 85
Table 33. Meadow Gold Dairy data summary 86
Table 34. Plum Creek Manufacturing data summary 90
Table 35. Stampede Packing Company data summary 91
Table 36. Groundwater quality limits for the end of the mixing zone to protect Class I groundwater 93
Table 37. International RV LLC data summary 93
Table 38. Glacier Ranch Subdivision permit limits 95
Table 39. Groundwater trigger values for monitoring well MW1A, MW1B, and MW1C 95
Table 40. Glacier Ranch Subdivision data summary 95
Table 41. Kootenai Lodge/Lake County Water and Sewer District permit limits for outfalls 001 and 002 97
Table 42. Groundwater trigger values for monitoring well MW1A 97
Table 43. Kootenai Lodge/Lack County Water and Sewer District data summary 99
Table 44. Hungry Horse WWTP permit limits 100
Table 45. Point of Pines Wastewater Treatment System permit limits 104
Table 46. Point of Pines Wastewater Treatment System data summary 104

Table 47. General MPDES permit for concentrated animal feeding operations in the Flathead Lake basin 108
Table 48. General MPDES permits for construction dewatering in the Flathead Lake basin 108
Table 49. General MPDES permits for fish farms in the Flathead Lake basin 108
Table 50. General MPDES permits for biosolids in the Flathead Lake basin 108
Table 51. General MPDES permits for disinfected waters in the Flathead Lake basin 109
Table 52. General MPDES permits for petroleum cleanup in the Flathead Lake basin 109
Table 53. General MPDES permits for pesticide in the Flathead Lake basin 109
Table 54. Creston National Fish Hatchery permit limits 112
Table 55. Flathead Lake Salmon Hatchery data summary 114
Table 56. General NPDES permits stormwater discharges associated with industrial activities in the Flathead Lake basin 116
Table 57. General NPDES permit for stormwater discharges associated with multiple separate storm sewer systems in the Flathead Lake basin 116
Table 58. General NPDES permits for stormwater that does not discharge off-site in the Flathead Lake basin 116
Table 59. Section 308 permits in the Flathead Lake basin 117
Table 60. Unpermitted facilities in the Flathead Lake basin 118
Table 61. BOD and TSS at the Lakeside treatment facility 121

Figures

Figure 1. Burlington Northern Whitefish Facility and permitted outfall. 7
Figure 2. Columbia Falls WWTP permitted outfall. 10
Figure 3. Columbia Falls WWTP service area. 11
Figure 4. Average daily flow at the Columbia Falls WWTP. 15
Figure 5. Total phosphorus at the Columbia Falls WWTP. 16
Figure 6. Ammonia at the Columbia Falls WWTP. 17
Figure 7. Whitefish WWTP permitted outfall. 19
Figure 8. Whitefish WWTP service area. 20
Figure 9. Average daily flow from the city of Whitefish WWTP. 24
Figure 10. Total phosphorus at the Whitefish WWTP. 25
Figure 11. Total nitrogen at the Whitefish WWTP. 27
Figure 12. Bigfork Water and Sewer District WWTF permitted outfall. 29
Figure 13. Bigfork Water and Sewer District WWTF service area. 30
Figure 14. Bigfork Water and Sewer District WWTF sludge injection sites. 33
Figure 15. Average daily flow from the Bigfork Water and Sewer District WWTF. 34
Figure 16. Total phosphorus from the Bigfork Water and Sewer District WWTF. 35
Figure 17. Total nitrogen from the Bigfork Water and Sewer District WWTF. 36
Figure 18. Polson WWTP permitted outfall. 38
Figure 19. Average daily flow at the Polson WWTP. 40
Figure 20. Ammonia from the city of Polson WWTP. 41
Figure 21. Kalispell WWTP permitted outfall. 43
Figure 22. Kalispell WWTP service area. 44
Figure 23. Average daily influent flow at the Kalispell WWTP. 47
Figure 24. Average daily effluent flow at the Kalispell WWTP. 48
Figure 25. Total phosphorus at the Kalispell WWTP. 49
Figure 26. Total nitrogen at the Kalispell WWTP. 50
Figure 27. Hungry Horse Dam WWTP permitted outfall. 52
Figure 28. Yellow Bay WWTP permitted outfall. 55

Figure 29. Average daily flow at the Yellow Bay WWTP. 57
Figure 30. Total phosphorus at the Yellow Bay WWTP. 58
Figure 31. Total persulfate nitrogen at the Yellow Bay WWTP. 59
Figure 32. Columbia Falls Aluminum Company and permitted outfalls. 61
Figure 33. Columbia Falls Aluminum Company groundwater monitoring sites. 63
Figure 34. Columbia Falls Aluminum Company surface water monitoring sites. 64
Figure 35. Whitefish WTP and permitted outfall. 66
Figure 36. Lake McDonald WWTP permitted outfalls. 69
Figure 37. Lake McDonald WWTP service area. 70
Figure 38. Donald G. Abbey house and permitted outfall. 73
Figure 39. John Collins pool house. 75
Figure 40. BNSF Railway Company KRY Site. 77
Figure 41. Flows for the eight facilities with phosphorus or nitrogen permit limits. 78
Figure 42. Permitted annual total phosphorus loads (pounds per year). 79
Figure 43. Permitted annual total nitrogen loads (tons per year) 80
Figure 44. Effluent flow (million gallons per year) at the largest continuously discharging facilities. 81
Figure 45. Influent flow (million gallons per year) at the largest continuously discharging facilities. 82
Figure 46. Total phosphorus loads (pounds per year) at the largest continuously discharging facilities. 83
Figure 47. Total nitrogen loads (tons per year) at the largest continuously discharging facilities. 84
Figure 48. Meadow Gold Dairy and permitted outfall. 87
Figure 49. Plum Creek Manufacturing and permitted outfalls. 89
Figure 50. Stampede Packing Company and permitted outfall. 92
Figure 51. International RV LLC and permitted outfall. 94
Figure 52. Glacier Ranch subdivision. 96
Figure 53. Kootenai Lodge/Lake County Water and Sewer District and permitted outfalls 98
Figure 54. Hungry Horse WWTP. 101
Figure 55. Proposed Cove Creek Ridge Subdivision. 103
Figure 56. Point of Pines Wastewater Treatment System. 105
Figure 57. Glacier Park International Airport Rental Car Facility Carwash. 107
Figure 58. Tutvedt Farms CAFO and manure land application areas 111
Figure 59. Creston National Fish Hatchery and permitted outfalls 113
Figure 60. Flathead Lake Salmon Hatchery and permitted outfall. 115
Figure 61. Elmo irrigation site and ponds 120
Figure 62. Lakeside WWTP, land application site, and ponds 122
Figure 63. Lakeside and Somers service area. 123

Abbreviations and Acronyms

BOD	biochemical oxygen demand
DEQ	Montana Department of Environmental Quality
DFWP	Montana Department of Fish, Wildlife and Parks
DO	dissolved oxygen
DMR	discharge monitoring reports
FCCHD	Flathead City-County Health Department
LCWSD	Lakeside County Water and Sewer District
MLWSD	Meadow Lake Water and Sewer District
MPDES	Montana Pollutant Discharge Elimination System
PCB	polychlorinated biphenyls
SCWSD	Somers County Water and Sewer District
TDS	total dissolved solids
TKN	total Kjeldahl nitrogen
TPN	total persulfate nitrogen
TSS	total suspended solids
U.S. EPA	U.S. Environmental Protection Agency
WTP	water treatment plant
WWTF	wastewater treatment facility
WWTP	wastewater treatment plant

Units of Measure

BTU	British thermal unit
°C	degrees Celsius
cfs	cubic foot per second
cfu	colony forming unit
gpd	gallons per day
lb/d	pounds per day
µS/cm	microsiemen per centimeter
mgd	million gallons per day
mg/L	milligrams per liter
mL	milliliters
NTU	Nephelometric turbidity units

Foreword

A series of brief technical reports have been prepared by the U.S. Environmental Protection Agency (EPA) in support of an effort by the Montana Department of Environmental Quality (DEQ) and EPA to establish Total Maximum Daily Loads (TMDLs) for nutrients and set up a water quality simulation model for the Flathead Basin. The series includes separate reports covering a broad range of topics including:

- Groundwater Quality and Hydrology
- Urban Stormwater Sources
- Point Source Discharges
- Agriculture/Irrigation
- Timber Harvest
- Forest Fires
- Roads
- Septic Systems
- Lakes and Reservoirs
- Existing and historic water quality in nutrient impaired waters

When combined, these technical reports are intended to define a preliminary conceptual understanding of the current water quality conditions relative to nutrients, sources of nutrients, and the ways in which water and nutrients are transported within the Flathead Lake basin. The information presented in this series of technical reports will be used to inform the modeling and TMDL processes.

It should be noted that the data and information presented in these reports reflects what was available at the time that the reports were published. It is acknowledged that in some cases, not all data could be compiled by the publication date. Additional information will be incorporated into the modeling and TMDL processes as it becomes available.

Executive Summary

Point sources (e.g., wastewater treatment plants, industrial facilities, fish hatcheries) are one of many potentially significant sources of pollutants within the Flathead Lake. The purpose of this technical report is to provide a summary of the extent and type of point sources that are located within the Flathead Lake basin. This report specifically focuses on the Montana Pollutant Discharge Elimination System (MPDES) permitted point sources, including those facilities covered under individual, general, and groundwater permits. Facilities or activities that are permitted to discharge stormwater are discussed in the context with other urban stormwater sources in the technical report titled, *Summary of Urban Stormwater Sources in the Flathead Lake Basin*.

There are 419 facilities in the Flathead Lake basin that are permitted to discharge wastewater to surface water or groundwater. Of the 419 permits, 275 are general MPDES permits for stormwater discharges. The facilities with individual permits consist of publicly owned water and wastewater treatment plants (WWTPs), industrial sites, fish hatcheries, and smaller privately owned treatment systems. Facilities with individual MPDES or Montana Groundwater Pollution Control System (MGWPCS) permits are summarized with their receiving waterbodies in Table 1.

Facility size (and design flow) varies from small package plants (e.g., Yellow Bay WWTP, with a design flow of 33,000 gallons per day) to large publically owned treatment plants (e.g., Kalispell WWTP, with a design flow of 5.4 million gallons per day). Permit limits vary for each facility and eight facilities have nitrogen or phosphorus permit limits.

Flow and water quality data were obtained from discharge monitoring reports (DMRs) and facility records to characterize the effluent. Based on the available data, the facilities that discharged the largest estimated loads of total phosphorus in 2012 were Whitefish WWTP (1,660 lbs/yr), Kalispell WWTP (1,318 lbs/yr), Columbia Falls WWTP (513 lbs/yr), and Bigfork Water and Sewer District WWTF (237 lbs/yr). Total nitrogen loads were estimated at 34 tons, 32 tons, 3.2 tons, 3.6 tons, respectively.

Nutrient loads from the four largest facilities varied over time based on technology upgrades and population growth. For example, upgrades to the Whitefish treatment plant in 1987 reduced total phosphorus loads from approximately 11,000 lbs/yr in 1986 to 1,800 lbs/yr in 1990. A brief analysis of trends at the four facilities (since the most recent plant upgrade) show generally increasing trends in flow, total phosphorus, and total nitrogen. For example, a comparison of the annual flow in the year following the most recent plant upgrade to the most recent annual flow indicates that they have increased at each plant (Kalispell WWTP by 34 percent; Whitefish WWTP by 4 percent; Columbia Falls WWTP by 3 percent; and Bigfork WWTF by 38 percent). Total phosphorus loads have similarly increased at the Kalispell and Columbia Falls WWTPs (43 and 52 percent, respectively).

Table 1. Individually permitted point sources in the Flathead Lake basin

Facility	Permit	Receiving waterbody
Bigfork Water and Sewer District WWTF	MT0020397	Flathead Lake
BNSF Railway KRY Site Petroleum Cleanup	MT0031739	Stillwater River
BN Whitefish Facility	MT0000019	Whitefish River
Columbia Falls Aluminum Company	MT0030066	Flathead River
Columbia Falls WWTP	MT0020036	Flathead River
Cove Creek Ridge Subdivision (TLW Properties LLC)	MTX000199	groundwater
Creston National Fish Hatchery	MT0031771 [a]	-- [a]
Crown Jewel Estates	MTX000200 [a]	groundwater
Donald G. Abbey, (aka Abbey Main House)	MT0030651	Flathead Lake
Ehrman Lease Subdivision	MTX000133 [b]	groundwater
FH Stoltze Land and Lumber Company	MTX000228 [b]	groundwater
Fox Hill Subdivision	MTX000173 [a]	groundwater
Gary Tallent (aka Tallent Home Project)	MT0031607 [b]	-- [b]
Glacier Gold, L.C.C.	MT0000999 [a]	-- [a]
Glacier International Airport Rental Car Facility Car Wash (FCA Rentals LLC)	MTX000220	groundwater
Glacier Ranch Subdivision	MTX000164	groundwater
Hungry Horse Wastewater Treatment Plant	MTX000193	groundwater
Hungry Horse Dam WWTP	MT0022578	South Fork Flathead River
International RV LLC (aka Paradise Pines RV Condominiums)	MTX000120 [b]	groundwater
John Collins Pool House	MT0031658	Whitefish Lake
Kalispell WWTP, city of	MT0021938	Ashley Creek
Kelsey Subdivision WWTF	MTX000155 [b]	groundwater
Kootenai Lodge Lake County Water and Sewer District	MTX000188	groundwater
Lake McDonald (Glacier National Park) WWTP	MT0030601	groundwater [c]
Meadow Dairy Gold	MTX000066	groundwater
Paradise Cove RV Condominium Community	MTX000183 [b]	groundwater
Plum Creek Manufacturing Facility	MTX000092	groundwater
Point of Pines Wastewater Treatment System	MTX000214	groundwater
Polson WWTP, city of	MT00020559	Flathead River
Stampede Packing Company (aka Meat Production Inc.)	MTX000100	groundwater
Whitefish WTP, city of	MT0030414	unnamed reservoir [d]
Whitefish WWTP, city of	MT0020184	Whitefish River
Yellow Bay (Flathead Lake Biological Station) WWTP	MT0023388	Flathead Lake

Notes

aka = also known as; LLC = limited liability company; RV = recreational vehicle; WTP = water treatment plant; WWTF = wastewater treatment facility; WWTP = wastewater treatment plant.

a. Montana DEQ identified the permit as pending (i.e., no permit has been written and no previous permit was written that could be administratively continued).

b. Montana DEQ identified the permit as no longer necessary (e.g., the permit was terminated).

c. The Lake McDonald WWTP discharges to groundwater that is hydrologically connected to McDonald Creek and the Middle Fork Flathead River.

d. The Whitefish WTP discharges to an unnamed reservoir in an unnamed tributary to Whitefish Lake.

1.0 Introduction

This is one of a series of brief technical reports prepared in support of an effort by the Montana Department of Environmental Quality (DEQ) and U.S. Environmental Protection Agency (EPA) to establish Total Maximum Daily Loads (TMDLs) for nutrients, sediment, and temperature and set up a water quality simulation model for the Flathead Lake basin. Point sources (e.g., wastewater treatment plants, industrial facilities, fish hatcheries) are one of many potentially significant sources of pollutants within the Basin that will ultimately be considered in the modeling effort. The purpose of this technical report is to provide a summary of the extent and type of point sources that are within the Flathead Lake basin. This report specifically focuses on the Montana Pollutant Discharge Elimination System (MPDES) permitted point sources, including those facilities covered under individual or general MPDES permits. Permitted groundwater discharges, under the Montana Ground Water Pollution Control System (MGWPCS), are also discussed. Facilities or activities that are permitted to discharge stormwater are discussed in the context with other urban stormwater sources in the technical report titled, *Summary of Urban Stormwater Sources in the Flathead Lake Basin*. The information contained in this technical report will be used to inform the modeling and TMDL processes, which will ultimately be used to define, and put into context, at the watershed-scale, the potential significance of permitted point sources as a source of pollutants in the Flathead Lake basin.

This document presents a summary of available information and data for each permitted facility, including a brief characterization of each facility and an evaluation of water quality data. At the time of this report, there were 419 permitted facilities in the basin, 17 of which are covered by individual MPDES permits and 16 of which are covered by MGWPCS permits (Table 2). Summaries of the permit limits for total phosphorus, total nitrogen, and total suspended solids (TSS) are provided in Table 3, Table 4, and Table 5, respectively. The following sections discuss each permitted facility individually.

Table 2. Summary of the types of permits in the Flathead Lake basin

Permit	Number of permitees
Individual MPDES	17
Individual MGWPCS	16
General MPDES	
Non-stormwater	
Biosolids	6
CAFO	1
Construction dewatering	11
Disinfected waters	2
Fish farms	2
Pesticide	6
Petroleum cleanup	1
Stormwater	
Construction Activity	255
Industrial Activity	9
MS4	1
No Exposure	5
Montana Permits	
Section 308	11
Section 318	75
Facilities not covered by permits	6

Note: CAFO = concentrated animal feeding operation; MGWPCS = Montana Ground Water Pollution Control System; MPDES = Montana Pollutant Discharge Elimination System; MS4 = municipal separate storm sewer system.

Table 3. Facilities covered by individual MPDES permits with total phosphorus limits

Permitee (effective date)	Facility type	Receiving waterbody	Design flow (mgd)	Concentration (mg/L) [a]		Load (lb/d) [b]		
				Max.	30-d avg.	Max.	30-d avg.	Ann. avg.
Kalispell WWTP (9/1/2008)	public sewerage system	Ashley Creek	5.4	--	1.0	--	25.8	--
Whitefish WWTP (9/1/2008)	public sewerage system	Whitefish River	1.8	--	1.0	--	10.4	--
Bigfork WSD WWTF (8/1/2010)	public sewerage system	Flathead Lake	0.69	--	1.0	--	4.2	--
Columbia Falls WWTP (5/1/2010)	public sewerage system	Flathead River	0.550	--	1.0	--	4.6	--
Lake McDonald WWTP (1/1/2012)	public sewerage system	groundwater [c]	0.25	--	0.7	--	1.2	--
BN Whitefish Facility (11/1/2009)	railroads, line-haul operations	Whitefish River	0.096	1.0	--	0.6	--	--
Yellow Bay WWTP (7/1/2012)	industrial sewerage system	Flathead Lake	0.033	--	--	--	--	2.0
Hungry Horse Dam WWTP (11/1/2008)	public sewerage system	South Fork Flathead River	0.009	--	1.0 [d]	--	0.8 [d]	--

Notes
The table is sorted from top to bottom by design flow from largest to smallest.
mgd = million gallons per day; MPDES = Montana Pollutant Discharge Elimination System; WSD = water and sewer district; WWTP = wastewater treatment facility; WWTP = wastewater treatment plant.
a. Concentration limits, in milligrams per liter (mg/L) as phosphorus, for either a daily maximum (max.) or thirty-day average (30-d avg.).
b. Load limits, in pounds per day (lb/d), for a daily maximum (max.), thirty-day average (30-d avg.) or annual average (ann. avg.).
c. The Glacier National Park's Lake McDonald WWTP discharges to groundwater that is hydrologically connected to McDonald Creek and the Middle Fork Flathead River.
d. Limits only apply to outfall 001 at the Hungry Horse Dam WWTP.

Table 4. Facilities covered by individual MPDES permits with total nitrogen limits

Permitee (issue date)	Facility type	Receiving waterbody	Design flow (mgd)	Conc. (mg/L) [a]	Load (lb/d) [b]			
				30-d avg.	Max.	Wk. avg.	30-d avg.	Ann. avg.
Kalispell WWTP (9/1/2008)	public sewerage system	Ashley Creek	5.4	--	--	379	286	--
Whitefish WWTP (9/1/2008)	public sewerage system	Whitefish River	1.8	--	426		273	
Bigfork WSD WWTF (8/1/2010)	public sewerage system	Flathead Lake	0.69	--	--	52.2	42.1	--
Columbia Falls WWTP (5/1/2010)	public sewerage system	Flathead River	0.550	--	--	63.5	37.1	--
Lake McDonald WWTP (1/1/2012)	public sewerage system	groundwater [c]	0.25	7.0	--	--	11.7	--
BN Whitefish Facility (11/1/2009)	railroads, line-haul operations	Whitefish River	0.096	--	20		--	--
Yellow Bay WWTP (7/1/2012)	industrial sewerage system	Flathead Lake	0.033	--	--	--	--	154

Notes

The table is sorted from top to bottom by design flow from largest to smallest.

mgd = million gallons per day; MPDES = Montana Pollutant Discharge Elimination System; WSD = water and sewer district; WWTP = wastewater treatment facility; WWTP = wastewater treatment plant.

a. Concentration limits, in milligrams per liter (mg/L) as nitrogen, for a daily maximum (max.).

b. Load limits, in pounds per day (lb/d), for a daily maximum (max.), weekly or seven day average (wk. avg.), thirty-day average (30-d avg.) or annual average (ann. avg.).

c. The Glacier National Park's Lake McDonald WWTP discharges to groundwater that is hydrologically connected to McDonald Creek and the Middle Fork Flathead River.

Table 5. Facilities covered by individual MPDES permits with TSS limits

Permitee (issue date)	Facility type	Receiving waterbody	Design flow (mgd)	Concentration (mg/L) [a]			Load (lb/d) [b]		
				Max.	Wk. avg.	30-d avg.	Max.	Wk. avg.	30-d avg.
Kalispell WWTP (9/1/2008)	public sewerage system	Ashley Creek	5.4	--	15	10	--	388	259
Whitefish WWTP (9/1/2008)	public sewerage system	Whitefish River	1.8	--	45	30	--	469	313
Bigfork WSD WWTF (8/1/2010)	public sewerage system	Flathead Lake	0.69	--	33	22	--	188	125
Polson WWTP (1/1/2013)	public sewerage system	Flathead River	0.650	--	135	100	--	--	--
Columbia Falls WWTP (5/1/2010)	public sewerage system	Flathead River	0.550	--	45	30	--	206	138
Lake McDonald WWTP (1/1/2012)	public sewerage system	groundwater [c]	0.25	--	45	30	--	75	50
BN Whitefish Facility (11/1/2009)	railroads, line-haul operations	Whitefish River	0.096	30	--	--	16	--	--
Yellow Bay WWTP (7/1/2012)	industrial sewerage system	Flathead Lake	0.033	--	45	30	--	--	--
BNSF Railway KRY Site (9/1/2012)	petroleum cleanup	Stillwater River	0.025	11.3	--	--	--	--	--
Hungry Horse Dam WWTP (11/1/2008)	public sewerage system	South Fork Flathead River	0.009	--	45 [d]	30 [d]		2.25	1.5
Columbia Falls Aluminum Company (2/1/1999)	aluminum production	Flathead River	n/a	--	45 [e]	30 [e]	--	--	--

Notes

The table is sorted from top to bottom by design flow from largest to smallest.

mgd = million gallons per day; MPDES = Montana Pollutant Discharge Elimination System; n/a = not available (i.e., not reported); TSS = total suspended solids; WSD = water and sewer district; WWTP = wastewater treatment facility; WWTP = wastewater treatment plant.

a. Concentration limits, in milligrams per liter (mg/L), for a daily maximum (max.), weekly or seven day average (wk. avg.), or thirty-day average (30-d avg.).

b. Load limits, in pounds per day (lb/d), for a daily maximum (max.), weekly or seven day average (wk. avg.), or thirty-day average (30-d avg.).

c. The Glacier National Park's Lake McDonald WWTP discharges to groundwater that is hydrologically connected to McDonald Creek and the Middle Fork Flathead River.

d. Limits only apply to outfall 001 at the Hungry Horse Dam WWTP.

e. Limits only apply to outfall 005 at the Columbia Falls Aluminum Company.

2.0 Individual MPDES Permits

Seventeen facilities with individual MPDES permits are allowed to discharge effluent to surface waters in the Flathead Lake basin (Table 6). The surface water discharges are issued permits that begin with MT. Required monitoring data, in the form of discharge monitoring reports (DMR), were downloaded from ISIS and provided by U.S. EPA Region 8[1] for all of these facilities (hereafter cited as *U.S.EPA 2013b*). Additional data were provided by certain facilities. All available data are presented in this section. Facilities without current permits (see footnotes *a* and *b* in Table 6) are not further discussed.

Table 6. Individual MPDES permits in the Flathead Lake basin

Permit no.	Name
MT0000019	BN Whitefish Facility
MT0000999 [a]	Glacier Gold, L.C.C.
MT0020036	Columbia Falls WWTP
MT0020184	Whitefish WWTP
MT0020397	Bigfork Water and Sewer District WWTF
MT0020559	Polson WWTP
MT0021938	Kalispell WWTP
MT0022578	Hungry Horse Dam WWTP
MT0023388	Yellow Bay (Flathead Lake Biological Station) WWTP
MT0030066	Columbia Falls Aluminum Company
MT0030414	Whitefish WTP
MT0030601	Lake McDonald (Glacier National Park) WWTP
MT0030651	Donald G. Abbey (aka Abbey Main House)
MT0031607 [b]	Gary Tallent (aka Tallent Home Project)
MT0031658	John Collins Pool House
MT0031739	BNSF Railway KRY Site Petroleum Cleanup
MT0031771 [a]	Creston National Fish Hatchery

Notes
aka = also known as; BNSF = Burlington North Santa Fe; WTP = water treatment plant; WWTF = wastewater treatment facility; WWTP = wastewater treatment plant.
a. Montana DEQ identified the permit as pending (i.e., no permit has been written and no previous permit was written that could be administratively continued).
b. Montana DEQ identified the permit as no longer necessary (e.g., the permit was terminated).

For additional information, the Flathead City-County Health Department (FCCHD) has studied public WWTP and sewer system infrastructure and evaluated potential expansion of each sewer system. FCCHD published its findings in two reports:

- *Flathead County Wastewater Study* (FCCHD 2009)
- *Sewage Treatment in the Flathead Basin* (FCCHD 2012)

[1] Jason Gildea, U.S. EPA Region 8 Montana Operations Office, compiled DMR data for all permitted facilities in Flathead, Lake, and Missoula counties and compiled all available MPDES permits from DEQ for individually permitted facilities in the Flathead Lake basin.

2.1 Burlington Northern Whitefish Facility (MT0000019)

The Burlington Northern Santa Fe Rail Yard is in Whitefish, Montana just downstream of Whitefish Lake and near the Whitefish River (Figure 1). The facility operates a three-cell facultative settling pond treatment system that receives wastewater from the Roundhouse shop, track pans, a groundwater remediation system, and a stormwater collection system (DEQ 1999). The facility was upgraded in 1998 to improve treatment by adding a lagoon cell and increasing residence time throughout the system (DEQ 1999). The current design flow of the system is 0.096 mgd.

The treatment facility is permitted to discharge effluent to the Whitefish River from one outfall (#001; refer to Figure 1) (DEQ 1999, 2009). The most recent MPDES permit limits for the outfall are shown in Table 7. The permit also requires the pH of the effluent to remain between 6.0 and 9.0 standard units and there cannot be any visible foam, oil sheen, or floating solids in the effluent.

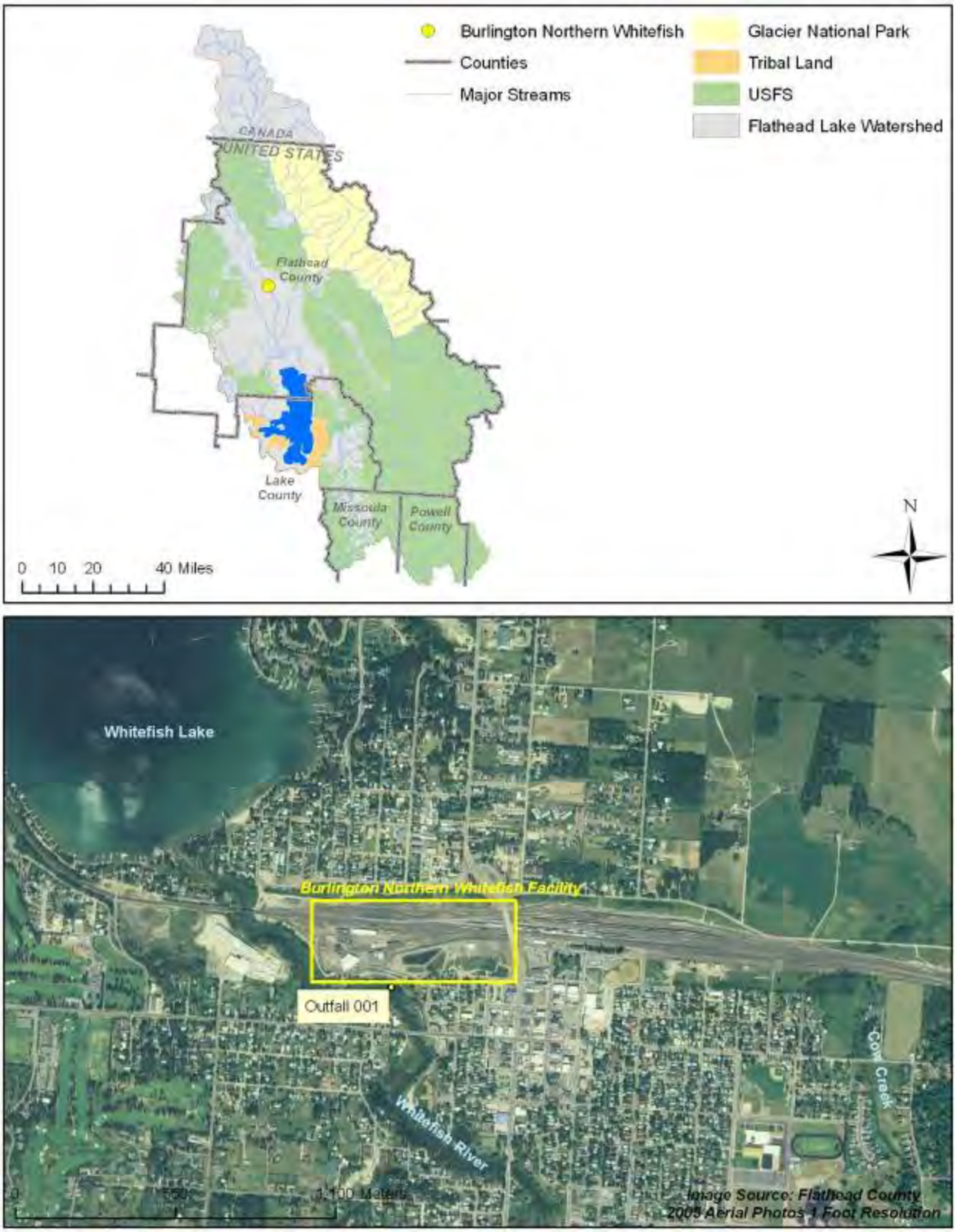


Figure 1. Burlington Northern Whitefish Facility and permitted outfall.

Table 7. Burlington Northern Whitefish Facility final permit limits

Constituent	Units	Maximum daily limit
BOD_5	mg/L	30
	lb/d	16
Cadmium (total recoverable)	mg/L	0.0018
Total Nitrogen	lb/d	20
Oil & Grease	mg/L	<10
Total Phosphorus	mg/L	1.0
	lb/d	0.6
TSS	mg/L	30
	lb/d	16

Source: DEQ 2009
Note: BOD_5 = five day biological oxygen demand; lb/d = pounds per day; mg/L = milligrams per liter; TSS = total suspended solids.

Table 8 summarizes the available effluent water quality data for outfall #001, which were obtained from ICIS (U.S. EPA 2013b). The average effluent flow from 2000 to 2012 was 0.0928 cfs, with an average total phosphorus concentration of 0.0261 mg/L and an average total nitrogen concentration of 0.86 mg/L.

Table 8. Burlington Northern Whitefish Facility data summary

Constituent	Start date	End date	No. of records	Avg.	Min.	Max.
Ammonia (total as N) (mg/L)	4/10/2000	9/18/2009	23	0.178	0.01	0.95
BOD, 5-day, 20 °C	4/10/2000	9/18/2009	23	4.41	1	10
Flow rate (cfs)	4/10/2000	10/3/2012	36	0.0928	0.00303	0.543
Nitrogen (total) (mg/L)	4/10/2000	9/18/2009	23	0.86	0.28	2.71
NO2NO3 (total as N) (mg/L)	4/10/2000	9/18/2009	23	0.145	0.005	1.78
Phosphorus (total) (mg/L)	4/10/2000	9/18/2009	23	0.0261	0.005	0.08
Temperature (°C)	4/10/2000	9/18/2009	22	16.2	3.33	25
TKN (total as N) (mg/L)	4/10/2000	9/18/2009	23	0.712	0.11	2.39
TSS (mg/L)	4/10/2000	9/18/2009	23	2.95	0.5	5.5

Source of data: ICIS (U.S. EPA 2013b)
Notes
DMR records from ICIS are monthly averages.
avg. = average (arithmetic mean); BOD = biological oxygen demand; C = Celsius; cfs = cubic feet per second; lb/d = pounds per day; max. = maximum; mg/L = milligrams per liter; min. = minimum; N = nitrogen; NO2NO3 = nitrite plus nitrate; P = phosphorus; TKN = total Kjeldahl nitrogen; TSS = total suspended solids.

2.2 Columbia Falls WWTP (MT0020036)

The City of Columbia Falls operates a wastewater treatment facility near the Flathead River just downstream of the City (Figure 2). The facility serves a population of approximately 4,000 people located in and around Columbia Falls (Figure 3), including the Meadow Lake Water and Sewer District (MLWSD) that serves a mostly seasonal population (FCCHD 2009, 2012).

Until 1980, the city used an aerated lagoon for wastewater treatment. A new facility was built in 1980 on the same site. Secondary treatment was added in 1984, and a tertiary phosphorus removal facility was added in 1988.[2] The facility uses alum in a flocculating clarifier for phosphorus removal (FCCHD 2009). In 2001, the facility added a sophisticated Supervisory Control and Data Acquisition (SCADA) system[3], a dissolved air flotation thickener (DAFT), and a belt filter press; tripling of the digester capacity and rehabilitation of the sludge storage basin.

In 2009, the city performed another major upgrade of the facility including the following: upgrade and modernization of the pretreatment building; convert the existing aeration basin to a flow equalization basin; construct a new bioreactor tank; upgrade the aeration supply equipment; and convert effluent disinfection from chlorine dosing to ultraviolet means. There were also improvements to the existing SCADA system. The bulk of the new construction was a 750,000 gallon bioreactor, consisting of two anaerobic basins, two anoxic basins, and one long aeration basin cordoned off into three separate zones. Biological nutrient removal is accomplished through the use of the new basins, largely negating the need for the tertiary phosphorus removal facility[4]. The design flow of the facility increased from 0.55 mgd to 0.62 mgd. The average daily flow in 2011 was 0.406 mgd (FCCHD 2012).

Columbia Falls operates eight lift stations. MLWSD owns and operates three lift station and its own collection system (FCCHD 2012). In 1985, the MLWSD lift station began operation (FCCHD 2009). Under the current agreement, the Columbia Falls WWTP will accept and treat up to 35 million gallons per year from MLWSD, which may not exceed a rate of 80,000 gpd (FCCHD 2012). In 2009, approximately 12 percent[5] of Columbia Falls WWTP treatment capacity was used for the Meadow Lake Sewer District (0.043 mgd or 0.350 mgd) (FCCHD 2009).

The WWTP is permitted to discharge effluent to the Flathead River from one outfall (#001) (DEQ 2010a). The most recent MPDES permit limits for the outfall are shown in Table 9. Additionally, the permit also requires the pH of the effluent to remain between 6.0 and 9.0 standard units and there cannot be any visible foam, oil sheen, or floating solids in the effluent. The permit also requires an 85 percent reduction in TSS and BOD_5 and for there to be no acute toxicity. The concentration of total residual chlorine cannot exceed 0.5 mg/L in any individual sample.

[2] Hugh Robertson, operator, Columbia Falls WWTP, personal communication, June 2, 2008.
[3] The term SCADA refers to centralized systems that monitor and control entire industrial sites.
[4] Hugh Robertson, operator, Columbia Falls WWTP, personal communication, September 19, 2011.
[5] Columbia Falls WWTP treated 0.350 mgd and 0.043 mgd was from the Meadow Lake County Sewer District.



Figure 2. Columbia Falls WWTP permitted outfall.

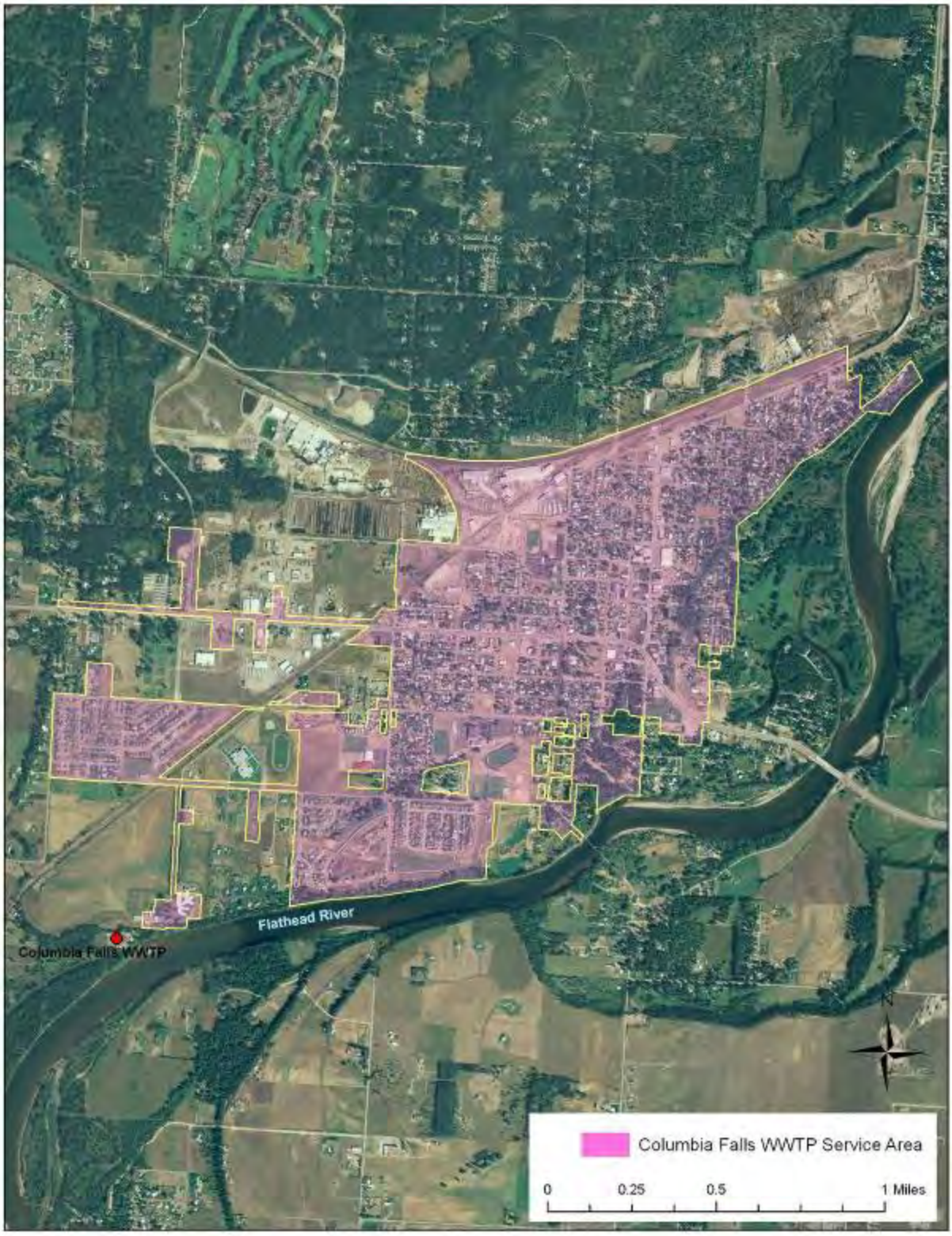


Figure 3. Columbia Falls WWTP service area.

Table 9. Columbia Falls WWTP final permit limits

Constituent	Units	Average monthly limit [a]	Average weekly limit [b]	Maximum daily limit
$CBOD_5$	mg/L	25	40	--
	lb/d	115	183	--
Chlorine (total residual)	mg/L	0.23	--	0.29
E. Coli Bacteria, winter[c,d]	cfu/100 mL	630	1,260	--
E. Coli Bacteria, summer[c,d]	cfu/100 mL	126	252	--
Oil & Grease	mg/L	--	--	<10
Total Phosphorus	mg/L	1.0	--	--
	lb/d	4.6	--	--
TSS	mg/L	30	45	--
	lb/d	138	206	--
Total Nitrogen[e]	lb/d	37.1	63.5	--
Total Ammonia	mg/L	30.7	40.9	--

Source: DEQ 2010a

Notes

$CBOD_5$ = five day carbonaceous biological oxygen demand; cfu/100 mL = colony forming units per 100 milliliters; lb/d = pounds per day; mg/L = milligrams per liter; TSS = total suspended solids.

a. The average of the daily sample result values collected during a single month must not exceed this limit.

b. The average of the daily sample results values collected during a single week must not exceed this limit.

c. Winter is November 1 through March 31: summer is April 1 through October 31.

d. Report geometric means if more than one sample is collected in the reporting period.

e. Calculated as the sum of Nitrate+Nitrite as N and Total Kjeldahl Nitrogen concentrations.

Table 10, Table 11, and Table 12 summarize the available water quality data for outfall #001; data were obtained directly from the WWTP[6] and from ICIS (U.S. EPA 2013b). Data provided by the facility are summarized herein; ICIS data may be used to supplement facility data during model development. The average effluent flow from 2008 to 2013 was 0.504 cfs and average total phosphorus concentration from 2001 to 2013 was 0.339mg/L (no phosphorus data are available prior to 2001). Ammonia (NH_3) averaged 5.23 mg/L and nitrate averaged 2.28 mg/L. Average total nitrogen from 2010 to 2013 was 11.3 mg/L and TKN data averaged 5.01 mg/L from 2001 to 2013.

The city of Columbia Falls WWTP also has a permit (MTG650009) to land apply sewage sludge (Category 2A of Montana's general MPDES permit for biosolids). Sludge is generally land applied twice per year (April/May and September/October) at several locations, including the Flathead County Landfill, various sites near the Veteran's Facility, near Walsh Road, and the current site of the Columbia Falls Junior High School.[7]

[6] Records provided in Excel spreadsheets from Hugh Robertson on June 9, 2008 and February 21, 2013.

[7] Hugh Roberson, Columbia Falls WWTP, personal communication, August 19, 2008.

Table 10. Columbia Falls WWTP data summary - Effluent data from Columbia Falls WWTP

Constituent	Start date	End date	No. of Samples	Avg.	Min.	Max.
Ammonia (total as N) (mg/L)	3/2/1993	2/11/2013	388	5.23	0.012	33.2
BOD, 5-day, 20 °C (Tertiary)	6/2/2008	2/11/2013	487	3.65	0.08	13.9
Dissolved Oxygen	5/8/2010	2/19/2013	570	4.59	2.76	7.43
Flow rate (cfs)	6/1/2008	2/19/2013	1,725	0.504	0	1.15
Nitrate (total as N) (mg/L)	12/2/1991	6/12/2006	135	2.28	0.05	14.8
NO_2+NO_3 (total as N) (mg/L)	6/2/2008	2/11/2013	299	3.83	0.01	22
Phosphorus (total) (mg/L)	11/1/2001	2/11/2013	1,742	0.339	0	8.13
Temperature (°C)	6/1/2008	2/19/2013	1,725	13.8	4.2	21.8
TKN (total as N) (mg/L)	6/9/2008	2/11/2013	178	5.01	0.59	28.9
TSS (mg/L)	11/1/2001	2/18/2013	1,689	6.59	1.1	38.1

Source of data: Hugh Robertson, Columbia Falls WWTP, June 9, 2008 and February 21, 2013.
Notes
avg. = average (arithmetic mean); BOD = biological oxygen demand; C = Celsius; cfs = cubic feet per second; max. = maximum; mg/L = milligrams per liter; min. = minimum; N = nitrogen; NO_2+NO_3 = nitrite plus nitrate; TKN = total Kjeldahl nitrogen; TSS = total suspended solids.

Table 11. Columbia Falls WWTP data summary - Influent data from Columbia Falls WWTP

Constituent	Start date	End date	No. of records	Avg.	Min.	Max.
BOD, 5-day, 20 °C	6/2/2008	2/14/2013	974	312	93.8	563
Flow rate (cfs)	1/1/1990	2/19/2013	9,298	0.542	0	1.26
Phosphorus (total) (mg/L)	6/2/2008	2/11/2013	924	6.81	2.8	12.3
Temperature (°C)	6/2/2008	2/18/2013	968	14	7.8	22.2
TKN (total as N) (mg/L)	6/9/2008	2/4/2013	112	52.5	31.6	69.8
TSS (mg/L)	6/2/2008	2/18/2013	984	316	125	711

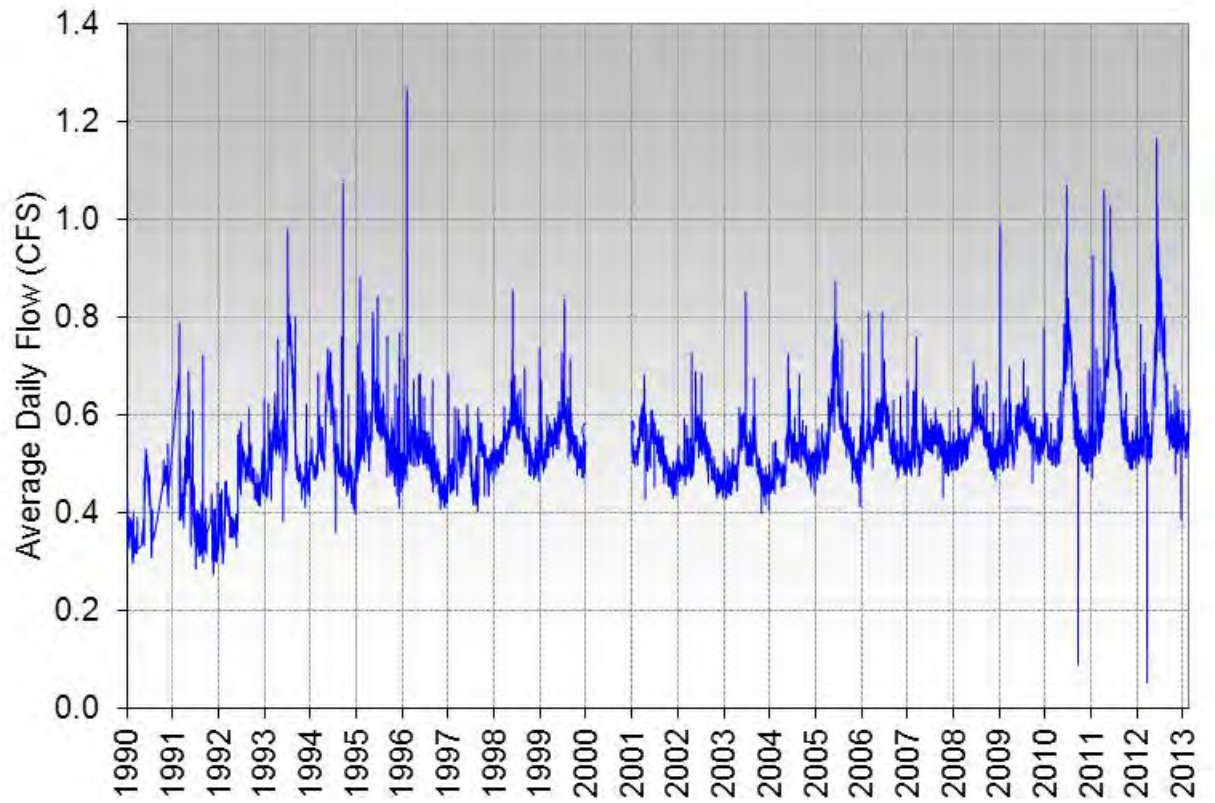
Source of data: Hugh Robertson, Columbia Falls WWTP, June 9, 2008 and February 21, 2013.
Note: avg. = average (arithmetic mean); BOD = biological oxygen demand; C = Celsius; cfs = cubic feet per second; max. = maximum; mg/L = milligrams per liter; min. = minimum; N = nitrogen; TKN = total Kjeldahl nitrogen; TSS = total suspended solids.

Table 12. Columbia Falls WWTP data summary - Data from ICIS

Constituent	Start date	End date	No. of Samples	Avg.	Min.	Max.
Ammonia (total as N) (mg/L)	6/18/2001	1/25/2013	140	3.96	0.02	29.1
CBOD, 5-day, 20 °C	6/18/2001	1/25/2013	140	2.87	2	6
Dissolved Oxygen	6/28/2010	1/25/2013	32	4.66	3.19	6.2
Flow rate (cfs)	6/18/2001	1/25/2013	140	0.317	0.207	0.574
Nitrogen (total) (mg/L)	6/28/2010	1/25/2013	32	11.3	4.39	50.8
NO_2+NO_3 (total as N) (mg/L)	6/18/2001	1/25/2013	140	3.44	0.1	14.8
Phosphorus (total) (mg/L)	6/18/2001	1/25/2013	140	0.365	0.024	1.68
TKN (total as N) (mg/L)	6/18/2001	1/25/2013	140	5	0.59	30.9
TSS (mg/L)	6/18/2001	1/25/2013	140	6.91	3	18.8

Source of data: ICIS (U.S. EPA 2013b).
Notes
DMR records from ICIS are monthly averages.
avg. = average (arithmetic mean); CBOD = carbonaceous biological oxygen demand; C = Celsius; cfs = cubic feet per second; max. = maximum; mg/L = milligrams per liter; min. = minimum; N = nitrogen; NO_2+NO_3 = nitrite plus nitrate; TKN = total Kjeldahl nitrogen; TSS = total suspended solids.

Figure 4 shows the average daily flows into the Columbia Falls WWTP between 2008 and 2013. Only influent flows were monitored before 2008; therefore, influent flow was used as a surrogate for effluent flow before 2008. Effluent flows ranged from 0 cfs to 1.15 cfs, and averaged 0.506 cfs. Influent flows ranged from 0.0513 cfs to 1.16 cfs, and averaged 0.427 cfs. A small increase in flows occurred between 1990 and 1995, and since then, flows appear to be increasing slightly.



Note: Influent flows from 1990 through 2007 were used as surrogates for effluent flows, which were not monitored during that time period.

Figure 4. Average daily flow at the Columbia Falls WWTP.

Total phosphorus loads have ranged from 0.007 lb/d to 26.47 lb/d and averaged 1.18 lb/d (Figure 5). Since 2001, gradually increasing loads have been observed in the facility effluent.

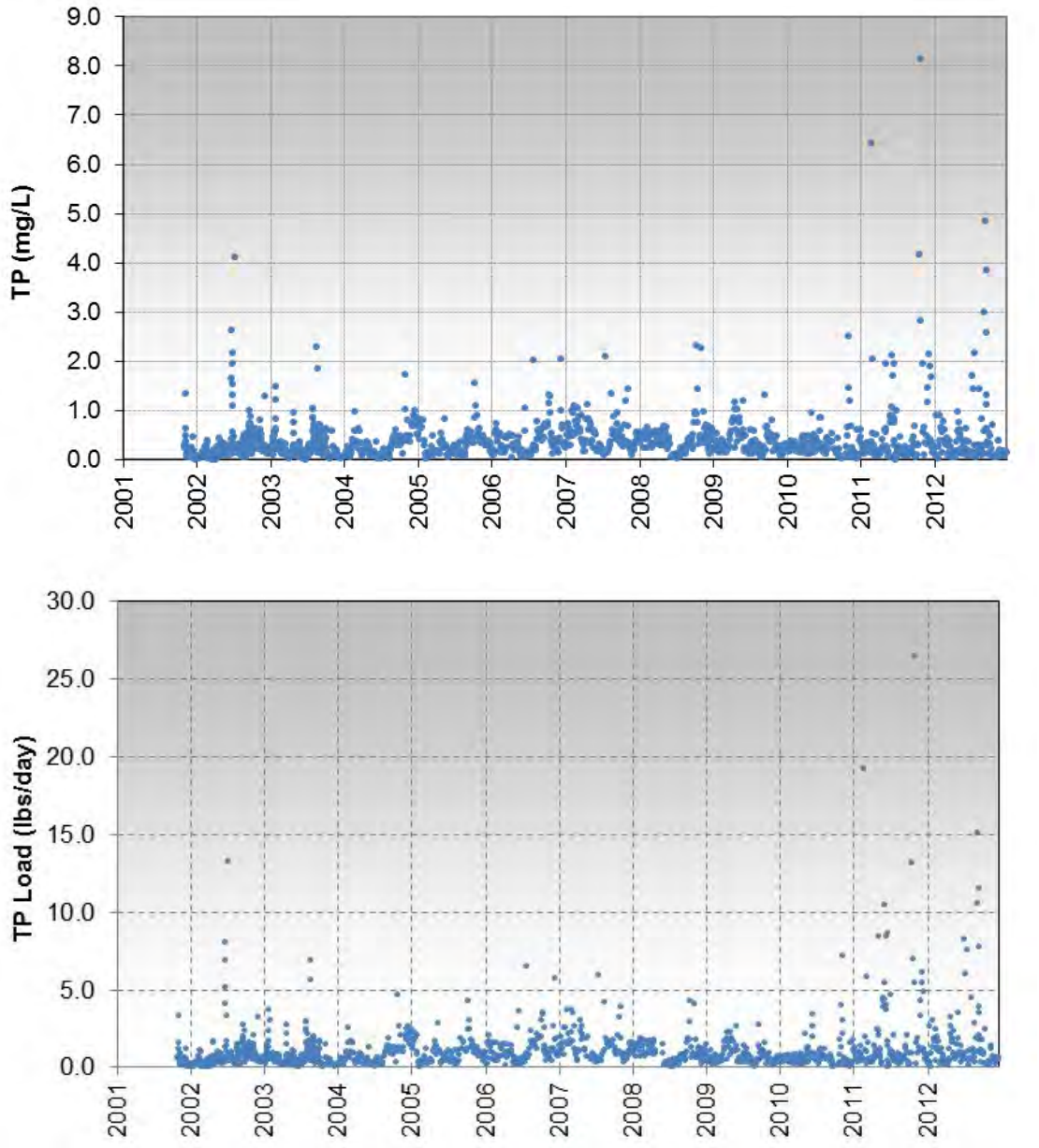


Figure 5. Total phosphorus at the Columbia Falls WWTP.

Typical of most lagoons, ammonia concentrations vary seasonally, and range from non-detect (recorded as "0" in the DMR records) to 43.6 mg/L with an average concentration of 5.1 (Figure 6). Ammonia loads have ranged from 0.03 lb/d to 129 lb/d and averaged 13.75 lb/d (ammonia concentrations reported as zero were excluded from the minimum and average calculations).

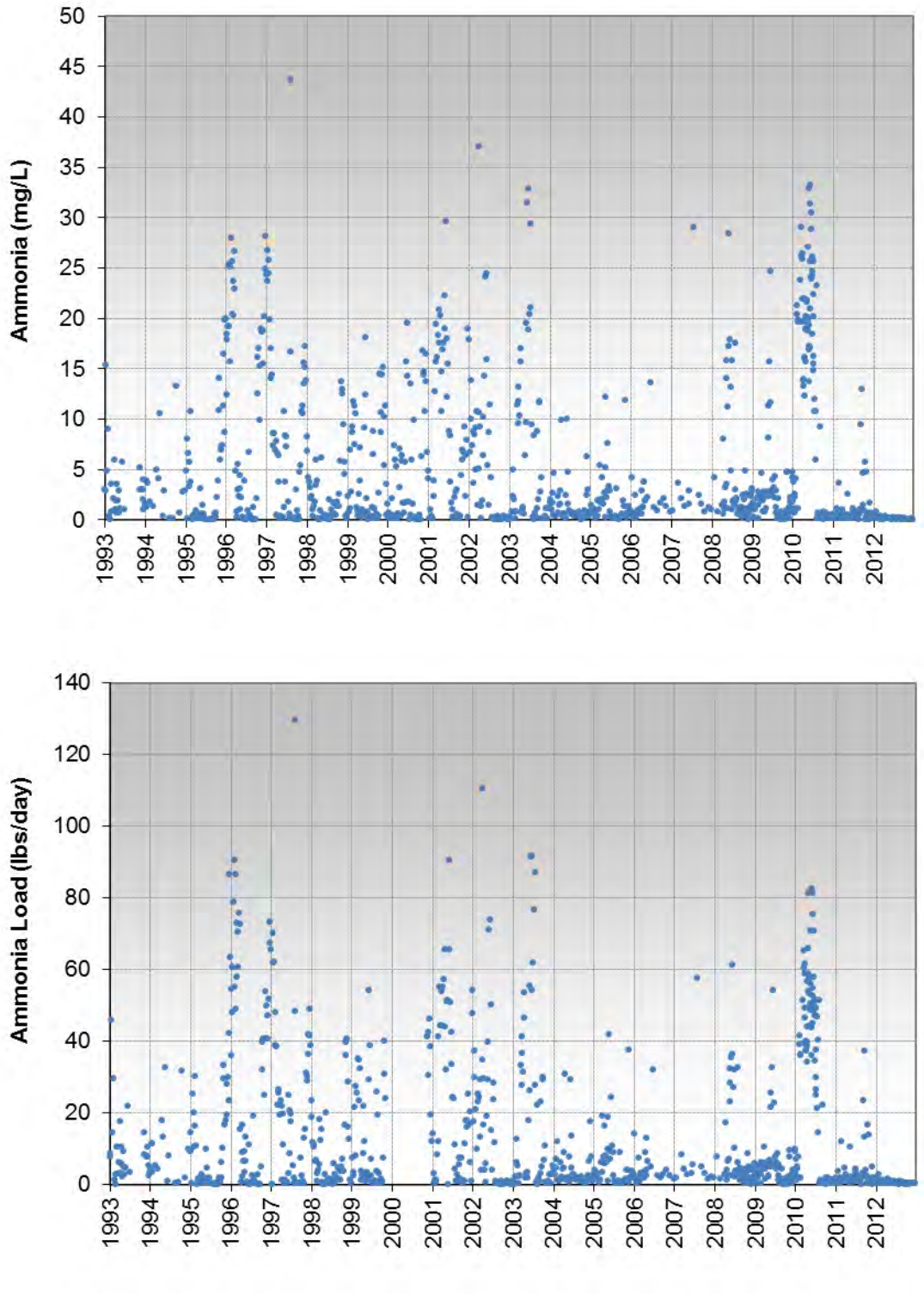


Figure 6. Ammonia at the Columbia Falls WWTP.

2.3 Whitefish WWTP (MT0020184)

The City of Whitefish operates a wastewater treatment facility composed of three partially mixed aerated lagoons that is near the Whitefish River just south of the city (Figure 7). The Whitefish WWTP serves the City of Whitefish and surrounding areas (Figure 8) and the WWTP serves 6,000 customers (FCCHD 2009). The City of Whitefish includes a considerable number of second and seasonal homes (FCCHD 2012). Under a 2002 agreement between the city of Whitefish and the Big Mountain Sewer District, which serves the Big Mountain Ski Resort, the Whitefish WWTP receives untreated wastewater from the Big Mountain Sewer District (FCCHD 2012).

The facility was built in 1960 and initially consisted of a series of facultative lagoons with an outfall to the Whitefish River.[8] Aeration was added to the lagoons in 1978, and phosphorus removal was added in 1987. After secondary treatment in the lagoons, a "flocculation clarifier further polishes the wastewater effluent, including the reduction of phosphorus" via alum (FCCHD 2009, p.7). In 2003, an upgrade to the aeration system provided for an increased design flow of 1.8 mgd.[9] In 2008 the WWTP began the process of upgrading the plant to construct headworks (mechanical screening) and add an additional phosphorus removal clarifier. Average daily flows are 0.75 mgd and the city of Whitefish has been repairing infrastructure and removing sum pump connections that may contribute to high peak flows (FCCHD 2012).

The Whitefish WWTP is permitted to discharge effluent to the Whitefish River from one outfall (#001) (DEQ 2007). The outfall consists of a pipe from the plant that discharges directly to the Whitefish River. The limits for the outfall are shown in Table 13. The permit also requires the pH of the effluent to remain between 6.0 and 9.0 standard units and there cannot be any visible foam, oil sheen, or floating solids in the effluent. The permit requires an 85 percent reduction in TSS and BOD_5 and for there to be no acute toxicity. Permit limits changed on July 1, 2011 to reflect winter and summer limits for *E. coli* as well as a new limit for total nitrogen.

[8] Greg Acton, Public Works Utilities Supervisor, City of Whitefish, personal communication, June 5, 2008.
[9] Ibid.

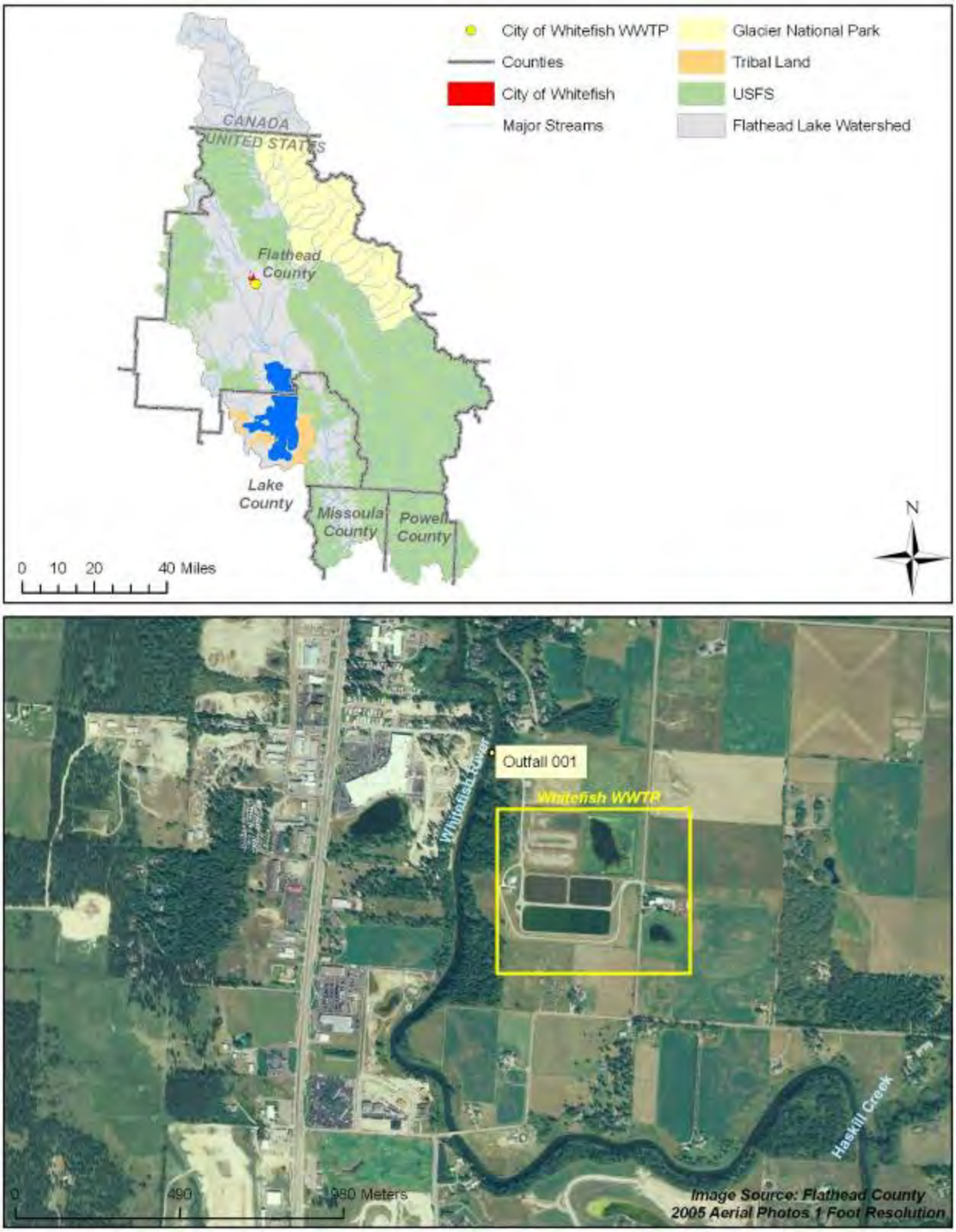


Figure 7. Whitefish WWTP permitted outfall.

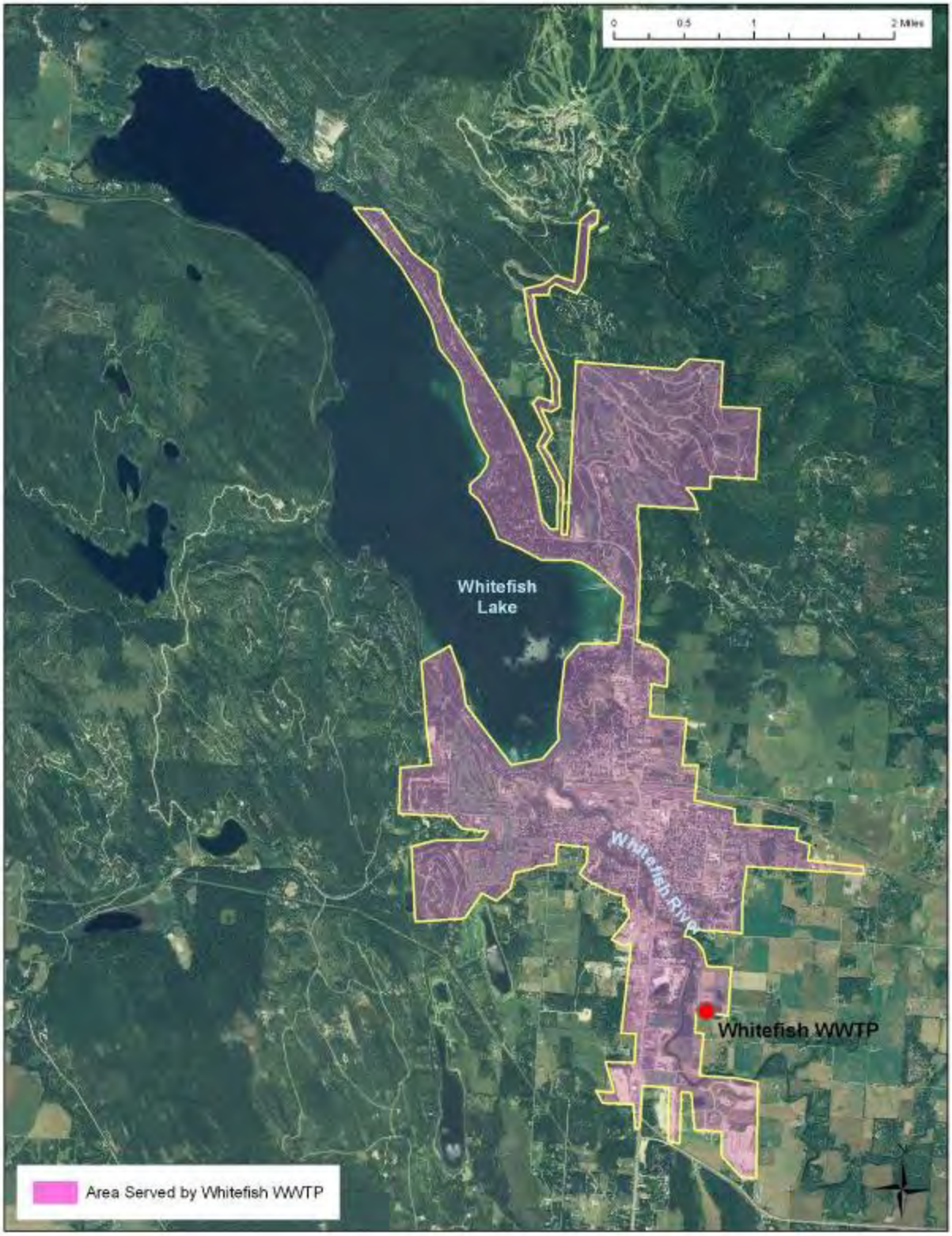


Figure 8. Whitefish WWTP service area.

Table 13. Whitefish WWTP final permit limits

Constituent	Units	Average monthly limit [a]	Average weekly limit [b]	Maximum daily limit
BOD_5	mg/L	30	45	--
	lb/d	255	382	--
Chlorine (total residual)	mg/L	0.011	--	0.019 L
E. Coli Bacteria, winter[c,d]	cfu/100 mL	630	--	1,260
E. Coli Bacteria, summer[c,d]	cfu/100 mL	126	--	252
Oil & Grease	mg/L	--	--	10
Total Phosphorus	mg/L	1.0	--	--
	lb/d	10.4		--
TSS	mg/L	30	45	--
	lb/d	313	469	--
Total Nitrogen[e]	lb/d	273	--	426

Source: DEQ 2007a
Notes
BOD_5 = five day biological oxygen demand; cfu/100 mL = colony forming units per 100 milliliters; lb/d = pounds per day; mg/L = milligrams per liter; TSS = total suspended solids.
a. The average of the daily sample result values collected during a single month must not exceed this limit.
b. The average of the daily sample results values collected during a single week must not exceed this limit.
c. Winter is November 1 through March 31: summer is April 1 through October 31.
d. Report geometric means if more than one sample is collected in the reporting period.
e. Calculated as the sum of Nitrate+Nitrite as N and Total Kjeldahl Nitrogen concentrations.

The facility is required to monitor the water quality of its effluent (outfall #001). Table 14, Table 14, and Table 15 summarize the available water quality data for outfall #001; data were obtained directly from the WWTP[10] and from ICIS (U.S. EPA 2013b). Data provided by the facility are summarized herein; data from ICIS may be used to supplement facility data during model development. The average effluent flow from this period (1981-2008) was 1.24 cfs, with an average total phosphorus concentration of 0.772 mg/L and an average total nitrogen concentration of 36.4 mg/L.

The Whitefish WWTP also has a permit (MTG650059) to store and treat sewage sludge onsite; no land application occurs.[11]

[10] Records provided as a series of Excel spreadsheets for 1984 through 2008 from Greg Acton on June 4, 2008. Records for 2009 through 2012 provided by Greg Acton on February 12, 2013.
[11] Greg Acton, Public Works Utilities Supervisor, City of Whitefish, personal communication, August 14, 2008.

Table 14. Whitefish WWTP data summary - Influent data from Whitefish WWTP

Constituent	Start date	End date	No. of records	Avg.	Min.	Max.
Ammonia (total as N) (mg/L)	12/6/2011	12/27/2012	52	23	6	45
BOD, 5-day, 20 °C	7/1/2008	12/28/2012	699	254	9	689
NO_2+NO_3 (total as N) (mg/L)	6/26/2012	10/2/2012	5	0.24	0.01	0.60
TKN (total as N) (mg/L)	11/20/2012	12/27/2012	5	40.8	33.6	47.8
TSS (mg/L)	7/1/2008	12/28/2012	700	211	26	1,150

Source of data: Greg Acton, Public Works Utilities Supervisor, City of Whitefish, February 12, 2013.
Note: avg. = average (arithmetic mean); BOD = biological oxygen demand; max. = maximum; mg/L = milligrams per liter; min. = minimum; N = nitrogen; NO_2+NO_3 = nitrite plus nitrate; TKN = total Kjeldahl nitrogen; TSS = total suspended solids.

Table 15. Whitefish WWTP data summary - Effluent data from Whitefish WWTP

Constituent	Start date	End date	No. of records	Avg.	Min.	Max.
Ammonia (total as N) (mg/L)	1/1/1984	12/26/2012	551	16.8	0	36
BOD, 5-day, 20 °C	1/1/1984	12/26/2012	474	7.82	2	37
Dissolved Oxygen	1/1/2008	12/25/2012	255	6.07	0.22	13.3
Flow rate (cfs)	1/1/1981	12/1/2008	300	1.24	0	3.12
Nitrogen (total) (mg/L)	1/1/1992	12/26/2012	433	36.4	0	4,930
NO_2+NO_3 (total as N) (mg/L)	5/1/1992	12/26/2012	409	16.2	0	4,900
Orthophosphate (as P) (mg/L)	5/4/2010	12/25/2012	123	0.346	0.12	1.76
Phosphorus (total) (mg/L)	1/1/1984	12/26/2012	498	0.772	0.1	7.4
Temperature (°C)	7/2/2008	12/25/2012	251	10.5	0.1	24
TKN (total as N) (mg/L)	5/1/1992	12/26/2012	410	22	0	1160
TSS (mg/L)	1/1/1984	12/26/2012	475	12.3	0.5	100

Source of data: Greg Acton, Public Works Utilities Supervisor, City of Whitefish, June 4, 2008 and February 12, 2013.
Note: avg. = average (arithmetic mean); BOD = biological oxygen demand; C = Celsius; cfs = cubic feet per second; max. = maximum; mg/L = milligrams per liter; min. = minimum; N = nitrogen; NO_2+NO_3 = nitrite plus nitrate; P = phosphorus; TKN = total Kjeldahl nitrogen; TSS = total suspended solids.

Table 16. Whitefish WWTP data summary - Data from ICIS

Constituent	Start date	End date	No. of records	Avg.	Min.	Max.
Ammonia (total as N) (mg/L)	7/29/1996	1/18/2013	197	16.3	0.13	36
BOD, 5-day, 20 °C	7/29/1996	1/18/2013	197	8.26	2	28
Conduit Flow (cfs)	7/29/1996	1/18/2013	199	1.35	0.345	3.2
Nitrogen (total) (mg/L)	7/29/1996	1/18/2013	197	22.3	0.15	38
NO_2+NO_3 (total as N) (mg/L)	7/29/1996	1/18/2013	197	3.58	0.005	24.7
Phosphorus (total) (mg/L)	7/29/1996	1/18/2013	198	0.473	0.16	1.69
Temperature (°C)	8/27/2008	1/18/2013	54	10.4	0.1	23.3
TKN (total as N) (mg/L)	7/29/1996	1/18/2013	197	18.8	1.19	37.9
TSS (mg/L)	7/29/1996	1/18/2013	197	11.4	4	46

Source of data: ICIS (U.S. EPA 2013b).
Notes
DMR records from ICIS are monthly averages.
avg. = average (arithmetic mean); BOD = biological oxygen demand; C = Celsius; cfs = cubic feet per second; max. = maximum; mg/L = milligrams per liter; min. = minimum; N = nitrogen; NO_2+NO_3 = nitrite plus nitrate; P = phosphorus; TKN = total Kjeldahl nitrogen; TSS = total suspended solids.

Figure 9 shows the average daily effluent flow from January 1981 through December 2013. Flows have increased slightly over time, with an average flow of 1.0 cfs in 1981, an average flow of 1.3 cfs in 2007, and an average flow of 1.5 cfs in 2012.

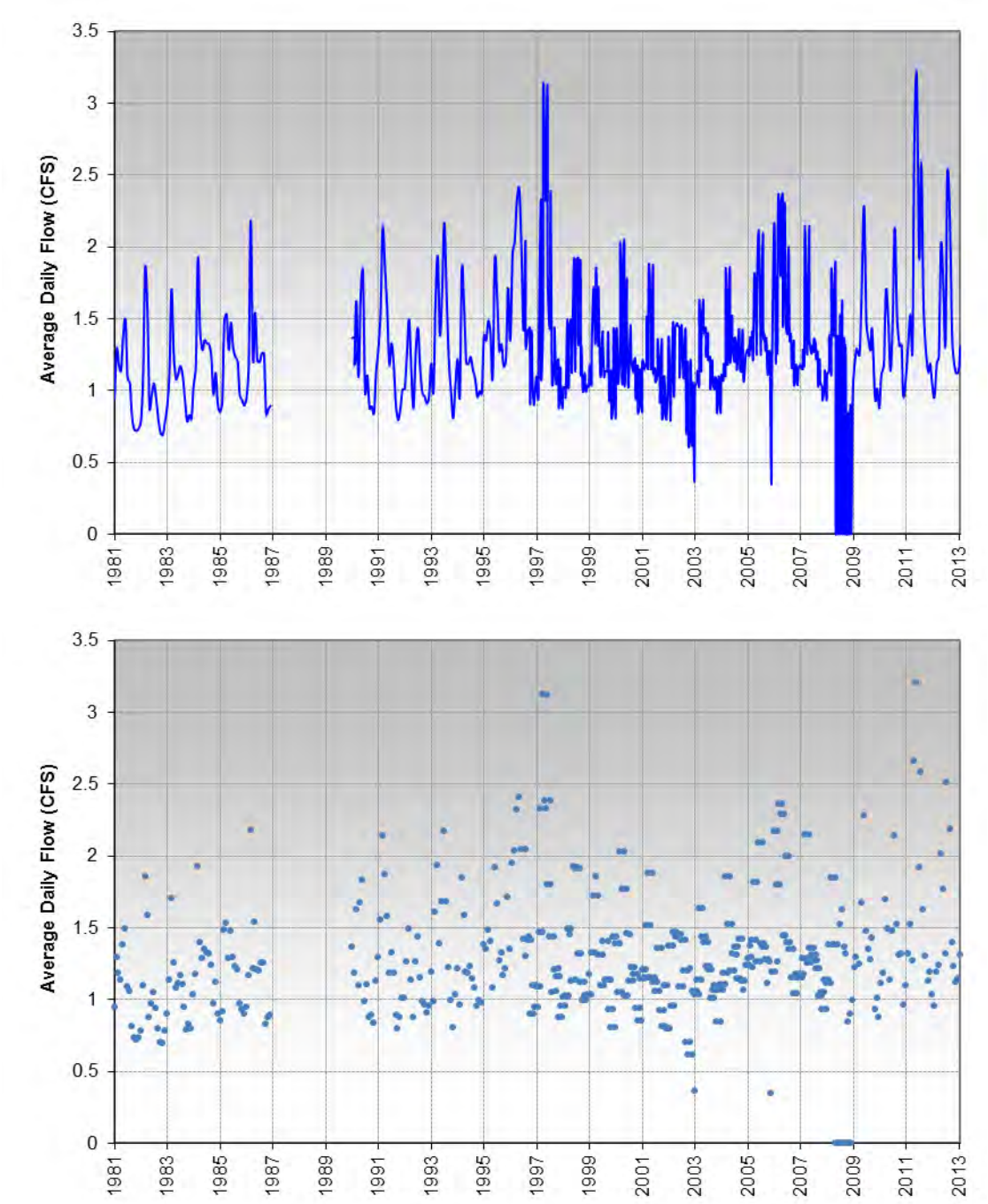


Figure 9. Average daily flow from the city of Whitefish WWTP.

Prior to 1986 plant upgrades, total phosphorus concentrations were much higher than current levels, and ranged from 3.1 to 7.4 mg/L (Figure 10). Since 1990, after the addition of phosphorus removal, the effluent total phosphorus concentrations have ranged from 0.1 mg/L to 4.79 mg/L with an average concentration of 0.50 mg/L (Figure 10). Total phosphorus loads since 1990 ranged from 0.69 lb/d to 59.7 lb/d and averaged 3.7 lb/d. The reduction in total phosphorus loads following the installation of phosphorus removal was approximately 90 percent. Since 1990, it appears that the total phosphorus loads, on average, have remained relatively constant.

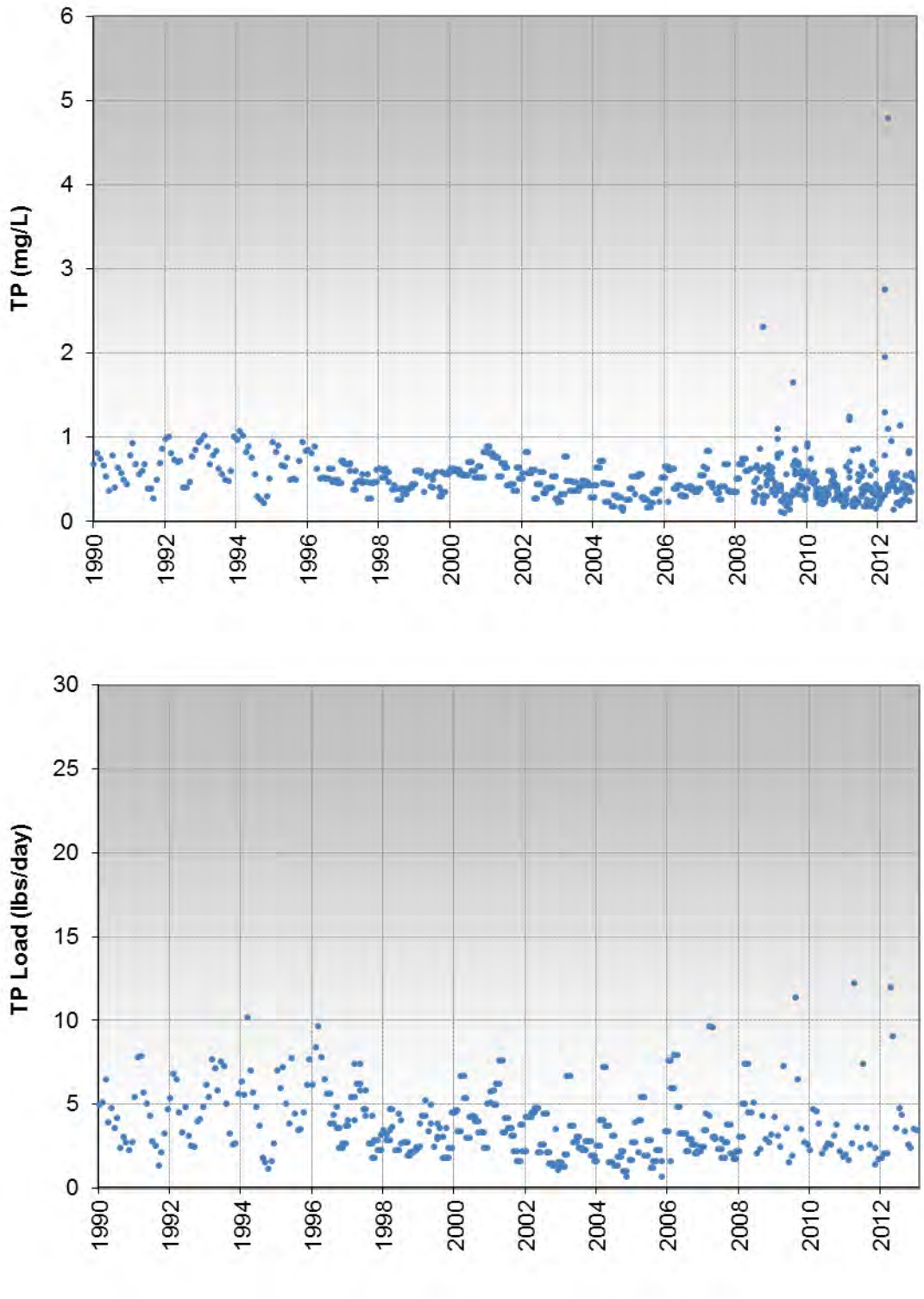
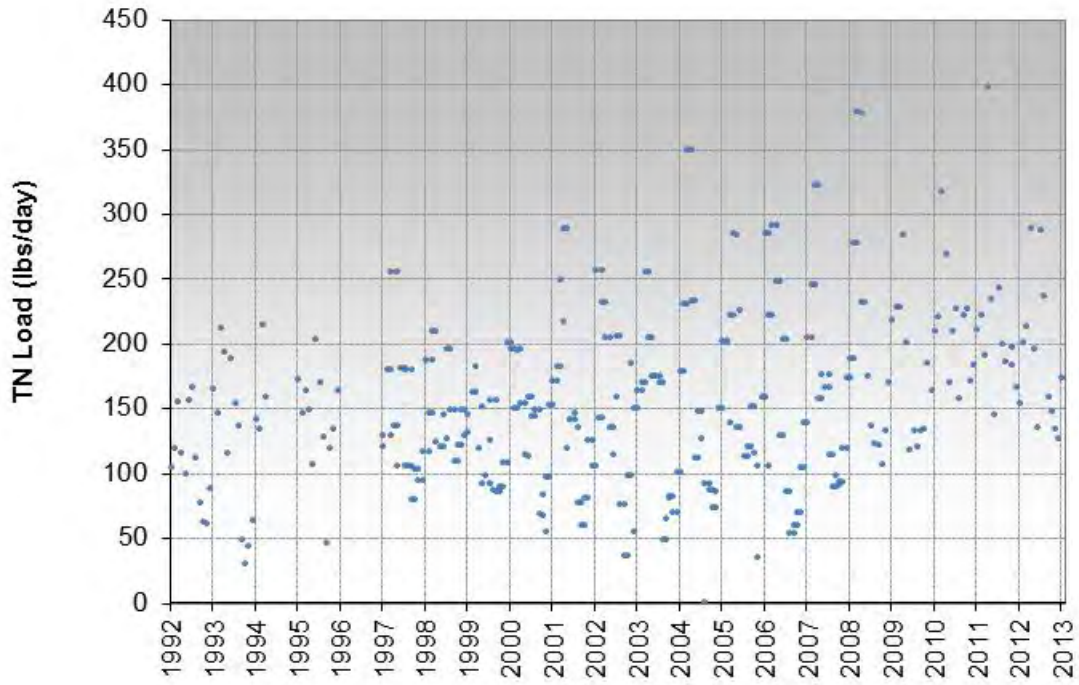


Figure 10. Total phosphorus at the Whitefish WWTP.

Nitrogen concentrations and loads appear to slightly increase between 1992 and 2013 (Figure 11), although the cause of this increase is unknown. Typical of most lagoon treatment systems, concentrations fluctuate seasonally and range from 0.15 mg/L to 38.87 mg/L.



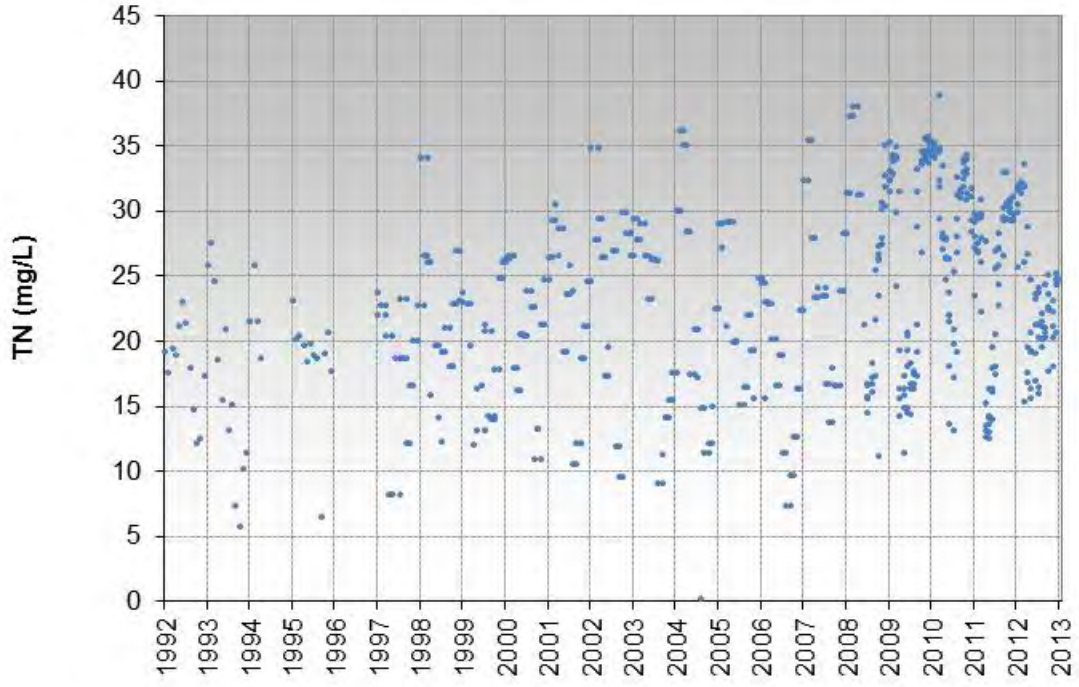


Figure 11. Total nitrogen at the Whitefish WWTP.[12]

[12] Data from 1996 are not displayed in the charts, as there appears to have been a plant upset with concentrations exceeding 1,000 mg/L for two months.

2.4 Bigfork Water and Sewer District WWTF (MT0020397)

The Bigfork Water and Sewer District operates a wastewater treatment facility (WWTF) that is near the confluence of the Swan River and Flathead Lake (Figure 12). The Bigfork Water and Sewer District WWTF serves the unincorporated community of Bigfork (refer to Figure 13) and includes 13 lift stations and approximately 1, 200 connections[13]. Bigfork is a summer recreational area with one-third of the housing units identified as seasonal, recreational, or occasional use (FCCHD 2012).

The original facility was constructed in 1965. A new facility was constructed in 1987 and consists of a tertiary advanced wastewater treatment system with a synthetic media filter, chemical precipitation for phosphorus removal, and ultraviolet disinfection.[14] The current design flow is 0.50 mgd, but the average flow was approximately 0.215 mgd in 2012[15]. In 2012, this facility installed improvements, including a new headworks building, and a membrane bioreactor system, described as follows:

> The Membrane Bioreactor system consists of biological treatment of carbonaceous material and nitrogen using activated sludge, chemical treatment for phosphorus, and membrane filtration to separate the solids from the liquid producing a very high quality effluent. The membranes have a nominal pore size of 0.4-microns allowing the effluent to consistently achieve turbidity within drinking water standards of 0.3 NTU or less. The Effluent is treated with Ultraviolet Disinfection prior to discharge.[16]

The WWTF is permitted to discharge effluent to Flathead Lake from one outfall (#001) (DEQ 2001). The most recent MPDES permit limits for the outfall are shown in Table 16. Additionally, the permit also requires the pH of the effluent to remain between 6.0 and 9.0 standard units and there cannot be any visible foam, oil sheen, or floating solids in the effluent. The permit also requires an 85 percent reduction in TSS and BOD_5 and for there to be no acute toxicity. The concentration of oil and grease cannot exceed 15 mg/L in any individual sample.

[13] Julie Spencer, operator, Bigfork Water and Sewer District, personal communication, June 14, 2013.
[14] Julie Spencer, operator, Bigfork Water and Sewer District, personal communication, May 21, 2008.
[15] Julie Spencer, operator, Bigfork Water and Sewer District, personal communication, June 14, 2013.
[16] Julie Spencer, operator, Bigfork Water and Sewer District, personal communication, June 14, 2013.

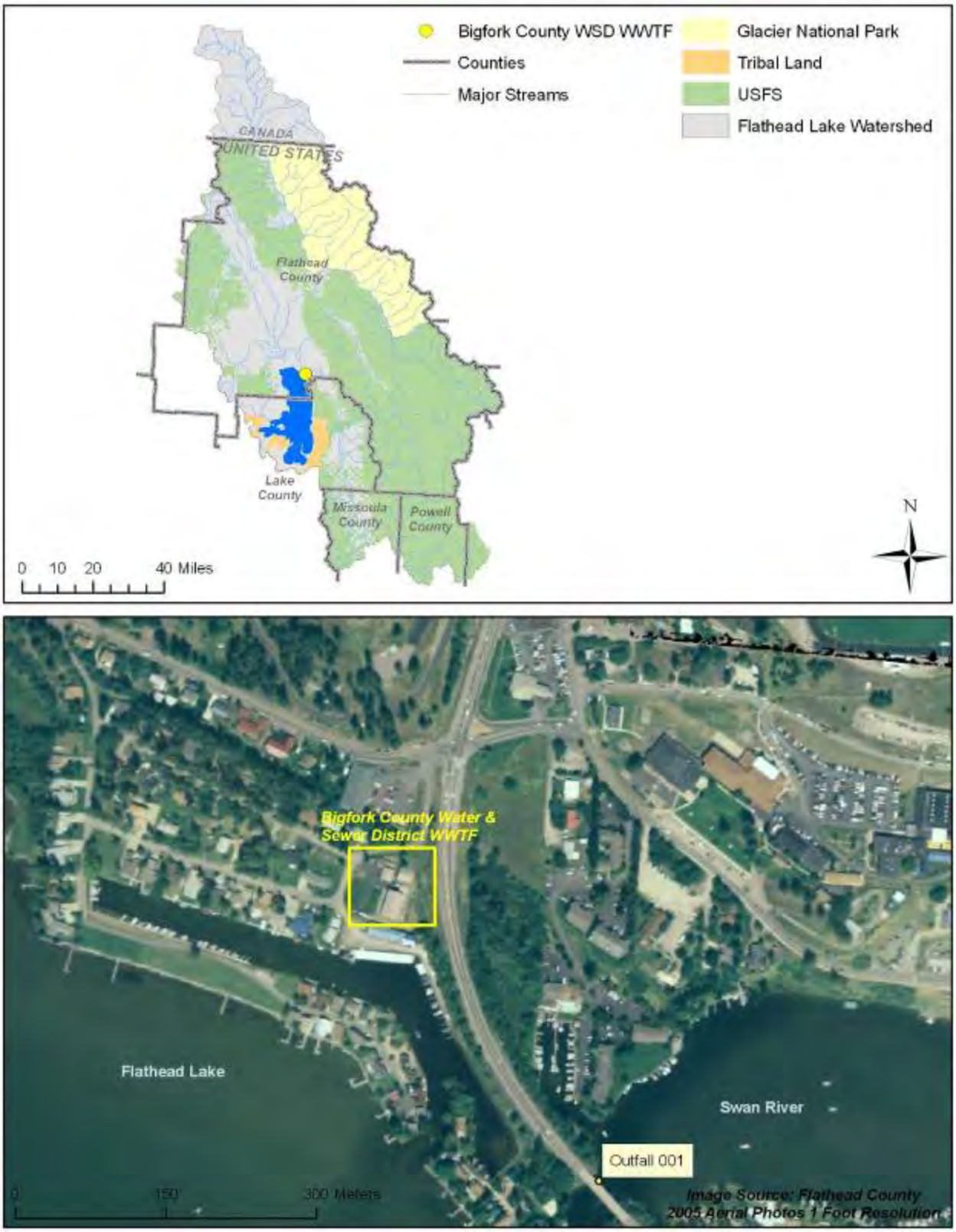


Figure 12. Bigfork Water and Sewer District WWTF permitted outfall.

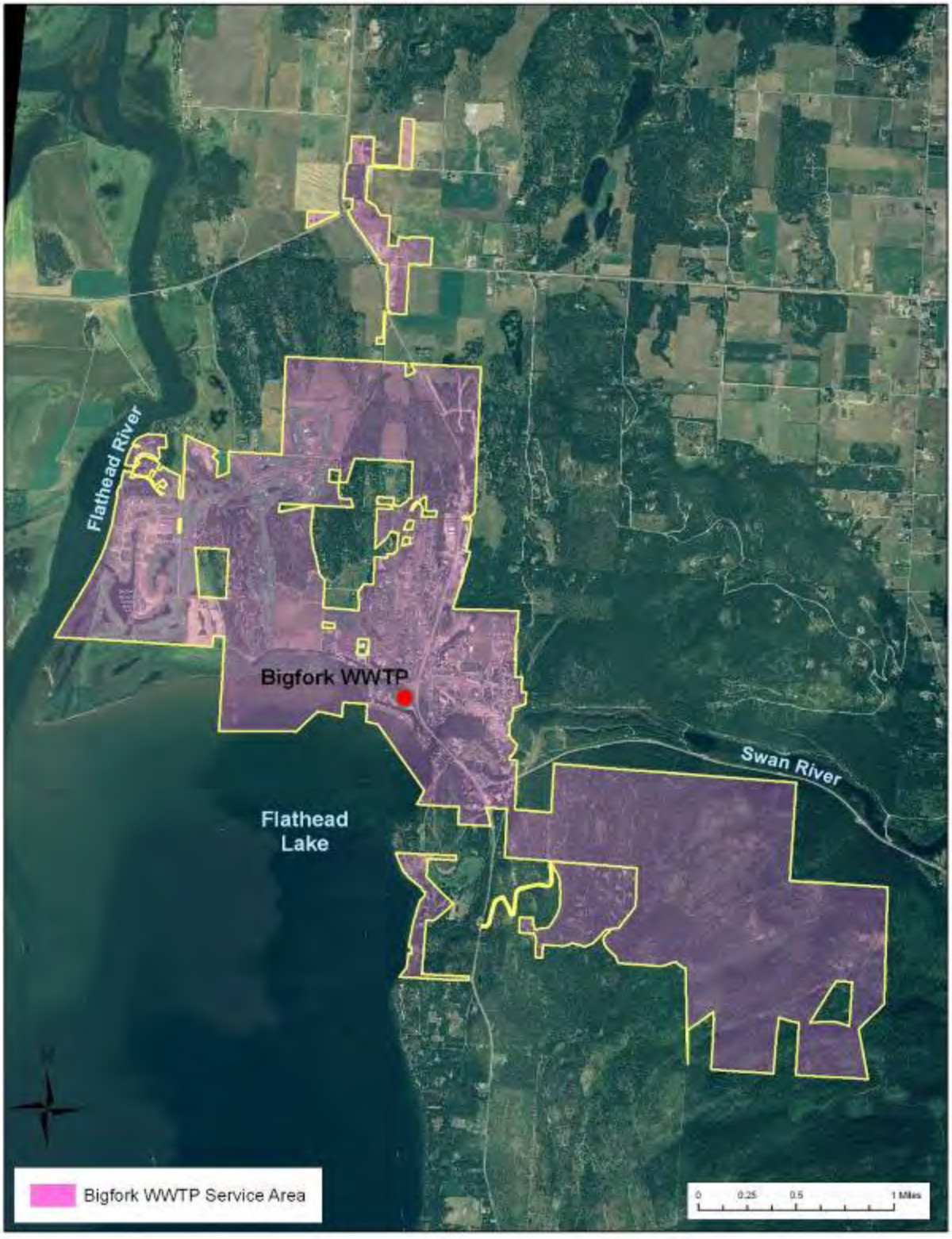


Figure 13. Bigfork Water and Sewer District WWTF service area.

Table 17. Bigfork Water and Sewer District WWTF permit limits

Constituent	Units	Concentration	
		7-day average	30-day average
$CBOD_5$	mg/L	45	30
TSS	mg/L	45	30
Total Phosphorus	mg/L	--	1.0
Fecal Coliform bacteria [a]	cfu/100mL	100	50

Source: DEQ 2001b
Notes
$CBOD_5$ = five-day carbonaceous biological oxygen demand; cfu/100mL = colony forming unit per 100 milliliters; mg/L = milligrams per liter; TSS = total suspended solids.
a. The fecal coliform bacteria limits apply from the period beginning April 1 and ending October 31.

Table 17 and Table 18 summarize the available water quality data for outfall #001; data were obtained directly from the WWTF[17] and from ICIS (U.S. EPA 2013b). Data provided by the WWTF are summarized herein; ICIS data (summarized in Table 18) may be used to supplement facility data during model development. The average effluent flow from 1993-2013 was 0.342 cfs, with an average total phosphorus concentration of 0.242 mg/L and an average total nitrogen concentration of 15.7 mg/L.

The Bigfork Water and Sewer District also has a permit (MTG650020) to land apply sewage sludge. The sludge is moved to an off-site sludge storage facility during the months of March to November and is eventually disposed of via subsurface injections (FCCHD 2009). Since 1997, the sludge has been injected to 317 acres of farmland at 384 Farm Road in Somers, Montana (Figure 14).[18]

Table 18. Bigfork Water and Sewer District WWTF data summary - Data from Bigfork Water and Sewer District WWTF

Constituent	Start date	End date	No. of records	Avg.	Min.	Max.
Ammonia (total as N) (mg/L)	11/1/1995	1/31/2013	240	0.326	0	6.72
Ammonia (total as N) (mg/L) (lab)	8/5/2010	1/3/2013	32	0.666	0.02	3.16
BOD, 5-day, 20 °C	3/4/2010	1/24/2013	272	40.2	1	540
BOD, 5-day, 20 °C (BFWS)	3/1/2012	1/31/2013	140	0.726	0.1	2.3
Dissolved Oxygen	8/5/2010	1/31/2013	129	7.49	5.16	8.86
Flow rate (cfs)	1/1/1993	1/31/2013	2,927	0.342	0.0928	0.823
Nitrogen (total) (mg/L)	3/1/1993	1/29/2013	254	15.7	0	33.2
NO_2+NO_3 (total as N) (mg/L)	11/1/1995	1/29/2013	241	15.2	0.25	28.7
Phosphorus (total) (mg/L)	1/1/1993	1/31/2013	329	0.242	0.01	1.43
Temperature (°C)	6/1/2008	1/31/2013	1,704	16.5	10.3	23
TKN (total as N) (mg/L)	11/1/1995	1/29/2013	232	1.21	0	18.1
TSS (mg/L)	3/4/2010	1/31/2013	413	1.75	0.05	7.8

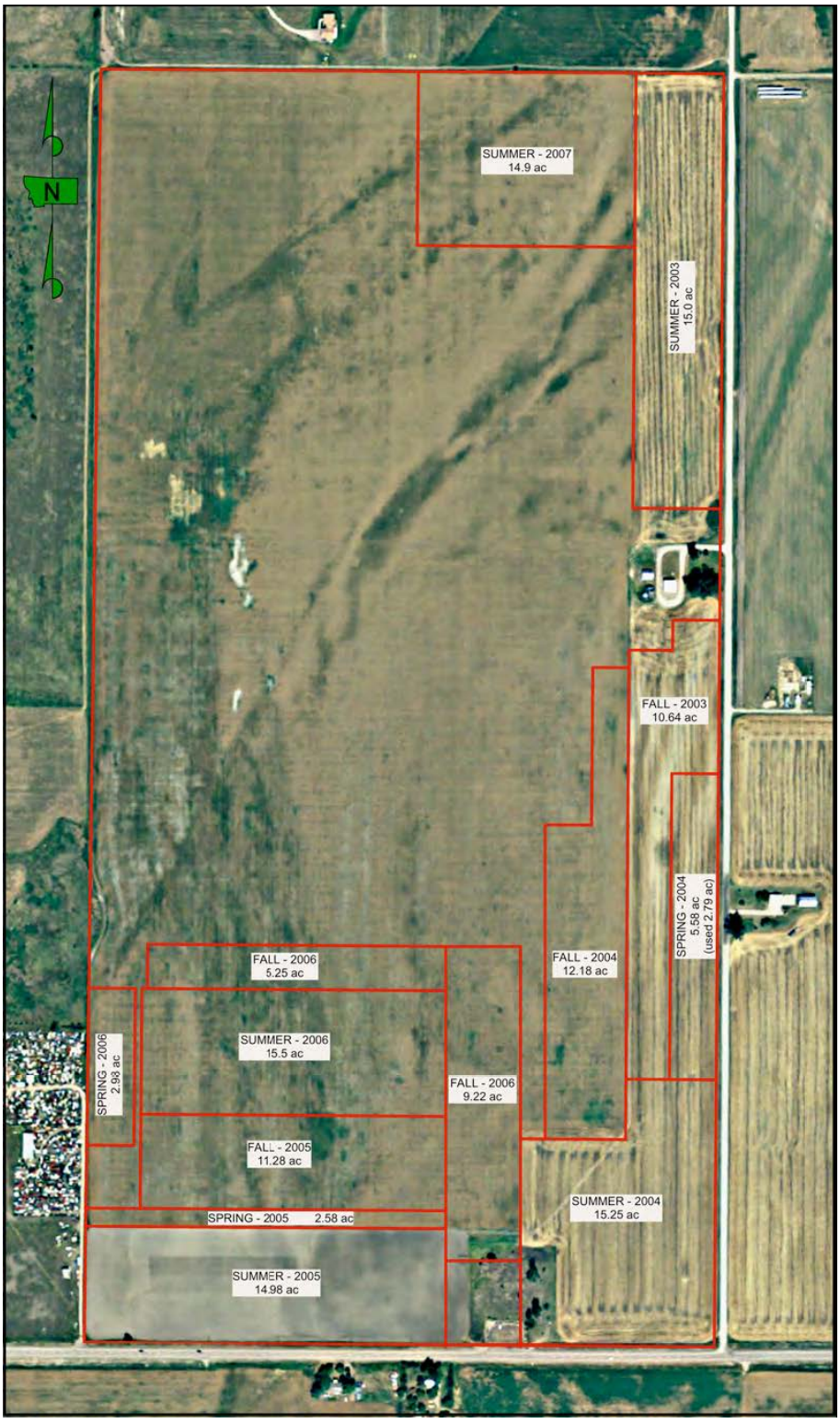
Source of data: Julie Spencer, operator, Bigfork Water and Sewer District, personal communication, February 21, 2013.
Note: avg. = average (arithmetic mean); BOD = biological oxygen demand; C = Celsius; cfs = cubic feet per second; max. = maximum; mg/L = milligrams per liter; min. = minimum; N = nitrogen; NO_2+NO_3 = nitrite plus nitrate; P = phosphorus; TKN = total Kjeldahl nitrogen; TSS = total suspended solids.

[17] Records provided in Excel spreadsheets from Julie Spencer on February 21, 2013.
[18] Julie Spencer, operator, Bigfork Water and Sewer District, personal communication, August 14, 2008.

Table 19. Bigfork Water and Sewer District WWTF data summary - Data from ICIS

Constituent	Start date	End date	No. of records	Avg.	Min.	Max.
Ammonia (total as N) (mg/L)	9/6/2001	1/11/2013	81	0.37	0	3.16
BOD, 5-day, 20 °C	9/6/2001	1/11/2013	137	1.8	0.23	22
Dissolved Oxygen	9/8/2010	1/11/2013	29	7.45	5.69	8.6
Flow rate (cfs)	9/6/2001	1/11/2013	138	0.21	0.11	0.38
Nitrogen (total) (mg/L)	1/4/2001	1/11/2013	80	17.8	6.44	28
NO_2+NO_3 (total as N) (mg/L)	9/6/2001	1/11/2013	80	16.7	5.5	27
Phosphorus (total) (mg/L)	9/6/2001	1/11/2013	137	0.205	0.04	0.84
TKN (total as N) (mg/L)	9/6/2001	1/11/2013	77	0.98	0.11	6.44
TSS (mg/L)	9/6/2001	1/11/2013	137	3.18	0.1	23

Source of data: ISIS (U.S. EPA 2013b)
Notes
DMR records from ICIS are monthly averages.
avg. = average (arithmetic mean); BOD = biological oxygen demand; C = Celsius; cfs = cubic feet per second; max. = maximum; mg/L = milligrams per liter; min. = minimum; N = nitrogen; NO_2+NO_3 = nitrite plus nitrate; P = phosphorus; TKN = total Kjeldahl nitrogen; TSS = total suspended solids.



Source: Julie Spencer, operator, Bigfork County Water and Sewer District WWTF

Figure 14. Bigfork Water and Sewer District WWTF sludge injection sites.

From 1993 through 2004 flow at the plant was only reported on the first of the month; flows ranged from 0.11 cfs to 0.51 cfs and averaged 0.27 cfs (Figure 15). Since 2004, flows have been reported daily; they ranged from 0.09 cfs to 0.82cfs and averaged 0.34 cfs. There appears to be a slight increase in flows from 1993 to 2013.

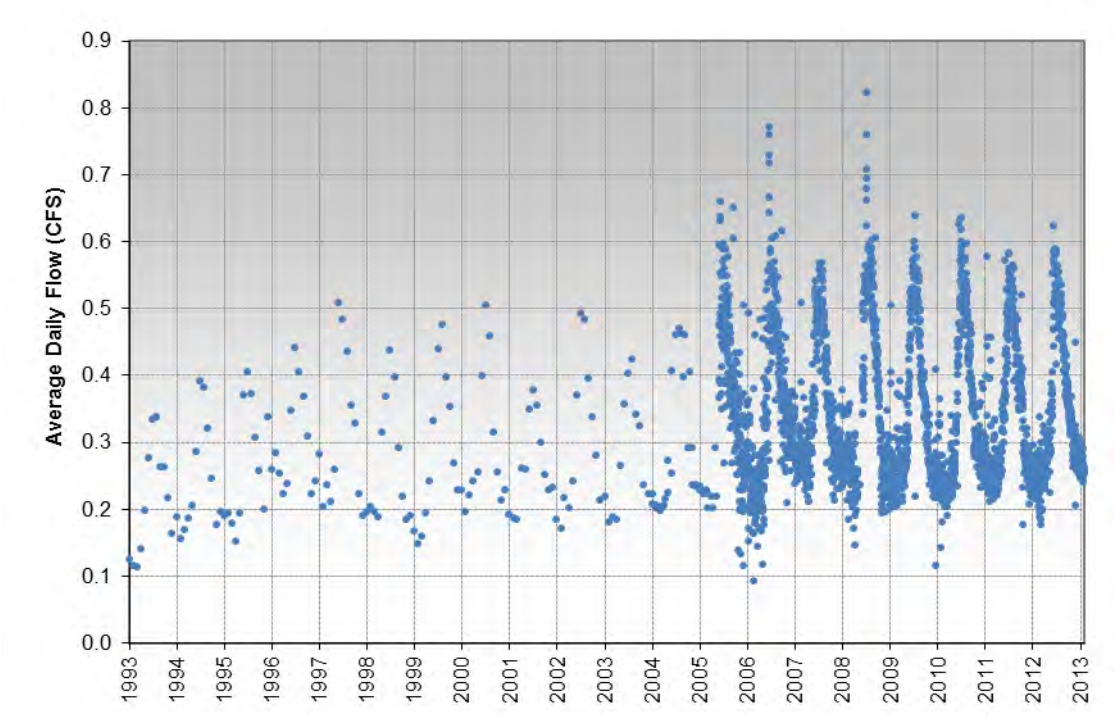


Figure 15. Average daily flow from the Bigfork Water and Sewer District WWTF.

Concentration and load varied over the period of record (1993-2013), and do not show any apparent temporal trends, though data from 2012 include several higher concentrations (Figure 16). Total phosphorus loads ranged from 0.02 lb/d to 2.31 lb/day and averaged 0.39 lb/day.

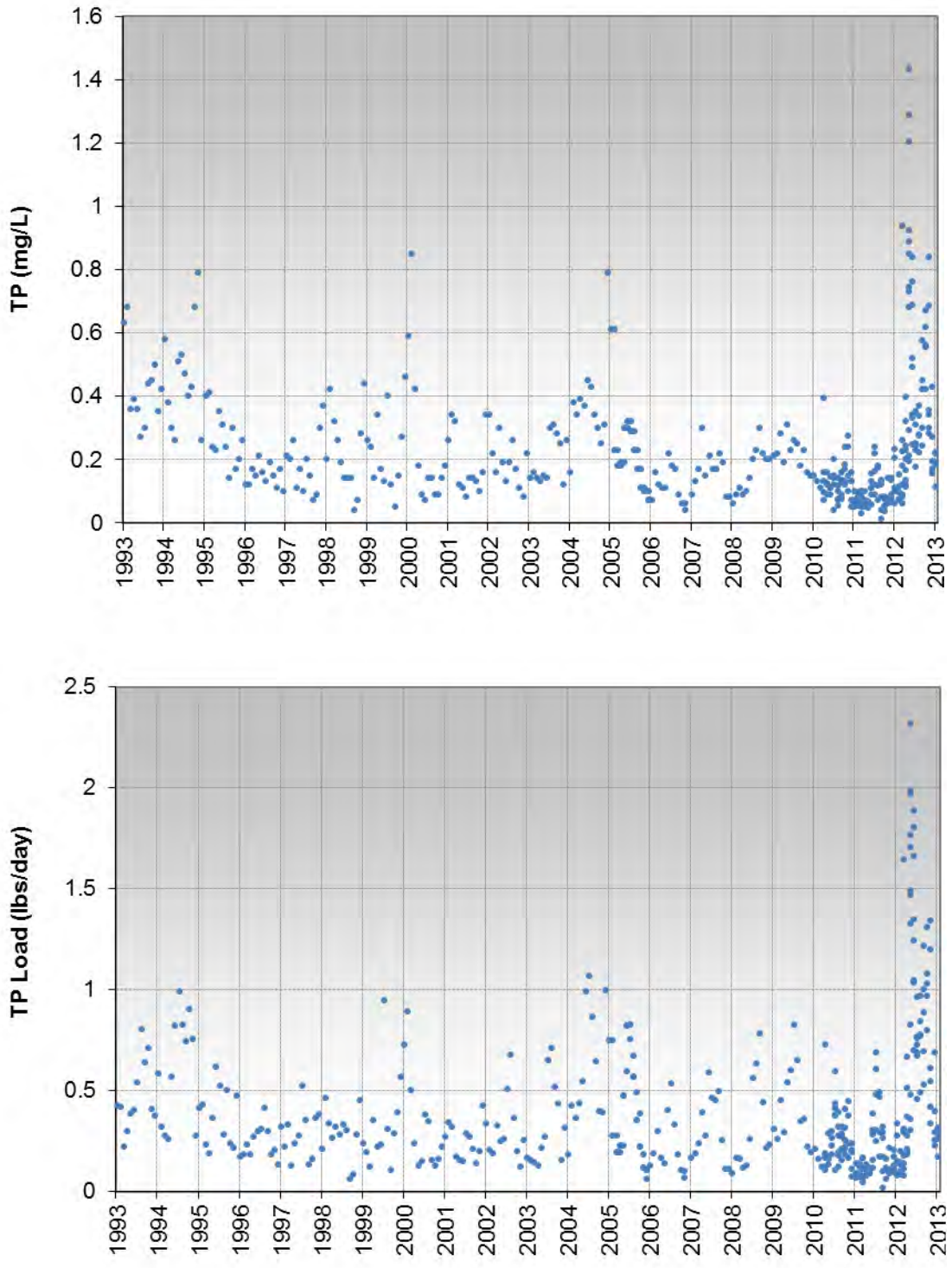


Figure 16. Total phosphorus from the Bigfork Water and Sewer District WWTF.

Figure 17 shows the total nitrogen concentrations and loads from 1995 through 2012. There appears to be a slight increasing trend in total nitrogen loads from 1995 to 2010, which is likely due to the slight increase in flow observed in the effluent; loads decreased from 2010 levels in 2011-2013. The range of concentrations has remained relatively stable over the period of record with a slight decrease in recent years.

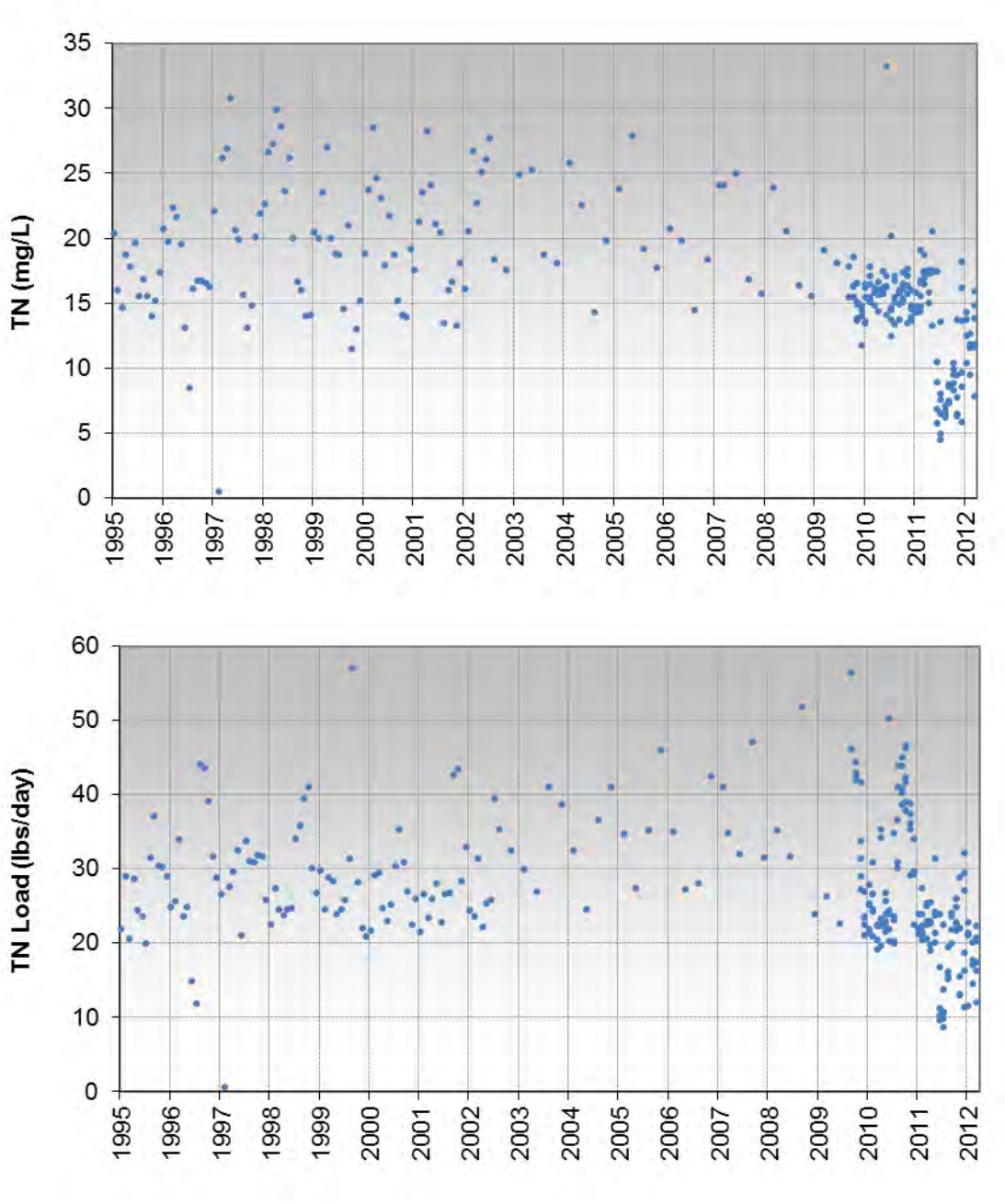


Figure 17. Total nitrogen from the Bigfork Water and Sewer District WWTF.

2.5 Polson WWTP (MT0020559)

The City of Polson operates a wastewater treatment facility that is at the south end of Flathead Lake near the Flathead River (Figure 18). It serves the city of Polson and the surrounding area and serves a population of approximately 5,000 people.

When originally built, the facility consisted of a 2-cell lagoon treatment system.[19] The WWTP was upgraded to a 4-cell lagoon system in 1981, and the aeration system was upgraded in 2001. Currently, the tapered multi-call aerated lagoon systems is composed of three aeration lagoons and one polishing lagoon (FCCHD 2012); the design flow of the system is 0.650 mgd.

The WWTP is permitted to discharge effluent to the Flathead River from one outfall (#001) (U.S. EPA 2007b). The outfall is on the Flathead River between Flathead Lake and Kerr Dam. The most recent MPDES permit limits for the outfall are shown in Table 19. Additionally, the permit also requires the pH of the effluent to remain between 6.0 and 9.0 standard units and states that there shall be no discharge of floating solids or visible foam in other than trace amounts, nor shall there be a discharge which causes a visible sheen in the receiving waters. The permit requires that the concentration of oil and grease, from any single sample, should not exceed 10 mg/L.

[19] Ash Walker, Assistant Water and Sewer Superintendent, City of Polson, personal communication, August 14, 2008.

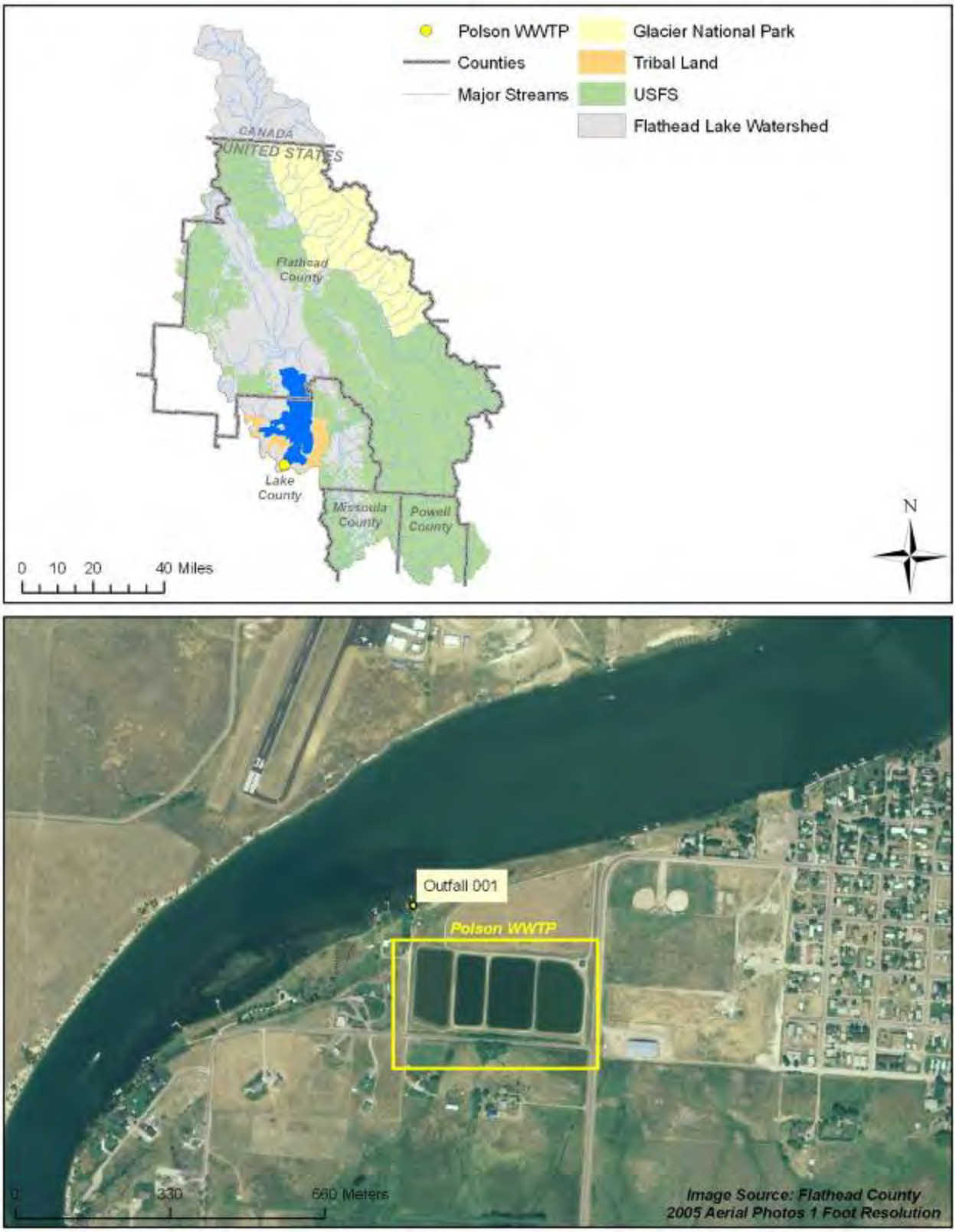


Figure 18. Polson WWTP permitted outfall.

Table 20. Polson WWTP permit limits

Constituent	Units	30-day average	7-day average
BOD_5	mg/L	30	45
E. coli [a]	cfu/100mL	126	252
Flow	mgd	0.650	--
TSS	mg/L	100	135

Source: U.S. EPA 2013
Notes
BOD_5 = five-day biological oxygen demand; cfu/100mL = colony forming units per 100 milliliters; mgd = million gallons per day; mg/L = milligrams per liter; TSS = total suspended solids.
a. The *E. coli* limits apply year round.

Table 20 and Table 21 summarize the available water quality data from outfall #001; data were obtained directly from the city of Polson (2000-2008) and from ICIS (U.S. EPA 2013b). The average effluent flow from ICIS during 2001 to 2013 was 0.751 cfs.

Table 21. Polson WWTP data summary - Data from Polson WWTP

Constituent	Start date	End date	No. of records	Avg.	Min.	Max.
Ammonia (total as N) (mg/L)	3/31/2000	6/30/2006	66	11.6	0.02	32.7
Nitrate (total as N) (mg/L)	3/31/2000	6/30/2006	52	3.25	0.07	10.3

Source of data: Ash Walker, Assistant Water and Sewer Superintendent, City of Polson, August 14, 2008.
Note: avg. = average (arithmetic mean); max. = maximum; mg/L = milligrams per liter; min. = minimum; N = nitrogen.

Table 22. Polson WWTP data summary - Data from ICIS

Constituent	Start date	End date	No. of records	Avg.	Min.	Max.
Ammonia (total as N) (mg/L)	3/13/2001	10/23/2008	61	11.7	0.02	32.7
BOD, 5-day, 20 °C	3/13/2001	1/18/2013	299	76.4	1.4	493
Flow (cfs)	4/13/2001	1/18/2013	123	0.751	0.499	1.24
Nitrate (total as N) (mg/L)	4/13/2001	10/23/2008	49	2.94	0.15	12.7
Nitrite (total as N) (mg/L)	4/13/2001	10/23/2008	51	2.93	0.15	12.7
TSS (mg/L)	3/13/2001	1/18/2013	232	42.1	2.51	135

Source of data: ISIS (U.S. EPA 2013b).
Notes
DMR records from ICIS are monthly averages.
avg. = average (arithmetic mean); BOD = biological oxygen demand; C = Celsius; cfs = cubic feet per second; max. = maximum; mg/L = milligrams per liter; min. = minimum; N = nitrogen; TSS = total suspended solids.

Figure 19 shows that the daily average flow from the Polson WWTP has ranged from 0.5 cfs to 1.2 cfs since 2000. No total phosphorus or total nitrogen data were available.

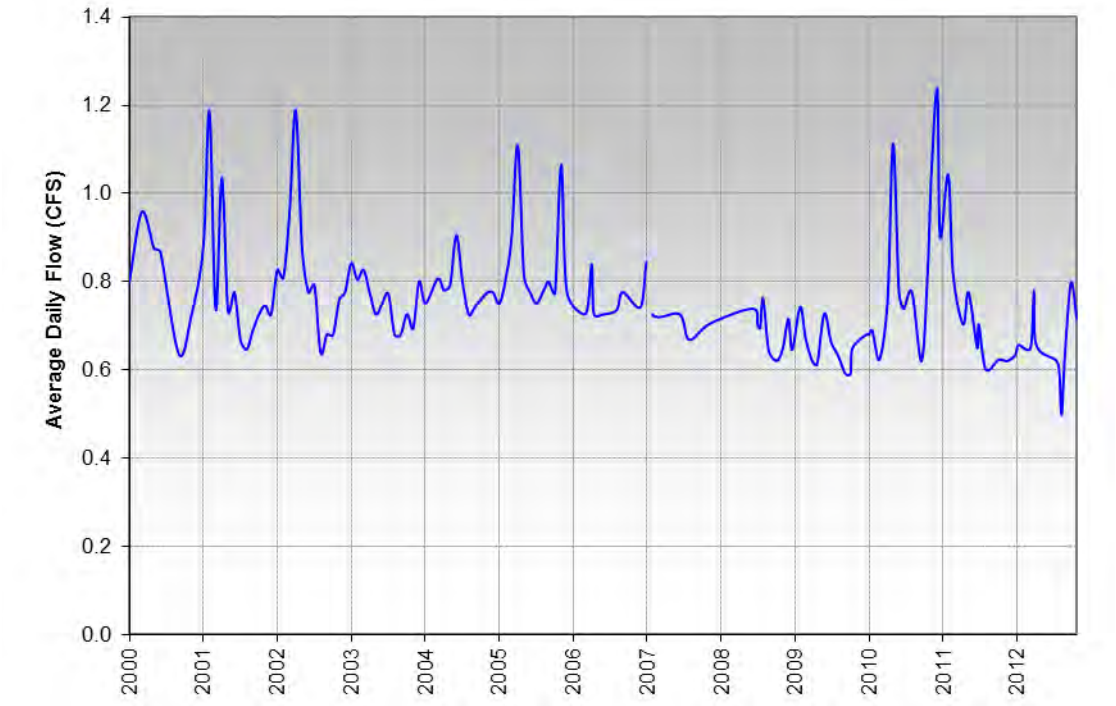


Figure 19. Average daily flow at the Polson WWTP.

Typical of lagoon treatment systems, ammonia concentrations from the Polson WWTP fluctuate seasonally and range from 0.02 to 32.70 mg/L. Figure 20 shows that since 2001, when the aeration system was upgraded, total ammonia concentrations and loads from the Polson WWTP were lowest from May/June through October/November of each year. Since 2002, peak loads ranged from 44.7 lb/d to 118 lb/d. There is no apparent trend in the data; the city of Polson did not provide data past 2006 for analysis, and the DMR data provided by U.S. EPA Region 8 does not include nutrients after 2008.

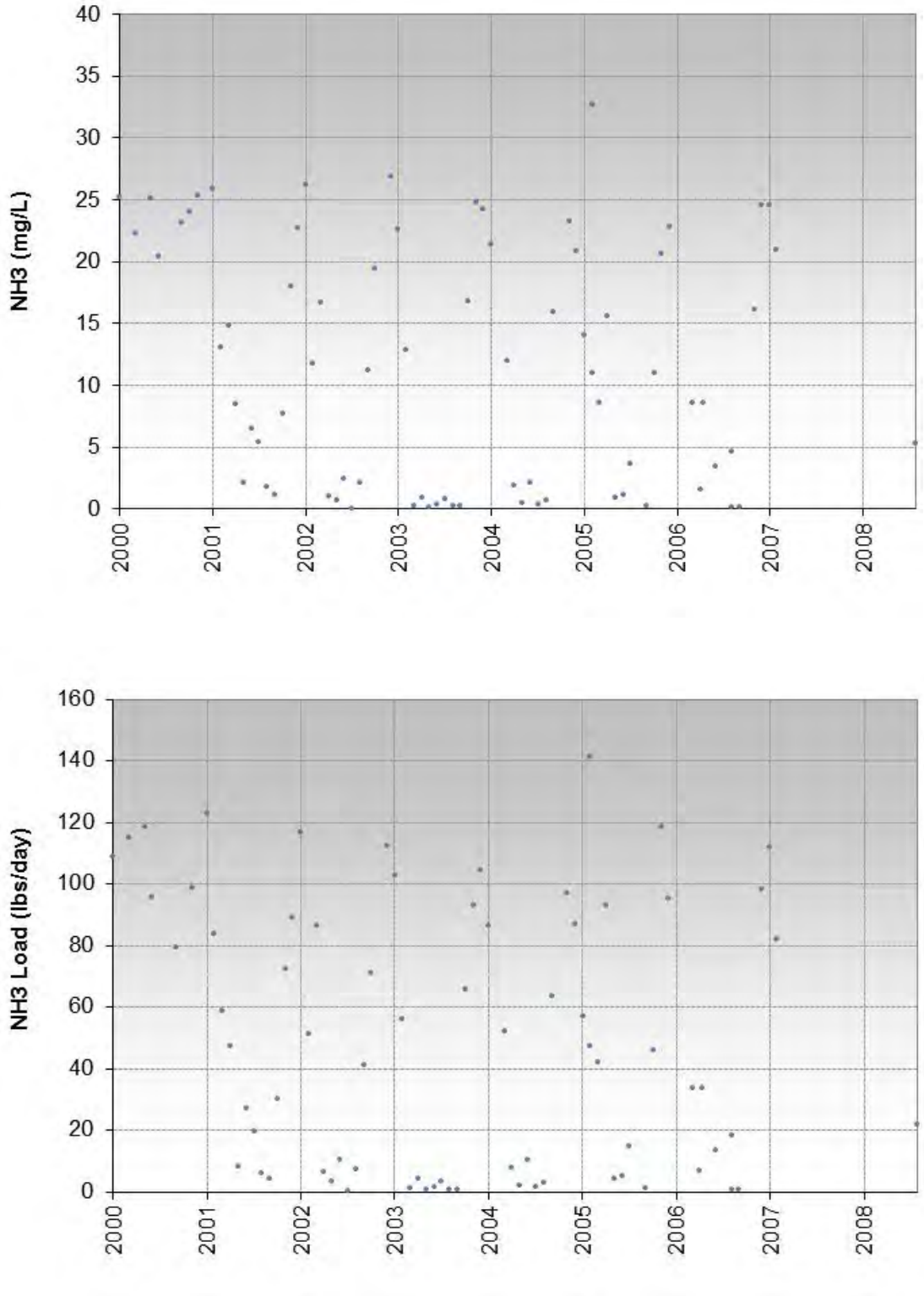


Figure 20. Ammonia from the city of Polson WWTP.

2.6 Kalispell WWTP (MT0021938)

The City of Kalispell operates an advanced wastewater treatment and biological nutrient removal facility that discharges to Ashley Creek (Figure 21). The original facility was built in 1974 and consisted of a simple biofilter process.[20] That facility was completely replaced in 1992 with a modified-University of Capetown biological nutrient removal process with a 3.1 mgd capacity[21]; the "biological removal treatment process with suspended growth" is used for phosphorus removal (FCCHD 2009, p. 5). Recently, the WWTP upgraded to a modified Johannesburg treatment system with a total capacity of 5.4 mgd capacity.[22]

The service area of the Kalispell WWTP is displayed in Figure 22, and the WWTP serves approximately 19,000 customers (FCCHD 2009). All properties within municipal boundaries are served by the Kalispell WWTP and new annexations are required to connect to the Kalispell sewer system.[23] The Kalispell WWTP is also contracted to treat wastewater from the Evergreen County Water and Sewer District through an inter-local agreement signed in 1990 (FCCHD 2009, 2012). The agreement expires in 2015 and the city of Kalispell and unincorporated community of Evergreen are in the process of negotiating a new agreement (as of June 2013)[24]. The agreement currently allows for the District to pump 0.682 mgd to the Kalispell WWTP (FCCHD 2009). In 2009, the Kalispell WWTP processed approximately 2.79 mgd, and 0.456 mgd of the 2.79 mgd was from the Evergreen County Waters and Sewer District (FCCHD 2009). Evergreen's average daily flow has increased slowly over time from 0.349 mgd in 1995 to 0.512 mgd in 2011 (FCCHD 2012).

The WWTP is permitted to discharge effluent to Ashley Creek from one outfall (#001) (DEQ 2008c) (Figure 21). Joni Emrick (plant manager) stated that, "when the flow leaves the sand filter/ultraviolet light treatment room, it flows by gravity to the re-aeration basin where fine bubble diffusers add air for a minimum 75 percent DO saturation. Then the water flows over a weir through a short pipe into Ashley Creek."[25]

Kalispell's MPDES permit (MT0021938) limits for its outfall on Ashley Creek are shown in Table 22. Additionally, the permit requires the pH of the effluent to remain between 6.0 and 9.0 standard units and there cannot be any visible foam, oil sheen, or floating solids in the effluent. The permit requires an 85 percent reduction in TSS and BOD_5 and for there to be no acute toxicity in the discharged effluent.

The Kalispell WWTP also has a permit (MTG650010) to dispose of sewage sludge. The majority of the sludge goes to Glacier Gold Compost, Inc. in Olney, Montana, where it is mixed with wood waste and sold as Glacier Gold Compost.[26] When Glacier Gold Compost Inc., cannot accept the sludge, the Flathead County Landfill will accept some sludge "during early morning hours before it is open to the public" (FCCHD 2009, p. 5).The occasional cleanings of the digester waste, approximately every 5 years, are land applied to a parcel of land south of the plant on EPA-City owned land (Category 2, Subcategory 2a of Montana's general MPDES permit for biosolids).

[20] Joni Emrick, plant manager, Kalispell WWTP, personal communication, August 15, 2008.
[21] Joni Emrick, plant manager, Kalispell WWTP, personal communication, April 30, 2008.
[22] Melee K. Valett, water quality specialist, DEQ – Permitting and Compliance Division – Water Protection Bureau – Water Quality Discharge Permits Section, personal communication, March 10, 2010.
[23] Rebekah Wargo, assistant civil engineer, city of Kalispell, personal communication, June 18, 2013.
[24] Curt Konecky, plant manager, Kalispell WWTP, personal communication, June 14, 2013.
[25] Joni Emrick, plant manager, Kalispell WWTP, personal communication, October 6, 2008.
[26] Joni Emrick, plant manager, Kalispell WWTP, personal communication, August 15, 2008.

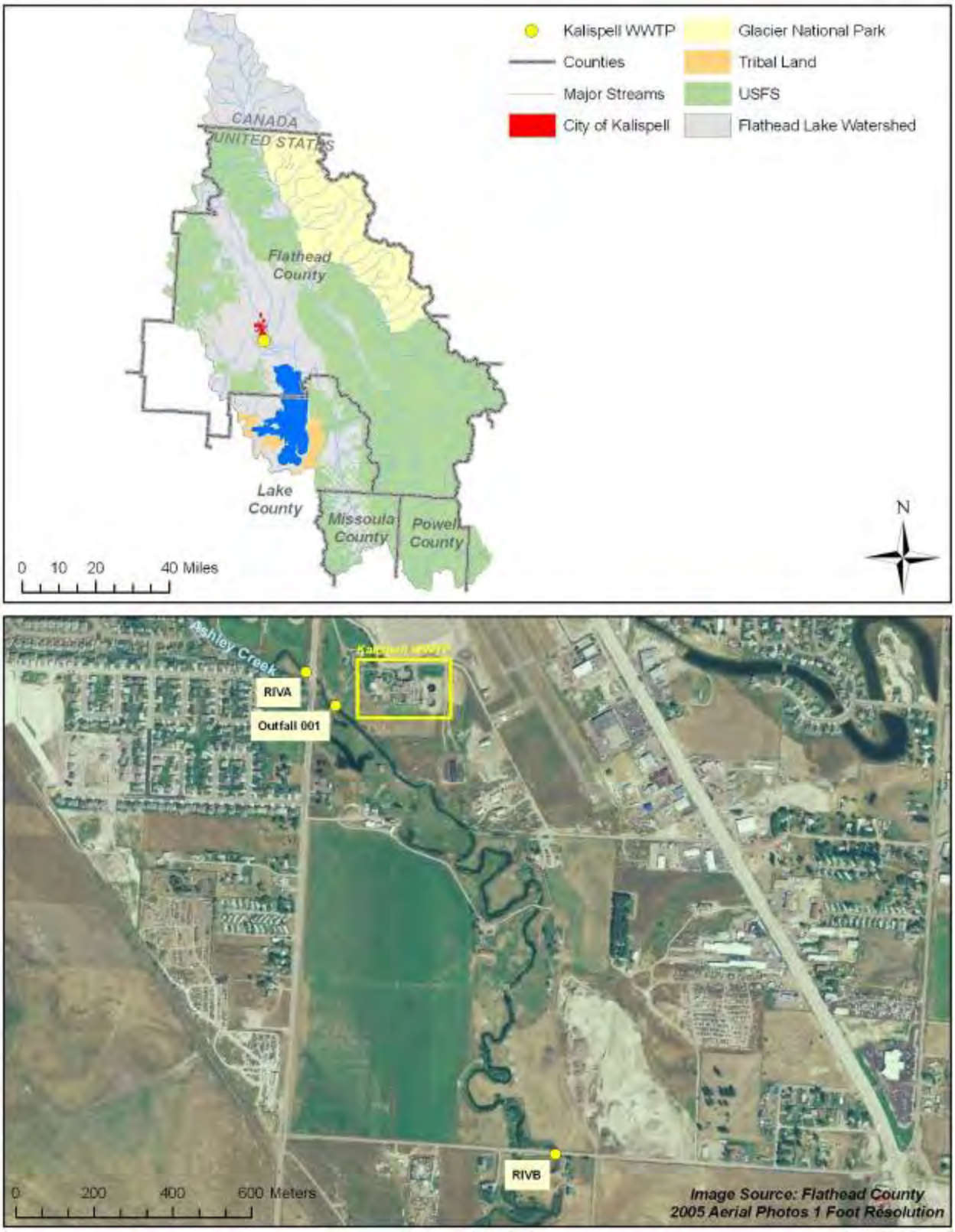
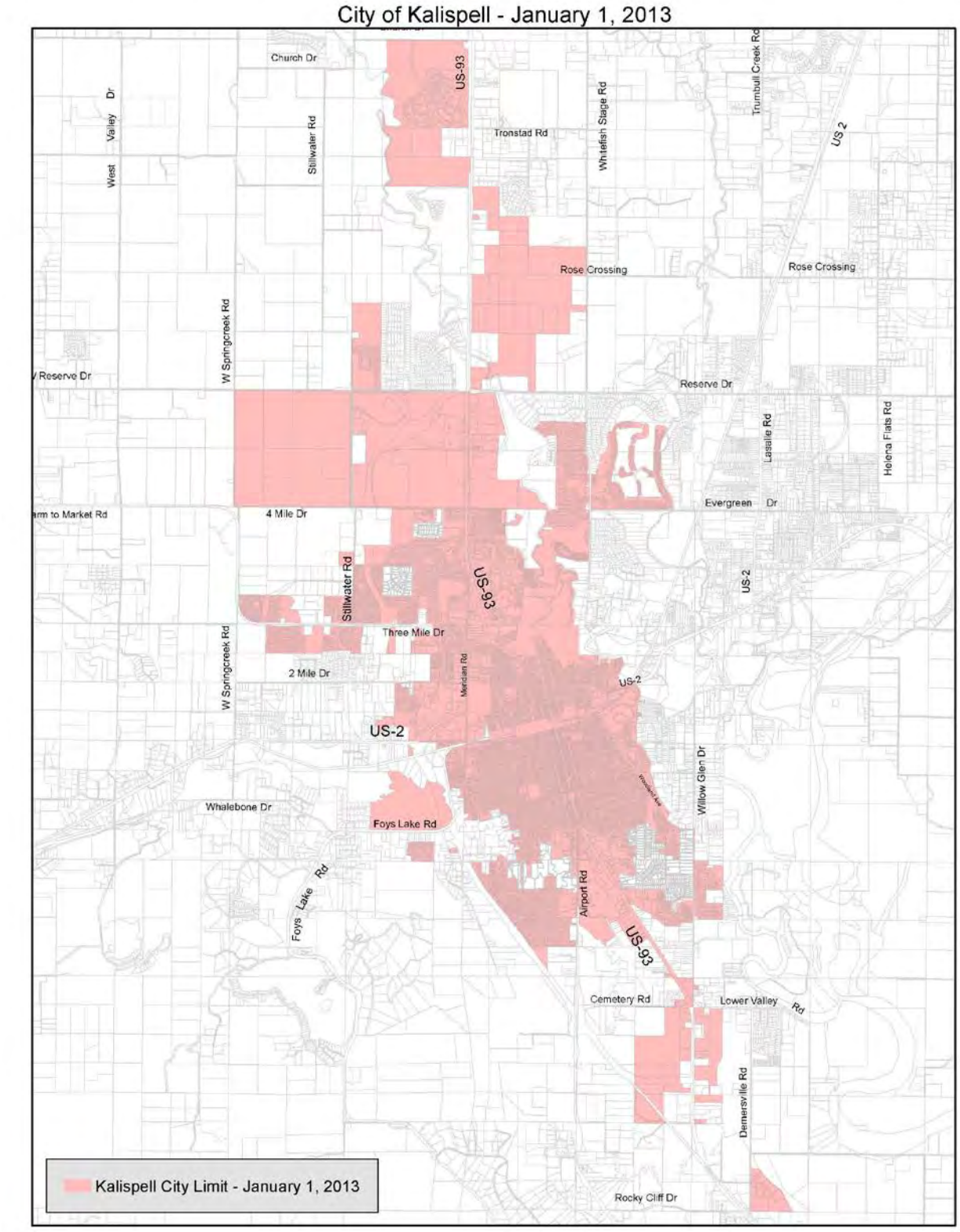


Figure 21. Kalispell WWTP permitted outfall.



Source of map: Rebekah Wargo, Assistant Civil Engineer, city of Kalispell, June 19, 2013.

Figure 22. Kalispell WWTP service area.

Table 23. Kalispell WWTP permit limits

Constituent	Units	Average monthly limit	Average weekly limit	Maximum daily limit
BOD_5	mg/L	10	15	--
	lb/day	259	388	--
TSS	mg/L	10	15	--
	lb/day	259	388	--
E. coli bacteria, winter [a]	cfu/100mL	630	--	1,260
E. coli bacteria, summer [b]	cfu/100mL	126	--	252
Total Phosphorus	mg/L	1.0	--	--
	lb/d	25.8	--	--
Total Nitrogen	lb/d	268	--	379
Total Ammonia, winter [a]	mg/L	2.16	--	2.22--
Total Ammonia, summer [b]	mg/L	1.23	--	2.22--
Oil and Grease	mg/L	--	--	10
DO Saturation	percent	--	--	>75%

Source: DEQ 2008c

Notes

BOD_5 = five-day biological oxygen demand; cfu/100mL = colony forming units per 100 milliliters; DO = dissolved oxygen; lb/d = pounds per day; mg/L = milligrams per liter; TSS = total suspended solids.

a. Winter is November 1 through March 31.

b. Summer is April 1 through October 31.

The facility is required to monitor the water quality of its effluent (outfall #001) and upstream and downstream of its outfall in Ashley Creek (RIVA and RIVB as shown in Figure 21). Table 23 and Table 24 summarize the available effluent water quality data at outfall #001; data were obtained directly from the Kalispell WWTP[27] and from ICIS (U.S. EPA 2013b). Influent data provided by the city of Kalispell are summarized in Table 23. Facility effluent data are summarized herein. ICIS data (summarized in Table 24) and facility influent data (Table 23) may be used to supplement facility effluent data during model development. The average effluent flow from 1998-2012 was 3.55 cfs, with an average total phosphorus concentration of 0.215 mg/L and an average total nitrogen concentration of 8.25 mg/L.

[27] Records provided as a series of Excel spreadsheets for 1993 through 2007 from Joni Emrick on May 28, 2008.

Table 24. Kalispell WWTP data summary - Influent data from Kalispell WWTP

Constituent	Start date	End date	No. of records	Avg.	Min.	Max.
BOD, 5-day, 20 °C	1/5/1993	12/30/2003	574	185	42	437
Flow rate (cfs)	1/1/1993	12/31/2007	5,478	3.41	0.13	10.51
Temperature (°C)	1/6/1993	12/31/2003	560	15.40	8.02	28.2
TSS (mg/L)	1/5/1993	12/30/2003	575	209	64	800

Source of data: Joni Emrick, plant manager, Kalispell WWTP, May 28, 2008.
Notes
avg. = average (arithmetic mean); BOD = biological oxygen demand; C = Celsius; cfs = cubic feet per second; max. = maximum; mg/L = milligrams per liter; min. = minimum; TSS = total suspended solids.

Table 25. Kalispell WWTP data summary - Effluent data from Kalispell WWTP

Constituent	Start date	End date	No. of records	Avg.	Min.	Max.
Ammonia (total as N) (mg/L)	1/28/1993	12/27/2012	856	0.213	0.01	8.2
BOD, 5-day, 20 °C	1/3/1993	12/27/2012	3,166	2.51	2	24
Flow rate (cfs)	1/1/1998	12/31/2012	3,244	3.55	2	9.33
Nitrate (total as N) (mg/L)	1/28/1993	12/25/2012	836	7.19	0.2	19.1
Nitrogen (total) (mg/L)	1/4/2012	12/25/2012	52	8.25	6.67	10.3
Orthophosphate (as P) (mg/L)	11/21/2006	5/5/2009	37	0.0719	0.01	0.25
Phosphorus (total) (mg/L)	1/3/1993	12/27/2012	3,178	0.215	0	11.1
Temperature (°C)	1/6/1993	12/31/2012	2,396	14.7	1	22.5
TKN (total as N) (mg/L)	1/28/1993	12/25/2012	436	1.47	0.03	10.9
TSS (mg/L)	1/3/1993	12/27/2012	3,176	2.48	0.3	276

Source of data: Joni Emrick, plant manager, Kalispell WWTP, May 28, 2008 and Curt Konecky, plant manager, Kalispell WWTP, February 21-26, 2013.
Notes
avg. = average (arithmetic mean); BOD = biological oxygen demand; C = Celsius; cfs = cubic feet per second; lb/d = pounds per day; max. = maximum; mg/L = milligrams per liter; min. = minimum; N = nitrogen; NO2+NO3 = nitrite plus nitrate; P = phosphorus; TKN = total Kjeldahl nitrogen; TSS = total suspended solids.

Table 26. Kalispell WWTP data summary - Data from ICIS

Constituent	Start date	End date	No. of records	Avg.	Min.	Max.
Ammonia (total as N) (mg/L)	4/28/1999	1/24/2013	166	0.163	0.015	8.2
BOD, 5-day, 20 °C	4/28/1999	1/24/2013	166	2.27	2	9.4
Conduit Flow (cfs)	4/28/1999	1/24/2013	150	3.95	2.41	6.48
Dissolved Oxygen	4/28/1999	1/24/2013	166	8.94	6.78	11.5
Nitrogen (total) (mg/L)	4/28/1999	1/24/2013	166	9.23	1.11	19.9
NO_2+NO_3 (total as N) (mg/L)	4/28/1999	1/24/2013	166	8.31	0.2	19.1
Phosphorus (total) (mg/L)	4/28/1999	1/24/2013	166	0.129	0.035	0.38
Temperature (°C)	4/28/1999	1/24/2013	166	15.1	9.6	21.8
TKN (total as N) (mg/L)	4/28/1999	1/24/2013	166	1.09	0.03	3.8
TSS (mg/L)	4/28/1999	1/24/2013	166	1.58	0.2	6

Source of data: ISIS (U.S. EPA 2013b)
Notes
DMR records from ICIS are monthly averages.
avg. = average (arithmetic mean); BOD = biological oxygen demand; C = Celsius; cfs = cubic feet per second; max. = maximum; mg/L = milligrams per liter; min. = minimum; N = nitrogen; NO_2+NO_3 = nitrite plus nitrate; TKN = total Kjeldahl nitrogen; TSS = total suspended solids.

Figure 23 shows the average daily influent flow from January 1993 through 2012. Influent flows have increased over time from an average of 2.2 cfs in 1993 to an average of 4.1 cfs in 2012. Effluent flow was not recorded for the entire period of record, as shown in Figure 24, which presents the average daily effluent flow from 1998 through 2012 and include data gaps. Effluent flows from 1998 through 2012 ranged from 2.0 cfs to 9.3 cfs with an average flow of 3.6 cfs.

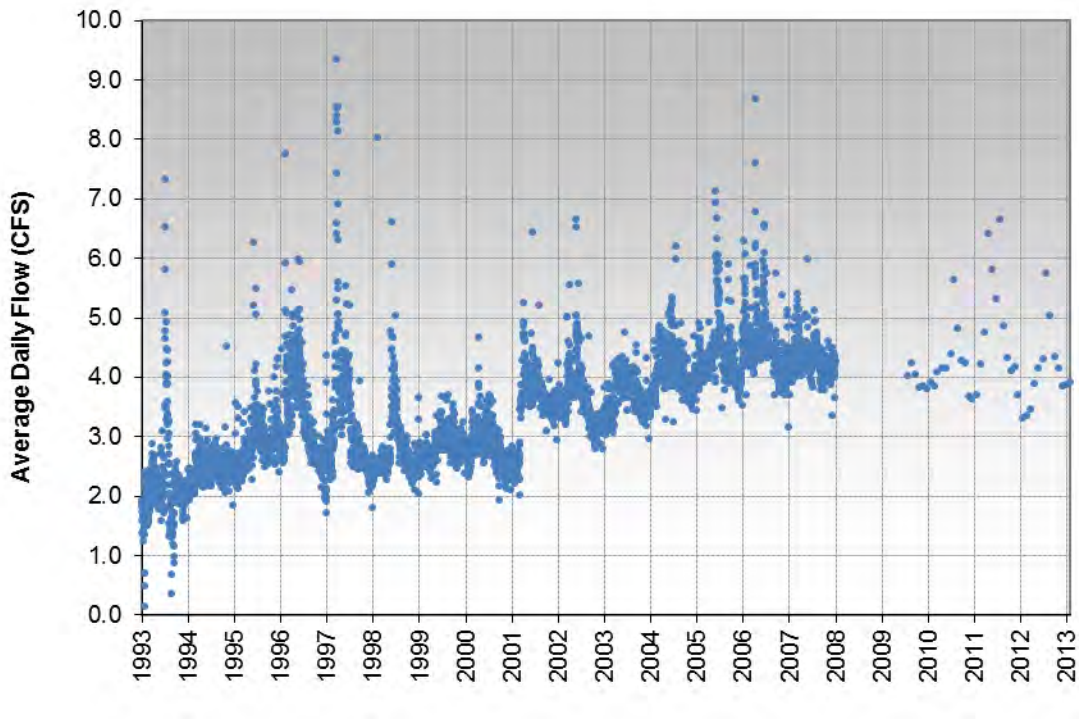


Figure 23. Average daily influent flow at the Kalispell WWTP

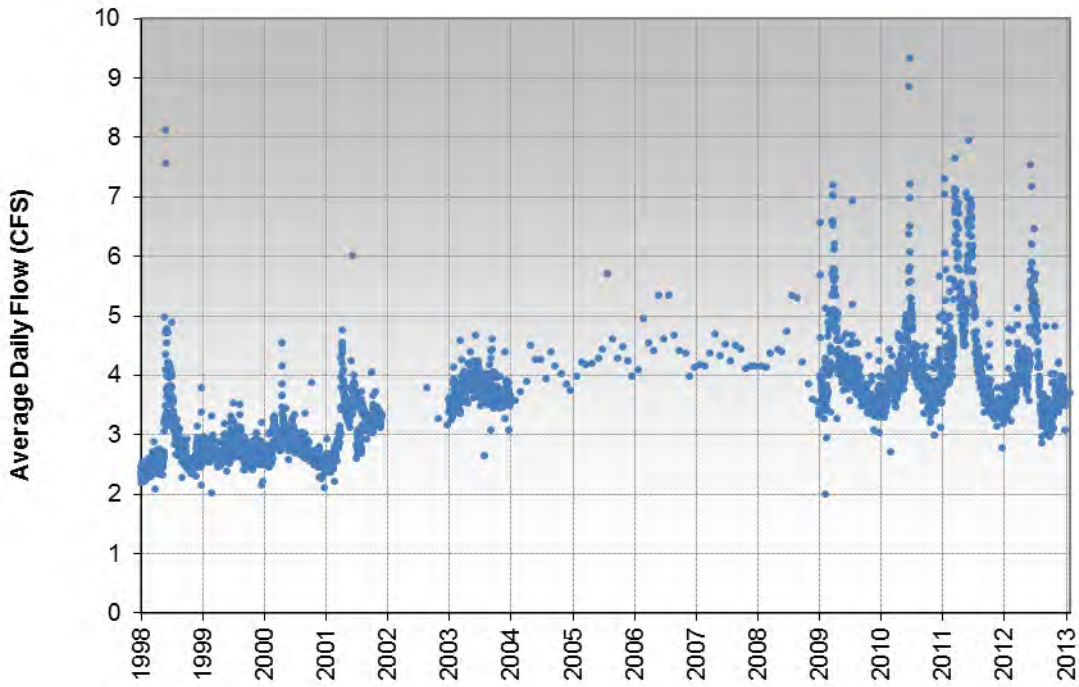


Figure 24. Average daily effluent flow at the Kalispell WWTP

Figure 25 shows the effluent total phosphorus concentrations and loads over time. Concentrations were highest in 1993 and lowest in 2000. Total phosphorus concentrations have remained relatively similar since 2000; however, total phosphorus loads have increased since 2000 due to increasing flows. The average daily load in 2000 was 1.6 pounds per day, and the average daily load in 2012 was 3.6 pounds per day.

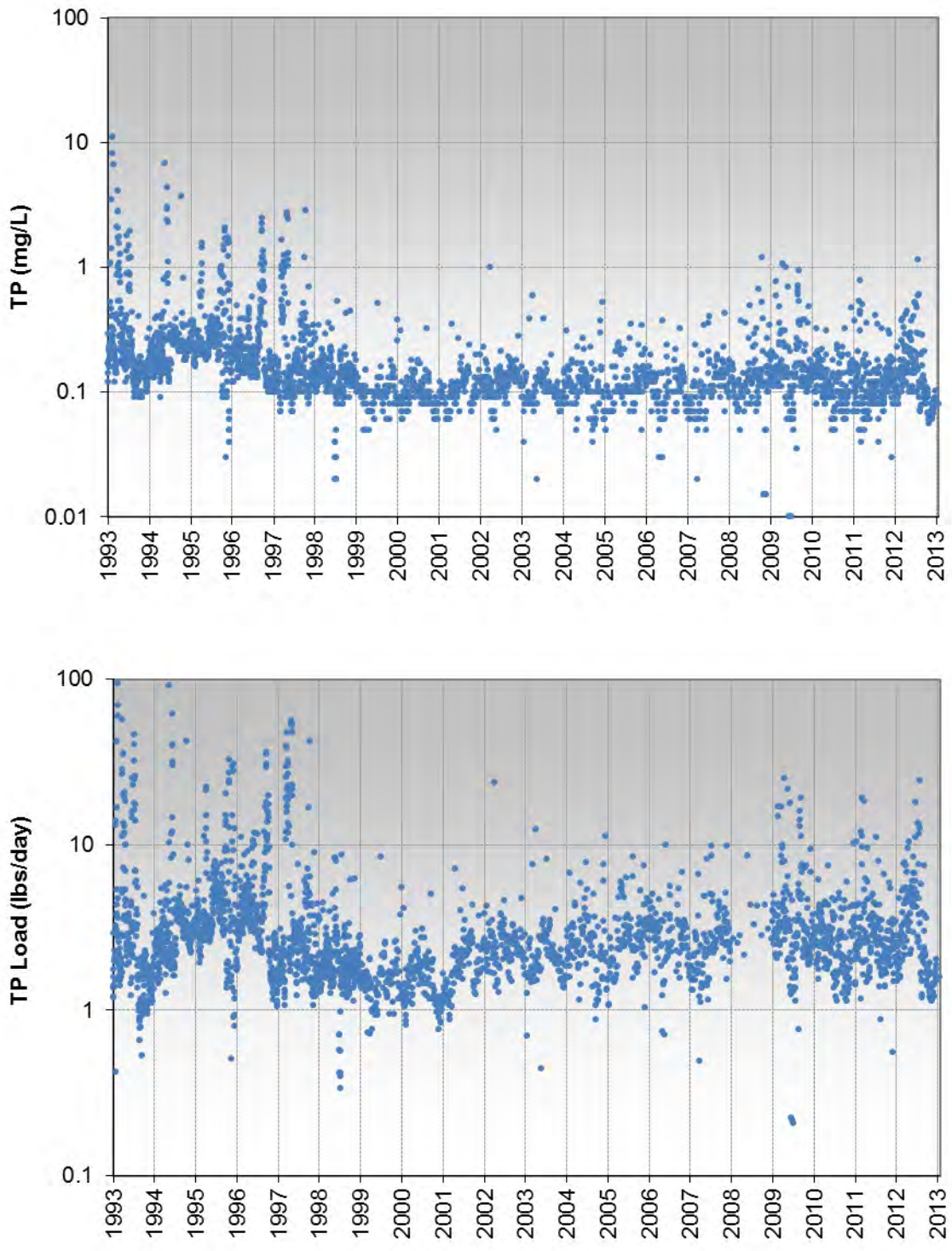


Figure 25. Total phosphorus at the Kalispell WWTP.

Figure 26 shows the effluent total nitrogen concentrations and loads over time. Total nitrogen concentrations were lowest in 1993 (average of 4.93 mg/L), increased during the 1990s, and have

remained fairly constant since 2000. Total nitrogen loads have increased over time due to both increasing flows and total nitrogen concentrations.

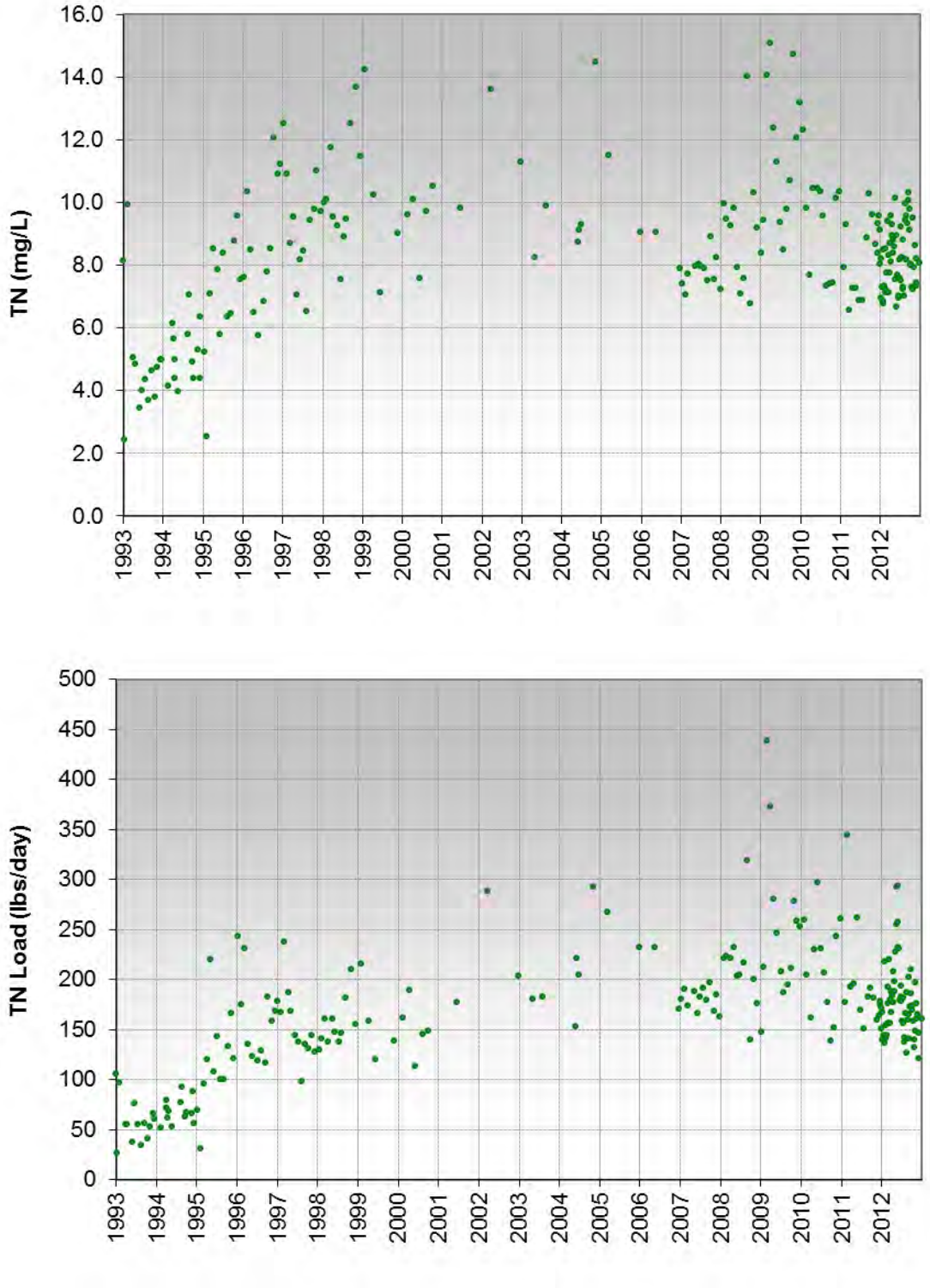


Figure 26. Total nitrogen at the Kalispell WWTP.

2.7 Hungry Horse Dam WWTP (MT0022578)

The Bureau of Reclamation, of the U.S. Department of the Interior, formerly operated a wastewater treatment facility that is located at the Hungry Horse Dam near Hungry Horse, Montana. A septic system with drainfield was recently installed in 2009 and there is no longer a discharge from the wastewater treatment facility.[28] Formerly, the plant served the Hungry Horse Dam facility. The WWTP was built in 1970 and consists of an extended aeration package plant with secondary and tertiary treatment.[29] The design flow was 0.009 mgd. No major upgrades have occurred since 1970. However, a design investigation was conducted in 2007 to look at alternatives to replacing the existing system with a system that does not discharge to the river. Even though the wastewater treatment facility is not actively used and does not discharge, the Bureau of Reclamation continues to maintain the permit in case they decide to reactivate the WWTP in the future.[30]

The WWTP is permitted to discharge effluent to the South Fork Flathead River from one outfall (#001) (DEQ 2008a). The most recent MPDES permit limits for the outfall are shown in Table 25. The permit also requires the pH of the effluent to remain between 6.5 and 9.0 standard units and there cannot be any visible foam, oil sheen, or floating solids in the effluent. The concentration of oil and grease cannot exceed 10 mg/L in any individual sample.

[28] Melee K. Valett, water quality specialist, DEQ – Permitting and Compliance Division – Water Protection Bureau – Water Quality Discharge Permits Section, personal communication, March 10, 2010.
[29] Dennis Philmon, Facility Manager, Hungry Horse Dam, personal communication, July 24, 2008.
[30] Melee K. Valett, water quality specialist, DEQ – Permitting and Compliance Division – Water Protection Bureau – Water Quality Discharge Permits Section, personal communication, March 10, 2010.

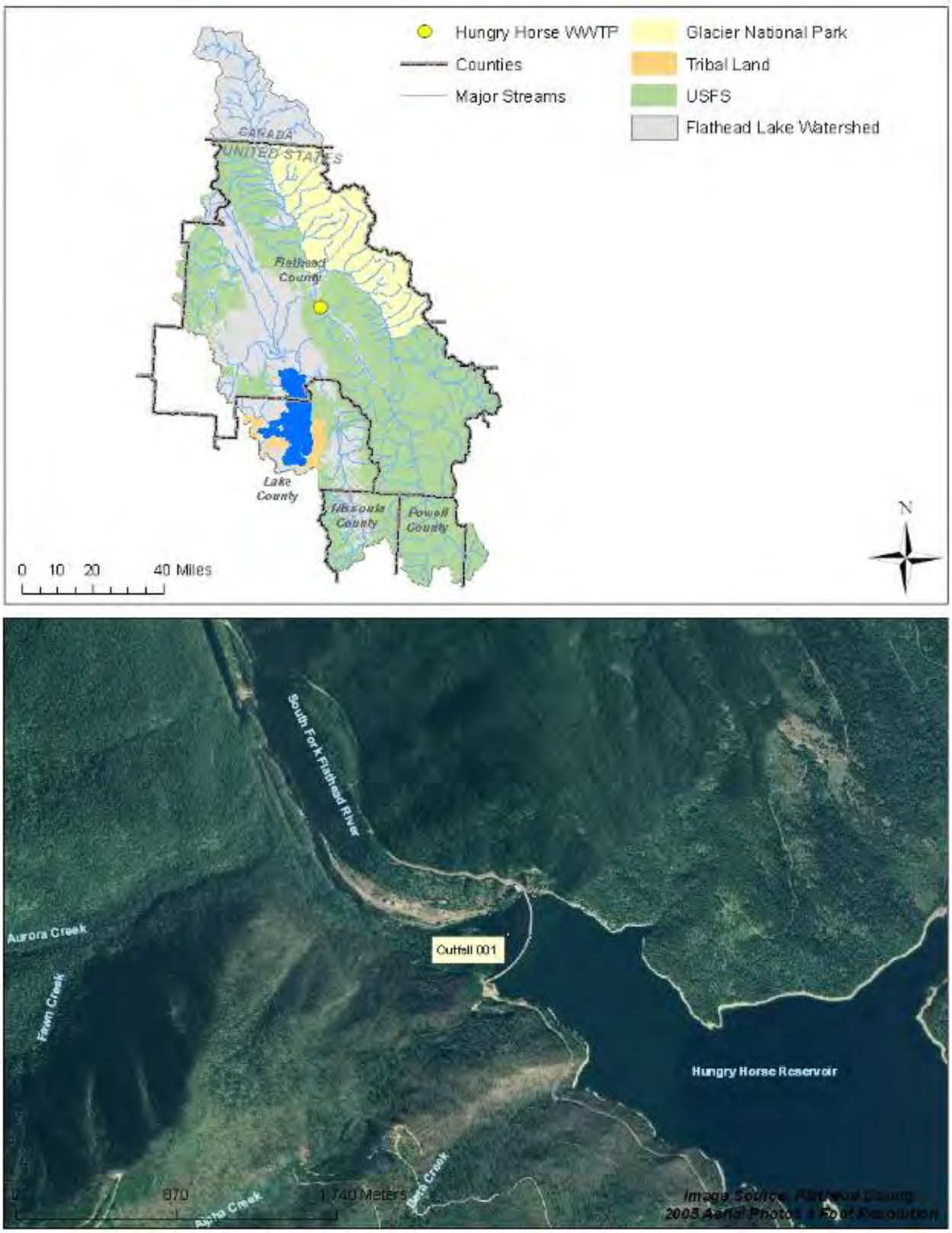


Figure 27. Hungry Horse Dam WWTP permitted outfall.

Table 27. Hungry Horse Dam WWTP permit limits

Constituent	Units	Average monthly limit	Average weekly limit	Maximum daily limit
BOD_5	mg/L	30	45	--
	lb/day	1.5	2.25	--
TSS	mg/L	30	45	--
	lb/day	1.5	2.25	--
E. coli bacteria, winter [a]	cfu/100mL	630	--	1,260
E. coli bacteria, summer [b]	cfu/100mL	126	--	252
Total Phosphorus	mg/L	1.0		
	lb/d	0.8	--	--
Total Residual Chlorine	mg/L	0.011		0.019

Source: DEQ 2008a.
Notes
BOD_5 = five-day biological oxygen demand; cfu/100mL = colony forming units per 100 milliliters; mg/L = milligrams per liter; TSS = total suspended solids.
a. This limitation applies from November 1 through March 31.
b. This limitation applies from April 1 through October 31.

Table 26 summarizes the available water quality data at outfall #001, which were obtained from ICIS (U.S. EPA 2013b; available for 1995 to 2013). The average effluent flow from 1995 to 2013 was less than 0.01 cfs, with an average total phosphorus concentration of 0.205 mg/L and an average total nitrogen concentration of 9.3 mg/L.

Table 28. Hungry Horse Dam WWTP data summary

Constituent	Start date	End date	No. of records	Avg.	Min.	Max.
Ammonia (total as N) (mg/L)	11/25/1995	4/29/2011	151	0.857	0.02	16
BOD, 5-day, 20 °C	10/25/1995	4/29/2011	163	3.44	1	17
Flow rate (cfs)	10/25/1995	1/9/2013	469	0.00359	0.0000245	0.0184
Nitrogen (total) (mg/L)	11/25/1995	4/29/2011	152	9.3	0.48	57.3
NO_2+NO_3 (total as N) (mg/L)	11/25/1995	4/29/2011	153	7.9	0.04	54.3
Phosphorus (total) (mg/L)	10/25/1995	4/29/2011	158	0.205	0.03	1
Temperature (°C)	12/15/2008	1/9/2013	58	15.5	10.4	27
TKN (total as N) (mg/L)	11/25/1995	4/29/2011	146	1.46	0.11	15.7
TSS (mg/L)	10/25/1995	4/29/2011	163	6.73	1	34

Source of data: ISIS (U.S. EPA 2013b)
DMR records from ICIS are monthly averages.
Note: avg. = average (arithmetic mean); BOD = biological oxygen demand; C = Celsius; cfs = cubic feet per second; lb/d = pounds per day; max. = maximum; mg/L = milligrams per liter; min. = minimum; N = nitrogen; NO_2+NO_3 = nitrite plus nitrate; P = phosphorus; TKN = total Kjeldahl nitrogen; TSS = total suspended solids.

2.8 Yellow Bay WWTP (Flathead Lake Biological Station) (MT0023388)

The Flathead Lake Biological Station operates a wastewater treatment facility (Yellow Bay) that is on the eastern shore of Flathead Lake (Figure 28). The plant serves the Flathead Lake Biological Station campus (30-120 people, depending on the season) and the Yellow Bay State Park (FCCHD 2012).

The facility was built in 1974 and consists of an extended aeration package plant with tertiary treatment for phosphorus (U.S. EPA 2007a; FCCHD 2012). There is also a small water treatment facility consisting of a sand filter and chlorine disinfection[31]. The design flow of the plant is 33,000 gpd, although in a normal year, the average discharge is 10,000 gpd in the summer and 2,000 gpd in the winter (University of Montana 2008). No major upgrades have occurred since 1974.

The WWTP is permitted to discharge effluent to Flathead Lake from one outfall (#001) (U.S. EPA 2012). The most recent permit limits for the outfall are shown in Table 27. Additionally, the permit also requires the pH of the effluent to remain between 6.5 and 9.0 standard units and there cannot be any visible foam, oil sheen, or floating solids in the effluent. The concentration of oil and grease cannot exceed 10 mg/L in any individual sample.

[31] Mark Potter, Assistant Director of Facilities and Properties, University of Montana, personal communication, July 17, 2008.

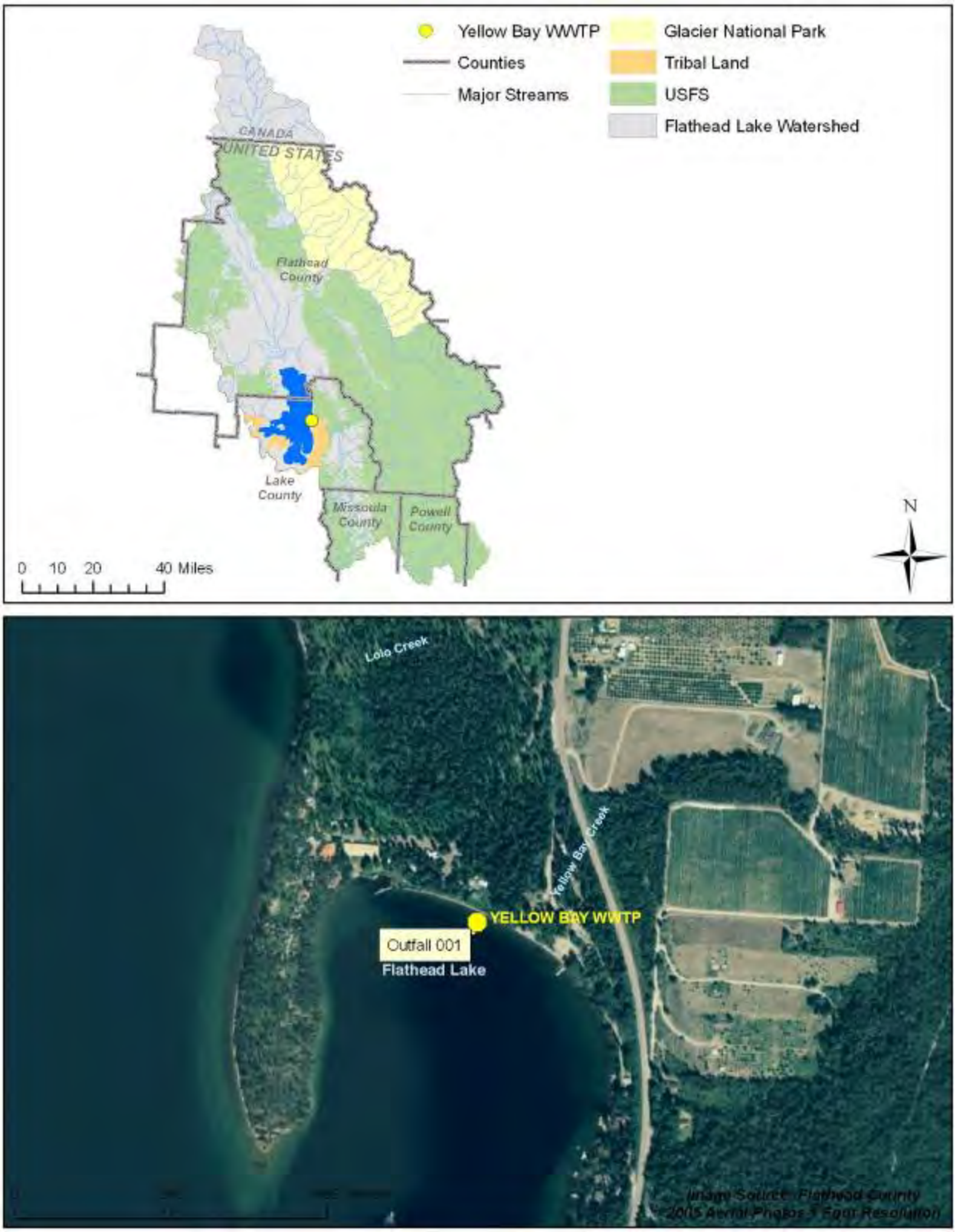


Figure 28. Yellow Bay WWTP permitted outfall.

Table 29. Yellow Bay WWTP permit limits

Constituent	Units	30-day average	7-day average	Daily maximum	Annual limit
BOD_5	mg/L	30	45	--	--
Chlorine (total residual)	mg/L	--	--	0.019	--
E. Coli Bacteria	cfu/100mL	32	50	--	--
Total Nitrogen	lb/year [a]	--	--	--	154
Total Phosphorus	lb/year [a]	--	--	--	0.3
TSS	mg/L	30	45	--	--

Source: U.S. EPA 2012
Notes
BOD_5 = five-day biological oxygen demand; cfu/100mL = colony forming units per 100 milliliters; lb/year = pounds per year; mg/L = milligrams per liter; TSS = total suspended solids.
a. Pounds of total nitrogen and total phosphorus discharged per month will be calculated by multiplying the average monthly flow time the average monthly concentrations of total nitrogen and total phosphorus. The amount discharged per year will be the sum of the pounds discharged each month.

Table 28 and Table 29 summarize the available water quality data from outfall #001; data were obtained directly from the Flathead Lake Biological Station and from ICIS (U.S. EPA 2013b). Data provided by the facility are summarized herein; ICIS data (summarized in Table 29) may be used to supplement facility data during model development.. FLBS reported that total phosphorus averaged 0.152 from 1983 to 2006. FLBS also reported that flow in 2007 averaged 0.00235 cfs. Finally, FLBS reported that total nitrogen in 2000 averaged 23.2 mg/L.

The Yellow Bay WWTP has a permit (MTG651004) to land apply sewage sludge.

Table 30. Yellow Bay WWTP data summary - Data from Flathead Lake Biological Station

Constituent	Start date	End date	No. of records	Avg.	Min.	Max.
Ammonia (total as N) (mg/L)	7/29/1983	1/3/2006	184	1.66	0	47.9
BOD, 5-day, 20 °C	2/28/2001	3/27/2007	51	1.32	0.07	4.6
Flow rate (cfs)	1/2/2007	3/30/2007	61	0.00235	0.00009	0.00812
Nitrogen (total) (mg/L)	1/31/2000	12/31/2000	12	23.2	18.1	28.2
NO_2+NO_3 (total as N) (mg/L)	3/21/1988	1/3/2006	135	16.8	0.802	44.2
Phosphorus (total) (mg/L)	7/29/1983	2/7/2006	1,000	0.152	0	6.62
TPN (mg/L)	10/12/1983	2/7/2006	261	15.6	0.487	29.8
TSS (mg/L)	2/28/2001	6/30/2005	48	0.593	0.25	9

Source of data: Mark Potter, Assistant Director of Facilities and Properties, University of Montana, July 17, 2008.
Note: avg. = average (arithmetic mean); BOD = biological oxygen demand; C = Celsius; cfs = cubic feet per second; max. = maximum; mg/L = milligrams per liter; min. = minimum; N = nitrogen; NO_2+NO_3 = nitrite plus nitrate; P = phosphorus; TKN = total Kjeldahl nitrogen; TPN = total persulfate nitrogen; TSS = total suspended solids.

Table 31. Yellow Bay WWTP data summary - Data from ICIS

Constituent	Start date	End date	No. of records	Avg.	Min.	Max.
BOD, 5-day, 20 °C	4/2/2001	1/28/2013	131	1.31	0.07	6.9
Conduit Flow (cfs)	4/2/2001	1/28/2013	131	0.00396	0.00124	0.0124
Nitrogen (total) (mg/L)	7/30/2007	8/17/2012	60	18.8	3.08	170
NO_2+NO_3 (total as N) (mg/L)	7/30/2007	1/28/2013	67	14.9	1.73	33.7
TKN (total as N) (mg/L)	7/30/2007	1/28/2013	66	0.451	0	6.74
TSS (mg/L)	4/2/2001	1/28/2013	122	0.449	0.25	2.5

Source of data: ISIS (U.S. EPA 2013b)
Notes
DMR records from ICIS are monthly averages.
avg. = average (arithmetic mean); BOD = biological oxygen demand; C = Celsius; cfs = cubic feet per second; max. = maximum; mg/L = milligrams per liter; min. = minimum; N = nitrogen; NO_2+NO_3 = nitrite plus nitrate; TKN = total Kjeldahl nitrogen; TSS = total suspended solids.

Average daily flow data is only available for three months in 2007, monthly and bi-monthly flows are available from 2001 to 2013. Figure 29 summarizes all available facility flows from 2001 through 2012. Flows range from 0.001 to 0.01 cfs averaging 0.004 cfs.

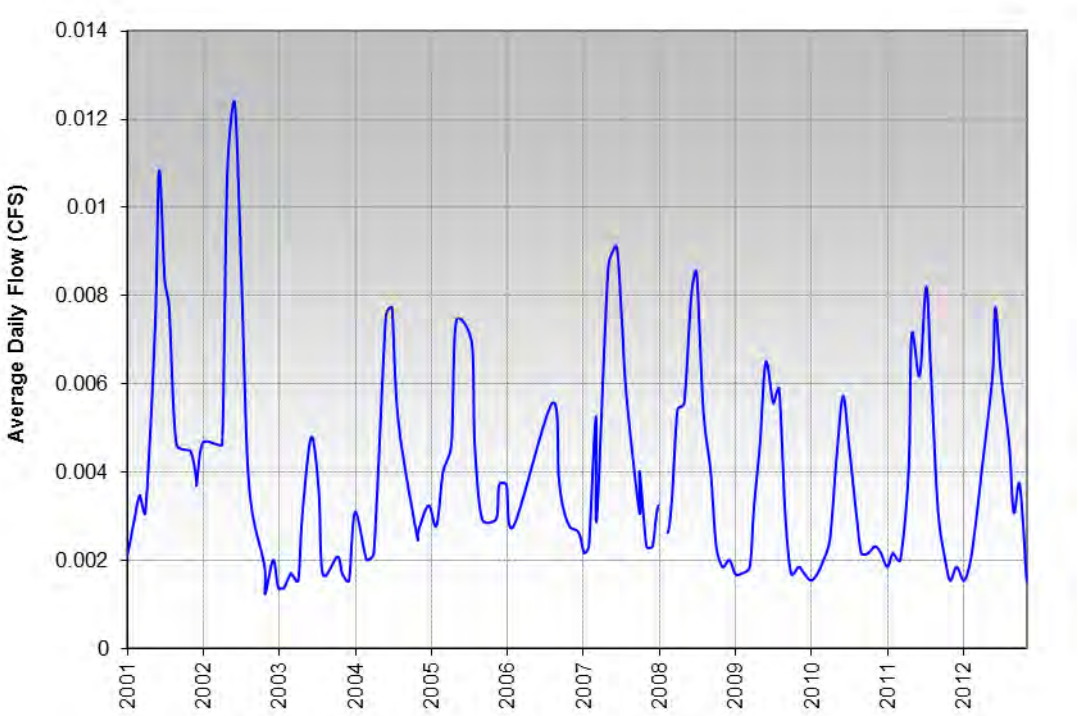


Figure 29. Average daily flow at the Yellow Bay WWTP.

Total phosphorus data are available from 1983 through February 7, 2006; however, since no corresponding flow data are available, loads cannot be calculated. Effluent total phosphorus concentrations have decreased since the early 1980s (Figure 30). From 1983 through 1990 concentrations ranged from 0.0008 mg/L to 5.80 mg/L and averaged 0.54 mg/L. From 1991 through February 7, 2006 concentrations ranged from 0.0062 mg/L to 6.62 mg/L and averaged 0.079 mg/L (total phosphorus concentrations reported as zero were excluded from the minimum and average calculations).

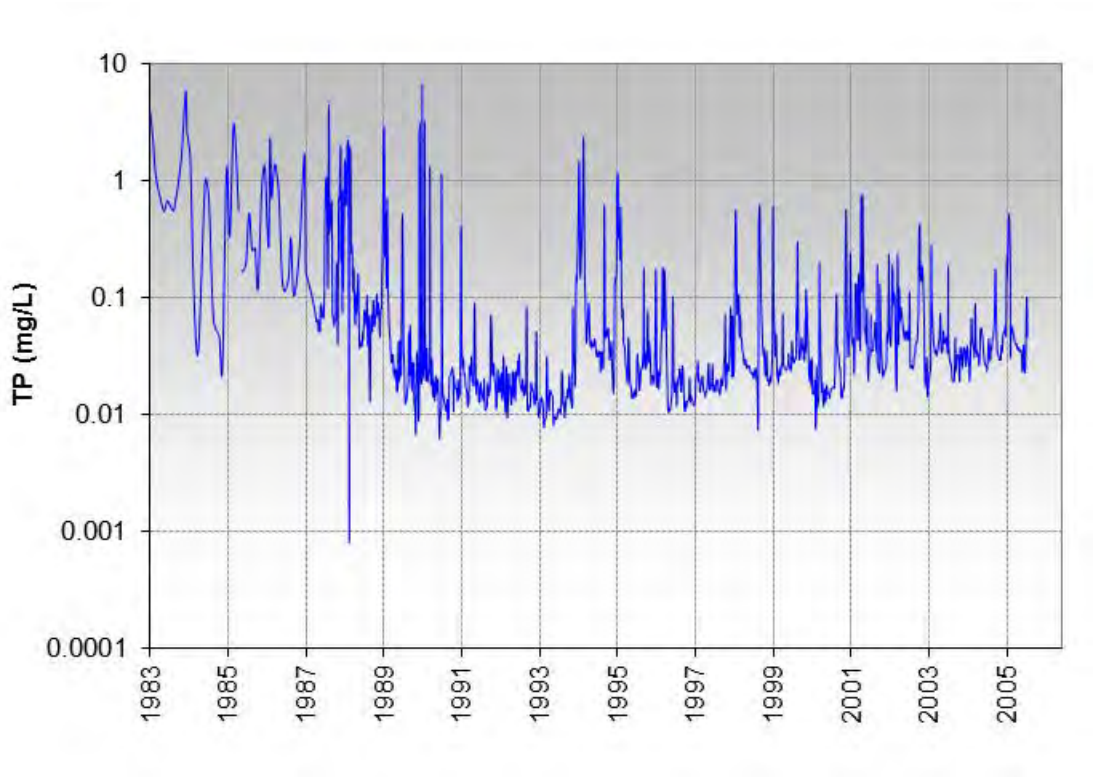


Figure 30. Total phosphorus at the Yellow Bay WWTP.

Total persulfate nitrogen data is also available from 1983 through February 7, 2006; however, no corresponding flow data are available. Concentrations display an increasing trend but stabilized in the mid-1990s through 2000s (Figure 31). From 2001 through February 7, 2006, concentrations have ranged from 12.5 mg/L to 29.8 mg/L and averaged 21.2 mg/L.

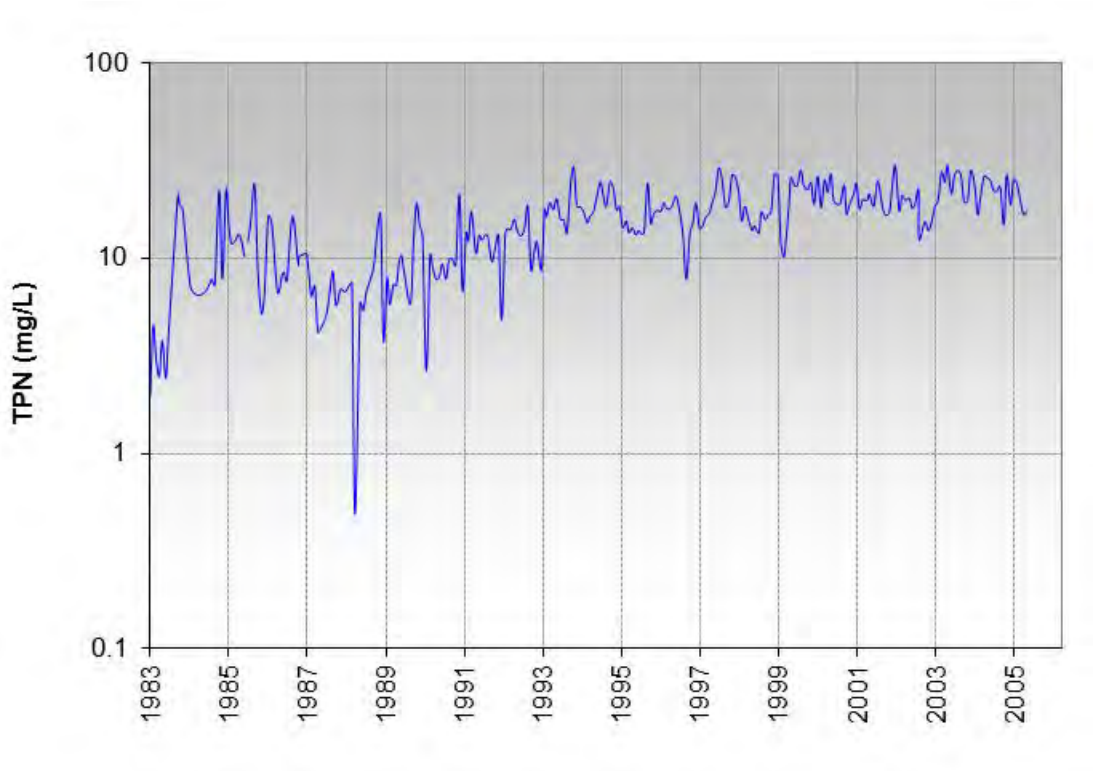


Figure 31. Total persulfate nitrogen at the Yellow Bay WWTP.

2.9 Columbia Falls Aluminum Co (MT0030066)

The Columbia Falls Aluminum Company is located in Columbia Falls, Montana on the Flathead River (Figure 32). The facility discharges wastewater from a series of industrial processes to five onsite percolation ponds that are hydrologically connected to the Flathead River through groundwater (DEQ 1999c). The facility is permitted to discharge from the following five outfalls (MT0030066):

- **Outfall #002** effluent is paste plant briquette cooling water from the coke and coal tar pitch mixer and extruder. It discharges from the end of the main briquette cooling belt, through a system of two percolation ponds north of the plant and into state groundwater that is hydrologically connected to the Flathead River.
- **Outfall #003** effluent is emissions scrubber water discharging to the scrubber effluent release basin within the plant. The release basin effluent discharges to a system of two percolation ponds north of the plant and into state groundwater that is hydrologically connected to the Flathead River.

  The flows of discharges 002 and 003 are combined with a discharge of compressor cooling water discharging through the compressor cooling water release line within the compressor house portion of the plant. The combined flow of discharges from outfalls #002, #003, and the compressor cooling water is approximately 2.5 mgd.
- **Outfall #004** effluent is contact cooling water from direct chill casting of aluminum ingots. The discharge is to three percolation ponds located approximately 1,500 feet south of the plant near the Flathead River. The percolation ponds discharge into state groundwater that is hydrologically connected to the Flathead River. The discharge ranges from 1.5 to 2.0 mgd.
- **Outfall #005** effluent is from the sewage treatment plant and discharges to the ingot cooling water pipeline that extends from the plant to the south percolation ponds. The percolation ponds discharge into state groundwater that is hydrologically connected to the Flathead River. The discharge is approximately 100,000 gpd.
- **Outfall #006** is groundwater flowing from beneath the plant site and discharging to surface water in the Flathead River. Groundwater receives water from the North Pond, South Pond, West Pond, dry wells, and historical disposal practices. The ponds and dry wells receive water from outfalls #002, #003,# 004, #005, stormwater, and many other facility discharges of cooling water, condensate, wash water, steam, and waste water.

Wastewater from the restrooms and laboratory sinks are treated at an on-site WWTP. The WWTP discharges to south #1 settling pond and its average 2008-2013 discharge was 0.09 mgd. Aluminum casting contact cooling water and rectifier non-contact cooling water also discharge to the south #1 settling pond. The South #1 settling pond discharges to south #2 and #3 settling ponds that infiltrate to groundwater hydrologically connected to the Flathead River[32].

The most recent MPDES permit limits (DEQ 1999c) are shown in Table 30 and Table 31. DEQ is in the process of revising the permit. The permit also requires the pH of the effluent from outfall 005 to remain between 6.0 and 9.0 standard units.

[32] Paul Skubinna and Christine Weaver, DEQ – Permitting and Compliance Division – Water Protection Bureau – Water Quality Discharge Permits Section, personal communication, June 27, 2013.

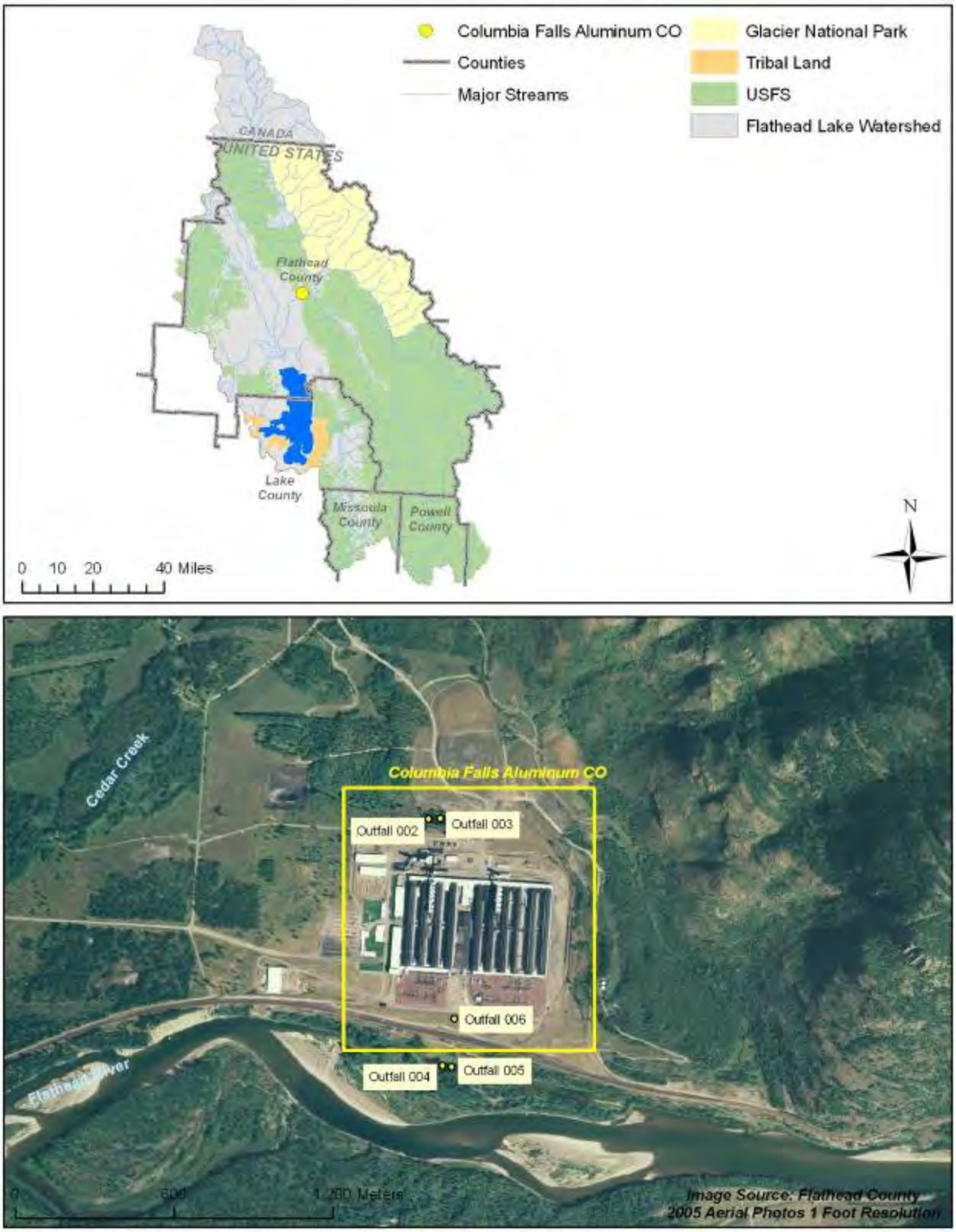


Figure 32. Columbia Falls Aluminum Company and permitted outfalls.

Table 32. Columbia Falls Aluminum Company permit limits for outfalls 002, 003, and 004

Parameter	Net monthly daily (kg/d)			Net monthly maximum (kg/d)		
	002	003	004	002	003	004
Benzo(a)pyrene	0.003 [a]	0.002	none	0.001 a	0.001	none
Antimony	0.189	0.123	1.579	0.066	0.043	0.53
Nickel	0.054	0.035	0.45	0.028	0.018	0.228
Aluminum	0.6	0.39	5	0.207	0.135	1.671
Fluoride	5.845	3.802	48.696	2.016	1.312	16.282

Source: DEQ 1999c
Notes
kg/d = kilogram per day
a. Benzo(a)pyrene limits are for gross rather than net values.

Table 33. Columbia Falls Aluminum Company permit limits for outfall 005

Parameter	Units	30-day average	7-day average
BOD	mg/L	30	45
TSS	mg/L	30	45

Source: DEQ 1999c
Note: BOD = biological oxygen demand; mg/L = milligrams per liter; TSS = total suspended solids.

The Columbia Falls Aluminum Company is required to monitor the water quality of its effluent. Monitoring is required for outfalls #002, #004, and #005. The facility is also required to do in-stream and well monitoring at several locations, as shown in Figure 33 and Figure 34. RIV-1 is a monitoring station on the Flathead River upstream of the south percolation ponds. RIV-2 and RIV-M are monitoring stations on the north bank of the Flathead River downstream of the south percolation ponds. There are 11 groundwater monitoring locations located around the facility (Figure 33).

DMR water quality results are not presented herein. Nutrients data, the focus of the TMDL project, are not available for any outfall. The waste stream is complex: a series of settling ponds, which receive various waste-, process-, and cooling-waters, that infiltrate to shallow groundwater hydrologically connected to the Flathead River. It is not known to what extent that nutrients discharged from restrooms may travel and if nutrient loads from the restrooms may reach the Flathead River.

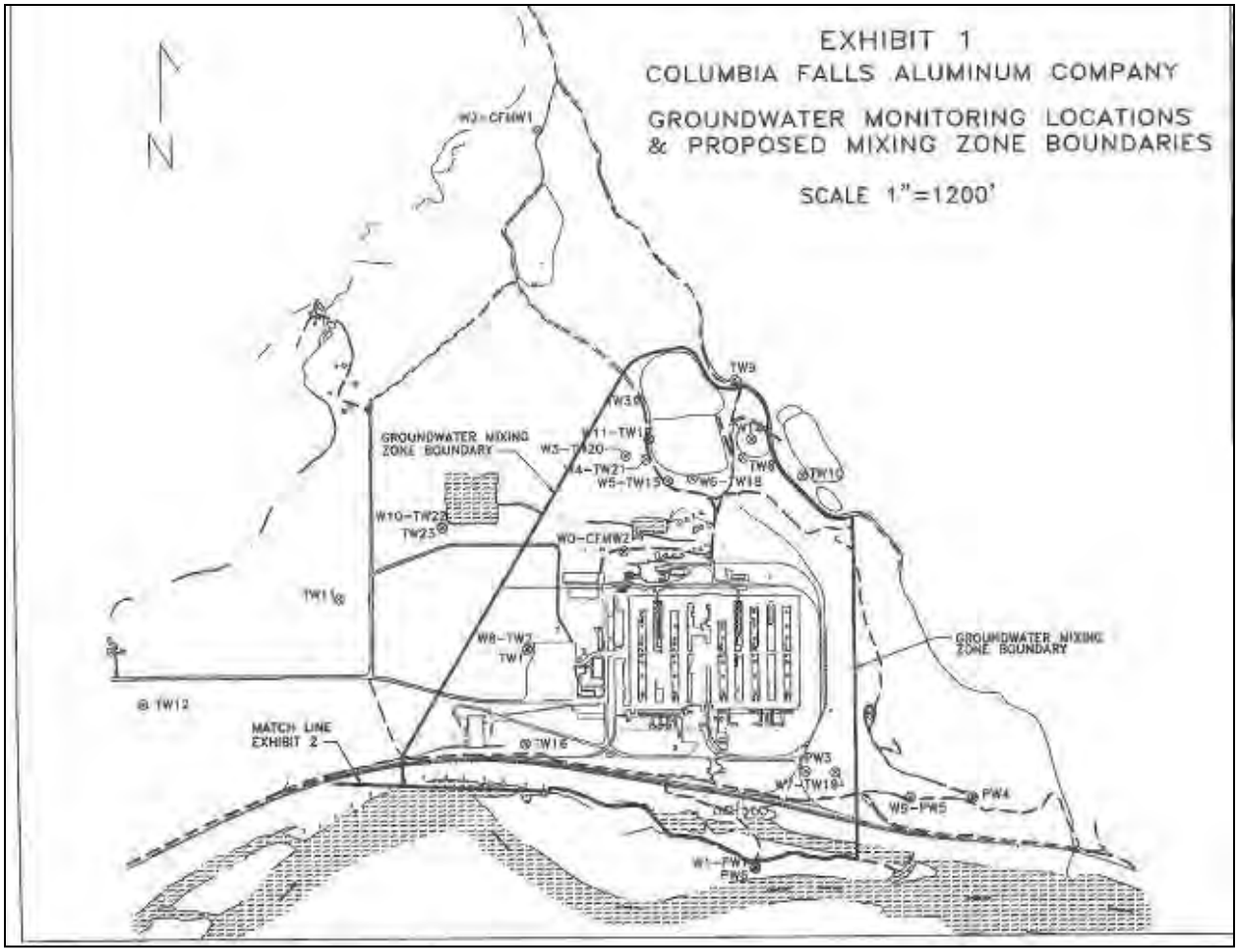


Figure 33. Columbia Falls Aluminum Company groundwater monitoring sites.

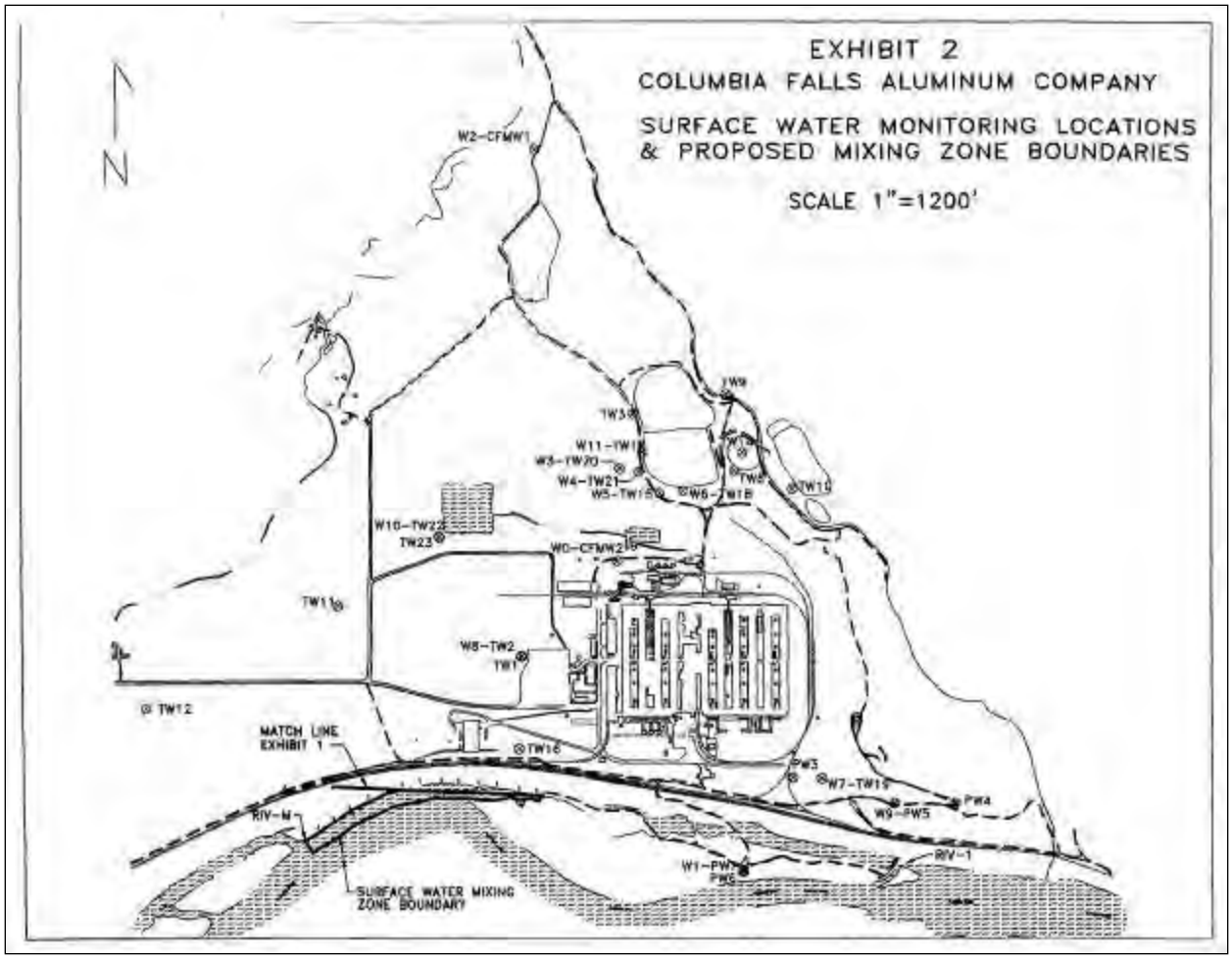


Figure 34. Columbia Falls Aluminum Company surface water monitoring sites.

2.10 Whitefish WTP (MT0030414)

There is only one MPDES permitted water treatment plant (WTP) in the Flathead Lake basin – the City of Whitefish WTP. It is in the Haskill Creek watershed, north and east of the City (Figure 35). The current facility was constructed in 2000. Prior to that, the city had no treatment other than chlorination. Raw water for treatment is withdrawn from the Haskill Creek watershed (First, Second, and Third Creeks) and from Whitefish Lake (although most of the water is withdrawn from the Haskill Creek watershed)[33]. Potable water is produced to supply the City of Whitefish, and the plant has a capacity 6.0 MGD.

The water treatment plant is permitted to discharge waste water (MT0030414) to a reservoir that eventually discharges to an unnamed tributary to Whitefish Lake (DEQ 2007b). The most recent MPDES permit limits for the outfall are shown in Table 33. The permit also requires the pH of the effluent to remain between 6.0 and 9.0 standard units and there cannot be any visible foam, oil sheen, or floating solids in the effluent.

[33] Greg Acton, Public Works Utilities Supervisor, City of Whitefish, personal communication, June 4, 2008.

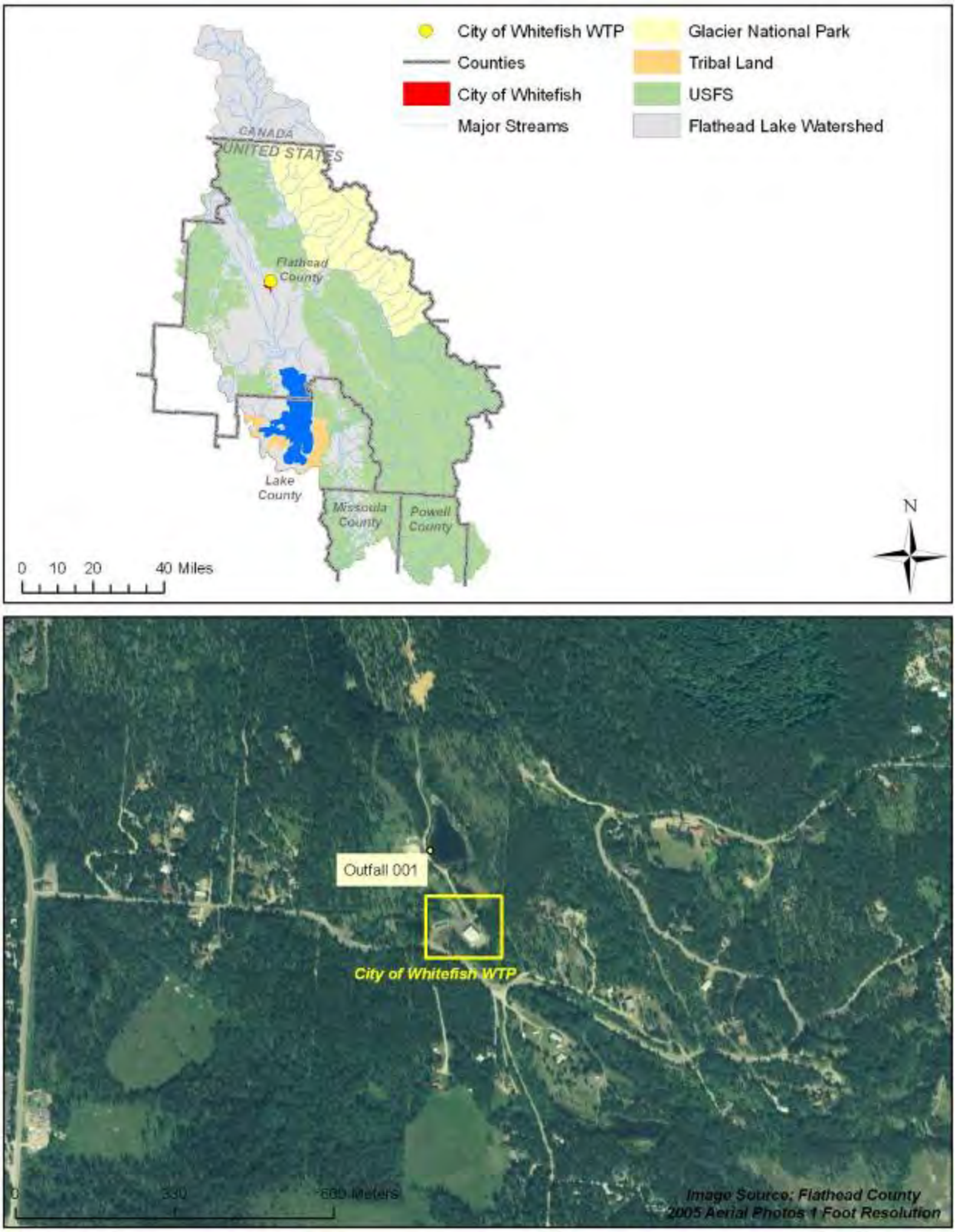


Figure 35. Whitefish WTP and permitted outfall.

Table 34. Whitefish WTP permit limits

Constituent	Units	Average monthly limit	Average weekly limit	Maximum daily limit
Aluminum (dissolved)	mg/L	--	--	0.75
	lb/d	--	--	0.4
Chlorine (total residual)	mg/L	0.011	--	0.019
Turbidity (net change)	NTU	--	--	≤0

Source: DEQ 2007b.
Note: lb/d = pound per day; mg/L = milligrams per liter; NTU = Nephelometric turbidity units.

Table 34 and Table 35 summarize the available water quality data from outfall #001, which were obtained from the city of Whitefish (2000 to 2008) and ICIS (U.S. EPA 2013b). The average effluent flow during this period was 0.0195 cfs. No nutrient data were available for this facility.

Table 35. Whitefish WTP flow (cfs) data summary - Data from Whitefish WTP

Location	Start date	End date	No. of records	Avg.	Min.	Max.
Haskill Reservoir	1/15/2001	5/15/2008	89	1.61	0.0869	3.27
Whitefish Lake PS	1/15/2001	5/15/2008	89	0.262	0	2.27

Source of data: Greg Acton, Public Works Utilities Supervisor, City of Whitefish, June 4, 2008.
Notes
Only flow in cubic feet per second is reported for this facility.
avg. = average (arithmetic mean); cfs = cubic feet per second; max. = maximum; min. = minimum.

Table 36. Whitefish WTP flow (cfs) data summary - Data from ICIS

Constituent	Start date	End date	No. of records	Avg.	Min.	Max.
Conduit Flow	12/29/2000	1/18/2013	143	0.0195	0.00866	0.0562

Source of data: ISIS (U.S. EPA 2013b)
Notes
Only flow in cubic feet per second is reported for this facility.
DMR records from ICIS are monthly averages.
avg. = average (arithmetic mean); max. = maximum; min. = minimum.

2.11 Lake McDonald (Glacier National Park) WWTP (MT0030601)

Glacier National Park operates a wastewater treatment facility that is on the west side of the park near the town of West Glacier, Montana (Figure 36). The plant serves the park headquarters, Apgar, Fish Creek, and western Lake McDonald regions of the park (Figure 37).[34] It was built in 2004, and consists of three aerated lagoons. The design flow is 0.25 mgd.

The WWTP is permitted to discharge effluent to a series of ponds which are used to store effluent (DEQ 2007c). All plant effluent is then land applied to a 10 acre field located on a bench next to the Flathead River.[35] Land application occurs almost continuously once the ground is thawed, generally from April to October of each year (Figure 36; MTG650045).

The most recent MPDES permit limits for the outfall are shown in Table 36. The permit requires the pH of the effluent to remain between 6.0 and 9.0 standard units and there cannot be any visible foam, oil sheen, or floating solids in the effluent. The permit also requires an 85 percent reduction in TSS and BOD_5 and for there to be no acute toxicity.

The Glacier National Park WWTP has a permit (MTG650045) to dispose of sewage sludge at the Glacier Gold facility in Olney, Montana. No sludge is land applied[36] (i.e., only effluent wastewater is land applied).

[34] Jim Foster, Deputy Chief of Facility Management, Glacier National Park, personal communication, July 18, 2008.
[35] Ibid.
[36] Jim Foster Deputy Chief of Facility Management, Glacier National Park, personal communication, July 18, 2008.

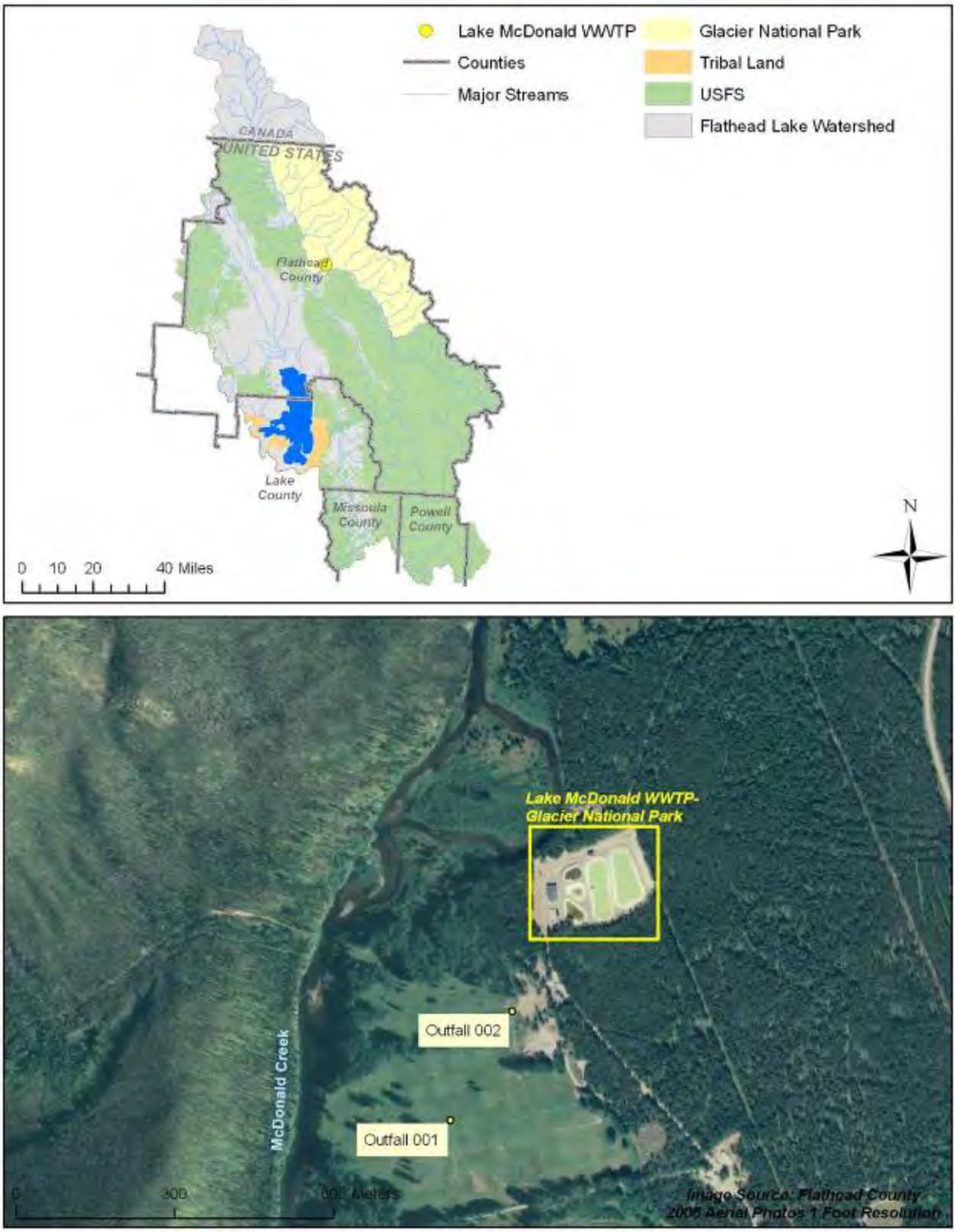


Figure 36. Lake McDonald WWTP permitted outfalls.



Figure 37. Lake McDonald WWTP service area.

Table 37. Lake McDonald WWTP permit limits

Constituent	Units	Average monthly limit	Average weekly limit	Maximum daily limit
BOD_5	mg/L	30	45	--
	lb/day	50	75	--
TSS	mg/L	30	45	--
	lb/day	50	75	--
E. coli bacteria[a]	cfu/100mL	32	64	--
Total Ammonia	mg/L	3.0	--	--
	lb/d	5	--	--
Total Nitrogen[b]	mg/L	7.0	--	--
	lb/d	11.7	--	--
Total Phosphorus	mg/L	0.7	--	--
	lb/d	1.2	--	--

Source: DEQ 2012b.
Notes
BOD_5 = five-day biological oxygen demand; cfu/100mL = colony forming units per 100 milliliters; mg/L = milligrams per liter; TSS = total suspended solids.
a. Report geometric mean is more than one sample is collected per month.
b. Total Nitrogen is the sum of Total Kjeldahl Nitrogen plus NO2- (nitrite) and NO3- (nitrate).

Table 37 summarizes the available water quality data for outfalls #001 and #002, which were obtained from ICIS (U.S. EPA 2013b). Average monthly data were available from April 2005 to January 2013. During months with discharges, the average flow was 0.0952 cfs, and total nitrogen and total phosphorus were 4.66 mg/L and 0.0547 mg/l respectively.

Table 38. Lake McDonald WWTP data summary

Constituent	Start date	End date	No. of records	Avg.	Min.	Max.
Ammonia (total as N) (mg/L)	2/28/2012	1/11/2013	12	0.863	0.108	2
BOD, 5-day, 20 °C	4/13/2005	1/11/2013	93	0.774	0	4.85
Flow rate (cfs)[a]	4/13/2005	1/11/2013	102	0.0952	0.00681	1.11
Nitrogen (total) (mg/L)	2/28/2012	1/11/2013	12	4.66	2.06	12.1
NO_2+NO_3 (total as N) (mg/L)	2/28/2012	1/11/2013	12	3.15	0.52	10.8
Phosphorus (total) (mg/L)	2/28/2012	1/11/2013	12	0.0547	0	0.27
TKN (total as N) (mg/L)	2/28/2012	1/11/2013	12	1.51	0.47	3.1
TSS (mg/L)	4/13/2005	1/11/2013	94	0.767	0	8.5

Source of data: ISIS (U.S. EPA 2013b)
Notes
DMR records from ICIS are monthly averages.
The facility did not discharge during every month of operation. Outfall #001 only had 6 months with reported discharge data, while outfall #002 had 35 months with reported discharge data from November 2003 to March 2008.
avg. = average (arithmetic mean); BOD = biological oxygen demand; C = Celsius; cfs = cubic feet per second; max. = maximum; mg/L = milligrams per liter; min. = minimum; N = nitrogen; NO_2+NO_3 = nitrite plus nitrate; TKN = total Kjeldahl nitrogen; TSS = total suspended solids.
a. Flows were reported as gallons per minute in the DMR reports. This was assumed to be incorrect, and the units were changed to gallons per day.

2.12 Donald G. Abbey House (MT0030651)

The Donald G. Abbey private residence is located on Shelter Island in Flathead Lake (Figure 38). The residence is authorized to discharge non-contact cooling water from a heat exchange system to Flathead Lake. The house has a heating and cooling system that consists of a closed loop heat exchange system that withdraws water from Flathead Lake, removes or adds heat to the source water and then returns the water to the lake. The water is pumped from and returned to the lake through intake and return pipes running along the bottom of Flathead Lake. The outfall location is located at a depth of 25 feet below minimum lake elevation, in a thermocline, and approximately 150 feet offshore. The water enters the system at approximately 44 degrees Fahrenheit (° F) and exits at 50° F in the summer (DEQ 2003). During the winter months, water enters at approximately 40° F and is discharged at 38° F. The discharge is at the south end of Shelter Island in Flathead Lake, which is just east of Big Arm Bay in Flathead Lake.

Effluent is required to have a temperature between 35° F and 79° F and a pH between 6.0 and 9.0 standard units; additionally, the effluent cannot cause a visible oil sheen in Flathead Lake (DEQ 2013). The facility is required to monitor its thermal discharges, flow, and pH. DMR data were obtained from ICIS by U.S. EPA (2013b). Table 38 summarizes the available DMR data. The design flow is 0.5 mgd. Flow data indicate an average of 0.419 cfs (0.27 mgd).

Table 39. Donald G. Abbey house data summary

Parameter	Start date	End date	No. of records	Avg.	Min.	Max.
Flow rate (cfs)	1/10/2005	1/7/2013	47	0.419	0.00511	0.8
Temperature (°C)	1/10/2005	1/7/2013	47	11.5	2.78	23.1

Source of data: ISIS (U.S. EPA 2013b)
Notes
DMR records from ICIS are monthly averages.
avg. = average (arithmetic mean); C = Celsius; cfs = cubic feet per second; max. = maximum; min. = minimum.

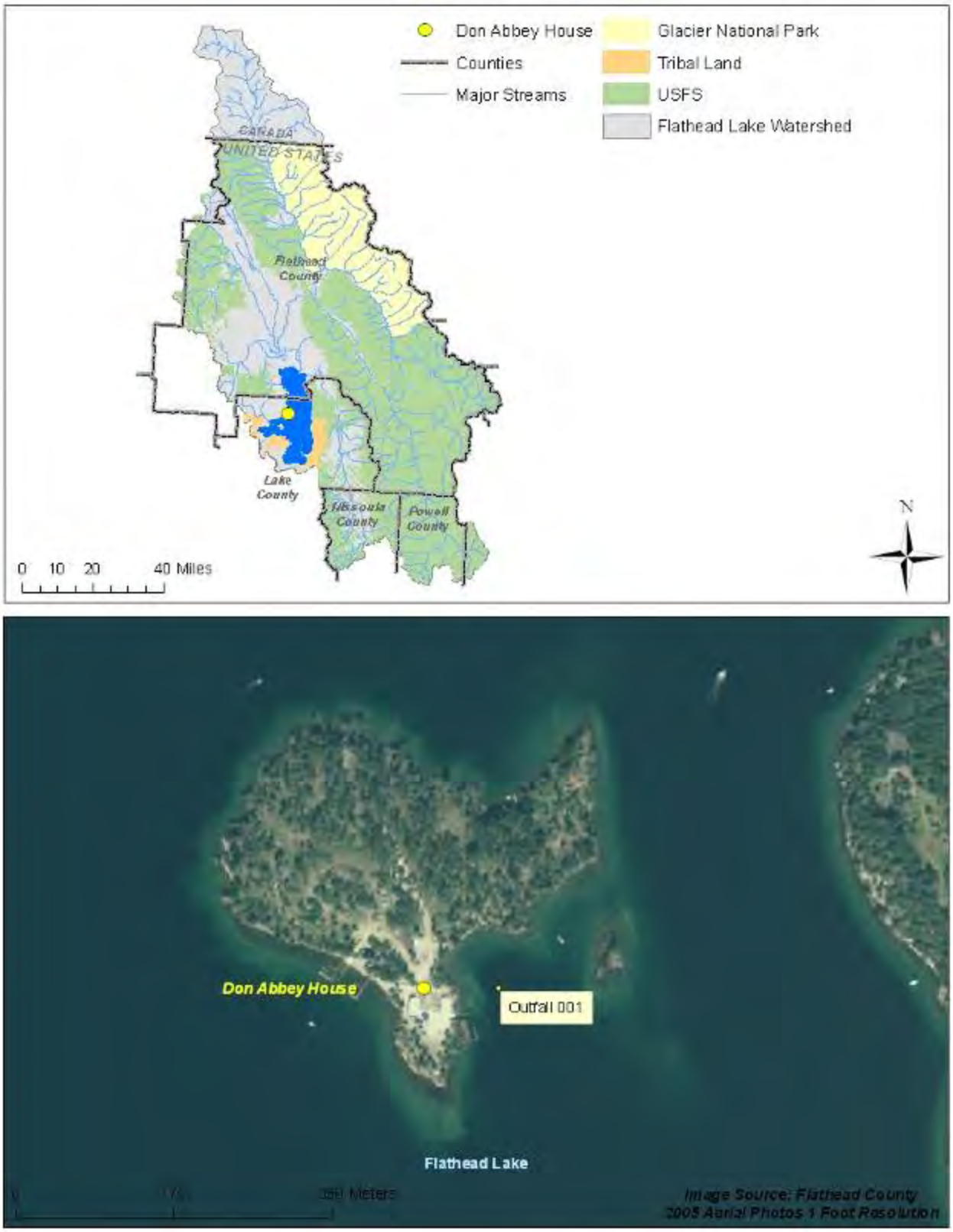


Figure 38. Donald G. Abbey house and permitted outfall.

2.13 John Collins Pool House (MT0031658)

The John Collins private residence is on Whitefish Lake (Figure 39). The residence is authorized to discharge non-contact cooling water from a heat exchange system to Whitefish Lake. The house has a heating and cooling system which consists of a closed loop heat exchange system that withdraws water from Whitefish Lake. The water is pumped from and returned to the lake through intake and return pipes (both are 3 inch polyethylene) running along the bottom of Whitefish Lake. The intake is at a 50 foot depth, approximately 50 feet offshore from Eagle Point. The outfall is at a depth of 80 feet and approximately 70 feet offshore from Eagle Point.

Effluent is required to have a temperature between 32° F and 66° F and a pH between 6.0 and 9.0 standard units; additionally, the effluent cannot cause a visible oil sheen in Flathead Lake (DEQ 2010b). The facility is required to monitor its thermal discharges, flow, and pH. DMR data were obtained from ICIS by U.S. EPA (2013b). Table 39 summarizes the available DMR data. Flow data indicate an average of 0.17 cfs.

Table 40. John Collins pool house data summary

Parameter	Start date	End date	No. of records	Avg.	Min.	Max.
Flow rate (cfs)	7/26/2012	1/28/2013	7	0.172	0.168	0.175
Temperature (°C)	7/26/2012	1/28/2013	7	19.6	14.6	24.6

Source of data: ISIS(U.S. EPA 2013b)
Notes
DMR records from ICIS are monthly averages.
avg. = average (arithmetic mean); C = Celsius; cfs = cubic feet per second; max. = maximum; min. = minimum.

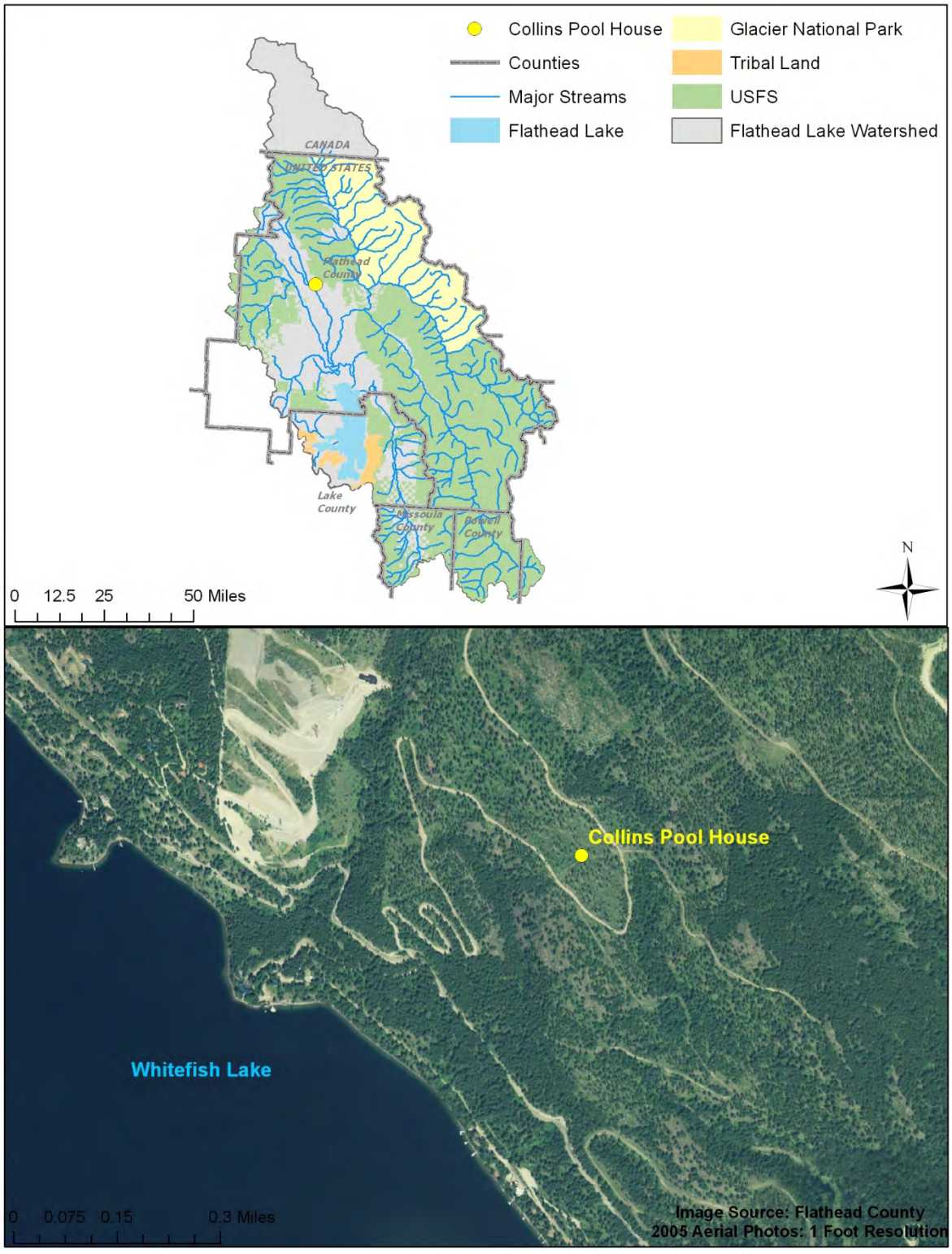


Figure 39. John Collins pool house.

2.14 BNSF Railway KRY Site Petroleum Cleanup (MT0031739)

Burlington North Santa Fe Railway Company operates a petroleum cleanup site in Kalispell Montana (Figure 40). The remedial wastewater treatment system is a rock wash, with a design flow of 0.025 mgd that discharges to the Stillwater River (DEQ 2012a).

The permit (MT0031739) includes limits to BOD, TSS, metals, and petroleum hydrocarbons (DEB 2012a). The BOD and TSS limits are 53.0 mg/L and 11.3 mg/L (respectively) and are maximum daily limits. The permit also requires the pH of the effluent to remain between 6.0 and 9.0 standard units and there cannot be any visible foam, oil sheen, or floating solids in the effluent. The facility must also perform whole effluent toxicity monitoring for acute toxicity each year.

U.S. EPA (2013b) obtained all available DMR data for the Flathead Lake basin; data were not available for this facility.

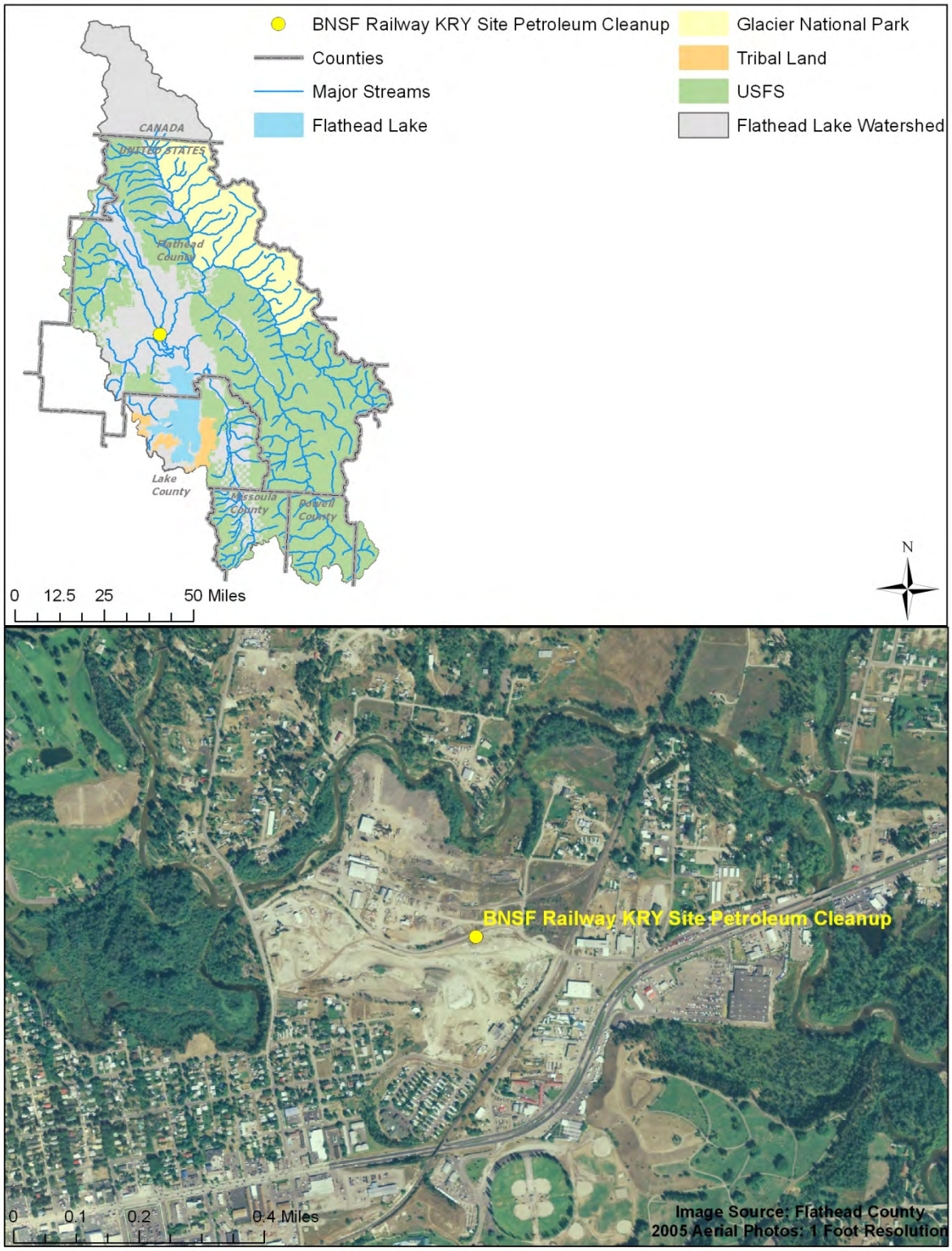
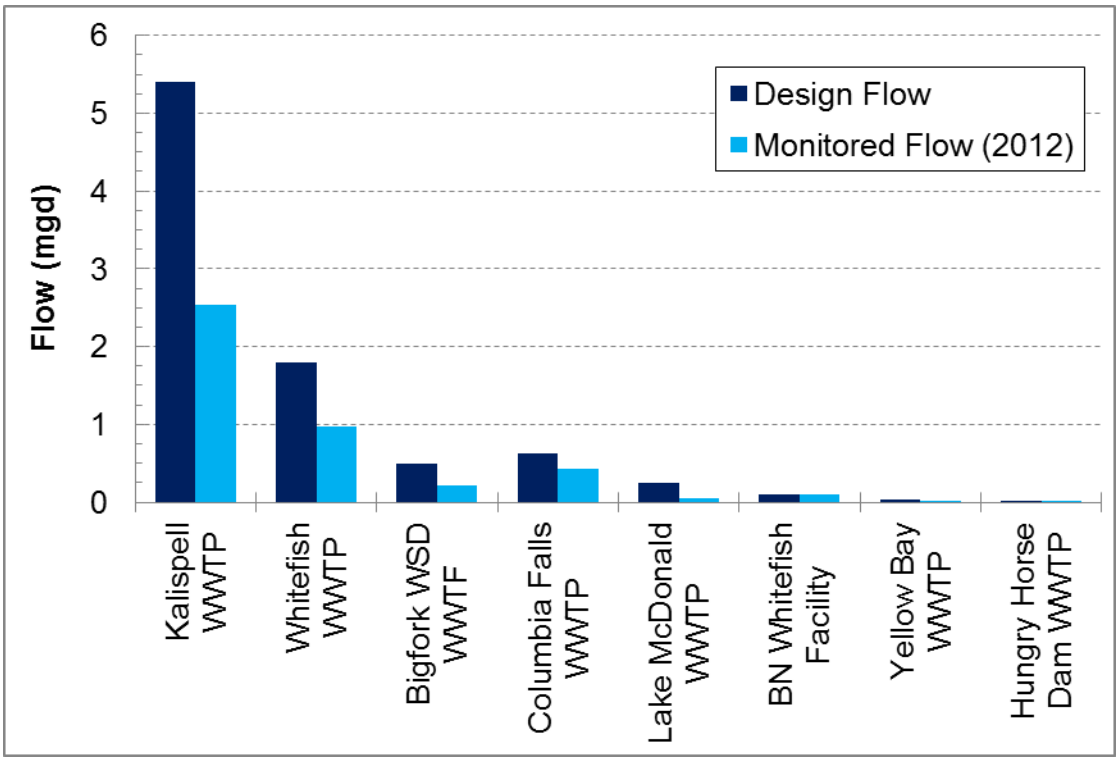


Figure 40. BNSF Railway Company KRY Site.

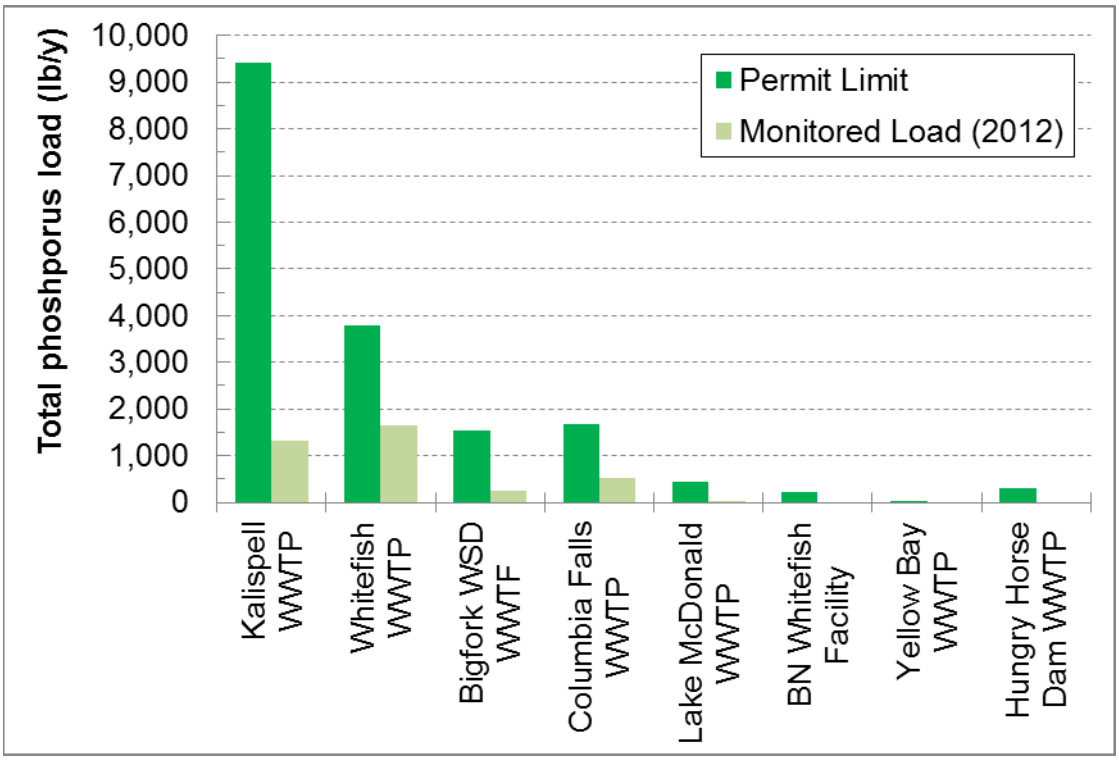
2.15 Comparing Nutrient Loads of Individual MPDES Permitees

Only eight of the 17 facilities with individual MPDES permits have nutrient permit limits: Bigfork WWTF, Burlington-Northern Whitefish Facility, Columbia Falls WWTP, Hungry Horse Dam WWTP, Lake McDonald WWTP, Kalispell WWTP, Whitefish WWTP, and Yellow Bay WWTP. Figure 41, Figure 42, and Figure 43 display the *permitted* and *actual* flow volumes, total phosphorus loads, and total nitrogen loads (respectively) for these facilities. These figures indicate the potential flow and loads that each facility is theoretically allowed to discharge according to the permits. Note that permits issued more recently require discharge concentrations that are less than those allowed from older permits.



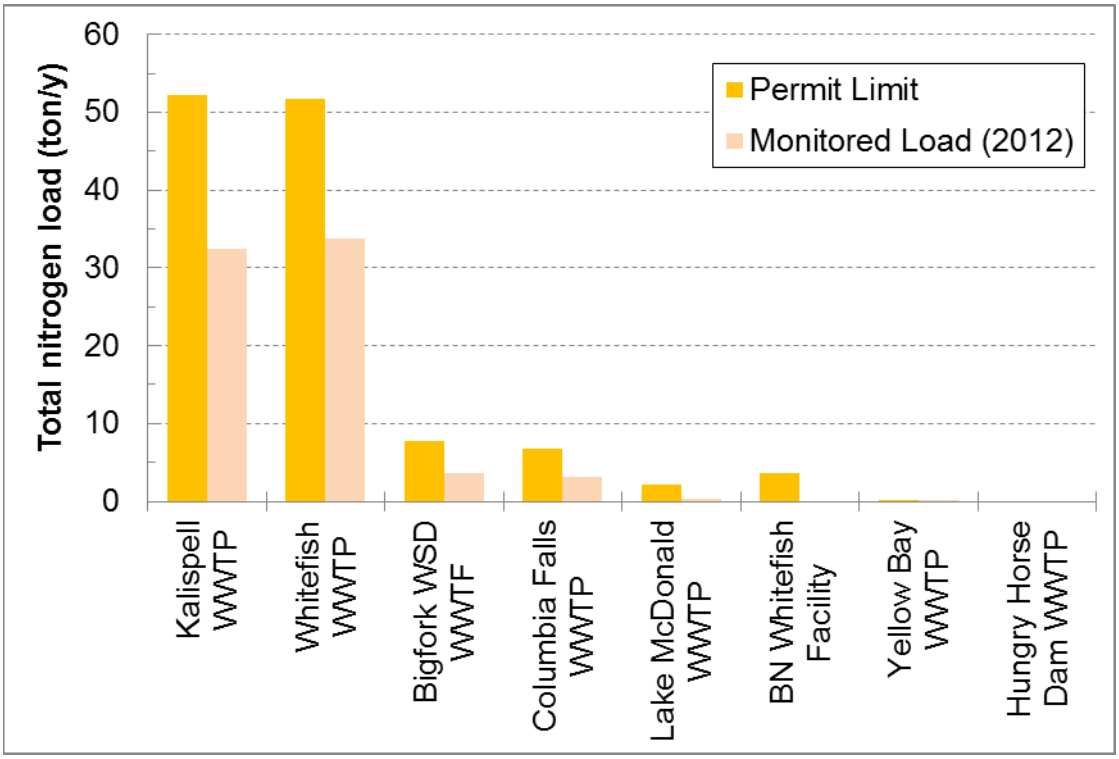
Sources of monitoring data: Curt Konecky (Kalispell WWTP), Greg Acton (Whitefish WWTP), Julie Spencer (Bigfork WSD WWTF , Hugh Robertson (Columbia Falls WWTP), and U.S. EPA 2013b for the other facilities.
Sources of permit information: DEQ 2001b, 2007, 2008a,c, 2009, 2010a, and 2012b; U.S. EPA 2012a

Figure 41. Flows for the eight facilities with phosphorus or nitrogen permit limits.



Sources of monitoring data: Curt Konecky (Kalispell WWTP), Greg Acton (Whitefish WWTP), Julie Spencer (Bigfork WSD WWTF , Hugh Robertson (Columbia Falls WWTP), and U.S. EPA 2013b for the other facilities.
Sources of permit information: DEQ 2001b, 2007, 2008a,c, 2009, 2010a, and 2012b; U.S. EPA 2012a
Note: Total phosphorus monitoring data are not available for the Burlington North Whitefish Facility or Hungry Horse Dam WWTP.

Figure 42. Permitted annual total phosphorus loads (pounds per year).



Sources of monitoring data: Curt Konecky (Kalispell WWTP), Greg Acton (Whitefish WWTP), Julie Spencer (Bigfork WSD WWTF , Hugh Robertson (Columbia Falls WWTP), and U.S. EPA 2013b for the other facilities.
Source of permit information: DEQ 2001b, 2007, 2008a,c, 2009, 2010a, and 2012b; U.S. EPA 2012a
Note: Total nitrogen monitoring data are not available for the Burlington North Whitefish Facility, Yellow Bay WWTP, or Hungry Horse Dam WWTP.

Figure 43. Permitted annual total nitrogen loads (tons per year)

2.16 Trends in Annual Nutrient Loads for the largest, continuously discharging facilities

An analysis of permit limits, facility status, and available data shows that the following four MPDES-permitted facilities are the largest continuously discharging facilities (by volume) in the basin: Kalispell WWTP, Whitefish WWTP, Columbia Falls WWTP, and Bigfork Water and Sewer District WWTF. Polson WWTP is excluded from this analysis and the rest of the analyses in this section because it discharges downstream of Flathead Lake.

Figure 44 and Figure 45 shows the annual effluent and influent flows at these four facilities. Annual effluent flow at the Whitefish WWTP and Columbia Falls WWTP has fluctuated from year to year. Annual effluent flow at the Kalispell WWTP generally increased from 1998 through 2008 and, with the exception of 2011, generally decreased from 2009 through 2012. Annual effluent flow at the Bigfork Water and Sewer District WWTF has slowly increased.

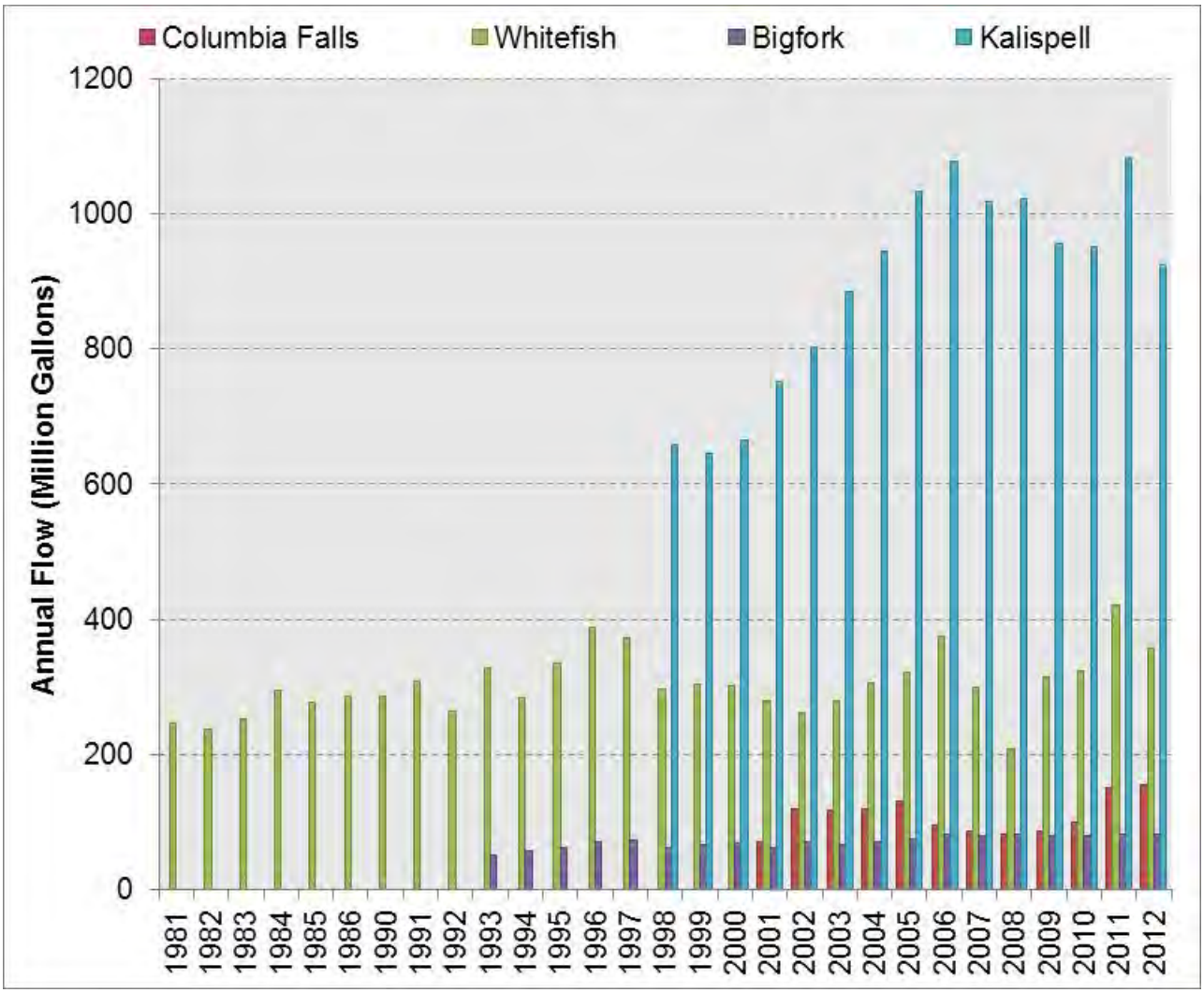


Figure 44. Effluent flow (million gallons per year) at the largest continuously discharging facilities.

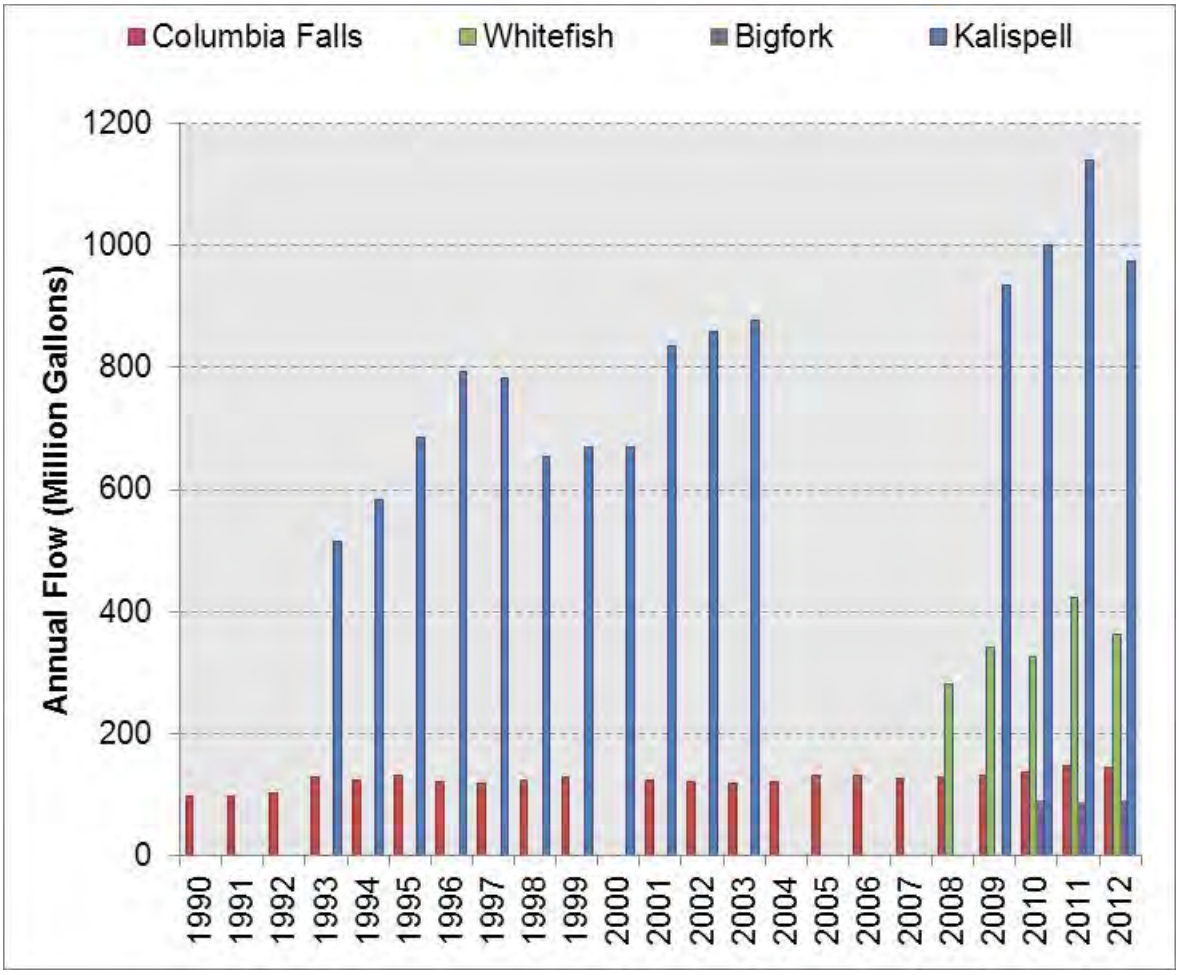


Figure 45. Influent flow (million gallons per year) at the largest continuously discharging facilities.

Similar to Figure 44, Figure 46 displays total phosphorus loads at these four facilities to the most recent year with data. Annual loads vary with fairly steady increases observed at all four facilities. It should be noted that the trends (or lack thereof) in annual loads could reflect actual conditions at the facilities or natural variations with the limited sampling data (i.e., most facilities only report a single phosphorus concentration per month which is suboptimal for calculating annual loads).

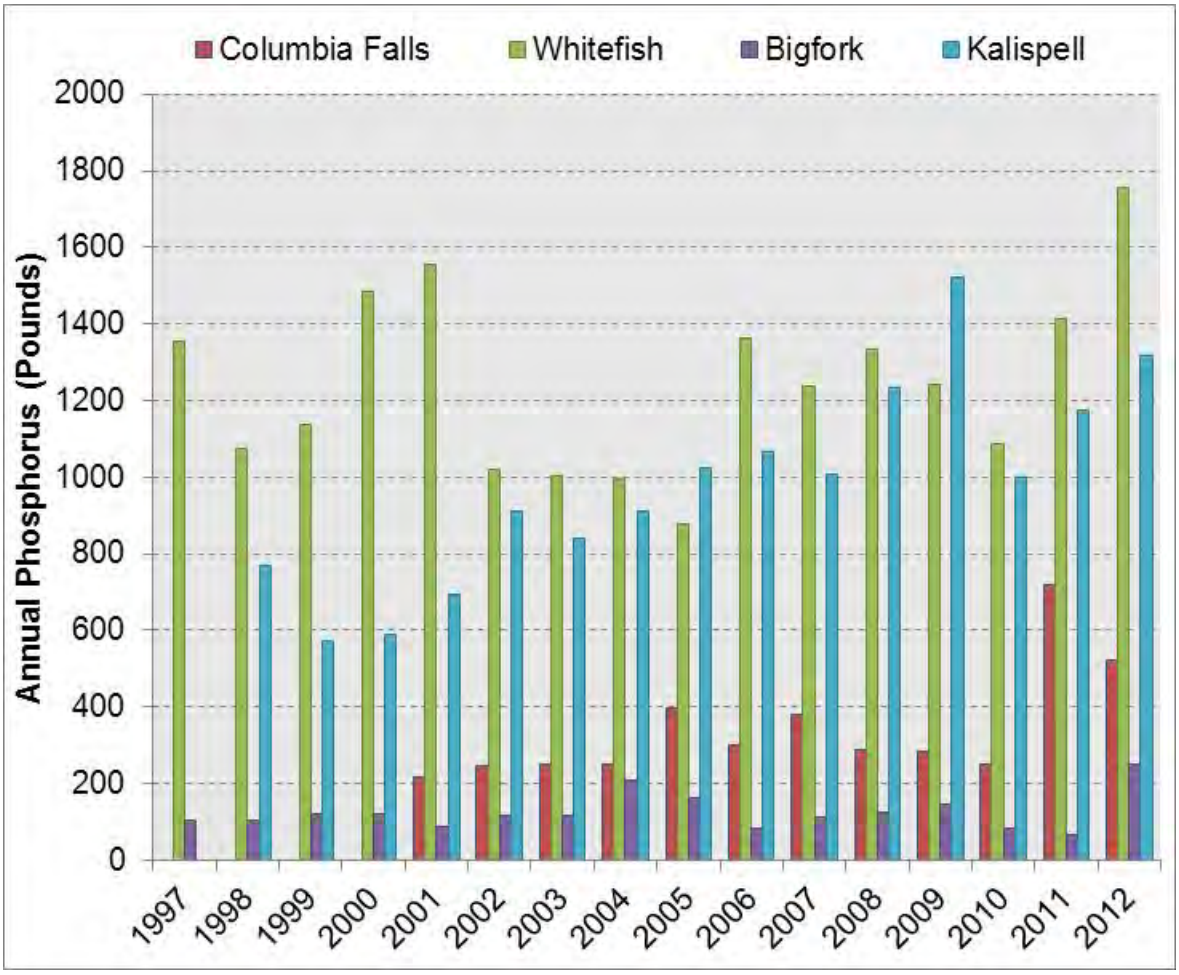


Figure 46. Total phosphorus loads (pounds per year) at the largest continuously discharging facilities.

Figure 47displays total nitrogen loads at these four facilities to the most recent year with data. Annual nitrogen loads varied with no consistent, obvious trends.

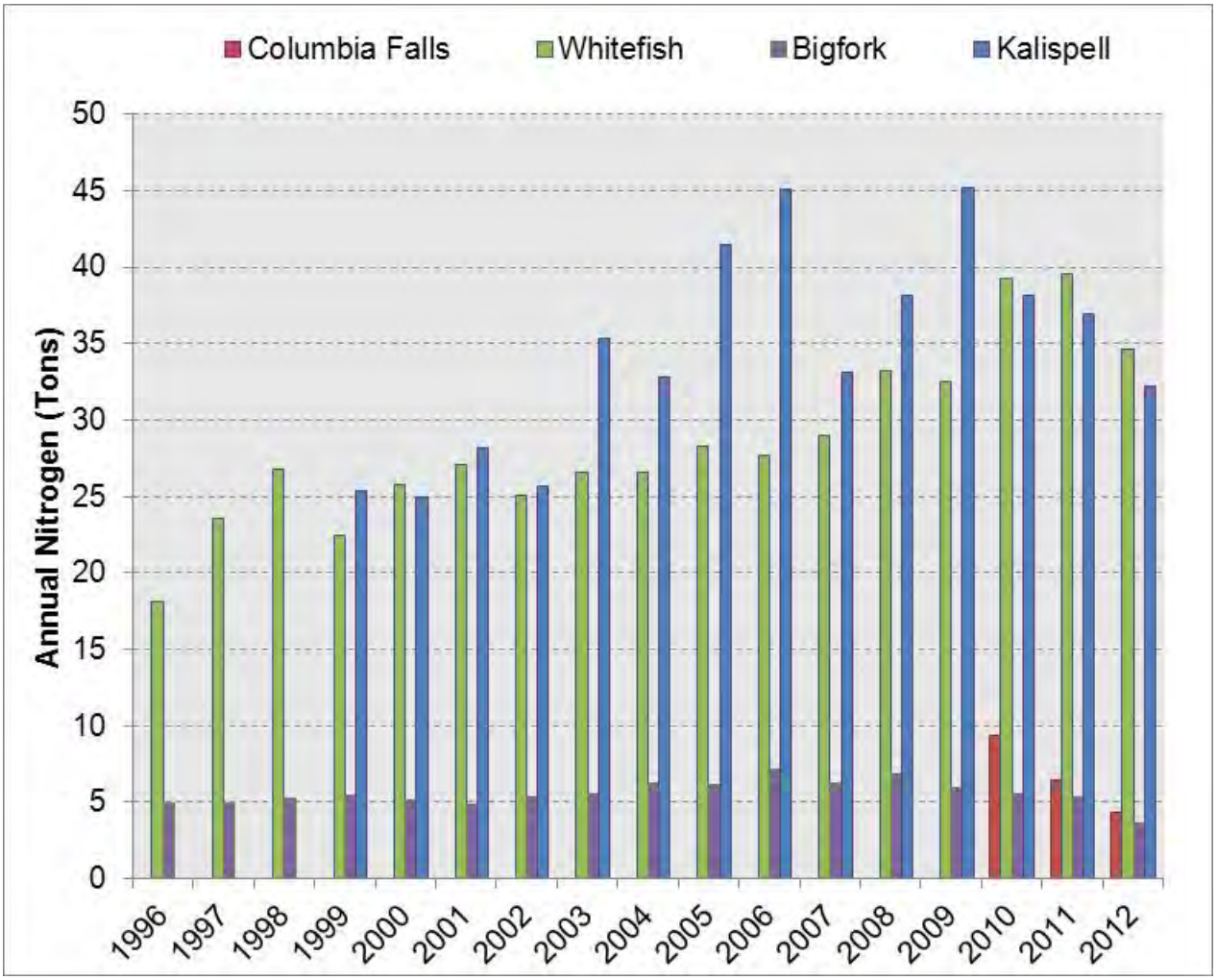


Figure 47. Total nitrogen loads (tons per year) at the largest continuously discharging facilities.

3.0 MGWPCS Permits

Sixteen facilities are permitted to discharge effluent to groundwater in the Flathead Lake basin (Table 40). DEQ administers the Montana Groundwater Pollution Control System and data are managed within the DMR framework[37]. The groundwater discharges are issued permits that begin with MTX, though they are not MPDES permits. Monitoring data are available for some of these facilities, which are presented in this section. It is noteworthy that some MGWPCS permitees formerly had individual MPDES permits. Facilities without current permits (see footnotes *a* and *b* in Table 40) are not further discussed, with the exception of International RV LLC (aka Paradise Pines RV Condominiums).

Table 41. MGWPCS permits in the Flathead Lake basin

Permit no.	Name
MTX000066	Meadow Dairy Gold
MTX000092	Plum Creek Manufacturing Facility
MTX000100	Stampede Packing Company (aka Meat Production Inc.)
MTX000120 [a]	International RV LLC (aka Paradise Pines RV Condominiums)
MTX000133 [a]	Ehrman Lease Subdivision
MTX000155 [a]	Kelsey Subdivision WWTF
MTX000164	Glacier Ranch Subdivision
MTX000173 [b]	Fox Hill Subdivision
MTX000183 [a]	Paradise Cove RV Condominium Community
MTX000188	Kootenai Lodge Lake County Water and Sewer District
MTX000193	Hungry Horse Wastewater Treatment Plant
MTX000199	Cove Creek Ridge Subdivision (TLW Properties LLC)
MTX000200 [a]	Crown Jewel Estates
MTX000214	Point of Pines Wastewater Treatment System
MTX000220	Glacier International Airport Rental Car Facility Car Wash (FCA Rentals LLC)
MTX000228 [b]	FH Stoltze Land and Lumber Company

Notes
aka = also known as; LLC = limited liability company; RV = recreational vehicle; WWTF = wastewater treatment facility.
a. Montana DEQ identified the permit as no longer necessary (e.g., the permit was terminated).
b. Montana DEQ identified the permit as pending (i.e., no permit has been written and no previous permit was written that could be administratively continued).

[37] Jason Gildea, U.S. EPA Region 8 Montana Operations Office, compiled DMR data for all permitted facilities in Flathead, Lake, and Missoula counties, including available groundwater monitoring data. He also compiled all available MGWPCS permits from DEQ for individually permitted facilities in the Flathead Lake basin.

3.1 Meadow Gold Dairy (MTX000066)

Meadow Gold Dairies, Inc. operates a milk-processing facility that is in Flathead County, near the City of Kalispell (Figure 48). The permit states that the dairy facility, "processes raw milk from area producers into fluid milk, cottage cheese, sour cream, butter, and dairy mixes (ice cream and milk shakes)" (DEQ 1996a). The milk-processing facility operates four days per week and produces two types of liquid wastes: (1) whey as a by-product of cottage cheese production and (2) rinse- and wash-water from the cleaning of production equipment. The whey is used as feed by local livestock producers. The weekly rinse- and wash-water volumes, ranging from 53,188 gallons to 94,600 gallons (Newman 1991), is land applied at two different locations. One area occupies stream deposits in and adjacent to the Smith Spring Creek floodplain. The other area is on poorly-sorted glacial till composed primarily of silt and clay intermixed with coarse sand, gravel, cobbles, and boulders (Montana Department of Health and Environmental Sciences Water Quality Bureau 1991).

The facility is required to monitor its outflow (outfall #001) and upstream and downstream in Smith Spring Creek. Monitoring data were obtained by U.S. EPA (2013b) from ICIS, and the data are summarized in Table 41. No data were available for the upstream or downstream stream sites on Smith Spring Creek.

Table 42. Meadow Gold Dairy data summary

Constituent	Start date	End date	No. of records	Avg.	Min.	Max.
BOD_5 (mg/L)	12/31/2002	10/15/2012	27	6,200	10	22,700
TKN (mg/L)	12/31/2002	10/15/2012	27	130	2.23	276

Source of data: ISIS (U.S. EPA 2013b)
Notes
DMR records from ICIS are monthly averages.
avg. = average (arithmetic mean); BOD_5 = five-day biological oxygen demand; max. = maximum; mg/L = milligrams per liter; min. = minimum; TKN = total Kjeldahl nitrogen.

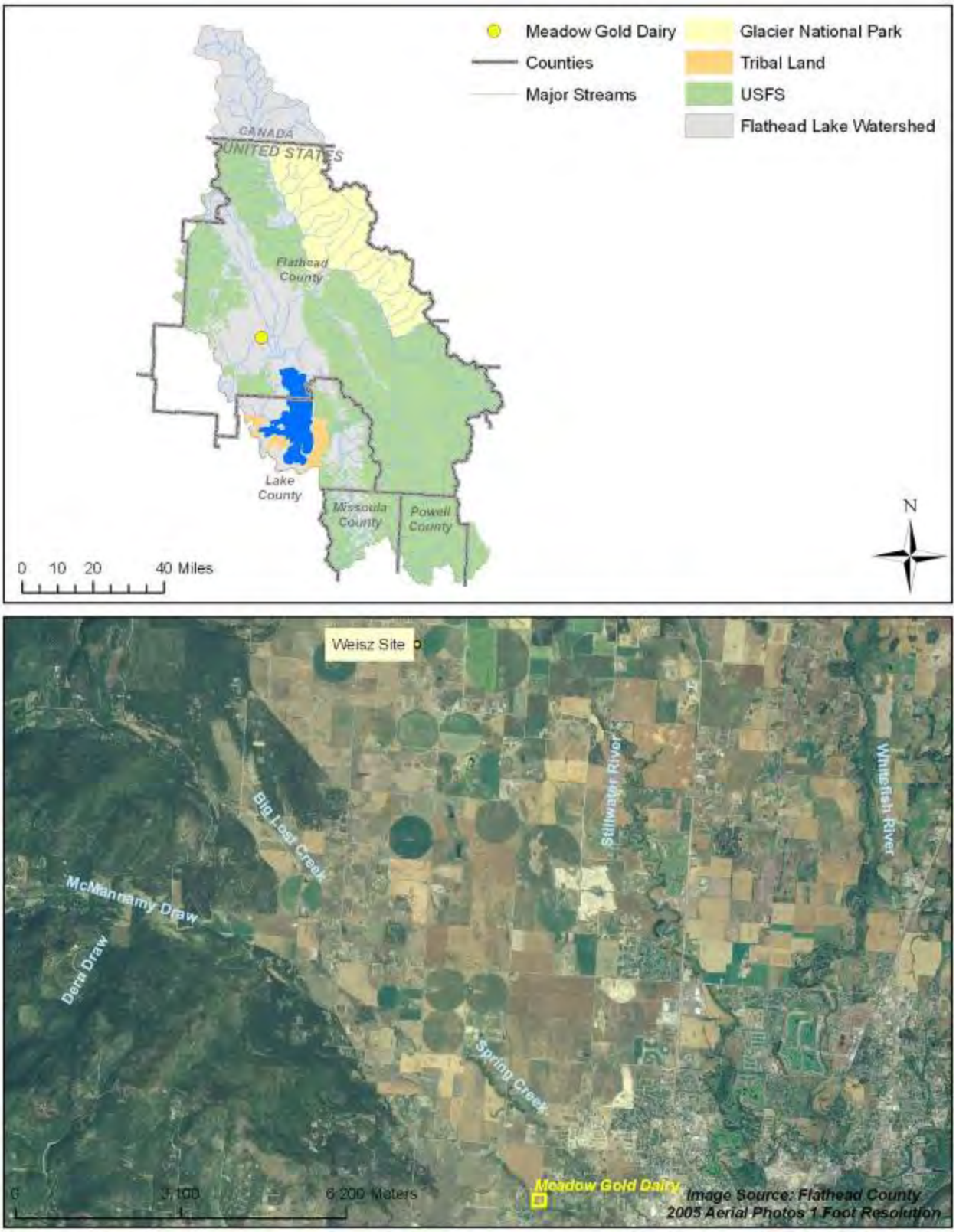


Figure 48. Meadow Gold Dairy and permitted outfall.

3.2 Plum Creek Manufacturing Facility (MTX000092)

Plum Creek Manufacturing, L.P. operates a sawmill that is in Columbia Falls, near the Flathead River (Figure 49). The facility is authorized to discharge process wastewater and stormwater to groundwater through one wastewater treatment and retention pond, a medium density fiberboard pond, an overflow pond, and a log pond (DEQ 1996b). The retention and treatment pond and medium density fiberboard pond receive process pit fluids and non-contact cooling water from the medium density fiberboard plant and stormwater routed from the log pond. The log pond receives boiler blowdown, softener backwash, boiler area washdown waster and excess log deck sprinkler runoff and storm water runoff. The MGWPCS permit limits (MTX000092) the pH of the effluent to remain between 6.0 and 9.0 standard units and limits nitrate plus nitrate to a maximum of 10 mg/L.

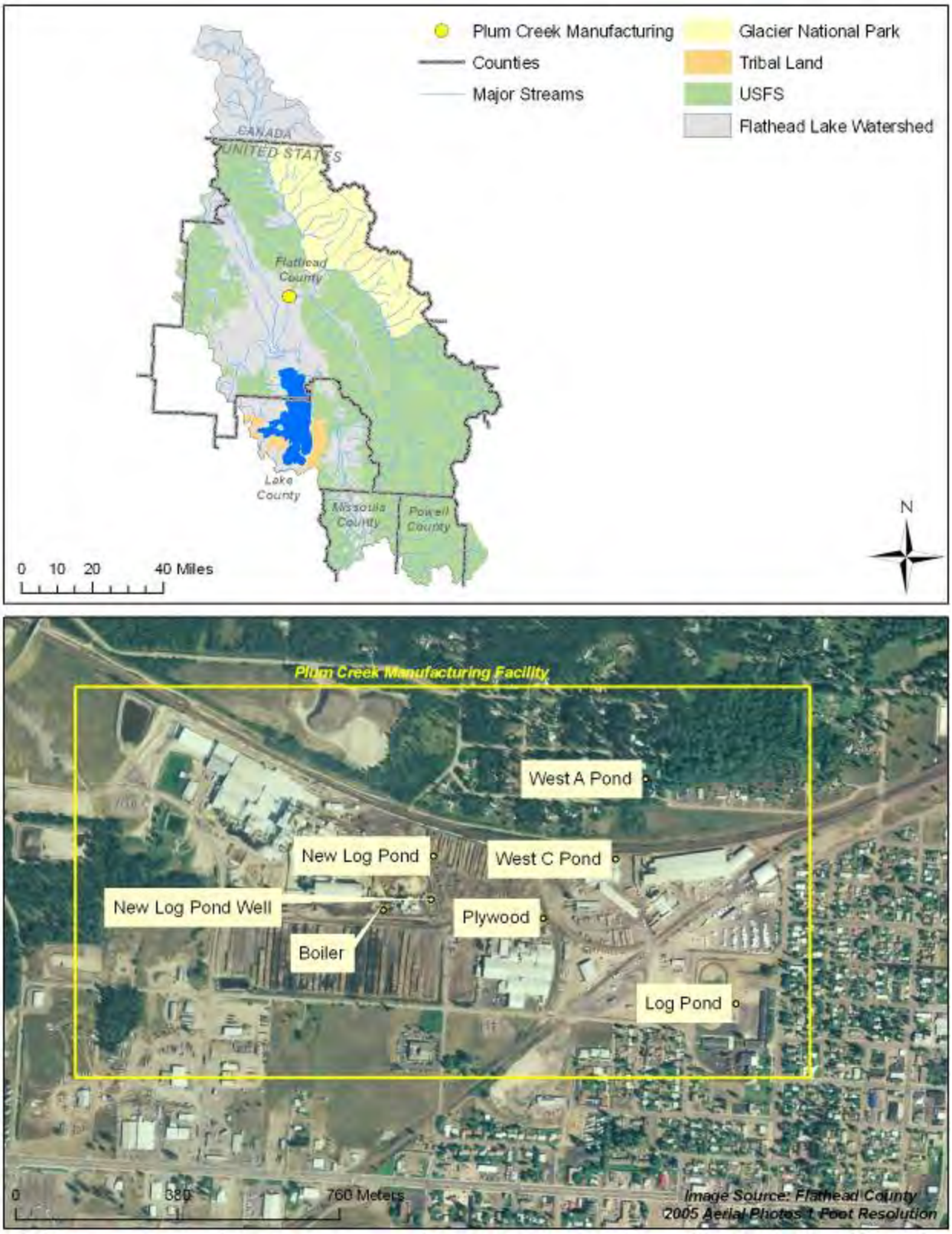


Figure 49. Plum Creek Manufacturing and permitted outfalls.

Water quality monitoring data for the facility were obtained from DMR records from ICIS that were provided by U.S. EPA (2013b) and are summarized in Table 42. DMR data are available for several monitoring wells and for four of the outfalls. The facility did not report flow data.

Table 43. Plum Creek Manufacturing data summary

Parameter	Start date	End date	No. of records	Avg.	Min.	Max.
Ammonia (total as N) (mg/L)	2/26/2003	10/27/2008	48	78.1	0.05	2,020
BOD, 5-day, 20 °C	5/1/2009	1/28/2013	94	79.1	1	705
Nitrogen (total) (mg/L)	5/1/2009	1/28/2013	111	3.92	0.25	17.1
NO_2+NO_3 (total as N) (mg/L)	10/25/2004	1/28/2013	77	0.739	0.005	2.06
Phosphorus (total) (mg/L)	5/1/2009	1/28/2013	115	1.05	0.005	3.03
TKN (total as N) (mg/L)	2/26/2003	1/28/2013	141	30	0.25	841

Source of data: ICIS (U.S. EPA 2013b)
Notes
DMR records from ICIS are monthly averages.
BOD = biological oxygen demand; C = Celsius; mg/L = milligrams per liter; N = nitrogen; NO_2+NO_3 = nitrite plus nitrate; TKN = total Kjeldahl nitrogen.

3.3 Stampede Packing Company (MTX000100)

The Stampede Packing Company (also known as Meat Production Inc.) is in Flathead County, near Kalispell (Figure 50). The facility is authorized to dispose of wastewater from meat cutting and packaging, laundry, and meat curing, into a standard pressurized drainfield (i.e., groundwater discharge) (DEQ 1997). Effluent from this facility is generated during cleanup of meat cutting, packaging and curing operations and laundry operations. The permit states that the daily maximum flow limit is 1,500 gpd with a daily average of 1,048 gpd (DEQ 1997). The facilities design flow is 0.002 mgd. The facility also has total nitrogen permit limits of 20.7 mg/L (maximum) and samples must be collected at the pump chamber prior to discharge to the drainfield (DEQ 2012b).

Monitoring data were obtained from ICIS (U.S. EPA 2013b) for 2012 to 2013. Table 43 summarizes the available DMR data for the Stampede Packing Company. Only two flow sampling dates were available in the DMR data. Flow averaged less than 0.01 cfs and total nitrogen averaged 58.8 mg/L.

Table 44. Stampede Packing Company data summary

Constituent	Start date	End date	No. of records	Avg.	Min.	Max.
Ammonia (total as N) (mg/L)	2/18/2004	10/27/2011	25	15.4	4.75	51.3
Flow rate (cfs)	12/10/2012	1/8/2013	2	0.00383	0.00368	0.00399
Nitrogen (total) (mg/L)	2/18/2004	1/8/2013	36	58.8	0.07	96.4
NO_2+NO_3 (total as N) (mg/L)	2/23/2012	1/8/2013	11	0.1	0.02	0.38
TKN (total as N) (mg/L)	2/23/2012	1/8/2013	12	66.7	45.2	96.4

Source of data: ICIS (U.S. EPA 2013b)
Notes
DMR records from ICIS are monthly averages.
cfs = cubic feet per second; mg/L = milligrams per liter; N = nitrogen; NO_2+NO_3 = nitrite plus nitrate; TKN = total Kjeldahl nitrogen.

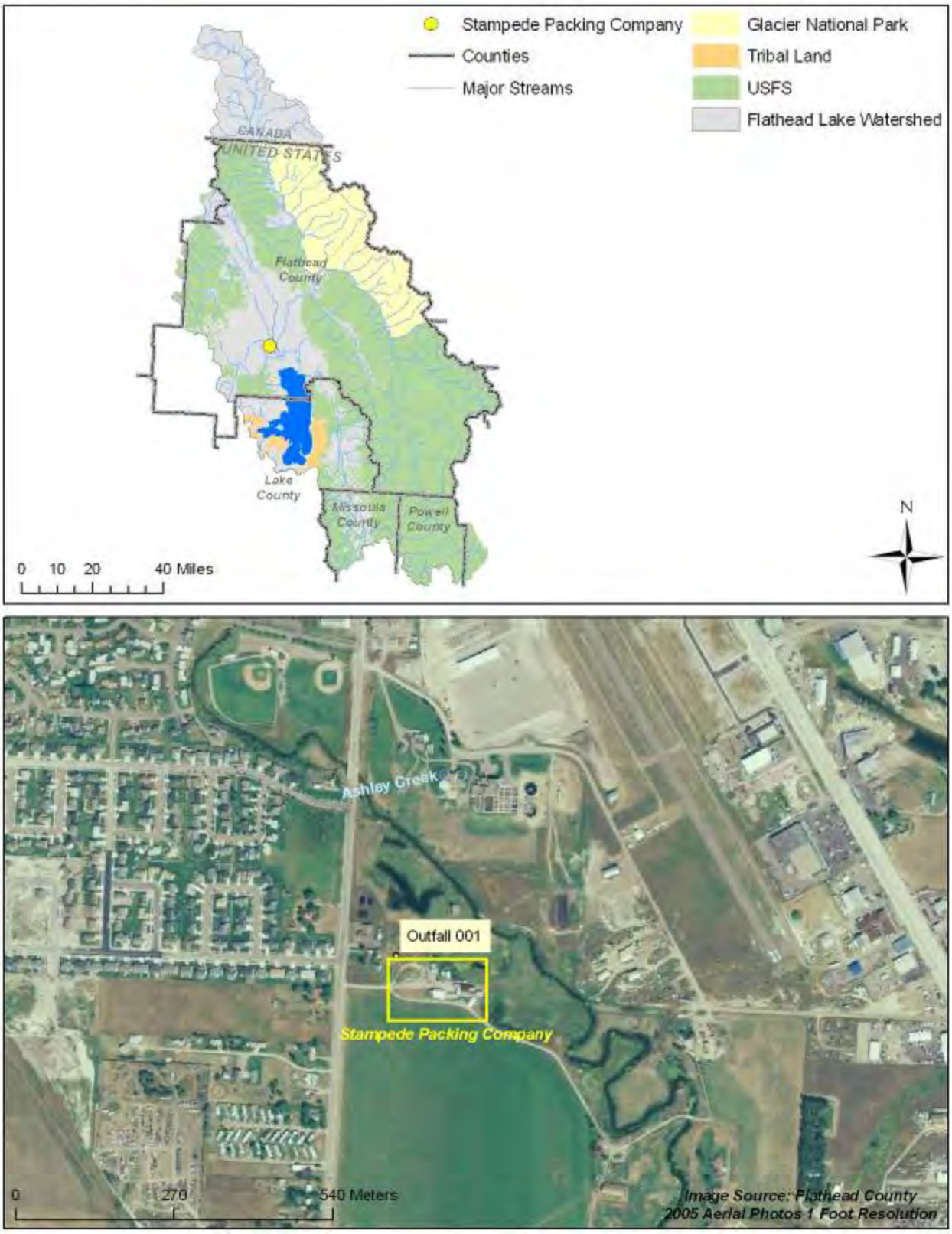


Figure 50. Stampede Packing Company and permitted outfall

3.4 International RV LLC (MTX000120)

International RV LLC (aka Paradise Pine RV LLC) is a mobile home and RV (recreational vehicle) community located in Lake County near the city of Polson, Montana (Figure 51). Wastewater from a single-family home, 15 mobile homes, 90 RV sites, and a restaurant is discharged to a sub-surface dosed drainfield to Class I groundwater (DEQ 2002). The 2002 MGWPCS permit was not renewed[38]. The old permit (DEQ 2002) had effluent limits for total inorganic nitrogen: 54 mg/L 30-day average concentration and 8.1 lb/d average annual load; the groundwater quality limits are shown in Table 44.

Table 45. Groundwater quality limits for the end of the mixing zone to protect Class I groundwater

Constituent	Units	Groundwater quality limits
Ammonia	mg/L	30
Nitrate plus nitrite	mg/L	10
Fecal coliform bacteria	organisms/100 mL	< 1
Specific conductance	µS/cm	≤ 1,000

Source: DEQ 2002.
Note: mg/L = milligram per liter; mL = milliliter; µS/cm = microsiemen per centimeter.

Monitoring data for outfall #001 were obtained from ICIS (U.S. EPA 2013b) and are summarized in Table 45. The average flow between 2006 and 2011 was 0.00657 cfs, with an average total phosphorus concentration of 6.01 mg/L and an average ammonia concentration of 40.8 mg/L.

Table 46. International RV LLC data summary

Constituent	Start date	End date	No. of records	Avg.	Min.	Max.
Ammonia (total as N) (mg/L)	8/10/2006	1/25/2011	51	40.8	4.84	89.1
BOD, 5-day, 20 °C	8/10/2006	1/25/2011	51	137	38	319
Flow rate (cfs)	8/14/2006	1/25/2011	53	0.00657	0.00000232	0.105
Inorganic nitrogen (total) (mg/L)	8/10/2006	1/25/2011	14	46.2	20.8	82.9
NO_2+NO_3 (total as N) (mg/L)	8/10/2006	1/25/2011	46	0.0359	0.01	0.24
Phosphorus (total) (mg/L)	8/10/2006	1/25/2011	51	6.01	1.46	11.8
TSS (mg/L)	8/10/2006	1/25/2011	51	41	9	194

Source of data: ICIS (U.S. EPA 2013b).
Notes
DMR records from ICIS are monthly averages.
cfs = cubic feet per second; mg/L = milligrams per liter; N = nitrogen; NO_2+NO_3 = nitrite plus nitrate; TSS = total suspended solids.

[38] DEQ declared that the facility did not need an MGWPCS permit. DEQ likely determined that the discharge was insignificant and did not impact nearby surface waters.

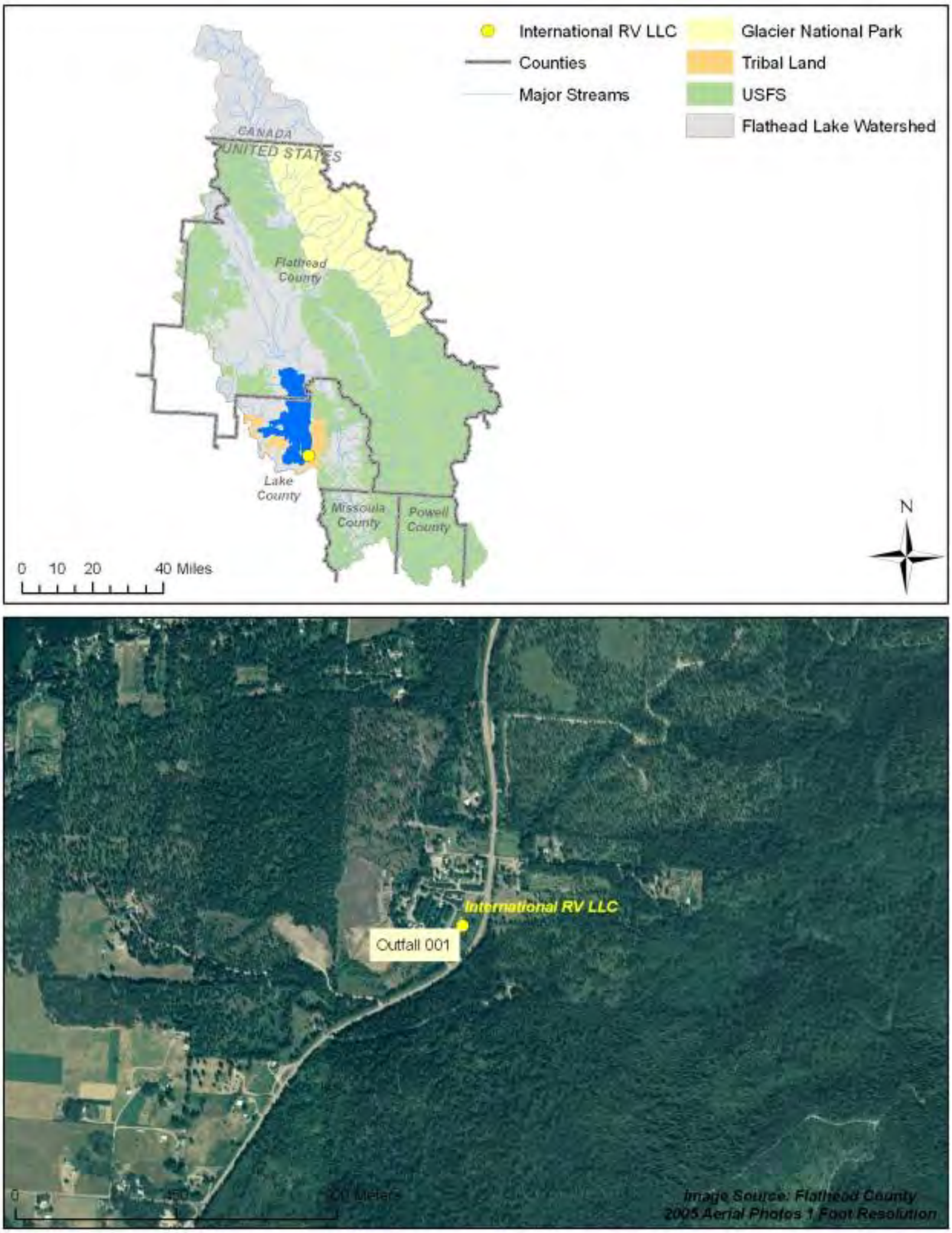


Figure 51. International RV LLC and permitted outfall.

3.5 Glacier Ranch Subdivision (MTX000164)

Glacier Ranch Subdivision (aka First Interstate Bank) is in Flathead County, north of Kalispell (Figure 52). Wastewater is discharged to a sub-surface dosed drainfield to Class I groundwater (DEQ 2007d). Information regarding the subdivision and wastewater treatment works was not reported in the MPDES permit. Additionally, the MGWPCS permit expired in 2012 and is assumed to be administratively continued.

The most recent MGWPCS permit limits are shown in Table 51; samples must be collected at the dose tank prior to discharge to the drainfields. The average daily design flow for outfall #001 is limited to no more than 52,000 gpd. The facility is also required to monitor groundwater from four shallow monitoring wells (MW1A, MW1B, MW1C, and MW1D). Three monitoring wells (MW1A, MW1B, and MW1C) are for monitoring compliance with the site-specific mixing zone and one monitoring well (MW1D) is for monitoring bacteria levels. The permit includes groundwater trigger values for all four monitoring wells. If at any time the trigger values are exceeded, Glacier Ranch Subdivision must implement additional permit requirements and corrective actions. Trigger values are shown in Table 50; the trigger value for MWID is only for *E. coli* (≥ 1 organisms per 100 mL).

Table 47. Glacier Ranch Subdivision permit limits

Constituent	Daily maximum concentration (mg/L) per outfall	30-day average load (lb/d) per outfall
Total Nitrogen, as N	26	6.51
Total Phosphorus, as P	2.5	1.08

Source: DEQ 2007d.
Notes: mg/L = milligram per liter; N = nitrogen; P = phosphorus.

Table 48. Groundwater trigger values for monitoring well MW1A, MW1B, and MW1C

Constituent	Units	Trigger values
E. Coli bacteria	organisms/100 mL	≥ 1
Nitrate	mg/L	7.5

Source: DEQ 2007d.
Note: mg/L = milligrams per liter; mL = milliliter.

Monitoring data were obtained from ICIS (U.S. EPA 2013b) and are summarized in Table 48. Data for the monitoring well show an average total nitrogen concentration of 0.69 mg/L. Only 3 sample event records were contained in the DMR dataset. No flows were reported.

Table 49. Glacier Ranch Subdivision data summary

Parameter	Start date	End date	No. of records	Avg.	Min.	Max.
Nitrate (total as N) (mg/L)	1/11/2012	1/11/2012	3	0.69	0.58	0.87
Nitrogen (total) (mg/L)	1/11/2012	1/11/2012	3	0.793	0.62	0.93
NO_2+NO_3 (total as N) (mg/L)	1/11/2012	1/11/2012	3	0.653	0.58	0.76
TKN (total as N) (mg/L)	1/11/2012	1/11/2012	3	0.27	0.21	0.35

Source of data: ICIS (U.S. EPA 2013b).
Notes
DMR records from ICIS are monthly averages.
avg. = average (arithmetic mean); max. = maximum; mg/L = milligrams per liter; min. = minimum; N = nitrogen; NO_2+NO_3 = nitrite plus nitrate; TKN = total Kjeldahl nitrogen.

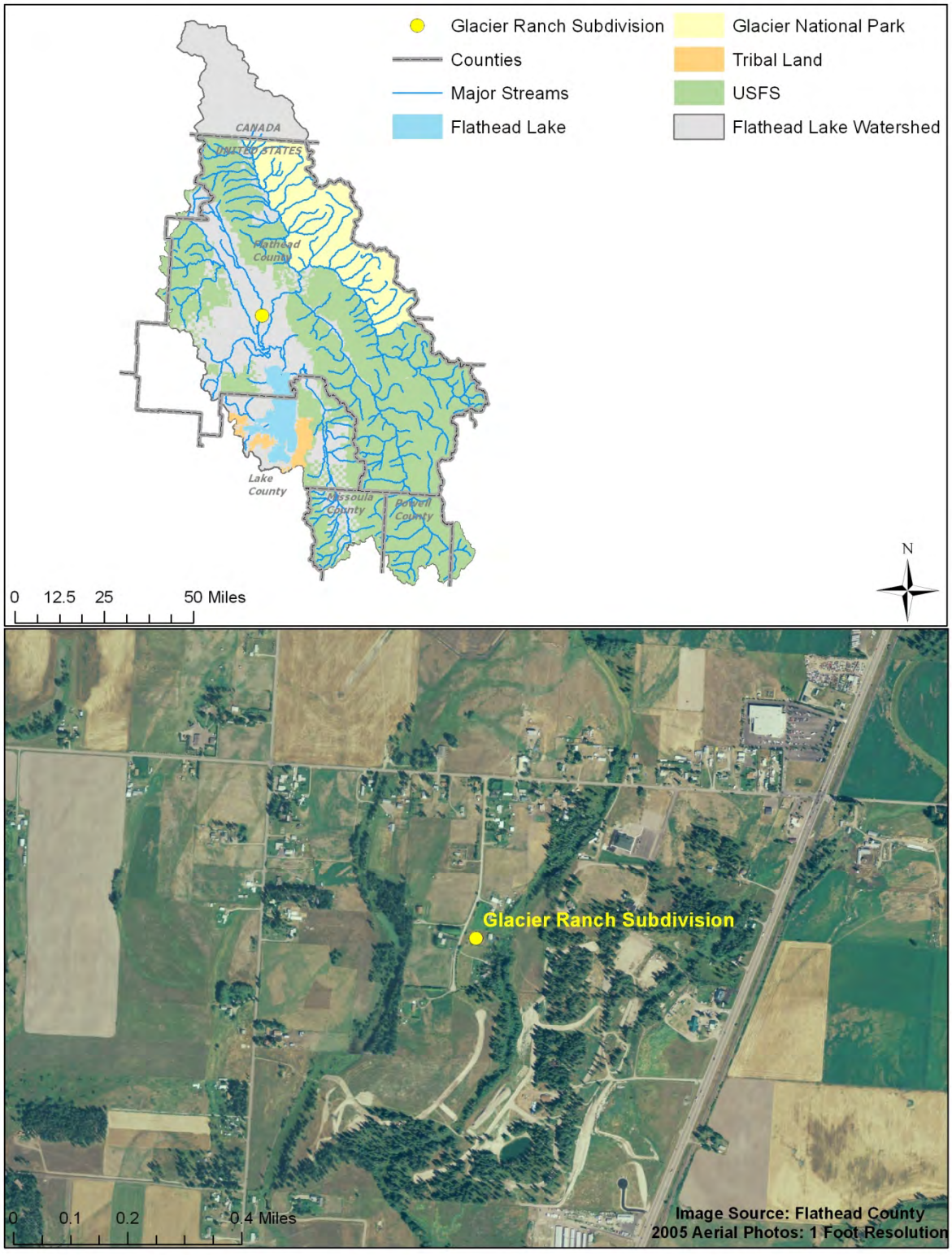


Figure 52. Glacier Ranch subdivision.

3.6 Kootenai Lodge/Lake County Water & Sewer District (MTX000188)

The Kootenai Lodge/Lake County Water and Sewer District is a residential development in Lake County near the town of Bigfork, Montana near the Swan River (Figure 53). The development complex consists of 53 single family homes, a lodge meeting room, and a pool. The Kootenai Lodge residential complex covers 40.9 acres of land. The facility is authorized to discharge to its sub-surface disposal to Class I groundwater (MTX000188). It has a design flow of 23,050 gpd.

The most recent MPDES permit limits are shown in Table 49. In addition to the limits listed below, the permit states that the average daily flow of effluent to outfall #001 and outfall #002 (combined) shall not exceed 15,100 gpd (DEQ 2007d). There must be at least 60 percent removal of total nitrogen from the raw influent. The permit includes groundwater trigger values for monitoring well MW1A (Table 50). Additional procedures and corrective actions are required if trigger values are exceeded (DEQ 2007d). Trigger values are shown in Table 50.

Table 50. Kootenai Lodge/Lake County Water and Sewer District permit limits for outfalls 001 and 002

Constituent	Daily maximum concentration (mg/L) per outfall	30-day average load (lb/d) per outfall
Total Nitrogen	67	8.34
Total Phosphorus	--	1.33

Source: DEQ 2007b.
Note: lb/d = pounds per day; mg/L = milligrams per liter.

Table 51. Groundwater trigger values for monitoring well MW1A

Constituent	Units	Trigger values
E. Coli bacteria	organisms/100 mL	≥ 1
Nitrate	mg/L	7.5

Source: DEQ 2007b.
Note: mg/L = milligrams per liter; mL = milliliter.

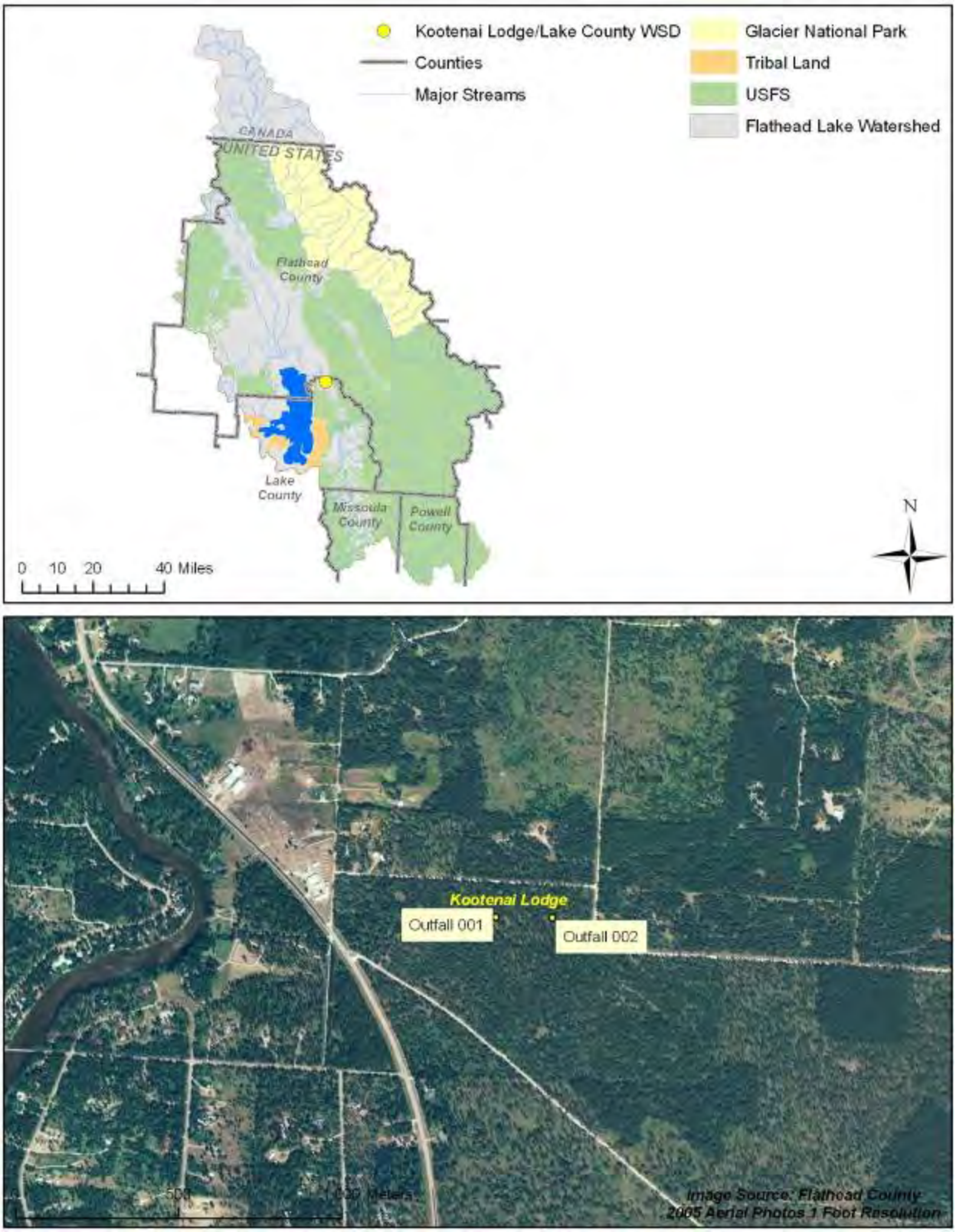


Figure 53. Kootenai Lodge/Lake County Water and Sewer District and permitted outfalls

Monitoring data for the two outfalls were obtained from ICIS (U.S. EPA 2013b) and are summarized in Table 51. Twenty flow samples were available from 2008 to 2013 with an average of less than 0.01 cfs. Data for the monitoring well show an average total nitrogen concentration of 10.8 mg/L and an average total phosphorus concentration of 1.34 mg/L.

Table 52. Kootenai Lodge/Lack County Water and Sewer District data summary

Constituent	Start date	End date	No. of records	Avg.	Min.	Max.
Ammonia (total as N) (mg/L)	4/22/2008	1/24/2013	20	0.512	0.04	3.6
BOD, 5-day, 20 °C	4/22/2008	1/24/2013	20	3.16	1	11
Flow rate (cfs)	4/22/2008	1/24/2013	20	0.000924	0.000381	0.00186
Nitrogen (total) (mg/L)	4/22/2008	1/24/2013	20	10.8	2.41	20.6
NO2NO3 (total as N) (mg/L)	4/22/2008	1/24/2013	20	10.2	2.28	20
Phosphorus (total) (mg/L)	4/22/2008	1/24/2013	20	1.34	0.32	2.57
TKN (total as N) (mg/L)	4/22/2008	1/24/2013	19	0.671	0.09	3.8
TSS (mg/L)	4/22/2008	1/24/2013	19	2.31	0.33	8.33

Source of data: ICIS (U.S. EPA 2013b)
Notes
DMR records from ICIS are monthly averages.
BOD = biological oxygen demand; cfs = cubic feet per second; mg/L = milligrams per liter; N = nitrogen; NO2NO3 = nitrite plus nitrate; TKN = total Kjeldahl nitrogen; TSS = total suspended solids.

3.7 Hungry Horse Wastewater Treatment Plant (MTX000193)

The Bureau of Reclamation, of the U.S. Department of the Interior, formerly operated a wastewater treatment facility that was located at the Hungry Horse Dam near Hungry Horse, Montana (Figure 54). A septic system with drainfield was installed in 2009.[39] The plant serves the Hungry Horse Dam facility.

The WWTP was built in 1970 and consisted of an extended aeration package plant with secondary and tertiary treatment.[40] The design flow was 0.009 mgd. No major upgrades have occurred between 1970 and 2009 when the new sub-surface disposal system was installed. Even though the wastewater treatment facility is not actively used and does not discharge, the Bureau of Reclamation continues to maintain the permit in case they decide to reactivate the WWTP in the future.[41]

A design investigation was conducted in 2007 to look at alternatives to replacing the existing system with a system that does not discharge to the river. The WWTP now discharges to an infiltration/percolation cell after UV disinfection and has a maximum discharge rate of 300,000 gpd (DEQ 2008d).

The WWTP is permitted to discharge effluent to the South Fork Flathead River from one outfall (#001) to the infiltration/percolation field (DEQ 2008d). The most recent MPDES permit limits for the outfall are shown in Table 52. A nested pair of monitoring wells is also required to be installed and groundwater quality must be monitored.

Table 53. Hungry Horse WWTP permit limits

Constituent	Units	Daily maximum	30-day average
Nitrate as N	mg/L	7.5	--
	lb/d	--	18.77
Total Phosphorus as P	lb/d	--	2.5
E. coli bacteria	organisms/100 mL	< 1	--

Source: DEQ 2007d.
Note: lb/d = pounds per day; mg/L = milligrams per liter; mL = milliliters; N = nitrogen; P = phosphorus.

U.S. EPA (2013b) obtained all available DMR data for the Flathead Lake basin; however, data were not available for this facility.

[39] Melee K. Valett, water quality specialist, DEQ – Permitting and Compliance Division – Water Protection Bureau – Water Quality Discharge Permits Section, personal communication, March 10, 2010.
[40] Dennis Philmon, Facility Manager, Hungry Horse Dam, personal communication, July 24, 2008.
[41] Melee K. Valett, water quality specialist, DEQ – Permitting and Compliance Division – Water Protection Bureau – Water Quality Discharge Permits Section, personal communication, March 10, 2010.

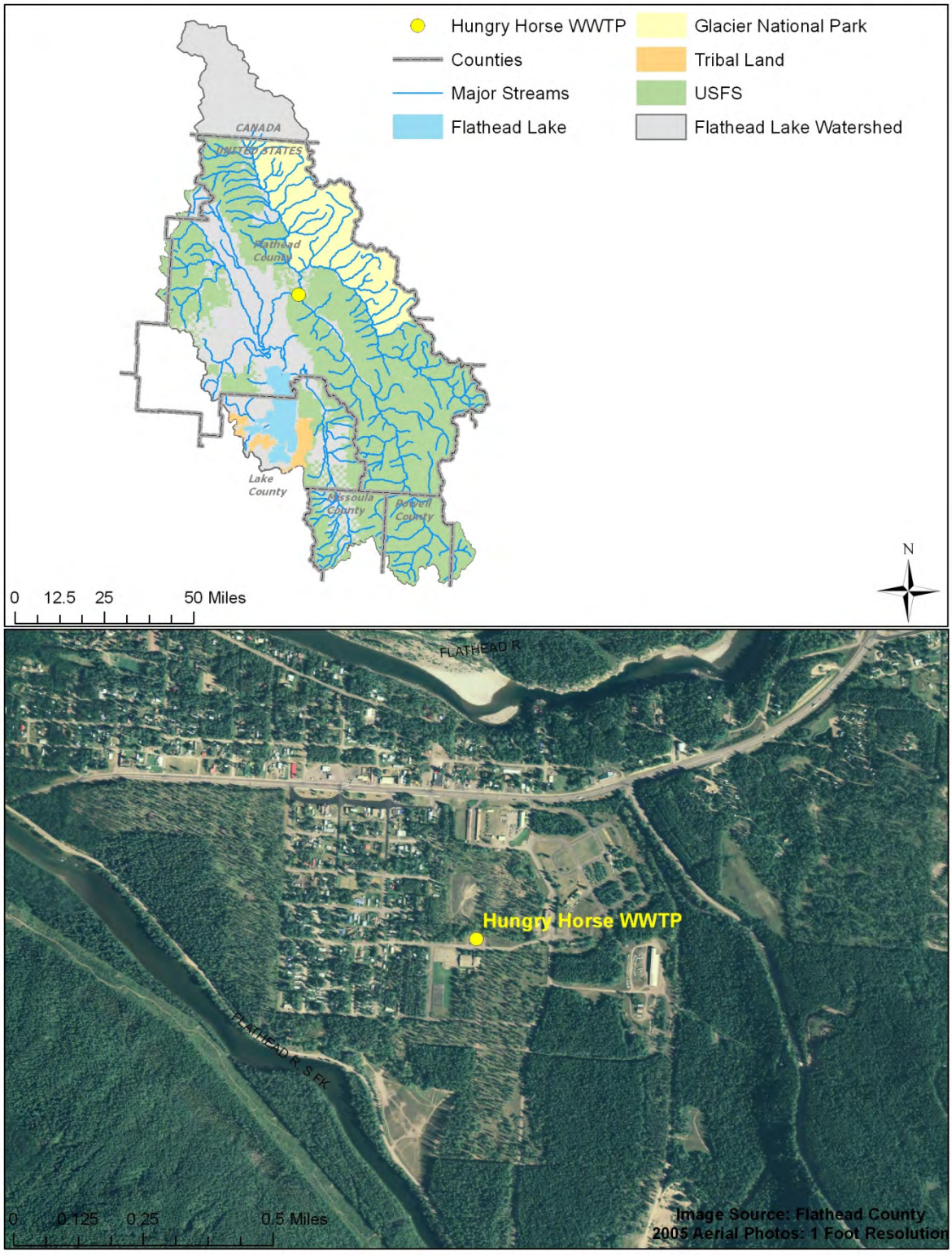


Figure 54. Hungry Horse WWTP.

3.8 Cove Creek Ridge Subdivision (MTX000199)

The Cove Creek Ridge Subdivision (aka TLW Properties, LLC) is a proposed 32-dwelling unit subdivision in Flathead County northeast of the unincorporated community of Evergreen and west of Lake Blaine (Figure 55). Wastewater would be discharged to two sub-surface drainfields to Class I groundwater (DEQ 2008e). The wastewater treatment works would include a sequencing batch reactor, coagulation injection system, gravity sand filtration system, two ultraviolet light disinfection units, 3,000 gallon feet tank, 8,000 gallon sludge tank, and 4, 000 gallon dose tank.

The MGWPCS permit limits are shown in Table 53. In addition to the limits listed below, the permit states that the average daily flow of effluent to outfall #001a and outfall #001b (combined) shall not exceed 11,200 gpd (DEQ 2008e). The permit also requires construction of a groundwater monitoring well and requires quarterly monitoring.

Table 54. Cove Creek Ridge Subdivision permit limits for outfalls 001a and 001b

Constituent	Daily maximum concentration (mg/L) per outfall	90-day average load (lb/d) per outfall
Total Nitrogen	7.5	0.7
Total Phosphorus	10.5	0.98

Source: DEQ 2008e.
Note: lb/d = pounds per day; mg/L = milligrams per liter.

U.S. EPA (2013b) obtained all available DMR data for the Flathead Lake basin; however, data were not available for this facility.

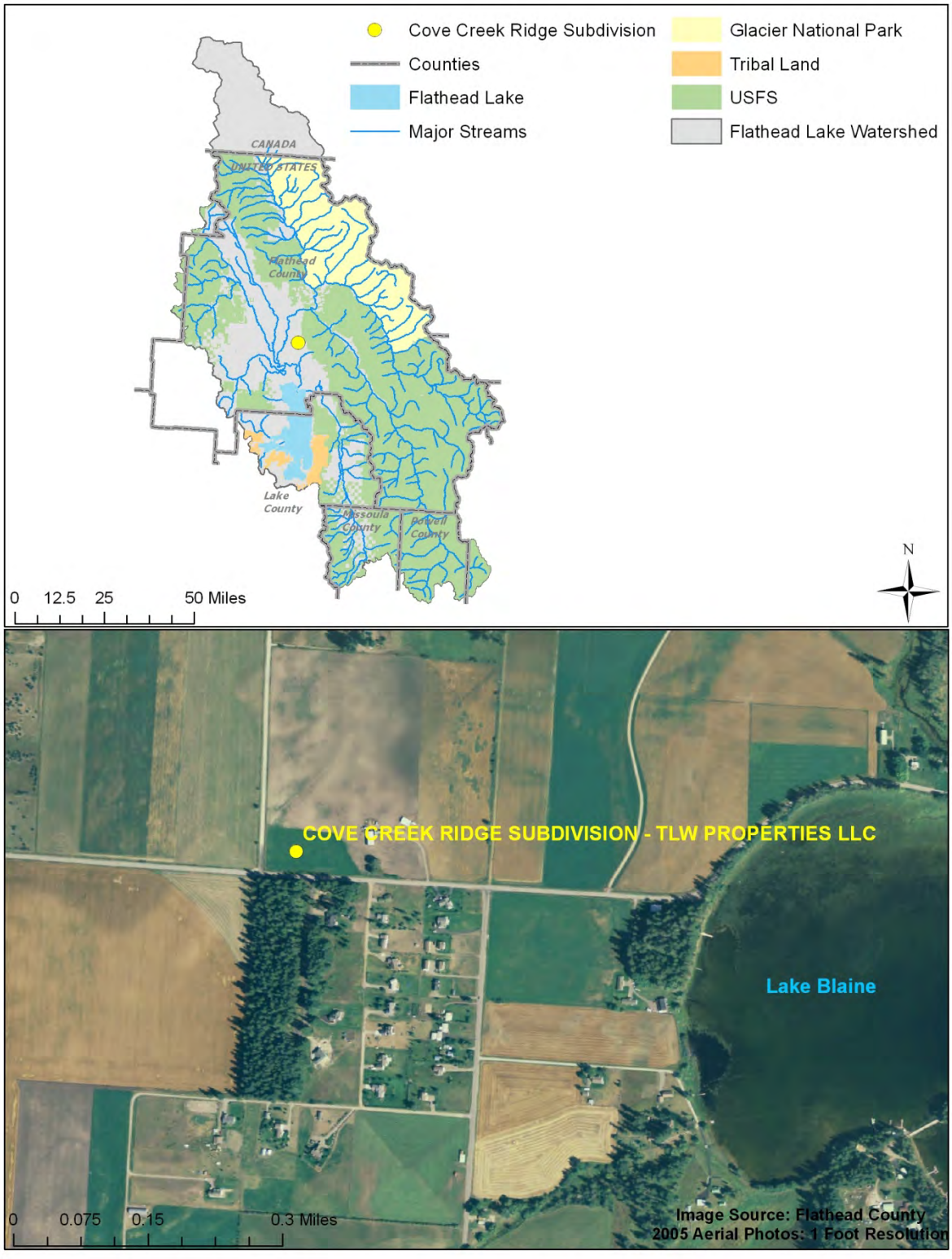


Figure 55. Proposed Cove Creek Ridge Subdivision.

3.9 Point of Pines Wastewater Treatment System (MTX000214)

The Point of Pines wastewater treatment system (aka Point of Pines Neighborhood Association, Inc.) is a subdivision in Flathead County northwest of Whitefish Lake (Figure 55). Information regarding the subdivision and wastewater treatment works was not reported in the MPDES permit. The facility is authorized to discharge to its sub-surface disposal system located in Flathead County to Class I groundwater at a maximum rate of 8,750 gpd (MTX000214). The most recent MGWPCS permit limits are show in Table 53.

Table 55. Point of Pines Wastewater Treatment System permit limits

Constituent	Units	Daily maximum	Annual maximum
Total nitrogen as N	mg/L	24	--
Total phosphorus as P	lb/y	--	99

Source: DEQ 2010c.
Note: lb/y = pounds per year; mg/L = milligrams per liter; N = nitrogen; P = phosphorus.

Monitoring data were obtained from ICIS (U.S. EPA 2013b) and are summarized in Table 54. Data for the monitoring well show an average total nitrogen concentration of 8.42 mg/L and an average total phosphorus concentration of 4.84 mg/L.

Table 56. Point of Pines Wastewater Treatment System data summary

Constituent	Start date	End date	No. of records	Avg.	Min.	Max.
Flow rate (cfs)	10/28/2012	1/28/2013	2	0.000503	0.000408	0.000598
Nitrogen (total) (mg/L)	10/28/2012	1/28/2013	2	8.42	0.04	16.8
NO_2+NO_3 (total as N) (mg/L)	10/28/2012	1/28/2013	2	12.9	11.6	14.1
Phosphorus (total) (mg/L)	10/28/2012	1/28/2013	2	4.84	4.45	5.22
TKN (total as N) (mg/L)	10/28/2012	1/28/2013	2	5.53	5.24	5.82

Source of data: ISIS (U.S. EPA 2013b)
Notes
DMR records from ICIS are monthly averages.
cfs = cubic feet per second; mg/L = milligrams per liter; N = nitrogen; NO_2+NO_3 = nitrite plus nitrate; TKN = total Kjeldahl nitrogen.

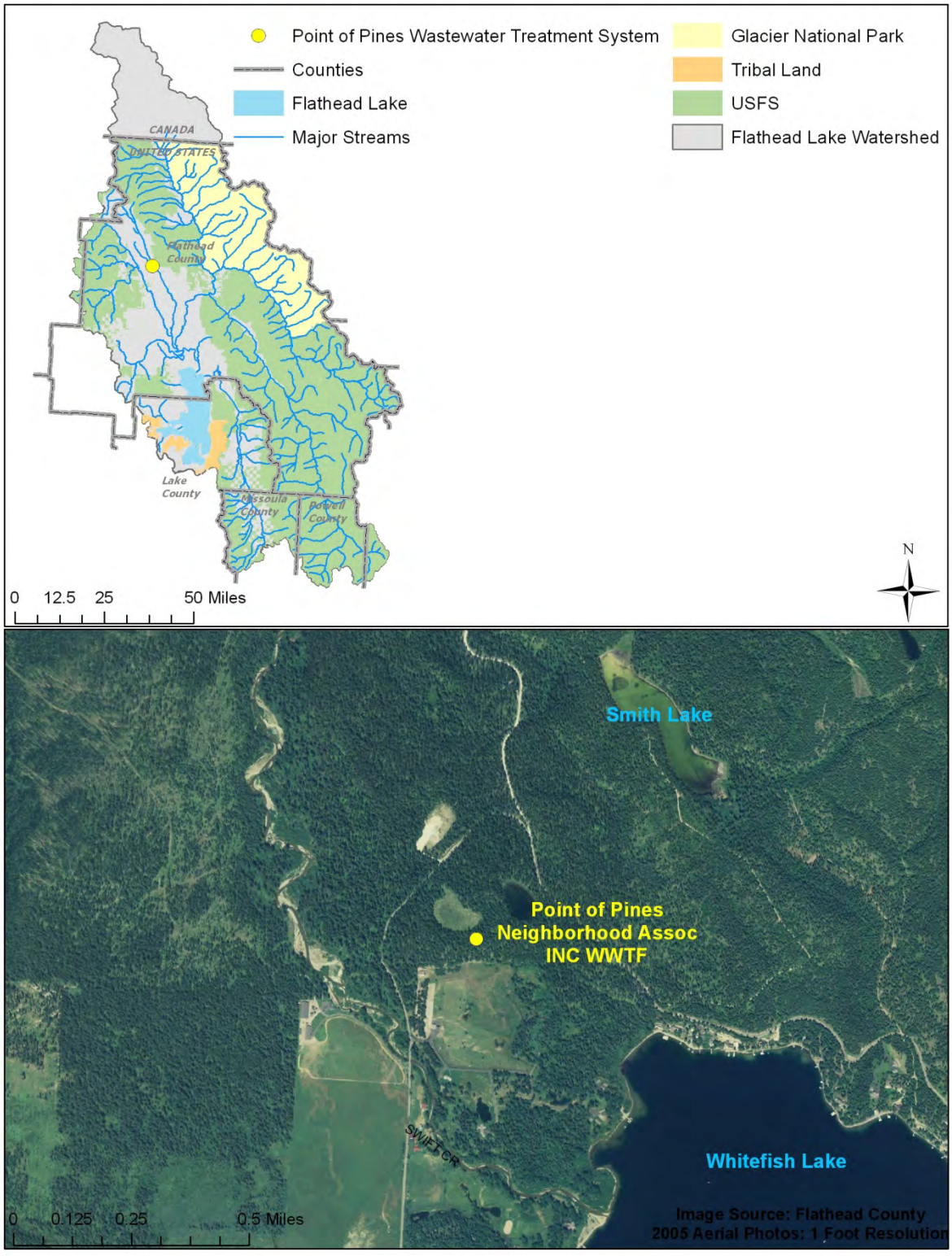


Figure 56. Point of Pines Wastewater Treatment System.

3.10 Glacier International Airport Rental Car Facility Car Wash (MTX000220)

The Glacier International Airport Rental Car Facility Car Wash (aka FCA Rentals LLC.) is a carwash at the Glacier International Airport in Flathead County northeast of Kalispell, Montana (Figure 56). The wastewater treatment system is composed of primary treatment and filtration (DEQ 2011b). The facility is authorized to discharge to its sub-surface disposal system located in Flathead County to Class I groundwater (MTX000220).

The wastewater treatment system is composed of a reverse osmosis system and HydroKleen filter and the system discharges to an infiltration pond (DEQ 2011b). The permit limits are for lead and total dissolved solids.

U.S. EPA (2013b) obtained all available DMR data for the Flathead Lake basin; however, data were not available for this facility.

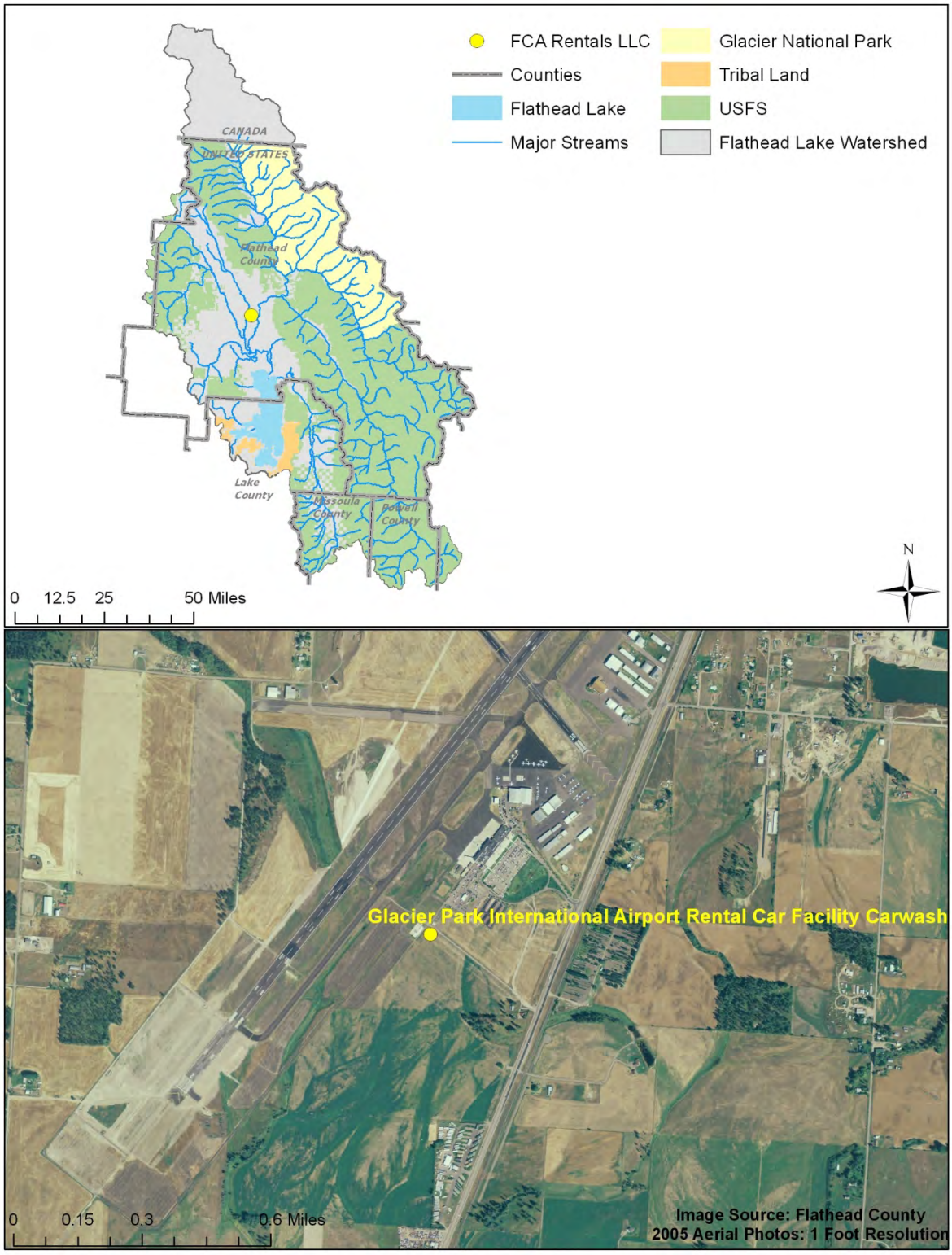


Figure 57. Glacier Park International Airport Rental Car Facility Carwash.

4.0 Non-Stormwater General MPDES Permits

Twenty-nine facilities are permitted to discharge to surface waters in the Flathead Lake basin under general, non-stormwater permits (Table 55, Table 56, Table 57, Table 58, Table 59, Table 60, and Table 61). The surface water discharges are issued general permits that begin with MTG.

Concentrated animal feeding operations (Table 55; Section 4.1) and biosolids operations (Table 58) are potential sources of nutrients and TSS. Additional information regarding biosolids operations at each WWTP is presented in Section 2.0 with the discussion of each WWTP's individual MPDES permit. Construction dewatering (Table 56), disinfected waters (e.g., swimming pools, hydrostatic test waters; Table 59), and petroleum cleanup (Table 60) are not likely significant sources of nutrients. General permits for construction dewatering and disinfected waters include turbidity and TSS limits; such facilities may be sources of TSS. Pesticide application varies by pesticide and target species; pesticides may be sources of nutrients. Fish farms are sources of nutrients and TSS and are further discussed in Sections 4.1 and 4.2.

Table 57. General MPDES permit for concentrated animal feeding operations in the Flathead Lake basin

Permit no.	Name
MTG010253	TUTVEDT FARMS

Table 58. General MPDES permits for construction dewatering in the Flathead Lake basin

Permit no.	Name
MTG070572	BIGFORK COUNTY WATER AND SEWER DIST. BAY DRIVE - SWAN RIVER PROJ.
MTG070574	NORTHSTAR ASSOCIATES LLC - THREE MILE DRIVE PROJ.
MTG070582	COP CONSTRUCTION LLC - 2001 AIRPORT ROAD PROJECT
MTG070594	JOHNSON WILSON CONSTRUCTORS NEW EFFLUENT TREATMENT SYSTEM
MTG070595	COP CONSTRUCTION LLC - HWY 93 WATER & WW SYSTEM EXTENSIONS
MTG070618	JOHNSON WILSON CONSTRUCTORS CRESTON NATIONAL FISH HATHERY
MTG070632	HUTTON RANCH PLAZA ASSOC LLC
MTG070634	SANDRY CONSTRUCTION - GLACIER RANCH SUBDIVISION
MTG070651	AMES CONSTRUCTION - KALISPELL BYPASS FOYS LAKE RD
MTG070663	MONTANA DEPT OF TRANSPORTATION - SWAN RIVER BRIDGE
MTG070676	MONTANA DEPT OF TRANSPORTATION FLATHEAD RIVER 3MI NW OF BIGFORK

Table 59. General MPDES permits for fish farms in the Flathead Lake basin

Permit no.	Name
MTG130007	Creston National Fish Hatchery
MTG130014	Flathead Lake Salmon Hatchery

Table 60. General MPDES permits for biosolids in the Flathead Lake basin

Permit no.	Name
MTG650009	Columbia Falls WWtP
MTG650010	Kalispell WWTP
MTG650020	Bigfork Water and Sewer District WWTF
MTG650045	Lake McDonald WWTP (Glacier National Park)
MTG650059	Whitefish WWTF
MTG651004	Yellow Bay WWTP (Flathead Lake Biological Station)

Table 61. General MPDES permits for disinfected waters in the Flathead Lake basin

Permit no.	Name
MTG770022	93 AND CHURCH SILVERBROOK CHLORINATION PROJECT
MTG770029	CITY OF KALISPELL LOWER ZONE DRINKING WATER TANK DRAIN LINE

Table 62. General MPDES permits for petroleum cleanup in the Flathead Lake basin

Permit no.	Name
MTG790012	BEARGRASS HOLDINGS LLP - MICHAEL'S WEST EXXON

Table 63. General MPDES permits for pesticide in the Flathead Lake basin

Permit no.	Name
MTG870016	FLATHEAD COUNTY MOSQUITO CONTROL
MTG870029	AFFORDABLE YARD SERVICE SUBDIVISIONS PESTICIDE
MTG870033	EAGLE BEND YACHT HARBOR ASSOC PESTICIDE
MTG870051	THE LAKES MASTER HOA PESTICIDE
MTG870055	DNRC BEAVER LAKE PESTICIDE
MTG870059	CITY OF WHITEFISH RIVERSIDE SW RETENTION POND WEED CONTROL

4.1 Tutvedt Farms (MTG010253)

Tutvedt Farms is in Flathead County northwest of Kalispell (Figure 58). The agricultural operations include a CAFO with approximately 2,200 head of cattle (DEQ 2012d). The CAFO is situated on 40 acres and the CAFO drains to an evaporation pond underlain by clay (DEQ 2012d). An additional 5 acres of land that is not part of the CAFO also drains to the evaporation pond. The evaporation pond is approximately 8 feet deep and has a capacity of 785,000 gallons. Approximately 200 tons of the 750 tons of manure produced annually is land-applied in the spring and fall. The manure is dried and then land applied via a manure spreader to 1,100 acres of irrigated wheat/alfalfa crops that are also part of Tutvedt Farms.

U.S. EPA (2013b) obtained all available DMR data for the Flathead Lake basin; however, data were not available for this CAFO.

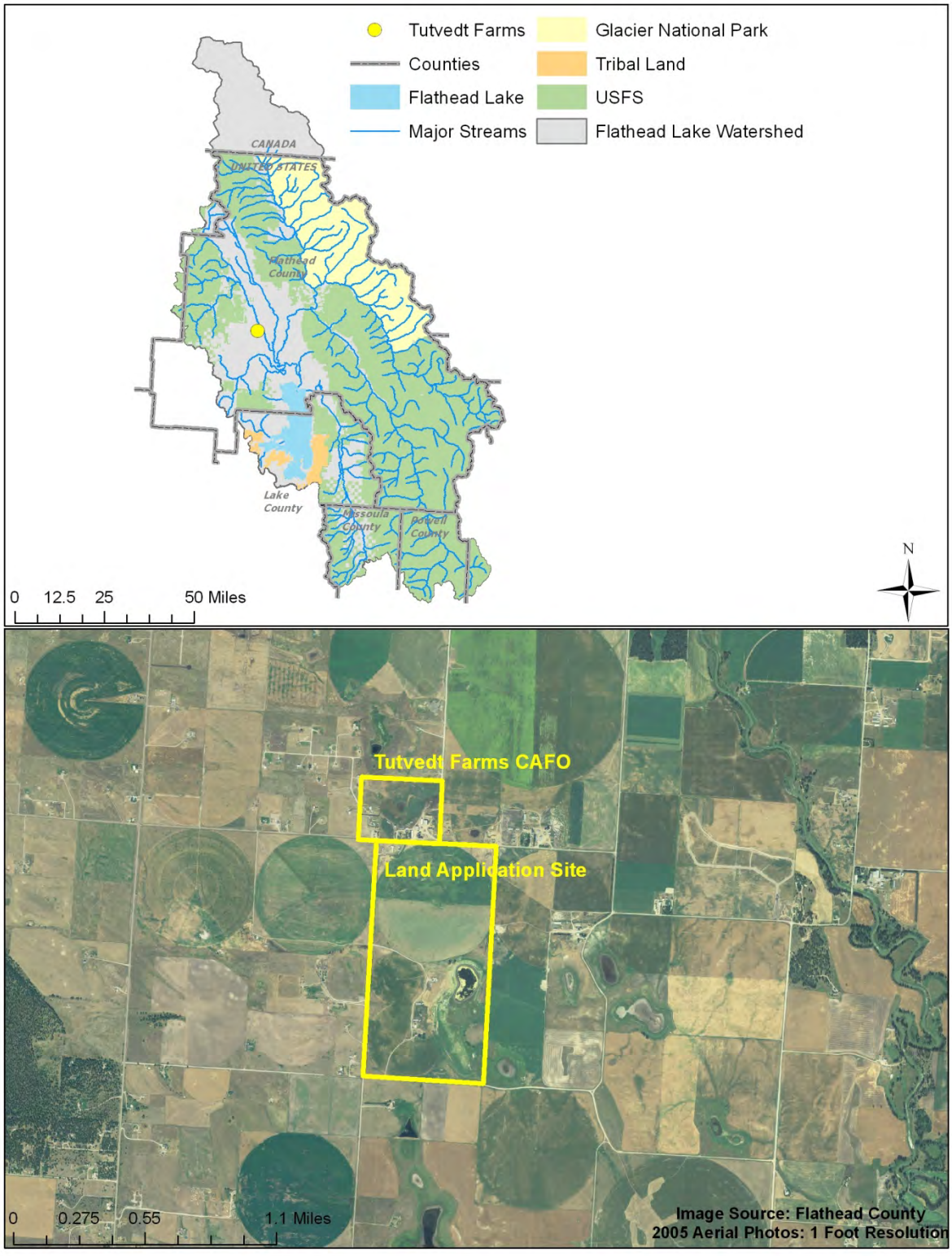


Figure 58. Tutvedt Farms CAFO and manure land application areas.

4.2 Creston National Fish Hatchery (MTG130007)

The Creston National Fish Hatchery is in Flathead County just east of the City of Kalispell (Figure 59). It is on Mill Creek and withdraws water from the Jessup Mill Pond, which is on Mill Creek just upstream of the fish hatchery. The fish hatchery is operated by the U.S. Fish and Wildlife Service and raises coldwater fish such as rainbow, cutthroat, and bull trout (DEQ Field Investigation Report 2005). The withdrawal/design flow of the facility is 19,000 gallons per minute. DEQ inspected the hatchery in July 2012 and ordered the hatchery to perform corrective actions to come into compliance with the general permit and its authorization letter (DEQ 2012c).

The hatchery is authorized to discharge wastewater to Mill Creek via several outfalls under Montana's Fish Farm General Permit (MTG130007; DEQ 2011a). The only permit limit is for polychlorinated biphenyls (PCBs) – less than 0.00065 µg/L in any sample. Facilities that produce more than 20,000 pounds per year are required to monitor TSS; Creston National Fish Hatchery produces 61,500 pounds per year, and thus, monitors TSS (DEQ 2011c).

The facility is required to monitor flow, PCBs, TSS, and fish food in its effluent. Monitoring data were obtained from ICIS (U.S. EPA 2013b) from 2007 to 2013 and are summarized in Table 62. Effluent flow data indicate an average of 14.1 cfs. TSS concentrations averaged 5.35 mg/L. No nutrient data were available.

Table 64. Creston National Fish Hatchery permit limits

Parameter	Start date	End date	No. of records	Avg.	Min.	Max.
Flow rate (cfs)	1/29/2007	1/28/2013	13	14.1	11.8	16.7
TSS (mg/L)	1/29/2007	1/28/2013	11	5.35	1	22.7

Source of data: ICIS (U.S. EPA 2013b).
Nots
DMR records from ICIS are monthly averages.
avg. = average (arithmetic mean); cfs = cubic feet per second; max. = maximum; mg/L = milligrams per liter; min. = minimum.

In a study of fish hatcheries in Washington State, the water quality within the receiving waters varied considerably but TSS and nutrient concentrations tended to increase, sometimes significantly (Kendra 1989). The researchers observed statistically-significant increases of ammonia (fish excretion), nitrogen (feed component), and phosphorus (feed component) in fish hatchery wastewater and that the "effects were more pronounced when dilution was poor and effluent was discharged to an oligotrophic waterscourse (Kendra 1989, p. 11). A review of published research by the authors found that "[effects] were variable, but included oxygen depression, solids deposition, and nutrient enrichment" (Kendra 1989, p. 15).

Readily-available literature that present nutrient loads derived from fish hatcheries is limited. Kendra (1989) converted phosphorus loading rates to population equivalents of domestically-treated wastewater. The results were that hatcheries discharged phosphorus loads at equivalents rates to communities of 300 to 2,300 people that have secondary treatment of domestic sewage (Kendra 1989, p.12).

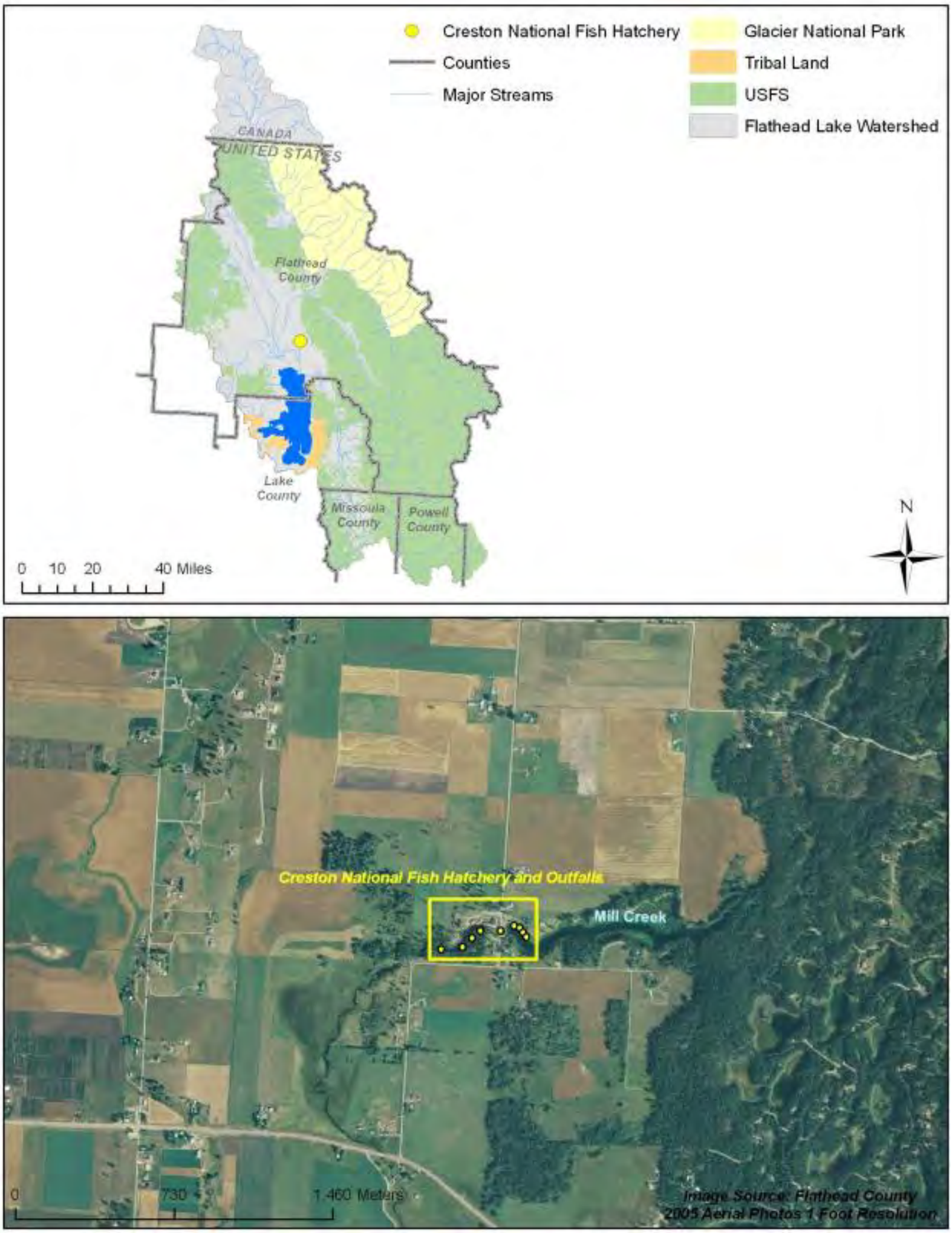


Figure 59. Creston National Fish Hatchery and permitted outfalls.

4.3 Flathead Lake Salmon Hatchery (MTG130014)

The Flathead Lake Salmon Hatchery is in Flathead County near the town of Somers, Montana (Figure 58). The fish hatchery is operated by Montana Department of Fish, Wildlife, and Parks (DFWP) and raises various coldwater fish species (DFWP 2008). No design flow for the facility has been specified. DEQ inspected the hatchery in March 2012 and found the hatchery to be in compliance with the general permit and its authorization letter (DEQ 2012d).

The hatchery is authorized to discharge wastewater to Flathead Lake under Montana's General Permit for Concentrated Aquatic Animal / Fish Farms (MTG130000; DEQ 2011a). The only permit limit is for PCBs – less than 0.00065 µg/L in any sample. Facilities that produce more than 20,000 pounds per year are required to monitor TSS; Flathead Lake Salmon Hatchery produces 2,781 pounds per year, and thus, is not required to monitor TSS (DEQ 2011d).

Monitoring data were obtained from ICIS (U.S. EPA 2013b; available for 2007-2013) and are summarized in Table 63. Effluent flow data indicate an average of 0.248 cfs. No nutrient data were available.

Table 65. Flathead Lake Salmon Hatchery data summary

Parameter	Start date	End date	No. of records	Avg.	Min.	Max.
Flow rate (cfs)	3/6/2007	1/28/2013	13	0.248	0.0223	0.691

Source of data: ICIS (U.S. EPA 2013b)
Notes
DMR records from ICIS are monthly averages.
avg. = average (arithmetic mean); cfs = cubic feet per second; max. = maximum; min. = minimum.

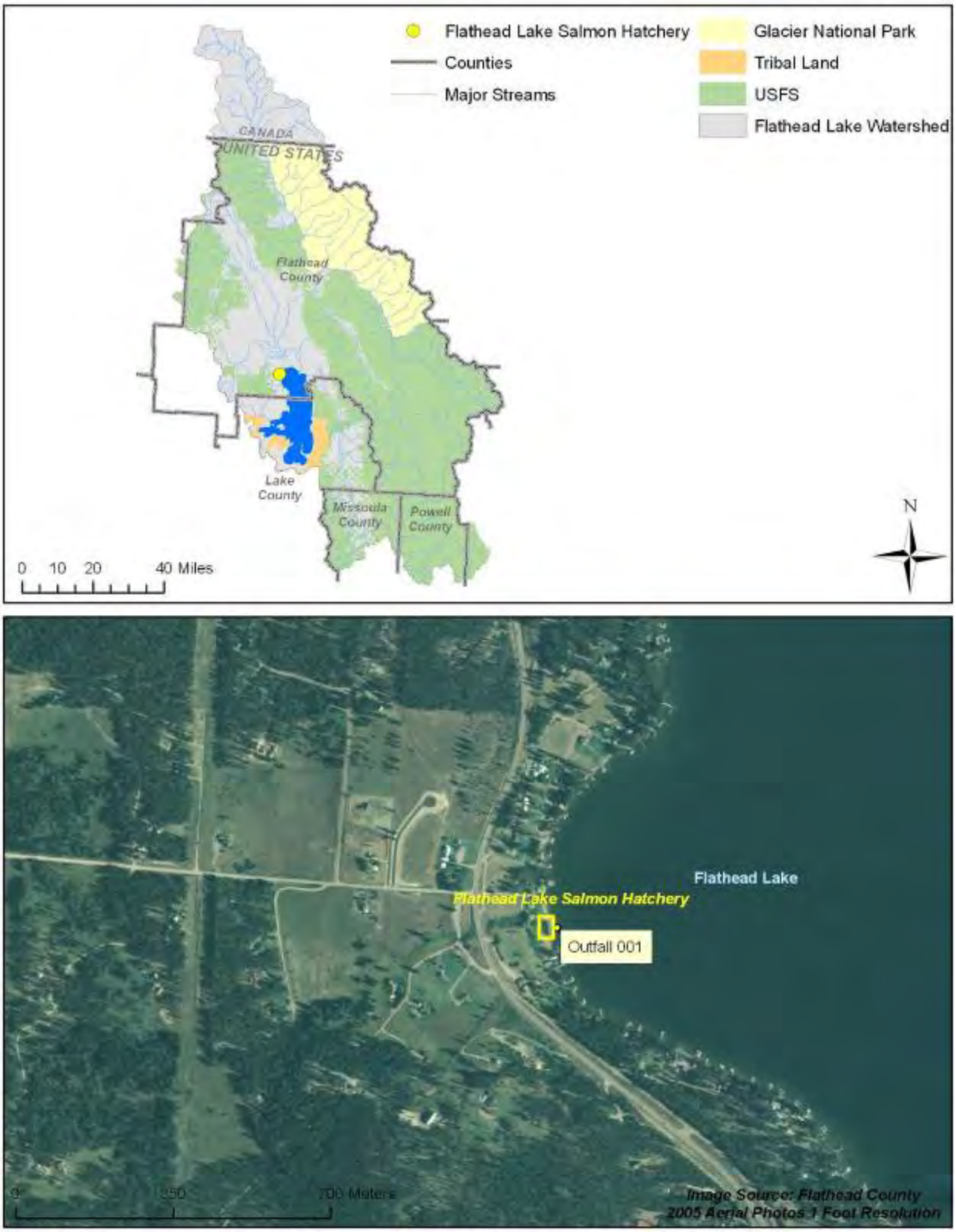


Figure 60. Flathead Lake Salmon Hatchery and permitted outfall.

5.0 Stormwater General MPDES Permits

Two hundred seventy facilities and sites are permitted to discharge stormwater to surface waters in the Flathead Lake basin under one of Montana's general MPDES permits for stormwater. The stormwater discharges are issued general permits that begin with MTR00 for industrial activities (Table 64), MTR04 for small multiple separate storm sewer systems (Table 65), and MTR10 for construction sites. The 255 permitees (as of February 2013) for stormwater discharges associated with construction sites are not presented herein because the permits are temporary as construction only occurs over a limited time frame. Five permits are for stormwater associated with industrial activities that does not discharge off-site and thus results in no exposure to pollutants (Table 66); these permits begin with MTRNE.

Table 66. General NPDES permits stormwater discharges associated with industrial activities in the Flathead Lake basin

Permit no.	Name
MTR000019	F H STOLTZE LAND AND LUMBER CO
MTR000251	WISHER'S AUTO RECYCLING
MTR000309	GLACIER PARK INTERNATIONAL AIRPORT
MTR000367	KALISPELL WRECKING
MTR000404	CITYSERVICEVALCON PLANT
MTR000419	BUILDING MATERIALS HOLDING CORP. - BMC WEST TRUSS PLANT
MTR000447	UPS - KALISPELL
MTR000465	GLACIER GOLD LLC
MTR000476	FLATHEAD COUNTY SOLID WASTE DISTRICT

Table 67. General NPDES permit for stormwater discharges associated with multiple separate storm sewer systems in the Flathead Lake basin

Permit no.	Name
MTR040005	CITY OF KALISPELL SMALL MS-4

Table 68. General NPDES permits for stormwater that does not discharge off-site in the Flathead Lake basin

Permit no.	Name
MTRNE0011	BMC MILLWORK INDUSTRIAL NO EXPOSURE
MTRNE0023	FEDEX EXPRESS CORPORATION - KALISPELL
MTRNE0028	FEDEX GROUND PACKAGE SYSTEM INC KALISPELL
MTRNE0031	CITY OF KALISPELL WWTP NO EXPOSURE
MTRNE0054	WHITEFISH WWTF

6.0 Montana Permits

Montana DEQ has issued two types of short-term permits under the authority of the Montana Water Quality Act that are not part of the MPDES program.

6.1 Section 308 Permits

Eleven facilities have short-term exemptions from surface water quality standards for emergency remediation (Table 67). Such short-term exemptions are authorized under section 308 of the Montana Water Quality Act. The exemptions are issued permits that begin with MTE but are not MPDES permits. No monitoring data are available for these facilities.

Table 69. Section 308 permits in the Flathead Lake basin

Permit no.	Name
MTE000112	MONTANA FWP NECKLACE CHAIN OF LAKES SMOKY CREEK
MTE000207	USFS - KOOTENAI NATIONAL FOREST BLUE LAKE
MTE000211	FWP WILDCAT LAKE ROTENONE TREATMENT PROJECT
MTE000307	STEVENSON POND
MTE000308	MT FISH WILDLIFE & PARKS - GRAVES CREEK DRAINAGE
MTE000311	LAKE POINTE HOA BIGFORK
MTE000510	FWP - MARGARET LAKE AND FOREST CREEK
MTE000610	FWP - CLAYTON LAKE AND CREEK
MTE000807	EAGLE BEND YACHT HARBOR BOATSLIP OWNERS ASSOC.
MTE002009	LAKE POINTE HOMEOWNERS ASSOC POND TREATMENT
MTE002108	LAKE POINTE HOMEOWNERS ASSOC MAN MADE POND

6.2 Section 318 Permits

Seventy-five facilities have short-term turbidity water quality standards for construction sites. Such short-term standards are authorized under section 318 of the Montana Water Quality Act. The exemptions are issued permits that begin with MTB but are not MPDES permits. The 75 permitees (as of February 2013) for surface water discharges with short-term turbidity water quality standards for construction sites are not presented herein because the permits are temporary as construction only occurs over a limited time frame. No monitoring data are available for these facilities.

7.0 Facilities that Do Not Need Permit Coverage

This section provides a summary of non-discharging facilities.

7.1 Unpermitted Facilities

Five non-discharging facilities that were evaluated by DEQ are in the Flathead Lake basin (Table 68). Such facilities, with an MPDES identifier of "MTU0 or MTUs" for tracking compliance, do not have MPDES permit coverage and are not allowed to discharge to waters of the United States. DEQ has verified that these five facilities do not discharge.

Table 70. Unpermitted facilities in the Flathead Lake basin

Permit no.	Name
MTU000019	Glacier Gold
MTUS00005	Andy Silvers
MTUS00006	Empire Estates
MTUS00130	Buffalo Mountain Estates
MTUS00131	Kalispell Wrecking

7.2 Elmo

Elmo is an unincorporated community in Flathead County on the western shores of the Big Arm of Flathead Lake (Figure 59). Elmo operates a lagoon system with aerated and storage lagoons and land applies treated effluent via spray irrigation (FCCHD 2012). Original unlined, facultative lagoons were replaced with lined lagoons through a Rural Development grant to the Confederated Salish and Kootenai Tribes of the Flathead Reservation. The facility is estimated to treat 229,000 gpd. The facility does not discharge, and thus, is not permitted under the MPDES program. The facility is discussed in this report because it is an important wastewater management facility in the Flathead Lake basin that has the potential to impact nutrient loading.

No additional information or data for this facility are available.

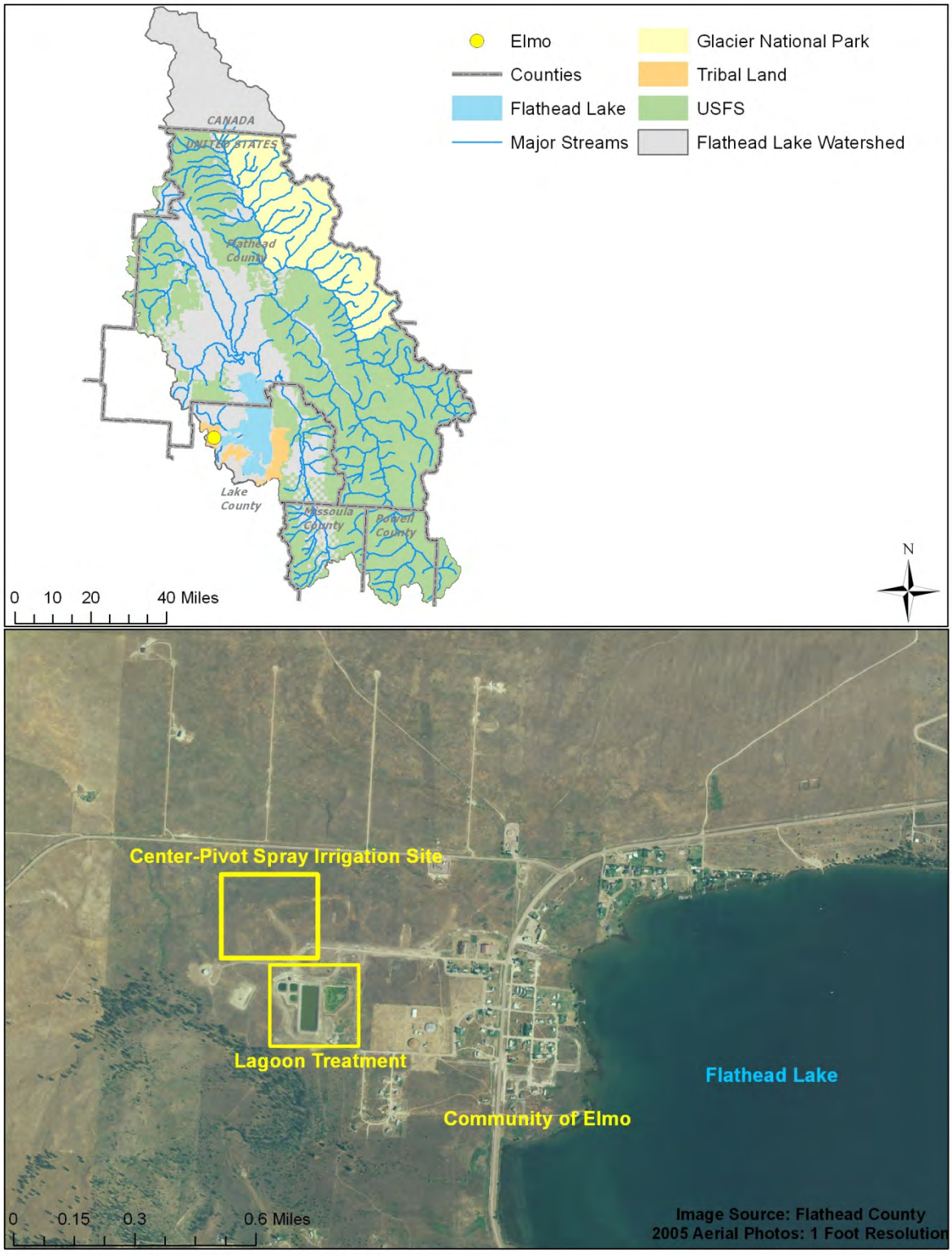


Figure 61. Elmo irrigation site and ponds

7.3 Lakeside/Somers

The Lakeside County Water and Sewer District (LCWSD) operates an aerated-lagoon treatment facility, land application facility, and wastewater collection system infrastructure (e.g., lift stations, force transmission lines) (Figure 60). The facility does not, however, discharge to surface water or groundwater, and therefore does not have an MPDES permit. The facility is discussed in this report because it is an important wastewater management facility in the Flathead Lake basin that has the potential to impact nutrient loading.

The system serves the communities of Lakeside and Somers and the areas between the two communities (Figure 61). As of 2007, the LCWSD WWTP served 1,165 equivalent dwelling units, with 925 in Lakeside and 240 in Somers (RPA 2007, p. 2-8). In 2005 and 2006, 51.3 million gallons and 56.3 million gallons (respectively) of wastewater were transmitted to the treatment facility (RPA 2007, p. 2-16). The inter-local agreement allows Somers to discharge up to 45,000 gpd of wastewater to the Lakeside WWTP (FCCHD 2012).

Much of the original facilities and system were constructed in 1987 and 1988. The LCWSD collection system includes 61,000 feet of 8-inch PVC and 500 feet of 10-inch PVC gravity main lines (RPA 2007, p. 2-9). The Somers County Water and Sewer District (SCWSD) maintains their own collection system. The wastewater treatment facility consists of two aerated treatment lagoons and two storage lagoons, for winter storage of treated effluent. Each treatment pond has a surface area of approximately 2.35 acres, includes three three-horse power and three five-horse power aspirators, and can treat 5.18 million gallons (RPA 2007, p. 2-12). It should be noted that many of the customers served by LCWSD are not connected to the public water supply (RPA 2007, p. 2-14).

The land application facility and storage ponds are located just north of the aerated cells. The Lakeside storage pond has a capacity of 46.9 million gallons and the Somers storage pond has a capacity of 24.0 million gallons (RPA 2007, p. 2-9). The pump is located adjacent west side of the storage ponds and pumps treated effluent to a nearby center pivot irrigation system on a 160-acre parcel of land (RPA 2007, p. 2-14). Alfalfa is currently grown but LCWSD had previously grown mint and corn (RPA 2007, p. 2-24).

Though not required to monitor water quality, because the facility is not permitted, LCWSD has monitored BOD and TSS (Table 69).

Table 71. BOD and TSS at the Lakeside treatment facility

Month	BOD			TSS		
	Influent (mg/L)	Effluent (mg/L)	Removal (%)	Influent (mg/L)	Effluent (mg/L)	Removal (%)
June 2001	268	9	94	243	25	90
June 2002	290	16	94	192	4	98
September 2002	310	5	98	289	28	90
August 2003	240	3	99	314	7	98
May 2004	311	5	98	263	8	97
October 2004	352	51	99	238	46	81
May 2006	220	14	98	--	--	--
October 2006	243	6	98	198	4	98

Source: RPA 2007, p. 2-23, Table 2-5 and Table 2-6.
Note: BOD = biological oxygen demand; mg/L = milligram per liter; TSS = total suspended solids.

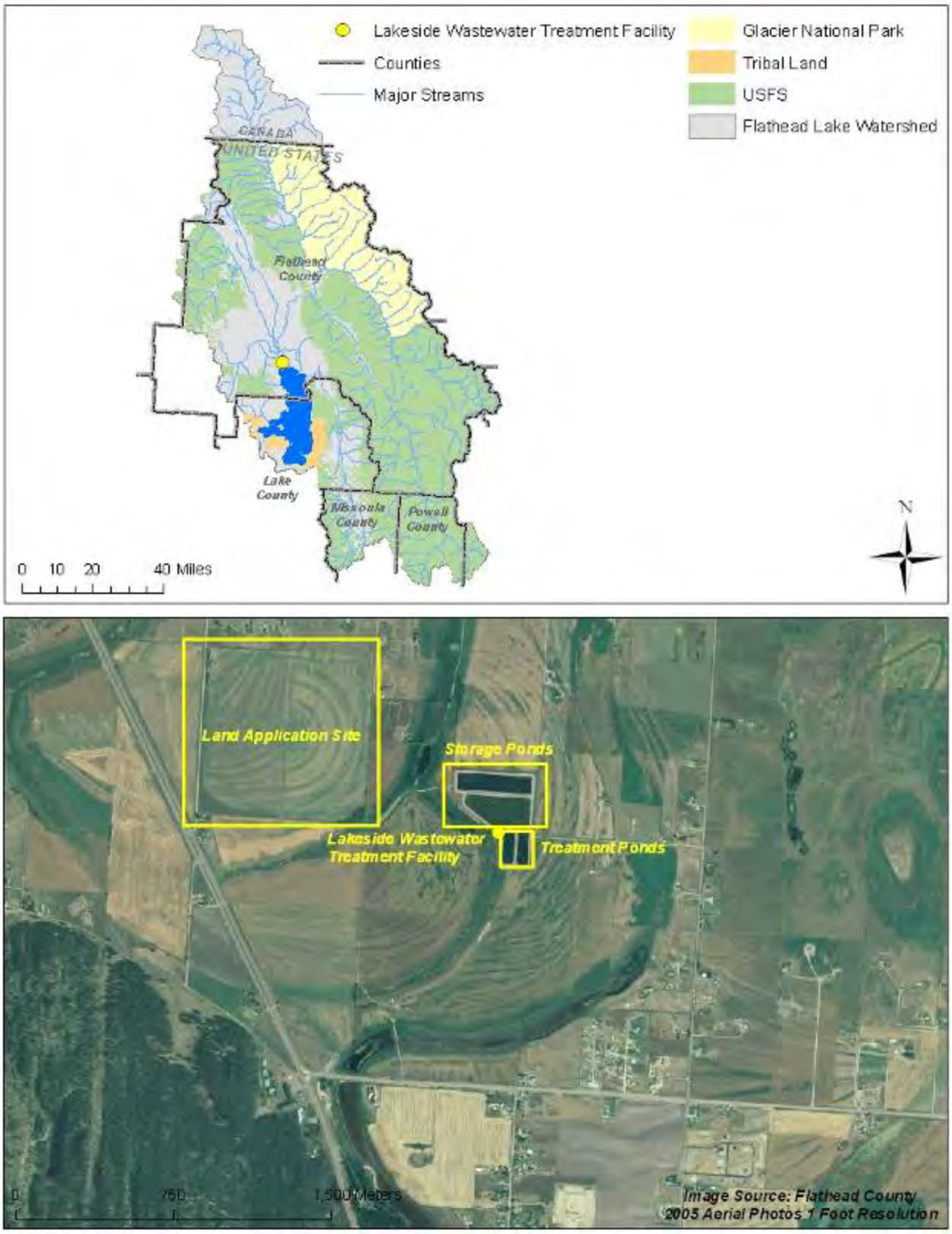


Figure 62. Lakeside WWTP, land application site, and ponds

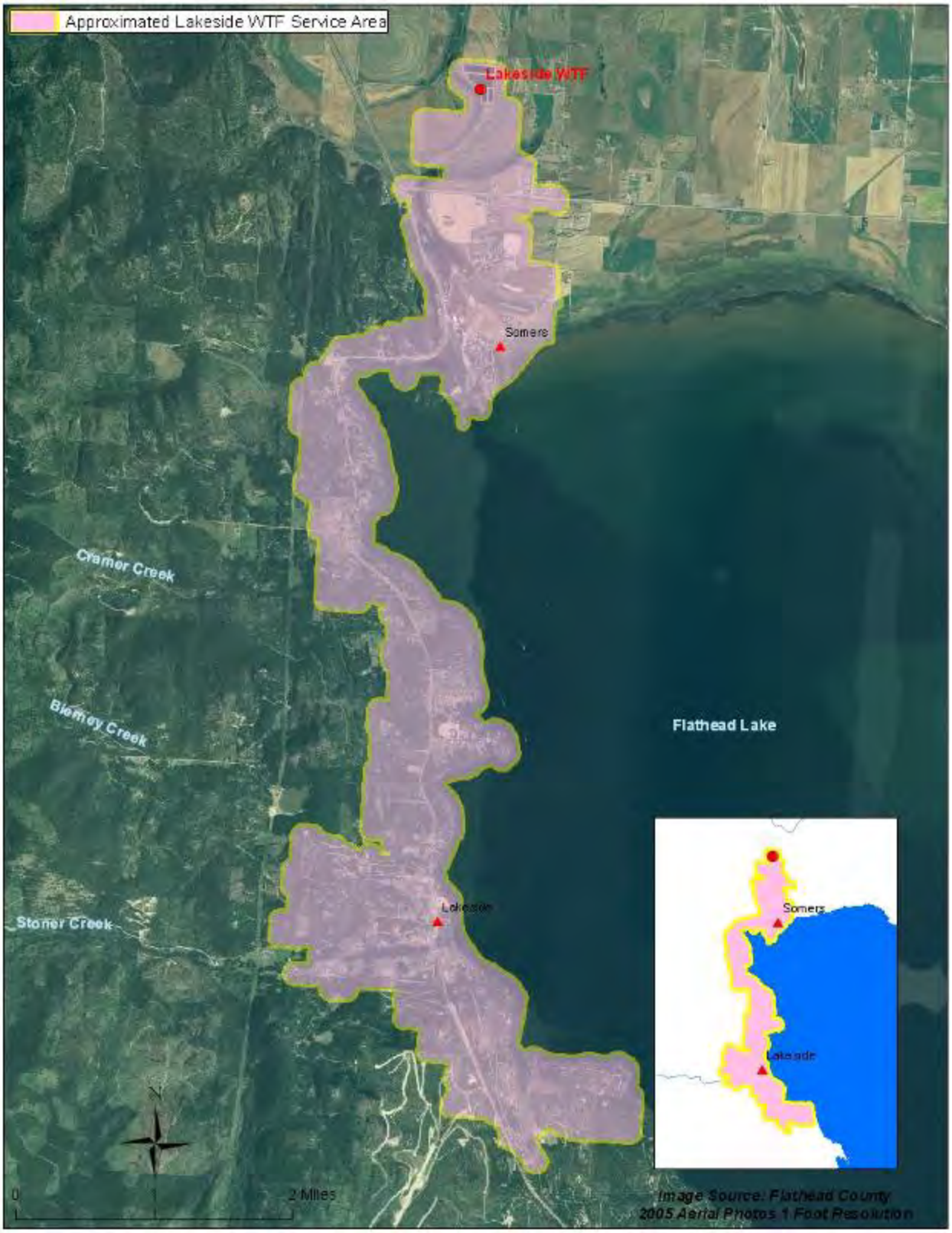


Figure 63. Lakeside and Somers service area.

8.0 Data Gaps

While this report has focused on MPDES permitted facilities in the Flathead Lake basin, there are a number of smaller, non-MPDES permitted facilities in the basin that dispose of wastewater via non-discharging ponds or spray irrigation. These facilities are not required to have a MPDES permit because they do not directly discharge to surface or ground water. However, they have the potential to collect or move wastewater over long distances from a variety of different households or businesses. An example of this type of facility is the Lakeside WWTP discussed in Section 7.3. In modeling the Flathead Lake basin, it is important to understand how these systems operate so that flow and pollutant loadings can be routed correctly. Additional information on any existing non-permitted facilities would improve model performance and TMDL development.

9.0 References

Bigfork Water and Sewer District. 2006. Wastewater Facilities Preliminary Engineering Report (PER). Morrison Maierle, INC. May 2006.

DEQ (Montana Department of Environmental Quality). 1996a. Authorization to Discharge under the Montana Ground Water Pollution Control System (MGWPCS) – Permit No.: MTX00066 – Meadow Gold Dairy, Inc. Montana Department of Environmental Quality (DEQ), Water Protection Bureau (WQPB), Permitting & Compliance Division (PCD). Helena, Montana.

DEQ. 1996b. Authorization to Discharge under MGWPCS – Permit No.: MTX000092 – Plum Creek Manufacturing. DEQ-WQPB-PCD. Helena, Montana.

DEQ. 1997. Authorization to Discharge under the MGWPCS – Permit No.: MTX000100 – Stampede Packing Company. DEQ-WQPB-PCD. Helena, Montana.

DEQ. 1999b. Authorization to Discharge under the Montana Pollutant Discharge Elimination System (MPDES) – Permit No.: MT0000019 – Burlington Northern Whitefish Facility. DEQ-WQPB-PCD. Helena, Montana.

DEQ. 1999c. Authorization to Discharge under the MPDES – Permit No.: MT0030066 – Columbia Falls Aluminum Company. DEQ-WQPB-PCD. Helena, Montana.

DEQ. 2001. Authorization to Discharge under the MPDES – Permit No.: MT0020397 – Bigfork Water and Sewer District WWTP. DEQ-WQPB-PCD. Helena, Montana.

DEQ. 2002a. Authorization to Discharge under the MGWPCS – Permit No.: MTX000120 – International RV LLC. DEQ-WQPB-PCD. Helena, Montana.

DEQ. 2002b. Authorization to Discharge under the MGWPCS – Permit No.: MTX000133 – Ehrman Nine Lease Subdivision (Glacier Partners, Inc.). DEQ-WQPB-PCD. Helena, Montana.

DEQ. 2003. Authorization to Discharge under the MPDES – Permit No.: MT0030651 – Don Abbey Household. DEQ-WQPB-PCD. Helena, Montana.

DEQ. 2007a. Authorization to Discharge under the MPDES – Permit No.: MT0020184 – City of Whitefish Wastewater Treatment Plant. DEQ-WQPB-PCD. Helena, Montana.

DEQ. 2007b. Authorization to Discharge under the MPDES – Permit No.: MT0030414 – City of Whitefish Water Treatment Plant. DEQ-WQPB-PCD. Helena, Montana.

DEQ. 2007c. Authorization to Discharge under the MGWPCS – Permit No.: MTX000120 – Kootenai Lake Lodge. DEQ-WQPB-PCD. Helena, Montana.

DEQ. 2007d. Authorization to Discharge under the MGWPCS – Permit No.: MTX000164 – Glacier Ranch Subdivision. DEQ-WQPB-PCD. Helena, Montana.

DEQ. 2008a. Authorization to Discharge under the MPDES – Permit No.: MT0022578 – Hungry Horse Dam. DEQ-WQPB-PCD. Helena, Montana.

DEQ. 2008b. Authorization to Discharge under the MPDES – Permit No.: MT0030601 – Lake McDonald WWTP. DEQ-WQPB-PCD. Helena, Montana.

DEQ. 2008ca. Authorization to Discharge under the MPDES – Permit No.: MT0021938 – City of Kalispell WWTP. DEQ-WQPB-PCD. Helena, Montana.

DEQ. 2008d. Authorization to Discharge under the MGWPCS – Permit No.: MTX000193 – Hungry Horse WWTP (Hungry Horse Development Partners, LLC). DEQ-WQPB-PCD. Helena, Montana.

DEQ. 2008e. Authorization to Discharge under the MGWPCS – Permit No.: MTX000199 – Cove Creek Ridge Subdivision (TLW Properties, LLC). DEQ-WQPB-PCD. Helena, Montana.

DEQ. 2009. Authorization to Discharge under the MPDES – Permit No.: MT0000019 – BNSF Railway Company. DEQ-WQPB-PCD. Helena, Montana.

DEQ. 2010a. Authorization to Discharge under the MPDES – Permit No.: MT0020036 – City of Columbia Falls WWTP. DEQ-WQPB-PCD. Helena, Montana.

DEQ. 2010b. Authorization to Discharge under the MGWPCS – Permit No.: MT0031658 – John Collins. DEQ-WQPB-PCD. Helena, Montana.

DEQ. 2010c. Authorization to Discharge under the MGWPCS – Permit No.: MTX000214 – Point of Pines Wastewater Treatment System. DEQ-WQPB-PCD. Helena, Montana.

DEQ. 2011a. Authorization to Discharge under the MPDES –Fish Farm General Permit MTG130000. DEQ-WQPB-PCD. Helena, Montana.

DEQ. 2011b. Authorization to Discharge under the MPDES – Permit No.: MTX000220 – Glacier International Airport Rental Car Facility Car Wash. DEQ-WQPB-PCD. Helena, Montana.

DEQ. 2011c. Re: Authorization MTG130007 to Discharge under the "Concentrated Animal Production General Permit". Letter to Mark Maskill (United States Fish and Wildlife Service, Creston National Fish Hatchery) from DEQ-WQPB, dated August 23, 2011.

DEQ. 2011d. Re: Authorization MTG130014 to Discharge under the "Concentrated Animal Production General Permit". Letter to Mark Kornick (Flathead Lake Salmon Hatchery) from DEQ-WQPB, dated August 23, 2011.

DEQ. 2012a. Authorization to Discharge under the MPDES – Permit No.: MT0031739 – KRY Site. DEQ-WQPB-PCD. Helena, Montana.

DEQ. 2012b. Authorization to Discharge under the MGWPCS – Permit No.: MTX000100 – Meat Production Inc. DEQ-WQPB-PCD. Helena, Montana.

DEQ. 2012c. Inspection Report: Creston National Fish Hatchery. DEQ-WQPB-PCD. Helena, Montana. August 1, 2012.

DEQ. 2012c. Inspection Report: Flathead Lake Salmon Hatchery. DEQ-WQPB-PCD. Helena, Montana. May 10, 2012.

DEQ. 2012d. Re: Authorization MTG010253 to Discharge under the "Concentrated Animal Feeding Operation General Permit". Letter to Bruce Tutvedt (Tutvedt Farms) from DEQ-WQPB, dated May 4, 2012.

DEQ. 2013. Authorization to Discharge under the MPDES – Permit No.: MT0030654 – Donald R. Abbey. DEQ-WQPB-PCD. Helena, Montana.

DFWP (Montana Department of Fish Wildlife and Parks). 2008. Flathead Lake Salmon Hatchery.. http://fwp.mt.gov/lands/site_279749.aspx. Accessed August 15, 2008.

FCCHD (Flathead City-County Health Department). 2009. *Flathead County Wastewater Study*. FCCHD, Environmental Health. Kalispell, Montana.

FCCHD. 2012. *Sewage Treatment in the Flathead Basin*. DNRC Contract No. RRG-10-1440. Prepared by Carver Engineering. FCCHD, Flathead Regional Wastewater Management Group, Kalispell, Montana.

Kendra, Will. 1989. Quality and Fate of Fish Hatchery Effluents During the Summer Low Flow Season. 89-17. Washington State Department of Ecology, Environmental Investigations Laboratory Services Program, Surface Water Investigations Section. Olympia, Washington. May 1989.

Montana Department of Health and Environmental Sciences Water Quality Bureau, 1991. Draft Environmental Assessment for Meadow Gold Dairies Inc. September 04, 1991.

Newman, Howard. 1991. Compliance plan for on-site land application of wastewater by Meadow Gold Dairy, Kalispell, Mt. Unpublished report to Borden Packaging and Industrial Products.

RPA (Robert Peccia and Associates). 2007. Lakeside Wastewater System: 2007 Preliminary Engineering Report. Prepared for Lakeside County Water and Sewer District. June 2007. http://lakesidesandw.com/lakesidewastewaterreport.pdf. Accessed March 12, 2010.

U.S. EPA (United States Environmental Protection Agency). 2012. Authorization to Discharge under the National Pollutant Discharge Elimination System – Permit No.: MT-0023388 – Flathead Lake Biological Station WWTP. U.S. Environmental Protection Agency. Helena, Montana.

U.S. EPA. 2013a. Authorization to Discharge under the National Pollutant Discharge Elimination System – Polson Wastewater Treatment Facility – Statement of Basis – NPDES Permit # MT0020559. U.S. Environmental Protection Agency. Helena, Montana.

U.S. EPA. 2013b. DMR data ISIS for Flathead, Lake, and Missoula Counties. Jason Gildea, U.S. EPA Region 8 Montana Operations Office, downloaded the data from ISIS on February 1, 2013.

ATTACHMENT C – SUMMARY OF URBAN STORMWATER SOURCES IN THE FLATHEAD LAKE BASIN



Summary of Urban Stormwater Sources in the Flathead Lake Basin

March 1, 2010

Final

U.S. Environmental Protection Agency
Montana Operations Office
10 West 15th Street, Suite 3200
Helena, MT 59601

Project Manager: Ron Steg

Revision History

Document Name	Revision	Release Date	Revisions
Flathead Basin TMDL Technical Report —Urban Stormwater Sources; Stakeholder Review Draft	1.0	June 16, 2009	Draft was sent to public entities that contributed data and information to the report.
Flathead Basin TMDL Technical Report — Urban Stormwater Sources; Public Review Draft	2.0	March 1, 2010	Received and incorporated comments from Kalispell, Whitefish, and Bigfork

Contents

1.0 INTRODUCTION **1**
1.1 Defining Stormwater 1
1.2 Stormwater Pollutant Concentrations and Yields 2
2.0 REGULATORY AUTHORITY **3**
2.1 State of Montana – Stormwater Point Sources 3
2.1.1 Construction 3
2.1.2 Industrial 4
2.1.3 Municipal Separate Storm Sewer Systems (MS4) 5
2.2 State of Montana – Nonpoint Stormwater Sources 5
2.3 Counties 6
2.4 Cities 6
3.0 CHARACTERIZATION OF PERMITTED STORMWATER SOURCES **7**
3.1 City of Kalispell and Montana Department of Transportation MS4 (MPDES ID MTR040005) 9
3.2 Industrial Facilities 13
3.2.1 Glacier Park International Airport (MPDES ID MTR000309) 13
3.2.2 F.H. Stoltze Land and Lumber Co (MPDES ID MTR000019) 16
3.2.3 Glacier Gold Chipping (MPDES ID MTR000465) 18
3.2.4 Wisher's Auto Recycling Facility (MPDES ID MTR000251) 20
3.2.5 Building Materials Holding Corporation West Truss Facility (MPDES ID MTR000419) 22
3.2.6 United Parcel Service (MPDES ID MTR000447) 24
3.3 Construction Sites 26
4.0 NON-PERMITTED STORMWATER RUNOFF FROM OTHER URBAN AREAS **28**
4.1 City of Whitefish 28
4.2 City of Polson 32
4.3 City of Columbia Falls 32
4.4 Village of Bigfork 32
4.5 Montana Department of Transportation 36
4.6 Impervious Surfaces 36
5.0 DATA GAPS **39**
6.0 REFERENCES **40**

Tables

Table 1. Summary of pollutant concentrations associated with stormwater runoff (median concentrations)..... 2
Table 2. Typical Urban Area Pollutant Yields (lb/acre/year or kg/ha/yr)[a] (as summarized in Burton and Pitt, 2001)..... 2
Table 3. Stormwater discharge monitoring data for the Kalispell MS4 system. 10
Table 4. Stormwater discharge monitoring data for the Glacier Park International Airport. 14
Table 5. Stormwater discharge monitoring data for the F.H. Stoltze Mill. 16
Table 6. City of Whitefish stormwater detention and settling ponds..... 29
Table 7. City of Whitefish stormwater treatment systems..... 30
Table 8. Stormwater subbasins in the Bigfork Village. 33
Table 9. Impervious land in the Flathead Lake watershed, U.S. portion only. 36

Figures

Figure 1. Location of industrial and MS4 permitted entities in the Flathead Lake watershed. 8
Figure 2. Extent of the Kalispell/MDT MS4 Permit and location of known stormwater outfalls, sewers, and culverts. 11
Figure 3. Delineation of areas drained by the Kalispell MS4. 12
Figure 4. Location of the Glacier Park International airport and stormwater outfalls..... 15
Figure 5. Location of the F.H. Stoltze lumber mill. 17
Figure 6. Location of the Glacier Gold Chipping Facility..... 19
Figure 7. Location of the Wishers Auto Recycling Facility. 21
Figure 8. Location of the BMC Truss Facility. 23
Figure 9. Location of the UPS Facility..... 25
Figure 10. Construction stormwater permits in the Flathead Lake Basin. Note: only sites with coordinates are shown..... 27
Figure 11. City of Whitefish and location of city owned stormwater treatment and detention systems. 31
Figure 12. Bigfork Village stormwater subbasins (Flathead County, 2009)..... 35
Figure 13. Location of impervious surfaces in the Flathead Lake watershed (Flathead Valley is displayed)..... 37

Foreward

A series of brief technical reports have been prepared by the U.S. Environmental Protection Agency (EPA) in support of an effort by the Montana Department of Environmental Quality (DEQ) and EPA to establish Total Maximum Daily Loads (TMDLs) for nutrients and set up a water quality simulation model for the Flathead Basin. The series includes separate reports covering a broad range of topics including:

- Groundwater Quality and Hydrology
- Urban Stormwater Sources
- Point Source Discharges
- Agriculture/Irrigation
- Timber Harvest
- Forest Fires
- Roads
- Septic Systems
- Lakes and Reservoirs
- Existing and historic water quality in nutrient impaired waters

When combined, these technical reports are intended to define a preliminary conceptual understanding of the current water quality conditions relative to nutrients, sources of nutrients, and the ways in which water and nutrients are transported within the Basin. The information presented in this series of technical reports will be used to inform the modeling and TMDL processes. However, specific details on model setup are not discussed in the technical reports – that information will be included in the forthcoming Modeling Quality Assurance Project Plan (QAPP).

It should be noted that the data and information presented in these reports reflects what was available at the time that the reports were published. It is acknowledged that in some cases, not all data could be compiled by the publication date. Additional information will be incorporated into the modeling and TMDL processes as it becomes available.

1.0 INTRODUCTION

This is one of a series of brief technical reports prepared in support of an effort by the Montana Department of Environmental Quality (DEQ) and U.S. Environmental Protection Agency (EPA) to establish Total Maximum Daily Loads (TMDLs) for nutrients, sediment, and temperature and set up a water quality simulation model for the Flathead Basin. Stormwater is one of many potentially significant sources of pollutants within the Basin that will ultimately be considered in the modeling effort. The purpose of this technical report is to provide a summary of the extent and type of stormwater sources and systems that are located within the Flathead Basin. The results will then be used to inform the modeling and TMDL processes, which will ultimately be used to define, and put into context at the watershed scale, the potential significance of storm water as a source of pollutants in the Flathead Basin.

It should be noted that the focus of this technical report is on stormwater originating from urban point and nonpoint sources, and specifically on the regulated (i.e., MPDES permitted) stormwater sources. Stormwater from urban sources can significantly alter watershed hydrology and water quality, and these sources must be well characterized to ensure that they are properly simulated in the Flathead Basin water quality model. Furthermore, the regulated stormwater sources must be well characterized to calculate existing loads, assign wasteload allocations, and incorporate those loads into stormwater permits per Clean Water Act regulations and EPA guidance (Wayland and Hanlon, 2002). While this document focuses on the urban stormwater sources, EPA acknowledges that the pollutant loads from urban sources may only be a small fraction of the total load from all stormwater sources. Other potential sources of stormwater pollution (e.g., agriculture, roads, timber harvest, fires, etc.) are discussed in separate technical memos.

1.1 Defining Stormwater

Stormwater can be defined as "water runoff that occurs when precipitation from rain or snowmelt flows over the ground," (USEPA, 2003). Stormwater runoff is natural in the environment, but can be exacerbated by impervious surfaces (e.g., parking lots, roads, roofs, etc.) that reduce infiltration and create excessive overland runoff. When stormwater runoff flows into a surface waterbody, the excess flow and pollutant loads can adversely impact beneficial uses (National Research Council, 2008). The following bullets illustrate how stormwater runoff can be detrimental to surface waterbodies:

- Impervious surfaces decrease the amount of infiltration and increase the amount of overland runoff during a storm event. For example, a parking lot decreases infiltration and causes water to flow over the pavement to the nearest point of discharge (e.g., a sewer/pipe, infiltration pond, stream/lake, or other landscape feature).
- As the stormwater runoff flows over the landscape, it can transport or dissolve pollutants that have accumulated over time (EPA, 2003). For example, stormwater runoff from a parking lot may contain excessive levels of oil and grease that have accumulated from vehicles.
- When stormwater runoff reaches a stream or lake, the pollutants contained in the runoff can adversely impact beneficial uses such as fish, aquatic life, recreational, or drinking water uses (Arnold and Gibbons, 1996; Maxted and Shaver, 1994; Schueler, 1994, 1995, 1996). For example, fish may suffer from the toxic effects of excessive metals in stormwater runoff that are otherwise not present in the stream.
- In addition to increased pollutant loads, excessive stormwater flows can impact beneficial uses by altering sediment processes and stream habitat (Shueler, 1996). For example, increased flows may result in excessive scouring which can alter aquatic life habitat.

Other secondary or tertiary impacts may develop because of increased impervious surfaces and its associated stormwater runoff (e.g., altered water tables or changes in flow paths). However, these impacts are outside of the scope of this memo.

1.2 Urban Stormwater Pollutant Concentrations and Yields

Burton and Pitt (2001) summarized the results of various studies that have looked at pollutant concentrations in stormwater runoff, including data from the Nationwide Urban Runoff Program (NURP) (EPA, 1983), Bannerman et al. (1979, 1983), Madison et al. (1979), and Pitt and McLean (1986). Typical stormwater concentrations (median values of multiple studies) are presented in Table 1, and typical land use yields are presented in Table 2. Some site specific stormwater quality data are also available for MPDES permitted cities and facilities in the Flathead watershed and those data are summarized with the facility characterizations in Section 3.0.

Table 1. Summary of pollutant concentrations associated with stormwater runoff (median concentrations).

Parameter	Residential	Mixed	Commercial	Open/ Non urban
BOD_5, mg/L	10	7.8	9.3	—
COD, mg/L	73	65	57	40
TSS, mg/L	101	67	69	70
Total Kjeldahl nitrogen, µg/L	1900	1289	1179	965
NO_2 + NO_3 (as N) µg/L	736	558	572	543
Total Phosphorus, µg/L	383	263	201	121
Soluble P, µg/L	143	56	80	26

From EPA. Results of the Nationwide Urban Runoff Program. Water Planning Division, PB 84-185552, Washington, D.C. December 1983 (as summarized in Burton and Pitt, 2001).

Table 2. Typical Urban Area Pollutant Yields (lb/acre/year or kg/ha/yr)[a] (as summarized in Burton and Pitt, 2001).

Land Use	Total Solids	Sus. Solids	TP	TKN	NH_3	NO_2 +NO_3	BOD_5	COD
Commercial	2100	1000	1.5	6.7	1.9	3.1	62	420
Parking lot	1300	400	0.7	5.1	2	2.9	47	270
High-density residential	670	420	1	4.2	0.8	2	27	170
Medium-density residential	450	250	0.3	2.5	0.5	1.4	13	50
Low-density residential[b]	65	10	0.04	0.3	0.02	0.1	1	7
Freeways	1700	880	0.9	7.9	1.5	4.2	NA[b]	NA
Industrial	670	500	1.3	3.4	0.2	1.3	NA	200
Parks	NA[c]	3	0.03	NA	NA	NA	NA	NA
Shopping center	720	440	0.5	3.1	0.5	1.7	NA	NA

a The difference between lb/acre/year and kg/ha/yr is less than 15%, and the accuracy of the values shown in this table cannot differentiate between such close values.
b The monitored low-density residential areas were drained by grass swales.
c NA = Not available.
Data from Bannerman et al. (1979, 1983); Madison et al. (1979); EPA (1983); Pitt and McLean (1986).

2.0 REGULATORY AUTHORITY

The National Pollutant Discharge Elimination System (NPDES) Stormwater Program states that industrial activities, construction activities, and municipal separate storm sewer systems (MS4) that have stormwater discharges require stormwater permits (40 CFR 122.26). As such, stormwater originating from these sources is considered a point source of pollution. In Montana, the state has regulatory authority over stormwater permits. However, some cities and counties also have more stringent stormwater regulations in addition to those imposed by the state and EPA. The following sections provide a brief summary of the regulatory authorities that exist in the Flathead Lake Basin.

2.1 State of Montana – Stormwater Point Sources

The state of Montana has regulatory authority for all point source discharges to surface waterbodies, including those discharges that are composed of stormwater runoff. The regulations are contained in the Administrative Rules of Montana [ARM] 17.30.1105, and state that:

> (1) Any person who discharges or proposes to discharge stormwater from a point source must obtain coverage under an [Montana Pollution Discharge Elimination System] MPDES general permit or another MPDES permit for discharges:
>
> a. Associated with construction activity;
> b. Associated with industrial activity;
> c. Associated with mining and oil and gas activity;
> d. From small municipal separate storm sewer systems [MS4] that are identified in ARM 17.30.1102 or designated pursuant to ARM 17.30.1107;
> e. For which the department determines that storm water controls are needed based on wasteload allocations that are part of TMDLs that address the pollutants of concern; and
> f. That the department determines are contributing to a violation of a water quality standard or are significant contributors of pollutants to surface waters.

The Montana Department of Environmental Quality's (DEQ) Permitting and Compliance Division has the regulatory authority to issue stormwater permits. The following sections describe the three types of regulated stormwater discharges that are located within the Flathead Lake Basin – construction, industrial, and MS4.

2.1.1 Construction

Storm water discharges associated with construction activities, as defined in ARM 17.30.1102(28)[1], require authorization from Montana DEQ. Montana DEQ's Permitting and Compliance Division issued a General Permit for Storm Water Discharges Associated with Construction Activity (Permit ID MTR100000) on April 16, 2007, and the permit is valid until December 31, 2011. Construction stormwater discharges are typically permitted under the MPDES General Permit.

The General Permit requires the permittee to complete a Notice of Intent (NOI) form and a Stormwater Pollution Prevention Plan (SWPPP) before authorization can be granted. The SWPPP has three primary objectives (1) to assess the characteristics of the site (2) to identify potential sources of pollutants, and (3)

[1]"Storm water discharge associated with construction activity" means a discharge of storm water from construction activities including clearing, grading, and excavation that result in the disturbance of equal to or greater than one acre of total land area. For purposes of these rules, construction activities include clearing, grading, excavation, stockpiling earth materials, and other placement or removal of earth material performed during construction projects. Construction activity includes the disturbance of less than one acre of total land area that is a part of a larger common plan of development or sale if the larger common plan will ultimately disturb one acre or more.

identify BMPs to minimize or eliminate pollutant discharges to state surface waters through stormwater runoff.

The following effluent limitations are imposed by the construction stormwater General Permit:

1. There must be no discharge of process wastewater pollutants to state surface waters.
2. Any discharge to state surface waters must be composed entirely of stormwater. Discharges must consist of water only generated through rainfall precipitation and snowmelt.
3. A discharge of stormwater must not cause or contribute to a violation of water quality standards.

The Montana stormwater regulations for construction sites have the authority to require stormwater monitoring. However, monitoring in the form of sampling and analytical testing is typically not required (Personal Communications, Brian Heckenberger, May 26, 2009).

At the time of this report, there were 205 authorizations to discharge stormwater from construction sites in the Flathead Lake Basin.

2.1.2 Industrial

ARM 17.30.11 requires industrial facilities to obtain a stormwater discharge permit for conveying stormwater runoff from manufacturing, processing, or raw materials storage areas. Two criteria determine whether an industrial facility needs to apply for an industrial stormwater permit: the type of industry and the presence of a storm water discharge to surface waters. Facilities that meet the criteria (defined in ARM 17.30.11) must apply for authorization from Montana DEQ to discharge industrial stormwater. Pursuant to ARM 17.30.1116, discharges composed entirely of stormwater are not regulated as discharges associated with industrial activity if there is no exposure of industrial materials and activities to rain, snow, snowmelt, and/or runoff, and the discharger satisfies the conditions of this Industrial No-Exposure Certification rule (DEQ, 2006).

Montana DEQ's Permitting and Compliance Division issued a General Permit for Storm Water Discharges Associated with Industrial Activity (Permit ID MTR000000) on August 30, 2006, and the permit is valid until December 31, 2011. The General Permit for stormwater runoff from industrial activities requires the permittee to complete an application form and a Stormwater Pollution Prevention Plan (SWPPP) before authorization can be granted. The objective of the SWPPP is to identify sources of potential pollution to stormwater discharges and to select Best Management Practices (BMPs) to reduce discharge of pollutants at the pollutant source and/or to remove pollutants contained in stormwater runoff.

The following effluent limitations are imposed by industrial stormwater General Permit:

1. There must be no discharge of process wastewater pollutants to surface waters.
2. A discharge of stormwater associated with industrial activity may occur based on water generated only through rainfall precipitation and snowmelt.
3. No discharge of stormwater associated with industrial activity shall cause or contribute to a violation of water quality standards.
4. Discharges of stormwater containing pollutants associated with industrial activity covered under this General Permit will be controlled through the development and implementation of a storm water pollution prevention plan (SWPPP). Best management practices identified in the SWPPP must help eliminate or minimize the discharge of pollutants to surface waters.
5. New or increased stormwater discharges associated with industrial activity on or after April 29, 1993 shall not cause degradation as described under ARM 17.30.715(3) and 75-5-301(5)(c)MCA.

The Montana regulations for industrial stormwater runoff require certain facilities to monitor stormwater discharges and report data to Montana DEQ (as defined in Part 3(a)(2) of the General Permit). The type of monitoring depends on the facility – for example, airports are required to monitor oil and grease, COD, ammonia as N, and flow. At the time of this report, there are six facilities that have industrial stormwater discharge permits in the Flathead Basin.

2.1.3 Municipal Separate Storm Sewer Systems (MS4)

The Administrative Rules of Montana (ARM 17.30.1102) defines a municipal separate storm sewer system (MS4) as:

> *A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains) that discharges to surface waters and is:(a) owned or operated by the state of Montana, a governmental subdivision of the state, a district, association, or other public body created by or pursuant to Montana law, including special districts such as sewer districts, flood control districts, drainage districts and similar entities, and designated and approved management agencies under section 208 of the federal Clean Water Act, which has jurisdiction over disposal of sewage, industrial wastes, storm water, or other wastes, and is:(i) designed or used for collecting or conveying storm water;(ii) not a combined sewer; and(iii) not part of a publicly owned treatment works (POTW) as defined in ARM Title 17, chapter 30, subchapter 13.*

EPA groups MS4s into three categories: small, medium, and large. Incorporated places (i.e., cities) and counties meeting EPA's definitions of medium and large MS4 are identified in the NPDES regulations in 40 CFR Part 122, Appendices F through I. At the time of this report, no medium or large MS4s exist in the State of Montana. Cities and other entities that qualify as "small" MS4s are identified by each state, and Montana's criteria for a small MS4 system are defined in ARM 17.30.1102. As defined in the ARM, the only designated small MS4s in the Flathead Lake Basin are within the City of Kalispell's limits (City of Kalispell and Montana Department of Transportation).

The Permitting and Compliance Division at Montana DEQ developed a General Permit for MS4 systems (Permit ID MTR040000), which is valid from November 5, 2004 through December 31, 2009. All small MS4 authorizations in the state are issued based on meeting the requirements in the General Permit. The General Permit requires the permittee to develop a Storm Water Management Program (SWMP) that is designed to reduce the discharge of pollutants from the permitted small MS4 to the maximum extent practicable (MEP), to protect water quality, and to satisfy the appropriate water quality requirements of the Montana Water Quality Act (DEQ, 2004). As defined in the SWMP, the permittee is required to implement six minimum control measures for MS4 systems including: Public Education and Outreach on Storm Water Impacts; Public Involvement/Participation; Illicit Discharge Detection and Elimination; Construction Site Storm Water Runoff Control; Post-Construction Storm Water Management in New Development and Redevelopment; and Pollution Prevention/Good Housekeeping for Municipal Operations.

2.2 State of Montana – Nonpoint Stormwater Sources

The State of Montana has regulatory authority over stormwater originating from subdivisions (i.e., a nonpoint source) through the subdivision permitting process defined in ARM 17.36.2. New subdivisions are required to apply for a permit through DEQ's Subdivision Review program, and as part of that permit, applicants must submit a storm drainage plan that meets the requirements set forth in Circular DEQ-8 – *Montana Standards for Subdivision Storm Drainage*. The permit for the subdivision is then contingent

upon approval of the storm drainage plan. DEQ does not require any follow up monitoring or inspections. No other nonpoint stormwater sources are regulated by the state.

2.3 Counties

Flathead, Lake, and Missoula Counties all have stormwater regulations for subdivisions that are similar to those required by the State of Montana in ARM 17.36.2 and DEQ Circular 8. The county regulations are contained in the following documents:

- Flathead County Development Code – Chapter 4 – Subdivision Regulations
- Flathead County Lake and Lakeshore Protection Regulations
- Subdivision Regulations of Lake County
- Missoula County Subdivision Regulations

None of the counties regulate any other stormwater sources.

2.4 Cities

There are four incorporated cities in the Flathead Lake watershed: Columbia Falls, Kalispell, Polson, and Whitefish. Each of the cities has its own subdivision regulations that require stormwater plans and controls for subdivisions. The regulations are contained in:

- City of Kalispell Subdivision Regulations; City of Kalispell Standards for Design and Construction
- City of Whitefish Municipal Code Title 12 (Subdivision Regulations) and Title 13 (Lake and Lakeshore Protection Regulations).
- City of Columbia Falls Municipal Code Title 17 (Subdivisions)
- City of Polson Development Code Chapter 18

In addition to the subdivision stormwater regulations, the City of Kalispell also regulates stormwater discharges from construction sites. Kalispell adopted Ordinance 1600 in 2007 titled, "Stormwater Discharges Resulting from Construction and Land Disturbance Activities." The ordinance defines the city's Construction Stormwater Management requirements and standards for land disturbance. The ordinance applies to all land disturbances within the City of Kalispell, including those that are less than one acre, and requires land owners to submit a permit and a Stormwater Management Plan to the city before construction begins. The ordinance states that the Stormwater Management Plan shall contain the following items (Kalispell Municipal Code Chapter 23-A):

- A completed Stormwater Management Plan checklist which outlines the project site's Best Management Practices (BMPs)
- A short narrative explaining how the permittee(s) will implement BMPs described on the checklist
- A map of the construction site showing the locations of the BMPs

In 2007, a total of 146 City Construction Stormwater Management Permits were submitted to the Public Works Office (Personal Communications, Susie Turner, City of Kalispell). Those construction sites that are equal to or greater than one acre are also subject to the requirements of Montana's regulations for construction activities (see Section 2.1.1). Prior to 2007, construction activities of less than one acre and their associated stormwater runoff were not regulated by any entity in the Flathead Basin.

The City of Kalispell also provides municipal regulation and enforcement of non-storm water discharges to the city storm drainage system. In May 2008 City Council adopted Ordinance 1634 establishing regulations controlling the introduction of pollutants into the City of Kalispell Municipal Separate Storm Sewer System (MS4). Ordinance 1634 address the following:

- Categories non-stormwater discharges or flows (i.e., illicit discharges) listed in the state general permit.
- Categories occasional incidental non-stormwater discharges (e.g. noncommercial or charity car washes) that will not be addressed as an illicit discharge.
- Outlines provisions prohibiting any individual non-stormwater discharge that is determined to be contributing significant amount of pollutants to the City's stormwater systems.
- Provides enforcement procedures and actions.

3.0 CHARACTERIZATION OF PERMITTED STORMWATER SOURCES

At the time of this report, there are two small MS4s, six industrial facilities, and approximately 205 construction sites with stormwater permits in the Flathead Lake Basin. Locations are shown in Figure 1. The following subsections provide additional information for the permitted stormwater sources.

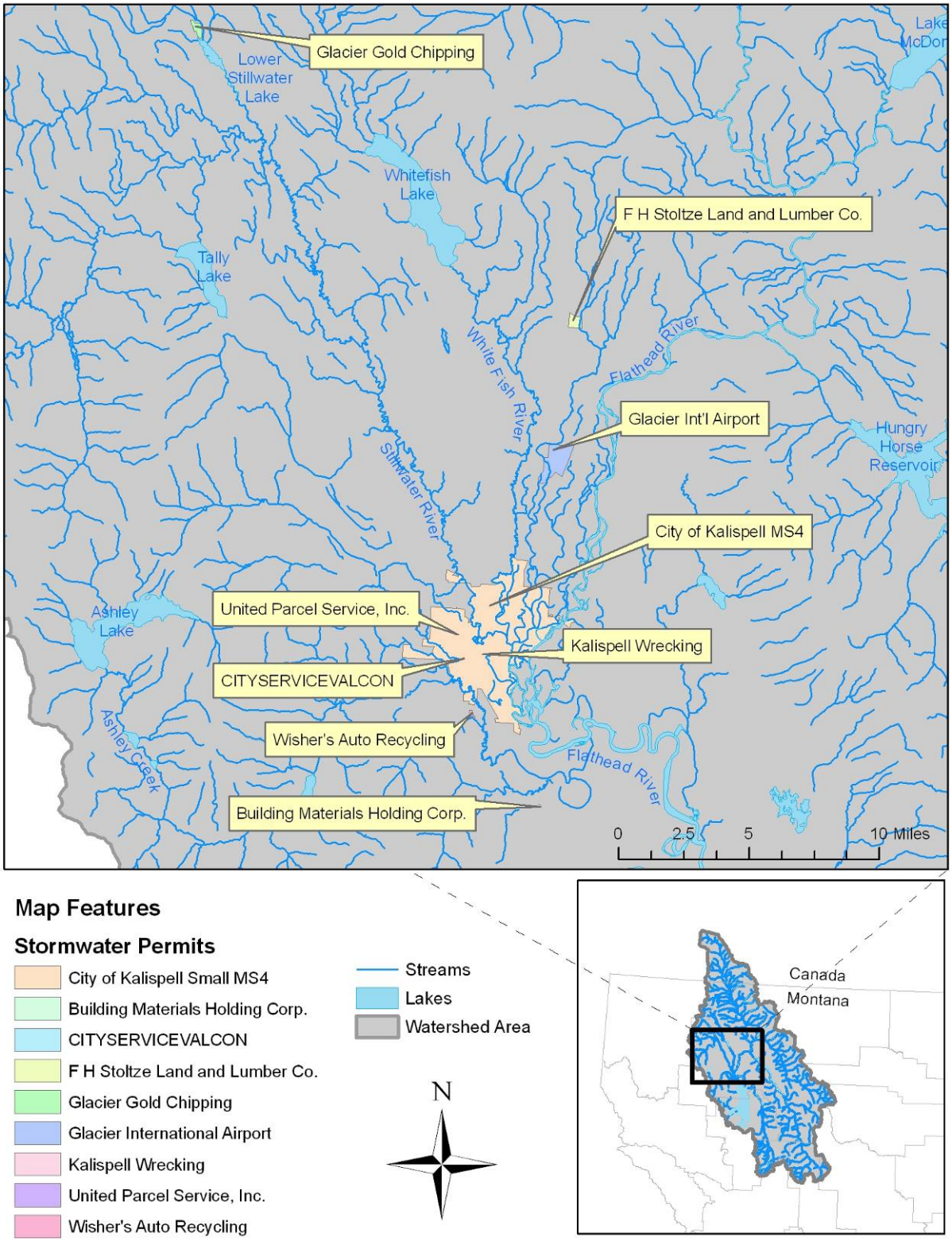


Figure 1. Location of industrial and MS4 permitted entities in the Flathead Lake watershed.

3.1 City of Kalispell and Montana Department of Transportation MS4 (MPDES ID MTR040005)

As stated in Section 2.1.3, the City of Kalispell meets the requirements for a small municipal separate storm sewer system (MS4). The City partnered with the Montana Department of Transportation (MDT) to apply for a MS4 authorization from Montana DEQ. Kalispell's MS4 was authorized on July 17, 2006 and is valid through December 31, 2009 (Permit ID MTR040005). The authorization is based on DEQ's general permit for MS4s (Permit ID MTR040000), and covers the entire incorporated area of Kalispell, and no land outside of the city limits. Per MS4 regulations, the permit is for all stormwater conveyances (e.g., roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, and/or storm drains) that are owned or operated by the City of Kalispell or MDT within the City of Kalispell limits. Discharges are permitted to the Whitefish River, Stillwater River, Ashley Creek, and Spring Creek (only the Stillwater River, Ashley Creek, and Spring Creek for MDT) in Flathead County (DEQ, 2006).

Kalispell's stormwater management program was contacted to help characterize the stormwater infrastructure covered under the MS4 permit. AutoCad and GIS coverages of the city's infrastructure (computer file dated June 2, 2008) were obtained and plotted in a GIS system[2]. Based on the information provided by the city, there are 54 known city owned stormwater outfalls and 81 miles of stormwater pipes and ditches (Figure 2). Two outfalls discharge to the Whitefish River, 23 outfalls to the Stillwater River, 12 outfalls to Ashley Creek, and 17 outfalls to Spring Creek (on the western edge of Kalispell, upstream of the confluence with Ashley Creek). Figure 3 shows which portions of the city drain to which outfalls (created by delineating the stormwater system based on the GIS files provided by the city). The MS4 system drains 4,381 acres of land out of 7,203 acres in the city limits[2].

Montana DEQ requires Kalispell to monitor stormwater runoff at one site that is primarily commercial/ industrial (001A) one that represents primarily residential (002A) runoff. As such, the monitoring locations provide data about stormwater runoff quality at the source, but the data do not necessarily represent the quality of water that reaches a lake or stream (Personal Communications, Brian Heckenberger, Montana DEQ, May 26, 2009). Kalispell's stormwater runoff data are presented in Table 3 for informational purposes only.

The City of Kalispell's 2007 MS4 SWMP Annual Report and the 2008 MS4 SWMP Update document what the City and MDT have accomplished under the SWMP to date and what future activities the co-permittees will conduct. To date, the City and MDT have implemented non-structural, source control management measures to fulfill requirements under the six minimum control measures. The BMPs implemented to date include education, training, operation and maintenance, and policies/ordinances.

[2] At the time of this report, the City of Kalispell is updating their stormwater infrastructure mapping, and the data presented in this report reflect what was available prior to 2008 (Personal Communications, Susie Turner, City of Kalispell, January 7, 2010). This report will be amended when the new data are available.

Table 3. Stormwater discharge monitoring data for the Kalispell MS4 system.

Site	Parameter	Count	Average	Min	Max	Period of Record
001	COD (mg/L)	3	62	22	118	2007-2008
	Copper, total recoverable (µg/L)	3	0.014	0.007	0.027	2007-2008
	Flow rate (cfs)	3	0.104	0.001	0.288	2007-2008
	Lead, total recoverable (µg/L)	3	0.045	0.018	0.080	2007-2008
	Nitrogen, total (as N) (mg/L)	3	1.41	0.66	2.62	2007-2008
	Oil and grease (mg/L)	3	19	15	24	2007-2008
	Phosphorus, total (as P) (mg/L)	3	0.19	0.10	0.34	2007-2008
	Solids, total suspended (mg/L)	3	100	45	167	2007-2008
	Zinc, total recoverable (µg/L)	3	0.174	0.09	0.34	2007-2008
002	COD (mg/L)	3	34	26	49	2007-2008
	Copper, total recoverable (µg/L)	3	0.017	0.005	0.031	2007-2008
	Flow rate (cfs)	2	0.041	0.011	0.072	2007-2008
	Lead, total recoverable (µg/L)	3	0.007	0.001	0.016	2007-2008
	Nitrogen, total (as N) (mg/L)	3	2.22	0.65	4.04	2007-2008
	Oil and grease (mg/L)	2	11	8	13	2007-2008
	Phosphorus, total (as P) (mg/L)	3	0.23	0.07	0.41	2007-2008
	Solids, total suspended (mg/L)	3	392	20	951	2007-2008
	Zinc, total recoverable (µg/L)	2	0.132	0.054	0.21	2007-2008

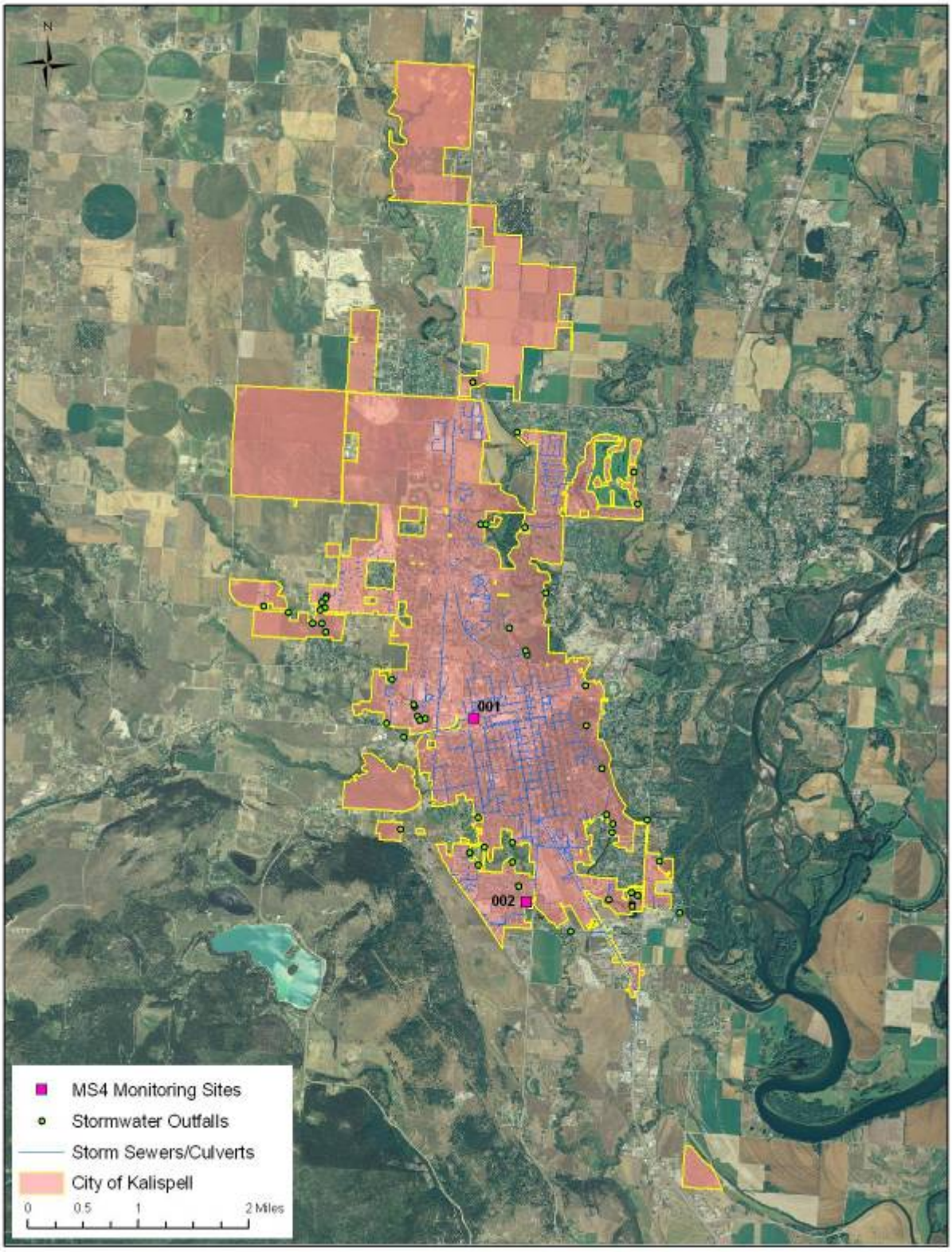


Figure 2. Extent of the Kalispell/MDT MS4 Permit and location of known stormwater outfalls, sewers, and culverts.

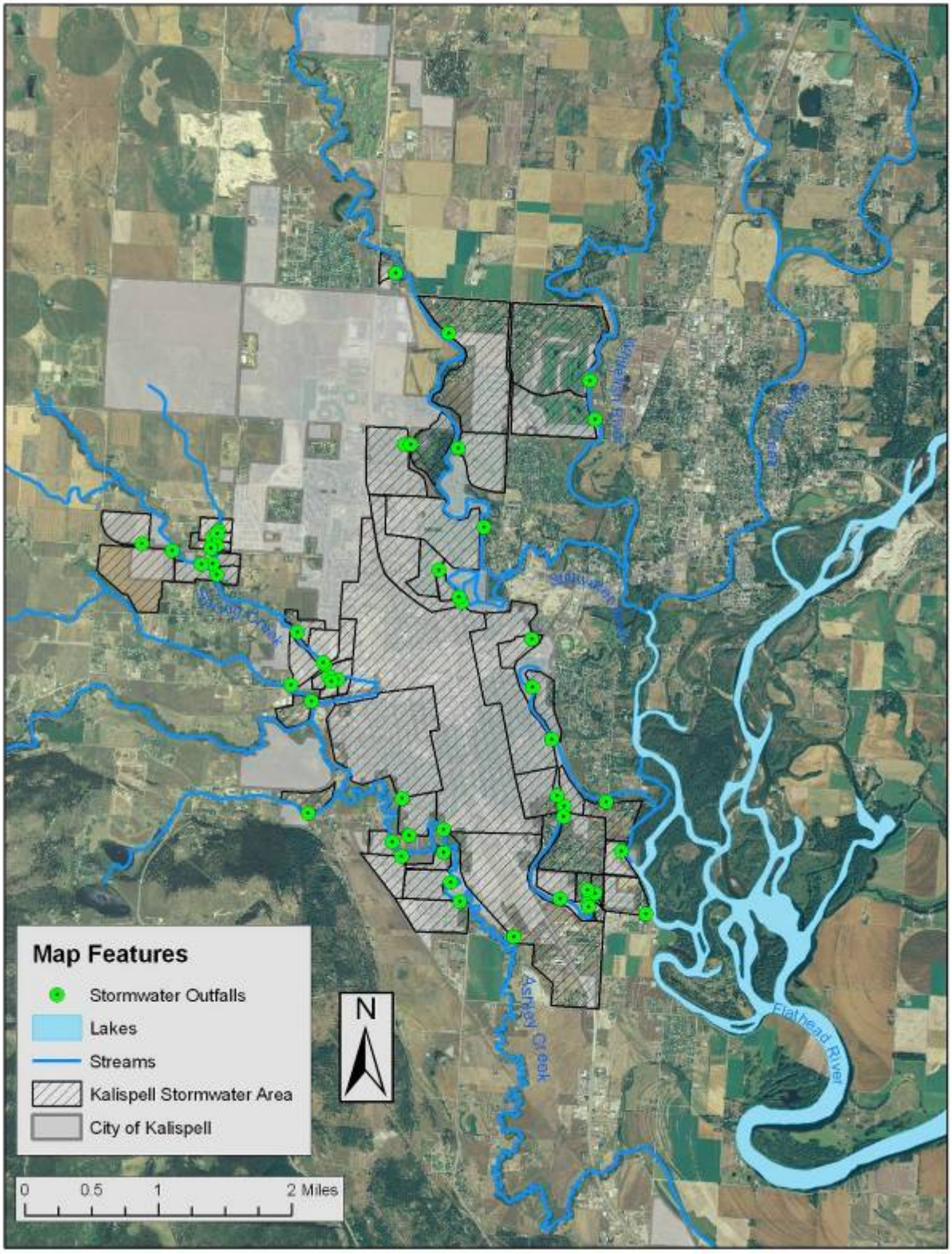


Figure 3. Delineation of areas drained by the Kalispell MS4.

3.2 Industrial Facilities

There are six industrial facilities in the Flathead Basin that have authorization to discharge under Montana's General Permit for Storm Water Discharges Associated with Industrial Activity (MTR000000). A discussion of each industrial facility in the Flathead Basin and the applicable stormwater permit requirements is provided below.

3.2.1 Glacier Park International Airport (MPDES ID MTR000309)

The Glacier Park International (GPI) Airport is located northeast of the City of Kalispell at 4170 Highway 2, and is approximately 1500 acres in size. The facility was constructed in 1942, and consists of two runways, an airline terminal, fueling station, maintenance buildings, car rental facility, airplane hangars, and numerous other small buildings and paved lots to support airport operations (Glacier Park International Airport, 2006).

Stormwater runoff from the airport is complex, with different portions of the facility discharging to eight stormwater retention basins (Glacier Park International Airport, 2006). Also, portions of the facility discharge to ditches with outfalls on Trumbull Creek and an unnamed tributary to Trumbull Creek (Figure 4). The airport Storm Water Pollution Prevention Plan (SWPPP) contains detailed maps showing the routing of stormwater to the basins and outfalls (Glacier Park International Airport, 2006).

Montana DEQ authorized the airport to discharge stormwater (Permit ID MTR000309) on December 18, 2006, with an expiration date of September 30, 2011. The permit requires the facility to perform semi-annual sampling at the stormwater detention basin located west and south of the main terminal building and near the U.S. Customs Building (i.e., Detention Basin) for the following parameters: visual observation of oil and grease; five-day BOD; COD; TSS; pH; and ethylene and propylene glycol. The same parameters are also sampled at Outfall 001 on a semiannual basis. No monitoring is required at the other outfalls or retention basins, as these discharges are not exposed to industrial materials. Table 4 summarizes the available data for the retention basin sampling location (see Figure 4) (obtained from ICIS on December 1, 2008).

Table 4. Stormwater discharge monitoring data for the Glacier Park International Airport.

Site	Parameter	Count	Average	Min	Max	Period of Record
Detention Basin	BOD, 5-day (mg/L)	1	170	170	170	1999
	Ethylene glycol (µg/L)	1	100	100	100	1999
	Flow rate (cfs)	7	0.112	0.029	0.288	2004-2007
	COD (mg/L)	8	222.88	8.00	1060.00	1999-2007
	pH	1	7.10	7.10	7.10	1999.00
	TSS (mg/L)	8	40.375	2	119	1999-2007
Outfall 001	BOD, 5-day (mg/L)	1	3	3	3	1999
	Ethylene glycol (µg/L)	1	10	10	10	1999
	Flow rate (cfs)	8	0.137	0.007	0.360	2004-2008
	COD (mg/L)	9	66.89	5.00	318.00	1999-2008
	pH	1	7.80	7.80	7.80	1999.00
	TSS (mg/L)	9	20.67	1.00	105.00	1999-2008

As part of the stormwater permit, the facility was required to submit a Stormwater Pollution Prevention Plan (Dated August 2006). The plan lists the following potential pollutants that could be present in its stormwater runoff: propylene glycol, glycol, urea, sodium chloride, pesticides, fertilizer, ammonium sulfate, ammonium phosphate, and waste gas, diesel, and oil. To prevent these chemicals from entering waterways, the facility has proposed preventative maintenance and good housekeeping BMPs. These, in addition to the stormwater detention basins, make up the facility's pollution prevention plan.



Figure 4. Location of the Glacier Park International airport and stormwater outfalls.

3.2.2 F.H. Stoltze Land and Lumber Co (MPDES ID MTR000019)

The F.H. Stoltze Lumber Mill is located in Flathead County west of the City of Columbia Falls on Half Moon Road. The original mill was constructed in 1923, and numerous rebuilds and upgrades have occurred over time (F.H. Stoltze Land and Lumber, 2008). The plant site consists of administrative offices, a log yard, random length sawmill, dry kilns and planing mill, and is 149 acres in size (F.H. Stoltze Land and Lumber, 2006) (Figure 5).

Stormwater runoff from the site is regulated by Montana DEQ through the MPDES program. Most recently, DEQ authorized the facility to discharge from October 20, 2006 through September 30, 2011 (Permit ID MTR04000019). This type of facility (SIC 2421) is not subject to self-monitoring and reporting requirements under the general stormwater permit. However, one sampling event was reported in ICIS, and the data are summarized in Table 5. Primary pollutants of concern associated with this particular facility includes pH and total suspended solids (TSS) related to the exposure of sawdust, planer shavings, bark, and wood chips at the site.

Table 5. Stormwater discharge monitoring data for the F.H. Stoltze Mill.

Parameter	Count	Value	Date
BOD, 5-day (mg/L)	1	5	1/25/96
COD (mg/L)	1	52	
pH	1	7.7	
TSS (mg/L)	1	46	
Nitrogen, Kjeldahl, total (as N) (mg/L)	1	0.52	
Phosphorus, total (as P) (mg/L)	1	0.95	

The mill's Stormwater Pollution Prevention Plan indicates that there are several stormwater detention basins on the property, and all stormwater flow "follows berms or ditches and flows through and over control devices and eventually can flow into Trumbull Creek," (F.H. Stoltze Land and Lumber, 2006). During the 2005 inspection of the facility, DEQ personnel noted that BMPs consisted of "thick vegetative cover around the periphery of the facility, three detention ponds, and straw bales" (DEQ, 2005). Figure 5 shows the location of the facilities stormwater detention ponds and outfall to Trumbull Creek.

Stormwater BMPs at the plant consist of good housekeeping practices, preventative maintenance, inspections, spill prevention and response plans, berms, detention basins, and grassed drainage ditches (F.H. Stoltze Land and Lumber, 2006).



Figure 5. Location of the F.H. Stoltze lumber mill.

3.2.3 Glacier Gold Chipping (MPDES ID MTR000465)

Glacier Gold Chipping operates a wood chipping facility that is located in Flathead County near the town of Olney, Montana (Figure 6). The facility was constructed in 1993, and has an area of 65 acres including remediated land from an old sawmill and composting site (Glacier Gold Chipping, 2007). Included on site are a timber chipping facility, warehouse storage, stockpiles of dirt, sawdust, and bark, and a sawmill for custom beams. The total impervious area is 10.3 acres (including paved areas and roofs). Stockpiles of dirt, sawdust, bark fines, and wood chips are exposed to stormwater runoff, and could potentially impact nearby surface waterbodies.

Stormwater runoff from the site is regulated by Montana DEQ through the MPDES program. DEQ issued the most recent industrial stormwater permit for October 1, 2006 through September 30, 2011 (Permit ID MTR04000465). This type of facility (SIC 2421 and 2429) is not subject to self-monitoring and reporting requirements under the general stormwater permit, and no recent monitoring data are available. Primary pollutants of concern associated with this particular facility includes pH and total suspended solids (TSS) related to the exposure of sawdust, bark, and wood chips at the site.

Stormwater runoff from the site is diverted to settling ponds before being discharged to either the Stillwater River or Lower Stillwater Lake. Stormwater runoff to Lower Stillwater Lake originates on the west side of the site, either draining directly to a settling pond following the natural slope of the site or to a manmade ditch that directs flow to the settling pond (Glacier Gold Chipping, 2007). Flow from the settling pond to the lake first passes through two layers of silt fence to further trap sediment. Stormwater discharges to the Stillwater River originate from the east side of the site and drains to one of two settling ponds along the east side of the site, with flow from the southeastern part of the site directed to one of the settling ponds by a manmade ditch (Glacier Gold Chipping, 2007). Stormwater leaving the settling ponds toward the river also pass through two layers of silt fence. The SWPPP states that the site drainage design and the BMPs, including the settling ponds and silt fences, will address the pollutants of concern related to the water quality impairments. No stormwater sampling has been conducted at this facility; therefore, there are no existing sampling data available to characterize stormwater-related pollutants from this site.



Figure 6. Location of the Glacier Gold Chipping Facility.

3.2.4 Wisher's Auto Recycling Facility (MPDES ID MTR000251)

Wisher's Auto Recycling Facility is located at 2190 Airport Road in Kalispell (Flathead County). The facility is 20 acres in size, and the construction date is unknown.

Stormwater runoff from the site is regulated by Montana DEQ through the MPDES program. DEQ issued the most recent industrial stormwater permit from October 1, 2006 through September 30, 2011 (Permit ID MTR000251). This type of facility (SIC 5039) is not subject to self-monitoring and reporting requirements under the general stormwater permit, and no recent monitoring data are available. Primary pollutants of concern associated with this facility include total suspended solids (TSS), BOD, COD, oils/grease, and nutrients.

Stormwater runoff from the facility flows towards the south and east to a ditch leaving the facility at the southeast corner (DEQ, 2007). Based on an assessment of local topography and stream networks, there are no perennial streams located near the facility. The nearest perennial stream is Ashley Creek, which is located 1700 feet from the facility.



Figure 7. Location of the Wishers Auto Recycling Facility.

3.2.5 Building Materials Holding Corporation West Truss Facility (MPDES ID MTR000419)

Building Materials Holding Corporation operates a facility for making trusses that is located in Flathead County in the City of Kalispell, Montana (Figure 8). The facility has an area of 6 acres and includes a truss manufacturing shop, saw shop, office, and lumber and truss storage areas. All manufacturing processes occur inside the various shops and are not exposed to stormwater runoff (BMC Truss, 2006). Materials exposed to stormwater runoff include asphalt, concrete, and graveled areas, and a spill-proof concrete bermed fueling area. The construction date of the facility is unknown.

Stormwater runoff from the site is regulated by Montana DEQ through the MPDES program. DEQ issued the most recent industrial stormwater permit from October 1, 2006 through September 30, 2011 (Permit ID MTR000419). This type of facility (SIC 2439) is not subject to self-monitoring and reporting requirements under the general stormwater permit, and no recent monitoring data are available. Primary pollutants of concern associated with this particular facility includes total suspended solids (TSS) related to the exposure of sawdust and dirt.

Stormwater runoff from the site is collected in a series of swales and ditches that eventually discharge to Ashley Creek (located two miles to the north). A perennial slough is located 0.25 miles to the east of the facility, although it is unclear from the SWPPP if the stormwater ditches are connected to the slough. BMPs at the facility include good housekeeping practices such as removal of debris, employee training for spills and cleanup, proper indoor storage of containers (BMC Truss, 2006). No stormwater sampling has been conducted at this facility; therefore, there are no existing sampling data available to characterize stormwater-related pollutants from this site.



Figure 8. Location of the BMC Truss Facility.

3.2.6 United Parcel Service (MPDES ID MTR000447)

The United Parcel Service facility is located at 1151 North Meridian, Kalispell in Flathead County (Figure 9). The facility is 2 acres in size and includes vehicle maintenance and washing areas, as well as an office and paved lot. Pollutants that are potentially exposed to stormwater include solvents, metals, and other vehicle fluids associated with maintenance and washing activities (United Parcel Service, 2006).

Stormwater runoff from the site is regulated by Montana DEQ through the MPDES program. DEQ issued the most recent industrial stormwater permit from October 1, 2006 through September 30, 2011 (Permit ID MTR000447). This type of facility (SIC 4215) is not subject to self-monitoring and reporting requirements under the general stormwater permit, and no recent monitoring data are available. Primary pollutants of concern associated with this particular facility includes total suspended solids (TSS), BOD, COD, oils/grease, solvents, and metals.

Stormwater runoff from the site is collected in two swales that are located parallel to the facility (see Figure 9). The swales discharge to a swale owned by the city of Kalispell that runs along North Meridian Road. The road swale is part of the Kalispell small MS4 system, and is regulated by Kalispell's MS4 permit (see Section 3.1).



Figure 9. Location of the UPS Facility.

3.3 Construction Sites

As stated in Section 2.1.1, construction sites that meet the requirements of ARM 17.30.1102 are required to develop a SWPPP and implement BMPs to reduce erosion. The ICIS database was queried to provide summary statistics for all of the constructions sites that are authorized to discharge stormwater in the Flathead Lake Basin. Data were downloaded on December 2, 2008 and were input into an Access database. The ICIS database contained information on permits authorized between 2002 and 2008, and at the time of the download, there were 1,993 authorizations to discharge under the General Permit for Storm Water Discharges Associated with Construction Activity. Coordinates, receiving waterbody, city, county, and HUC data were assessed for each site to determine which sites were in the Flathead Lake Basin. It is estimated that 188 out of the 1,993 authorizations are located in the basin. However, location information was not always provided, and the estimate is partially based on best professional judgment. Of the 188 sites, 128 (68%) had active permits – the remaining permits were expired or terminated.

In the Flathead Lake Basin, 115 (61%) of the sites had coordinate information, and these sites are displayed in Figure 10. Sites are generally clustered around the cities of Whitefish and Kalispell. However, it appears the there are some positional errors in the data, as several sites plotted in the wilderness areas or in the middle of lakes. Because of the large number of sites, no effort was made at this time to correct site locations or to locate sites with no positional information. Site sizes are available in the individual permits, but no effort was made at this time to obtain that information because of the large number of sites in the basin. Also, No water quality data were available for the sites in the Flathead Lake Basin.

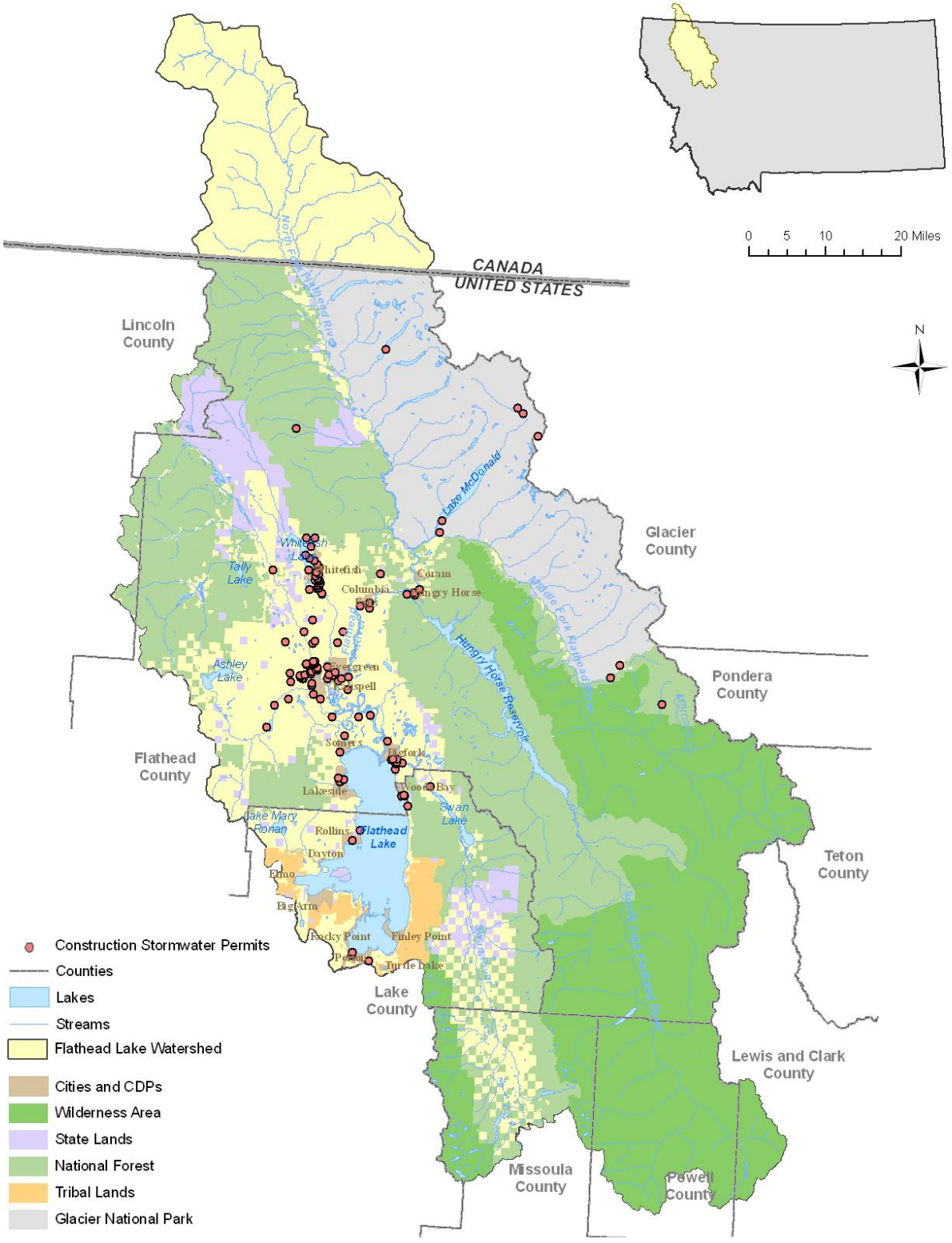


Figure 10. Construction stormwater permits in the Flathead Lake Basin. Note: only sites with coordinates are shown.

4.0 NON-PERMITTED STORMWATER RUNOFF FROM OTHER URBAN AREAS

Stormwater runoff from urban and urbanizing areas and associated land use activities that are not covered under the NPDES Stormwater Program can also contribute pollutant loads. For the purposes of this Technical Report, these unregulated stormwater sources are considered urban nonpoint source runoff. Sources to consider include commercial areas, construction sites less than one acre that are not subject to local ordinances, and municipal and residential areas that fall outside the definition of a regulated small MS4 under the NPDES Phase II program. These areas have impervious surfaces that have the potential to contribute similar pollutants via stormwater runoff as those areas covered under the NPDES Stormwater Program. The following sections summarize the major nonpoint urban stormwater sources in the Flathead Lake Basin.

4.1 City of Whitefish

The City of Whitefish was not classified as a small MS4 community in Montana's Administrative Rules or the General MS4 permit, and therefore the city is not required to have a stormwater permit. However, the city does have a stormwater system consisting of "detention ponds, swales, roadside ditches, pipes, manholes, catch basins, and treatment systems that convey and treat storm runoff from the City of Whitefish and the surrounding area prior to discharge to Whitefish Lake, the Whitefish River, and Cow Creek," (City of Whitefish, 2006). The City's Stormwater System Utility Plan further describes the system as follows:

> *The existing storm drainage collection system is comprised of roadside ditches, catch basins, manholes, pipes and swales located primarily within the central portion of the city. Piping ranges in size from 8 to 42 inches and is comprised mainly of plastic (PVC). Concrete catch basins, inlets, and manholes convey surface runoff to the piping network. Drainage is conveyed to Cow Creek, Whitefish Lake, and the Whitefish River. There are currently fifteen outfalls to the Whitefish River, three outfalls to Whitefish Lake and six outfalls to Cow Creek. The majority of the new development that has occurred since the previous stormwater planning efforts (Robert Peccia & Associates, 1997) does not connect to existing infrastructure within the system and is comprised primarily of detention ponds, and infiltration systems. There are approximately 500 catch basins, 300 manholes, 8,100 lineal feet of 8-inch pipe, 25,000 lineal feet of 12-inch pipe, 2,100 lineal feet of 15-inch pipe, 12,000 lineal feet of 18-inch pipe, 1,900 lineal feet of 21-inch pipe, 7,580 lineal feet of 24-inch pipe, 800 lineal feet of 36-inch pipe and 140 lineal feet of 42-inch pipe in the exiting system.*

There are 14 settling/detention ponds in the stormwater system to store and treat stormwater runoff. These are summarized in Table 6 and shown in Figure 11. There are also 11 other treatment structures ranging from swales to mechanical filters (summarized in Table 7 and Figure 11).

The City provided GIS files of the stormwater system on July 21, 2008. The files contained information on the location, type, and extent of the City owned stormwater system. Using the data in the file, the areas draining to each city owned stormwater outfall or pond were delineated and are shown in Figure 11. In all, the stormwater system collects runoff from 1,249 acres (1.95 sq miles) of land (compared to 2,849 acres within the city limits).

Table 6. City of Whitefish stormwater detention and settling ponds.

Pond	Location	Estimated Capacity or Approx. Dimensions	Type of Inlet Structure	Type of Outlet Structure	Location of Outfall	Maintenance
Pond A	Hospital Pond					City
Pond B	Riverside Pond					Private
Pond C	Riverwood Pond					Private
Pond D	MDT Pond					MDT
Pond E	Mall Pond	1500' x 700'	None	None	No outlet	City
Pond F	MDT Baker Avenue Pond	Unknown	Unknown	None	No outlet	MDT
Pond G	Park Avenue Pond	18,200 cf	2-24" RCP pipes w/ safety grates	Perforated manhole	Cow Creek	City
Pond H	Dairy Queen Pond	Unknown	24" RCP w/ flared end	24" RCP pipe	Whitefish River	City
Pond I	Riverside Park Pond	44,000 cf	1-42" HDPE pipe; 1-18" HDPE pipe	Multiple orifice concrete structure w/36" pipe	Whitefish River	City
Pond J	Mountain Trails Park Pond					City
Pond K	Crestwood Court Pond	70' x 50'	None	None	No Outlet	Private
Pond L	Mountain Harbor Pond	Unknown	Unknown	Unknown	Whitefish Lake	Private
Pond M	Mountain Park Pond	7,000 cf	Trap swale; 8' wide x 1' deep	Multiple orifice concrete outlet w/ 12" CMP overflow	Roadside ditch on Mountain Lion Rd.	Private
Pond N	Willow Brook Pond	70' x 50'	8" PVC pipe	8" PVC pipe	Cow Creek	Private

Source: Whitefish 2005 Stormwater System Utility Plan.

Table 7. City of Whitefish stormwater treatment systems.

Number	Location	Type of System	Project Design Engineer	Year Installed
1	13th Street System	Mechanical filters	Billmayer Eng.	1998
2	Baker Avenue Outfall	Perforated manhole/washed rock outfall	Morrison-Maerle	1999
3	Second Street East	Grassy Swale	Peccia & Assoc.	2000
4	Greenwood Drive	Stormceptor/ grassy swale	HKM	2001
5	Riverpark Subdivision	Stormceptor	Stokes Eng.	2005
6	Kay Beller Park	Perforated manhole/washed rock outfall	Peccia & Assoc.	2002
7	Bay Point Drive	Stormwater Management Filter	Peccia & Assoc.	2001
8	Ramsey Avenue	Vortechs Model 1000	Billmayer Eng.	2002
9	Whitefish Lake Lodge	Stormceptors (privately maintained)	WMW	2005
10	Baker Ave./10th	Perforated manhole/washed rock outfall	WMW	1995
11	Columbia Ave. north of bridge	Perforated manhole/washed rock outfall	WMW	1997

Source: Whitefish 2005 Stormwater System Utility Plan.

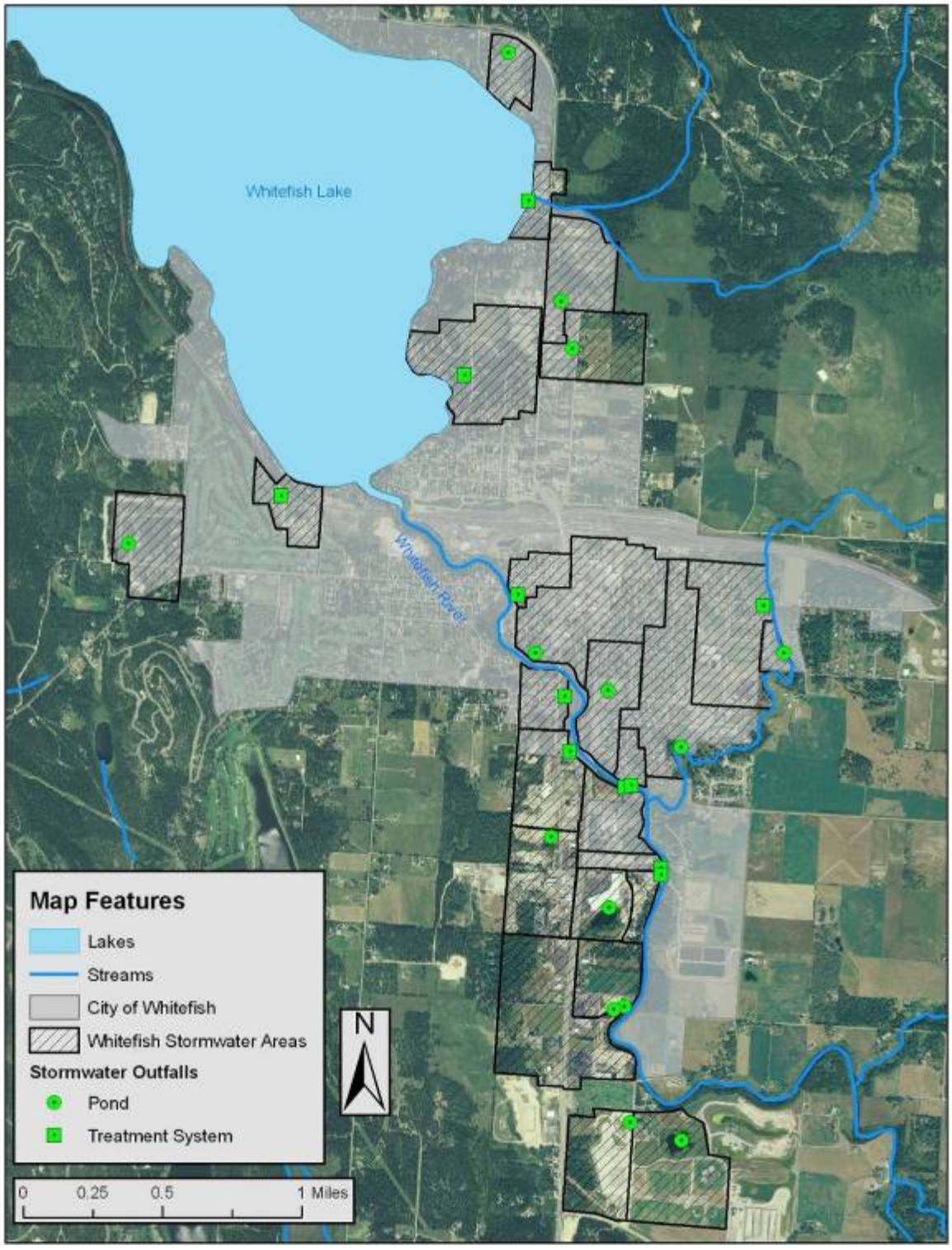


Figure 11. City of Whitefish and location of city owned stormwater treatment and detention systems.

4.2 City of Polson

The City of Polson was not classified as a small MS4 community in Montana's Administrative Rules or the General MS4 permit, and therefore the city is not required to have a stormwater permit. However, the city does have a stormwater sewer system consisting of the following (Personal Communications, Tony Porrazzo, Polson Water and Sewer Superintendant, January 7, 2009):

- A series of laterals installed in the early 1900s that were originally part of a federal irrigation project (40 inch main with multiple laterals). The laterals discharge to a separator/vault treatment system before being discharged to the Flathead River.
- A centralized stormwater sewer system spanning approximately 20 blocks of downtown Polson (approximately 20 percent of the city is sewered). Eleven stormwater outfalls from this system discharge to Flathead Lake (no treatment systems exist).
- Stormwater retention ponds associated with city parks.

A map of the stormwater system and outfalls was not available at the time of this report, but Mr. Porrazzo indicated that a stormwater mapping and engineering study for the city are currently underway (Personal Communications, Tony Porrazzo, Polson Water and Sewer Superintendant, January 7, 2009).

4.3 City of Columbia Falls

The City of Columbia Falls was not classified as a small MS4 community in Montana's Administrative Rules or the General MS4 permit, and therefore the city is not required to have a stormwater permit. However, the city does have a stormwater system consisting of dry wells and detention ponds, none if which have surface water discharges (Personal Communications, Loren Lowry, April 28, 2008). A map of the stormwater system was not available at the time of this report.

4.4 Village of Bigfork

The Village of Bigfork was not classified as a small MS4 community in Montana's Administrative Rules or the General MS4 permit, and therefore the city is not required to have a stormwater permit. However, the city does have a stormwater sewer system that was created in the early 1900s when the city was first settled (Personal Communications, Bill Buxton, Morris and Maerle, May 28, 2008).

A recent report titled "Bigfork Stormwater Facilities Assessment Report" documents the existing stormwater infrastructure in Bigfork (Flathead County, 2009). The report divides Bigfork into 28 subbasins (140 total acres) that have unique stormwater drainage patterns. The subbasins and their discharge locations are described in Table 8.

Table 8. Stormwater subbasins in the Bigfork Village.

SUB-BASIN	DEFINITION	SIZE (ac)	DESIGNATION
FB-1	FLATHEAD BANK	3.61	SW Corner/MK-1
MK-1	MARINA KAY	19.47	Bay/Boat Dock
TR-1	HIGH SCHOOL TRACK	11.85	Closed Basin
GC-1	GRAND DR / COMM ST	8.34	SW Corner/GD-2
SD-1	SCHOOL DISTRICT	0.56	Drywell/GD-2
SD-2	SCHOOL DISTRICT	2.23	Infiltration Facility/GD-2
SD-3	SCHOOL DISTRICT	4.73	Infiltration Facility/GD-2
SD-4	SCHOOL DISTRICT	1.96	GD-1
SD-5	SCHOOL DISTRICT	4.33	SW Corner/GC-1
GD-1	GRAND DRIVE	3.44	Catch Basins to GD2
GD-2	GRAND DRIVE	5.91	Catch Basins to Bay
GD-3	GRAND DRIVE	2.93	Curb Flow to GD2
COM-1	COMMERCE STREET	7.57	South/GD-1 & GD-2
COM-2	COMMERCE STREET	8.01	South/GD-3
BAY-1	FLATHEAD LAKE BAY	3.83	Bay
BAY-2	FLATHEAD LAKE BAY	0.72	Bay
BAY-3	FLATHEAD LAKE BAY	2.52	Bay
BAY-4	FLATHEAD LAKE BAY	1.28	Bay
BAY-5	FLATHEAD LAKE BAY	15.53	Bay
RS-1	RIVER STREET	3.37	Catch Basins to Bay
CAS-1	CASCADE AVE	1.44	Closed Basin
EA-1	ELECTRIC AVENUE	1.24	Drywells/Bay
BSN-1	BRIDGE STREET NORTH	3.35	Catch Basins to River
OC-1	OSBORN CONDO'S	0.8	Drywell/BSN-1
BSS-1	BRIDGE STREET SOUTH	7.05	North/BSS-2
BSS-2	BRIDGE STREET SOUTH	3.87	North/BSS-3
BSS-3	BRIDGE STREET SOUTH	3.67	Culvert to River
PC-1	PACIFIC CORPORATION	6.64	River

Source: Flathead County, 2009.

Each of the subbasins was then grouped into 6 watersheds. Of these 28 sub-basins, 11 contribute to the Grand Drive watershed, 1 contributes to the River Street watershed, 1 contributes to the Electric Avenue watershed, 2 contribute to the Bridge Street North watershed, 3 contribute to the Bridge Street South watershed, and the remaining 10 are identified as "other" sub-basins. Of these "other" sub-basins 2 are closed basins and 8 directly influence the Bigfork Bay or Swan River through routing across private land ownership. Figure 12 shows the subbasins and watersheds. The watersheds and their outfalls are described below (Flathead County, 2009):

- **Grand Drive Watershed:** Is comprised of 11 sub-basins and equates to 50.01 acres. The watershed includes sub-basins GC-1, SD-1, SD-2, SD-3, SD-4, SD-5, GD-1, GD-2, GD-3, COM-1, and COM-2. This watershed discharges to the Bigfork Bay via an existing outfall pipe.
- **River Street Watershed:** Is comprised of one sub-basin and equates to 3.37 acres. The watershed includes only sub-basin RS-1. This watershed discharges to the Bigfork Bay via an existing outfall pipe.
- **Electric Avenue Watershed:** Is comprised of one sub-basin and equates to 1.24 acres. The watershed includes only sub-basin EA-1. It is undetermined how this watershed officially discharges to the Bigfork Bay.
- **Bridge Street North Watershed:** Is comprised of two sub-basins and equates to 4.15 acres. The watershed includes sub-basins BSN-1 and OC-1. This watershed discharges to the Swan River via an existing outfall pipe.

- **Bridge Street South Watershed:** Is comprised of three sub-basins and equates to 14.59 acres. The watershed includes sub-basins BSS-1, BSS-2, and BSS-3. This watershed discharges to the Swan River via an existing outfall pipe.
- **Other:** Technically is not deemed as a watershed, but for the purposes of this report, is used only to account for the remaining sub-basins. The remaining subbasins equate to 66.89 acres and include FB-1, MK-1, TR-1, BAY-1, BAY-2, BAY-3, BAY-4, BAY-5, CAS-1, and PC-1.

Additional information is available in the Assessment Report regarding the specific location and stormwater conveyance for each of the subbasins.

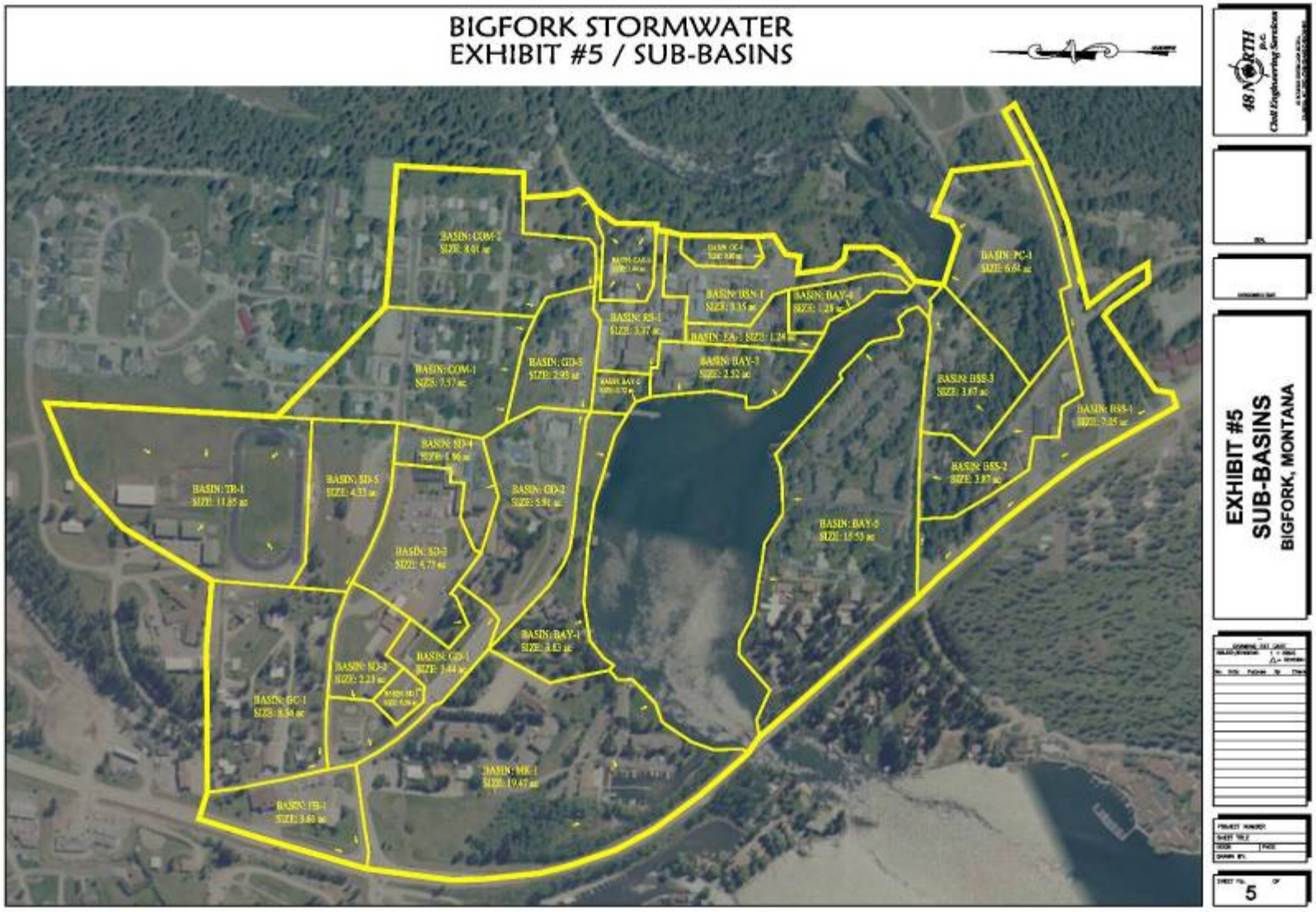


Figure 12. Bigfork Village stormwater subbasins (Flathead County, 2009).

4.5 Montana Department of Transportation

As described in Section 3.1, stormwater runoff associated with roads maintained by the Montana Department of Transportation (MDT) and located within the Kalispell City limits are permitted by the MS4 program. Stormwater runoff and outfalls from this system are described in conjunction with Kalispell's system in Section 3.1. MDT was contacted to obtain information on stormwater runoff from MDT roads located outside of Kalispell and within the Flathead Lake Basin. At the time of this report MDT personnel indicated that stormwater conveyances for individual roads are available as part of road design specifications or erosion control plans for specific projects on file at MDT (Personal Communications, Daniel Ham, Montana Department of Transportation, January 7, 2009). However, all stormwater conveyances from MDT managed roads outside Kalispell City Limits are not currently mapped or summarized in any reports or databases. Additional field verification may be needed to locate and quantify these conveyances.

4.6 Impervious Surfaces

Studies have shown that watersheds having greater than 10 percent impervious surfaces gave degraded biotic integrity in streams and decreased channel stability and fish habitat (Arnold and Gibbons, 1996; Maxted and Shaver, 1994; Schueler, 1995, 1996). Once impervious cover exceeds 20 to 25 percent, nutrient loading begins to exceed background levels (Schueler, 1995).

The 2001 National Land Cover Data (NLCD) GIS coverage of Impervious Surfaces was downloaded and analyzed to determine the amount and location of impervious surfaces in the U.S. portion of the Flathead Lake watershed (http://www.epa.gov/mrlc/nlcd-2001.html). The NLCD classified 30 meter by 30 meter cells with a percent impervious cover of 0 to 100% for each cell (Vogelman et al., 2001). The impervious cover for the central portion of the Flathead Valley is displayed in Figure 13, and the total acres in the entire watershed are summarized in Table 9. It should be noted that that NLCD coverage was based on late 1990s satellite imagery, and there is likely more impervious cover in the basin today. As of the date of the satellite imagery, less than one percent of the Flathead Basin in the U.S. has greater than 10 percent impervious cover. No impervious land use data were available for British Columbia.

Table 9. Impervious land in the Flathead Lake watershed, U.S. portion only.

Percent Impervious Cover	Acres	Percent of Total
0%	4,044,771	97.78%
1-10%	54,468	1.32%
11-25%	17,698	0.43%
26-50%	14,256	0.34%
51-75%	4,195	0.10%
76-100%	1,012	0.02%
Total	4,136,400	100.00%

Source: NLCD 2001

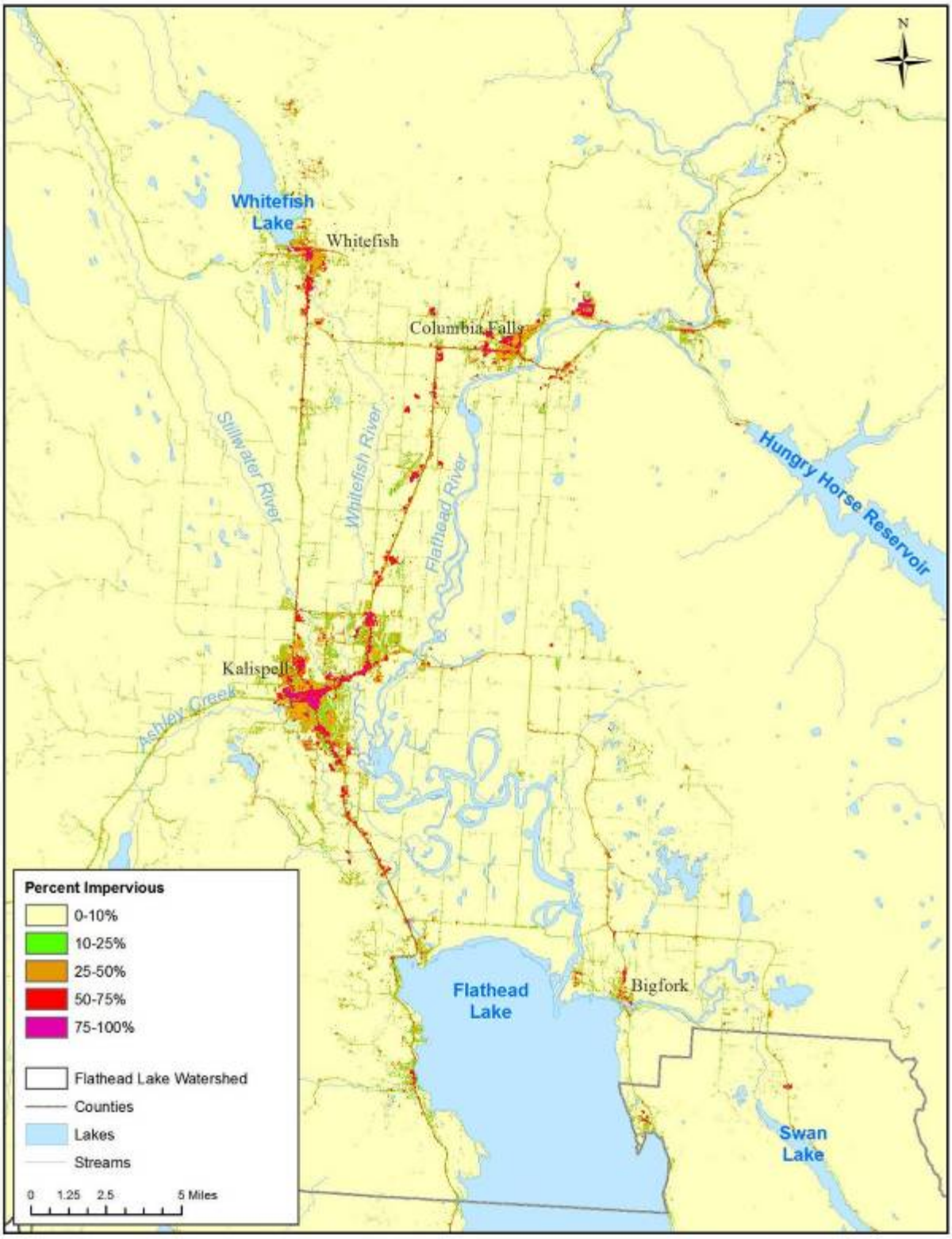


Figure 13. Location of impervious surfaces in the Flathead Lake watershed (Flathead Valley is displayed).

5.0 DATA GAPS

The previous sections provided a summary of the major urban stormwater sources and systems in the Flathead Lake Basin. However, several data gaps remain:

Private Stormwater Collection Systems. The major cities in the Flathead Lake Basin provided information on the type and extent of the city owned stormwater systems in the basin (e.g., storm sewers, detention basins, outfalls, etc.). Information is lacking, however, for smaller villages and other privately owned stormwater systems (e.g., privately owned commercial and residential areas).

Water Chemistry. Little information is available regarding the water chemistry of urban stormwater runoff in the basin. The city of Kalispell and several industrial facilities are required to monitor water chemistry, but the data are not comprehensive enough to describe urban stormwater runoff quality throughout the basin.

Data Currency for Impervious Surfaces. Although recent data and information has been obtained for all of the regulated stormwater facilities in the basin, the analysis of impervious surfaces (Section 4.6) is based on satellite imagery collected in the late 1990's and reported in 2001. Considerable residential and commercial development has occurred since that time.

6.0 REFERENCES

Arnold, Chester L. Jr., and C. James Gibbons. 1996. Impervious Surface Coverage: The Emergence of a Key Environmental Indicator. Journal of the American Planning Association 62, 2: 243-258.

Bannerman, R., J. Konrad, D. Becker, G.V. Simsiman, G. Chesters, J. Goodrich-Mahoney, and B. Abrams. 1979. The IJC Menomonee River Watershed Study — Surface Water Monitoring Data. EPA-905/4-79-029. U.S. Environmental Protection Agency, Chicago, IL.

BMC Truss. 2006. Stormwater Pollution Prevention Plan. Kalispell, Montana.

Burton, A.G., and R.E. Pitt. 2001. Stormwater Effects Handbook – A Toolbox for Watershed Managers, Scientists, and Engineers. Lewis Publishers. Boca Raton, Florida.

City of Whitefish. 2006. City of Whitefish Stormwater System Utility Plan. Whitefish, Montana.

DEQ. Undated. Storm Water Requirements for Construction Activity. Montana Department of Environmental Quality. Helena, Montana. Available online at http://www.deq.state.mt.us/wqinfo/MPDES/StormwaterConstruction.asp

DEQ. 2004. Fact Sheet – Montana Pollutant Discharge Elimination System (MPDES) General Permit for Storm Water Discharges Associated with Small Municipal Separate Storm Sewer System (MS4s). Montana Department of Environmental Quality, Water Protection Bureau, Permitting and Compliance Division. Helena, Montana.

DEQ. 2005. Inspection Report – F.H. Stoltze Lumber Company. Montana Department of Environmental Quality, Permitting and Compliance Division. Helena, Montana.

DEQ. 2006. General Permit for Stormwater Discharges Associated with Industrial Activity. Permit # MTR000000. Montana Department of Environmental Quality, Water Protection Bureau, Permitting and Compliance Division. Helena, Montana.

DEQ. 2007. Inspection Report – Wisher's Auto Recycling. Montana Department of Environmental Quality, Permitting and Compliance Division. Helena, Montana.

DEQ. 2008. Application for Water Quality (Watershed) Restoration Projects: Bigfork Stormwater Quality Improvement Program. Helena, Montana.

EPA. 2003. After the Storm. U.S. Environmental Protection Agency. EPA 833-B-03-002.

F.H. Stoltze Land and Lumber. 2006. Stormwater Pollution Prevention Plan. Columbia Falls, Montana.

F.H. Stoltze Land and Lumber. 2008. Company History [online]. Available at http://www.stoltzelumber.com/index.php?fuseaction=main.history&PHPSESSID=a9f8c3bf8324f85b7da75209.

Flathead County. 2009. Bigfork Stormwater Facilities Assessment Report. Prepared by 48 North for Flathead County. December 22, 2009.

Glacier Gold Chipping. 2007. Stormwater Pollution Prevention Plan. Olney, Montana.

Glacier Park International Airport. 2006. Storm Water Pollution Prevention Plan. Kalispell, Montana.

Kalispell Wrecking. 1995. Stormwater Pollution Prevention Plan – Kalispell Wrecking. Kalispell, Montana.

Madison, F., J. Arts, S. Berkowitz, E. Salmon, and B. Hagman. 1979. Washington County Project. EPA 905/9-80-003, U.S. Environmental Protection Agency, Chicago, IL.

National Research Council. 2008. Urban Stormwater Management in the United States. Committee on Reducing Stormwater Discharge Contributions to Water Pollution. Water Science and Technology Board, Division on Earth and Life Studies. Washington, D.C. Available online at http://cfpub.epa.gov/npdes/home.cfm?program_id=6.

Pitt, R. and J. McLean. 1986. Humber River Pilot Watershed Project, Ontario Ministry of the Environment, Toronto, Canada. 483 pp.

Schueler, Thomas. 1994. The Importance of Imperviousness. Watershed Protection Techniques. 1, 3: p.100.

Schueler, Thomas. 1995. Site Planning for Urban Stream Protection. Metropolitan Washington Council of Governments: Washington D.C.

Schueler, Thomas. 1996. Crafting Better Urban Watershed Protection Plans. Watershed Protection Techniques. 2, 2: p. 329.

Shaver, E. J., and Maxted, J. R. 1995, The Use of Impervious Cover to Predict the Ecological Condition of Wadable Nontidal Streams in Delaware. 7 pp.

Shaver, E. J., and Maxted, J. R. 1996, Technical Note 72 Habitat and Biological Monitoring Reveals Headwater Stream Impairment in Delaware's Piedmont. Watershed Protection Techniques, 2, 2: 358-360.

United Parcel Service. 2006. Stormwater Pollution Prevention Plan. Industrial Stormwater Permit #MTR000447. Kalispell, Montana.

USEPA. 1983. Results of the Nationwide Urban Runoff Program. Water Planning Division, PB 84-185552, Washington, D.C. December 1983.

USEPA. 2003. "What is Stormwater Runoff?" [Online]. U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds. EPA 833-B-03-002. Washington, D.C.

Vogelmann JE, Howard SM, Yang L, Larson CR, Wylie BK and Van Driel N. 2001. Completion of the 1990s National Land Cover Data Set for the Conterminous United States from Landsat Thematic Mapper Data and Ancillary Data Sources. Photogrammetric Engineering and Remote Sensing 67:650-662.

Wayland, Robert H. and James A. Hanlon. 2002. Establishing Total Maximum Daily Load (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs. Memorandum from Robert H. Wayland, III (Director, Office of Wetlands, Oceans and Watersheds, UESPA) and James A. Hanlon (Director, Office of Wastewater Management, USEPA) to USEPA Regional Water Division Directors.