Water Quality Protection Plan and TMDLs
for the
Swan Lake Watershed

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Montana Department of Environmental Quality

Lake County Conservation District

EXECUTIVE SUMMARY

This document presents a Water Quality Protection Plan and Total Maximum Daily Loads (TMDLs) for the Swan Lake Watershed in Montana. A TMDL is a pollutant budget identifying the maximum amount of a particular pollutant that a waterbody can assimilate without causing applicable water quality standards to be exceeded. Section 303 of the Federal Clean Water Act and the Montana Water Quality Act (Section 75-5-703) require development of TMDLs for impaired waterbodies that do not meet Montana water quality standards. TMDLs are also required for threatened waterbodies where water quality trends suggest a potential future impairment. Section 303(d) also requires identification of impaired and threatened waterbodies on a list, referred to as the 303(d) list. This 303(d) list is updated every two years and submitted to the U. S. Environmental Protection Agency (EPA) by the Montana Department of Environmental Quality (DEQ).

Table E-1 provides a summary of the TMDL and related water quality protection components within this plan. The focus is on the threatened conditions for Swan Lake and impairments in both Jim and Goat Creeks. Swan Lake was identified as a threatened waterbody on the 2002 303(d) list due to excess particulate organic carbon (POC) loading and linkages to low dissolved oxygen (DO) conditions at the bottom of the lake. This threatened condition still exists based on the assessment and analysis work detailed within this plan, and therefore a TMDL is required for this pollutant. This plan provides a protection strategy and TMDL for nutrients (phosphorous and nitrogen) to further protect Swan Lake and help ensure reduced downstream nutrient loading to Flathead Lake.

Excess POC or nutrient loading to any waterbody in the watershed has the potential to enter Swan Lake. Therefore, development of a POC and nutrient protection strategy for Swan Lake involves efforts to limit pollutant loading throughout the watershed. This plan also recognizes that there are linkages between POC, nutrient and sediment loading. These linkages are recognized via load allocations and protection strategies that combine POC and nutrient loading sources, and sometimes apply sediment loading as a surrogate for POC and nutrient (primarily phosphorous) loading to Swan Lake.

In addition to Swan Lake, four tributary streams were assessed in detail for TMDL development purposes. These four streams include Jim Creek, Goat Creek, Piper Creek, and Elk Creek. All four of these streams were listed as impaired waterbodies on both the 1996 and 2002 303(d) lists. Most of the impairments to water quality within these streams were found to no longer exist as a result of the assessment and analysis work detailed within this plan. The improvements to water quality are attributed to recovery from past timber harvest practices, application of timber harvest best management practices (BMPs) for water quality protection, and protection of riparian zones.

The remaining stream impairments are associated with excess sediment in Goat and Jim Creeks and additional habitat alterations in upper Jim Creek. Even these impaired streams were found to be recovering from past water quality and habitat impacts. Table E-1 provides a detailed summary of impairment conditions, TMDL components, and additional restoration goals and objectives for these two streams as well as Swan Lake.

Although there was significant focus on Swan Lake and the four assessed tributaries, water quality and land use information from other tributaries is also presented in this document. Additional target conditions, several which can apply to these other tributaries, are presented to help provide an additional layer of protection.

Table E-1. Water Quality Plan and TMDL Summary Information.

Impaired or Threatened Beneficial Uses	• Swan Lake: Threatened for Cold-Water Fish and Aquatic Life. • Goat and Jim Creeks: Impaired (partially supporting) for Cold-Water Fish and Aquatic Life.
Impairment or Threatened Conditions	• Swan Lake: Threatened by POC (Particulate Organic Carbon) and linkage of POC to dissolved oxygen conditions at the bottom of the lake; additional concerns about water quality impacts from development pressure in the watershed and associated increased loading of nutrients (phosphorous and nitrogen). • Goat Creek: Impaired by elevated sediment (suspended) loading. • Jim Creek: Impaired by elevated fine sediment in spawning gravels; also impaired due to degraded habitat in upper reaches.
Major Pollutant Source Categories	• Timber Harvest: Includes forest roads, historical riparian harvest and slash disposal, ground disturbing activities and removal of canopy cover and trees. • Private Development: Includes private roads, riparian disturbances, stream encroachment, septic systems and livestock.
Target Development Strategies	• Swan Lake: DO trend in the bottom waters must not indicate decreasing water quality; other water quality indicators (chlorophyll *a*, secchi depth, nutrients, etc) must not indicate decreasing water quality; several secondary targets developed to help track TSS and nutrient loading, road sediment loading and riparian health indicators. • Jim Creek: Acceptable levels of fine sediment in spawning gravels, improved habitat conditions via increased woody debris in upper reaches. • Goat Creek: Acceptable levels of suspended solids during runoff. • Jim Creek & Goat Creek: Macroinvertebrate communities at acceptable levels using standard analysis protocols.
TMDLs	• Swan Lake: No increasing load of POC; no increasing nutrient loads. • Jim Creek: 10% reduction of fine sediment loading to spawning gravels. • Goat Creek: 33% reduction in fine suspended sediment loads during peak flow conditions based on 1997 loading data.
Allocation Strategies	• Swan Lake: Reduction in pollutant loads from road erosion, road traction sanding and riparian removals; no increased pollutant loading from timber harvest; septic and near shore nutrient load limits; pollutant loading reductions from airborne sources consistent with Flathead Lake allocations (once developed). • Jim Creek: Limit on road sediment loading; no increased upland/hillslope loading from timber harvest; loading reductions and improved habitat associated with riparian recovery in upper reaches. • Goat Creek: Reduction in road sediment loading; no sediment loading increases from other timber harvest activities.

Table E-1. Water Quality Plan and TMDL Summary Information.

Primary Restoration Strategies and Other Recommended Protection Measures	• Continued BMP application for timber harvest activities. • Application of road BMPs for forest roads, including roads associated with private home development. • Application of BMPs to address existing roads (for timber harvest and private homes) that are not up to standards, including culvert upgrades. • Protect riparian areas from existing and future private (non-timber harvest) development. Allow recovery in previously impacted areas. • Landowner education and assistance with efforts to limit septic and other private development impacts to water quality. • Stakeholder coordination and monitoring of natural and human impacts on water quality throughout the watershed. • Continued monitoring of fishery trends and additional monitoring along the Swan Lake shoreline and in streams where potential impairment conditions may exist. • Focus on protection of key spawning locations for bull trout. • Protect or restore fish passage where desirable.
Margin of Safety	• Impairment determinations based on assessment of multiple beneficial use support indicators and conservative assumptions for Swan Lake, Goat and Jim Creeks. • Additional biota targets for streams and application of secondary targets to Swan Lake. • Additional focus on nutrient loading via nutrient TMDL for Swan Lake. • Identification of land use indicators to help track potential loading sources of concern. • Reduction in loading from several sources incorporated into load allocations even though the TMDL for Swan Lake are for no increased loading. • Adaptive management applied to targets, TMDLs, and load allocations with a well-developed monitoring strategy to help apply this approach.
Seasonal Considerations	• Identification of pollutant source pathways and pollutant source loading considered seasonal variations, with highest loads typically occurring during spring runoff. • All targets have specific seasonality considerations and monitoring requirements for eventual compliance determinations.
Impairments No Longer Existing Based on the Information Presented in this Document	• Goat Creek: nutrients/organic enrichment/DO; flow alterations; fine sediment deposition; habitat alterations. • Piper Creek: Fine sediment deposition; habitat alterations. • Elk Creek: Fine sediment deposition; habitat alterations.

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Acronyms

BMP – Best Management Practice
cfs – Cubic feet per second
Chl-a – Chlorophyll *a*
CMZ – Channel migration zone
CS – Clear sky
CWA – Clean Water Act
DEQ – Department of Environmental Quality, Montana
DNRC – Department of Natural Resources and Conservation, Montana
DO – Dissolved Oxygen
DOC – Dissolved Organic Carbon
ECA – Equivalent clearcut areas
EMAP – Environmental Monitoring and Assessment Program
EPA – Environmental Protection Agency, United States
FRS – Forest Road Sediment
FRS-SAM – Forest Road Sediment-Source Assessment Method
FWP – Fish Wildlife and Parks, Montana Department of
GIS – Geographic Information System
GPS – Global Positioning System
LWD – Large Woody Debris
MCA – Montana Code Annotated
mg/l – Milligrams per liter
MOS – Margin of safety
NDOC – Non-dissolved organic carbon
NTU – Nephelometric units
NFHCP – Native Fish Habitat Conservation Plan
NRIS – Natural Resource Information System
POC – Particulate Organic Carbon
SCD/BUD – Sufficient and Credible Data/Beneficial Use Determination
SD – Secci depth
SMZ – Streamside Management Zone

SRP - Soluble Reactive Phosphorous
TAG – Technical advisory group
TIN – Total inorganic nitrogen
TIP - Total inorganic phosphorous
TKN – Total Kjeldahl Nitrogen
TMDL – Total Maximum Daily Load
TN – Total Nitrogen
TP – Total Phosphorous
TPN – Total persulfate nitrogen
TSI – Trophic State Index
TSS – Total Suspended Solids
ROS – Rain-on-snow
USEPA – United States Environmental Protection Agency
USFWS – United States Fish and Wildlife Service
USFS – United States Forest Service

SECTION 1.0
INTRODUCTION

This document presents a Water Quality Protection Plan that incorporates Total Maximum Daily Loads (TMDL) for the Swan Lake Watershed in Montana. The Swan Lake Watershed is a forested drainage, encompassing approximately 421,727 acres in Lake and Missoula Counties (Map 1-1). The Swan Lake Watershed is one of more than 90 TMDL planning areas in the State of Montana in which water quality is currently or was previously listed as impaired or threatened. In each of these TMDL planning areas, the State of Montana is required to develop TMDLs to reduce pollutant loading and eliminate other negative impacts to water quality in impaired and threatened waterbodies.

The purpose of this Water Quality Protection Plan and associated TMDL is to synthesize available and relevant data, describe the current status of water quality within the Swan Lake Watershed, and finally, to lay out a plan to improve and protect water quality within the Swan Lake Watershed. Ultimately, the goal of this effort is to eliminate threats and impairments to water quality and ensure full compliance with Montana's water quality standards now and in the face of potential future development conditions. An additional goal is to help protect water quality downstream in Flathead Lake, which represents a potential receiving waterbody for increased pollutant loading in the Swan Lake Watershed.

SECTION 2.0
REGULATORY FRAMEWORK

2.1 TMDL Development Requirements

Section 303(d) of the Federal Clean Water Act requires states to identify those waterbodies within its boundaries that do not meet water quality standards. Section 303 goes on to require that States develop TMDLs for impaired or threatened waterbodies.

A TMDL is a pollutant budget for a waterbody identifying the maximum amount of a particular parameter that a waterbody can assimilate without causing applicable water quality standards to be exceeded. 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 can also be expressed as the maximum allowable concentration of a parameter, as a required load reduction(s), or as specific conditions assuring the water quality standards are met (EPA, 1999a). TMDLs account for loads/impacts from point and nonpoint sources in addition to natural background sources, and need to incorporate a margin of safety and consider seasonality. TMDL development is often done in the context of an overall water quality plan. The water quality plan includes not only the actual TMDL, but also includes information that can be, or in some cases, is being used to effectively protect and/or restore water quality.

State Law directs the Montana Department of Environmental Quality (DEQ) to develop TMDLs for threatened or impaired waterbodies (Montana Water Quality Act; Section 75-5-703). 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 water quality standards (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: (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 Water Quality Act; Section 75-5-103(31)).

To satisfy the Federal Clean Water Act and Montana State Law, TMDLs are developed for each waterbody-pollutant combination and are often presented within the context of a water quality restoration or protection plan. State Law (75-5-703(8)) also directs 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.

2.2 Water Quality Standards

The Montana Surface Water Quality Standards and Procedures (Water Quality Standards: Title 17, Chapter 30, Sub-Chapter 6) are a part of the Administrative Rules of Montana. These standards provide a basis for 303(d) listing decisions as well as a basis for setting water quality targets. Per Section 17.30.608 of the Water Quality Standards, all waterbodies in the Swan Lake Watershed are classified as B-1 except for Swan Lake, which is classified as A-1 (Appendix A).

There are several sections within the Water Quality Standards that are applicable to waterbodies classified as either A-1 or B-1 and applicable to water quality restoration and TMDL development in the Swan Lake Watershed. These sections are provided in Appendix A. Review of the Appendix A water quality standards reveals that the standards of interest are nearly identical for B-1 and A-1 classified waterbodies. An A-1 classification has stricter protection requirements associated with allowable levels of turbidity (Section 17.30.622(3)(c)). This turbidity standard is part of the basis for setting protective water quality goals for Swan Lake that not only address organic carbon and associated siltation, but also other nutrient and sediment loading sources that can be linked to organic carbon and/or lead to unacceptable increases in turbidity.

It should also be noted that there are no numeric standards applicable in the Swan Lake Watershed for parameters associated with sediment and nutrients. These pollutants and related conditions such as siltation and organic enrichment are instead addressed via narrative standards identified in Appendix A. The relevant narrative standards prohibit harmful or other undesirable conditions (including undesirable aquatic life) related to pollutant increases above naturally occurring levels or from pollutant discharges to state surface waters. This is interpreted to mean that water quality should be restored as near as possible to reference conditions given current and historic land use activities where all reasonable land, soil, and water conservation practices have been applied (reference the definition of “naturally occurring” in Appendix A). In defining a reference condition and determining compliance with narrative water quality standards, consideration must be given to variability both in natural systems and in sampling and analyses methods used to compare conditions in one stream with conditions in another. This variability can justify the use of a statistical range around any given reference condition parameter when making impairment determinations and when setting water quality target conditions.

2.3 Waterbodies and Pollutants of Concern

Section 303 of the Clean Water Act requires states to submit a list that includes impaired and threatened waterbodies (streams, lakes, wetlands) to the U.S. Environmental Protection Agency (EPA) every two years. This list, known as the 303(d) list, identifies which beneficial uses are impaired and indicates the probable causes (i.e., the pollutant such as sediment) and the probable sources of the impairment (i.e., activities, land uses, or conditions such as forest roads or bridges). Table 2-1 provides 303(d) listing information for the waterbodies of concern in the Swan Lake Watershed. Table 2-1 includes the waterbody names and probable causes for the 1996 and 2002 EPA-approved 303(d) lists. Note that all impairment determinations in the Swan Lake Watershed are associated with partial support conditions for aquatic life and cold-water fish beneficial uses. Also note that in several waterbodies identified in Table 2-1, beneficial uses are listed as threatened. Map 1-1 highlights the waterbodies identified in Table 2-1.

The Montana 2002 303(d) List (DEQ, 2002a) is the most current EPA-approved list. Some waterbody – pollutant/cause combinations previously identified on the 1996 303(d) list were not incorporated into the 2002 303(d) list because of either a lack of sufficient credible data (SCD) or because SCD showed that the waterbody was no longer considered impaired or threatened from the previously identified pollutant/cause of concern. Where SCD is lacking, a waterbody is prioritized for reassessment and subsequent TMDL development if reassessment shows impairment conditions. The 1996 303(d) list information is presented and incorporated into this water quality plan to document this process as it relates to waterbodies in the Swan Lake Watershed.

2.3.1 Swan Lake Listing History and Water Quality Plan Development Strategy

In response to low dissolved oxygen (DO) concentrations and evidence that historical logging practices have contributed to increased siltation within the lake, Swan Lake was placed on the 1996 list of impaired waterbodies (the 303(d) list). Siltation and related organic enrichment/DO were identified as the probable causes of impairment. For the 2002 303(d) list, the status of Swan Lake was changed from impaired to threatened, with siltation identified as the cause of concern. The rational cited in the Sufficient Credible Data/Beneficial Use Determination files (DEQ, 2004) is as follows:

> "Data indicate that beneficial uses are being supported, however there is a documented adverse pollution trend as evidenced by the Spencer (1991b) sediment-core study. This study clearly shows that the sedimentation in Swan Lake has increased >3 times its historic (late 1800's) rates, and that much of the increase occurred concurrently with large-scale timber harvest in the watershed since the 1960's. This increased sediment/nutrient/carbon load to the sediments *may* be responsible for the oxygen depletions noted in the deeper basins. A more recent work (Ellis et al., 1999a) has failed to make a clear connection between land use and water quality, but that study indicated that the complexities of this flood plain riverine system make such a correlation difficult. An increase in the noted oxygen depletions is to be avoided in order to maintain the lake in its current oligotrophic state."

Organic Enrichment/DO (dissolved oxygen) has been removed from the more recent 2002 303(d) list as a probable cause category to avoid redundancy. The remaining siltation listing is associated with increased accumulation of inorganic and organic material (specifically organic carbon) to the lake bottom/sediments, with siltation being consistent with the definition of "settleable solids" provided in Appendix A. The increased organic material in lake sediments can lead to DO reductions and subsequent depletion (anoxic conditions). A reduction in DO can directly limit aquatic life and cold-water fish habitat, and can also lead to conditions where phosphorus is released from the bottom sediment layer. This phosphorus could then enter the water column, leading to additional negative impacts to aquatic life and cold-water fish due to nutrient enrichment conditions in Swan Lake, as well as increasing downstream nutrient loading to Flathead Lake.

Throughout this document the Swan Lake cause/pollutant categories associated with siltation, organic enrichment, and low levels of dissolved oxygen are addressed together via the development of one protection strategy that addresses the linkage between these parameters. Loading pathways are analyzed from a variety of potential sources or source categories. The protection strategy also addresses turbidity and nutrient levels in the water column of Swan Lake since these conditions can contribute to excess loading of organic material to lake sediments and can also cause beneficial use support problems if elevated at unacceptable levels within the water column. The water quality protection strategy for Swan Lake is also consistent with the allocation portion of the *Nutrient Management Plan and Total Maximum Daily Load for Flathead Lake, Montana (DEQ, 2001).* The Flathead Lake allocation plan identifies a need to set specific future nutrient allocations to identified controllable air, point, and nonpoint sources throughout the Flathead Lake Watershed, which includes the Swan Lake Watershed.

As part of this overall water quality planning strategy and TMDL development process for Swan Lake, additional assessment work in the Swan Lake Watershed was undertaken during 2001 and 2002. This includes the assessment work for tributaries identified as being impaired per the 303(d) list as discussed below in Section 2.2.1 and a detailed assessment of eroding banks along the lower portion of the Swan River.

2.3.2 Tributary Listing History and Water Quality Plan Development Strategy

Six streams in the Swan Lake Basin were listed as in need of TMDL development on the 1996 303(d) list (Table 2-1). These streams include:

1. Goat Creek
2. Squeezer Creek
3. Jim Creek
4. Elk Creek
5. Lion Creek
6. Piper Creek

Squeezer, Lion, and the upper segment of Piper Creek down to Moore Creek were removed from the 303(d) list due to full support conditions for cold-water fish and aquatic life. In making the decision to remove these streams from the 303(d) list in 2000, DEQ determined that the existing data were sufficient and credible for making a full support determination for cold-water fish and associated aquatic life. A full support condition does not necessarily reflect pristine conditions with no impacts, and streams can sometimes have minor levels of impact and still be considered fully supporting beneficial uses. Because the above-identified streams/segments were removed from the 303(d) list, TMDL development is not necessary for these specific segments.

In addition, the recent 2002 303(d) list was refined for Elk and Jim Creeks. Although each stream was originally listed in its entirety, no indication of impairment was provided for the upper sections of each stream, and thus the 303(d) list was modified to reflect this fact. The streams that remained on the 2002 303(d) list for TMDL development are divided into 5 reaches:

1. Goat Creek above Squeezer Creek;
2. Goat Creek below Squeezer Creek;
3. Piper Creek below Moore Creek;
4. Jim Creek below the west fork;
5. Elk Creek below Section 16.

Appendix B provides additional 303(d) listing rationale based on DEQ files for these stream segments. All of these streams were listed in 1996 and/or 2002 as being impaired by siltation and habitat alteration. The upper segment of Goat Creek was also listed for suspended solids in 2002. These interrelated causes of impairment can be addressed collectively in a sediment TMDL, consistent with EPA guidance (EPA, 1999a). Impacts are typically linked to cold-water fish beneficial use support. In most cases, a modification in sediment size and/or distribution in the listed stream segments is thought to have resulted in impacts to spawning success and/or a reduction in suitable habitat for various fishery age classes. Multiple indicators of beneficial use support are often incorporated into the TMDL target development strategy to address relevant habitat, channel, and streambed conditions.

In addition to the sediment and habitat type of impairment causes discussed above, several stream segments were identified as having additional impairment causes. The entire length of Elk Creek was identified as impaired due to organic enrichment/DO on the 1996 303(d) list (Table 2-1). This impairment was not identified on the 2002 303(d) list since there was a lack of sufficient data to support this cause of impairment. The entire length of Goat Creek was identified as impaired due to flow alteration and organic enrichment on the 1996 303(d) list. Goat Creek was subsequently divided into two separate reaches for the 2002 303(d) list, with the addition of a nutrient impairment cause to the segment above Squeezer Creek. The flow alteration and organic enrichment/DO causes were not included on the 2002 303(d) list since there was a lack of sufficient data to support this cause of impairment.

The overall water quality plan development strategy for the tributaries involves:

- assessment of available water quality data and beneficial use indicators, particularly relating to data obtained in the past several years;
- identification and quantification of sediment and nutrient loading sources in conjunction with source assessment work for the Swan Lake Watershed as a whole;
- both aerial photo interpretations and field assessment of stream habitat conditions as indicators of potential impairment associated with habitat alterations and sediment problems as well as indicators of potential sediment or nutrient loading to Swan Lake; and
- collection of water quality samples for nutrients and collection of periphyton (attached algae) samples as indicators of impairment conditions.

All five 2002 303(d) listed tributaries segments were assessed as part of the 2001 and 2002 assessment work. The upper sections of Piper and Elk Creeks were also both assessed since they represent potential reference conditions; upper Piper due to a full support determination and the upper portion of Elk Creek due to minimal upstream activity. The upper portion of Jim Creek was also assessed since no formal beneficial use support determination regarding 1996 list conditions has been made and to ensure consideration of potential upstream impacts to the downstream section of Jim Creek.

2.3.3 Document Organization

Section 3.0 of this document provides a watershed characterization for the Swan Lake TMDL Planning Area. Section 4.0 provides a discussion of Swan Lake water quality status and watershed conditions potentially impacting water quality in Swan Lake. Section 5.0 provides a discussion of assessment data and recent assessment results for the Swan Lake Watershed and tributaries of concern. Section 6.0 provides updated impairment conclusions based on assessment information discussed in this document. Sections 7.0 and 8.0 develop water quality goals in the form of planning targets (Section 7.0) and methods to achieve these targets in the form of allocations (Section 8.0), including identification of TMDLs where required. Implementation, adaptive management, and monitoring recommendations and requirements are presented in Sections 9.0 and 10.0.

Table 2-1. Impaired and Threatened Waterbodies Identified on the Montana 303(d) List (1996 – 2002).

Waterbody Name	Stream Segment No. (2002)	1996 Use Support Conditions	1996 Probable Cause (pollutant or pollutant category)	2002 Use Support Conditions	2002 Probable Cause (pollutant or pollutant category)
Swan Lake	MT76K002_010	Partial support for aquatic life and cold-water fish	Siltation/Organic Enrichment/DO	Threatened conditions for aquatic life and cold-water fish	Siltation
Goat Creek (Headwaters to Squeezer Creek)	MT76K003_031	Partial support for aquatic life and cold-water fish	Organic Enrichment/DO; Sediment (Siltation; Other Habitat Alterations); Flow Alteration	Partial support for aquatic life and cold-water fish	Nutrients; Sediment (Suspended Solids)
Goat Creek (Squeezer Creek to Mouth)	MT76K003_032	Partial support for aquatic life and cold-water fish	Organic Enrichment/DO; Sediment (Siltation; Other Habitat Alterations); Flow Alteration	Partial support for aquatic life and cold-water fish	Sediment (Siltation; Other Habitat Alterations)
Piper Creek (Headwaters to Moore Cr)	MT76K003_061	Threatened conditions for aquatic life and cold-water fish	Sediment (Siltation; Other Habitat Alterations)	Full Support of cold-water Fish and Aquatic Life	No probable causes of impairment identified
Piper Creek (Moore Creek to Mouth)	MT76K003_062	Threatened conditions for aquatic life and cold-water fish	Sediment (Siltation; Other Habitat Alterations)	Partial support for aquatic life and cold-water fish	Sediment (Siltation; Other Habitat Alterations)
Jim Creek (Headwaters to W. Fk)	MT76K003_010	Threatened conditions for aquatic life and cold-water fish	Sediment (Siltation; Other Habitat Alterations)	No impairment identified	No probable causes of impairment identified
Jim Creek (W. Fk to Mouth)	MT76K003_010	Threatened conditions for aquatic life and cold-water fish	Sediment (Siltation; Other Habitat Alterations)	Partial support for aquatic life and cold-water fish	Sediment (Siltation)
Elk Creek (Headwaters to Section 16 Road Crossing)	MT76K003_040	Partial support for aquatic life and cold-water fish	Organic Enrichment/DO; Sediment (Siltation; Other Habitat Alterations)	No impairment identified	No probable causes of impairment identified
Elk Creek (Section 16 Road Crossing to Mouth)	MT76K003_040	Partial support for aquatic life and cold-water fish	Organic Enrichment/DO; Sediment (Siltation; Other Habitat Alterations)	Partial support for aquatic life and cold-water fish	Sediment (Other Habitat Alterations)
Squeezer Creek (Headwaters to Mouth)	MT76K003_070	Partial support for aquatic life and cold-water fish	Sediment (Siltation; Other Habitat Alterations)	Full Support of cold-water Fish and Aquatic Life	No probable causes of impairment identified
Lion Creek (Headwaters to Mouth)	MT76K003_050	Partial support for aquatic life and cold-water fish	Sediment (Siltation; Other Habitat Alterations)	Full Support of cold-water Fish and Aquatic Life	No probable causes of impairment identified

SECTION 3.0
SWAN LAKE WATERSHED CHARACTERIZATION

Appendix C contains a detailed description of the physical characteristics of the Swan Lake Watershed completed by Whitehorse Associates.

SECTION 4.0
OVERVIEW OF SWAN LAKE WATER QUALITY STATUS

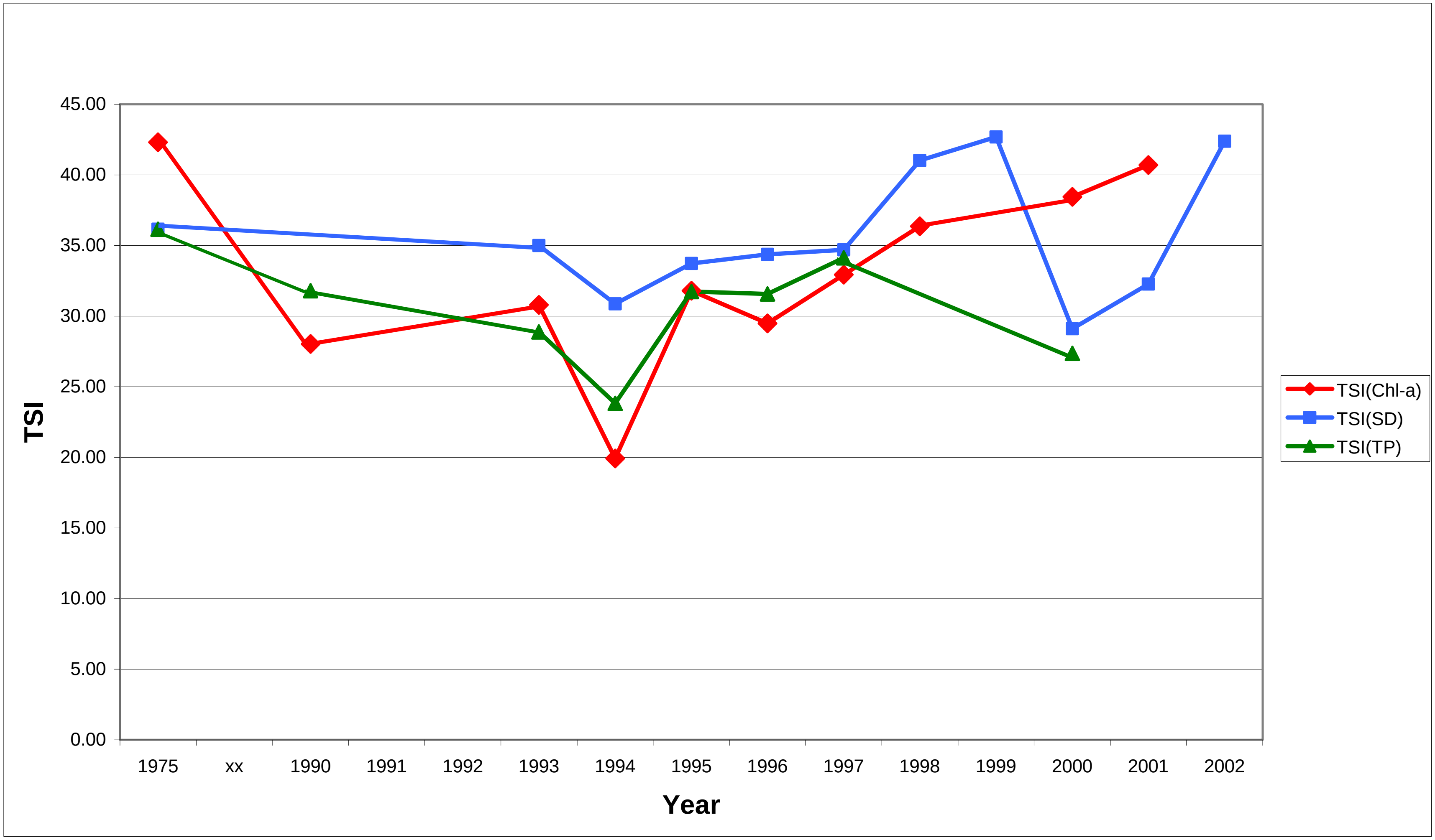
4.1 Water Quality Data and Dissolved Oxygen Concern

Water quality in Swan Lake is generally good, with levels of nutrients, primary production, and chlorophyll *a* at values typical of oligotrophic conditions (Spencer and Schelske, 1998; Butler et al., 1995). Table 4-1 provides a summary of water quality monitoring results for Swan Lake from many of the various studies that have taken place over the years. Note that there is very little water quality data prior to 1991, with a significant increase in data since 1991. The Table 4-1 (a and b) results show consistently low nutrient levels throughout the year, particularly for total phosphorous (TP) and soluble reactive phosphorous (SRP) or otho-phoshorous. The consistently high secchi depth levels also indicate high water clarity. These low nutrient levels and relatively high water clarity are indicators of oligotrophic conditions and desirable water quality in Swan Lake. Table 4-1 (a) also presents various nitrate to phosphorous ratios (TN/TP and TIN/TIP), again indicating high quality water due to the generally high N to P ratios. These high N to P ratios also suggest that phosphorous is the limiting nutrient.

Nevertheless, some secchi depth values tend to fall more within the ranges reported for mesotrophic lakes (Vollenweider and Kerekes, 1980). The Carlson trophic state index (TSI; Carlson, 1977) values for Swan Lake, based on the Table 4-1 secchi depth (SD), chlorophyll *a* (Chl-a), and total phosphorous (TP) data, tend to be in the range of 30 to 40 and often less than 35 (Figure 4-1). These values are consistent with oligotrophic conditions and high quality water, but they also sometimes overlap with the 40 to 50 range for mesotrophic lakes (Carlson and Simpson, 1996).

Table 4-1 also presents minimum dissolved oxygen (DO) values from various data sources typically taken during the late summer and early fall in the deepest parts of the lake. Of particular concern is the fact that the DO concentrations decline to unusually low levels for an oligotrophic lake, and even what may normally be considered low levels for a mesotrophic lake (Novotny and Olem, 1994). This is particularly evident in the south basin of the lake, where DO concentrations as low as 0.1% of saturation have been recorded (Butler et al., 1995). This is further supported by recent (2001) Land & Water sampling (Map 4-1), and 1996 through 1999 Plum Creek Timber Company sampling results (Table 4-1 (c)). These studies have all shown October DO levels less than 1 mg/l at or within a few feet of the bottom of the south basin of the lake prior to fall turnover, with values as low as 0.07 mg/l (0.6% saturation) based on the 1999 Plum Creek results. The studies have also shown DO values less than 2 mg/l as early as August in the lower few feet of the south basin. North basin October DO values prior to fall turnover were also low, with 2001 values falling below 3 mg/l at the deepest areas of the lake, which are substantially deeper than the south basin (Map 4-1). Note that the 1977 EPA data do not indicate low DO levels. This is probably because they did not sample deep enough.

Figure 4-1: Carlson Trophic State Index (TSI) Values.



Low DO concentrations are of particular concern due to the potential for a release of sediment-bound phosphorus if the DO levels drop below 1 mg/l. Since autotrophic production by most lakes in the area (e.g. Flathead, McDonald) is phosphorous limited or co-limited by phosphorous and nitrogen, such a release could lead to accelerated eutrophication of Swan Lake while further elevating nutrient levels in Flathead Lake.

Unfortunately, the results shown in Table 4-1 and Figure 4-1 do not reveal obvious trends in water quality data. Variations in measurement techniques and timing can confound efforts to directly compare results from year to year. Nevertheless, there are a few potential indicators of improving water quality including an apparent decrease in SRP and possible increases in maximum N to P ratios. On the other hand, Chlorophyll *a* results may indicate a potential decline (water quality improvement) between 1977 and early 1990's, but more recent data from the Flathead Basin Commission may indicate a potential increasing trend (poorer water quality) starting about 1998 (Table 4-1 (b) and calculated TSI for Chl-*a* in Figure 4-1). Given the seasonal and depth variations for DO (Map 4-1), the Table 4-1 results are not extensive enough to make any conclusions concerning DO trends other than to say that the extremely low DO conditions still existed as of 2001.

To further evaluate the potential for improving water quality in Swan Lake, satellite imagery was utilized to map the distribution of chlorophyll (Appendix D) over time. Using this method, a distinct trend in primary productivity (as indicated by changes in chlorophyll *a* impacting light attenuation) was difficult to identify in part due to confounding impacts from variations in lake water temperatures between years.

4.1.1 Potential Natural Causes of Low Dissolved Oxygen

The DO concentrations in Swan Lake prior to human settlement of the Swan Basin are unknown. There is evidence to suggest that the DO deficit in the deepwater basins of Swan Lake is, to some extent, the result of natural processes. No other oligotrophic lake in the Flathead Basin is known to have DO levels as low as those in Swan Lake (Butler et al., 1995; Spencer, 1991a; Spencer, 1991b). Given that other lakes in the Flathead region have had extensive logging, road building, and development in their watersheds without experiencing DO depletion as severe as in Swan Lake, it seems plausible that there is something unusual about Swan Lake that predisposes it to low DO conditions.

As previously discussed, Swan Lake has a Carlson TSI typically less than 40 (generally in the range of 30 to 40) based on its chlorophyll *a* content, secchi depth values, and total phosphorous concentrations (Figure 4-1). Lakes with Carlson TSI ranges from 30 to 40 are generally considered oligotrophic, but shallower ones may exhibit anoxic hypoliminia during summer stratification (Carlson & Simpson, 1996). Swan Lake has a mean depth of 16 meters, which means it is neither particularly shallow, nor particularly deep (Rawson, 1955; Sakamoto, 1966). It is not unreasonable to believe that the low dissolved oxygen (DO) levels in the deep basins of the lake may be, in part, a natural consequence of the lake's morphometry.

Butler et al. (1995) hypothesized that the southern end of Swan Lake may serve as natural nutrient and organic matter sink due to its proximity to the Spring Creek wetland complex at the inlet area of the Swan River and lack of vigorous deepwater mixing. Dissolved oxygen and temperature profiles from Butler et al. (1995) provide limited, inconclusive evidence that the south basin did not completely mix in the fall of 1992 and 1993. This suggests that because of the lake's morphometry, the deep basins are at times hydraulically disconnected from the rest of the lake. A similar scenario is thought to cause low DO levels in the deep waters of Big Arm Bay of Flathead Lake as well as several oligotrophic lakes in the Sawtooth Mountains of Idaho (Budy et al., 1995). Also, very low dissolved oxygen values (as low as 0.4 mg/l) within 1 meter of the bottom have also been observed in Lake Agnes in the Pioneer Mountains of Montana as discussed in Appendix A. Although direct comparison between Swan Lake and these other lakes can be difficult because of differences in land use, geology, and lake size, the results from Budy et al. (1995) and for Lake Agnes do lend credence to the assertion that natural processes could be responsible for the low DO concentrations observed in Swan Lake.

In addition to affecting mixing dynamics, the morphometry of Swan Lake may also directly influence the rate of oxygen depletion in the deepest parts of the lake. Cornett (1989) and Molot et al. (1992) found that the ratio of water volume to lake sediment surface area (VSA ratio) at a given depth strongly influenced the rate of oxygen depletion at that depth. Small VSA ratios were associated with large declines in oxygen concentrations at a given depth in summer. VSA ratios in Swan Lake range from a maximum of 383 at a depth of 6 meters to a minimum of 0.79 at a depth of 41 meters. VSA ratios decline rapidly in the deepest parts of Swan Lake due to the morphometric influence of the 2 deep water basins which may account, in part, for the unusually low DO levels in the deepest parts of the lake.

4.1.2 Potential Human Causes of Low Dissolved Oxygen

It is plausible that DO concentrations are lower today than they were historically, and that this may be attributable to human activities in the watershed. Land management and water quality studies have been conducted by the Flathead Lake Biological Station (Bio-Station) and by other scientists throughout the country. These studies have found that timber production (also referred to as logging or silviculture in this document), one of the primary land uses in the Swan Lake Watershed, and the attendant road building are often correlated with increased export of fine sediment, particulate organic carbon (POC) and nutrients from watersheds (Likens et. al., 1970; Martin et. al., 1986; Hauer and Hill, 1997; Ellis et al., 1998 & 1999b; Craft et al., 1999). Spencer (1991b) gathered data from a sediment core in Swan Lake as well as two other lakes in the region and showed that elevated sediment loading to each lake was correlated with historic timber production and/or road building for all three lakes.

It is also known that increased POC and nutrient loading are the primary anthropogenic causes of oxygen depletion in lakes worldwide (Wetzel, 1983), and that increased sediment delivery is a major source of nutrient loading. In varying amounts, POC is a fraction of eroded material, and phosphorus, one of the primary causes of eutrophication in lakes, is also attached to soil particles. Therefore, if human activities have increased sediment, POC and nutrient loading to Swan Lake, they could also have plausibly caused a reduction in oxygen levels.

4.1.2.1 Mechanisms Contributing to Increased POC Loading in the Swan Lake Watershed

At a stakeholder meeting in Bigfork, Montana, on January 30, 2002, the Swan stakeholders agreed that, to the extent the low DO levels in Swan Lake could result from human activities, increased loading of particulate organic carbon (POC) is probably the most significant problem at this time, as elevated nutrient and algae levels in the lake have not been identified as a problem (Spencer and Schelske, 1998; Butler et al., 1995).

This section summarizes five potential mechanisms by which POC loading to Swan Lake could have increased due to land use.

A. *Elevated in-stream nutrient concentrations*: Several of the studies mentioned above found that logging is associated with increased in-stream concentrations of nitrogen and phosphorous. Where nutrients are the limiting factor for algal growth, increased nutrient loading associated with timber harvest could be expected to increase algal levels. This is particularly true when: (1) logging units include riparian harvest, which would increase incident solar energy, or (2) where width-to-depth ratios have increased as a result of logging-induced bank instability (shallower waters equate to more solar energy for algae production).
B. *Increased erosion*: Roads, skid trails, and compaction by equipment all act to concentrate runoff and increase the energy available for transport of material by water. Riparian harvest and increased peak flows can destabilize stream channels, further increasing erosion. The scientific literature linking increases in erosion with timber harvest, and particularly new road construction, is abundant. As long as some fraction of the eroded materials is organic (litter, duff, organic soils), then increased erosion is a potentially significant anthropogenic source of POC to Swan Lake. As the POC decomposes, it also provides additional nutrients to the system, potentially causing further increases in algae growth and thus additional POC loading.
C. *Increased efficiency of POC transport through the system*: Reductions in LWD as a result of timber harvest could speed the transport of POC through the Swan system, reducing the fraction of POC converted to dissolved organic carbon (DOC) before its arrival in Swan Lake. Where timber harvest also increases maximum discharge, the speed of POC transport could be further increased.
D. *Historical logging practice*: Splash dams, log drives, and in-stream slash disposal all occurred within the Swan Lake Watershed (Photo 4-1). The POC load from these practices was probably quite large, and it could still be contributing to the DO sag in Swan Lake in the form of large material at the bottom of Swan Lake.
E. *Private development of homes*: Impacts to streams via removal of stream buffer zones and similar impacts to water quality as discussed above under A, B and C.

Photo 4-1. ***Example of a log drive in Western Montana pre-dating protective environmental regulations***

4.1.2.2 Evidence of POC Loading in the Swan Lake Watershed

The Bio-Station has done several studies in the Flathead Basin that found a correlation between timber harvest and in-stream levels of POC. Ellis et al. (1998) found that as road miles/acre increased, POC increased proportionately. Craft et al. (1999) found that POC in Lion Creek was higher in the downstream logged section than in the unlogged headwaters section, and in a paired watershed study, Ellis et al. (1999b) found that peak concentrations of POC were 1.4 times higher in harvested sections of Goat Creek than in unharvested sections of Lion Creek.

However, other studies have failed to find a strong correlation between harvest and increased POC concentrations. For example, Ellis et al. (1999b) found no statistically significant relationships between land management and water quality in the Swan River at a basin-wide scale based on a one-year monitoring period.

Additional evidence linking forest management to POC was provided by Hauer and Blum (1991), who found that timber harvest was correlated with increased algal density on stream bottoms. To the extent that this additional algae is scoured from stream bottoms and transported to Swan Lake, it is a source of POC and could contribute to the DO deficit.

Timber harvest can also lead to increases in peak flows. Hauer (1991) found evidence that timber harvest in the watershed of the North Fork of the Flathead River was correlated with an increasing trend in the maximum discharge of spring runoff. According to Hauer, “The maximum discharge of spring runoff has demonstrated a general trend toward increasing in the North Fork…” Research in other parts of the country has similarly found that timber harvest and its attendant road building have the potential to increase peak stream flows (Burton, 1997; Jones and Grant, 1996; Cheng, 1989). To the extent that higher maximum flows occur in the Swan, particularly in lower order tributary watersheds, these flows could increase the scour and transport of algae, and decrease the in-stream retention time of all POC, thus limiting its conversion to DOC by stream organisms before its arrival in Swan Lake. This would be exacerbated by the reduction of in-stream LWD that results from riparian harvest (fewer sediment traps).

In summary, it appears likely that timber harvest and road building to some extent have 1) increased the amount of POC in the watershed by causing erosion; 2) increased the scour and transport of this POC to Swan Lake; and 3) reduced the proportion of total POC that is converted to DOC before its arrival in Swan Lake. As in many watersheds, a lack of data often limit the ability to define the extent of water quality impacts and to make firm connections between land management activities and water quality. Adding to this difficulty is the potential for downstream transport of organic material to occur over time as a series of deposition and re-suspension events, rather than a continuous flow to Swan Lake via the Swan River (Butler et al., 1995). Efforts to establish relationships and trends continue to be hindered by the lack of a comprehensive water quality monitoring and data management program that can provide yearly data for key water quality parameters in various locations, although there have been some recent efforts to address this lack of information.

Despite the fact that DO levels in some parts of Swan Lake are low and land management practices may have contributed to this condition, there is reason to believe that there could be an improving trend in water quality in the Swan Lake Watershed due to improvements in forestry practices. Statewide best management practices (BMPs) for forestry were not adopted in Montana until 1989, and the streamside management zone (SMZ) law (77-5-301, MCA) was not enacted until 1991. The SMZ law limits the extent of riparian vegetation removal for commercial timber harvest and also limits potentially harmful timber harvest practices near waterbodies. Much of the logging that has occurred in the Swan Basin was completed prior to the implementation of these resource protection policies and at a time when there was little understanding of the potential environmental impacts of logging activities (Photo 4-1).

The load of POC and nutrients reaching or having the potential to eventually reach Swan Lake as a result of timber harvest and road building in the Swan Basin has likely decreased significantly in the past 15 years as a result of BMP and SMZ implementation. In-stream slash disposal and related bank erosion associated with debris accumulation were cited as the primary causes of impairment in the six streams listed in 1996 (Appendix B). This practice is now illegal under the SMZ law, and compliance with BMPs has risen steadily from 78% of audited practices in 1990 to 96% in 2000. In 2000, BMP audit teams found that BMPs provided adequate resource protection in 98% of their applications (Ethridge and Heffernan, 2001).

Reductions in POC and nutrient loading as a result of BMPs and the SMZ law are probably occurring in a variety of ways:

A. *Nutrients and Algae*: Reductions in riparian harvest (as a result of BMP and SMZ compliance) can be expected to: 1) reduce the amount of solar radiation available for algae growth by increasing or maintaining shade of streams and 2) reduce the logging associated nutrient load by preserving buffer strips that, a) intercept nutrient rich particles in overland flow of water and, b) extract soluble nutrients from ground and surface water before they can reach the streams.

B. *Erosion*: Reductions in riparian harvest will help maintain bank stability. Construction of new roads according to BMPs and the upgrading of existing roads to BMPs should substantially reduce erosion associated with roads. Because eroded particles are potential sources of both POC and nutrients, reductions in erosion should reduce loading of these pollutants to Swan Lake and reduce the threat of low DO levels in Swan Lake.
C. *Efficiency of POC Transport*: Reductions in riparian harvest will increase the amount of large woody debris (LWD) in streams, thus decreasing the rate of downstream transport of POC and encouraging conversion to dissolved organic carbon (DOC).
D. *Slash*: Because of the SMZ law, the disposal of slash in streams is now illegal, thus reducing erosion and undesirable accumulations of organic material that can be easily transported to Swan Lake.
E. *Stream Crossing*: Better culvert sizing and reduction of roads and harvest in sensitive areas both reduce the potential for mass wasting and associated sediment and nutrient loads.

Despite the apparent improvements made in forestry practices as a result of BMP and SMZ implementation, forestry practices and other human activities still represent potentially significant sources of POC as well as nutrients and total suspended solids. Because of this concern, a primary goal of this plan is to ensure that there are no preventable decreases in water quality in Swan Lake including no preventable increases in the extent of the low dissolved oxygen conditions near the bottom of Swan Lake. Also, if possible, this goal includes a reversal of any degradation of water quality that may have occurred within Swan Lake.

4.2 Other Concerns (Phosphorous and Nitrogen)

A consensus was reached at the January 2002 meeting of Swan stakeholders in Bigfork that nutrient enrichment, as it relates to the traditional problem of excess phosphorous and/or nitrogen, was not the main reason for the DO deficit in Swan Lake. Nutrient concentrations in the lake do not appear to be high enough to support algal growth sufficient to deplete oxygen levels to the extent seen in Swan Lake (Butler et al., 1995).

Nevertheless, nutrients should be addressed in the Swan Lake TMDL for several reasons. First, although nutrient concentrations are low in Swan Lake, they are also comparable to those concentrations in Flathead Lake (Spencer, 1991a; Butler et al., 1995) that have been identified as causing detrimental water quality impacts. Further, the Flathead Lake TMDL specifically directs the development of load allocations for nutrients within the Swan Watershed so that controllable sources of nutrient loading within the Swan Basin can be identified and their impacts to Flathead Lake can be limited. Given its already very low DO concentrations, Swan Lake probably cannot assimilate safely the additional organic carbon loading that would likely result from any significant increases in nutrient enrichment and subsequent algal growth. Therefore, as a part of the Swan Lake TMDL, nutrient targets will be set in Swan Lake to ensure that nutrient and algae do not become a major contributor to DO depletion and to aid in nutrient reduction efforts in Flathead Lake.

Second, regardless of how low nutrient levels in Swan Lake are today, some nutrient sources are increasing, including septic system disposal from increased private home development. Incorporating nutrient targets into this restoration plan will help ensure evaluation of impacts and trends from existing and future nutrient sources to Swan Lake and ultimately to Flathead Lake. Although current nutrient levels do not appear to be impairing beneficial uses in Swan Lake, nutrient targets will help ensure that nutrient concentrations depart no further from their historic levels or possibly are even reduced, and will help ensure that there are no unacceptable increases in lake turbidity associated with algae growth.

Third, given that the primary goal of the Swan Lake TMDL is to prevent anoxia on the lake bottom and a subsequent release of sediment-bound phosphorous, nutrient targets will provide an important benchmark against which to compare future phosphorous concentrations for signs that internal loading has occurred.

Increased nutrient loading to Swan Lake as a result of human activities probably results from some or all of the following sources:

- Phosphorus that is attached to soil particles from logging and road related erosion.
- Decomposition of organic material added to streams by logging.
- Leaching from recently logged areas.
- Leaching from septic systems, leaking septic tanks and failing septic systems.
- Bank trampling and direct input of nutrients by livestock.
- Yard waste and disposal of fireplace ashes in the lake (these potential sources were mentioned by several area residents).
- Increased atmospheric deposition.
- Increased soil particles from development and associated building of roads, bridges, culverts, and other structures on private lands.
- Riparian clearing associated with private land development and associated land use practices as well as riparian clearing associated with logging practices.

These above sources of nutrient loading in addition to sources of organic enrichment and POC discussed in Section 4.1.2 provide much of the basis for source assessment and development of water quality goals and implementation strategies throughout this document.

Table 4-1a. Historic Data for Swan Lake – Numerous Sources from 1977 to 1995.

Study	EPA 1977*						Spencer 1991								Butler 1995				Butler 1995		Study
Location	Three locations						North Basin				South Basin				South Basin				South Basin		Location
Date	6/2/1975		7/28/1975		9/5/1975		6/6/1990		9/11/1990		6/6/1990		9/11/1990		Runoff 1993		Late Summer 1993		6/10/1993	9/6/1993	Date
Depth	0-7.6 m	10.7-24.4 m	0-7.6 m	9.1-25.9 m	0-10.1 m	14.3-22 m	5m	30 m	5m	30 m	5m	30 m	5m	30 m	5 m	30 m	5 m	30 m	5 m	5 m	Depth
NDOC/POC															0.22 - 0.38	0.13 - 0.19	0.24 - 0.27	0.15 - 0.21			NDOC/POC
NH3-N or NH4 (ug/l)	≤ 20	< 20 - 30	< 20 - 30	≤ 20	< 20	< 20	3.5	13.3	1.9	2.4	4.5	11.2	3.5	4.6	4 - 7	10 - 26	4 - 5	4 - 5	7	5	NH3-N (ug/l)
TKN (ug/l)	200 – 500	< 200 - 300	< 200	≤ 200	≤ 200	< 200 - 300															TKN (ug/l)
NO2/NO3 (ug/l)	< 20 – 40	40-60	≤ 20	< 20 - 100	< 20	< 20 - 80	56.1	54.8	< 3	109	61.7	62.2	< 3	117	50 - 60	55 - 60	5 - 30	85 - 135	56	10	NO2/NO3 (ug/l)
TPN or Total N (ug/l)							107	117	49	166	126	133	90	164	105 - 165	130 - 145	50 - 65	175 - 195	107	55	TPN or Total N (ug/l)
SRP or Ortho Phos(ug/l)	4 – 12	4 - 6	3 - 4	3 - 8	< 2 - 4	<2 - 6	1.7	1.3	0.8	0.9	1.3	1	1.1	1.4	0.4 - 1.0	0.6 - 1.5	0.4 - 0.7	0.4 - 1.0	.5	.5	SRP or Ortho Phos(ug/l)
TP (ug/l)	8 – 21	8 - 16	5 - 13	7 - 11	7 - 11	7 - 41	6.1	6.4	5.3	4.4	6.5	4.6	9.3	5.6	6 - 11	5 - 7	4 - 6	6 - 7	5.9	5.8	TP (ug/l)
TN/TP	25 – 43		17 - 44		20 - 37		18		9		19		10		< 28		< 17		18	10	TN/TP
TIN/TIP	3 – 15		10 - 17		10 - 20		35		6.1		51		6		< 168		< 88		126	30	TIN/TIP
SD (m)**	3.0		5.6		7.1																SD (m)
Chl a (ug/l)	1.3		1.3		7.2		0.79		0.76		0.2		1.07		0.5 - 0.7 (integrated)		1.1 - 1.3 (integrated)				Chl a (ug/l)
min. DO (mg/l)	9.2 at 15.2 m		5.4 at 16.8 m		6.0 at 21.9 m		5.37 at 38.3 m on May 4, 1990				0.50 at 34 m on October 18, 1990				0.07 at 36 meters on October 21, 1992						min. DO (mg/l)

* Shallow ranges for each date represent data from epilimnion and deeper ranges for each date represent data from hypolimnion and possibly metalimnion.

**Land and Water consulting also measured Secchi depth in 5 locations in October 10, 2001, the average Secchi depth was 6.7 meters.

Table 4-1b. Historic Data for Swan Lake – Flathead Basin Commission Data.

Study	Flathead Basin Commission									
Location	Average of Multiple Locations									
Date	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
TP (ug/l)	5.2	3.913	6.780	6.7	8.0			5.0		
SD (m)	5.67*	7.55*	6.19*	5.92*	5.79*	3.73**	3.33**	8.53**	6.85**	3.39**
Chl a (ug/l)	1.4	0.34	1.13	0.89	1.27	1.8		2.23	2.8	
min. DO (mg/l)			2.5 at 34.4 m on August 30, 1995 at South Basin site	5.2 at 29 m on August 12, 1996 at State Island site	7.25 at 33 m on July 28, 1997 at State Island site					

*SD from FBC for 1993-1997 is the average of multiple locations, over multiple days from June through September.

**SD from FBC for 1998-2002 is from multiple locations one day per year.

Table 4-1c. Historic Data for Swan Lake – Plum Creek Minimum Dissolved Oxygen Measurements.

Plum Creek - minimum Dissolved Oxygen measurements											
North Basin						South Basin					
	1996	1997	1998	1999	2001		1996	1997	1998	1999	2001
	5.2 at 39.3 m on October 17, 1996	6.1 at 39 meters on Sept. 3, 1997	7.4 at 40 meters on August 5, 1998	4.21 at 27 m on Sept. 30, 1999	2.53 at 39.5 m on October 19, 2001		0.4 at 37 meters on Oct. 16, 1996	3.4 at 34 meters on Sept. 3, 1997	4.6 at 34 meters on Aug. 5, 1998	1.42 at 34 m on Sept. 30, 1990	0.49 at 36.2 m on Oct. 19, 2001

SECTION 5.0
SOURCE ASSESSMENTS AND ASSESSMENTS OF BENEFICIAL USE SUPPORT CONDITIONS

This section summarizes or references the results from assessment related activities within the Swan Lake Watershed. Most of the assessment work discussed within this section and throughout this document is identified in Table 5-1. These assessment efforts have focused on 1) information on land use activities and the relative impacts these land uses may have on water quality and aquatic life, typically referred to as source assessment; 2) information associated with beneficial use support conditions, typically focused on aquatic life; or 3) information that can be used for both source assessment and evaluation of aquatic life support purposes.

Source assessment is meant to evaluate relative impacts from land uses or land use types, often via pollutant loading determinations or other measures of impact. Examples include evaluating sediment loads from forest road crossings or nutrient impacts from septic systems. The assessment of beneficial use support conditions focuses on water chemistry measurements that can be linked to aquatic life support, habitat conditions important to aquatic life, or direct measures of aquatic life. Examples include 1) the monitoring of lake parameters such as nutrients, 2) the monitoring of physical stream conditions such as percent fines or percent pools, 3) macroinvertebrate sampling, and 4) counting bull trout spawning redds.

Note that some of the assessment work identified in Table 5-1 is focused only on Swan Lake, whereas other assessment efforts are focused on the whole watershed or a specific subset of tributaries. Much of the tributary and Swan River assessment work, especially relating to source assessment, is also applicable to the assessment of impacts to Swan Lake since pollutant loading and other water quality conditions in individual tributary drainages can ultimately result in pollutant loading and other impacts to Swan Lake. Also, certain fish populations, such as bull trout, rely on both healthy tributary streams as well as a healthy lake due to their use of both during various life stages.

Most source assessment work associated with sediment loading also links directly to nutrient loading. This is because eroded soils include varying levels of attached nutrients such as phosphorous, nitrogen, and carbon. For example, timber harvest activities that directly increase sediment loading will also increase nutrient loading. Assessment work associated with nutrient loading will not always be linked to sediment sources. For example, nutrient loading from septic systems does not involve increased sediment loading.

Other source assessment efforts can involve both sediment and nutrient loading associated with differing mechanisms of impact. For example, riparian harvest can lead to increased nutrient loading as discussed in Section 4.0 for Particulate Organic Carbon (POC). Riparian harvest can also lead to increased bank erosion that can also lead to an increase in both sediment and nutrient loading.

Table 5-1. Swan Lake Watershed Assessment Related Activities.

Assessment Related Activity	Date of Work or Published Report	Scale	Sources Assessed	Potential Beneficial Use Support Indicators
(1) DEQ SCD/BUD Files: Reviews of Multiple Assessments including Historical DEQ Field Assessments	Late 1980s to present (DEQ)	Swan Lake and 303(d) Listed Tributaries	Multiple sources based on review of existing data	Multiple indicators based on review of existing data
(2) Swan Lake Water Quality Measurements	1977 - 2001 (several studies, reference Table 4-1)	Swan Lake	Potential indicators of human impacts	DO, nutrients, chlorophyll *a*, other parameters
(3) Remote Sensing of Chlorophyll *a* Over Time	2001 (Terradynamics)	Swan Lake	Potential indicator of trend in human impacts	Chlorophyll *a* - nutrient enrichment
(4) Forest Road Sediment Delivery	2001 - 2002 (Land & Water)*	Watershed	Forest roads	Sediment (and related nutrient inputs)
(5) Goat and Piper Creek Watershed Analysis	1996 (Resource Assessment Team)	Tributaries (Goat & Piper)	Multiple impacts from logging and natural conditions	Habitat conditions, fish data, sediment (and nutrient) loading
(6) Forest Service Culvert Assessments	Ongoing	Watershed Tributaries	Culverts	Indicators of potential sediment loading and fish passage problems
(7) Swan River Bank Stability	2001 (Land & Water)*	Swan River	Natural & human causes of bank erosion	Physical condition of river
(8) Air Photo Analysis of Swan River Drainage	1989 (Gordan Grant)	Swan River	Indicators of multiple impacts to channel morphology	Physical condition of river
(9) Evaluation of Historical Sediment Deposition and Land Use	1991 (Spencer)	Swan Lake	Historical logging and land uses	Rate of sedimentation in Swan Lake
(10) Nutrient & Carbon Loading in Swan River Watershed	1999 (Ellis et al), 1995 (Stanford et al.)	Swan River & tributaries	Nutrient loading sources and synoptic studies	Nutrient inputs
(11) Forest Harvest Impacts in Goat Creek	1997 - 1998 (Ellis et al.)	Tributaries (Goat and Lion Creeks)	Logging activities	Nutrient and sediment parameters
(12) Water Quality in Cat and Dog Creek	1998 - 1999 (Bansak et al.)	Tributaries (Cat and Dog Creeks)	Logging activities	Nutrient and sediment parameters
(13) Forest Harvest Impacts in Lion & Elk Creek	1994 & 1995 (Flathead Basin Commission)	Tributaries (Lion and Elk)	Logging activities	Nutrient and sediment parameters
(14) Nutrient Loading at Swan Lake	1995 (Butler et al.)	Swan Lake & Watershed	Nutrient loading sources	Nutrient inputs
(15) Atmospheric Nutrient Deposition	Ongoing	Swan Lake/Flathead Watershed	Multiple airborne nutrient sources	Nutrient inputs
(16) Evaluation of Septic Impacts to Swan Lake	1977 (EPA), 2003 (DEQ)*	Swan Lake	Septic systems	Nutrient inputs
(17) Evaluation of private land ownership & potential development impacts	2002 (Land & Water)*	Watershed	Human development, logging	Large scale indicators of potential nutrient and sediment loading changes
(18) Aerial Assessment of Riparian Conditions for TMDL Development Support	2002 (DEQ)*	Swan River and tributaries (Elk, Goat, Piper, Jim, Squeezer)	Multiple near-stream potential sources of riparian removal and habitat degradation	Riparian health, near stream encroachment of structures
(19) Tributary Physical Assessments for TMDL Development Support	2002 (Land & Water & DEQ)*	Tributaries (Elk, Goat, Piper, Jim)	Multiple near-stream sources	Multiple habitat parameters (riparian health, pools, LWD, other parameters)
(20) Forest Service Physical Assessments (e.g. R1/R4 Fish Habitat Inventory)	1997 for Elk Creek	Several tributaries	Indicators of multiple impacts	Multiple habitat parameters (riparian health, pools, LWD, other parameters)
(21) McNeil Core Sampling	1987 - present (FWP)	Several Tributaries	Indicator of multiple sources of fine sediment	Percent fines - linked to spawning success
(22) Nutrient and Chlorophyll *a* Sampling	2002 (Land&Water & DEQ)*, 2003 (DNRC)	Tributaries (Elk, Goat, Piper, Jim)	Potential indicators of human impacts	Nutrient & Chlorophyll *a* values
(23) Redd (Spawning Sites) Counts	1982 - present (FWP)	Several Tributaries	Potential indicator of human impacts	Fish populations, tributary use for spawning
(24) Periphyton (attached algae) Sampling	2002 (Land & Water & DEQ)*	Tributaries (Elk, Goat, Piper, Jim)	Potential indicators of human impacts	Biological integrity, species composition
(25) Macroinvertebrate Sampling	1991 (Plum Creek Timber)	Several Tributaries	Potential indicator of human impacts	Aquatic life populations/metrics

* Represents a significant assessment activity pursued for TMDL development during 2001 through 2003.

The DEQ SCD/BUD information from Assessment Activity (1) in Table 5-1 was already discussed in Section 2.0 and Appendix B, and will be further referenced within this section. The Swan Lake data from the various studies associated with Assessment Activity (2) were discussed in Section 4.0 and also summarized further in Table 4-1. Section 4.0 and Appendix D also presented and discussed remote sensing information from Assessment Activity (3). Section 4.0 also referenced some of the other assessment activities in Table 5-1, although this section will discuss each of these and other assessment work presented in Table 5-1 in greater detail. Significant focus is on assessment work pursued for TMDL development during the 2001 through 2003 period.

5.1 Point Sources versus Nonpoint Sources

All source assessment efforts within the Swan Lake Watershed are focused on non-point sources. This is because there are no existing point source discharge loads associated with nutrients, POC, or sediment that are subject to permit conditions under the National Pollutant Discharge Elimination System (NPDES). Therefore, no waste load allocations to address regulated point sources are required. Although no NPDES permits for discharges of the pollutants of concern are anticipated in the near future, any such discharges would likely be involved with residential wastewater treatment. This potential discharge scenario is discussed under the implementation section.

5.2 Determination of Sediment Loads from Forest Roads

5.2.1 Methods

The Forest Road Sediment – Source Assessment Method (FRoS-SAM) was utilized to calculate natural background sediment and to measure road sediment loading to streams, with most field work occurring in 2001 as identified by Assessment Activity (4) in Table 5-1. The sediment loads represent erosion of the road tread surface and erosion from road cut slopes and fill slopes. This sediment loading would also include loading of attached nutrients such as phosphorous, nitrogen and POC; although nutrient concentrations in road sediment were not measured. A detailed description of this method is provided in Appendix E.

GIS and field data indicated that there were 1,110 stream crossings in the Swan Lake Watershed. For simplicity a “stream crossing” is defined as a location where a road crosses a stream or one where the road is in close enough proximity to the stream to be a source of sediment. Since it was impractical to physically visit all of these crossings, a sample of the crossings was visited and measured results were extrapolated to some of the more inaccessible sites. The steps of this extrapolation process were as follows:

1. All stream crossings in the watershed were categorized as having either a “low” or “high” potential for sediment delivery to streams. Low potential sites (Photo 5-1) were those that met one or more of the following criteria:

Photo 5-1. ***Example of a road considered to have low potential for sediment delivery to streams.***

a) Roads that had extensive revegetation on their surfaces,
b) Roads that were gated or blocked (Kelly Hump, etc.) and, as a result, appeared to no longer be in use, and
c) Roads that had no evidence of recent vehicular traffic.

A sample of the low potential sites was assessed on the ground and results were extrapolated to non-visited low potential sites to derive a total estimated sediment load from all low potential sites.

2. All other potentially contributing road locations (either at stream crossings or closely paralleling streams) were categorized as "high potential for fine sediment delivery." All of the high potential sites were visited and evaluated using the FRoS-SAM, except on private land where permission for access could not be obtained. A typical high potential site is shown in Photo 5-2.

Photo 5-2. ***Example of a road considered to have a high potential for erosion and sediment delivery.***

5.2.2 Results

Of the 1,110 identified stream crossings, 702 were visited on the ground. Of those, 318 were found to be contributing sediment to streams, 228 were determined to be non-contributing due to extensive revegetation, and 156 were stream crossings that appeared on GIS mapping layers but did not actually exist on the ground. The 318 contributing sites were estimated to have a combined sediment load of 799 tons/year.

Of the 318 contributing sites visited on the ground, 25 were on non-industrial private land. These 25 private crossings had an average sediment contribution of 2.1 tons/year, and this average was applied to the 110 private crossings that were not visited on the ground, resulting in a total estimated sediment load from non-inventoried private crossings of 231 tons/year. Note that in this analysis, “private” refers to private land other than that owned by Plum Creek Timber Company, who provided unlimited access to the company’s land.

Of the 318 contributing sites, 260 were low potential sites with an average estimated sediment load of 0.19 tons/year each. This average was applied to each of the remaining 298 sites that were not visited, all of which were low potential sites, resulting in a total estimated sediment load from non-inventoried low potential sites of 57 tons/year. Thus the total estimated sediment load from all road crossings in the Swan Lake Watershed was 1087 tons/year (799 + 231 + 57).

A ranking of all sediment sources in the basin along with locator maps and complete road sediment data sheets are provided in Appendix F. The results of the road sediment assessment for the entire Swan Lake Watershed are summarized in Table 5-2. Figure 5-1 shows a cumulative distribution for road sediment in the Swan Lake Watershed. As can be seen by the dotted line on Figure 5-1, approximately 70% of the total watershed-wide road sediment can be attributed to only the 50 largest road sediment sources. Table 5-3 shows a ranking of the worst 20 sediment sources from this set of 50.

Table 5-2. Swan Lake Watershed Sediment Load Summary.

Source	Fine Sediment Load (tons/year) Delivered to Swan Lake or its tributaries
Natural Background*	4,600
Forest Road Sediment	1,087 *(24% above natural background; 19% of total))*
TOTAL	5,687

*Average of the results from two calculation methods described in Appendix E: Landtype method and soil creep method.

Figure 5-1. Cumulative Distribution of Road Sediment in the Swan Basin.

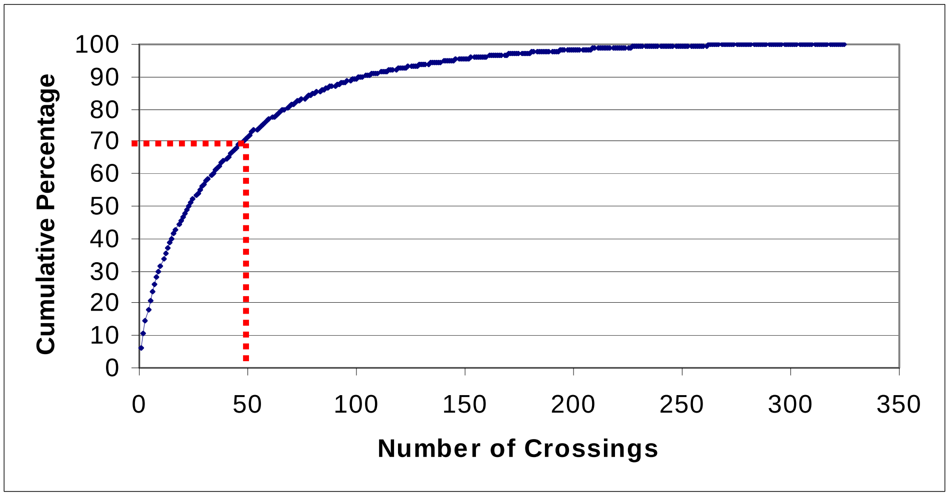


Table 5-3. Largest 20 Road Sediment Sources in Swan Lake Watershed.

Rank	Map Code	Drainage Location	Tons/Year
1	SWC190	S. Woodward	51
2	SWC125	Cold	37
3	SWC20	(Unnamed)	32
4	SWC21	(Unnamed)	28
5	SWC216	Soup	24
6	SWC19	(Unnamed)	22
7	SWC159	Alder	21
8	SWC202	S. Woodward	16
9	SWC78	Windfall	16
10	SWC251	Hall	15
11	SWC279	S. Lost Creek	15
12	SWC136	(Unnamed)	14
13	SWC72	Windfall	14
14	SWC64	Rumble	13
15	SWC168	Fatty	13
16	SWC132	(Unnamed)	12
17	SWC85	Glacier	11
18	SWC142	(Unnamed)	10
19	SWC145	(Unnamed)	10
20	SWC33	(Unnamed)	10

Figure 5-2 shows the road sediment from inventoried sites in all of the drainages in the Swan Lake Watershed. This figure shows substantial differences in sediment loading from drainage to drainage, with road sediment loads as high as approximately 96 tons/year in S. Woodward Creek drainage. Other drainages with higher sediment loads (greater than 35 tons/year) include Cold Creek (43 tons/year), Glacier Creek (46 tons/year), and Soup, Windfall, and Fatty Creeks (all 35 tons/year). These loads include inventoried sites only, and could be somewhat higher if sediment loads that were extrapolated to non-inventoried sites were included.

Figure 5-2. Road Sediment Load to Stream in the Swan Basin (inventoried sources in named drainages only).

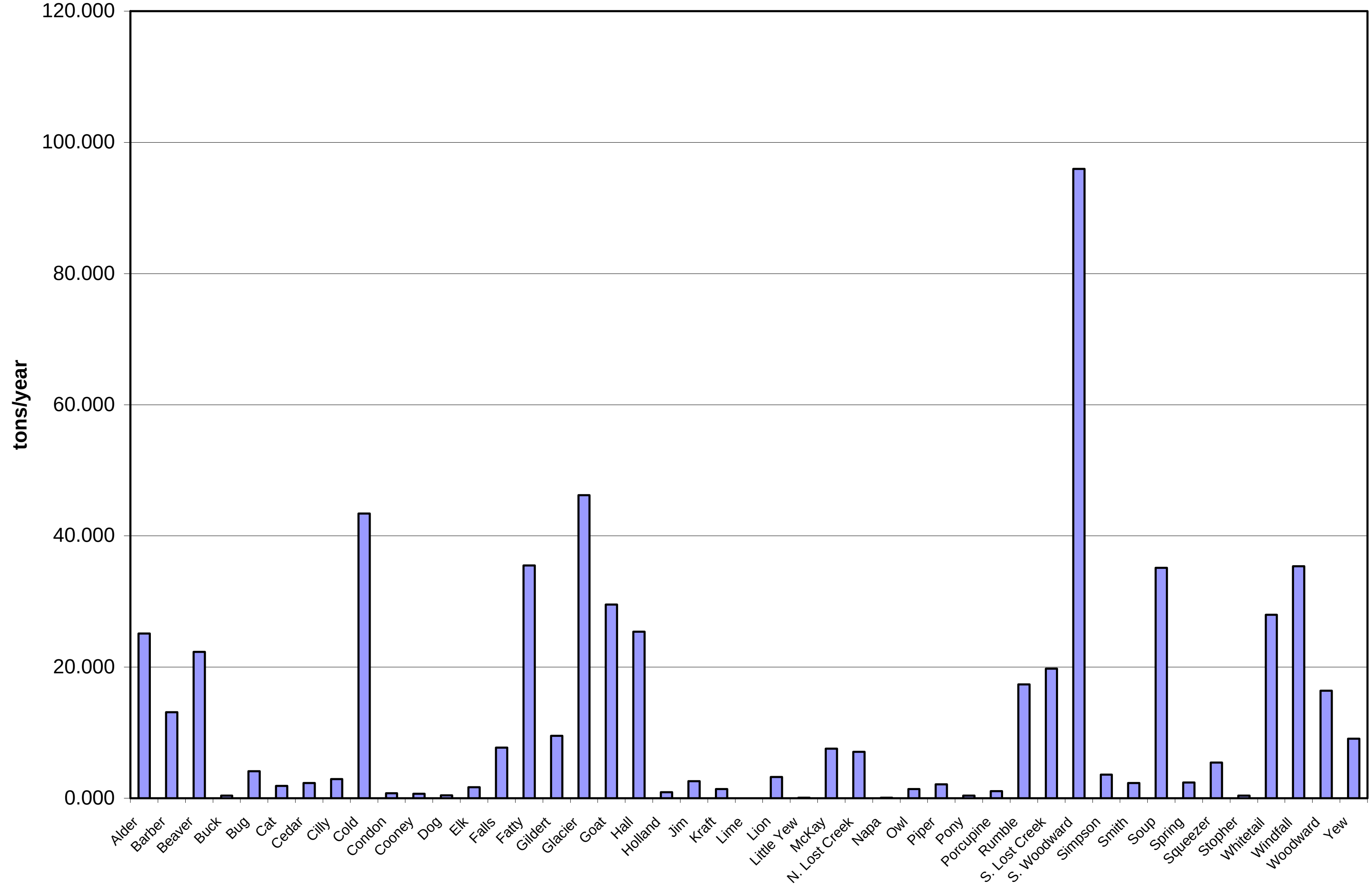
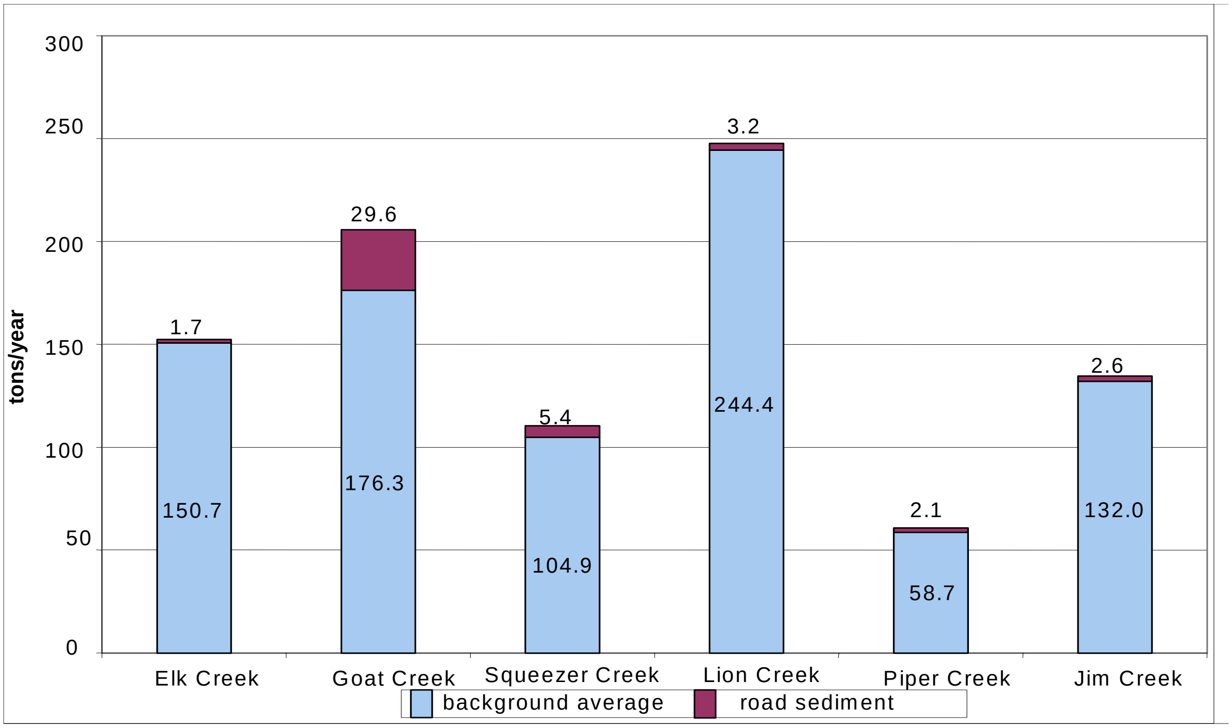


Figure 5-3 shows calculated road and background sediment load values for the six 1996 listed 303(d) streams. The road sediment loads in comparison to natural background loading is comparatively small in five of the six drainages. In the sixth drainage (Goat Creek), the estimated road sediment load is relatively high when compared to background loads. The road sediment loads and percent above natural background load for each of the drainages is: Elk: 1.7 tons/yr (1.1% above background), Goat: 29.6 tons/yr (16.8% above background), Squeezer: 5.4 tons/yr (5.1% above background), Lion: 3.2 tons/yr (1.3% above background), Piper: 2.1 tons/yr (3.6% above background), Jim: 2.6 tons/yr (2.0% above background).

Figure 5-3. Total Sediment Load for the Six 1996-listed 303(d) Streams.



5.2.3 Previous Forest Roads Sediment Loading Analysis Study in Goat and Piper Creek Watersheds

Another assessment of sediment loading to streams from forest roads was done in 1996 under the direction of Plum Creek Timber Company (Watson et al, 1998) as part of a watershed analysis for Goat Creek and Piper Creek (identified as Assessment Activity (5) in Table 5-1). The method utilized was different but comparable to the FroS-SAM. In the Goat Creek watershed (including Squeezer Creek drainage), estimated sediment production from roads was 39.3 tons/year, of which 72% was from road tread and 28% from cut slopes and fill slopes. The road erosion in the Goat Creek watershed (above Squeezer Creek) was estimated at 11% above natural background, and estimated at only 0.2% above background in the Squeezer Creek drainage since the assessment of sediment loading from this portion of the Goat Creek watershed was less than 1 ton/year. This is in comparison to the 30 tons/year 2001 results for Goat Creek (17% above natural background) and the 5.4 tons/year 2001 results for Squeezer Creek (5.1% above natural background).

In the Piper Creek watershed, the 1996 estimate of sediment production from roads was 25.5 tons/year, which was estimated to be 24% above natural background. This is in comparison to the 2.1 tons/year 2001 results for Piper Creek (3.6% above natural background).

As was found in the 2001 analysis, the majority of the sediment loading from the 1996 analysis came from a minority of stream crossings in both the Goat and Piper watersheds, with the worst five crossings contributing 70% of the total sediment load in the Goat Creek watershed.

Variations in methodologies and field crews; as well as apparent variations in how natural background loading is calculated, likely add to some of the variability between studies. Additional differences between 1996 and 2001 results are likely due to:

a) Some crossings with very high sediment loads may have had erosion control best management practices (BMP) applied between 1996 and 2001;
b) The building of new roads for logging or other purposes;
c) The closing or reduced use of logging related roads between 1996 and 2001; and
d) Potential failures of BMPs on roads with previous low loading rates.

A comparison of the specific sites visited, as presented in each report, and the resulting erosion numbers from each study indicates that some combination of all of the above conditions apparently exist in both drainages. On the other hand, many crossings, particularly those with low sediment erosion values, had little change between 1996 and 2001. This type of variability and changes in sediment inputs from road crossings over time would be expected throughout the Swan Lake Watershed.

5.3 Other Road Crossing Pollutant Loading Considerations

5.3.1 Culvert Washout at Road Crossings

When culvert crossings become obstructed with debris or when flood discharge is greater than culvert capacity there is the potential for a substantial amount of sedimentation to occur due to a complete or partial road crossing failure (Photo 5-3). Culverts can also cause an increase in sediment load due to scour conditions upstream and downstream of the culvert itself. The frequency and magnitude of culvert washout or partial failure events in a given watershed is affected by several factors including:

- The structural integrity of individual crossings;
- The amount and mobility of woody debris which is available from upstream riparian area and can plug the culvert;
- The alignment of the stream at the culvert entrance;
- The size of the culvert relative to the hydrology of the drainage area; and
- Maintenance work associated with clearing of potential obstructions on a routine basis and checking for damage or other unfavorable conditions that could lead to failure.

Photo 5-3. ***Example of culvert failure.***

Determining a quantitative frequency of occurrence of culvert failures and a subsequent estimate of the amount of sediment that would be introduced into streams from culvert failures and scour conditions was not pursued for this potentially significant sediment source. However, performance based measures to limit impacts from culverts are provided as part of the allocation strategy presented in Section 8.0. This approach coincides with ongoing Forest Service efforts to inventory culvert crossing and evaluate failure risks (Assessment Activity (6) in Table 5-1).

Note that the above evaluation (Section 5.2) of sediment input from stream crossings identified more than 1000 total stream crossings in the Swan Lake drainage. Many of the non-contributing crossings or low potential sites would still represent roads with a potential high risk of culvert failure due to the age of the road, lack of culvert maintenance, and the fact that many culverts were likely not designed to pass acceptable flood flows. This is supported by analyses performed in other TMDL planning areas (unpublished results from St. Regis and Lolo TMDL planning areas) where significant numbers of undersized culverts represent a significant risk of failure and sediment inputs during floods of less than a 25-year runoff event. At this time, culverts represent a significant unmanaged sediment loading risk throughout the drainage.

5.3.2 Bridge Crossings

Bridge crossings have the potential to negatively impact streams and sediment transport in several ways such as:

- Spans of inadequate length alter natural sediment transport capacity often bringing about upstream aggradation.
- Bridge piers within the active channel may bring about localized scour and downstream aggradation.
- Bridge approaches across floodplains constrict flood flows and may alter floodplain hydrology and degrade floodplain vegetation communities.
- To ensure that rivers and streams remain aligned with bridge openings, bank-hardening techniques are often used upstream and downstream of the bridge crossing. These treatments preclude natural channel dynamics and degrade aquatic habitat.

No loading impacts were determined for bridges as a separate source, although increased bank erosion and impacts associated with riparian removals are addressed via other assessment methodologies such as the bank erosion assessment discussed below in Section 5.4.

5.3.3 Road Sanding Contributions

To provide safer winter driving conditions, significant quantities of road sand are applied to about 48 miles of State Highway 83 within the Swan Lake Watershed. The road sand is periodically plowed off the highway, resulting in a nearly continuous layer of sand/sediment on the road shoulder. The proximity of Highway 83 to Swan Lake and to the Swan River and its tributary streams creates a potential for delivery of the road sand to the waters of the Swan Lake Watershed at numerous locations. Highway 83 parallels the eastern shore of Swan Lake for several miles, with some short sections of the highway coming closer than 100 feet to Swan Lake, thus providing a potential pathway for delivery of road sand directly to the lake. Additionally, a map and GIS review revealed 37 locations in the watershed where Highway 83 crosses a stream and could thus potentially deliver road sand.

Although much of Highway 83 drains to low lying areas with little or no connectivity potential to streams, the near shore road segments along Swan Lake and at the 37 stream crossings represent a significant source of sand/sediment loading to the Swan River and Swan Lake. To the extent that the road sanding materials contain nutrients or organic carbon, they are potential sources of these pollutants as well. Most of the stream crossings tend to be perpendicular to the streams, although Highway 83 parallels a few streams, such as Cilly Creek, for a short distance where the stream abuts the highway fill. The contributing length of sanded road to each stream crossing is estimated to range from 100 to 1000 feet depending predominately on local topography, with an average of about 300 feet based on field observations. At each crossing, road sand can potentially be delivered from both sides of the road on either side of the crossing, resulting in four contributing areas at each crossing. Based on field observations taken in March of 2004, the road sand forms a layer on both sides of Highway 83 that is about 10 feet wide, and about ¼ to ½ inch thick for an average thickness of about 0.03 feet. Using 300 feet as an average contributing road length, this equates to an average potential yearly load of 5 tons for each of the 4 contributing road sections at each crossing [(300 ft)(10 ft)(0.03 ft)(1 cubic yd/27cubic ft)(1.5 tons/cubic yard); or about 20 tons per stream crossing from all four sections.

The proportion of the potential load that is actually delivered to streams varies by site, and delivery can be significantly mitigated by roadside vegetation. Where the ditch is more than 10 feet from the highway and thus beyond the typical snow-throw distance of the plows, the vegetation within the ditch provides significant mitigation to sediment transport. Where the ditch is within 10 feet of the highway, the vegetation can be completely covered by road sand (based on March 2004 observations) and there is limited sediment transport mitigation within the ditch until later in the year when the vegetation grows above the new sand layer. Fortunately, many of the ditches along the roads drain to low catchment areas and/or very densely vegetated areas prior to reaching a stream. Much of the material being transported is the finer portion of the road sand based on visual observation of settled material within catchment areas. At bridge crossings, road sand is often plowed directly into streams, as was evident at the Highway 83 crossing of Lion Creek and other streams assessed during March 2004.

As part of the March 2004 assessment of road sand delivery, a sampling of 8 stream crossings along Highway 83 between Lion Creek and Rumble Creek were evaluated for their potential for sediment loading to Swan River and, ultimately, to Swan Lake. Two additional crossings (Cilly Creek and Perry Creek) were also evaluated since the highway parallels each stream for 50 to 100 feet on one side of each stream. Most other sites did not appear to have significant stretches of road paralleling the stream.

Of the 32 total contributing sides from the 8 typical crossings, 13 appeared to have a low potential for sediment delivery due to the mitigating effects of vegetation discussed above, and likely contributed less than 5% of the potential 5 tons. The other contributing sides appeared to have a slightly higher potential for delivery, which was estimated at 10%. This 10% delivery factor is consistent with findings and estimates from other TMDL development analyses within the St. Regis watershed (Land and Water unpublished data) and within the Blackfoot River Headwaters (DEQ et al., 2004). Assuming 10% load delivery at the sides with higher loading potential, and 3% at the low potential sides, the total estimated load delivery at the 8 crossings is (19 sides)(0.1)(5 tons) + (13 sides)(0.03)(5 tons) = 11.5 tons, or about 1.5 tons/year per crossing on average. Review of Table F-2 shows that this 1.5 tons/year is consistent with the type of sediment load from a typical contributing forest road crossing. Extrapolating this load across the total 37 crossing locations provides a load estimate of 55 tons/year.

In addition, it is estimated that the two locations where the stream is parallel to the road (Cilly Creek and Perry Creek) contribute an additional 50% of the potentially deliverable material over a total of 150 feet where the road paralleled the stream, resulting in an approximate additional load of 1 tons/year. Additionally, it is estimated that 500 feet of Highway along Swan Lake contributes 20% of the applied road sand from the side of the road closest to Swan Lake for a total additional yearly load of about 2 tons directly to Swan Lake. Finally, each of the 37 crossings contributes directly to each stream on two sides over an estimated average stream width of 12 feet. This 12 foot estimate is based on a typical culvert size of 10 feet for many of the streams while allowing for the fact that a few crossings such as Lion Creek are 25 feet or greater in width at a bridge crossing. Assuming 90% delivery at each bridge crossing based on a similar analysis done for the St. Regis River, this adds an additional yearly load of 13 tons [(0.9)(37)(2 sides)(12 feet/side)(10 feet)(0.03 feet)(1 cubic yard/27 cubic feet)(1.5 tons/cubic yard)], or about 0.35 tons per crossing.

Assuming that all of the road sand that enters Swan River at Highway 83 crossings is eventually delivered to Swan Lake, then winter sanding provides a total estimated road sand/sediment load of about 71 tons per year [(55) + (1) + (2) + (13)] to Swan Lake, which will include a portion of attached phosphorous and some POC. A portion of this load is delivered to the lower section of Goat Creek. This additional Goat Creek load is estimated at about 2.0 tons per year. This is based on the 1.5 tons per year average delivery via ditch drainage at each crossing, plus about another 0.5 tons from the bridge crossing, which will be higher than the 0.35 tons per year average since Goat Creek is wider than most other stream crossings. Highway 83 crosses no other tributaries identified as being impaired on the 303(d) list.

5.4 Swan River Bank Stability Field Assessment

5.4.1 Methods

Riverbank stability on the Swan River was assessed in October of 2001 (Assessment Activity (7) in Table 5-1). The assessment reach extended from Piper Creek to Swan Lake. Individual locations of bank erosion were mapped, measured (length and width), and photographed. In addition, information was recorded to describe land use, human impacts, and condition of riparian vegetation. GIS software was used to produce maps showing locations and photos of eroding banks and to compare the length of eroding banks to the total length of banks evaluated.

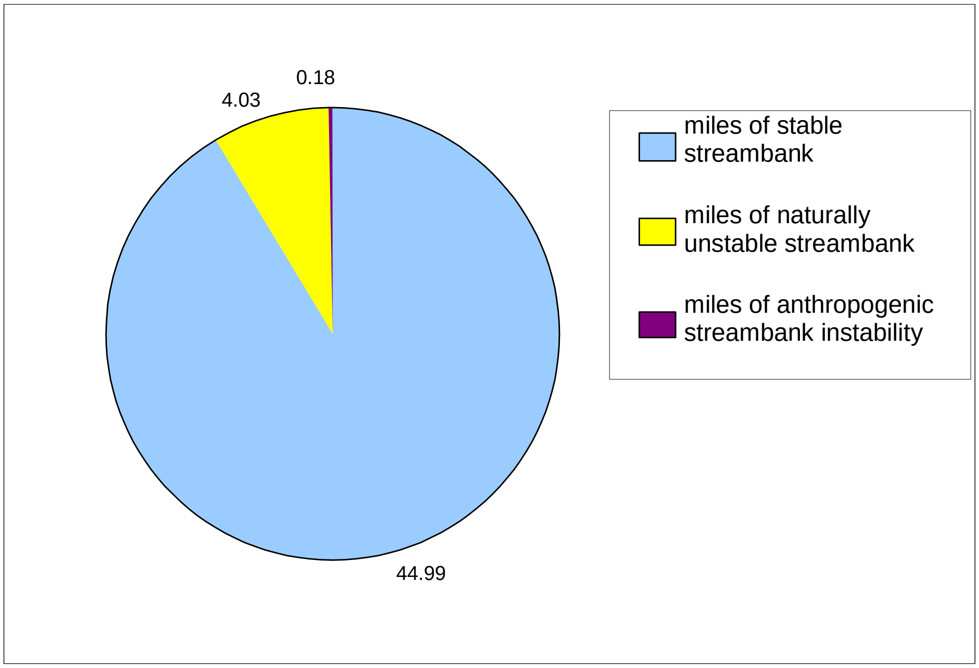
5.4.2 Results

The erosion that was observed along the Swan River appeared to be almost entirely natural in origin. There were eroding high terraces and eroding low banks but there was no apparent, systemic, anthropogenic causes of this erosion. Obvious human impacts were limited to three locations where bridges, grazing, recreation, and/or encroachment by structures appeared to have moderately destabilized the banks.

Figure 5-4 shows the miles of stable and unstable banks within the 24.6 miles of inventoried river between Piper Creek and Swan Lake. Of the 49.2 miles of riverbanks in this reach, 45.0 miles (91.4%) were determined to be in stable condition (Photo 5-4); 4.0 miles (8.2%) of riverbanks were determined to be naturally unstable (Photo 5-5) based on a lack of obvious human contributions to the unstable conditions; and an additional 0.2 miles (0.4%) were determined to be unstable due to human impacts (Photo 5-6). Some of the erosion associated with what appears to be naturally unstable banks could actually be associated with upstream human impacts such as increased peak flows. Because such impacts are often spatially and temporally disconnected from the bank instability that can result from them, a cause and effect relationship is difficult to establish.

The results of the Swan River Bank Stability inventory are presented in Appendix G. This data set includes maps with representative photos for the entire assessment reach. Because of the scarcity of obvious human impacts to the banks of the Swan River, there may be limited opportunities for pollutant source reductions, although eroding banks are addressed as part of the future growth threat and associated allocations for private development discussed in Section 8.0. The maps and data from Appendix G can serve as a baseline against which to compare future data. The assessment presented here can easily be repeated to evaluate changes to the bank stability conditions of the Swan River over time.

Figure 5-4. Swan River Bank Stability, Piper Creek to Swan Lake (10/01).



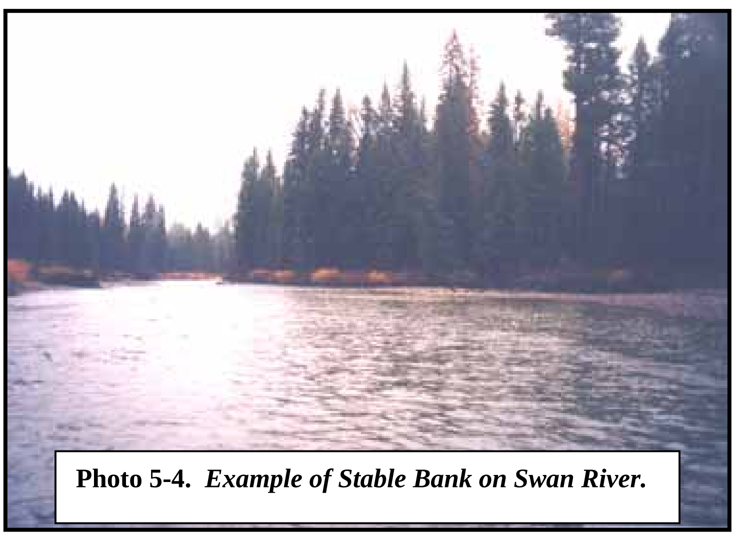


Photo 5-4. ***Example of Stable Bank on Swan River.***

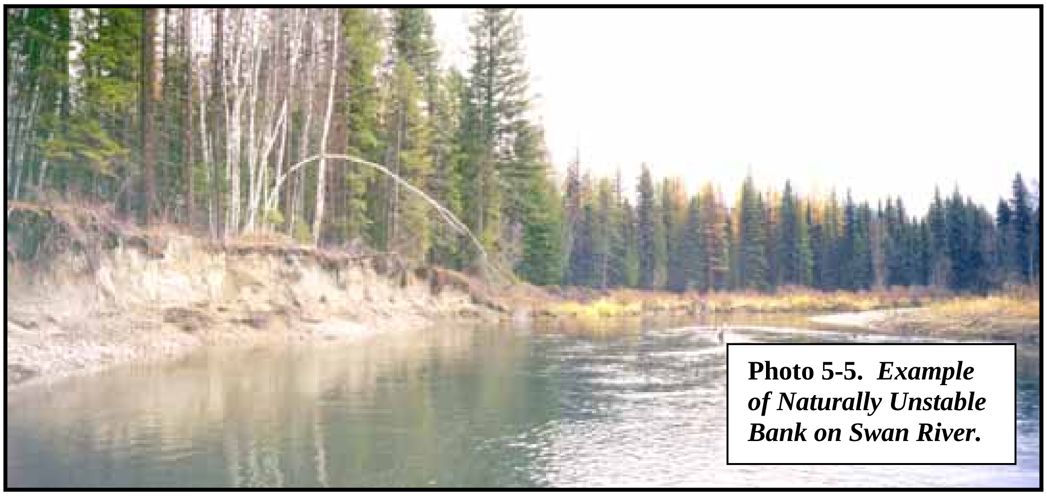


Photo 5-5. ***Example of Naturally Unstable Bank on Swan River.***

Photo 5-6. ***Example of anthropogenic bank instability on Swan River. Site contains an old streamside road and shows evidence of past grazing.***

5.5 Additional Source Assessment Activities Focused on Evaluating Impacts from Timber Harvest

5.5.1 Hillslope Erosion from Timber Harvest Areas

The removal of trees and disturbance of soils in a harvest area can increase hillslope surface erosion for several years with the greatest impacts occurring shortly after the logging activities occur and before vegetation can be reestablished, although not all hillslope erosion ends up being directly delivered to a stream channel. Ground cover, once reestablished, effectively prevents forest soils from being detached by raindrop impact, particularly in areas such as the Swan Lake Watershed where significant ground cover is established shortly after harvest. In timber harvest areas, hillslope erosion and subsequent sediment delivery to streams are typically not observed when forestry BMPs are applied to logging skid trails and Streamside Management Zones (SMZs) are retained (as is required under state law). This assertion has been supported by the biennial state BMP audits (Ethridge and Heffernan 2001). In a review of watershed analyses completed throughout the Pacific Northwest (McGreer et al. 1998), this same conclusion was reached.

The Goat Creek and Piper Creek Watershed Analysis (Watson et al., 1998) evaluated hillslope erosion on six recently harvested areas within each watershed. Local areas of soil disturbance were observed on hillslopes, typically as a result of ground-based equipment operation, or by logs being skidded (by cable or tractor). In at least two locations hillslope erosion was associated with improper application of drainage control BMPs. Though localized disturbance and erosion was observed in harvested areas, no sediment was observed to have routed to a stream channel due to implementation of BMPs and protection of streamside management zones.

A more thorough analysis of potential timber harvest impacts on hillslope erosion does not appear to exist for the Swan Lake drainage. Many of the analyses and studies presented within Section 5.0 are indirect measures of the impacts that hillslope erosion can have on water quality.

5.5.2 Mass Wasting and Landslides

Timber harvest activities also have the potential to increase landslides and other mass wasting features due to concentration of runoff and/or loss of vegetation. The above analysis by Watson et al. (1998) included an assessment of landslides and mass wasting events. Aerial photographs, field reconnaissance, and topographic, geologic, and landform maps were used to assess the historic and current distribution of mass wasting in the context of forest management in the two watersheds (Goat and Piper). The study found numerous avalanche chutes, rockfalls and one large deep-seated landslide that occurred naturally. Five mass wasting sites and six landslides were linked to forest management activities, with limited observed direct delivery of sediment to drainages.

It was concluded that forest management in these two watersheds had avoided steep slopes and had not appreciably increased the amount of mass wasting. Most landslides associated with forest management occurred from steep cut slopes or from concentrating drainage onto steep slopes. The report identified areas of risk based on factors such as hillslope gradients, geology, and groundwater flows/seeps and stressed the need for careful planning of any future timber harvest activities.

A more thorough analysis of potential timber harvest impacts on mass wasting and landslides does not appear to exist for the Swan Lake drainage. Many of the analyses and studies presented within Section 5.0 are indirect measures of the impacts that mass wasting and landslides can have on water quality.

5.5.3 Increased Streambank Erosion and Overall Sediment Transport Due to Increased Peak Flows

Harvested areas can also increase water yield due to vegetative removal at a large scale. This water yield increase can lead to an increase in peak flows and/or an increase in the duration of higher flows, which can in turn increase in-streambank erosion, particularly in meandering channel types or channels with poor vegetative cover along the banks. Many National Forest hydrologists in the Northern Region use some adaptation of the equivalent clearcut area (ECA) procedure to forecast average streamflow responses to vegetation removal by timber harvesting, road building, and fire (King, 1989). A water yield increase of 10%, which may be adjusted depending on channel stability or soil characteristics or both, has been suggested and sometimes used as a timber cutting guideline to avoid water quality impacts (King, 1989). In watersheds where riparian conditions protect banks from elevated erosion, a higher increase such as a 12% will likely not cause significant increases in bank erosion or other stream impacts. In a watershed with a more erodable banks and/or limited protective riparian vegetation, a lower increase such as 8% could potentially lead to significant increases in bank erosion and other negative stream impacts.

Based on analyses done in the 1980's, calculated water yield increases were identified as being less than 10% in nearly all cases for Swan River tributaries (U.S. Forest Service, 1988). Watson et al. (1998) calculated water yield and peak flow increases for Goat and Piper Creeks (reference Assessment Activity (5) in Table 5-1). The assessment was based on a standard methodology presented in the state of Washington watershed analysis manual. Evaluated conditions associated with peak flows included rain-on-snow (ROS) events for the 2, 5, 10, 25, 50, and 100-year storms. Calculated maximum increases were 6.5% for the Goat Creek drainage and 5.3% for the Piper Creek drainage, with the higher values occurring during the more common 2-year storm events. Peak flows related to snowmelt under clear sky (CS) conditions were also discussed, although no values were calculated. As with other analyses of land use impacts, differing methods and assumptions can make direct comparisons between studies somewhat difficult.

No recent basin-wide analysis of harvest-induced water yield is available in the Swan Lake Watershed. The limited data that are available and the on-the-ground assessment results discussed later in Section 5.14 suggest that water yield and peak flow increases have typically been below thresholds thought to initiate degradation to stream channels, at least for the four 303(d) listed streams assessed.

5.6 Evaluation of Timber Harvest (Historical and Existing) on Measured Water Quality Parameters and Physical Conditions

As discussed to some degree in Section 4.0, there have been several studies and assessments efforts to evaluate impacts from harvest/logging activities on chemical water quality parameters and physical stream conditions or stream stability. Some of these assessments activities are discussed below as part of this section.

5.6.1 Historical Air Photo Analysis for Swan River (Assessment Activity (8) in Table 5-1)

An air photo analysis was undertaken in 1989 by the Forest Service (Grant, 1989), with a goal of evaluating impacts to Swan River physical conditions from harvest activities within the watershed. Air photos were analyzed between the years 1934, 1966, and 1985. Although significant channel changes and instabilities were identified, no evidence linking these conditions to timber harvest was found. The author also pointed out that some of the channel instabilities associated with meanders and braiding were indicators of natural conditions for the Swan River given its low gradient and high discharge in the area evaluated, and given at least two high flood flows during the period evaluated. The author suggested that potential impacts from streamside harvest and large woody debris conditions may exist but could not be evaluated by this assessment method.

5.6.2 Evaluation of Historical Sediment Deposition and Land Use (Assessment Activity (9) in Table 5-1)

As discussed in Sections 2.0 and 4.0, Spencer (1991b) showed that sedimentation rates in Swan Lake were closely correlated with harvest activities within the Swan Lake Watershed. The same correlations were found with harvest and/or road building activities in two other watersheds in the Flathead Basin as well. This increased sedimentation may be linked to increased POC loading and a potential decrease in DO as discussed in Sections 2.0 and 4.0 of this document.

Given the extent of historical logging and associated practices, including riparian harvest and an overall lack of erosion protection at levels pursued today, the documented increases in sedimentation during historical periods of harvest are of no surprise. The increased levels of sedimentation in Swan Lake attributed to historical timber harvest are probably not indicative of levels that one would find from harvest activities over the last decade due to BMP implementation.

5.6.3 Determination of Nutrient and Carbon Loading in the Swan River (Assessment Activity (10) in Table 5-1)

Ellis et al. (1999a) measured water quality parameters (nutrients, total suspended sediment (TSS)) along several drainage area segments of the Swan River. The level of harvest along each segment was evaluated based on historical records. This review of land use showed that for the period of record (up to about 1991), about 26.8% of the whole Swan Lake basin had some form of harvest. Most of this harvest was heavy in severity (92.2 $miles^2$); another 10.5 $miles^2$ was harvested at light intensity, and 55.5 $miles^2$ was harvested at medium intensity. Most of the harvest activity took place between 1987 and 1991, with the period prior to 1977 showing the second greatest level of harvest. Overall road density in the Swan Lake Watershed was 2.30 $miles/miles^2$, with the highest densities of 2.33 to 2.88 $miles/miles^2$ within three of the drainage area segments along the Swan River. The total number of road crossings was also evaluated.

Statistical analyses showed no land use characteristics or land cover types were correlated to discrete nutrient and carbon concentrations or discrete loading in the Swan River corridor at p=0.10 (90% level of certainty/confidence). The authors noted the difficulty in detecting and predicting cumulative human impacts on storage and flux of materials (i.e. nutrients and sediment) in a large basin due to complex interactions among natural and human sources of variation in addition to the limited sampling time frame (less than one year). They also concluded that sorting out sources of pollutant loading variations is more accurately done in small watersheds.

5.6.4 Influences of Forest Harvest on Water Quality in Goat Creek

Ellis et al. (1999b; Assessment Activity (11)) measured water quality parameters in a somewhat extensively harvested and roaded (2.3 miles/miles^2) watershed (upper Goat Creek) and in a similar watershed not affected by timber harvest activities (upper Lion Creek). The measurements were taken in 1997, which was a year with significantly high stream flows due to a very large snowpack. The maximum TSS, total phosphorous, and POC concentrations were substantially higher in Goat Creek than in Lion Creek even though Lion Creek had higher flows. Statistical analysis at a 90% confidence level showed that several nutrient levels were significantly higher in Goat Creek than Lion Creek at low flow, and soluble phosphorous was significantly higher in Goat Creek during runoff. POC (particulate organic carbon, referred to as non-dissolved organic carbon or NDOC in many reports) and TSS were higher in Goat than Lion during runoff, with the differences being only slightly below the 90% statistical confidence level. The peak TSS value in Goat Creek was significantly higher than Lion Creek and as high as about 45 mg/L, whereas the peak TSS value in Lion Creek did not exceed 20 mg/L and ranged from about 15 to 20 mg/l during the higher runoff conditions. The data show that the earlier part of runoff period was associated with the biggest increases in TSS, TP, and POC for the harvested watershed (Goat Creek). The results from this study suggest a significant suspended sediment and nutrient/POC loading increase from human activities to both Goat Creek and Swan Lake.

The maximum TSS value of about 45 mg/l in Goat Creek found by Ellis et al (1999b) occurred when the TSS value in Lion Creek was about 14 mg/l, representing a 31 mg/l variation between a heavily harvested and natural background condition in Lion Creek. Additional data show Goat Creek TSS values that tend to be 10 to 12 mg/l higher than Lion Creek during the earlier part of the runoff.

Bansak et al. (2000) measured TSS and turbidity in Cat and Dog Creeks in 1998 (Assessment Activity (12)). Their results indicate an approximate 2 to 1 ratio of TSS, measured in mg/l, versus turbidity, measured as nephelometric units (NTU) over a TSS range of about 13 to 16.5 mg/l. Based on this relationship, the 31 mg/l change in TSS in Goat Creek when compared to Lion Creek during runoff in 1997 represents an approximate 15.5 change in NTUs, and the smaller 10 to 12 mg/l variations during high flow represent changes of approximately 5 to 6 NTUs. Efforts to correlate TSS and turbidity in eastern Montana (unpublished DEQ data) indicate more of a 1 to 1 relationship over a greater range of TSS values, meaning that a given TSS change in the range of 14 to 45 mg/l could result in a higher NTU change, although it is recognized that the TSS to NTU relationships in eastern Montana could be inherently different than those in the Swan Lake Watershed. Nevertheless, the NTU changes between Goat and Lion Creek, specifically at peak flow conditions, appear to be greater than the 5 nephelometric units increase allowed by Montana Water Quality Standards and discussed in Appendix A, with significant differences of 15 NTUs or more during the higher flow conditions. TSS variations between both streams throughout much of the remainder of the year are within the 5 NTUs based on low flow data.

Since the Goat Creek comparison is to a stream segment (upper Lion Creek) not affected by timber harvest or other land management activities, it could be argued that the Lion Creek drainage does not represent a “naturally occurring” condition (reference Appendix A), and the actual turbidity changes from naturally occurring conditions would be less than those reported above. It is worth noting that high flow TSS values of 12 to 16 mg/l in Dog Creek (Bansak et al., 2000), a drainage with some timber harvest, are similar to the high flow TSS values for Lion Creek, although runoff conditions varied between these two years. This indicates that some level of timber harvest and related activity can occur without significantly increasing TSS values.

It is likely that increased TSS values are indicators of sediment erosion from forest roads in addition to the possible transport of smaller sized suspended sediment particles from hillslope erosion, mass wasting and other logging related impacts.

The Montana Department of Natural Resources and Conservation (DNRC) sampled TSS and other nutrients in Goat Creek and several other streams during 2003 (M. Vessar, unpublished data 2003). The peak flow TSS value for Goat Creek was 19 mg/l vs. the 45 mg/l from 1997. The 2003 snowpack was at about 89% of normal, whereas the 1997 snowpack was at about 158% of normal. Other streams sampled in 2003 had similarly low TSS results, with the exception of Woodward Creek where TSS was significantly higher at 36 mg/l. Note that S. Woodward and Woodward Creek road sediment loading values shown by Figure 5-2 are both high, with S. Woodward Creek values being the highest of any drainage.

The above results indicate elevated loading of suspended sediment and nutrients from harvest activities, with the possibility of reduced loading from Goat Creek since 1997. The high flows associated with 1997 complicate this analyses and conclusions.

5.6.5 Analysis of Land-use in Relation to Total Suspended Solids (TSS) and Total Phosphorous (TP) Loading Rates (Assessment Activity (13))

Measurements of TSS and TP were made in upper and lower Lion Creeks as well as Elk Creek in 1994 and 1995 (FBC, 1996). For both years, the TSS and TP load/acre values increased between the upper near pristine portion of Lion Creek and the lower portion of Lion Creek where significant timber harvest had occurred. The resulting TSS loading rate increase was about 60% even though the lower portion of the Lion Creek watershed was considered to be at low risk of sediment routing to the stream, and the TP loading rate increased by about 20%. Of particular interest is the fact that the TSS and TP results for both years, on a load/acre basis, were higher for Elk Creek than for either sampling location on Lion Creek, which was considered to have very little timber harvest. As pointed out in the summary of these results, this information also demonstrates some of the natural, inherent differences between watersheds. Again, the above results indicate elevated loading of suspended sediment and nutrients from harvest activities. The study also indicates high natural variability between drainages.

5.6.6 Water Quality in Cat and Dog Creeks (Assessment Activity (12))

Starting in 1998, monitoring of multiple water quality parameters was started in Dog and Cat Creeks. Cat Creek represents a natural background or control condition and Dog Creek, at least at the onset of the study, represented a drainage with limited recent forest management or timber harvest activities and possible increased future management activities. A report covering the results from 1998 (Bansak et al, 2000) includes the TSS and NTU information discussed above in Section 5.6.4. This report also provides additional data on nutrient and sediment related parameters including POC. Similar to other studies, the higher TP, POC, and TSS values were noted during the spring runoff period.

5.6.7 Swan River Tributary Nutrient Synoptic Sampling (Assessment Activity (10))

Synoptic sampling was done in 1995 at many Swan River tributary sites as part of a larger study to obtain a better understanding of human caused sources of nutrients from within the Flathead Lake basin (Stanford et al., 1997). Streams sampled within the Swan watershed included Glacier, Elk, Jim, Piper, Lion, Goat, Woodward, and Lost Creeks. Full analysis of potential land use impacts was difficult since funding limitations prevented a determination of clearcut cover types in the Swan watershed. However, Glacier Creek and Elk Creek were roadless whereas other creeks sampled had been substantially harvested and roaded. Comparison of instantaneous nitrogen and phosphorous loading in Glacier and Elk Creeks relative to the other creeks sampled revealed significant loading in 16 of 24 possible combinations.

Overall, the authors concluded that the data strongly suggests that nutrient loads are substantially elevated in Flathead Basin streams with significant timber management activities. The authors note that much greater resolution of the influences of various land use practices on non-point nutrient loading is needed, particularly in relation to past and current forest management activities. They also note that the importance of variations in geology, soil nutrient retention characteristics and other biophysical influences on export of nutrients from the catchment need to be included in future load allocations.

5.7 Nutrient Loading Calculations from Water Quality Monitoring Studies

Several of the above referenced studies and other assessment efforts have involved enough monitoring and data collection, including seasonal flow measurements, to calculate nutrient loading within the Swan Lake Watershed. Butler et al. (1995; Assessment Activity (14) in Table 5-1) determined mean daily loads over a period of about 15 months in 1992 and 1993 for total phosphorous (TP), nitrate/nitrite, and total persulfate nitrogen (TPN) entering Swan Lake from four source areas. These source areas include Swan River, two tributaries to Swan Lake, and precipitation. Relative contributions from these source areas are also presented in their analysis. Similar loads are also identified for particulate organic carbon (POC).

The assessment work of Ellis et al. (1999a) provided total loads in Swan River for a 10-month period in 1997 and 1998. Parameters include most nutrients of concern including TP, TPN, nitrate/nitrite, and POC. Discrete loads along several segments of the Swan River were also calculated. Also, the Goat and Lion Creek assessment work (Ellis et al. 1999b) provides annual loads for many of these same parameters, as well as TSS, for both Goat Creek and Lion Creek.

The 1977 EPA Swan Lake water quality analyses work identified in Table 4-1 and as part of Table 5-1 Assessment Activities (2) and (16), also determined nutrient loading from the Swan River to Swan Lake.

Table 5-4 summarizes some of the results from these various loading studies. Many of the Butler and Ellis values were obtained from figures in the respective reports and therefore are approximate values. The following are some observations from Table 5-4:

- Total Phosphorous (TP) loading from the 1974 EPA and the 1997 Ellis et al. (1999a) studies are similar (14,500 vs. 19,000 kg/yr). The TP loading from Butler 1992 - 1993 study is much lower due to a combination of lower flow conditions and one very low sample result that could be a sampling error since such a low value would not be expected. The 1997 Goat and Lion Creek TP loading values each represent about 2 to 3% of the total TP load measured in the Swan River at the Porcupine site.
- Nitrate plus nitrite (NO3 + NO2) loading values are not available from the EPA study, but show good consistency between the Butler and Ellis studies (33,000 kg/yr vs. 39,000 kg/yr). The Goat and Lion Creek values represent about 8 and 14% of the total NO3 + NO2 load in the Swan River respectively.
- Total nitrogen (TN or TPN) values are more variable from one study to another, with the EPA value being significantly higher than the 75,000 and 137,000 kg/yr values from Butler and Ellis. The Goat and Lion Creek values represent about 3 and 7% of the TN load in the Swan River respectively.
- Particulate Organic Carbon (POC) loading values are not available from the EPA study, but show good consistency between Butler and Ellis (500,000 vs. 563,000 kg/yr). The Goat and Lion Creek values each represent about 3% of the POC load in the Swan River.
- Total Suspended Solids (TSS) loading is only calculated from the Ellis et al. (1999a) study, with a value of 16,264,000 kg/yr. The Goat and Lion Creek values each represent about 2 to 3% of the POC load in the Swan River.
- TP, POC and TSS loading percentages for Lion and Goat Creeks are all similar within the range of 2 to 3%, further suggesting a strong linkage between these pollutants.
- The 1975 (EPA study year) and 1993 (Butler study year) Swan River peak flows were between 5000 and 5500 cfs, whereas the peak flow in 1997 (Ellis study year) was much greater at more than 8000 cfs. This is likely contributing factor toward higher loading from the Ellis versus the more recent Butler study.

Table 5-4. Swan River and Tributary Loading Values.

SWAN RIVER LOADING (all values are kg/yr)						
Study	**Time of work**	**TP**	**NO2NO3**	**TPN or TN**	**POC**	**TSS**
EPA	10/1974 - 09/1975	14,500		638,000		
Butler[1]	07/1992 - 11/1993	2,300	33,000	75,000	500,000	
Ellis[2]	04/1997 - 02/1998	19,000	39,000	137,000	563,000	16,264,000
GOAT CREEK LOADING (all values are kg/yr)						
Study	**Time of work**	**TP**	**NO2NO3**	**TPN or TN**	**POC**	**TSS**
Ellis	04/1997 - 02/1998	400	2,000 - 4,000	2,000 - 4,000	15,000	450,000
LION CREEK LOADING (all values are kg/yr)						
Study	**Time of work**	**TP**	**NO2NO3**	**TPN or TN**	**POC**	**TSS**
Ellis	04/1997 - 02/1998	500	4,000 - 6,000	6,000 - 8,000	15,000	405,000

NOTES:

1 - Low TP value is primarily due to one low value at peak flow that could be a sampling error since such a low value would not be expected.

2 - Loads are from Porcupine Site.

5.8 Comparisons Between Inlet and Outlet Concentrations in Swan Lake

The 1977 EPA Swan Lake report also compared total lake inputs and outputs of TN and TP. The results suggested a TN loading increase of about 16% from Swan Lake to the lower Swan River and Flathead Lake. This level of calculated increase could be within the study variability. The results also suggested a TP reduction of about 58%. This suggests that Swan Lake creates a TP loading sink and thus mitigates TP loading to the lower Swan River and Flathead Lake.

Spencer (1991b) performed more recent analyses of input and output nutrient loading for Swan Lake by looking at Swan River inlet and outlet concentrations during June and September of 1990. SRP concentrations at the inlet were similar in June and somewhat higher in September, suggesting a potential loading sink possibly due to nutrient uptake by algae. On the other hand, TP values were also similar in June but the outlet concentration was significantly higher, suggesting a potential source of TP from within Swan Lake. Ammonia (NH4) and NO3 + NO2 concentrations at the inlet and outlet were the same for both sampling dates, whereas the TN value was higher at the outlet, similar to the findings of the EPA study. The limited number of sampling events makes it hard to draw firm conclusions from this information.

5.9 Atmospheric Nutrient Deposition

No accurate estimates of the airborne nutrient load to Swan Lake exist. However, data from Flathead Lake suggest that the load could be significant (DEQ, 2001). Stanford et al. (1997) estimated that between 1991 and 1995, Flathead Lake received an average of 16 % of its phosphorous load and 7% of its nitrogen load from airborne sources. At present, the individual airborne nutrient sources are not characterized well enough to be addressed specifically in either the Flathead Lake or the Swan Lake TMDLs. A conceptual strategy for collecting additional data

(Assessment Activity (15) in Table 5-1) is outlined in the Flathead Lake TMDL (DEQ, 2001). As more data on the issue become available, they can be incorporated into future source reduction efforts as necessary.

5.10 Livestock Grazing Impacts

Large scale livestock grazing does not occur within the Swan Lake Watershed and is was not evaluated separately as a source of water quality degradation and nutrient or sediment loading to Swan Lake and the major tributaries. It is recognized that small acreage private land development in rural areas is often associated with small numbers of horses, cattle, or other grazing animals that can have negative impacts on riparian vegetation, and that some of these impacts are occurring throughout the Swan Lake Watershed. Various assessment efforts discussed within this section (Section 5.0) capture impacts that livestock grazing may have on riparian degradation and/or eroding banks and provide indicators of potential future impacts from increased development. These efforts include the inventory of eroding banks and evaluations of riparian health during physical stream assessments, and the evaluation of threats associated with increasing private home development.

5.11 Nutrient Loading from Septic Systems

Septic systems can contribute nutrient loads to waterbodies typically via ground water. By design, some treatment occurs in a septic tank and some treatment occurs through the leach field prior to reaching ground water, although a standard system will have elevated levels of nitrate reaching ground water with the potential for elevated levels of phosphorous or other contaminants also reaching ground water depending on conditions such as local soil characteristics and system performance. Once in the ground water, natural attenuation may prevent nutrients from reaching a surface waterbody, typically more so for phosphorous than nitrate due to the tendency for phosphorous to attach to soil particles. A 1977 study by the EPA (Assessment Activity (16)) estimated that septic tanks contributed 0.3 % of the total yearly nitrogen and phosphorous load to Swan Lake. Approximately 1990 kg of nitrogen and 55 kg of phosphorous were attributed to septic tank loading at the time using a conservative approach for determining nutrient loads. The EPA’s estimate was based on 180 dwellings and one campground within 100 meters of the lake (EPA, 1977).

The Natural Resource Information System (NRIS) On-Line Interactive Map Builder (Montana State Library, 2002) shows septic tank density to be increasing in the vicinity of Swan Lake (Figure 5-5). In 1990, 96.6% of the area showed low hazard potential associated with the density of the tanks. Also in 1990 3.4% of the area was at medium hazard and zero percent of the area was at a high hazard. In 2000, 92.9% of the area was rated as low hazard, 6.9% as medium, and 0.1% as high hazard. The 0.1% in the high category translates to approximately 9 acres around Swan Lake at a high hazard level due to septic density. This increase in septic density from 1990 to 2000 reflects an estimated increase in population from 309 to 476 within one half mile of Swan Lake.

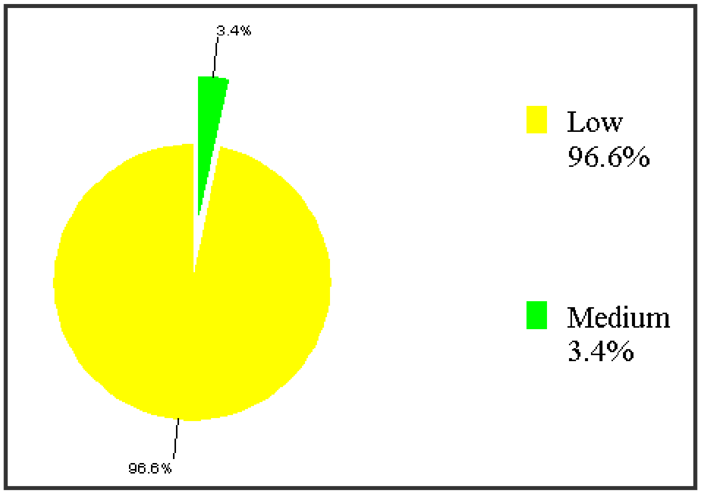
Figure 5-5. Septic Density Around Swan Lake.

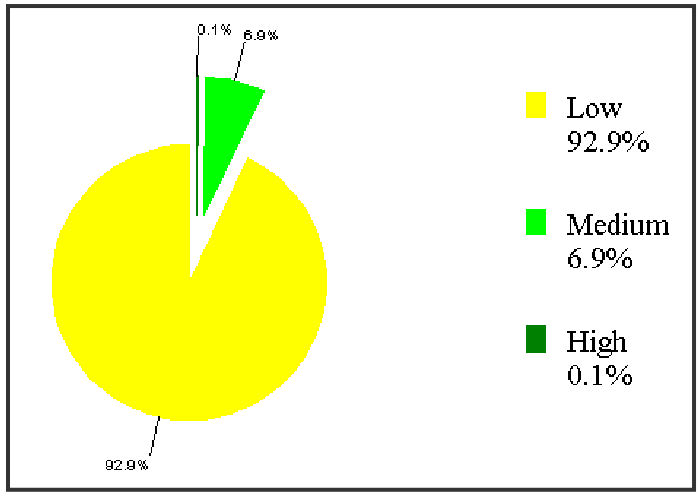
1990 SEPTIC DENSITY

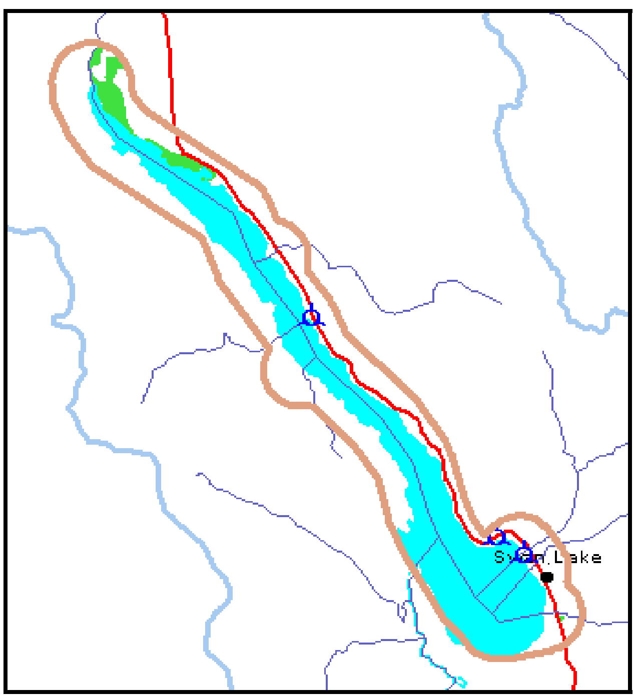
Acres	1990 Septic Density
7,086.93	Low
246.42	Medium
7333.35	Total

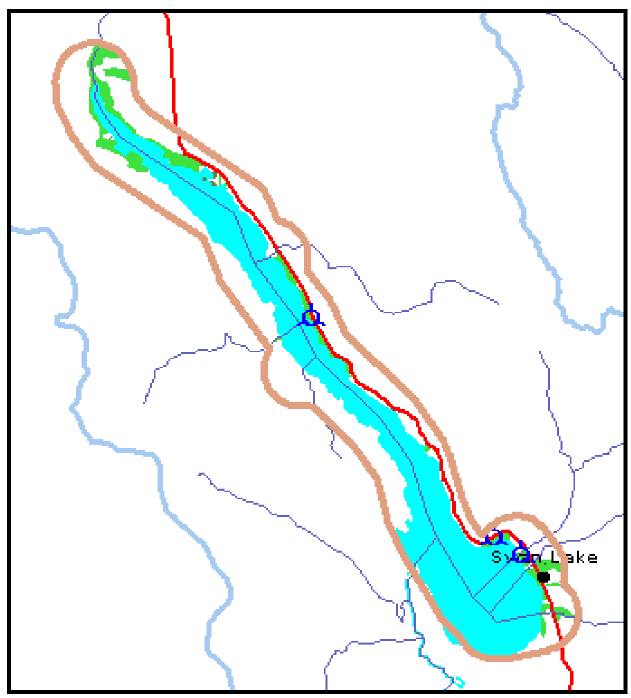
2000 SEPTIC DENSITY

Acres	2000 Septic Density
6,815.60	Low
508.71	Medium
9.04	High
7333.35	Total









High Hazard - >300 septic systems (750 persons) per square mile
Medium Hazard - >50 septic systems (125 persons) but < 300 septic systems per square mile
Low Hazard - <50 septic systems (125 persons) per square mile
Census 2000 Total Population = 476
Census 1990 Total Population = 309

NRIS uses U.S. Census data to estimate septic density and makes an assumption that there is an average of 2.5 people per installed septic tank. NRIS assumes cities are sewered. This does not affect the town of Swan Lake because it was not identified as a city in the census, nor is it sewered. NRIS does not include provisions for areas such as campgrounds that have non-resident populations. Further evaluation shows two resorts (Birch Glen and Deer Lick Resorts) and one campground (Swan Lake Annex Campground) near the town of Swan Lake with significant populations that may contribute to septic tank influences in Swan Lake. The combined non-resident population of these three entities is estimated at 374.

Using the 1977 EPA method for estimating nitrogen and phosphorus loading with the 2000 census data of 476 residents and 374 non-residents it is estimated that septic tanks are now inputting approximately 3635 kg of nitrogen and 100 kg of phosphorus per year. This 2000 estimation is based on populations within one half mile of Swan Lake while the 1977 estimation is based on populations within 100 meters of Swan Lake. However, population densities are centered along the shores of the lake. This method for estimating loads again results in a conservatively high estimate. Although the estimated nitrogen and phosphorus loads attributed to septic tanks have almost doubled, the phosphorous load is small fraction of the total yearly phosphorus load to the lake. This phosphorous load is less than 1% based on the 1977 EPA loading numbers and also less than 1% than the loading numbers from Ellis et al (1999a) per Table 5-4. The total nitrogen (TN) loads, on the other hand, may be more significant given more recent lower total load values in Table 5-4. These TN loads are perhaps as high as 3 to 5% of the TN load delivered via Swan River and as much as 5 to 10% of the NO3 + NO2 load since most or all septic loading would be via this soluble form of nitrogen.

Although the total yearly nutrient loading contribution from septic systems appears to be small, it could be a significantly higher percentage of the total load during the summer when nuisance algal blooms would most likely occur. This increased septic loading contribution would be due to a few factors: 1) the septic loading rate would be somewhat higher during the summer due to the transient status of much of the human population; 2) most of the nutrient loading from the Swan River and other tributaries would occur during runoff with there being significantly lower loads entering the lake during the summer, although some of the increased algal growth and nutrient cycling associated with runoff conditions may still impact summer algal growth conditions; and 3) some of the summer nutrient loading entering the lake via the much colder Swan River may end up under the thermocline where the nutrients may not be readily available for algal growth.

The increase in population around Swan Lake can also result in or contribute to the potential for near shore issues, such as high algal growth rates. Even relatively low levels of septic-related nutrients can promote near-shore algae blooms, which can in turn result in recreation and aesthetic impairments to the lake and could ultimately impact aquatic life. Although there is no known data on near-shore algal levels in Swan Lake, lakeshore residents have commented that algal levels are noticeably higher than they were in the past. In response, an investigation of near-shore algae is recommended as part of the monitoring plan described in Section 10.0.

It is also worth noting that septic systems throughout the watershed, particularly near streams, have the potential to add additional nutrient loads to individual tributary streams and the Swan

River, and thus increase loading to Swan Lake. No loading estimates were made from these additional systems, although this additional loading is estimated to be less than the loading from the septic systems around the lake based on population in the watershed and potential for nutrient reductions due to nutrient uptake within streams.

The State of Montana's nondegradation rules (ARM 17.30.7) address septic systems and potential impacts to nutrient concentrations within ground water as well as nutrient loading to interconnected surface waters. For example, the phosphorous adsorptive capacity of soils in an area where any septic systems are added must indicate that the phosphorous will be removed for a period of 50 years prior to discharge to any surface waters (ARM 17.30.715 (e)). There are also mixing zone requirements for nitrate to provide protection of surface waters. Furthermore, Lake County requires licensing of septic contractors and can revoke a license where new systems or upgrades do not meet certain requirements consistent with the nondegradation rules. These requirements include, but are not limited to, locating a system at least 100 feet away from surface water and meeting certain types of soil percolation conditions relative to the system design. It is important to note that there may be many old systems around Swan Lake that are not covered by the nondegradation requirements until upgraded, and thus there could be significant nutrient loading to Swan Lake from many of these older systems.

5.12 Evaluation of Floodplain Management and Private Land Development

Development of private land can have impacts on water quality in several ways:

- Increase in sediment load from new roads and new stream crossings.
- Clearing of riparian or near-stream vegetation reduces bank stability due to the loss of high quality rooting mass to hold banks together.
- Cattle or other grazing animals can trample banks, contributing to bank instability.
- Clearing of riparian vegetation degrades aquatic and terrestrial habitat, including a loss of shade leading to higher temperatures, a reduction in undercut bank habitat, and a reduction in large woody debris recruitment which will have significant impacts on aquatic life habitat and overall stream stability.
- Dwellings, structures and roads can encroach upon a stream or can interfere with floodplain function leading to increased bank erosion, downcutting and other stream stability problems often due to the bank hardening efforts undertaken to protect property.
- Septic tanks increase nutrient inputs to tributaries and Swan Lake.

The above concerns are addressed under the various assessment sections of this section (Section 5.0). For example, private roads were inventoried as part of the road sediment assessment (Section 5.2). The current sediment load from private roads generally associated with home development totals 231 tons per year as estimated by the road sediment assessment. Septic tank impacts are discussed in Section 5.11, and potential impacts associated with riparian clearing and floodplain encroachment along the Swan River and several tributaries are discussed in Section 5.3 above and Section 5.13 below.

Additional analyses (Assessment Activity (17) in Table 5-1) to help evaluate the potential for future water quality impacts from private land development include a review of land ownership along the Swan River and a review of applicable floodplain and streambank protection regulations and requirements currently in place.

Results of the land ownership analysis (Table 5-5) indicate that nearly 39.6% of the land within 200 feet of the banks of the Swan River is owned by non-industrial private entities/individuals. This indicates a major potential future source of water quality impacts if the development of private homes and other structures is not managed properly.

Table 5-5. Ownership Within a 200-foot Corridor Along Swan River.

Owner	Acres Within 200-ft Buffer	Percentage of Total Acres	Missoula County	Lake County
Montana State Trust Lands - DNRC	1,125.1	9.9%	0.0	1,125.1
Plum Creek Timber Company	1,335.6	11.8%	496.0	839.5
The Nature Conservancy	55.0	0.5%	0.0	55.0
U.S. Fish and Wildlife Service	501.6	4.4%	0.0	501.6
U.S. Forest Service	3,815.7	33.7%	2,213.4	1,602.3
Undifferentiated Private lands	4,484.1	39.6%	1,963.6	2,520.6
TOTAL	**11,317.0**		**4,673.0**	**6,644.0**

To evaluate the overall potential for impacts from private development, both Missoula and Lake County Planning Offices were surveyed for regulations that are in place for the protection of water quality. Specifically, the focus was on regulations that are intended to protect riparian areas and ultimately protect water quality.

Section 5.02(D)10, of the Missoula County floodplain regulations is a listing of prohibited uses within jurisdictional floodplains. It includes the following reference to prohibited activity: *"Within 50 feet from the ordinary high water mark of a watercourse, large-scale clearing of native vegetation that could result in streambank erosion."* This restriction should effectively prevent any such activity since it is likely that any large scale clearing could result in streambank erosion. Article 3, Section 3-13 of the Missoula County Subdivision Design Standards includes the rules specifically targeted to riparian areas. These are provided in Appendix H (Section H-1).

Lake County also has floodplain regulations that to some extent address potential floodplain development impacts as well as requiring buffer strips along waterways. Appendix H (Section H-2) includes pertinent sections from the Lake County floodplain regulations.

Plum Creek Timber Company plans to sell several thousand acres of their land in the Swan Lake Watershed. This will significantly increase the percentage of Undifferentiated Private Lands within 200 feet of a stream (Table 5-5). As part of the development of the Native Fish Habitat Conservation Plan (NFHCP) with the U.S. Fish and Wildlife Service (USFWS), Plum Creek now places restrictive deed covenants on each of the properties that it sells in the Swan Lake Watershed that are within a Tier 1 watersheds. A Tier 1 watershed is one that supports spawning and rearing of native fish as defined by USFWS. Not all streams in the Swan Lake Watershed are included in the Tier 1 category, but many of the major tributaries as well as the Swan River are covered. Pertinent covenants to water quality are included within Appendix H (Section H-3). The covenants are a deed restriction on the land and can be enforced by Plum Creek filing an action in court. They are also monitored by the USFWS as part of the NFHCP to help ensure that violations are corrected.

Overall, the covenants, where applicable, provide a layer of additional water quality protection on top of the county regulations. Note that the covenants define a Restricted Zone that is between 50 to 100 feet from the channel migration zone (CMZ). The use of a CMZ versus a normal high water mark recognizes the natural variability of channel migration in some stream segments such as the Swan River migrations noted in the air photo assessment done by Grant (1989). In many stream segments within the Swan Lake Watershed, large woody debris can redirect all or a portion of a channel thus creating a fairly active CMZ over time. Note that in Appendix H (Section H-3) no buildings are allowed within the Restricted Zone per Section 2.a. of the covenants and that all new roads shall be in compliance with forestry road BMPs per Section 2.b. These BMPs would help minimize road crossing sediment inputs, such as those evaluated in Section 5.2 above. Also note that no timber harvest is allowed in the Restricted Zone per Section 2.e., allowing for a high level of riparian protection. Section 2.e. can also be used to help limit grazing impacts to riparian communities and should, at a minimum, be interpreted to require grazing BMPs as practical methods for protecting the riparian area within the Restricted Zone.

A significant law for protecting water quality applicable to all land ownership is the Natural Streambed and Land Preservation Act (75-7-101 through 75-7-124, MCA; and ARM 36.2.401 through 36.2.410). This act is also referred to as the “310 Law”. The 310 Law states “(I)t is the policy of the State of Montana that its natural rives and streams and the lands and property immediately adjacent to them within the state are to be protected and preserved to be available in their natural or existing state and to prohibit unauthorized projects and in so doing to keep soil erosion and sedimentation to a minimum, except as may be necessary and appropriate after due consideration of all factors involved. Further, it is the policy of this state to recognize the needs of irrigation and agricultural use of the rivers and streams of the State of Montana and to protect the use of water for any useful or beneficial purpose as guaranteed by the Constitution of the State of Montana.” The law requires review of any proposed projects that may result in a physical alteration or modification of a perennial-flowing stream. Any person proposing such a project must pursue this review by notifying the appropriate conservation district, which would either be the Lake County or Missoula County Conservation District within the Swan Lake Watershed. Representatives from both the conservation district as well as the Montana Department of Fish, Wildlife and Parks perform the review. Review team members can recommend denial, approval or modification of a project to ensure consistency with 310 Law and protection of water quality. Work on a project may not take place without written consent from the conservation district, although there are exceptions for emergencies and stream exclusions.

Additional protection is also provided by storm water permitting requirements through the DEQ. Construction activity, such as land development, that results in disturbance of equal to or greater than 1 acre of total land area requires a permit to ensure compliance with the NPDES regulation for storm water. The permit would typically fall under a general permit category that would require standard BMPs to reduce or eliminate pollutant discharges to surface waters.

5.13 Aerial Assessment and Analyses of Impacts to Streambank and Riparian Health from Private Development and Timber Production

The clearing of riparian vegetation due to private land development can take on several forms which include, but are not limited to, the building of structures near the stream, removal of trees and other vegetation for landscaping purposes, reduction in riparian cover due to grazing of horses, cattle or other livestock, and the clearing of vegetation for road and bridge access. Impacts from timber harvest are often associated with riparian clearing for roads and bridges and removal of trees for commercial purposes (riparian harvest).

Streambank and riparian conditions were evaluated along the lower portion of the Swan River (Piper Creek to Swan Lake) as described in Section 5.3 (Assessment Activity (7) in Table 5-1). The estimated total length of eroding streambanks resulting from private land development in the reach from Piper Creek to Swan Lake is 950 feet (0.4% of reach length).

Additional aerial assessment analyses were done for streambank and riparian conditions along the Swan River, the four tributaries listed as impaired in the 2002 303(d) list, and Squeezer Creek using 1997 color aerial photos. This work is identified as Assessment Activity (18) in Table 5-1. Appendix I presents the methodology and results from this aerial assessment. Table A1 in Appendix I provides summary information regarding the condition of the riparian vegetation along both the right and left banks for all streams assessed. Overall, the assessment addressed a total of 152 stream segments along the Swan River, from Swan Lake upstream to Lindbergh Lake, for a combined total of 304 left and right bank segments.

For the lower sections of the Swan River up to Piper Creek (Reach Numbers Swn 1 through Swn 57), a total of 15 of the 114 riparian/bank areas (either left or right bank or both) have indications of reduced or absent vegetation and/or erosion or channel widening potentially from human activities (as indicated by a “BR” or “RR” in the left bank or right bank condition columns in Table A1 of Appendix I). This amounts to a total of 13% of the riparian or near-bank areas showing potentially anthropogenic impact. It appears that this 13% impact potential is leading to only a minor increase in obvious eroding bank impacts based on the Swan River bank erosion analyses discussed above and within Section 5.3. These areas with potential human impacts may not result in obvious eroding banks but still have the potential to cause an overall reduction in canopy cover, buffer width, and reduction in large trees which can equate to other impacts such as a reduction in woody debris recruitment and a decrease in stream shading.

Overall, a total of 62 (20%) of the 304 right or left banks along the Swan River had indicators of negative human impacts. Some of the middle sections of the Swan River where there are large areas of private land development (Reach Numbers 64 through 76, for example) had well over 50% of the banks showing potential human impacts, indicating a probable increase in eroding banks in comparison to other reaches with less private land development such as the segment of river assessed for bank erosion (Section 5.3). The results for Goat, Piper, Jim, and Elk Creeks show similar results regarding the above-discussed indicators of stream health, with Jim Creek having the highest number of banks with potential human impacts.

Other indicators of stream health include measures of the canopy density and the riparian buffer associated with tree cover, with values included in Table A1 of Appendix I. These measures are focused on identifying an overall presence or absence of larger trees as an indicator of potential human impacts associated with a loss of stream stability, loss of shade, or a loss of woody debris recruitment. It is important to recognize that areas of low canopy density can still have healthy riparian communities comprised of shorter plants such as willows or alders. These would not contribute to the canopy density measures but would contribute to overall bank stability and positive riparian buffer conditions.

Overall, the average canopy density for all six assessed streams is about 50% and the average buffer width is 210 feet, although there is significant canopy density variability between streams and among different reaches of the same stream. Figure 5-6 presents the average canopy density values for all 6 streams evaluated. Note that the Swan River has the lowest average canopy density of about 30%. Figure 5-7 presents the percent canopy density at discrete measures ranging from 0 to 80% in increments of 10% as well as the cumulative percent curves for assessed reaches of the Swan River. Overall, about 27% of the total bank length evaluated along the Swan River was determined to have a canopy density of 0%, and about 45% was determined to have a canopy density of 20% or less. The majority of the river where the canopy density was 0% along both banks was in the lower segment below Piper Creek and above Swan Lake, with much of the 0% length being just upstream of Swan Lake where a large natural wetland area exists. Based on the Swan River Bank Stability Field Assessment (Section 5.3), it would appear that most of this lower reach is in stable condition. It is unknown to what extent riparian clearing, either from logging and/or private development may have reduced larger trees and thus contributed to a lower canopy density numbers since field assessment work did not focus on this condition as was done for the tributary work discussed in Section 5.14 below. In general, it appears that a much larger percentage of the Swan River banks have naturally low canopy densities in comparison to the tributaries that were given similar aerial evaluations, and direct comparisons between these tributaries and Swan River are not recommended at this time.

Figures 5-8 through 5-11 present the discrete percent canopy density results and cumulative percent curves for Goat, Piper, Elk, Squeezer and Jim Creeks. Note that for all of these tributaries except Jim Creek, the discrete canopy density measures and resulting cumulative percent canopy density curves are similar, resulting in average canopy densities ranging from 0.5 (50%) to 0.6 (60%) as shown by Figure 5-6. On the other hand, the resulting information for Jim Creek (Figure 5-11) shows a different distribution resulting in an overall average canopy density of 0.4 (40%) as shown by Figure 5-6. The cumulative percentage of canopy density less than 20% for Jim Creek is 48% in comparison to the 11% cumulative percentage of canopy density less than 20% for Goat Creek. Other streams had the following values: Elk Creek – 21%; Squeezer Creek – 15%; Piper Creek – 6%; Jim Creek also has a higher cumulative percentage of canopy density less than 50% in comparison to any of the other streams (64% for Jim Creek vs. 54% for Elk Cr., 43% for Goat Cr., 38% for Squeezer Cr., and 44% for Piper Cr.). Many of these lower values in Jim Creek are due to riparian harvest conditions in portions of the upper drainage, as further discussed in Section 5.14 below.

Figure 5-6. Average Canopy Density.

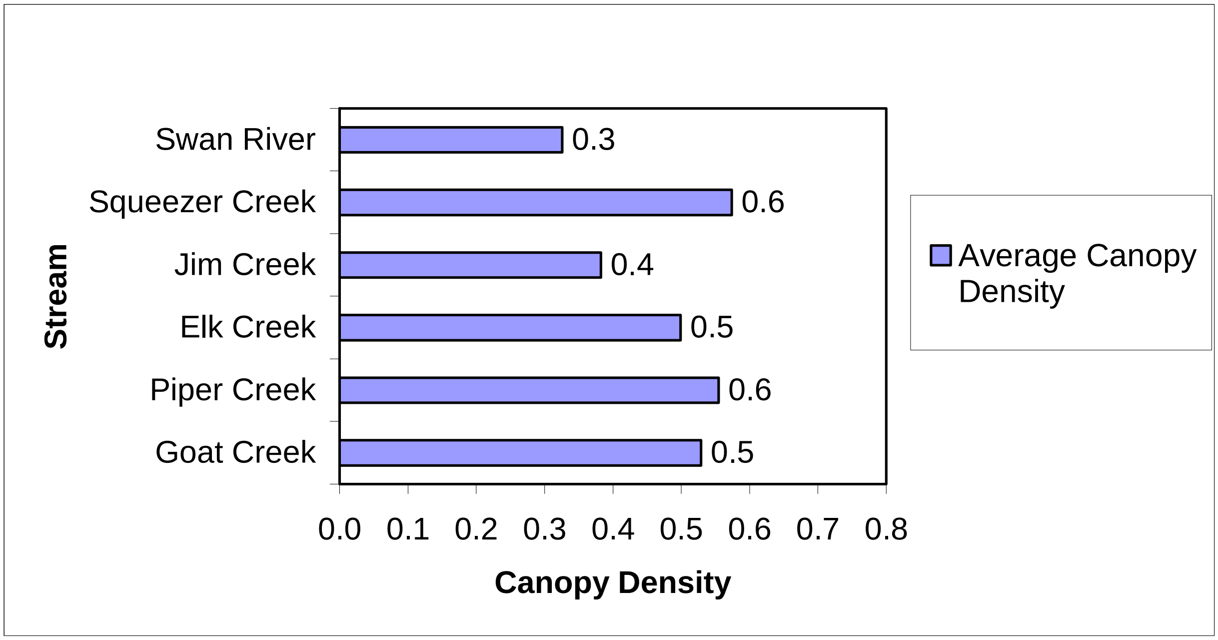


Figure 5-7. Swan River Aerial Canopy Density.

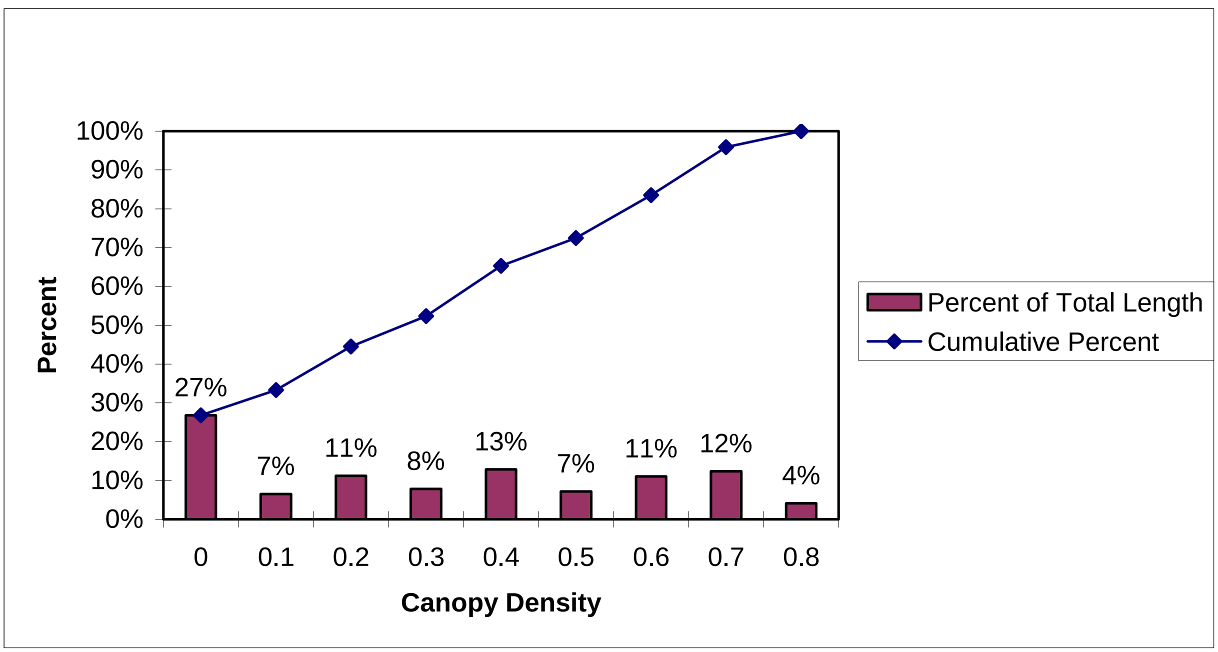


Figure 5-8. Goat Creek Aerial Canopy Density.

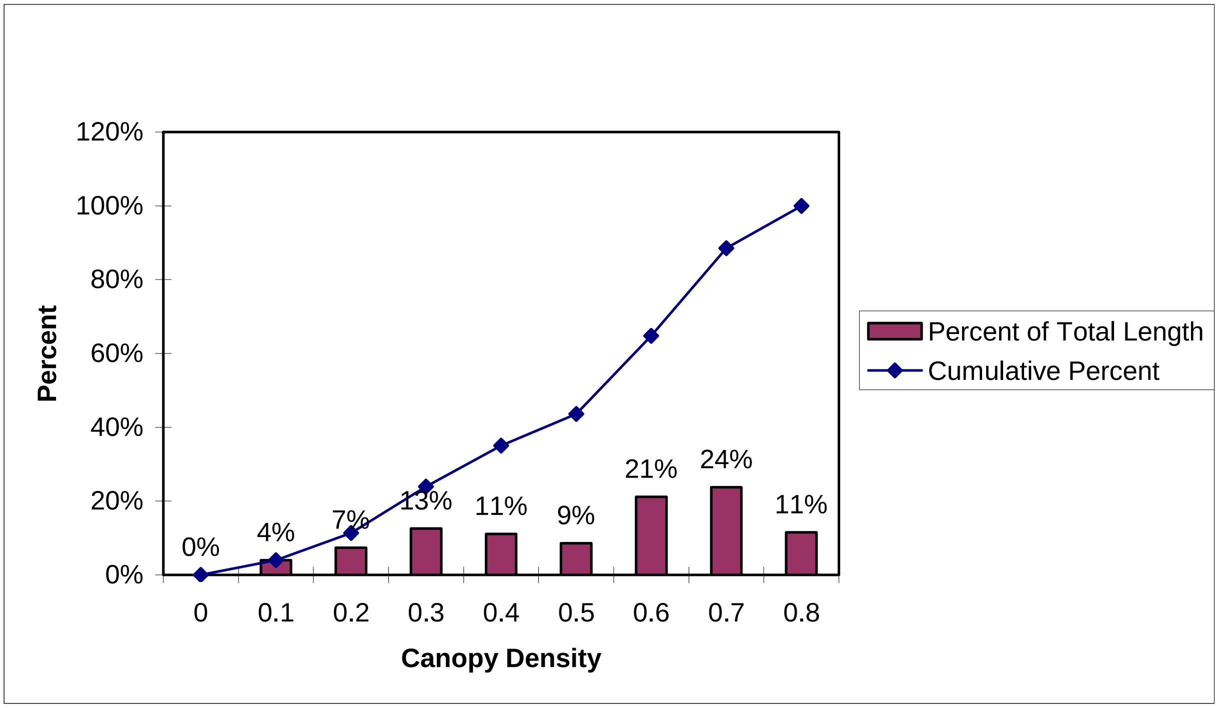


Figure 5-9. Piper Creek Aerial Canopy Density.

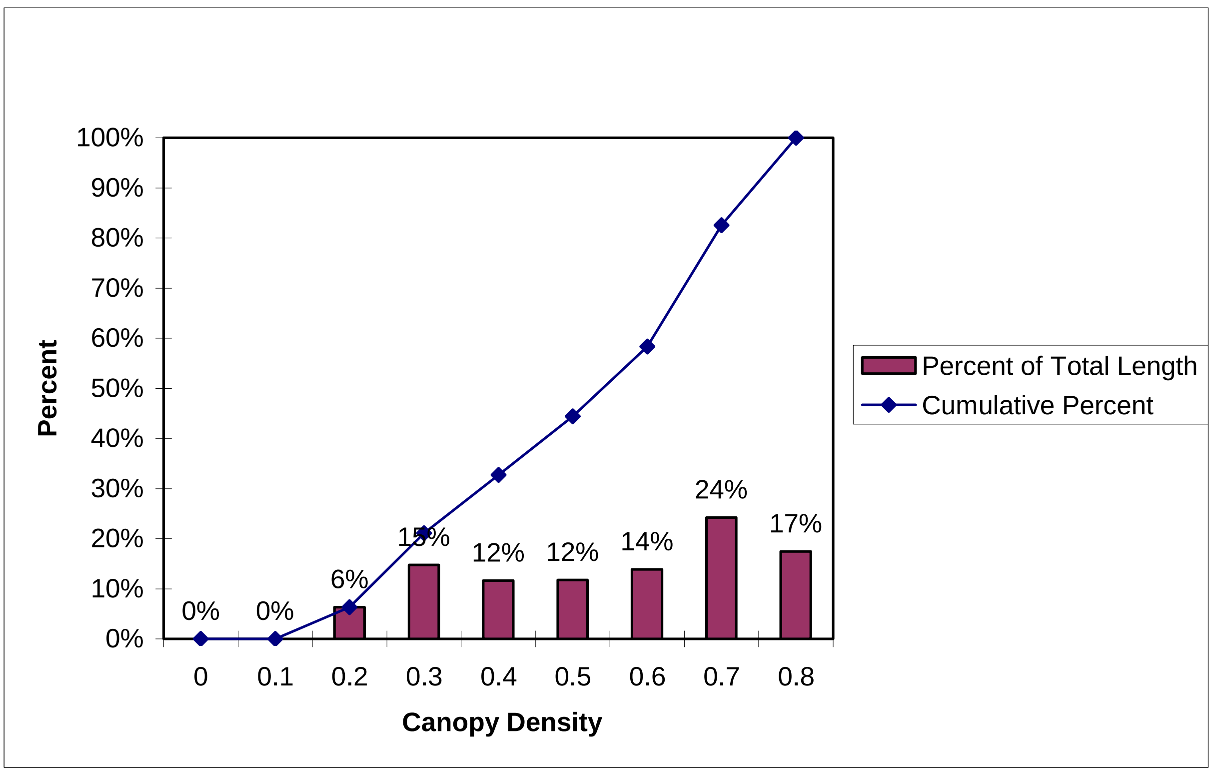


Figure 5-10. Elk Creek Aerial Canopy Density.

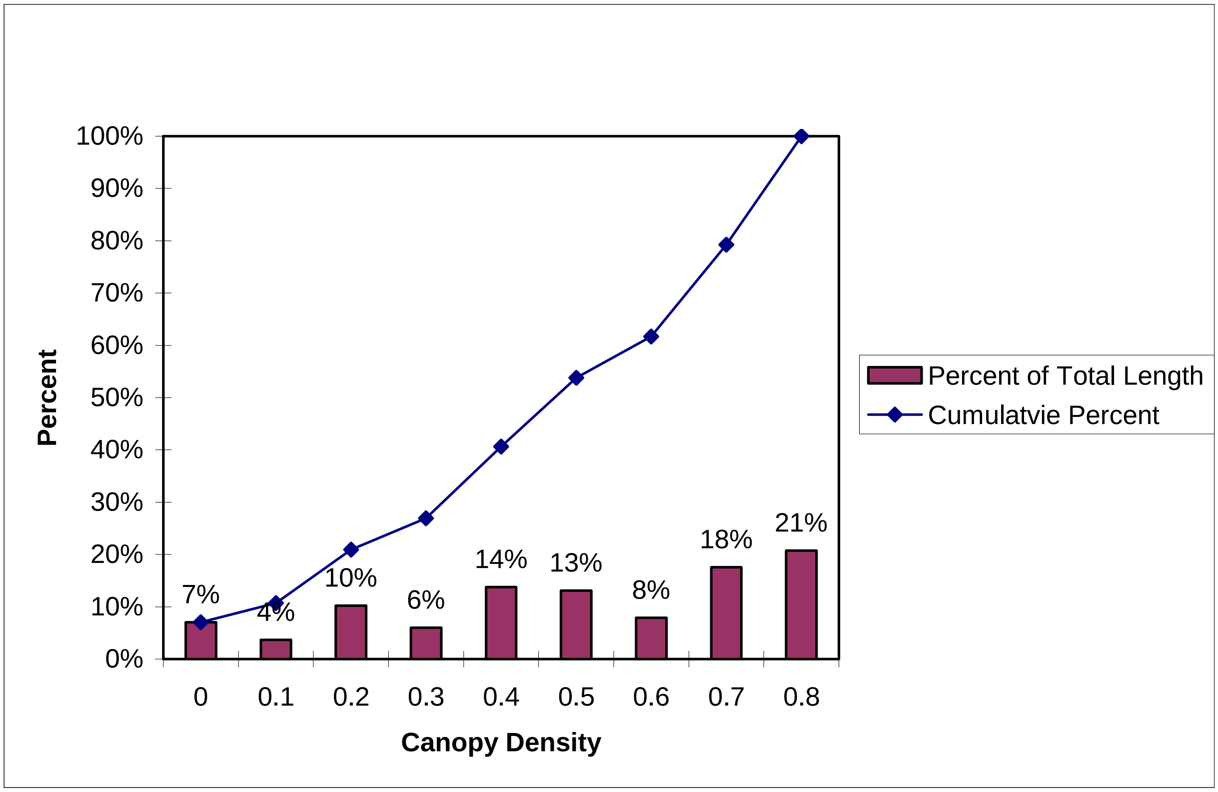
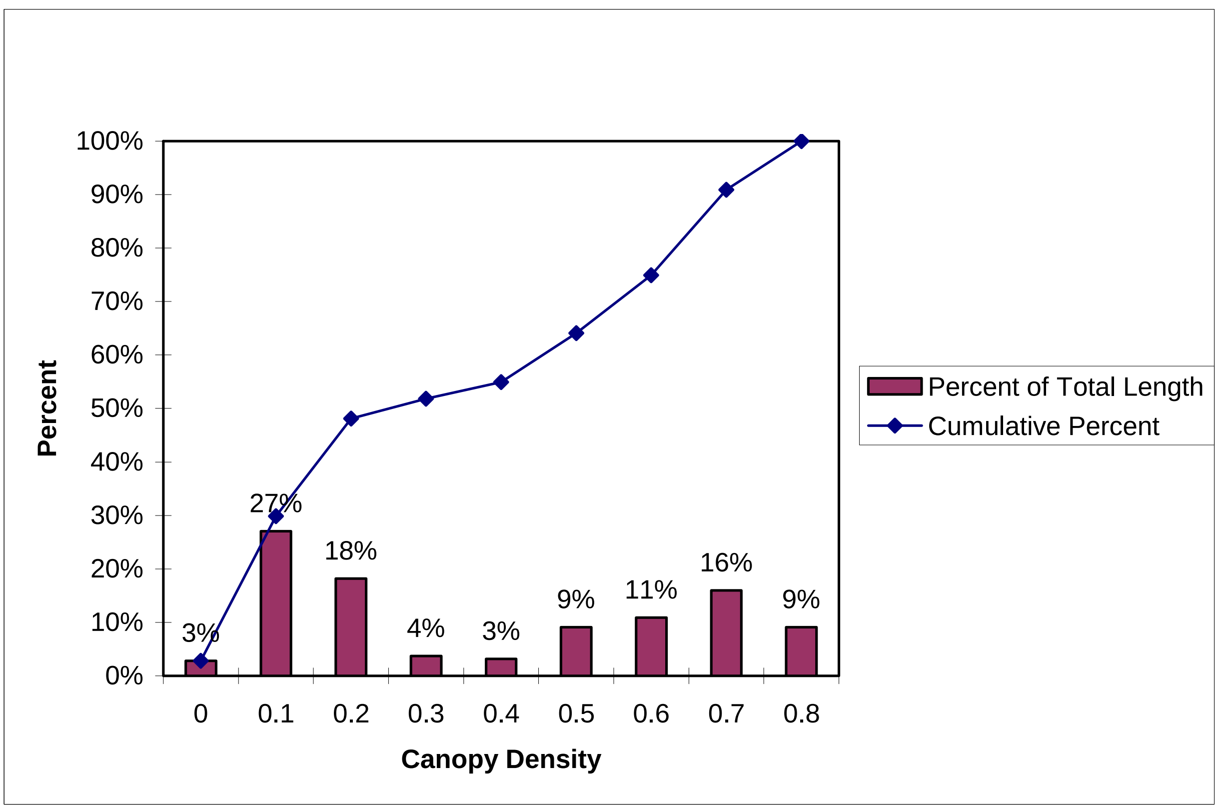


Figure 5-11. Jim Creek Aerial Canopy Density.



Appendix I identifies an additional purpose of the aerial assessment effort, which was to help determine locations for physical stream assessment work in the four tributaries remaining on the 2002 303(d) list of impaired waterbodies (Jim, Goat, Elk, and Piper Creeks). The physical assessment methodology and results, along with additional reference to the aerial assessment results, are discussed below in Section 5.14 and in Appendix J.

5.14 Tributary Physical Assessments for TMDL Development Support

5.14.1 Assessment Methodology and Goals

Physical assessments on the 2002 303(d)-listed tributaries (Goat, Piper, Elk and Jim Creeks) were conducted during late summer of 2002 (after publication of the 2002 303(d) list) with some minor follow-up field reconnaissance work in 2003. This work is identified as Assessment Activity (19) in Table 5-1. The assessment methodology, many of the assessment results, and a detailed discussion of these results for each stream are presented in Appendix J. A goal of the assessment methodology was to assess enough representative reaches so that the information could be viewed as a fair representation of overall stream conditions. The reaches were defined by the aerial assessment work and selections were made based on areas that appeared to have either relatively high or low apparent impacts from human activities.

The assessment work focused on evaluating human impacts to the stream channel and to the riparian and near bank areas. Other information collected in the assessments included eroding banks and probable causes, overall riparian health, total number and length of pools, pool depth, pool cover, amount of large woody debris (LWD), width to depth, and level of stream entrenchment. Section 5.14.2 (below) summarizes some of the key findings; most of which are discussed in Appendix J, and Section 5.14.3 (below) provides additional data comparisons among the assessed streams.

5.14.2 Discussion of Assessment Results

5.14.2.1 Summary of Key Findings From Appendix J Discussion

In all situations, the field visual riparian estimates (Reference the Visual Riparian Estimates Form at the end of Appendix J) associated with tree density closely matched the aerial assessment results for canopy cover. Where tree densities were moderate or sparse, the larger woody shrub and sapling and/or the smaller woody shrub and seedling estimated values tended to be higher such that there was almost always good bank protection in each of the four tributaries. There were some noted inconsistencies with human impact indicators since the aerial assessment work was not always able to identify whether some areas of lower canopy density were due to natural conditions versus historical riparian harvest. These inconsistencies are noted in Appendix J.

As further discussed in Appendix J, the assessment work found an extremely low number and low percentage of eroding banks due to the stabilizing nature of riparian growth even in areas that had received significant historical riparian harvest. This good bank protection and overall stream stability would also be expected to reduce the potential for impacts from increased peak flows associated with harvest activities as discussed above in Section 5.5.3.

Also, most reaches assessed did not have obvious indicators of significant problems associated with pool formation, pool cover (typically associated with LWD), stream stability, and riparian health (from a bank stability and sediment filtering perspective). Large trees were lacking in many areas where riparian harvest had occurred, resulting in a reduction in LWD recruitment potential that may persist over several decades in some reaches.

5.14.2.2 Data Comparisons Between Assessed Tributary Streams

Table 5-6 presents summarized human influence results based on field evaluations, and several other parameters of interest for all assessed reaches. Three categories of impact were noted: "None", "Rip Impacts (Lim.)" for limited riparian harvest and or other impacts typically from private home development, and "Rip Impacts (Sign.)" for more significant riparian impacts associated with riparian timber harvest in all situations. Review of the large woody debris numbers, both single pieces and aggregates per 1000 ft., shows a wide range of variability among all reaches. The one exception or outlier is Jim Creek Reach 24 ("Jim-24"), which has the lowest large woody debris numbers. The Appendix J data on LWD show that all higher elevation "B" or "B/C" type streams reaches (Goat 16, Piper 14 and Piper 10) have individual LWD and/or aggregate totals in excess of 50, with median and average values above 80. The current level of 13 pieces and 0 aggregates per 1000 feet in the upper part of Jim Creek is well below both of these values from other potential reference streams in the Swan Lake watershed. The low LWD is also reflected in the percent of pools with cover associated with LWD, where Jim-24 has only 19% compared to greater than 50% in all other reaches (Table 5-6), with no other apparent trends between impacted and non-impacted reaches in these other reaches. Overall, there do not appear to be any obvious trends between impacted and non-impacted reaches for pool length or number of pools every 1000 feet.

Table 5-6 also summarizes total scores for near bank (out to about 30 feet) and total bank riparian conditions (out to about 100 feet or more depending on floodplain dimensions), using normalized values for desirable riparian indicators. These desirable indicators include trees with trunks greater than 1 foot diameter, trees with trunks less than 1 foot diameter, and measures of woody shrubs, saplings and seedlings. A higher number represents a greater extent of all four categories of desirable riparian vegetation. The average "Total Near Bank Score" for areas with no riparian impact is 4.5, whereas the average scores for areas with limited and significant riparian impacts are 3.5 and 3.4 respectively. The average "Total Bank Influence Area Score" for areas with no riparian impact (as verified in the field) is 4.1, whereas the average scores for areas with limited and significant riparian impacts are 3.5 and 3.3 respectively. In most situations, this is due to a lower percentage of larger diameter trees, which fortunately from a bank stabilization and sediment filtering perspective are typically compensated for by woody shrubs and smaller trees.

Table 5-7 is a summary of multiple habitat parameters for all four streams. There appear to only be a few potential outliers when stratified by Rosgen stream type, including the low LWD value and low % pools with cover for Jim-24 as discussed above. Table J-12 in Appendix J had previously identified the low number of pools greater than 3 feet in bankfull depth as a concern for Jim-24, but when evaluated from the perspective of the number of pools greater than 2 ½ feet deep in narrower streams (less than 25 feet wide), this parameter no longer appears to be an indicator of a stream health problem. Elk-3 has the highest width to depth ratio, but this value and all other width to depth values are within an anticipated range for a C or B type stream within the Swan Lake Watershed based on a discussion with a Forest Service representative (personal discussion with Beth Gardner, June 2003) and based on additional results for upper sections of Elk Creek where the Forest Service has performed detailed analyses referred to as an R1/R4 Fish Habitat Inventory (Assessment Activity (20) in Table 5-1).

The large woody debris values (except Jim-24) and pool numbers for the C and B type reaches are also within anticipated ranges of variability based on the Elk-13 results and the results from the Forest Service R1/R4 survey. Although Reaches Goat-3, Goat-9, and Piper-5 pool related values might appear to be toward the lower end of expected values based on Table 5-7 results, the results may also be indicative of more of a B versus C or A stream type over some of the sections evaluated. The Forest Service Elk Creek R1/R4 (unpublished data) results show % pool values ranging from 23 to 55% (the equivalent of 230 to 550 feet of pools per 1000 feet) for a C type stream, whereas the % pool values range from 3 to 15% for a B type stream. Rosgen types can be difficult to identify on a small-reach scale without obtaining stream slope and more accurate entrenchment ratio values. It is probable that many of the reaches visited as part of the 2002 physical assessment effort consisted of one or more stream types and the particular assessed 800 to 1000 foot section may have had a different stream type than the average for the overall reach as defined in the aerial assessment report in Appendix I and presented in Tables 5-6 and 5-7. A more detailed stream assessment methodology than what was done for the purpose of this field assessment effort would be necessary to determine stream classifications with a higher degree of certainty.

Overall, the field assessment results do not indicate significant habitat related problems with the probable exception of some localized and potentially long term reductions in desirable habitat associated with the loss of woody debris from historic riparian harvest and, to a lesser extent, private home development and roads. Whereas trees will typically grow back in areas of riparian harvest, private home development and permanent roads tend to create permanent reductions in woody debris recruitment. Riparian harvest can also contribute to temperature impairment problems due to a loss of shade. Because temperature has not been considered a beneficial use support problem in these four tributaries, the potential impacts of riparian removals on increased temperatures were not further evaluated.

Table 5-6. Summary of Riparian Health and Pool Cover.

Rosgen Classification*	Stream Order	ID	Near Bank Big Trees (trunks >1' diameter)	Near Bank Small Trees (trunks < 1' diameter)	Near Bank Large (0.5 - 5 m) Woody Shrubs and Saplings	Near Bank Small (< 0.5 m) Woody Shrubs and Seedlings	Total Bank/ Floodplain Big Trees (trunks >1' diameter)	Total Bank/ Floodplain Small Trees (trunks < 1' diameter)	Total Bank/ Floodplain Large (0.5 - 5 m) Woody Shrubs and Saplings	Total Bank/ Floodplain Small (< 0.5 m) Woody Shrubs and Seedlings	% Pools with Cover
A/B											
	3	Jim-24	1	1.6	2.5	1.8	1	1.3	2.3	1.5	19
B											
	3	Goat-16	2	2.3	2	1.9	1.5	2.3	2.4	2	74
	3	Jim-5U	1.5	1.6	2	1.6	1.8	1.6	2	1.5	NC
	3	Piper-3	1.9	2.4	1.8	1.8	2.4	2.1	1.6	1.8	NC
	3	Piper-6	2.9	1.9	1.5	1.5	2.8	1.8	1.4	1.9	62
B/C											
	2	Piper-14	3.8	2.8	1.8	1	3.8	2.8	1.8	1	68
	3	Goat-10	1.6	1.8	2.5	2	1.5	1.8	2.5	2	NC
	3	Piper-10	2.3	1.9	1.8	1.8	1.9	1.6	1.9	2	56
	3	Piper-2	1.4	1.5	2.1	1.1	1.4	1.6	2	1	80
C											
	3	Goat-7	1.1	1.6	2.1	1.9	1.4	2.3	2.3	1.8	100
	3	Goat-9	1.8	2	2.8	1	1.8	2	3	1	83
	3	Jim-5L	1.5	1.8	2.3	3	2	1.8	2	3	67
	4	Elk-13	1	3	3	2	1	3	2	2	64
	4	Elk-2	1	1.6	2.4	2	1	1.9	2.4	2	NC
	4	Elk-3	1	1.6	2.6	2	1	1.9	2.1	2	89
	4	Elk-6	1.9	2.4	2.3	2.3	2	2.4	2.1	2.1	59
	4	Goat-2	2	1.5	2	1.8	2	1.6	1.8	2	NC
C/B											
	4	Goat-3	1.5	1.6	2.5	2.1	1.9	1.8	2.3	2.1	67
C/E											
	3	Piper-5	1.8	1.8	2.6	1	2	1.5	2.1	1	55
E/C											
	3	Jim-11	2	2.5	2	2	2	2.5	2	2	83

* Classification is based on w/d ratio, entrenchment ratio, aerial assessment, and field observations
NC - Not Counted
Key: 1 = < 10% coverage (sparse); 2 = 10 - 40% coverage (moderate); 3 = 40 - 75% coverage (heavy); 4 = > 75% coverage (very heavy)

Table 5-7. Stream Habitat Parameters.

Rosgen Classification *	Stream Order	ID	Average Bankfull Width (Feet)	Width/Depth Ratio	Entrenchment Ratio	Pool length/1000 Ft	# Pools/1000 Ft	% Pools > 2.5' deep in streams < 25' wide	%Pools > 3'	% Pools > 3.5' deep in streams > 25' wide
A/B										
	3	Jim-24	18	8	1.2	230	20	81	0	N/A
B										
	3	Goat-16	23	14	1.5	254	19	95	74	N/A
	3	Jim-5U	NC	NC	NC	NC	NC	NC	NC	NC
	3	Piper-3	NC	NC	NC	NC	NC	NC	NC	NC
	3	Piper-6	24	16	2.1	235	16	92	46	N/A
B/C										
	2	Piper-14	21	16	>2.2	346	28	77	41	N/A
	3	Goat-10	NC	NC	NC	NC	NC	NC	NC	NC
	3	Piper-10	23	12	>2.2	428	23	100	72	N/A
	3	Piper-2	24	16	>2.2	260	15	87	53	N/A
C										
	3	Goat-7	19	12	>2.2	276	18	86	71	N/A
	3	Goat-9	19	12	>2.2	208	15	92	50	N/A
	3	Jim-5L	30	12	>2.2	390	19	N/A	100	80
	4	Elk-13	35	15	>2.2	370	14	N/A	79	71
	4	Elk-2	NC	NC	NC	NC	NC	NC	NC	NC
	4	Elk-3	45	22	>2.2	528	11	N/A	100	78
	4	Elk-6	38	17	>2.2	418	17	N/A	65	35
	4	Goat-2	NC	NC	NC	NC	NC	NC	NC	NC
C/B										
	4	Goat-3	36	18	>2.2	159	9	N/A	56	44
C/E										
	3	Piper-5	20	8	>2.2	157	11	82	64	N/A
E/C										
	3	Jim-11	24	9	>2.2	420	30	100	88	N/A

* Classification is based on w/d ratio, entrenchment ratio, aerial assessment, and field observations

NC - Not Counted

5.14.3 Comparison of 2002 Physical Assessment Results to Other Assessment Efforts

The results from the 2002 tributary physical assessment work, particularly the measures associated with total pool length, are consistent with the Forest Service's R1/R4 Fish Habitat Inventory results for Elk Creek. In addition, Watson et al. (1998) evaluated riparian function in Goat and Piper Creeks (Assessment Activity (5) in Table 5-1). The riparian function assessment evaluated the condition of riparian areas relative to their ability to supply LWD to stream channels and to provide shade to maintain desirable stream temperatures. Criteria were based on an assessment methodology used in the state of Washington. Watson et al. (1998) concluded that most segments within the Goat and Piper Creek watersheds met or exceeded the LWD and stream shading criteria with a few exceptions associated with riparian harvest prior to the 1991 SMZ law. This seems to indicate fewer potential LWD related impacts from riparian harvest than indicated in the 2002 physical assessment work discussed above, but it must be remembered that the reach sizes and breaks for the 2002 assessment work are different than those used by Watson et al. (1998), with reach breaks for the 2002 assessment work often defined by areas of apparent impact (e. g. riparian harvest).

The following excerpt from Watson et al. (1998) concerning the SMZ law and adequacy in providing LWD and shade is of significance: "The requirements of the SMZ law were determined to be effective in providing LWD and shade to moderately confined and confined channels, but the potential for deficiencies exist in stream segments exhibiting unconfined channels. This can occur where the channel migration zone (CMZ) are wider than the SMZ leave strip. In these situations the stream can potentially migrate outside of the buffer......." This CMZ versus SMZ protection concept has been subsequently adapted into the Plum Creek covenants discussed above in Section 5.12 and presented in Appendix H.

5.15 McNeil Core Fine Sediment Data (Assessment Activity (21))

The Montana Department of Fish Wildlife and Parks (FWP) has provided McNeil core fine sediment data for three of the four 2002 303(d)-listed streams in the Swan Lake Watershed (no recent data have been collected on Piper Creek). Similar data are also available for several other streams in the watershed. The procedure involved taking 12 samples near bull trout spawning sites in each stream and reporting the average. Sampling occurs during the winter shortly before fry emergence. The data up through 2001 (based on spawning year 2001, with collection occurring during February 2002) are presented in Figure 5-12 for the three 2002 303(d) listed streams (Goat, Jim, and Elk) in addition to data for Squeezer and Lion Creek. The percent fines results in this plot represent the percentage of material less than 6.35 mm, a value commonly used as a measure of potential impact to fry emergence (Weaver and Fraley, 1991). Figure 5-13 provides results for all sites in Figure 5-12 plus sample results for Soup, South Lost, Woodward and South Woodward Creeks. Locations of the data collection sites are shown in Map 5-1.

The following is a summary of the results for many of the streams:

- Goat Creek: Percent fines are at or slightly below 30% starting in the late 1980's. Values then vary between 28 and 37% over the next few years until they go below 30% in 1993 and remain in the 27 to 29% range all through 2001.
- Jim Creek: Percent fines start out above 40% in 1988, increase to 50% and then decrease to below 40% in 1991. Since 1995 the values have ranged between 38 to 40%.
- Elk Creek: The sample location for Elk Creek corresponds to Reach Elk-13, above which there is very little human activity and thus the trend can be used as an indicator of natural variability. Values start out averaging around 35% in the late 1980's, increase to 40% in 1990, and then vary between 35 to 40% for the next several years. In 1995, the percent fines value is 27%, and has since varied between 31 and 35% with a 2001 value of 32%.
- Lion Creek: The Lion Creek values may represent a near reference condition based on sampling location and limited upstream land management activities. Values start out in the upper 30's in the late 1980's, and increase to 43% in 1990 and remain between 40 and 42% through 1994. Since 1994, the values have remained consistently between 37 and 39%. The Lion Creek results follow a similar temporal trend as those for Goat Creek, but with less variability in the mid 1990's. Note how consistent the Lion Creek results are to the Jim Creek results over the past several years.
- Squeezer (old) site follows a similar trend as Elk Creek, with values starting in the high 30's and increasing and remaining in the low 40's through 1996 until the sampling location was no longer used. Squeezer (new) has much lower results and has consistently remained in the mid 20's since data collection started in 1994.
- Woodward and S. Woodward Creeks: Both streams have results that vary quite a bit between the mid 20's and mid 30's over the past several years, perhaps due to harvest activities (note the large road sediment inputs to Woodward Creek identified in Figure 5-2.
- S. Lost and Soup Creeks: Both streams have results that vary from the mid to upper 30's over the past several years, with recent results in the upper 30's and very similar to Jim and Lion Creeks.

Note the low amount of variability within many streams over the past several years (Figure 5-13). Several streams with significant land management activities have the potential of having percent fines values consistently less than 30%. These streams or stream segments include Goat, South Woodward, Squeezer (new), and Woodward. Most other streams seem to have values naturally greater than 30%, with some streams approaching 40%. The Flathead Basin Forest Practices Water Quality and Fisheries Cooperative Program (FBC,1991) identified fine sediment (<6.35 mm) exceeding 35% as a threat to bull trout based on an average of 31.7 percent for streams with little to no potential human impact. That same data indicated average values of 36.4% fines for streams within the Swan Lake Watershed that had lower upstream indicators of human impact based on the 1989 Sequoia index values (Weaver and Fraley, 1991). These streams included Goat, Squeezer (old), Elk, Lion, and Piper for which the 1989 data, except for Piper Creek, is presented in Figures 5-12 and 5-13. Jim Creek had a high Sequoia index and a high percent fines value of 50%, with a significantly lower value of about 40% upstream of a timber sale but still below an area of significant harvest activity. The 50% fines value was linked to mass wasting and other sediment loading from a timber sale discussed in Appendix B. Data from 2001 shows a value of 37% fines for Jim Creek and an average value of about 33% fines for three other sites (Elk, Goat, and Lion) that are still sampled on a yearly basis. Although the percent fines in Jim Creek are still elevated above the other three streams, the deviation between

Jim Creek and these other three streams is not as great as it was in 1989 (50% vs. 35% in 1989; 38% vs. 33 % in 2001). The Jim Creek results are also very similar to the Lion Creek results as noted above.

The overall trend in fines data shown in Figure 5-13 implies that some streams can be expected to have significantly lower percent fines (<6.35 mm) values than the above suggested averages of 31.7, 33, or 36.4%, even under conditions where relatively significant levels of timber harvest may be occurring. These streams include Goat, Squeezer (new), S. Woodward and Woodward Creeks, all of which seem capable of maintaining percent fines levels below 30%. Other streams, such as Lion Creek, may rarely, if ever, obtain values below 35% due to natural background conditions affected by soils and other erosion factors.

Given average percent fines values over the past several years, it is reasonable to expect that McNeil Core results for most streams in the Swan Lake Watershed should not exceed a 30 to 35% target range. Therefore, 35% can be used as an upper limit water quality target based on existing watershed conditions. Where sufficient data are available for a given stream, the target can be at the low end of this range. For example, Goat Creek data indicate a target level of 30% or even lower is more appropriate than 35%. On the other hand, natural conditions in some streams, such as Lion Creek, may make it impossible to expect McNeil Core values below 35%.

There did not appear to be any trends in pebble count data presented in Appendix J except for the noted high D_{50} in Jim Creek apparently due to reduced LWD. Also, there does not appear to be a correlation between the pebble count data when compared to the McNeil Core percent fines data. This is not surprising given the inherent nature of pebble count data when used for making percent fines determinations and a lack of correlation to percent fines results for sediment core results, as documented in literature (Kondolf, 1997). Whereas the pebble count measures surface fines, the McNeil core sampling incorporates subsurface fines.

Figure 5-12. McNeil Core Sample Results for Elk, Goat, Jim, Lion, and Squeezer Creeks.

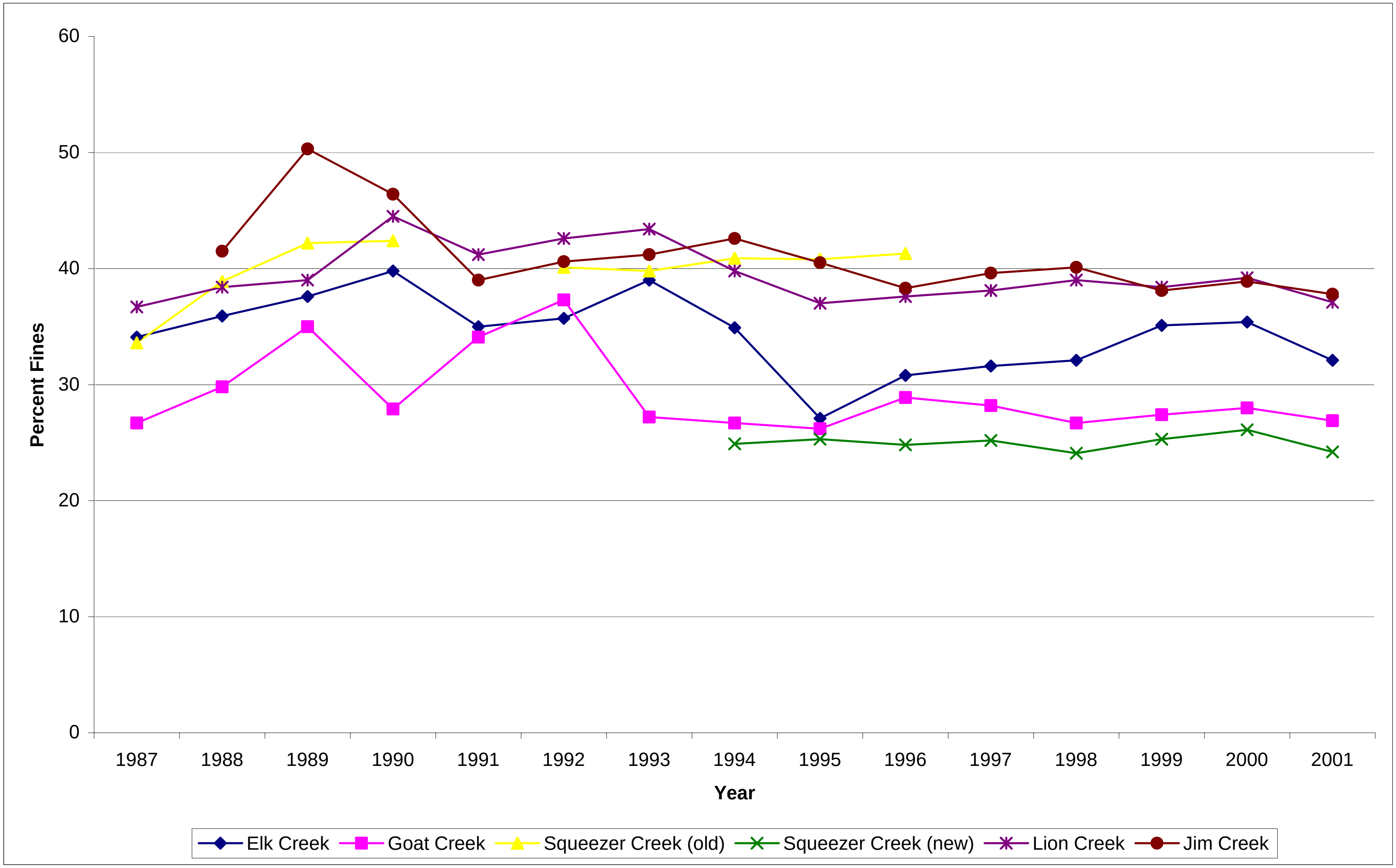
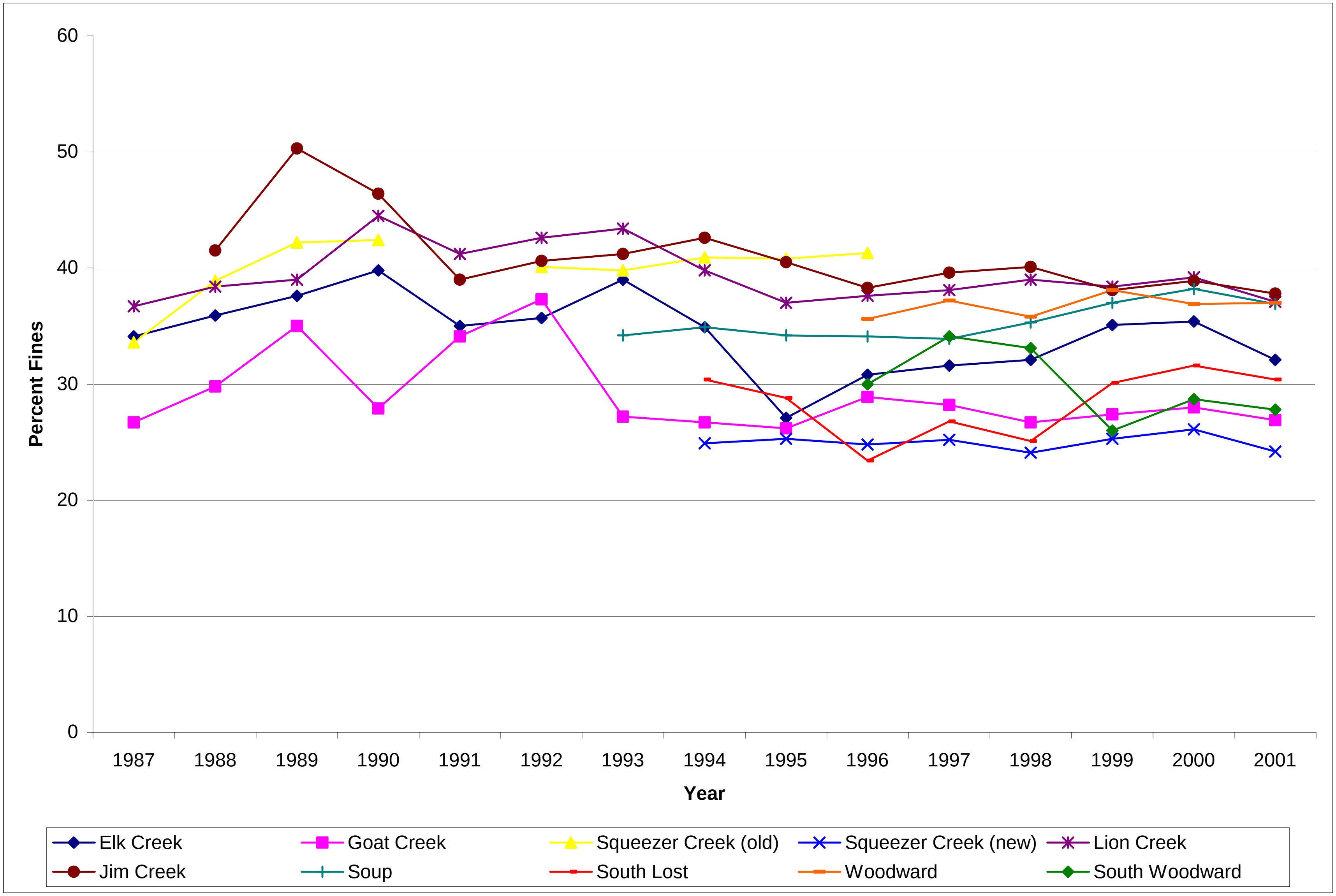


Figure 5-13. McNeil Core Sample Results for Tributaries in Swan Lake Watershed.



5.16 Nutrient and Chlorophyll *a* Sample Results

As mentioned in Section 1.0 and discussed in Appendix B, Goat Creek and Elk Creek were both identified on the 1996 303(d) list as being impaired due to organic enrichment and/or nutrients. Only Goat Creek above Squeezer Creek was subsequently determined to have sufficient credible data to maintain the impairment status beyond 1996 for any of these conditions. Goat Creek was listed due to elevated nitrate + nitrite levels, typically ranging as high as 100 ug/l in the upper segment of Goat Creek. The primary source of this data is Ellis et al (1999a), where sampling done between April 1997 and February 1998 showed values that usually ranged from 50 to 100 ug/l during lower (base) flows and up to about 180 ug/l during higher (runoff) flows. These are higher values for nitrate + nitrite than what might be expected based on EPA's Ambient Water Quality Criteria Recommendations (EPA, 2000) for streams in Nutrient Ecoregion II, with Nutrient Ecoregion II representing a large ecoregion across portions of several states with over 1000 sampled streams for nitrate-nitrite. On the other hand, per Ellis et al. Lion Creek also had high nitrate + nitrite values of up to about 200 ug/l during higher (runoff) flows and relatively high values (ranging from about 20 to 80 ug/l) during lower (base) flows. Nevertheless, the baseflow nitrate + nitrite values for Goat Creek, a watershed with significant timber harvest activities, were shown to be significantly higher in comparison to the baseflow values for an undeveloped portion of Lion Creek (Ellis, et al 1999b).

During the September 2002 physical assessment work, several reaches were sampled for nutrients and chlorophyll *a* (Assessment Activity (22) in Table 5-1) under baseflow conditions. Table 5-8 presents the results from this sampling. The Goat Creek nitrate + nitrite results range from 90 to 130 ug/l, with values of 90 to 100 ug/l for Reaches 7 and 9. These two reaches are closest to the Ellis et al. sampling locations for which the 1997 September nitrate + nitrite results were about 60 ug/l. Nitrate + nitrite results for Piper Creek range from 30 to 40 ug/l and for Elk Creek range from 40 to 50 ug/l. One site on Jim Creek has a value of 70 ug/l. The potential reference stream or least disturbed locations of Elk-13 and Pipe-14 have values of 50 and 40 ug/l respectively, similar to lower flow 1997 Lion Creek potential reference stream results of about 40 to 70 ug/l. Butler et al. (1995) nitrate + nitrite results for low flow late summer 1992 tend to range from about 20 to 30 ug/l for the Swan River and generally less than 20 ug/l for Six Mile Creek. Late fall and early winter results from both Butler and Ellis show increasing levels of nitrate-nitrite in comparison to late summer (September) values.

The chlorophyll *a* results range from 7.1 to 37.5 mg/m2 (Table 5-8). It is interesting to note that the two highest chlorophyll *a* values (Jim-5L and Goat-3) are in the streams with the highest nitrate + nitrite levels. All chlorophyll *a* values appear to be consistent with expected values for higher mountain streams and are all below the 25^{th} percentile of the EPA Ecoregion II results of 33 mg/m2 with the exception of the results for the lower part of Goat Creek (Goat-3 at 37.5 mg/m2). The potential reference reach values for Elk-13 and Piper-14 have much lower values of 13.7 and 9.4 mg/m2 respectively, significantly lower than the 37.5 mg/m2 for Goat-3 and the 32.5 mg/m2 for Jim-5L. Nevertheless, these values are still less than what would be the anticipated nutrient criteria for this region of Montana based on DEQ nutrient criteria development for northeastern portions of Montana (unpublished data and personal communication with Mike Suplee, DEQ 2003). Thus far, it appears that nutrient criteria development from reference streams in northeastern Montana will be based on values well above the EPA 25th percentile recommendation. It is anticipated that nutrient criteria development for areas of western Montana, such as the Swan Lake Watershed, will follow a similar trend whereby any final impairment criteria based on chlorophyll *a* will be significantly greater than the 33 mg/m^2 25th percentile value from EPA.

Table 5-8. 2002 Nutrient and Chlorophyll *a* Sample Result.

Stream Reach	Chlorophyll *a* mg/m2	Nitrate plus Nitrate as N (ug/l)	Total Kjeldahl Nitrogen (ug/l)	Total Phosphorous (ug/l)	Soluble N to Total P Ratio*
Piper - 2	12.1	30	< 100	< 1	30
Piper - 14	9.4	40	< 100	< 1	40
Jim - 5L	32.5	70	< 100	< 1	70
Elk -3	14.9	40	< 100	< 1	40
Elk - 13	13.7	50	< 100	< 1	50
Goat - 3	37.5	100	< 100	< 1	100
Goat - 7	9.4	90	< 100	< 1	90
Goat - 9	11.6	100	< 100	< 1	100
Goat - 16	7.1	130	< 100	< 1	130

* This represents a conservatively low representation of a nitrogen to phosphorous ratio since it is assumed that the Total Phosphorous values are all 1.0.

Currently, DEQ's Appendix A guidance document, which is part of the 2002 303(d) list (DEQ, 2002a), identifies 50 mg/m^2 chlorophyll *a* as a criteria for making recreation impairment determinations based on nuisance algae levels. This guidance also identifies 100 mg/m2 chlorophyll *a* as criteria for making aquatic life use support impairment determinations. None of the Table 5-8 values exceed even the lower of these two criteria, and there have been no reports of nuisance algae levels in any of the four tributaries.

Note that all phosphorous concentrations shown by Table 5-8 are very low, at levels below the detection limit of 1 ug/l. Table 5-8 also includes soluble nitrogen to total phosphorous ratios. The approach used to calculate these values results in conservatively low numbers as noted, and yet the results still represent high N to P ratios. These high N to P ratios imply that phosphorous is probably the limiting nutrient in each stream and that the higher nitrate + nitrite values would not likely impact the beneficial uses and contribute to excessive algae growth in these streams. This is supported by a lack of evidence associated with algae blooms or other impairment related conditions associated with periphyton or macroinvertebrate community measurements as discussed below in Sections 5.18 and 5.19.

5.17 Status of the Bull Trout Fishery

The Montana Department of Fish Wildlife and Parks (FWP) has been monitoring the status of the Swan Basin's bull trout fishery since at least 1982 by conducting annual counts of bull trout spawning sites commonly known as redds (Assessment Activity (23) in Table 5-1). These annual counts are performed on identical index reaches of several streams throughout each tributary watershed. Results of this effort are presented in Figure 5-14. The number of spawning sites observed by FWP increased steadily from a low of 205 in 1982 to a high of 833 in 1997, and then declined to 540 in 2002, the last year for which data are available. The original six 303(d)-listed streams were included in FWP's bull trout spawning site inventories. Results from these streams are presented in Figure 5-15. Note that Squeezer, Lion, and Elk consistently have the higher number of redds, generally greater than 100 redds and at times greater than 250 redds for Elk Creek. Jim and Goat Creek tend to have 25 to just over 50 redds, and Piper Creek has the fewest with a maximum of just over 25 in 1996 and recent values of less than 5 redds, similar to very low values prior to the 1990s.

It is likely that a number of habitat and fisheries management actions have led to the overall increase in bull trout redds since the 1980's, including the habitat improvements associated with more protective timber harvest practices discussed throughout this document.

When compared to the percent fines data presented above in Section 5.15, there does not appear to be a good correlation between the percent fines results and bull trout redd numbers. This lack of a correlation still seems to exist even when the results are adjusted 7 to 9 years to compensate for the time between fry emergence and growth to spawning age. Recent reductions from peak values in 1997 and 1998 may well be within the range of natural variability (personal correspondence from S. Rumsey, FWP, 2003) and therefore could be due to natural conditions. Part of this natural variability could be associated with recent drought conditions, although flows in the key spawning tributaries in the Swan Lake Watershed have not been impacted as severely as other waters throughout Montana. Other factors such as non-native species interactions within Swan Lake could also be influencing bull trout numbers.

Figure 5-14. Total Bull Trout Spawning Sites from Ten Swan River Tributaries.

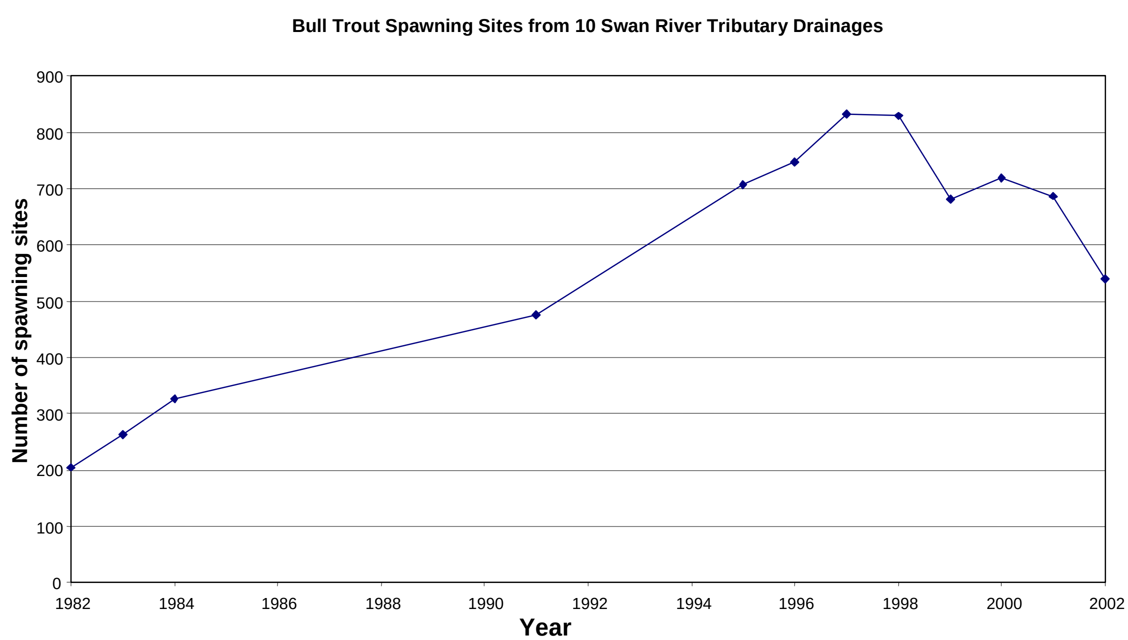
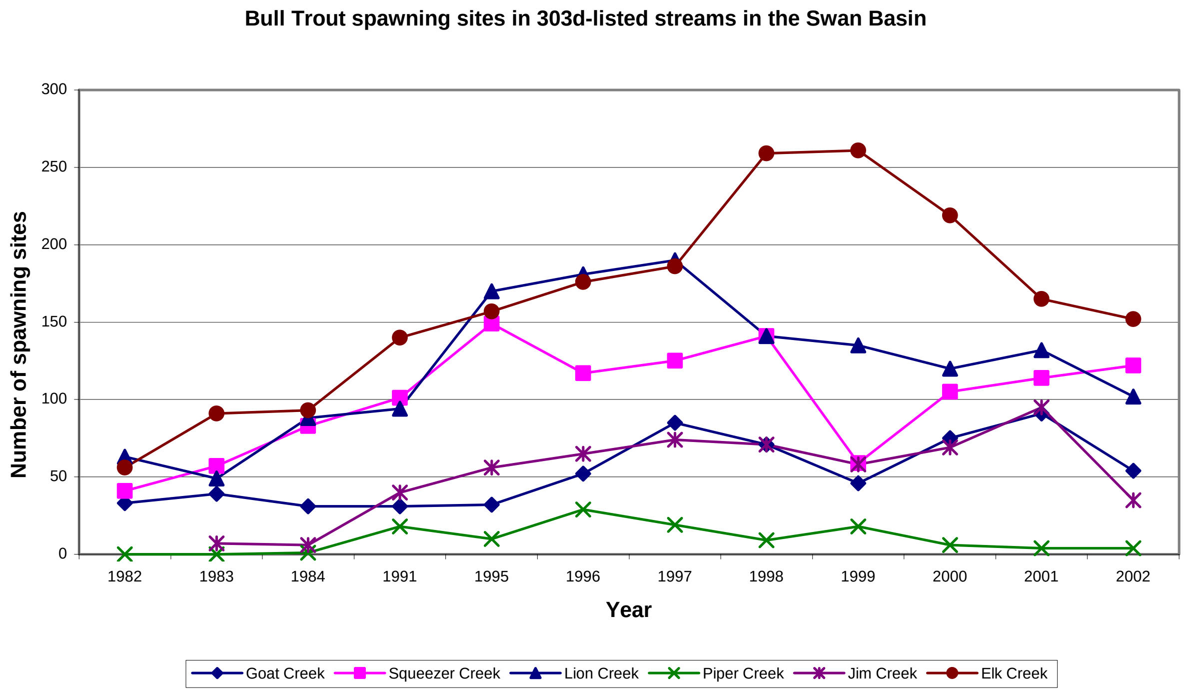


Figure 5-15. Bull Trout Spawning Sites in the Six 1996 303d-listed Swan Tributaries.



Baxter et al. (1999) evaluated geomorphology, logging roads, and the distribution of bull trout spawning redds in the Swan River. They found that over 75% of the spawning in the Swan Basin takes place in less than 10% of the available stream length, due to a preference for spawning sites in bounded alluvial valley segments where ground water is hydraulically interactive with surface water and therefore contributing to channel flow. They also found a statistically significant correlation between redd counts and road densities, with increasing redd counts found in areas of lower road density for the 1982 through 1995 period. They noted that surface-subsurface water interchange rates are not immune to the effects of roads and their associated land uses, particularly with respect to ground water exchange occurring at reach and habitat unit scales.

Recent reductions in redd counts, even in streams with relatively low road densities such as Elk, Squeezer, and Lion Creeks (Figure 5-14), seem to indicate that factors other than roads and related timber harvest may be responsible for these reductions. As noted by Baxter et al (1999), physical and biological lags between upland disturbance, stream habitat change, and a perceived response in redd counts could exceed 10 – 15 years. This means that activities occurring in the mid to late 1980's, if significant within all these drainages, could still be a potential cause of more recent reductions in redds due to reduced fry survival and/or reduced juvenile survival in the tributaries.

5.18 Periphyton/Benthic Algae Sampling Results (Assessment Activity 24)

In addition to the nutrient and chlorophyll *a* sampling discussed above, periphyton was also sampled at each of the 9 sites identified in Table 5-8. The sampling was done following a modified USEPA rapid bioassessment protocol for wadeable streams. Analysis was done to help evaluate the overall biological integrity of each stream based on the species composition and structure of periphyton (benthic algae, phytobenthos). The overall results indicated that organic enrichment, sedimentation, and toxic metals had little or no effect on the benthic algae of these streams and that the four tributaries and stations within each tributary are fairly uniform in their water quality characteristics as indicated by the periphyton data (Bahls, 2003). It is interesting to note that the results for Jim Creek indicate that this stream supported larger sediment and organic nutrient loads than the other streams, but these periphyton/benthic algae results were still within the range indicating excellent biologically integrity for a mountain stream. The data also indicate some organic loading, consistent with the nutrient and chlorophyll *a* results discussed above in Section 5.16.

5.19 Macroinvertebrate Sample Results

Six streams in the Swan Lake watershed were sampled in 1991 for macroinvertebrates under the direction of Plum Creek Timber Company (Assessment Activity (25) in Table 5-1). The sampled streams include Goat Creek below the confluence with Squeezer Creek (just below Reach Goat-3), the upper segment of Piper Creek where FS Road 966 crosses Piper Creek (just below Reach Piper-14), the lower portion of Squeezer Creek in Section 21, Jim Creek near Forest Road 888 about 2 miles above the mouth of Jim Creek, and the upper portions of Elk and Lion Creeks above most or all timber harvest and other potential human impacts. Five samples were analyzed for each site and the sampling technique likely involved a Hess or Surber sampling device and therefore represents a different methodology than DEQ's typical sampling protocol for beneficial use assessment. Because these methods are identified within the DEQ Standard Operating Procedure (DEQ, 2002b), the data provided were deemed sufficient for metric calculations used to help with beneficial use support determinations.

Two different metric calculations were performed consistent with typical evaluations performed for macroinvertebrate samples and beneficial use support determinations in Montana. The results are normalized and compared to a regional reference condition, with a score of 75% or greater considered within the range of anticipated natural variability and therefore representing full support conditions for macroinvertebrate communities. The results (Table 5-9) using both criteria showed full support conditions for Goat, Piper and Squeezer Creeks, with all values based on the DEQ metric ranging from 84% for Squeezer Creek to 97% for Goat Creek. Only one criterion (DEQ's standard assessment metric for macroinvertebrates) could be evaluated for the other three streams. These three streams also showed full support conditions with values ranging from 93% to 98%. This would be expected for Elk and Lion Creeks due to the relatively pristine nature of the drainage area upstream from the sampled locations in these two streams.

No changes to the above full support conclusions would be expected for any of the sampled stream locations given the date of the macroinvertebrate sampling and subsequent improvements in forestry practices, such as reduced riparian harvest, since 1991. The lower, more impacted segments of Piper and Elk Creeks would likely show similar full support conditions for macroinvertebrate communities as was seen for the lower segments of Goat and Squeezer Creeks.

Table 5-9. 1991 Swan Drainage Macroinvertebrate Analyses Results.

Stream	Location	Avg Score DEQ Metric[1]	Avg Score Bollman Metric[2]
Goat	Hwy 83, below Reach G-3	97%[3]	87%[3]
Piper	FS road 966, below Reach P-14	92%3	85%[3]
Squeezer	Section 21, lower portion of drainage	84%[3]	81%[3]
Jim	FS road 888 crossing, about 2 miles above the mouth of Jim Creek	95%[3]	NA[4]
Lion	Upper section below wilderness	93%[3]	NA[4]
Elk	Upper section below wilderness	98%[3]	NA[4]

Notes:

1 - Based on DEQ standard metric

2 - Based on Bollman's Western Montana Criteria (Bollman, 1998)

3 - A score of 75% or greater is considered within the range of anticipated natural variability and represents full support conditions for macroinvertebrate communities

4 - Data not available for making this calculation

5.20 Fish Passage Analyses

The Flathead National Forest is in the process of inventorying all culverts in the Swan Lake Watershed within bull trout "priority watersheds" which amounts to approximately 40% of all streams (part of Assessment Activity (6) in Table 5-1). Data being collected includes pipe gradient, pipe condition, substrate in pipe, low flow discharge, estimates of high flow, dimensions of outlet pool, and substrate size. This data will be used to prioritize culverts for fish passage improvements in conjunction with other culvert improvement efforts. Careful consideration will be given to species composition and genetic purity of fish populations prior to upgrading or removing culverts. Information from Fish Wildlife and Parks fisheries management and other biologists regarding availability and quality of habitat, life history characteristics, and risk of extinction will be considered in the prioritization of culvert removal or upgrade projects. In some cases, it may be desirable to keep a culvert as a fish passage barrier since there may be a desire to prevent undesirable species from moving into areas they currently do not inhabit. Where fish passage is desirable, the presence of a fish passage barrier can provide the basis for an impaired waterbody determination due to the fact that the fish passage problem can prevent a waterbody from fully supporting the cold-water fish beneficial use. Although the strategy to address fish passage problems can be thought of as an issue outside the context of the TMDL development process, it is an important component to any water quality protection or restoration plan and is therefore included within this document.

SECTION 6.0
UPDATED WATER QUALITY IMPAIRMENT DETERMINATIONS

This section provides a narrative summary of the impairment conclusions that have been derived from the information provided in this document. The information will be used to update the 303(d) list. Table 6-1 provides a summary of the updated impairment determinations, which all apply to the aquatic life and cold water beneficial uses.

6.1 Updated Impairment Determinations for Elk Creek

6.1.1 Sediment and Stream Channel Habitat Impairment Determinations for Elk Creek

All indicators for sediment and related stream channel habitat conditions suggest that Elk Creek should not be listed as impaired for "siltation" and "other habitat alterations." The physical and aerial assessment results did not identify significant channel conditions that would indicate sediment or stream channel habitat impairment. These results support the continued use of the upper portion of Elk Creek, above the Section 16 road crossing, as a reference condition. The McNeil Core results do not indicate an excess level of fines in spawning areas, although data were only available for the upstream reference reach. Fortunately, the physical assessment information provided additional indication of full beneficial use support conditions for sediment in the lower reach.

Given ongoing timber harvest, past riparian harvest, and private land development in this drainage, some sediment and channel related impacts such as reduced woody debris are likely. Nevertheless, the assessment activities within this stream and for other streams with greater levels of impact support the observation that these land use activities are not currently causing an impairment for sediment or stream channel habitat conditions. The very low sediment loading results from the forest roads assessment, as shown by Figures 5-2 and 5-3, further support this conclusion. Many of the impairment indicators from the 1989 DEQ stream assessment (Appendix B) were no longer obvious and there has been substantial recovery in areas of riparian harvest. Therefore, although sediment and stream channel conditions in the lower channel may not be pristine, they are likely within the range of "naturally occurring", as defined in Appendix A, and do not justify an impairment determination.

The periphyton results do not indicate sediment or habitat concerns, and the bull trout spawning numbers, the highest for all streams assessed in the Swan Lake Watershed, indicate that the stream is fully supporting this fishery and likely providing full support for all cold-water fish. The macroinvertebrate data also indicate full support for aquatic life, although the results are only applicable to the upstream segment of Elk Creek.

Table 6-1. Summary of Updated Impairment Determinations.

Water Body (DEQ Stream Segment)	Aquatic Life & Cold Water Fish Beneficial Use Status (2004)	2004 Causes of Threatened or Impaired Uses	Causes Removed Between 2002 and 2004 Based on this Plan	Previous 1996 Causes Removed Between the 1996 303(d) List and 2002 303(d) List and Justified within this Plan[1]	2004 Causes Added Based on this Plan
Swan Lake	Threatened	Siltation[2]	None	None[2]	None
Jim Creek (headwaters to mouth)[3]	Partial Support (Impaired)	Siltation (below W. Fk Jim Creek); Other Habitat Alterations (above W. Fk Jim Creek)	None	None	Other Habitat Alterations (above W. Fk Jim Creek)
Goat Creek (headwaters to Squeezer Creek)	Partial Support (Impaired)	Suspended Solids	Nutrients	Organic Enrichment/DO, Flow Alteration	None
Goat Creek (Squeezer Cr. to mouth)	Full Support	None	Siltation, Other Habitat Alterations	Organic Enrichment/DO, Flow Alteration	None
Elk Creek (headwaters to mouth)[4]	Full Support	None	Other Habitat Alterations	Organic Enrichment/DO, Siltation	None
Piper Creek (headwaters to Moore Creek)	Full Support	None	None	None	None
Piper Creek (Moore Cr. to mouth)	Full Support	None	Siltation, Other Habitat Alterations	None	None
Lion Creek (headwaters to mouth)	Full Support	None	None	None	None
Squeezer Creek (headwaters to mouth)	Full Support	None	None	None	None

Notes:
1: Additional causes identified in Table 2-1 that have been removed between the 1996 303(d) list and the 2002 List are justified within the DEQ SCD/BUD files due to full support determinations for the stream segment or specific reach of concern.
2: This siltation is linked to the siltation of POC which links to low DO at and near the bottom of Swan Lake and therefore covers the same issue identified by the 1996 Organic Enrichment/DO impairment cause.
3: Although Jim Creek is one stream segment in DEQ files, DEQ has been identifying the specific beneficial use support and impairment conditions for the upper and lower reaches of this segment.
4: Although Elk Creek is one stream segment in DEQ files, DEQ has been identifying the specific beneficial use support and impairment conditions for the upper and lower reaches of this segment. All of Elk Creek can now be identified as fully supporting aquatic life and cold-water fish.

6.1.2 Organic Enrichment and Nutrient Impairment Determinations for Elk Creek

The nutrient, periphyton, and chlorophyll *a* sample results for Elk Creek all indicate acceptable levels and no impairment. This data supports the determination that it is not necessary to identify any organic enrichment or nutrient impairments on the 303(d) list.

6.2 Updated Impairment Determinations for Piper Creek

6.2.1 Sediment and Habitat Impairment Determinations for Piper Creek

Similar to Elk Creek, all indicators for sediment and related stream channel habitat conditions suggest that Piper Creek should not be listed as impaired for "siltation" and "other habitat alterations." The physical and aerial assessment results, as well as other assessment activities in Piper Creek over the past few decades, did not identify significant channel conditions that would indicate sediment or habitat impairment.

Given ongoing timber harvest, past riparian harvest, and private land development in this drainage, some sediment and channel related impacts such as reduced woody debris in the channel are likely. Nevertheless, the assessment activities within this stream and for other streams with high levels of impact support the observation that these land use activities are not currently causing an impairment for sediment or stream channel habitat conditions. The relatively low sediment loading results from the forest roads assessment, as shown by Figures 5-4 and 5-5, further support this conclusion. The impairment indicators from the previous DEQ stream assessment (Appendix B) were no longer obvious enough to support an impairment determination. Therefore, although sediment and stream channel conditions may not be pristine, they appear to be within the range of "naturally occurring" and do not justify an impairment determination.

The periphyton results do not indicate sediment or habitat concerns. Bull trout spawning numbers are low in recent years, but these reductions are not attributed to sediment or stream channel habitat conditions. The macroinvertebrate data also indicate full support for aquatic life, although the results are only applicable to the upstream segment of Piper Creek.

6.2.2 Organic Enrichment and Nutrient Impairment Determinations for Piper Creek

The nutrient, periphyton, and chlorophyll *a* sample results for Piper Creek all indicate acceptable levels and no impairment. This data supports the determination that it is not necessary to identify any organic enrichment or nutrient impairments on the 303(d) list.

6.3 Updated Impairment Determinations for Jim Creek

6.3.1 Sediment and Stream Channel Habitat Impairment Determinations for Jim Creek

Several of the indicators for sediment and related stream channel habitat conditions suggest that Jim Creek should remain listed as impaired for "siltation". One major indicator of impairment is the relatively high percent fines values and potential impacts to bull and cutthroat trout spawning. These percent fines values have been as high as 50% and in recent years have declined to around 37%, indicating recovery from past land use activities identified in Section 5.0 and Appendix B. Nevertheless, these values are still above the 35% target condition developed in Section 5.15, indicating a sediment impairment due to excess fines deposition. The high level of fines are also consistent with visual observations in lower reaches of Jim Creek, where 2002 physical assessment personnel noted more fines in this portion of Jim Creek than in other streams.

Sources of sediment are related to harvest activities identified in Appendix B as well as those identified during the aerial and physical assessment efforts. The road sediment loading results show very low current road sediment loads, and upstream areas with significant harvest indicate recovery from a bank stability perspective. This implies that existing sediment sources are somewhat under control and within reasonable limits, and that impairment conditions are primarily associated with past loading conditions. The percent fines values for Jim Creek closely follow those for Lion Creek, and may indicate that Jim Creek is currently reaching its potential in the area assessed. Many of the habitat indicators in the lower sections toward the mouth indicate high quality pools, good LWD numbers, and good bank stability, even with evidence of riparian harvest and some private development along the channel. Nevertheless, siltation-type impacts from historical sediment loading will also need to be further evaluated in these lower reaches prior to any full support determinations.

In the upper reaches of Jim Creek, low values of LWD, poor quality pools, and a lack of overall aquatic life habitat due to a shortage of finer sediment storage where there has been significant riparian harvest suggest a potential impairment that will need further investigation. As pointed out in Section 5.0, this upstream reduction of LWD is one of the downstream sediment loading sources due to lost sediment storage. Intermittent conditions in the upper reaches may limit overall aquatic life potential and would need to be taken into consideration when performing a use support determination.

The periphyton results do indicate potential sediment loading in Jim Creek, but not to the level to make an impairment determination on this data alone. Bull trout spawning numbers are down in recent years, but these reductions have not been attributed to habitat, sediment or other pollutant conditions at this time. The macroinvertebrate data indicate full support of aquatic life, although the results are only applicable to the middle section of Jim Creek and may not be representative of upper and lower sections.

6.3.2 Organic Enrichment and Nutrient Impairment Determinations for Jim Creek

The nutrient, and chlorophyll *a* sample results for Jim Creek are elevated above reference conditions, but are not high enough to cause an impairment based on the periphyton data and a lack of other indicators of nutrient enrichment. Therefore, it is not necessary to include organic enrichment or nutrient impairments on the 303(d) list.

6.4 Updated Impairment Determinations for Goat Creek

6.4.1 Sediment and Stream Channel Habitat Impairment Determinations for Goat Creek

Most indicators for sediment and related stream channel habitat conditions suggest that Goat Creek should not be listed as impaired for "siltation" and "other habitat alterations". The physical and aerial assessment results did not identify significant channel conditions that would indicate a sediment or stream channel habitat impairment. Even in the reach most heavily affected by riparian harvest (Appendix B), on-the-ground assessment revealed substantial recovery, with good bank stability and functioning pools and other aquatic life habitat, although there is an apparent reduction in LWD. Assessment of lower reaches where problems were noted in earlier DEQ assessments (Appendix B) also indicated that these earlier problems were no longer a significant issue. The McNeil Core sample results are consistently below 30%, indicating good fishery support, although bull trout spawning numbers are reduced similar to other monitored streams in the Swan Lake Watershed. The macroinvertebrate results from the lower segment of Goat Creek do not indicate sediment and habitat problems, nor do any of the periphyton results indicate such problems. Based on this analysis, the "siltation" and "habitat alterations" are within the range of naturally occurring conditions and these impairments will be removed from the future 303(d) list.

The physical assessment work and previous assessments for Goat Creek indicate continued sediment as well as nutrient loading sources. The sediment loading results from the forest roads assessment, as shown by Figures 5-2 and 5-3, continue to be relatively high for the Goat Creek drainage, similar to values from the mid-1990s. Significant levels of timber harvest in this drainage appear to be impacting overall suspended and nutrient loading, based on 1997 data. Recent 2003 results for the upper segment of Goat Creek indicate lower TSS values. As discussed in Section 5.0, the 1997 data for the upper segment of Goat Creek, along with indicators of timber related sources of impairment were used to justify the suspended solids impairment cause on the recent 2002 303(d) list. Basing this impairment on high flow conditions and measured changes to turbidity levels above a reference conditions is consistent with Montana's water quality standard for turbidity (Appendix A). This approach is also consistent with how several other states apply a turbidity and/or TSS standard (Rowe et al., 2003). Therefore, the upper segment of Goat Creek will remain impaired for suspended solids until more information is available to ensure that the lower 2003 TSS results, which were from a relatively low flow year, are representative of current and future expected conditions.

6.4.2 Organic Enrichment and Nutrient Impairment Determinations for Goat Creek

The nutrient and chlorophyll *a* sample results for Goat Creek are elevated above reference conditions. Nevertheless, the results along with the periphyton and macroinvertebrate data support the determination that it is not necessary to identify organic enrichment or nutrient impairments to either of the two Goat Creek segments at this time. Therefore, the 303(d) list will no longer include nutrients as an impairment cause.

6.4.3 Flow Alteration Impairment Determination for Goat Creek

The flow alteration impairment determination on the 1996 303(d) list was based on measurements taken during a drought year. Assessment work did not identify stream diversions and other human related dewatering activities that would lead to significantly reduced low flow conditions. Any flow alterations are considered to be within the range of naturally occurring conditions and this impairment cause will remain off existing and future 303(d) lists.

6.5 Other Tributaries in the Watershed

It is important to note that use support determinations have been made in this document only for the previously listed tributary streams. At this time it is unknown if there are other impaired waterbodies within the drainage. Previous efforts to identify impaired waterbodies in this and other drainages via the 303(d) list should have resulted in listing of those waterbodies with the highest likelihood of being impaired. The fact that two of the previously listed streams (Piper and Elk) were no longer found to be impaired, and that some of the Goat Creek impairments no longer exist, is encouraging.

Nevertheless, road sediment loading determinations (e. g. South Woodward Creek) along with increased development and elevated levels of timber harvest in some drainages are indicators of potential problems. For example, the Swan Valley Conservation Agreement for grizzly bears concentrates logging and road construction into four bear management subunits at a time. This timber harvest approach can lead to increased pollutant loading and other water quality impacts to streams within the subunit where the work is concentrated. The subunits are rotated every three years, with Woodward Creek being part of the subunit that was open for concentrated activities between 2000 and 2002.

In recognition of the potential that other waterbodies are or could become impaired due to human activities, some targets and allocations are developed in this document for tributary watersheds to help protect Swan Lake while also helping to protect the beneficial uses of individual tributaries. Where future assessment determines an impairment in a tributary, formal TMDL development may be necessary if the targets and allocations within this plan are not sufficient to protect impacted beneficial uses. Furthermore, Sections 9 and 10 recommend expanded tracking of land use and water quality indicators that can help evaluate potential water quality impacts within tributary drainages of concern.

Even those tributaries no longer considered impaired should be routinely monitored to ensure that new land use activities do not create a new impairment. Further evaluations should look at historic riparian harvest impacts on temperature in these streams and also provide a better understanding of causes of bull trout redd declines in many of the streams, particularly in Piper Creek.

6.6 Updated Impairment Determinations for Swan Lake

Based on previous DEQ data analyses and the data evaluated in Section 4.0 and Appendix A, it is concluded that Swan Lake is not impaired, consistent with the 2000 and 2002 303(d) lists. Overall, water quality is still good, with low DO levels near the lake bottom a main cause of concern. There is also concern that some of the water quality indicators presented in Table 4-1 may be indicative of a trend toward lower water quality, but not to the extent that an impairment determination can be justified.

The various studies within the Swan Lake Watershed and within individual tributaries show impacts from timber harvest activities in the form of increased sediment and nutrient loading to streams, which can increase loading to Swan Lake. It is important to note that Montana's water quality standards recognize that human activities, such as timber harvest, can be considered a naturally occurring part of the watershed if pollutant loading is controlled via reasonable land, soil and water conservation practices. Reasonable land, soil and water conservation practices generally include BMPs, but may require additional conservation practices, beyond BMPs, to achieve compliance with water quality standards and restore beneficial uses (internal DEQ guidance, 1999). The assessment results from Section 5.0 and impairment conclusions for tributaries suggest an overall improving trend in water quality and an overall reduction in pollutant loading in many of the tributaries. This improving trend is most likely the result of the implementation of forestry best management practices (BMPs) and the streamside management zone (SMZ) law in the Swan Basin as well as a reduction in overall harvest on public land.

Timber harvest activities are still a significant land use and are anticipated to remain so. This will continue to cause some loading of sediment and nutrients to the system. Several tributaries assessed, such as Woodward Creek, show how excess pollutant loading from sources such as forest roads may always represent some risk. Also of concern are the non-quantified risks associated with undersized and under-maintained culverts and abandoned roads. These and other risks, such as mass wasting events, should be minimized via forestry BMPs and possibly via additional efforts that could qualify as reasonable land, soil and water conservation practices.

Even with such concerns, the assessment results in this document suggest that the primary threat to Swan Lake water quality (which is silviculture (logging) according to the most recent 303(d) lists) has been significantly mitigated at the Swan Lake Watershed scale since the late 1980s and early 1990s. On the other hand, there is an additional threat of private land development along many waterbodies throughout the watershed. This type of development has caused significant water quality concerns and problems throughout the state. Unlike logging, many activities such as the building of a structure very close to a stream can result in a permanent type of impact. Although there are local and state laws and covenants to help mitigate impacts, these do not fully reduce the potential threat from cumulative impacts along streams and associated riparian corridors.

Therefore, future private land development, along with some of the continued impacts from timber harvest activities in the watershed, still provide a significant sediment and nutrient loading threat. This loading threat, along with continued low DO values, uncertainty about the causes of these low DO values, and recent concerns about other Swan Lake water quality indicators, provide adequate justification to continue to treat Swan Lake as a threatened waterbody and to implement associated water quality protection strategies identified within this plan.

SECTION 7.0
WATER QUALITY PROTECTION GOALS AND TARGETS

This section presents water quality goals and targets for Swan Lake Watershed. Below is a list of some of the primary water quality protection goals.

1. Reduce the overall threat of an impairment to any of the beneficial uses supported by Swan Lake;
2. Ensure full recovery of the cold-water fish beneficial uses to Goat and Jim Creeks;
3. Avoid conditions where additional waterbodies within the Swan Lake Watershed become impaired;
4. Limit pollutant loading consistent with protection of Flathead Lake;
5. Promote a cooperative approach to water quality protection activities among landowners and other stakeholders; and
6. Continue to monitor conditions in the watershed to identify additional impairment conditions, track progress toward protecting waterbodies in the watershed, and provide early warning if water quality starts to deteriorate.

The last two goals (Goals 5 and 6) are further developed as part of the implementation strategy and monitoring plan sections of this document (Sections 9.0 and 10.0).

To help define measurable objectives toward meeting Goals 1 through 4, targets are developed within this section of the document, and TMDLs and allocations are developed in Section 8.0. The water quality targets are numeric or measurable values that represent desired conditions and achievement of water quality standards, both numeric and narrative, for each stream. For the Swan Lake Watershed, the targets primarily address impairments and threats to the cold-water fish and aquatic life beneficial uses, as discussed in earlier sections of this document.

TMDLs are developed in Section 8.0 to address those impairments and threatened conditions that can be linked to pollutants. The TMDL identifies the maximum pollutant loading, pollutant reductions, and/or other conditions necessary to achieve target values. The TMDL is then allocated among the various existing or future sources of concern identified in Section 5.0. Together, the water quality goals and measurable objectives (targets, TMDLs, and allocations) provide a basis for prioritizing efforts and measuring success of improvement activities in the Swan Lake Watershed. Sections 9.0 and 10.0 then provide implementation and monitoring recommendations to achieve the goals defined in Sections 7.0 and 8.0.

The targets cover a range of pollutant and habitat related impairment conditions. Swan Lake targets focus on POC related impairment or threats, mainly the link to low DO at the bottom of Swan Lake. Swan Lake targets also focus on nutrients, specifically phosphorous and nitrogen, to avoid nutrient-induced algal blooms and related eutrophication. The Swan Lake targets also help avoid excess turbidity that could be linked to excess POC, nutrients, and/or sediment loading. Water quality targets developed for tributaries identified as impaired in Section 6.0 (Goat Creek and Jim Creek) address sediment and habitat related impairment conditions.

Targets that must be met in order to obtain full support conditions are referred to as primary targets. If a primary target is not satisfied, then an impaired or threatened condition still exists. Secondary targets, also referred to as supplemental indicators in some documents, are applied to Swan Lake in Section 7.1.2 to help track progress toward meeting primary targets and as additional indicators of watershed and lake health. Not meeting some of the secondary targets may be justification for a continued threatened determination for Swan Lake. In some situations, not meeting a secondary target is an indication of a new impairment that should be further investigated. Additional data would typically be needed to make an impairment determination, which could then lead to additional water quality protection planning and TMDL development. The implications of not meeting primary or secondary targets are discussed as each target is presented in this section.

Additional target conditions are also defined for Swan Lake and tributaries throughout the Swan Lake Watershed in Section 7.4. These conditions can be used for future target development and as the basis for additional impairment determinations in Swan Lake and in tributary streams within the Swan Lake Watershed. They apply to water quality and impairment concerns not addressed by an existing or recent 303(d) list. Together, the target conditions and Swan Lake secondary targets provide additional water quality and beneficial use protection measures in the watershed.

7.1 Swan Lake Water Quality Targets

Two types of targets are identified for Swan Lake, primary and secondary targets. Primary targets are based on direct measures or direct indicators of beneficial use support within the lake. Secondary targets are based on loading conditions or surrogates for loading conditions within the watershed. The difficulty in establishing baseline conditions and the time that could be involved with identifying trends associated with the primary targets for Swan Lake make the use of secondary targets desirable. These secondary targets help identify potential problems or progress toward resolving water quality concerns in the watershed.

7.1.1 Swan Lake Primary Targets

Dissolved Oxygen (Swan Lake Primary Target #1): ***No decreasing percent saturation of DO in the bottom waters of Swan Lake and no increase in the spatial extent of the low DO area in the lake.*** Not meeting this target represents an increased threat to aquatic life and other beneficial uses in Swan Lake and would likely justify an impairment determination. Until more data is available to make trend related conclusions, Swan Lake may be considered a threatened water body.

Rationale:

This target addresses the primary reason for listing Swan Lake as a threatened waterbody on Montana’s 303(d) list. In spite of the fact that the low DO in Swan Lake may not be unusual (reference Section 4.0 and Appendix A) it must be monitored for a period of time to ensure that conditions are not becoming worse due to human activities. Extremely low DO values increase the risk of rapid eutrophication, or lake “aging”, and therefore increase the risk of diminishing water quality in the lake. A steady or rapid increase in the spatial extent of the low DO area year after year would suggest there are unresolved POC sources in the watershed. If data suggest that higher deepwater DO concentrations are achievable, then these higher DO concentrations and presumably smaller spatial extent of the low DO area will provide the new target baseline conditions. These new baseline conditions will ensure improved conditions are maintained and therefore further protect the resource and to ensure consistency with Montana Water Quality Standards.

Target Applicability Considerations

The natural variability for the DO parameters has not been well defined. Any final target compliance considerations must take natural variability into account, while at the same time also considering land use changes throughout the watershed. Improved tracking of land use indicators and large natural disturbances such as fires throughout the watershed may be necessary to help determine if a water quality trend or change in water quality parameters can be attributed to natural variability or changes in land use. Even under similar land use levels within the watershed, it can take many years of data to detect a water quality trend, with the number of years needed to detect a trend being a function of the amount of sampling and desired level of certainty.

In-Lake Nutrient and Chlorophyll *a* Concentrations (Swan Lake Primary Target #2): *No increasing trend of nutrient and chlorophyll a concentrations, no increasing trophic state index trends, and no decreasing trend in Secchi Depth values in Swan Lake.* Not meeting this target represents a decreasing trend in water quality and may justify a continued “threatened” condition associated with POC/siltation. Not meeting this target also represents an additional threat associated with phosphorous and/or nitrogen (typical pollutant(s) associated with a nutrient impairment), and may justify a new impairment to aquatic life and/or other beneficial uses in Swan Lake.

Rationale:

This target will prevent or minimize algae blooms within the lake and therefore provide protection for cold-water fish and aquatic life beneficial uses, and will further avoid additional POC loading associated with increased algal growth. It will also protect lake aesthetics and help ensure that turbidity remains within the range of naturally occurring levels as defined under State Law (reference 17.30.622(3)(c) in Appendix A). Another goal of this target is to minimize potential nutrient loading to Flathead Lake.

Target Applicability Considerations

The natural variability for the nutrients and other water quality indicators in Swan Lake has not been well defined. The data presented within Section 4.0 may indicate long-term trends, but detailed statistical analysis of this data is lacking. Any final target compliance considerations must take natural variability into account, while at the same time also considering land use changes throughout the watershed. Improved tracking of land use indicators and large natural disturbances such as fires throughout the watershed may be necessary to help determine if a water quality trend or change in water quality parameters can be attributed to natural variability or changes in land use. Even under similar land use levels within the watershed, it can take many years of data to detect a water quality trend, with the number of years needed to detect a trend being a function of the amount of sampling and desired level of certainty.

7.1.2 Swan Lake Secondary Targets:

Nutrient and TSS Loading (Swan Lake Secondary Target #1): *No increasing trend in phosphorous, nitrogen, TSS and organic carbon loads associated with human impacts entering Swan Lake from the Swan River.* Not meeting this target represents a potential continued threat to water quality and beneficial use support within Swan Lake and is a potential indicator of elevated loads within the watershed. The specific nutrient parameters to track should include TP, TN, SRP, TSS, POC, and nitrate-nitrite, or a representative subset of these parameters.

Rationale:

Section 4.0 discusses several mechanisms by which timber harvest and private land development can increase nutrient loading. Section 5.0, particularly Section 5.6, presents information from several studies where increased nutrient loads were attributed to timber harvest activities. It is anticipated that nutrient loads from timber harvest can be kept to reasonable values and that continued BMP implementation and recovery from past harvest practices will potentially lead to reduced nutrient loading, even with continued timber harvest within the Swan Lake drainage. On the other hand, increased private development has the potential to offset any gains from past timber harvest activities. This secondary target directly addresses POC and nutrient loading (phosphorous and nitrogen) and will help ensure that Swan Lake Primary Targets are met.

An additional purpose of this target is to protect Flathead Lake. The Flathead Lake TMDL is based on a 15% reduction in nutrient loading to Flathead Lake (DEQ, 2001) from existing sources. Based on measurements below Swan Lake, the Flathead Lake TMDL identifies the Swan River Watershed as the source of a relatively small portion of the total nutrient load entering Flathead Lake (about 4 to 7% depending on the specific parameter/nutrient). The Swan River above Swan Lake is likely a significantly smaller portion of the load given the upstream location and possible nutrient “sink” conditions within Swan Lake (Section 5.8). Controlling the nutrient loading in the Swan River above Swan Lake would help prevent eutrophication of Swan Lake. Increased eutrophication could ultimately cause a significant nutrient loading increase from within Swan Lake to Flathead Lake.

This secondary target is focused on the Swan River since this is the primary pollutant loading source to Swan Lake. Ideally the target would incorporate other loading sources to Swan Lake, such as from tributaries directly flowing into Swan Lake, especially if land use changes suggest the need for increased tracking of other pollutant pathways in addition to the Swan River. This target could be tracked via monitoring within the Swan River and/or monitoring within a representative subset of tributaries. Monitoring within tributaries representing a range of land uses in the watershed may be more desirable since tracking changes in the storage and flux of pollutants in a larger river system can be difficult as noted by Ellis et al (1999a) in Section 5.6.3.

Road Sediment Loading (Swan Lake Secondary Target #2): ***Application of Montana Adapted Forestry BMPs at steam crossings (including locations where roads are adjacent to streams). This applies to all stream crossings and is not limited to stream crossings associated with timber harvest activities. Specific target objectives include:***

- ***Applying BMPs to the extent practical to the top 70 sediment-producing sites identified in Section 5.2 and Appendix F. These are locations where the estimated sediment load is greater than approximately 3 tons/year and thus where BMP upgrades are likely to produce significant sediment load reductions. Any newly identified road crossings with sediment loading values similar to these top 70 sites will also have BMPs applied to the extent practical. Alternatively, proper road decommissioning is a viable approach to permanently reduce the sediment load from the any of these top 70 sites or any locations where a road crosses or is near a stream.***
- ***Applying BMPs to all new road segments. BMP application rates in the Swan Lake Watershed should, at a minimum, be consistent with overall forest practices audit results for BMP compliance in Montana.***

Not meeting the above target does not represent an impairment condition to a stream or to Swan Lake unless additional indicators of impairment also exist (percent fines, channel conditions, turbid conditions, increased productivity, decreases in DO, etc.). Not meeting this target does represent a threat of increased eutrophication and turbidity in Swan Lake from sediment and nutrients. Not meeting the target also represents an increased threat of percent fines impairment in tributary streams. The significance of the threat and appropriate response is proportional to the predicted additional sediment loading that could be prevented if BMPs were properly implemented.

Rationale:

Erosion from roads, particularly at stream crossings and where roads are adjacent to a stream, is a major source of fine sediment loading and elevated levels of suspended sediment/solids to receiving waterbodies during runoff or storm events. This target also helps ensure compliance with turbidity and suspended sediment/solids related standards (reference 17.30.623(2)(d) and 17.30.622(3)(c) in Appendix A), especially as they apply to Swan Lake, which is an A-1 classified waterbody. Although the Secchi Depth component of Swan Lake Primary Target #2 is also geared toward the turbidity component of water quality standards, it is more directed toward turbidity problems associated with nutrient enrichment.

The sediment loading from roads is also a source of increased nutrient loading, mainly phosphorous, and particulate organic carbon to a lesser extent. Therefore, this target also represents an important approach to minimizing nutrient loading to Swan Lake and perhaps even Flathead Lake.

The source assessment work for this water quality plan focused heavily on road sediment loading, and this pollutant source category represents a significant water quality threat to Swan Lake and individual tributaries that can be mitigated. Pursuing road sediment reductions, or total elimination of yearly sediment loads via road decommissioning, for the top 70 sediment-producing sites is a reasonable approach to minimize known impacts from existing roads. Pursuing BMPs at a high rate of compliance for other existing or new roads will further ensure water quality protection.

Riparian and Streambank Vegetative Health (Swan Lake Secondary Target #3)*: Based on the 1997 color aerial photos, no reductions in overall average canopy density for significant stream segment, and no increases in the spatial extent of the riparian zone in which canopy density is less than 50%.* Significant segments can include every perennial stream, although it is anticipated that focus will be on the Swan River, significant bull trout or cutthroat trout streams, and streams where development indicators suggests a potential problem.

Not meeting this target, especially in major streams or multiple streams, represents a potential increased threat to Swan Lake water quality and represents a need to investigate the land use activities that have led to this condition. The stream(s) where riparian cover has been reduced will also need to be evaluated for potential impacts to water quality and beneficial use support depending on the severity of riparian impacts. Potential canopy density impacts from natural events such as fire will need to be taken into account. Determinations concerning target compliance should consider certain types of salvage work, such as thinning small trees near a stream. This salvage work may seem inconsistent with this target but overall may help promote large tree growth or help prevent more significant water quality impacts linked to unnaturally high fuel buildup along streams where historical timber harvest or fire suppression practices created undesirable conditions.

Rationale:

Riparian health is a valuable indicator of streambank stability and shade potential and overall beneficial use support. Healthy vegetation on and near streambanks and in floodplains reduces the potential for increased sediment and nutrient loads to Swan Lake and to the tributaries of concern. Reduced canopy cover can also lead to undesirable increases in temperature. This vegetation indicator not only links to all pollutants of concern, it also provides an easy methodology for identifying areas on-the-ground where landowner participation in water quality protection can be encouraged and where water quality protection measures can be applied. Some adjustment to the application of this secondary target might be necessary to account for conditions where very large mature riparian forest growth can actually lead to minor decreases in average canopy density, although values would still be very high in the area evaluated.

7.2 Jim Creek Targets

This section describes water quality targets for Jim Creek. All Jim Creek targets are primary targets and must all be met in order satisfy a full support condition in Jim Creek, subject to potential target modification as described below. The targets address habitat alterations in the upper segments of Jim Creek as well as excess fines in the lower segment below the West Fork of Jim Creek.

<u>Percent Fines from Core Sampling (Jim Creek Primary Target #1):</u> ***A target of 35% channel substrate fines (<6.35 mm) based on the McNeil Core method described by Weaver and Fraley (1991).***

Rationale:

This target is directly linked to the sediment impairment described by the siltation cause on the 2002 303(d) list. Elevated levels of fine sediment from human activities reduce fry emergence and are therefore a direct indicator of impairment conditions. The discussion of percent fines data in Section 5.15 suggest an upper target limit of 35%.

Target Applicability Considerations

The recent percent fines values in Jim Creek have ranged from about 38% to 40% since 1996, with recent values closer to 38% (Figure 5-12). As discussed in Section 5.15, some streams may not be able to achieve the 35% target most years due to naturally high sediment loading conditions. There is a possibility that the percent fines values in Jim Creek are naturally higher than 35%. This is supported by the consistent percent fines values over the past several years in spite of apparently low sediment loading from road erosion. It is also supported by apparent consistency with Lion Creek results, which may ultimately represent a reference condition for Jim Creek. On the other hand, there are historical human sediment loading sources associated with past timber harvest activities, and more time may still be needed to allow flushing of elevated sediment loads through the stream channel.

If a similar percent fines pattern continues for Jim Creek over the next five to ten years, then this target may be modified upward toward the 37 to 40% range. The extent of potential sediment loading within the drainage over this time period and how the Jim Creek values responds relative to the percent fines data from other streams must be taken into account prior to any modifications to this target.

<u>Pools and Large Woody Debris (Jim Creek Primary Target #2)</u>: ***Targets of 50% pools with cover and greater than 50 pieces of large woody debris (LWD) per 1,000 feet of channel length for Jim Creek, with specific focus on the upper riparian harvested reaches above and below Jim Lake.***

Rationale:

Woody debris is an important component for fisheries and aquatic life habitat. A significant lack of woody debris can provide a basis for an impairment determination due to loss of aquatic habitat. Woody debris also helps establish streambed stability, dissipates energy, and directly influences sediment storage (Rosgen, 1996). The Jim Creek stream assessment revealed the LWD and pool numbers with cover in the area of Reach 24 were significantly reduced when compared to parts of this and other streams that were apparently less impacted by riparian harvest. The percent pools with cover and number of LWD in the other reaches assessed with similar stream type conditions were greater than 50% and 50 respectively. Targets of 50% and 50 were chosen to provide some allowance for variability between streams.

The low levels of LWD and pools represent a “habitat alterations” cause of impairment unique to the “siltation” cause addressed primarily by the percent fines target. It is recognized that the loss of woody debris may have contributed excess fines to the lower portions of the drainage. This condition probably no longer contributes an unnaturally high sediment load since streambank stability was not identified as an issue during the physical assessments. On the other hand, increased LWD could increase storage of fine sediment and help mitigate downstream concerns with siltation of excess fines.

Target Applicability Considerations

The first few miles of Jim Creek below the lower Jim Lake were dry in late summer of 2002 and 2003, and could be naturally intermittent. This can impact the applicability of these types of habitat targets depending on potential fisheries use and aquatic life impacts during periods of stream flow. If further analyses by DEQ, with input from fisheries specialists, suggest limited impact to aquatic life, then these target conditions may no longer apply. Until such time, it is assumed that the significant loss of habitat components is impairing aquatic life and/or cold-water fish at some level along the upper reaches of Jim Creek.

Also, it is possible that the natural potential for LWD and pools with cover within Jim Creek below Jim Lake is naturally lower than expected because Jim Lake limits woody debris recruitment in the area. Target compliance may, therefore, end up focusing on the upper sections of Jim Creek where aerial assessment results also indicate the potential for low LWD and pools with cover due to historical harvest practices.

Macroinvertebrate Communities (Jim Creek Primary Target #3): ***Macroinvertebrate community metrics associated with sediment must indicate full support conditions based on standard DEQ protocols.***

Rationale:

This standard water quality target is consistently applied to all waterbodies in Montana, and provides a direct indication of beneficial use support for aquatic life.

Target Applicability Considerations

This target should be applied at two to three locations along Jim Creek. The locations should correspond to a middle section in areas impacted by past harvest activities, the lower reach in the vicinity of Jim Creek Reach 4 or 5 that may represent an area of excess sediment deposition, and in the upper reaches impacted by riparian harvest if suitable sampling locations exist given potential intermittent conditions. Based on previous results (Section 5.19), there is a good chance that macroinvertebrate communities would show full support in the middle reach suggested for monitoring.

7.3 Goat Creek Targets

This section describes water quality targets for Goat Creek. Both Goat Creek targets are primary targets and must be met in order satisfy a full support condition in Goat Creek relative to sediment impairment conditions. Targets were not developed for pools and large woody debris since the physical assessment results did not identify specific problems in Goat Creek.

<u>**Total Suspended Solids (Goat Creek Primary Target #1):**</u> ***A total suspended solids (TSS) target of less than 30 mg/l is applied to Goat Creek during peak flow conditions.***

Rationale:

This target is based on the fact that streams in the Swan Lake drainage with limited or no human impacts appear to have peak flow TSS values in the 15 to 20 mg/l range (Section 5.6.4), representing an indication of the range of naturally occurring conditions. Using a two-to-one relationship for NTUs and TSS as discussed in Section 5.6.4, a TSS increase of about 10 mg/l would result in a turbidity increase of about 5 NTUs. Therefore, the TSS increase above naturally occurring conditions should be less than 10 mg/l to keep the turbidity NTU increase less than 5 NTUs as required by Montana Water Quality Standards (Appendix A). This 10 mg/l increase is therefore added to 15 to 20 mg/l range of naturally occurring variability to result in a target value that must fall below the upper end of the resulting 25 to 30 mg/l range.

Target Applicability Considerations

The recent TSS data from 2003 suggest that Goat Creek may currently satisfy this target condition. Another year of representative peak flow data with TSS results less than 20 mg/l, or two more similar years with results less than 30 mg/l may suggest that this target is currently satisfied in Goat Creek. Compliance with this target allows for consideration of duration and magnitude of any sample results greater than 30 mg/l. Examples where the target condition can still be met include situations where a large representative data set shows that TSS values remain below 35 mg/l for less than one week during runoff, or remain below 40 mg/l for less than two days during runoff.

<u>**Macroinvertebrate Communities (Goat Creek Primary Target #2)**</u>**:** ***Macroinvertebrate community metrics associated with sediment must indicate full support conditions based on standard DEQ protocols***.

Rationale:

This standard water quality target is consistently applied to all waterbodies in Montana, and provides a direct indication of beneficial use support for aquatic life.

Target Applicability Considerations

This target should be applied at two or three locations along Goat Creek, with at least one location above and one location below the confluence with Squeezer Creek consistent with the two separate segments from the 303(d) list.

7.4 Additional Target Conditions in the Swan Lake Watershed

This section provides indicator parameters or conditions that can be used as the basis for additional impairment determinations in Swan Lake and in tributary streams within the Swan Lake Watershed. These additional conditions are meant to address potentially new impairments versus those specifically identified on the existing or a recent 303(d) list and otherwise addressed by the above targets. Based on these indicator parameters and further analyses, additional water quality planning and TMDL development may be necessary on a case-by-case basis. The purpose of this section is to draw attention to specific issues or threats that exist or may exist in the watershed. This, then, provides another tool to help with future water quality planning and goal setting.

Swan Lake Near Shore Beneficial Use Protection (Additional Target Condition #1): ***No human-caused near-shore algal blooms that would result in a beneficial use impairment based on DEQ protocols.*** Near shore algal blooms may indicate septic or other nutrient impacts. A near-shore algal investigation will be conducted to identify potential nutrient sources. If such sources are found, a source reduction strategy will be developed as part of the implementation of this water quality restoration plan.

Rationale:

This target condition addresses near-shore aquatic life beneficial use support indicators and provides an overall indication of excess nutrient loading to shallow waters. It can also ensure protection of lake aesthetics. One of the water quality concerns is increased development around Swan Lake and potential impacts from septic and other nutrient sources. Monitoring suggestions to address this target condition are provided in Section 10.0.

Current Indications of Impairment

At this time data does not exist to suggest an impairment condition, other than apparent observations of near shore water quality degradation noted by local residents.

Fish Passage (Additional Target Condition #2): ***With input from fisheries professionals, culverts or other human related fish passage barriers will be removed or mitigated to allow for fish passage and ensure proper utilization of streams by desirable fish species.*** Not meeting this target condition can provide the basis for an impairment determination on a stream, although this type of impairment would not require TMDL development since it is not linked to a pollutant.

Rationale:

Where fish passage is desirable, the presence of any individual fish passage barrier can provide the basis for an impaired waterbody determination due to the fact that the fish passage problem can prevent a waterbody from fully supporting the cold-water fish beneficial use. In some cases, it may be desirable to keep a culvert as a fish passage barrier to prevent undesirable species from moving into areas they currently do not inhabit. Input from fisheries professionals will be used to determine where fish passage barriers are a significant concern.

Current Indications of Impairment

Fish passage barriers are not unusual based on results in other TMDL planning areas around the state. Some undesirable human caused fish passage barriers likely exist in the Swan Lake drainage. The Flathead National Forest is currently evaluating fish passage capabilities for culverts in priority fish bearing streams in the Swan Lake Watershed.

Protection of Bounded Alluvial Valley Stream Segments Where Bull Trout Spawning Occurs (Additional Target Condition #3): ***Significant human related impacts to bounded alluvial valley segments must be avoided***. Significant impacts to even one of these segments could lead to an impairment determination for the impacted stream. Impacts can include activities that directly or indirectly reduce spawning habitat, such as channel alterations that reduce pools, watershed changes that negatively impact hydrogeologic flow conditions, increased percent fines, or riparian alterations that reduce large woody debris and/or significantly increase temperature. Increased percent fines are partially addressed as a separate target (Additional Target Condition #4 below) due to the availability of McNeil Core data.

Where potentially significant impacts may have occurred along one of these stream segments, DEQ can evaluate alterations relative to reference or pre-disturbance conditions and make an impairment determination. Targets could then be developed based on these results, and additional TMDL development may be necessary.

Rationale:

As discussed in Section 5.17, bounded alluvial valley stream segments are critical for bull trout spawning success in the Swan Lake Watershed. Therefore, these stream segments can represent some of the primary habitat for supporting the cold-water fish beneficial use. The evaluation of potential impacts from human activities should include focused evaluations of individual bounded alluvial valley stream segments. Assessments must take into account that significant impacts in a major spawning reach may not otherwise seem significant when averaged across a longer stream segment. The McNeil Core sampling essentially addresses excess fines in spawning gravels in these reaches, and is used as the basis for separate target conditions.

Current Indications of Impairment

At this time, assessment activities have not identified any new significant impacts to a bounded alluvial valley segment. It is presumed that this target condition, other than the potential for excess fines in Jim Creek and other streams as discussed below, may be satisfied in most or all locations due to riparian protection requirements associated with timber harvest.

Tributary Fine Sediment Levels (Additional Target Condition #4): ***McNeil Core percent fines values should be consistent with suggested target values discussed in Section 5.15 and applied to Jim Creek above***. The target range is identified as 30 to 35%, with 35% representing the normal upper target value. Where sufficient results are available for a given stream, the target can be at the low end of this range. On the other hand, natural conditions in some streams may make it impossible to expect McNeil Core values below 35% most years.

Rationale

Elevated levels of fine sediment from human activities reduce fry emergence and are therefore a direct indicator of impairment conditions. Given the variability of natural fine sediment levels within a glaciated environment like the Swan Valley, this target may be modified on a stream-by-stream basis as additional results are collected.

Current Indications of Impairment

A review of Figure 5-13 shows that in addition to Jim and Lion Creeks, Soup and Woodward Creeks are also above this 35% level. The data also show some recent relatively significant increases in percent fines in South Lost Creek. Because there is significant spatial and temporal variability in percent fines data (Section 5.15) and because some streams are naturally above 35%, the high percent fines values alone are not sufficient to warrant an impairment determination for any of these streams at this time. These high values do indicate that further investigation into the cause of high or recently increased fines should be pursued, particularly in streams with significant recent timber harvest activities. Based on further analyses, the percent fines values can then be used as an impairment indicator and for eventual TMDL target development.

7.5 Target Applicability and Development of New Targets

7.5.1 Adaptive Management Approach

An adaptive management approach is applied toward the water quality targets defined within this section. Adaptive management has been defined as “an innovative technique that uses scientific information to help formulate management strategies in order to ‘learn’ from programs so that subsequent improvements can be made in formulating both successful policy and improved management programs" (Halbert, 1993). Adaptive management will help address important considerations such as the feasibility and uncertainty in establishment of targets. Despite implementation of all restoration activities, the attainment of some targets may not be feasible due to any number of reasons. Natural disturbance as discussed below may impact natural sediment loading and can influence McNeil Core data for a period of time. Similarly, it is possible that the natural potential of some streams will preclude achievement of a target. Conversely, some targets may be underestimates of the potential of a given stream and more protective targets may be appropriate where supported by sufficient data. In light of these issues, it is important to recognize that the adaptive management approach provides the flexibility to refine targets as necessary to ensure protection of the resource or to adapt to new information concerning target achievability.

7.5.2 Natural Disturbances Such as Fires or Floods

The targets all apply under normal conditions of natural background loading and natural disturbance. It is recognized that under some natural conditions such as a large fire or flood event, it may be impossible to satisfy some of the targets, such as percent fines, for a period of time. The goal under these conditions will be to ensure that management activities within the watershed or individual tributaries are undertaken in such a way that the recovery time to conditions where the targets can be met is not delayed. Another goal will be to ensure that potentially negative impacts to beneficial uses from natural events are not significantly increased due to human activities. This approach is not intended to preclude activities such as salvage harvest, but is instead intended to help ensure any such efforts are undertaken in a manner that is protective of water quality.

7.5.3 Development of New Targets in Tributaries

As any one tributary watershed undergoes a substantial increase in development, or has undergone a significant increase in development to the point where impairment conditions could reasonably be anticipated, then a stream assessment should be performed. Specific targets may then need to be developed to ensure that many of the channel and other indicators are within the range of other waterbodies in the watershed and will stay within that range via the application of BMPs and reasonable land, soil and water conservation practices. There may be several streams where the existing road analyses or future aerial assessment work could be used to justify this additional assessment work. The additional target conditions defined in Section 7.4 can help focus additional assessment and target setting efforts.

SECTION 8.0
TOTAL MAXIMUM DAILY LOADS (TMDLS) AND ALLOCATIONS

This section identifies total maximum daily loads (TMDLs) and allocations to correct impairments and threatened conditions in the Swan Lake Watershed and to help prevent future impairments. TMDLs are developed for pollutants such as sediment, POC, and nutrients (phosphorous and/or nitrogen). The TMDL identifies the maximum pollutant loading, pollutant reductions, and/or other conditions necessary to achieve target values. Allocations are then developed to identify how the TMDL can be accomplished, and, more importantly, how water quality can be restored and protected. The allocations apply to existing sources that contribute to impairments or threatened conditions. Allocations can also be developed for future activities that have the potential to significantly contribute to impairments or threatened conditions if not properly managed (EPA, 1999a).

8.1 Swan Lake Watershed TMDLs

8.1.1 Swan Lake Organic Carbon and Nutrient TMDLs

The technical definition of TMDL is "the sum of load allocations plus waste load allocations plus a factor of safety." The definition implies that the TMDL is expressed as a pollutant mass load per time, but the TMDL can instead be expressed through appropriate measures other than mass loads per time (40 CFR 130.2). The use of an alternative approach for TMDL analysis is justified in guidance developed by EPA (EPA, 1999a). A commonly used alternative approach is to express the TMDL as a percent reduction in loading. This reduction can be based on the departure from target conditions or based on estimates of human loading conditions above natural background loading.

For Swan Lake, the particulate organic carbon (POC) TMDL is identified as no increase in total POC loading to Swan Lake. This TMDL directly addresses the threatened condition associated with low DO and the loading (siltation) of organic carbon to the bottom of Swan Lake. Preventing increased POC loading should eventually mitigate the low DO threat in the bottom of Swan Lake. Although many of the historic land uses and associated impacts contributing to POC loading have been mitigated via forestry BMPs, there is still a significant threat of increased POC loading from private development as well as some continued POC loading from silviculture practices. Section 5.0 identified opportunities for reduced POC loading from silviculture even with continued harvest throughout the watershed. One such opportunity for reduced POC loading includes continued recovery of riparian areas. Another involves POC associated with road erosion and subsequent delivery of eroded material to streams. The road sediment loading analysis (Section 5.2.2) identifies significant loading conditions that can be mitigated, providing the basis for Swan Lake Secondary Target #2 in Section 7.1.2.

An additional nutrient TMDL is also developed to ensure protection of Swan Lake from excess phosphorous and nitrogen loading. This nutrient TMDL is identified as no increase in total phosphorous and nitrogen loading to Swan Lake, based on the rationale provided for the POC TMDL. This nutrient TMDL serves several purposes listed below.

- It should protect Swan Lake from impairments associated with excess algal growth due to nutrient enrichment.
- It helps control additional POC loading to the bottom of Swan Lake due to excess algal growth.
- It helps satisfy additional Clean Water Act goal of TMDL development for all waterbodies as defined under Section 303(d)(3) of the Clean Water Act.
- It is consistent with efforts to protect Flathead Lake.

8.1.2 Jim Creek Sediment TMDL

A sediment TMDL is developed for Jim Creek to address the excess fines associated with the elevated McNeil Core results. The recent percent fines range of 38 to 40% over the past several years would require an average reduction of about 10% ((39-35)/39) to achieve the 35% target. Therefore, the sediment TMDL for Jim Creek is expressed as a 10% reduction in yearly loading of fine sediment to spawning gravels.

The upper Jim Creek impairment conditions are linked to habitat alterations that are not caused by excess sediment or pollutant loading to the affected stream segment. Although a TMDL is not developed to address this impairment, the necessary restoration objectives to ensure full support conditions and compliance with Montana Water Quality Standards are defined below in Section 8.2.2.2 as part of a comprehensive water quality planning approach.

8.1.3 Goat Creek Sediment TMDL

A sediment TMDL is developed for Goat Creek to address the elevated total suspended solid (TSS) levels during runoff conditions. The 45 mg/l TSS value measured in 1997 is about 33% above the target value of 30 mg/l (Section 7.3). Therefore, the sediment TMDL for Goat Creek is expressed as a 33% reduction in fine suspended sediment loads during peak flow conditions based on 1997 loading data.

8.2 Swan Lake Watershed Allocations

This section identifies allocations that support the TMDLs developed above for Swan Lake. The goal is to ensure that the Section 7.0 water quality targets are met and, more importantly, that beneficial uses are restored and/or protected. The allocations all apply to nonpoint sources and are therefore defined as load allocations. Waste load allocations are not required since there are no permitted point sources regulated under the National Pollutant Discharge Elimination System.

Because many of the allocations are based on voluntary implementation of management practices, it will require the assistance of all landowners to ensure protection of water quality. If a landowner or set of landowners exceeds an allocation relative to their percentage of land ownership, then the risk of not meeting water quality targets is increased. Under these conditions, an additional burden could be placed on other landowners to compensate for the unexpected increase in impact/loading if Swan Lake is to be protected. Nevertheless, some allocations should be applied to major landowners or major landowner category as discussed within Sections 8.2.1 through 8.2.3.

Based on the water quality discussion and assessment results in Sections 4.0 and 5.0, significant sources and pollutant loading pathways of concern for current and continued water quality impairments and threats in Swan Lake and its tributaries are as identified below (not listed in any order of relative contribution).

- Sediment loading from road erosion and road sanding. This includes nutrients, primarily inorganic phosphorous, that tend to attach to sediment particles. The road sediment load may be highest in areas of recent road building such as South Woodward Creek (Figure 5-4). Sediment loads from new roads and existing roads, as well as road sand, will also include a portion of POC.
- POC loading and other types of pollutant loading (sediment and nutrients) from other timber management impacts as generally discussed in Section 4.1.2.1.
- Nutrient, sediment and POC contributions from septic tanks, domestic animals, and other rural land development activities typically associated with private home development. These other development activities can result in bank erosion and pollutant loading pathways similar to many of the loading pathways associated with timber harvest (Sections 4.0 and 5.0).

8.2.1 Swan Lake Allocations

The load allocations for Swan Lake are summarized in Table 8-1. Because of similar loading sources, the POC and nutrient TMDL allocations are combined into one set of allocations. The allocations are set at levels that are intended to reflect implementation of reasonable and acceptable land management practices and water quality protection expectations. Sediment loading is used as a surrogate for POC and nutrient loading in some allocations since the assessment methodologies focused on measures of sediment versus POC and nutrients. Several of the allocations involve a reduction in POC and nutrient loading to Swan Lake. These provide a margin of safety since both the POC and nutrient TMDLs are no increased loading of these pollutants. The allocations also effectively address future growth considerations since they limit existing pollutant loading impacts and effectively set upper limits for future pollutant loading impacts for the identified sources of concern.

Table 8-1. Source Load Allocations for Swan Lake.

Source Area/Type	Allocation	Methods to Achieve Allocation
Road Erosion: Nutrient and POC loading associated with sediment delivery from road erosion.	40% total reduction in modeled sediment loading from road stream crossings (as defined in Section 5.2.1) based on the FRS method.	Road BMPs.
Riparian and Streambank Protection: Nutrient and POC loading associated with eroding banks, loss of woody debris and riparian vegetation impacts.	10% decrease in total loading throughout the Swan Lake Watershed. Canopy density is used as a surrogate to measure progress.	Protect vegetation and banks on private, non-forest lands; recovery from past riparian harvest; maintain and protect adequate channel migration zones; compliance with Montana's SMZ law.

Table 8-1. Source Load Allocations for Swan Lake.

Source Area/Type	Allocation	Methods to Achieve Allocation
Other Timber Harvest Impacts: Nutrient and POC loading from timber harvest (other than road erosion and riparian harvest covered above); this also includes road culvert failures.	No loading increase	Ensure that mass wasting, peak flow increases, road failures, and hillslope erosion impacts are controlled via implementation of BMPs and reasonable land, soil and water conservation practices.
Septic, Near-Shore (Swan Lake) and Additional Private (non-timber) Landowner Management Activities: Nutrient and POC loading from these sources.	Septic loading directly to Swan Lake: 3635 kg of nitrogen 100 kg of phosphorous per year – this reflect no increase to Swan Lake based on conservatively high loading estimates from Section 5.10. Also, no increased loading due to near-shore and other landowner property management activities.	Septic maintenance, upgrades and other BMPs; private landowner management practices to limit pollutant loading; continued training and education of septic contractors; adherence to state nondegradation policy and other applicable state and local regulations.
Road Traction Sanding	Reduced loading via development and implementation of road sanding and sediment delivery BMPs (performance-based allocation).	Development and implementation of road sanding and sediment delivery BMPs.
Airborne Sources: Nutrient loading from airborne sources.	Allocation is contingent upon Flathead Lake TMDL phased allocation approach for this source category.	Sources and loading rates need better definition.
Future Point Sources: Potential nutrient loading from yet-to-be identified point sources.	An allocation consistent with the nutrient TMDL will be developed if a point source is proposed.	Wastewater and other water treatment methods.

The Table 8-1 allocations are discussed in further detail in Sections 8.2.1.1 through 8.2.1.6 below.

8.2.1.1 Road Erosion

The allocation for nutrient and POC loading associated with sediment delivery from roads is based on a reduction of 430 tons per year throughout the watershed using the FRS analysis described in this document. This erosion from roads applies cumulatively to all road types. This equates to a 40% reduction in road sediment load. An example of how this might be accomplished is to reduce the sediment load from the worst 20 sites (Table 5-2) by 75% and by 50% for the next 50 worst sites (Table F-2). Of course, some sites may have higher or lower potential reductions, and other sites that did not fall within the top 70 sediment producers may have potential reductions.

From an implementation perspective, the road erosion allocation can be further divided to individual landowners since a given landowner can only be expected to address excess erosion from roads under their ownership. Under these circumstances, the anticipated load reduction for an individual landowner would be consistent with road ownership and the potential for load reductions through implementation of BMPs and other measures, such as road decommissioning, to reduce road sediment loading. This performance-based approach would focus on the landowner's performance of actions or practices to reduce sediment loading using management practices such as erosion BMPs or a reduction in total road crossings for roads under their responsibility. This approach may be appropriate since some landowners may have a relatively high percentage of roads contributing high levels of sediment and in need of BMPs, thus justifying a higher percent reduction in sediment loading. Other landowners may have fewer roads in need of BMPs and a lower level of controllable erosion, thus making a 40% reduction unattainable. Nevertheless, the allocation is still applied to the total calculated road sediment load such that all landowners should work together to ensure that this allocation is obtained.

8.2.1.2 Riparian and Streambank Protection

The allocation for riparian and streambank protection addresses impacts from both private, non-industrial land development (e.g. private home development) as well as from timber harvest activities. The allocation addresses stream health and pollutant loading reductions by promoting improved large woody debris recruitment and protection of floodplains, riparian areas and streamside management zones including channel migration zones. The allocation indirectly addresses potential eroding bank concerns since continued riparian protection will help keep eroding bank loads at relatively low values as implied by assessment efforts discussed in Section 5.0 and Appendix J.

Canopy density can be used as a surrogate to measure progress. An increase in average canopy density of about 10%, using the 1997 aerial photos as the baseline, is considered achievable based on aerial and physical assessment results. The continued tree growth is a measure of continued recovery from past riparian harvest. Canopy density can also be a measure of how well riparian areas are being protected as private land development increases within the watershed. Additional aerial assessment indicators such as average buffer width, amount of impervious surface near streams, and structures within riparian zones should also be tracked as part of the surrogate measure of meeting this allocation. Any significant increases, such as greater than a 10% increase along a stream segment, for any of these parameters would be an indication that the goals of this allocation are not being satisfied.

Although the above measures indirectly address eroding banks, it would be desirable to further evaluate eroding bank lengths in upper reaches of the Swan River to determine a baseline condition and ensure that there are no further increases in human caused bank erosion. A repeat of the bank erosion inventory for the lower portion of the Swan River can also be an indicator of satisfying this criterion since a 10% increase in bank erosion from the 2001 measured levels would be an indication that the goals of this allocation are not being satisfied. In evaluating bank erosion, any riprap or similarly armored bank should be counted as a contribution to down streambank erosion equivalent to the length of armored bank.

Compliance with Montana's SMZ law is an important method to help achieve this allocation. In general, landowners involved with forestry practices can meet this allocation by limiting or avoiding harvest near stream channels and limiting impacts associated with roads or grazing. As discussed in Montana's Forestry BMPs (Logan, 2001), the protected area needs to account for the channel migration zone in order to provide effective protection over time. For private homeowners, this allocation can be met by limiting or avoiding the removal and disturbance of riparian areas associated with logging, grazing, structures, roads, and general landscaping activities. Future assessment of progress toward meeting the goals of this allocation can be based on individual landowner or landowner categories and their contributions toward achieving the goals of this allocation.

Similar to the salvage harvest discussion under Swan Lake Secondary Target #3 (Section 7.1.2), some types of salvage work, such as thinning small trees near a stream, may seem inconsistent with this allocation, but can be consistent with the overall water quality protection intent. Examples may include projects to help promote large tree growth in previously harvested areas or projects to help prevent more significant water quality impacts linked to unnaturally high fuel buildup along streams where historical timber harvest or fire suppression practices created undesirable conditions. Nevertheless, timber harvest for the purpose of paying for salvage activities will count against the allocation since other funding mechanisms could be provided.

8.2.1.3 Other Timber Harvest Impacts

The allocation for other timber harvest impacts is for no loading increase to Swan Lake from current POC and nutrient loading levels. This primarily applies to hillslope and mass wasting loading and impacts associated with increased water yield and corresponding peak flow increases. Scheduled forest practice audits indicate a high level (96%) of BMP compliance associated with new timber harvest activities. A continued high level of compliance for new and existing harvest activities is anticipated as the primary method to achieve this allocation.

Certain types of management activities may seem inconsistent with this allocation but can be consistent with the overall water quality protection intent. For example, prescribed fires, where used to avoid more catastrophic events from unnaturally high fuel buildups, can be considered a suitable management practice to help limit unnaturally high pollutant loading pulses. Impacts from road additions or modifications would still need to be accounted for and mitigated via BMPs and other measures. Furthermore, timber harvest for the purpose of paying for salvage or prescribed fire activities will count against the allocation since other funding mechanisms could be provided.

To further ensure that the intent of this allocation is satisfied and to help differentiate between human caused and natural loading, land use indicators should be tracked within tributary watersheds. These include harvest levels on sensitive land types and total equivalent clearcut areas (ECA) in tributary watersheds. Where significant harvest occurs on sensitive land types, or where ECA values are very high in a watershed, additional effort should be made to evaluate the overall success of BMP implementation and potential for accelerated pollutant transport. Defining what constitutes significant harvest on sensitive land types or significant ECA values should involve key technical stakeholders and landowners in the watershed.

Another tributary land use indicator that should be tracked is the increase in modeled water yield as a surrogate to increased runoff and peak flow. As discussed in Section 5.5.3, timber harvest activities can impact water yield such that peak flows increase, potentially causing increased bank erosion and bed scour. Consideration of water yield and related impacts to streams is consistent with EPA guidance for sediment TMDLs (EPA, 1999a) where it is stated: “In some settings, land management changes cause changes in runoff even if they do not result in increased upslope erosion. Where this occurs, channel erosion or sediment deposition may increase. It might be appropriate to develop sediment TMDLs to address this type of situation." Montana State Water Quality Standards also support consideration of water yield and related increased flows for TMDL development. According to state standards, activities that increase mean monthly flows above a certain value (15% in a *healthy* stream) can require an authorization to degrade (ARM 17.30.715).

Stable banks and healthy vegetation in streams assessed during 2001 and 2002, along with relatively high levels of large woody debris in many segments, suggest that most tributaries in the Swan Lake Watershed are not particularly sensitive to peak flow increases. Nevertheless, increases in peak flows above 12% due to timber harvest, based on equivalent clearcut area (ECA) protocols developed by the Forest Service (King, 1989), should warrant additional evaluation to ensure consistency with the goals of the "other timber harvest impacts" allocation. In evaluating potential impacts and/or determining whether this indicator level has been reached, the historic structure of conifer stands can be a consideration. In other words, some types of thinning efforts may actually end up increasing water yield, but the increase may be more representative of naturally occurring conditions. Alternatively, forest roads are to be added to the ECA. For watersheds where fire has significantly increased water yield, then increases in water yield due to timber harvest are to be evaluated to ensure that management activities within the watershed or individual tributaries are undertaken in such a way that the recovery time to conditions where the targets can be met is not significantly delayed. Another goal will be that water yield increases due to human related clearing do not significantly increase the extent of negative water quality or habitat impacts during the recovery period from a natural event.

A final tributary land use indicator is risk associated with culvert failures. This planning effort did not include a detailed analysis of the potential loading associated with undersized culverts. Analyses performed in other watersheds, such as for St Regis TMDL development (Lolo National Forest, unpublished data) indicate that the sediment loading risk associated with undersized or poorly maintained culverts could be significant within individual tributaries of the Swan Lake Watershed. An indicator of the potential risk is overall road density, since a higher road density indicates more stream crossings and more potential undersized culverts. The USDA Forest Service classified road density in examining the characteristics of aquatic/riparian ecosystems in the Columbia River Basin. Road density was considered "high" if it exceeded 1.7 miles per square mile (U.S. Forest Service, 1996). Therefore, whenever new road building is pursued and the road density exceeds or will exceed 1.7 miles/sq. mi in a third order or greater tributary drainage, then the risks associated with culvert failure should be evaluated. Where there are undersized culverts (i.e. those that cannot at least pass a 25-year storm event), then new timber harvest activities should account for this risk in determining overall potential cumulative impacts. It may be necessary to reduce the sediment loading risk from culvert failure to offset additional sediment loading risk associated with new culverts or other silviculture impacts on a case-by-case basis to ensure consistency with the timber harvest impacts allocation. Similar to the road sediment allocation, a given landowner can only be expected to assess and mitigate undersized culverts on roads under their ownership, although the total road density indicator value must consider all roads under all ownership including abandoned roads where culverts may still be in place.

Ideally, all road crossings and culverts would be upgraded to pass the 25-year storm event, and tributary drainages with a high road density would have the majority of road crossings and culverts upgraded to pass a 50 to 100 year storm event in order to minimize total loading risk associated with high road densities. Also, key road crossings along important bull trout or cutthroat trout streams should be upgraded to pass a 50 to 100 year storm event and to ensure fish passage. Proper road decommissioning with total culvert removal is also an appropriate method to address undersized culverts.

A number of approaches can be taken to quantify the risk and risk reduction associated with culvert failure. For example, upgrading a culvert that currently can pass a 25-year runoff event to one that can pass a 50-year runoff event can be considered a 50% reduction in failure or loading risk for that particular culvert over a 100 year period since the number of times runoff exceeds the culvert capacity is approximately cut in half over a typical 100 year period.

Road density and the total number of road crossings should be tracked within tributary watersheds. Tributaries with significant increases in road density and/or a large number of crossings can be priority areas to ensure proper BMP implementation, particularly for new roads built for private home development.

8.2.1.4 Septic, Near-Shore (Swan Lake) and Additional Private (non-timber) Landowner Management Activities

The allocation for septic loading is no nutrient loading increases to Swan Lake based on the conservative loading estimates of 3635 kg of nitrogen and 100 kg of phosphorous per year. These values were identified as a relatively low percentage of the total load to Swan Lake. The actual load is likely significantly less than this value due to the nature of the method used to estimate the load in Section 5.10. A more accurate determination of the existing load, via a more sophisticated modeling approach supplemented with ground water quality monitoring, is recommended and discussed in Section 10.0. Also, this allocation includes no loading increases due to near-shore and other landowner property management activities. The near shore loading was not identified as a significant source of total nutrients and POC loading to Swan Lake, but is the type of loading threat that should be kept to a minimum via standard lawn care and other private home BMPs. Furthermore, nutrient and POC loading reductions need to be pursued by private landowners in support of this allocation for special situations such as fish pond operations or other unique activities that can lead to increased nutrient loading.

The septic and near-shore nutrient load allocations discussed above are focused on meeting the Swan Lake nutrient TMDL. This allocation is contingent upon a satisfactory beneficial use determination associated with Additional Target Condition #1 (Section 7.4), which requires that a near shore investigation of excess nutrient impacts on aquatic life must indicate a full support condition. If problems are noted, then a new impairment may be identified on the 303(d) list, possibly requiring additional nutrient TMDL and allocations in the form of load reductions to ensure protection of Swan Lake beneficial uses. Even if problems are not noted, efforts should be pursued to limit septic and near-shore impacts as discussed in Sections 5.11 and 9.2.4. Although not identified as a significant source within the allocations for Swan Lake, septic impacts to ground water throughout the whole Swan Lake Watershed should be limited to the extent practical via BMPs and compliance with applicable state and local regulations.

8.2.1.5 Road Traction Sanding

The performance-based road sanding allocation is based on ongoing efforts by the Montana Department of Transportation to incorporate BMPs. This includes ongoing research to identify the best designs and procedures for minimizing road sand impacts to adjacent waterbodies. These BMPs must also be compatible with the safety of the traveling public and road maintenance crews. Road sand BMPs may include a reduction in plowing speeds, improved maintenance and road sand recovery, and the increased use of chemical deicers as long as doing so does not create a safety hazard or cause undue degradation to plant and water quality. Additional BMPs can include measures to further reduce road sand delivery within the drainage system, including improved vegetative buffers, routing flows away from streams, and additional catchment areas for improved settling of transported material. It is anticipated that additional BMPs, once implemented, can lead to reduced road sand loading and provide additional protection of water quality within the watershed.

8.2.1.6 Future Allocation Considerations for Airborne Sources and Regulated Point Sources

Airborne sources of nutrients above naturally occurring levels have been identified as a likely significant source of nutrient loading to Flathead Lake. Airborne sources are currently being evaluated as part of implementation efforts for the Flathead Lake Nutrient Management Plan. Results from this work can be used to set allocations based on potential source reductions that could ultimately be pursued for Flathead Lake. Once the allocation work has been completed for Flathead Lake, it will be decided if this information should be incorporated into Swan Lake water quality protection efforts in the form of an additional allocation.

Although no future point sources are anticipated at this time within the Swan Lake Watershed, it is possible that a community or subdivision could end up dealing with human waste via a wastewater treatment facility which discharges to a waterbody. This discharge would then be regulated as a point source under the National Pollutant Discharge Permit System. Under this scenario, the discharge limits (waste load allocations) would need to be set at values consistent with the allocations within this section.

8.2.2 Jim Creek Allocations and Restoration Strategy

8.2.2.1 Allocations for the Jim Creek Sediment TMDL

The Jim Creek load allocations to address excess fine sediment and satisfy the sediment TMDL are summarized in Table 8-2. These allocations are in addition to the Section 8.1 Swan Lake allocations that are applicable to tributaries, although focus is on sediment producing impacts since these allocations are linked to the Jim Creek sediment TMDL. This sediment TMDL is specifically identified as 10% reduction in yearly loading of fine sediment (< 6.35 mm) to spawning gravels. This is in recognition that any elevated sediment load within spawning gravels in Jim Creek is apparently from historic sediment loading (Section 5.15 and Appendix B) already within the stream channel versus newer sources of loading. The strategy is to maintain a low level of sediment loading to the stream channel while providing more time for flushing of potentially elevated existing in-stream sediment loads through the system. The allocations effectively address future growth considerations since they limit existing pollutant loading impacts and/or effectively set upper limits for future pollutant loading impacts for the identified sources of concern.

Table 8-2. Source Load Allocations for Jim Creek.

Source Area/Type	Allocation	Methods to Achieve Allocation
Road Erosion: Sediment delivery to streams from road erosion.	Total sediment delivery load to remain below 6 tons/yr based on FRS model.	Road BMPs; allocation currently satisfied.
Riparian and Streambank Protection: Sediment loading associated with stream storage changes and eroding banks.	Protection of streambanks and improved large woody debris recruitment using canopy density as a surrogate measure. Specific focus on increased canopy density (from current average of 0.2 to an average of 0.5) in upper reaches of Jim Creek, and no decrease in canopy density for the lower reaches of Jim Creek.	Protect vegetation and banks on private, non-forest lands; recovery from past riparian harvest; maintain and protect adequate channel migration zones; compliance with Montana's SMZ law.
Other Timber Harvest Impacts: Sediment loading from timber harvest.	No sediment loading increases other than potential minor predicted impacts associated with 100% compliance with forestry BMPs.	Ensure that mass wasting, peak flow increases, road failures, and hillslope erosion impacts are controlled via implementation of BMPs and reasonable land, soil and water conservation practices.

The Table 8-2 allocations are discussed in further detail Sections 8.2.2.2.1 through 8.2.2.2.3 below.

8.2.2.1.1 Sediment Delivery from Roads

A review of Table F-2 shows that no road crossings within the Jim Creek drainage are within the top 70 sediment delivery points used as the basis for Swan Lake road erosion allocation discussed in Section 8.2.1.1. The current (2001) Jim Creek drainage sediment delivery was calculated at 2.6 tons/yr or about 2% above natural background. Most of this delivery is from road crossings below the location where the McNeil Core sampling is performed (Map 5-1 and Appendix F results). This 2% above natural background in the Jim Creek drainage is substantially less than the current average of 24% above natural background throughout the Swan Lake Watershed. It is also substantially less than the desired average of 14% above natural background for the Swan Lake Watershed that would exist once the road reduction allocation (Section 8.2.1.1) has been satisfied. Review of the Goat Creek McNeil Core sample results (Figure 5-13), Goat Creek sampling location (Map 5-1), and specific sediment delivery locations (Appendix F) indicates that a calculated sediment delivery of about 6 tons per year above the

Goat Creek McNeil Core sample site has not resulted in excessive fines loading to the spawning area evaluated. The drainage area above the Goat Creek McNeil Core site is similar in size to the area above the Jim Creek sample location. Therefore, a total road sediment delivery allocation of 6 tons per year is applied to the Jim Creek drainage to avoid excess fines loading to spawning gravels within the Jim Creek drainage. This allocation is applied to the whole drainage as an additional margin of safety and to also ensure protection of downstream aquatic life uses and compliance with Jim Creek Primary Target # 3.

The allocation for road sediment loading is greater than the existing load in recognition of the fact that the impairment is from excess fines loading that occurred several years ago and may still need to flush through Jim Creek. It is also in recognition that water quality standards are based on deviations from naturally occurring conditions where reasonable land, soil and water conservation practices are in place. Maintaining a road sediment delivery load of 6 tons per year or less via the use of standard road crossing BMPs is consistent with the intent of the water quality standard. If all allocations are satisfied and spawning gravel fines are still elevated for several more years above the target level identified in Section 7.2, then the target may need to be modified in recognition of the stream's potential if responsible timber harvest activity is pursued within the watershed.

8.2.2.1.2 Riparian and Streambank Protection

The purpose of this allocation is the same as described above for the Swan Lake allocation in Section 8.2.1.2, with canopy density used as a surrogate to measure progress. The surrogate canopy density allocation for the upper portions of Jim Creek (Reaches Jim-22 through Jim-31) is an increase in average canopy density from 0.2 to 0.5 based on aerial assessment results used in Appendix I. This upper portion of Jim Creek is lacking larger trees within riparian areas, with historical riparian harvest having a significant impact on canopy density and resulting large woody debris. An increase in large woody debris could, over time, contribute to increased sediment storage and some reduced downstream loading of fines to spawning gravels. Protecting the riparian area will also help protect streambanks from excessive erosion. The riparian and streambank protection allocation for the remainder of Jim Creek is no decrease in average canopy density since values are relatively high over most of the remaining reaches in Jim Creek.

In general, landowners involved with forestry practices can meet this allocation by limiting or avoiding harvest near stream channels and limiting impacts associated with roads or grazing, particularly in the upper portion of Jim Creek. For private homeowners, this allocation can be met by limiting or avoiding the removal and disturbance of riparian areas associated with logging, grazing, structures, roads, and general landscaping activities. Future assessment of progress toward meeting the goals of this allocation can be based on individual landowner or landowner categories and their contributions toward achieving the goals of this allocation.

8.2.2.1.3 Other Timber Harvest Impacts

The allocation for other timber harvest impacts is for no increased delivery of sediment load to Jim Creek other than potential minor predicted impacts associated with 100% compliance with forestry BMPs. All land use indicators apply as discussed in Section 8.1.2.3. Historic harvest under this allocation category is considered the primary source of elevated fine sediment. Although this harvest may no longer be contributing significant loads to Jim Creek, the elevated fines in spawning gravels suggest the possibility of significant loads remaining within Jim Creek from past delivery to the stream.

8.2.2.2 Jim Creek Restoration Objectives to Address Upstream Habitat Impairment Conditions

The upstream portions of Jim Creek are lacking in pools with cover and large woody debris, thereby having a probable negative impact on aquatic life. Jim Creek Primary Target #2 was developed to specifically address this impairment. A TMDL has not been developed for this habitat alteration since the impairment is not caused by excess sediment accumulation in this segment of Jim Creek. Nevertheless, a restoration objective to address this impairment is developed here to ensure eventual compliance with Montana Water Quality Standards for all identified impairment conditions.

The restoration objective is to increase large woody debris recruitment and to eventually achieve increased large woody debris within the channel and improved habitat conditions for aquatic life. The Section 8.2.2.1.2 sediment TMDL allocation for increased canopy density from an average of 20% to 50% in the upper portions of Jim Creek, to be accomplished by protecting the riparian area from harvest and other forms of development, effectively provides the restoration strategy for this impairment condition. This riparian protection objective will likely apply to the upstream portion of Jim Creek long after resolution of downstream sediment impairment conditions.

8.2.3 Goat Creek Allocations

The Goat Creek load allocations to address excess fine sediment and satisfy the sediment TMDL are summarized in Table 8-3. These allocations are in addition to the Section 8.1 Swan Lake allocations applied to tributaries, although focus is on sediment producing impacts since these allocations are linked to the Goat Creek sediment TMDL. The allocations are in recognition of potentially improved conditions within the watershed since the 1997 sampling events that the excess total suspended solids impairment determination is based on. The allocations effectively address future growth considerations since they limit existing pollutant loading impacts and effectively set upper limits for future pollutant loading impacts for the identified sources of concern.

The Table 8-3 allocations are discussed in further detail in Sections 8.2.3.1 through 8.2.3.3 below. An allocation is not specifically identified for Highway 83 road sanding since the highway crosses Goat Creek below the confluence with Squeezer Creek and below the identified impairment.

Table 8-3. Source Load Allocations for Goat Creek.

Source Area/Type	Allocation	Methods to Achieve Allocation
Road Erosion: Sediment delivery to streams from road erosion.	Total sediment delivery load in the upper Goat Creek watershed above Squeezer Creek to remain below 17 tons/yr based on FRS model	Road BMPs.
Riparian and Streambank Protection: Sediment loading associated with stream storage changes and eroding banks.	Performance based protection of streambanks and improved large woody debris recruitment using canopy density as a surrogate measure.	Protect vegetation and banks on private, non-forest lands; recovery from past riparian harvest; maintain and protect adequate channel migration zones; compliance with Montana's SMZ law.
Other Timber Harvest Impacts: Sediment loading from timber harvest.	No sediment loading increases other than potential minor predicted impacts associated with 100% compliance with forestry BMPs.	Ensure that mass wasting, peak flow increases, road failures, and hillslope erosion impacts are controlled via implementation of BMPs and reasonable land, soil and water conservation practices.

8.2.3.1 Sediment Delivery from Roads

A review of Table F-2 shows that several road crossings within the Goat Creek drainage are within the top 20 to 70 sediment delivery points where a 50% reduction in loading was used as the basis for Swan Lake road erosion allocation discussed in Section 8.2.1.1. The current (2001) Goat Creek drainage sediment delivery was calculated at 29.6 tons/yr or about 16.8% above natural background. If the application of BMPs to the top sediment producing road crossings can decrease sediment loading by 50%, then the road sediment load within Goat Creek would be below 17 tons per year. This allocation is essentially the same as the allocation for Swan Lake POC and nutrient reductions applied to Goat Creek.

8.2.3.2 Riparian and Streambank Protection

The purpose of this allocation is similar to the riparian and streambank protection allocation for Swan Lake in Section 8.2.1.2, with focus on prevention of streambank erosion. The same 10% increase in canopy density is used as the primary surrogate for this allocation.

8.2.3.3 Other Timber Harvest Impacts

The allocation for other timber harvest impacts is for no sediment loading increases to Goat Creek other than potential minor predicted impacts associated with 100% compliance with forestry BMPs. All land use indicators apply as discussed in Section 8.1.2.3.

8.3 Adaptive Management Approach to TMDLs and Allocations

Some level of uncertainty is inherent to pollutant load determinations and determination of relative source impacts in all non-point source TMDLs. Further uncertainty arises from the assumption that the load allocations defined for each stream and for Swan Lake will result in meeting all target conditions. This assumption necessitates an adaptive management approach to the TMDL. Under the adaptive management approach, as water quality protection efforts are implemented in a manner consistent with the TMDL and load allocations, implementation monitoring will occur to evaluate progress toward meeting the targets defined in Section 7.0. If it looks like greater reductions in loading or additional source controls are necessary to meet targets, then a new TMDL and/or new allocations will be developed based on achievable reductions via application of reasonable land, soil and water conservation practices. On the other hand, it is possible that a stream or Swan Lake will satisfy targets and be considered fully supporting even if the TMDL and/or some load allocations have not been satisfied, implying achievement of water quality protective goals. This stresses the point that meeting the targets represents compliance with applicable water quality standards and that the targets drive development of TMDL and allocations.

SECTION 9.0
WATER QUALITY PROTECTION AND IMPROVEMENT STRATEGY

9.1 Agency and Stakeholder Coordination

An important component of this Water Quality Protection Plan will involve maximizing and documenting the implementation efforts of the major land stewards in the basin. Achieving the targets and allocations set forth in this plan and as part of the TMDL development process will require a coordinated effort between land management agencies and other important stakeholders including the two County Governments and Conservation Districts (Lake and Missoula), private landowners including Plum Creek Timber Company, state and federal agency representatives, and representatives from conservation, recreation and community groups with water quality interests in the Swan Lake Watershed. Coordination of water quality protection in the Swan Lake Watershed can be facilitated via a formal watershed group and/or stakeholder group.

A watershed group can encourage consistent data collection and provide for a feedback mechanism whereby stakeholders can discuss and document water quality improvements being made. The group can provide peer input to monitoring plans and analysis of results, and help identify new water quality concerns and methods to document impacts. The group can also compile reports, and serve as a repository for data being collected throughout the Swan Lake Watershed.

A Swan Lake Watershed Technical Advisory Group (TAG) recently formed to help coordinate stakeholder involvement with water quality efforts consistent with the above goals. Prior to the release of this report, this group had met on two occasions and is focused on implementing several water quality strategies, including many of the monitoring recommendations in Section 10.0.

9.2 Implementation Strategies and Recommendations by Source Type/Category

This section describes water quality protection and improvement strategies for specific land use activities that can negatively impact water quality. The Swan Lake Watershed TAG is pursuing several of these strategies, as noted below.

9.2.1 Timber Harvest Activities (Silviculture)

Many of the components of this water quality protection strategy, as they relate to timber harvest practices, are already in place in the Swan Basin. For example, as part of its Native Fish Habitat Conservation Plan (NFHCP), Plum Creek has agreed to meet or surpass the protective measures outlined in Montana's forestry best management practices and to apply restoration measures to major sediment sources on its lands. The DNRC, on its lands, is already using road inventory data collected during the TMDL process to plan for restoration of several major sediment sources. Many of the most damaging forestry practices of the past – log drives, in-stream slash disposal, and riparian clear cutting – have been abandoned by the timber industry. Future harvests and road building associated with silviculture will be conducted according to best management practices (BMPs) and the Montana streamside management zone (SMZ) law.

Compliance with BMPs and the SMZ law is the primary strategy to protect and improve water quality within the watershed. Additionally, modeling water yield increases and tracking land use indicators are important to help evaluate potential water quality impacts (or lack thereof), from timber harvest activities in drainages where significant harvest occurs. The major landowners involved with timber harvest should facilitate this effort with development of GIS layers and shared databases. This information could then be coordinated with tributary monitoring activities such as those recommended in Section 10.0.

The 2002 physical assessment effort noted significant spotted knapweed infestations along several logging roads and old logging sites. Although not specifically identified as a problem along streams, noxious weeds such as knapweed should be controlled to prevent conditions where weeds out-compete more desirable riparian vegetation.

Implementation strategies for other harvest-related source categories like road sediment and culverts are addressed separately below because these impacts are also associated with other land use categories.

9.2.2 Reduction in Forest Road Sediment Loading

The forest road sediment assessment (Section 5.2) determined that there are 318 road sediment sources in the Swan Lake Watershed delivering a total of 1087 tons of sediment per year to streams throughout the Swan Basin. The assessment results indicate that road sediment appears to be less of a problem in streams that appear on the 303(d) list than in some streams that are not on the list. The largest sediment contributing road sections were in areas of new road development. Roads in the Swan Lake Watershed conform to what has been typically found in most studies of forest road sediment delivery to streams: sediment delivery from forest roads is typically highest in the first few years after construction, and declines rapidly thereafter. The finding does, however, illustrate that opportunities for reducing sediment delivery from roads that still exist in the Swan Basin.

In response, the following is a list of recommendations to help protect water quality and satisfy allocations:

1. Major landowners in the basin (Plum Creek, USFS, and DNRC) should prioritize sediment contributing road sections and stream crossings for upgrading and sediment load mitigation, including potential road decommissioning. Specific locations and methods of sediment reduction will be left up to the judgment of the land managers. The FRS method (Appendix E) or equivalent approach can be utilized before and after sediment reduction activities to quantify the amount of reduction. This process should be pursued as a coordinated effort so that total road sediment reductions can be tracked in a consistent manner.
2. Assessments should occur for roads within watersheds that have experienced recent timber management operations. The information gathered during these assessments will

allow for timely feedback to land managers about the impact their activities could have on water quality and achievement of TMDL targets and allocations. This feedback mechanism is intended to keep sediment load calculations current and avoid impacts that go undetected for an extended period of time.

3. An effort should be made to work with small landowners and county representatives to identify significant sediment contributions from private (non-industrial) and county roads and to help develop methods to mitigate the sediment load. This assistance could also include identification of funding sources for BMP implementation where appropriate. This is an activity that the Swan Lake TAG is currently interested in pursuing.
4. The Swan Lake Watershed TAG is also interested in ensuring that existing and potential future private landowners are provided information on how to design roads and mitigate impacts associated with road sediment delivery. This could include support from realtors, Plum Creek and other landowners planning to subdivide to incorporate this information up front to potential new home owners/builders in the watershed. This can also include efforts to help ensure compliance with road building and maintenance requirements per the Plum Creek covenants (Appendix H).

Efforts to protect against road sediment delivery should be facilitated via continued development of GIS layers and a shared database to track road upgrades and new sediment loading determinations as well as tracking new stream crossing locations. Major landowner cooperation will be critical to make this work. The FroS-SAM results and GIS layers presented in this document (Section 5.2 and Appendix F) provides a template to work from. The TAG can help facilitate this effort and could help keep the database updated for private lands not under ownership of the major landowners. This continually updated information could then be coordinated with tributary monitoring activities such as those recommended in Section 10.0.

9.2.3 Impacts Associated with Stream Crossings

9.2.3.1 Culvert Failure and Fish Passage

The risk of culvert failure and undesirable fish passage problems can be mitigated by properly decommissioning roads at stream crossings or by upgrading culverts and bridges at stream crossings. New or replaced culverts, or culverts on upgraded roads throughout the watershed should be sized for either a 25, 50 or 100-year flood event. The 25-year event design is consistent with state BMPs, although in areas of high existing culvert density, new culverts should be designed for a 50 to 100-year event instead of a 25-year event. This would help mitigate for the already elevated risk of culvert failure created by having a high density of culverts. Other design considerations should include avoiding negative impacts to local fish habitat from stream constriction and avoiding floodplain restrictions by using bottomless arches or other appropriate designs. Culverts should also be designed and installed to prevent fish passage restrictions.

The Flathead National Forest is currently pursuing the above goals for new and upgraded culverts by ensuring passage of a 100-year flood event to meet their native fish protection requirements. The Forest Service is also performing a fish passage inventory for culverts located on fish bearing streams throughout the watershed.

An analysis of existing culverts and the potential for culvert failure should be undertaken in conjunction with ongoing Forest Service efforts. Each crossing should be assigned a priority for restoration based on the risk of failure, the amount of sediment loading from a failure, and the level of disturbance associated with culvert replacement or upgrade. The matrix shown in Table 9-1 is an example of how some of the priority considerations could be applied.

Table 9-1. Prioritization Matrix for Culvert Replacement/Removal.

Level of Disturbance to Existing Mature Vegetation Required for Culvert Replacement/Removal Activities		**Flood Capacity***		
		High Capacity	***Moderate Capacity***	***Low Capacity***
	High level of Disturbance	Low Priority	Low Priority	Medium Priority
	Moderate Disturbance	Low Priority	Low Priority	High Priority
	Low Disturbance	Low Priority	Medium Priority	High Priority

*If the culvert is calculated to have a capacity for the 2-yr or the 5-yr flood, it is considered to have “low” capacity, if it is sized for the 10-year or 25-yr flood it is considered to have “moderate” capacity, and if it is sized for the 50-yr or 100-yr it is considered to have “high” capacity. The amount of sediment loading from a failure and possible other considerations such as fish passage would also need to be factored in.

Detailed on-the-ground assessments would need to be completed as part of the prioritization. The Swan Lake TAG could assist with prioritization and also assist small landowners with resolution to problems on private property, including potential funding assistance via 319 or other water quality grants. Fish passage would also need to be considered as an additional component to the prioritization process. Input from biologists will be critical to determine the relative value of providing fish passage in each situation.

Where large landowners such as Plum Creek are selling property for private development or other uses an evaluation of existing culverts should be performed. The landowner should upgrade culverts that cannot pass a 25-year flood event and upgrade culverts that represent an undesirable fish passage condition. These upgrades will help ensure that new landowners are not left with a high probability of culvert failure during flood events and not left with fish passage liabilities.

9.2.3.2 Bridges

An additional study should be undertaken to identify areas where bridge crossings are contributing to negative stream impacts, especially sediment loading conditions and localized negative impacts to aquatic life. This study should identify all bridge crossings along with potential impacts, solutions, and cost considerations. A decision can then be made regarding any bridge mitigation projects to pursue.

9.2.3.3 Other Stream Crossing Considerations

The following are additional considerations to help mitigate impacts from stream crossings and further protect aquatic life.

- In accordance with State Law, Lake and Missoula Conservation Districts and Montana Fish, Wildlife and Parks will continue to work to protect fish and aquatic habitat through 310 and 124 permits. Proposed stream crossings in known active bull trout spawning areas, particularly bounded alluvial valley segments, should be treated with special concern and avoided.
- A watershed or stakeholder group can help provide technical solutions, when requested, to 310 related issues and concerns.

Implementation of the above recommendations would need to be done in a manner that limits advertisement of bull trout spawning locations to protect against illegal take.

9.2.4 Septic Systems

The Swan Lake Watershed TAG is currently involved with development and implementation of an educational program to provide landowners with information on ways to minimize or eliminate water quality impacts from their septic systems. This will include information on septic maintenance and information on siting of septic systems and septic system design options. The Swan Lake Watershed TAG will also pursue design and implementation of a near-shore algae investigations and determine what special approaches should be pursued for septic systems located adjacent to Swan Lake.

Septic regulations intended to satisfy the State of Montana's nondegradation rules (ARM 17.30.7), discussed in Section 5.11, must be followed to protect Swan Lake from excess nutrient loading. Lake County licensing requirements and enforcement activities help ensure compliance with septic system regulations in the vicinity of Swan Lake.

9.2.5 Road Traction Sanding

The performance-based road sanding allocation in Section 8.0 is based on ongoing efforts by the Montana Department of Transportation to develop and incorporate BMPs. These BMPs may involve one or more of the following approaches in the Swan Lake Watershed:

- A reduction in plowing speeds near major stream crossing locations with greatest pollutant delivery potential.
- Improved road sand recovery at stream crossings and near Swan Lake.
- Increased use of chemical deicers near stream crossings as long as there is not undue degradation to plant and water quality from the chemical deicer.
- Reduce sand delivery to streams by improving vegetative buffers, routing flows away from streams, and/or building or upgrading catchment areas for improved settling of transported material.

Also, it may be possible to reduce nutrient loading by using sand with a lower phosphorous content and/or using harder material that can resist being ground down to finer particles (Regenmorter et al., 2002).

9.2.6 Floodplain Management, Streambank Protection and Private Land Development Concerns

As development pressure increases along the banks of the Swan River and its tributaries, there is likely to be a reduction in riparian vegetation and floodplain function if appropriate measures are not taken to prevent such a reduction. This would lead to channel instability, streambank erosion, increased temperatures, and increased loading of nutrients, organic carbon, and sediment. Impacts from private land development, especially where a structure is located adjacent to or on the bank of a stream or lake, can be harder to mitigate once they occur in comparison to many of the impacts associated with logging or other land use practices.

Many of the impacts associated with private land development are associated with septic systems and roads and stream crossings. These impacts and potential solutions are discussed in Sections 9.2.2, 9.2.3, and 9.2.4.

The targets and allocations that apply to private land development tend to focus on riparian health and associated indicators of riparian health. Water quality protection includes avoiding bank erosion from human causes, improving riparian health and increasing canopy density, avoiding the need for riprap and other “stabilization” work, and avoiding placement of structures in the floodplain or close to streambanks. Construction of structures such as houses, barns, roads, and corrals within the zone of historical channel migration is of major concern since this can lead to an eventual need for hard riverbank stabilization to avoid the loss of structures as the river migrates laterally through the floodplain.

To meet the TMDL targets and allocations and reduce water quality threats, especially as they relate to riparian removal and floodplain or streambank encroachment, the following actions are recommended:

- A comprehensive educational effort needs to be undertaken to stress the importance of riparian protection. The effort should include grazing management practices, home and structure siting consideration, storm water permitting requirements and erosion BMPs, and other factors applicable in the Swan Lake Watershed. The Swan Lake Watershed TAG is currently pursuing this as a high priority effort.
- Additional floodplain and streambank protection regulations should be evaluated and updated to ensure protection of the resource. Stakeholders can work with the Planning Offices of Lake County and Missoula County to help develop effective regulations that can be part of the County Growth Plans, Subdivision Regulations, or Floodplain regulations. It is important to note that these types of land use planning and regulatory decisions are made at the local (i.e. county) versus the State level.
- Lake County is in the process of developing a Growth Plan. The Swan Valley is being dealt with as a separate geographical area within the Plan. Riparian protection and restrictions on floodplain development should be included in this growth plan. At a minimum, Lake County should consider setback requirements similar to those required in Missoula County, and/or develop stream protection regulations similar to what is required by Plum Creek covenants. Setback requirements should also consider the need for

protecting areas of likely channel migration, particularly for larger streams such the Swan River and major tributaries.

- The effectiveness of voluntary versus regulatory measures should be tracked. This would include evaluating the effectiveness of Plum Creek covenants and Lake and Missoula County regulations aimed at protecting riparian and floodplain areas and streambanks. At a minimum, updated aerial photographs, when available, should be analyzed to provide measures of impact indicators such as canopy cover or structures within a certain distance from a stream. This information can then be used as a feedback mechanism to measure success and to help identify whether or not an increased focus is needed on regulatory versus voluntary protection measures regarding riparian, floodplain, and/or streambank protection.
- Land use impact indicators should be tracked along with water quality data to ensure that proper statistical analyses are performed to help track impacts. This should include temperature as well as nutrients and sediment loading.
- Where Plum Creek land is sold for private development, the TAG and/or interested stakeholders should work with the new landowners to ensure proper implementation of the restrictive deed covenants discussed in Section 5.12. Similar protective measures, at a minimum, should be promoted for all private landowners located near streams throughout the watershed, even if not covered by the Plum Creek covenants.
- The TAG should work with landowners to ensure protection of important bull trout spawning areas in locations where homes or other private development have the potential to impact a bounded alluvial valley stream segment. This effort should include recommendations to avoid depletion of ground water in areas where ground water is upwelling to surface waters, as well as recommendations on how to protect riparian areas and the stream channel.
- Landowners should be encouraged to control noxious weeds to help prevent conditions where weeds out-compete more desirable riparian vegetation.

In addition to the above activities, the Missoula and Lake Conservation Districts, along with Montana FWP, will continue to provide oversight and protection of riparian resources and stream health through the 310 Law, as discussed in Section 5.12 and above.

SECTION 10.0
WATER QUALITY MONITORING AND ASSESSMENT PLAN

Monitoring is an important component of water quality planning and is a requirement for TMDL implementation. This monitoring plan for the Swan Lake Watershed is a multi-strategy approach that is broken down into two main categories: (1) implementation monitoring and (2) additional assessment and watershed characterization monitoring. Both categories are discussed further in Sections 10.1 and 10.2. The Swan Lake Watershed Technical Advisory Group (TAG) is currently coordinating and pursuing several of the monitoring recommendations discussed in this section. In addition, there are ongoing modeling and monitoring efforts for Flathead Lake to facilitate implementation of the Flathead Lake Nutrient Management Plan. Swan Lake Watershed monitoring associated with implementation of this plan should be closely coordinated with Flathead Lake modeling or monitoring projects.

10.1 Implementation Monitoring

As defined by Montana State Law (§§75-5-703(7) & (9)), DEQ is required to evaluate progress toward meeting TMDL goals and satisfying water quality standards associated with beneficial use support at least every five years. Implementation monitoring is, therefore, necessary to assess progress toward meeting the primary targets developed in Section 7.0. Where targets are not being met, additional implementation monitoring may be necessary. This additional implementation monitoring may evaluate progress toward meeting secondary targets and/or allocations. This implementation monitoring is also an integral component of the implicit margin of safety incorporated in the TMDLs developed in this restoration plan. Although DEQ is responsible for aspects of implementation monitoring, other agencies and entities often perform significant aspects of the monitoring.

10.1.1 Implementation Monitoring Focused on Primary Targets

Table 10-1 is a summary of minimal target compliance monitoring parameters and likely monitoring locations with focus on monitoring for the primary targets. All monitoring efforts are to be done using standard DEQ sampling and analyses protocols where applicable, or sampling and analyses protocols approved by DEQ. Some methodologies and sampling details, such as DO measurements, are being developed with the assistance of the Swan Lake Watershed TAG. Based on further stakeholder input and DEQ approval, some of the Table 10-1 details such as monitoring locations or methodologies may be modified. In many cases, more sampling is desirable to establish an improved baseline condition. This is particularly true for the Swan Lake parameters where primary target conditions are based on trends.

Table 10-1. Monitoring Locations and Parameters to Evaluate Primary Target Compliance.

Waterbody	Parameter(s)	Location(s)	Sample Method	Sample Period
Swan Lake	Percent saturation and spatial extent of dissolved oxygen (DO)	Lower portions of water column, focus on deeper basins.	DO measurements at depth, variable locations including deeper portions of South Basin	Prior to fall turnover
Swan Lake	Sechi Depth, Chlorophyll *a*, Total Phosphorous	North and South basins, possible additional locations as desired for tracking trends.	Standard protocols for measuring these parameters	Summer
Jim Creek	McNeil core sampling	Existing sample locations used by Fish Wildlife and Parks.	Existing McNeil Core procedure used by Fish Wildlife and Parks	Low flow
Jim Creek	Pools with Cover; Large Woody Debris	Representative upper reaches of Jim Creek above and below Jim Lake.	Methodology used for 2002 assessment work (Appendix J) or equivalent	Low flow; summer to early fall
Jim Creek and Goat Creek	Macroinvertebrate assemblages	Jim Creek: two to three locations including a middle reach section below the West Fork of Jim Creek and also in a lower Rosgen C stream type in the vicinity of Jim Creek Reach 4 or 5. Goat Creek: two or three locations including at least on location above and one location below the confluence with Squeezer Creek.	Standard DEQ protocol	Low Flow, summer to early fall
Goat Creek (headwaters to Squeezer Creek)	Total Suspended Solids	Lower portion of this segment, above confluence with Squeezer Creek.	Standard protocols for TSS measurements	Runoff period, focus on rising limb and peak flow

Below is additional discussion for monitoring the primary target parameters identified in Table 10-1.

Dissolved Oxygen (Swan Lake)

Dissolved oxygen (concentration and percent saturation) and temperature profiles should be taken from monumented (through GPS documentation of latitude and longitude) locations in the north and south basins of the lake. Sampling will need to occur just prior to fall turnover and possibly at regular intervals between spring and fall turnover to document oxygen dynamics in the lake. Sampling at several locations and two or more depths at each location prior to fall turnover will be necessary to define and track the spatial extent of the low DO area. To the extent possible, these measurements should be taken every few years to further establish baseline conditions and help track trends consistent with Swan Lake Primary Target #1.

Swan Lake Water Quality Parameters

Depth-integrated samples of chlorophyll *a*, total phosphorous and possibly total nitrogen will need to be collected from the north and south basins of Swan Lake during the summer to allow for continued water quality evaluations. Sechi depth must also be monitored, preferably at several locations throughout the lake. Sampling should be done every year or once every few years. The results along with calculated TSI values (Figure 4-1) will be used to track water quality trends in Swan Lake consistent with Primary Target #2 (Section 7.1.1). Voluntary monitoring efforts are currently providing some or all of this data on a yearly basis.

Jim Creek Percent Fines Monitoring

McNeil Core sampling will provide the necessary data to determine compliance with Jim Creek Primary Target #1 (Section 7.2). The Montana Department of Fish, Wildlife and Parks (FWP) performs this monitoring on a yearly basis. The FWP also monitors several other tributaries (Section 5.15), thus providing important water quality and beneficial use support information throughout the watershed. The data from other streams, particularly Lion Creek, are also important for determining eventual achievability of the 35% percent fines target for Jim Creek. Monitoring should continue applying the same methodologies at the same locations in Jim Creek and other streams.

Jim Creek Pools and Large Woody Debris Monitoring

As implied by Table 10-1, this monitoring should be based on the methodology used for the 2002 assessment work or an equivalent methodology to evaluate the positive habitat aspects of woody debris. It is anticipated that recovery of large woody debris could take a significant amount of time so there is little need for routine evaluation of these parameters between five-year assessments. This monitoring only applies to the upper reaches of Jim Creek. Future monitoring should evaluate upper impacted reaches both above and below Jim Lake. This data can be used to evaluate potential natural impacts that Jim Lake may have on downstream woody debris recovery.

Jim and Goat Creek Macroinvertebrate Sampling

Table 10-1 identifies macroinvertebrate sampling requirements for both Jim and Goat Creeks. The goal is to obtain samples in locations where potential impairment conditions would most likely exist using standard DEQ protocols for sample collection and analysis.

Goat Creek Total Suspended Solids Sampling

Table 10-1 identifies the desired total suspended solids sampling location, consistent with the impaired segment of Goat Creek and also consistent with recent sampling performed by the Montana Department of Natural Resources and Conservation. The goal is to obtain a few more years of data, depending on the results, during spring runoff conditions to evaluate Goat Creek Primary Target #1.

10.1.2 Implementation Monitoring Focused on the Status of Secondary Targets and Load Allocations

Per Montana State Law (75-5-703(7) & (9)), if the primary target monitoring discussed above demonstrates that water quality standards have not been achieved within 5 years after approval of a TMDL, then DEQ is required to conduct a formal evaluation of progress in restoring water quality and the status of reasonable land, soil, and water conservation practice implementation to determine if:

a) the implementation of a new or improved phase of voluntary reasonable land, soil, and water conservation practices is necessary;
b) water quality is improving but a specified time is needed for compliance with water quality standards; or
c) revisions to the TMDL are necessary to achieve applicable water quality standards.

This type of monitoring supports the adaptive framework for either refining targets or altering allocations and restoration goals for achieving the targets. The Swan Lake secondary targets (Section 7.1.2) were developed to specifically assist with this effort. To further facilitate the goals of this type of implementation monitoring, it may also be desirable or necessary to evaluate progress toward meeting load allocations presented in Section 8.0.

This type of implementation monitoring could include the activities identified below.

1) Nutrient, POC and TSS monitoring should be performed to evaluate loading and concentration trends in the Swan River and/or key tributaries within the watershed to develop baseline data and help track water quality trends. Monitoring within tributaries representing a range of land uses in the watershed may be more desirable since tracking changes in the storage and flux of pollutants in a larger river system such as the Swan River can be difficult. The information can help determine if a land use changes, water quality protection measures, or natural conditions are associated with any noted trends. This monitoring can help answer questions about loading trends to Swan Lake as intended by Swan Lake Secondary Target

#1, and can also identify potential problems in important tributaries before they have significant impacts on beneficial use support.

2) Consistent with Swan Lake Secondary Target #2 and allocations in Section 8.0, road sediment assessments using the FRS method (Appendix E) or similar approach could be pursued for:
   a) select watersheds in which recent forest management activities have taken place;
   b) the roads that were found to be significant contributors of sediment in order to evaluate BMP implementation progress;
   c) new roads associated with private home development to help document and track impacts from this significant source of concern;
3) The FRS method should be used to perform a stratified random sampling of road crossings throughout the Swan Lake Watershed every five to ten years as an indicator of overall road erosion trends and BMP implementation. To effectively do this, GIS layers of road crossing layers will need to be updated and maintained.
4) At least once every five to ten years, based on availability of recent aerial photos and level of land use change, canopy density and other indicators of riparian health should be documented. Focus should be along the Swan River and along key tributaries of concern where development could be impacting riparian areas. This information could be used to track progress toward meeting Swan Lake Secondary Target #3 and related riparian health allocations in Section 8.0. The methodology defined in Appendix I, or an equivalent approach should be used.
5) Land use indicators identified in Section 8.0 should be tracked, possibly in conjunction with the nutrient and TSS monitoring discussed above. This type of monitoring could include evaluation of culvert flood passage capabilities as well as identification of the rate of culvert failures after large flood events. Predicted water yield levels should be tracked in drainages with significant harvest. Also, a method to identify and track harvest on sensitive areas could also be useful for identifying potential impacts from harvest, including evaluation of the rate of mass wasting associated with roads and harvest in sensitive areas versus the rate of mass wasting in other areas of the watershed without harvest and where harvest occurs in less sensitive areas.

10.1.3 Project Effectiveness Monitoring

An additional type of implementation monitoring involves efforts to assess the effectiveness of specific restoration or water quality improvement activities. All water quality projects should have some form of monitoring to assess overall effectiveness. In some situations, the monitoring can provide feedback for future projects or feedback on maintenance requirements. This monitoring can take on many forms, and can be as simple as before and after photos.

10.2 Monitoring and Assessment Recommendations

The additional assessment and watershed characterization monitoring has several potential roles. This type of monitoring can provide:

- additional information on land uses and impacts to aquatic life and pollutant loading throughout the watershed;

- information for making beneficial use support determinations in streams not yet evaluated where land management activities indicate a potential impairment;
- an improved understanding of reference or baseline conditions for evaluating beneficial use support and setting target conditions; and
- an improved understanding of the aquatic life and other beneficial uses to be protected.

This type of monitoring is broken into two priority categories of high and medium, although future stakeholder input and evaluation of new information could impact subsequent prioritization of these projects and activities.

10.2.1 High Priority Monitoring and Assessment Recommendations

Below is a list of the higher priority monitoring and assessment recommendations. These are in addition to the implementation monitoring recommendations in Section 10.1, which area all high priority monitoring activities. Many of these high priority monitoring recommendations are related to the additional target conditions defined in Section 7.4.

1) A near-shore algae investigation to address Additional Target Condition #1 is a very high priority to better define potential impacts associated with septic systems and increased growth in the vicinity of Swan Lake.
2) Efforts should be made to identify and eventually remediate undesirable fish passage barriers consistent with the goals of Additional Target Condition #2. A fish passage limitation can prevent a stream from ever being at a “full support” condition for cold-water fish.
3) The FWP monitoring of bull trout spawning redds and documentation of the results should continue. Additional monitoring and reporting on juvenile bull trout as well as other native fish such as cutthroat trout is also recommended. Although not specifically used for target conditions, this fishery information along with other information within the watershed can help link watershed conditions to beneficial use support impacts.
4) Because beneficial use support decisions and potential future target development are typically based on local reference conditions, continued identification and monitoring of reference streams is recommended. Existing Forest Service data on potential reference reaches and other waterbodies in the watershed should be organized into a database and GIS format to assist with this effort.
5) Monitoring impacts from fires and significant flood events, in areas with and without land management activities, is suggested to help define pollutant loading and other potential impacts to streams under varying conditions.
6) The FWP should continue with their McNeil Core sampling program.
7) An assessment of channel conditions, percent fines, riparian health, macroinvertebrate communities, and/or other geomorphic indicators that can be linked to cold-water fish and aquatic life use support should be pursued for:
    - the whole length of the Swan River to help determine existing conditions and help track potential future impacts to this important waterbody;
    - streams where there are or have been indicators of potential impairment conditions such as substantial increases in development or other land use impact indicators, with focus on bounded alluvial valley stream segments consistent with Additional Target Condition #3; and

- streams where significant development is planned to provide baseline information to help analyze the impacts of the development, again with focus on bounded alluvial valley stream segments as appropriate.

10.2.2 Medium Priority Monitoring and Assessment Recommendations

The following list of monitoring activities and projects are considered medium priority at this time, but could be considered higher priority depending on further stakeholder planning and subsequent priority determinations. Many of these recommendations could end up being a higher priority if DO or nutrient conditions became worse in Swan Lake.

1) Modeling could be done to better estimate nutrient loads from septic systems, especially in the vicinity to Swan Lake, and to also estimate potential load increases from future development. Any such efforts should take into consideration any documented near shore nutrient impairment concerns. If near shore impairments are identified, then this could become a high priority.
2) Craig Spencer's (1991b) sediment cores from Swan Lake as well as two other lakes provided evidence that increased timber harvest and/or road construction increased the rate of sediment deposition in each lake. Additional cores could be taken from Swan Lake and from an additional control lake if one can be identified. It would be especially interesting to determine if the rate of sediment deposition in Swan Lake has decreased since 1990 as a result of BMP implementation. It may also be worthwhile to determine the extent of submerged logs in the lake bottom as part of this study or as part of a separate study.
3) A study of the mixing dynamics of the lake could be completed with an emphasis placed on determining the extent to which the deep-water basins are hydraulically isolated from the rest of the lake.
4) Efforts could be pursued to better understand the loading impacts that the wetlands along the south basin have on Swan Lake water quality.
5) Temperature monitoring in tributaries could be pursued to providing a better understanding of temperature conditions and also provide baseline data to evaluate future land use impacts.
6) Lindbergh, Cygnet and Holland Lakes should be monitored to provide baseline information concerning nutrients levels and document any existing impacts to beneficial uses. This is especially important for these two waterbodies given the threat posed by increasing development, specifically around Lindbergh Lake. Some of these lakes may be monitored during 2004 as part of a statewide lake monitoring project that DEQ is sponsoring.

SECTION 11.0
SEASONALITY AND MARGIN OF SAFETY

Seasonality

Addressing seasonal variations is an important and required component of TMDL development. Throughout this plan, seasonality is an integral factor. Water quality and habitat parameters such as fine sediment, bull trout redds, dissolved oxygen, and nutrients are all explicitly recognized to have seasonal cycles.

Specific examples of how seasonality has been addressed are as follows:

- Assessment work incorporated seasonal POC, nutrient and sediment loading using information from previous studies. Models that predict sediment loading, such as from road erosion, inherently incorporate runoff flows when erosion is greatest. Evaluation of suspended sediment levels in Goat Creek was based on data from runoff conditions when impacts were greatest.
- Targets are applied during specific seasons. Examples include: application of the dissolved oxygen target prior to lake turnover in the fall; application of the suspended sediment target in Goat Creek during spring runoff; and the application of percent fines and macroinvertebrate targets at low flows with macroinvertebrate sampling occurring during the summer for accurate population analyses.

Margin of Safety

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

- A large amount of data and assessment information were considered prior to finalizing any impairment determinations. Impairment and threatened determinations were based on conservative assumptions that favored the resource for Swan Lake and Jim and Goat Creeks.
- Additional biota targets are applied in conjunction with the sediment targets for Jim and Goat Creeks.
- The secondary target and related load allocations linked to riparian indicators provide an early warning method to identify pollutant loading threats that may not otherwise be identified by conventional monitoring.
- A nutrient TMDL is developed for Swan Lake to help prevent eutrophication and subsequent increased POC loading to the lake bottom.
- Land use indicators are added to the allocations section to help identify and address sediment loading sources of concern.

- The road erosion, road traction sanding and riparian health allocations both would result in a reduction in POC and nutrient loading to Swan Lake, therefore providing a built in MOS to the Swan Lake TMDLs.
- The adaptive management approach evaluates target attainment and watershed conditions via a comprehensive monitoring strategy (Section 10.0) that can allow for refinement of load allocations, targets, and restoration strategies to ensure restoration of beneficial uses.

SECTION 12.0 PUBLIC AND STAKEHOLDER INVOLVEMENT

Public and stakeholder involvement is a component of TMDL planning efforts supported by EPA guidelines and Montana State Law. Public and stakeholder involvement is desirable to ensure development of high quality, feasible plans and increase public acceptance. Stakeholders, including the Lake County Conservation District and the Flathead National Forest, were involved with initial project planning and grant application for the development of this document. During document development, the three major landowners (Flathead National Forest, Montana Department of Natural Resources and Conservation, and Plum Creek Timber Company), and other stakeholders met to discuss and provide comments on the draft document strategy and outline. A stakeholder review draft was subsequently provided to several agency representatives, key landowners, conservation districts and government representatives, and representatives from conservation and watershed groups. Significant comments were provided and substantially addressed. During development of the final public review draft, several stakeholders were consulted in their areas of expertise on specific sections of the document.

An additional opportunity for public involvement is the 30-day public comment period. This public review period was initiated on March 8, 2004 and extended to April 9, 2004. A public meeting on March 24, 2004 in Big Fork, Montana provided an overview of the Water Quality Protection Plan and TMDLs for the Swan Lake Watershed and an opportunity to solicit public input and comments on the plan. Appendix K includes the public comments received from this meeting and via mail, as well as the DEQ response to each of these comments. Many of the comments were incorporated into this plan.

DEQ provides another opportunity for public comment during the biennial review of the 303(d) list. This includes public meetings and opportunities to submit comments either electronically or through traditional mail. DEQ announces the public comment opportunities through several media including press releases and the Internet.

SECTION 13
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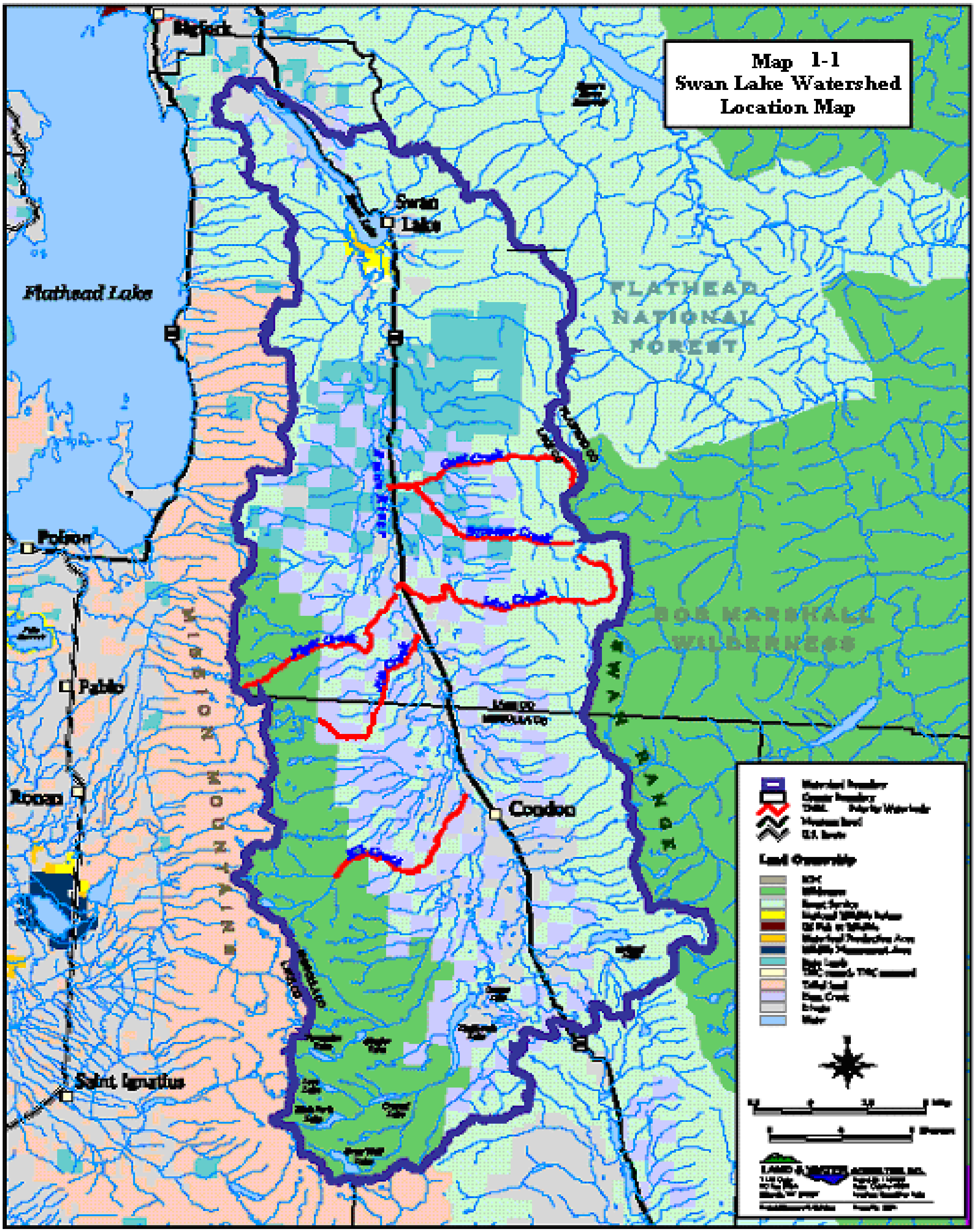
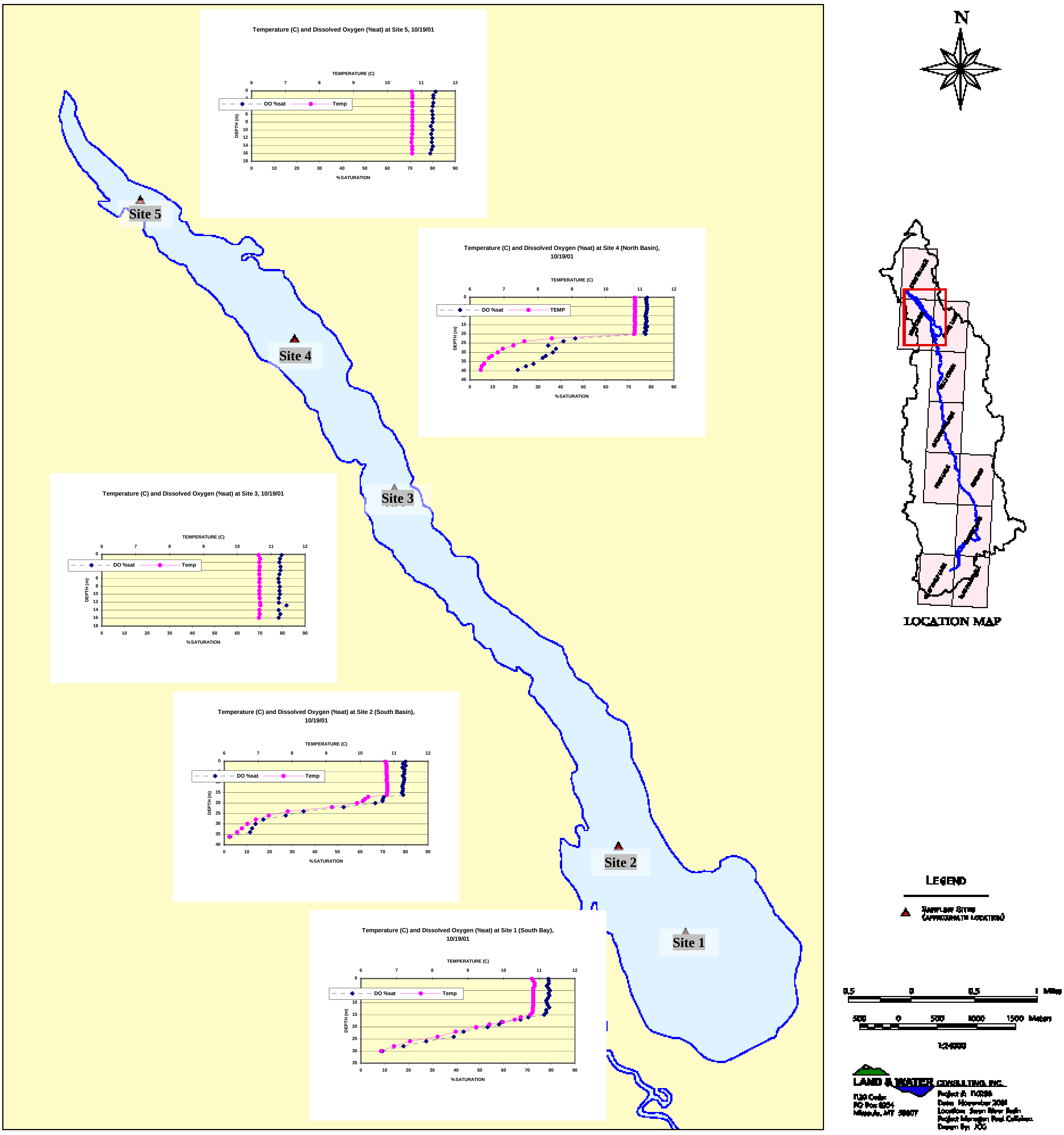
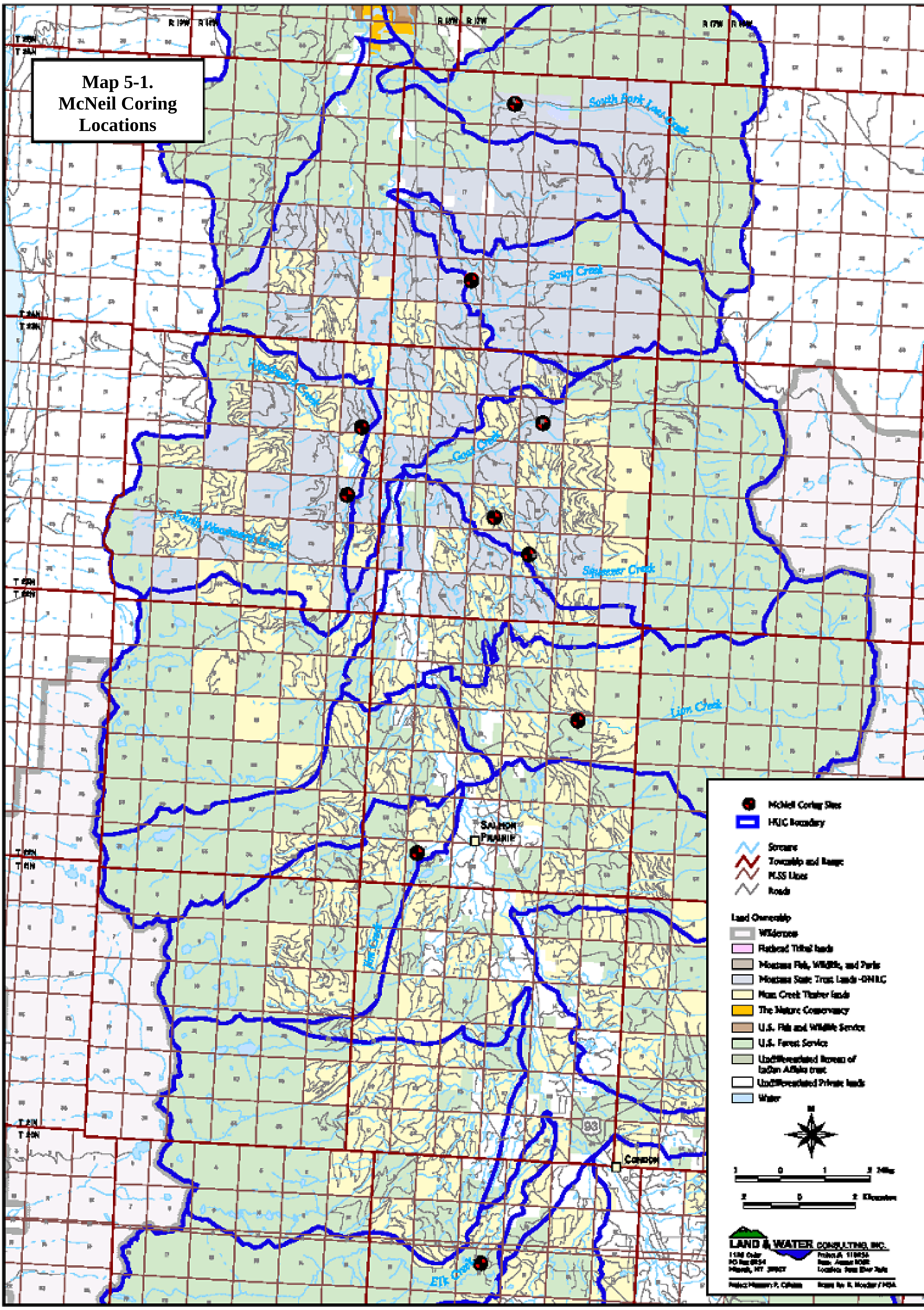


Map 1-1
Swan Lake Watershed
Location Map
Bigfork
Swan Lake
Flathead Lake
Polson
Pablo
Ronan
Saint Ignatius
Condon
FLATHEAD NATIONAL FOREST
BOB MARSHALL WILDERNESS
MISSION MOUNTAINS
SWAN RANGE
Land Ownership

Map 4-1
SWAN LAKE
DISSOLVED OXYGEN CONCENTRATION SAMPLING SITES



Map 5-1.
McNeil Coring Locations



APPENDIX A:
APPLICABLE WATER QUALITY STANDARDS

The Montana Surface Water Quality Standards and Procedures (Water Quality Standards: Title 17, Chapter 30, Sub-Chapter 6) are a part of the Administrative Rules of Montana. These standards provide the basis for 303(d) listing decisions as well as the basis for setting water quality targets. Per Section 17.30.608 of the Water Quality Standards, all waterbodies in the Swan Lake Watershed are classified as B-1 except for Swan Lake, which is classified as A-1. The following information provides language applicable to waterbodies classified as either A-1 or B-1 and also applicable to water quality restoration and TMDL development in the Swan Lake Watershed. In addition, the primary pollutant(s) of concern addressed by the standard, as they relate to this document, are also listed. Where A-1 and B-1 standards are the same, it is noted.

17.30.623(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.*"

Pollutants: All (includes sediment, organic carbon) (a waterbody is impaired when the beneficial use is not fully supported)

17.30.622:

(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.*"

(2) *"Water quality must be 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.*"

Pollutants: All (includes sediment, organic carbon)(a waterbody is impaired when the beneficial use is not fully supported)

17.30.623(2) and 17.30.622(3): [Applies to B-1 and A-1 classifications]

"*No person may violate the following specific water quality standards for waters classified B-1 (A-1 for 17.30.622(3)):*" *Relevant* specific standards are discussed below:

17.30.623(2)(d): [Applies to B-1 classification only]

"The maximum allowable increase above naturally occurring turbidity is five nephelometric turbidity units except as permitted in 75-5-318, MCA."

Pollutant: Sediment (suspended solids);
Nutrients (nutrient enrichment: algae blooms)

75-5-318, MCA allows for short-term turbidity increases if authorized by the DEQ (can also be authorized by the department of fish, wildlife and parks in conjunction with DEQ) and if specific conditions, as defined by 75-5-318, MCA, are satisfied.

17.30.622(3)(d): [Applies to A-1 classification only]
"No increase above naturally occurring turbidity or suspended sediment is allowed except as permitted in 75-5-318, MCA."
Pollutant: Sediment (suspended solids)
Nutrients (nutrient enrichment: algae blooms)

17.30.623(2)(f) and 17.30.622(3)(f): [Applies to B-1 and A-1 classifications]
"*No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except at 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.*"
Pollutant: Sediment; Organic Carbon, Nutrients

17.30.623(2)(h) and 17.30.622(3)(h): [Applies to B-1 and A-1 classifications]
"*Concentrations of carcinogenic, bioconcentrating, toxic, or harmful parameters which would remain in the water after conventional water treatment may not exceed the applicable standards set forth in department Circular WQB-7."*

WQB-7 identifies dissolved oxygen values ranging from 3 to 9.5 depending on species life stages and whether the value is a 30 day mean, a 7 day mean, a 7 day mean minimum, or 1 day minimum.

17.30.637(1): [This is from a section of the water quality standards applicable to all waterbodies including those classified as either B-1 or A-1]
"*State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will:"*

17.30.637(1)(a): [Applies to B-1 and A-1 classifications]
"*settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines;*"
Pollutants: Sediment

17.30.637(1)(d): [Applies to B-1 and A-1 classifications]
"*create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life;*"
Pollutants: All (includes sediment, organic carbon)

17.30.637(1)(e): [Applies to B-1 and A-1 classifications]
"*create conditions which produce undesirable aquatic life;*"
Pollutants: Nutrients (linked to undesirable algae growth), Organic Carbon (linked to decreased dissolved oxygen & subsequent nutrient enrichment)

17.30.602 Definitions [All apply to B-1 and A-1 classifications]:

17.30.602 (19):

"Naturally occurring" means conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil and water conservation practices have been applied. Conditions resulting from the reasonable operation of dams in existence as of July 1, 1971 are natural.

Pollutants: All

17.30.602(24):

"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.

Pollutants: All

17.30.602(28):

"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.

17.30.602(30):

"Settleable solids" means inorganic or organic particles that are being transported or have been transported by water from the site or sites of origin and are settled or are capable of being settled from suspension.

Below are some notes associated with the above water quality standards:

- The standards of interest are nearly identical for B-1 and A-1 classified waterbodies. An A-1 classification has stricter protection requirements associated with allowable levels of impurities for drinking, culinary and food processing purposes (ARM 17.30.622) and stricter protection requirements associated with allowable levels of turbidity (ARM 17.30.622(3)(d)).
- The term "naturally occurring" is not the same as "natural background." "Naturally occurring" can incorporate some limited level of human influence under conditions where reasonable land, soil, and water conservation practices are applied whereas "natural background" as used in this document is not intended to incorporate any human influences.

- There are no numeric standards for inorganic or organic sediment or settleable solids. Even turbidity is more narrative than numeric since values are based on naturally occurring conditions, which can vary and require interpretation.
- The definitions of sediment and settleable solids both include particulate organic carbon, thus providing the linkage between the siltation listing and particulate organic carbon.
- The WQB-7 dissolved oxygen values, which are based on minimum allowable concentrations, are currently not being met in areas of Swan Lake. However, it is known that certain lake types have naturally low dissolved oxygen levels in their bottom waters during summer stratification. Unfortunately, the current classification system for state waters does not discern between different types of waterbodies (i.e. rivers, streams, lakes, etc.), and occasions do arise when the numeric standards are not consistent with natural background conditions. The applicability of the Swan Lake oxygen standards under WQB-7 are preceded by “No person may violate the following specific water quality standards ....” per ARM 17.30.622(3), implying that natural background conditions cannot be considered a violation of the numeric standards.

  To address the above dissolved oxygen condition, the Standards section of DEQ has been actively developing a lake- and reservoir-specific classification system, to which more accurate standards could be applied. The classification system will assign a Carlson trophic state index (TSI) to each class of lake or reservoir. This index has a 0-100 scale and is essentially a measure of the abundance of phytoplankton in the lake. Swan Lake’s Carlson TSI is currently between 30 and 40, and preliminary analyses indicate that Swan Lake would fall into a class with other somewhat shallow Western Montana lakes having a typical Carlson TSI index of about 35. Other similar lakes in the area are Lake of the Woods, Peterson Lake, and Glen Lake. Lakes having this index value are usually oligotrophic (they have low algae population densities), however some of the shallower lakes in this index range (like Swan Lake) may have anoxic bottom waters during the summer. In fact, low dissolved oxygen has been observed in the bottom waters of other oligotrophic lakes in Montana. Dissolved oxygen profiles of Lake Agnes in the Pioneer Mountains near Dillon were measured in July and August 2003. The results showed that DO concentrations within 1 meter of the bottom were as low as 0.4 mg/L. Yet, Lake Agnes has a Carlson TSI of between 22 and 33 (based on either chlorophyll *a* or secchi depth, respectively), and is located in a remote watershed with no on-lake development other than a primitive hike-in campsite. Like Swan Lake, the watershed has been logged in the past, the lake has a similar relative depth, and the lake supports a thriving native fish population. Therefore, the low DO in parts of Swan Lake’s bottom waters may not be so unusual for the type of lake that it is, and the existing levels are considered within the range of natural background conditions for the purpose of making an impairment determination.

APPENDIX B: IMPAIRMENT DETERMINATION LISTING DETAILS FOR THE 1996 AND 2002 303(D) LISTS

This appendix summarizes information used for defining water quality problems and making beneficial use determinations for tributaries identified as impaired on the 2002 303(d) list. Because of its more complicated listing history, Goat Creek is treated separately, while the remaining stream reaches are treated as a group in this appendix[1].

Goat Creek

In 1996, all of Goat Creek was listed as impaired by flow alteration, organic enrichment/DO, siltation, and other habitat alterations. In 2002, the headwaters to Squeezer Creek section was listed for nutrients and suspended solids, while the Squeezer Creek to Swan River section was listed for siltation and other habitat alterations. The impairments causes and impaired uses in Goat Creek are summarized in Table B-1.

Table B-1. Goat Creek 303(d) Listing History

Location	1996 303(d) list probable causes	2002 303(d) list probable causes	Impaired Uses
Headwaters to Squeezer Creek	Flow alteration Organic enrichment/DO Siltation Other habitat alteration	Nutrients Suspended solids	Aquatic Life Cold Water Fishery
Squeezer Creek to Swan River	Flow alteration Organic enrichment/DO Siltation Other habitat alteration	Siltation Other habitat alterations	Aquatic Life Cold Water Fishery

The basis for impairment determinations for the 2002 303(d) list are summarized in the DEQ SCD/BUD worksheets (DEQ, 2004) and the below discussion is derived from documentation contained within DEQ files. The 1996 basis for impairment determinations are not well documented, although in most cases they can be inferred from the SCD/BUD documentation.

Goat Creek (Headwaters to Squeezer Creek)

- *General Comments:* At the time of the DEQ's most recent SCD/BUD review it was determined that there was minor impairment in upper Goat Creek resulting from elevated nitrate and suspended sediment concentrations, as well as logging-related habitat impairments, including slash in the stream, excessive sedimentation, blow downs, and equipment crossings. DEQ notes that this section of Goat Creek was probably close to fully supporting its beneficial uses.

[1] Of all of the Swan tributaries cited on the 1996/2002 303(d) lists and within DEQ's database, only Piper Creek has sufficient and credible data (SCD) to allow for evaluation of its support of the "drinking water" beneficial use. Therefore, additional data will need to be collected for drinking water support determinations. Collection of this information is not a required component of ongoing TMDL development.

- *Siltation (1996):* A 1989 DEQ stream assessment found localized instances of elevated levels of sediment in the stream, particularly in Section 7.
- *Habitat Alteration (1996):* A 1989 DEQ stream assessment found that Goat Creek in Sections 8 and 9 was in good condition, but that in Section 7 slash, blowdowns, and equipment crossings in the stream created localized impacts.
- *Flow Alteration (1996):* A study by Leathe et al. (1983) recommended a minimum flow of 11 cfs for Goat Creek; flow fell to 6 cfs in 1988.
- *Organic Enrichment/DO (1996):* The reason for this listing is unclear. A possible explanation might be related to indirect effects of elevated sedimentation and nutrient concentrations in this reach.
- *Nutrients (2000):* Nutrient data analyzed from various sources indicated nitrate levels from 0.06 to 0.10 mg/l, and nitrite + nitrate levels around 0.07 mg/l.
- *Suspended Solids (2000):* Ellis et al. (1999a) found that total suspended solids (TSS) were higher in logged portions of Goat Creek than in unlogged portions of Lion Creek.

Goat Creek (Squeezer Creek to Swan River)

- *General Comments:* According to DEQ's SCD/BUD documents, lower Goat Creek is currently impaired, particularly near the mouth, because cut logs and slash in the stream have created debris jams that have led to bank erosion and severe sediment scour and deposition.
- *Siltation (1996 and 2000):* A 1989 DEQ stream assessment found elevated levels of sediment deposition, braiding of the stream channel, and embeddedness of the stream substrate. A 1996 Plum Creek study found signs of elevated sedimentation, erosion, and channel migration, particularly near the mouth of the creek.
- *Flow Alteration (1996):* A study by Leathe et al. (1983) recommended a minimum flow of 11 cfs for Goat Creek; flow fell to 6 cfs in 1988.
- *Habitat Alteration (1996 and 2000):* A 1989 DEQ stream assessment found full support in the upper part this reach (assessment score = 82%), but only partial support near the mouth (assessment score = 66%). Problems near the mouth included logging slash, litter, and manure in the stream; debris jams from slash were causing vertical erosion, sever scour and deposition, reduced pools, and braiding of the channel.
- *Organic Enrichment/DO (1996):* The reason for this listing is unclear. A possible explanation might be related to indirect effects of elevated sedimentation and nutrient concentrations in this reach.

<u>Other Tributaries</u>

All three of the following stream or stream reaches are cited on the 1996 and 2002 303(d) lists as impaired by siltation and other habitat alterations. In 1996, Elk Creek was also listed for organic enrichment/DO.

1. Piper Creek below Moore Creek;
2. Jim Creek
3. Elk Creek

The reasons for the listing of these streams as explained by the SCD/BUD documentation are as follows:

1. *Piper Creek below Moore Creek*: A DEQ stream reach assessment found moderate impairment from excess fine sediment in the channel mainly from timber harvest and roads. Based on this assessment, 53% of the stream reach was found to have reduced riparian recruitment due to harvest within the SMZ.
2. *Jim Creek:* The decision to list this section of Jim Creek was based primarily on a study by Brown et al. (1990) that found 1) fisheries habitat was significantly deteriorated, 2) bull trout eggs all died in the area studied, and 3) westslope cutthroat trout experienced a survival rate of only 4% if spawning took place below the timber sale in the west fork. This timber sale involved significant riparian harvest. A stream assessment by DEQ in 1989 also found logging slash and bridge material in the stream and bank trampling from cattle. A comparison of % fine sediment (very limited data) between Lion Creek and Jim Creek suggested that Jim Creek had a sedimentation level 60 to 130% above the recommended literature sediment levels for bull trout. DEQ SCD/BUD files currently indicate that these noted impacts are below the west fork and that there is a lack of impairment indicators for the portion of Jim Creek above the west fork.
3. *Elk Creek:* According to a 1989 DEQ stream assessment, the lower 4 miles of Elk Creek were impaired by cut logs and bridge parts in the channel, channel migration and bank instability, and reduced riparian shade, all of which resulted in the decision to list Elk Creek for both siltation and habitat alterations in 1996. Elk Creek was also listed for organic enrichment/DO in 1996, possibly related to cattle activities and/or elevated sedimentation in this reach. DEQ SCD/BUD files currently indicate that these noted impacts are below Section 16 and that there is a lack of impairment indicators for the portion of Elk Creek above Section 16.

APPENDIX C: SUMMARY ECOLOGICAL CLASSIFICATION SWAN RIVER BASIN, MONTANA

SUMMARY

ECOLOGICAL CLASSIFICATION

SWAN RIVER BASIN

MONTANA

Prepared for:

Plum Creek Timber Company, L.P.
Columbia Falls, Montana

Prepared by:

White Horse Associates
Logan, Utah

JANUARY, 1996

Ecological Classification Swan River Basin Montana

ACKNOWLEDGEMENTS

This report is a compilation of map and descriptive information from several sources. Dean Sirucek (Soil Scientist, Flathead National Forest) provided descriptions of Landtype Associations, identified habitat types, was principally responsible for the riparian landtype mapping and descriptions, facilitated transfer of Forest Service information to White Horse Associates and reviewed the draft report. Vicki Bachurski (Flathead National Forest) assisted in extending mapping of riparian landtypes from Forest Service Lands to intermingled private lands in Swan River Basin. John Krogstad (GIS Specialist, Flathead National Forest) facilitated the transfer of Forest Service map information to White Horse Associates. Most of the classification and inventory information was compiled from maps and reports provided by the Flathead National Forest.

Brian Sugden (Forest Hydrologist, Plum Creek Timber Company) coordinated the study and reviewed the draft document. Brian Gilbert (Wildlife Biologist, Plum Creek Timber Company) reviewed mapping and descriptions of habitat types and reviewed the draft report.

The report was compiled by Sherman Jensen (Physical Ecologist, White Horse Associates) and Ted Dean (GIS Specialist, White Horse Associates).

EXECUTIVE SUMMARY

An ecological classification was conducted for Swan River basin in northwest Montana. The basin is 408,630 acres with a stream network totaling about 1,257 linear miles. The ecological classification provides a framework and descriptive attributes from which interpretations regarding habitats and the effects of land uses can be interpreted.

The framework is an ecological classification that facilitates analysis from several perspectives. Hierarchical levels include ecoregion, geologic district, subsection, landtype association, landtype, habitat type and riparian landtype. Descriptive attributes include elevation, slope, aspect, annual precipitation and ownership. Descriptive attributes can be summarized for any combination of the hierarchical layers.

The Swan River basin falls within a single ecoregion (Northern Rockies) and geologic district (Precambrian Sedimentary). Three (3) subsections were discriminated by geologic structure: 1) Alpine glacial sedimentary scarp slope; 2) Alpine glacial sedimentary dip slope; and 3) Continental glacial sedimentary valley. Eleven (11) Landtype associations were identified by the Flathead National Forest and group landtypes with distinctive erosion potential and sediment delivery efficiency. Landtypes were identified as part of an Order III Land System Inventory in the northern Rocky Mountains of northwest Montana (Martinson and Basko 1983) and from an Order IV survey of landtypes in the Mission Mountain Wilderness. A total of 46 Order III and IV landtypes were combined into eleven (11) more general landtype classes. Sirucek (1994) developed a map of habitat types (described by Pfister et al. 1977) from empirical models, forest stand data and an existing layer of forest structural classes. Twelve (12) major habitat types and twenty six (26) minor habitat types were identified. Riparian landtypes are defined by valley-bottom gradient, dominant streambed materials and dominant vegetation community type. They were mapped and described for Forest Service lands in the Flathead National Forest (Sirucek and Bachurski 1995). In a cost-share agreement with Plum Creek Timber, the Flathead National Forest also extended the riparian landtype mapping to private lands in the Swan River basin and to the Mission Mountain wilderness.

A Geographical Information System (GIS) was used to compile hierarchical map layers, plot maps and to output map data summaries. Maps, descriptions and data summaries are provided for each hierarchical level. Digital GIS map layers have also been provided to Plum Creek Timber and to the Flathead National Forest.

TABLE OF CONTENTS

1.0 INTRODUCTION

An ecological classification was conducted for the 408,630 acre Swan River basin in the Northern Rocky Mountains of northwest Montana. The ecological classification provides a framework and descriptive attributes from which interpretations regarding habitats and effects of land uses can be interpreted. The framework consists of a hierarchical classification that facilitates analysis of the project area from several different perspectives. Hierarchical levels include ecoregion, geologic district, subsection, landtype association, landtype, habitat type and riparian landtype. Descriptive attributes include elevation, slope, aspect, annual precipitation and ownership, each assembled as a separate map layer. Descriptive attributes can be sorted and summarized for any combination of hierarchical layers. Descriptive attributes can also serve as stand-alone map layers (e.g. elevation) or combined map layers (e.g. elevation/aspect/precipitation) for specific applications. Digital map files (ARC-INFO format) have been provided to facilitate subsequent analyses.

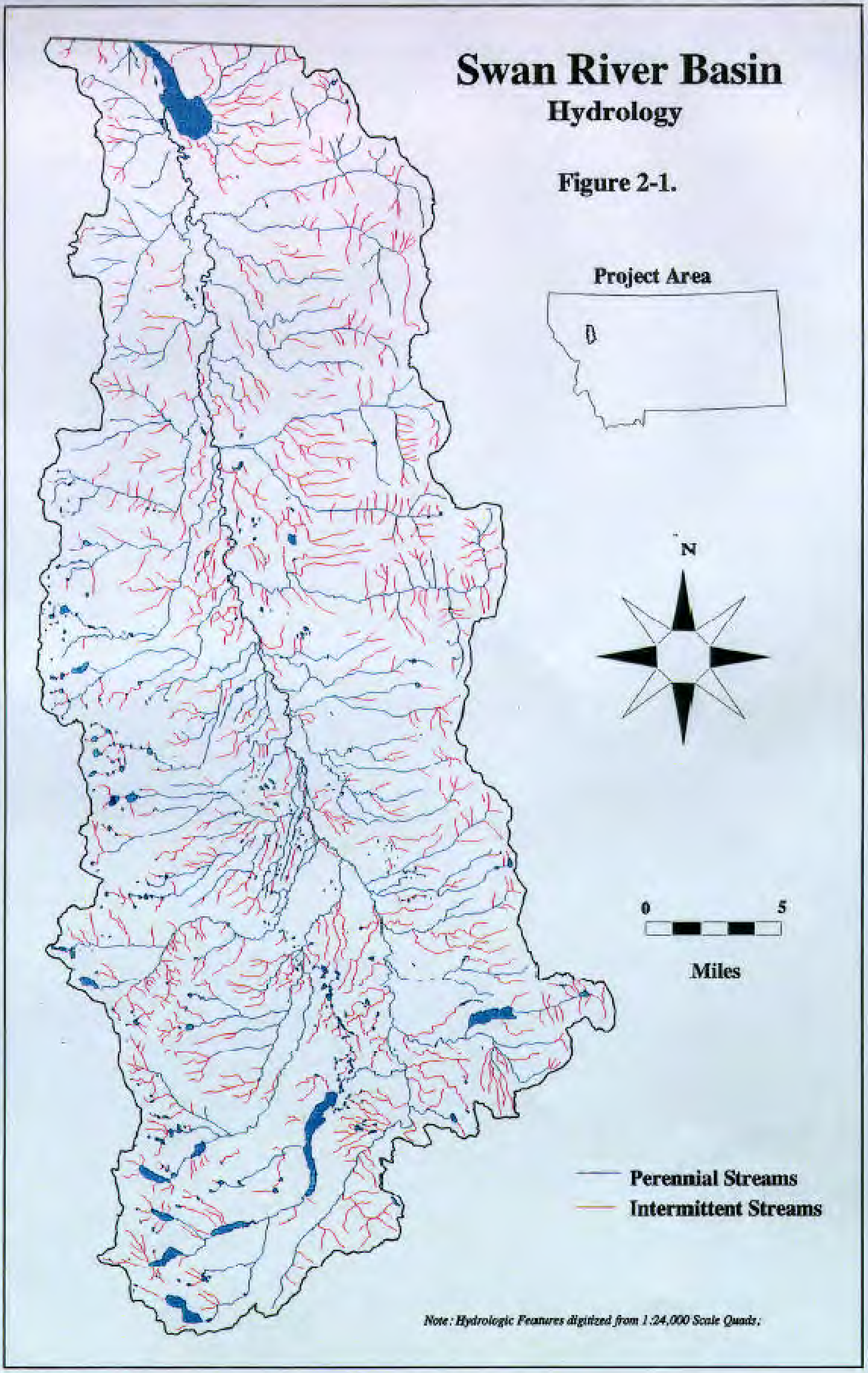
2.0 SWAN RIVER BASIN PROJECT AREA

The Swan River basin is shown in Figure 2-1. It is bounded on the west by the Mission Mountain Range and on the east by the Swan Range. A subtle divide separates the headwaters of the Swan River basin from the headwaters of the Clearwater River.

Elevations range from 9,402 feet at Glacier Peaks in the Swan Range to 3,066 feet at Swan Lake. Elevation, slope and aspect classes were generated from 1:24,000 scale Digital Elevation Models (DEMs). The distribution of elevation, slope and aspect classes for the Swan River basin are illustrated in Figure 2-2. Maps of elevation, slope and aspect classes are presented as Figures 2-3, 2-4, and 2-5, respectively.

The Swan Valley lies between the Mission Range on the west and the Swan Range on the east. Both ranges are Precambrian sedimentary formations. The Swan Valley was created in response to block faulting, with the upthrust fault scarp along the east side of the valley (Swan Range) and the dip slope along the west side of the valley (Mission Range). Glacial processes are evident in the topography of the Swan River basin (Figure 2-6). A lobe of the Cordilleran ice sheet pushed south through the Swan River valley during the Bull Lake ice age (Alt and Hyndman 1986). During the subsequent Pinedale glaciation it is believed that a Swan Valley glacier arose in the Swan and Mission mountains and flowed north to meet the south flowing Cordilleran ice sheet near Big Fork (Johns 1970; Witkind 1978). Evidence of glaciation include U-shaped canyons carved to the base of the mountains and an undulating valley floor with a myriad of small lakes and bogs. Nearly 50 percent of Swan River basin is mantled by secondary glacial deposits.

Annual precipitation ranges from 20 to 30 inches at lower elevations in Swan Valley to 80 inches along the highest mountain crests (Figure 2-7). The distribution of precipitation classes is shown in Figure 2-8. Average annual precipitation over the Swan River basin, estimated as the mid-point of precipitation classes, is about 1,482,404 acre-feet.


Swan River Basin
Hydrology
Figure 2-1.
Project Area
N
0
5
Miles
Perennial Streams
Intermittent Streams
Note: Hydrologic Features digitized from 1:24,000 Scale Quads;

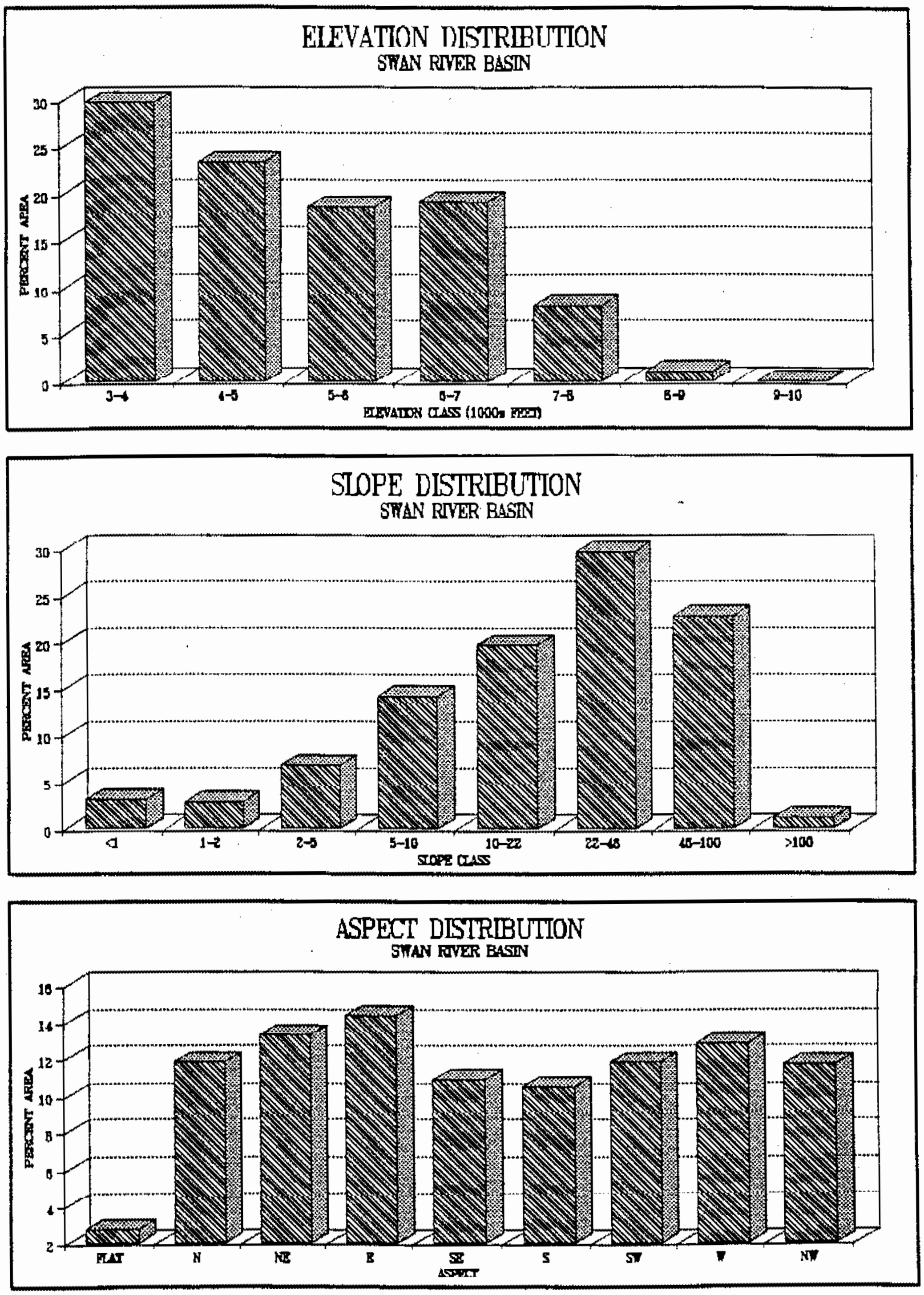
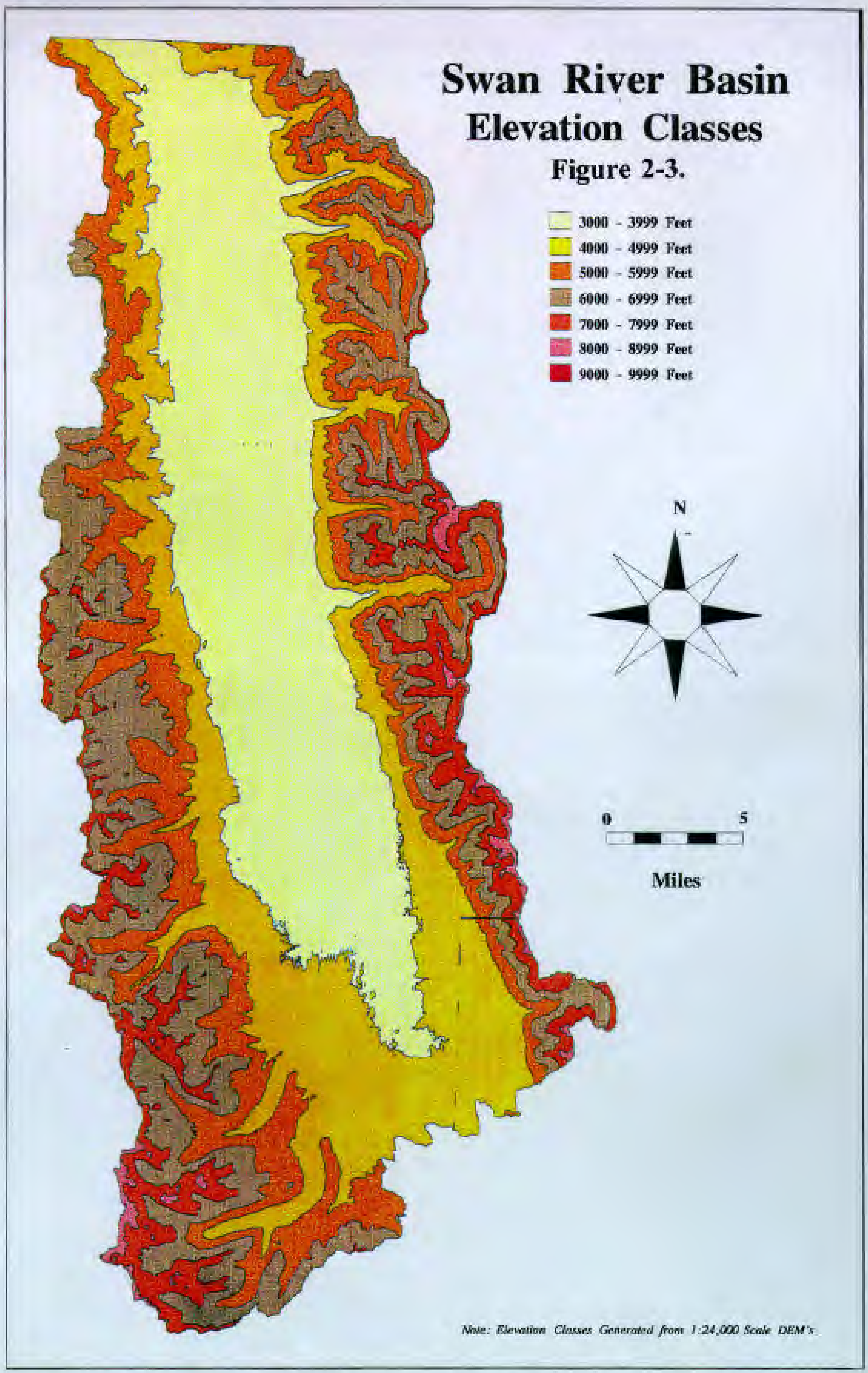
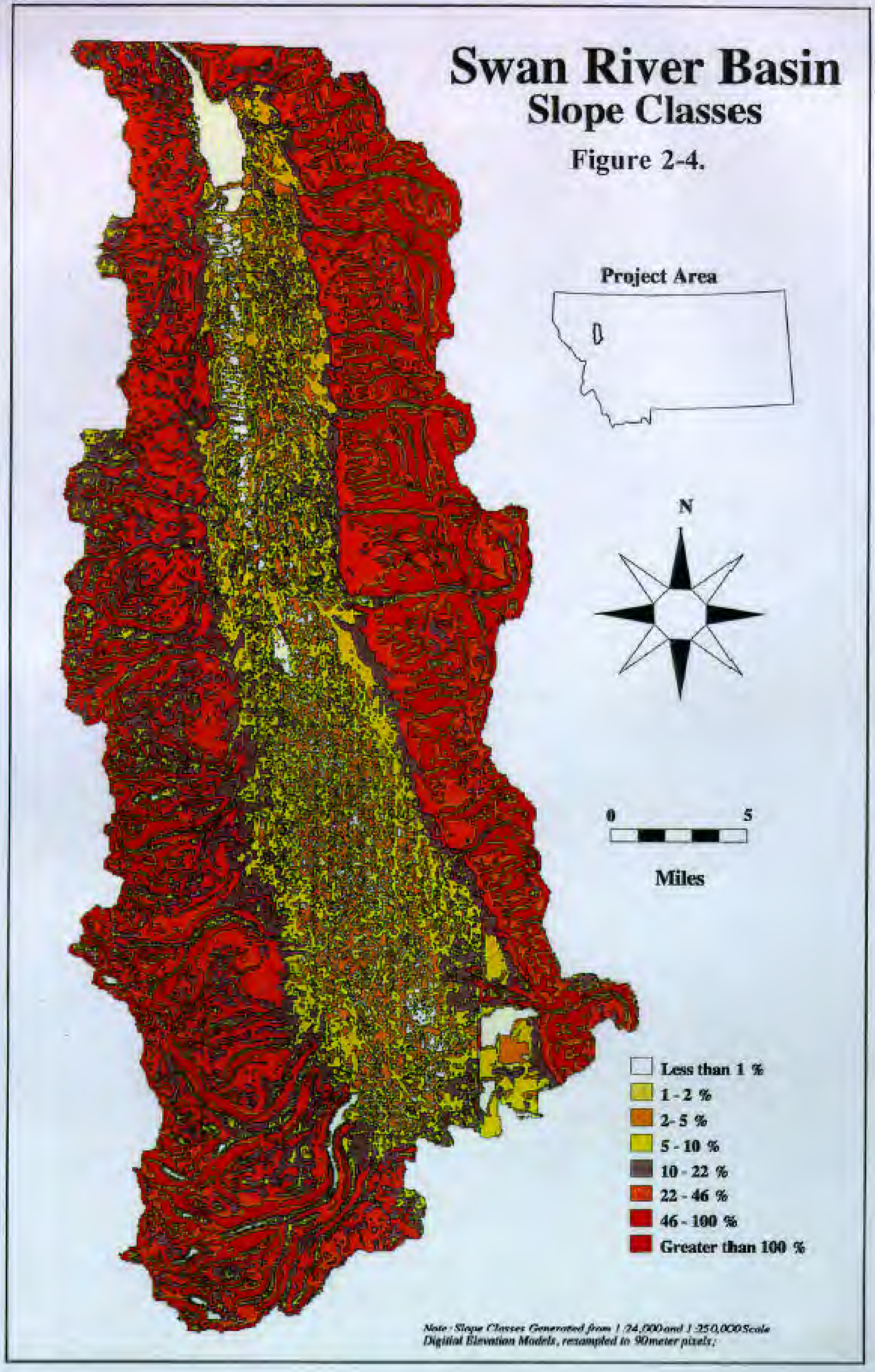
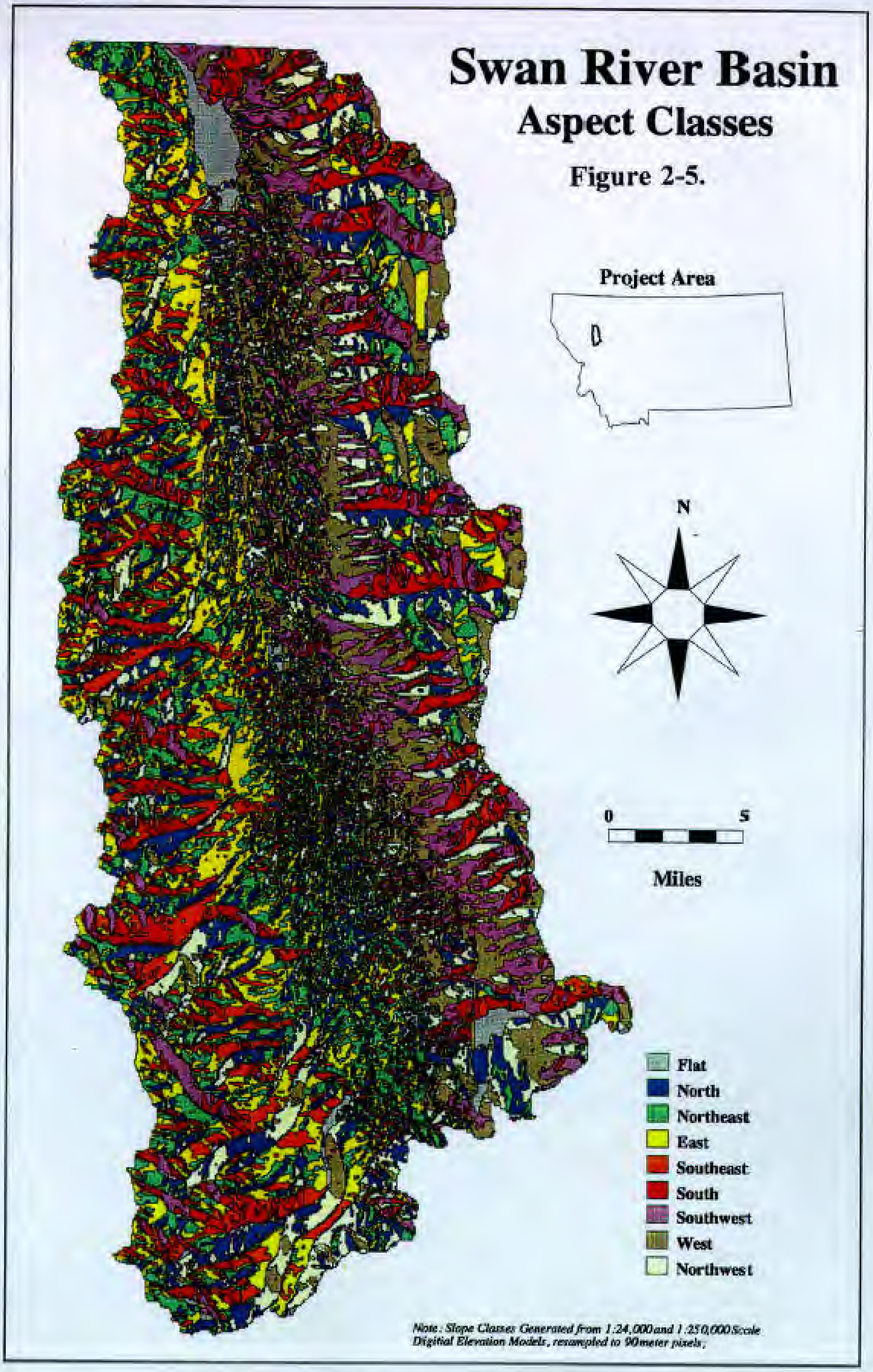


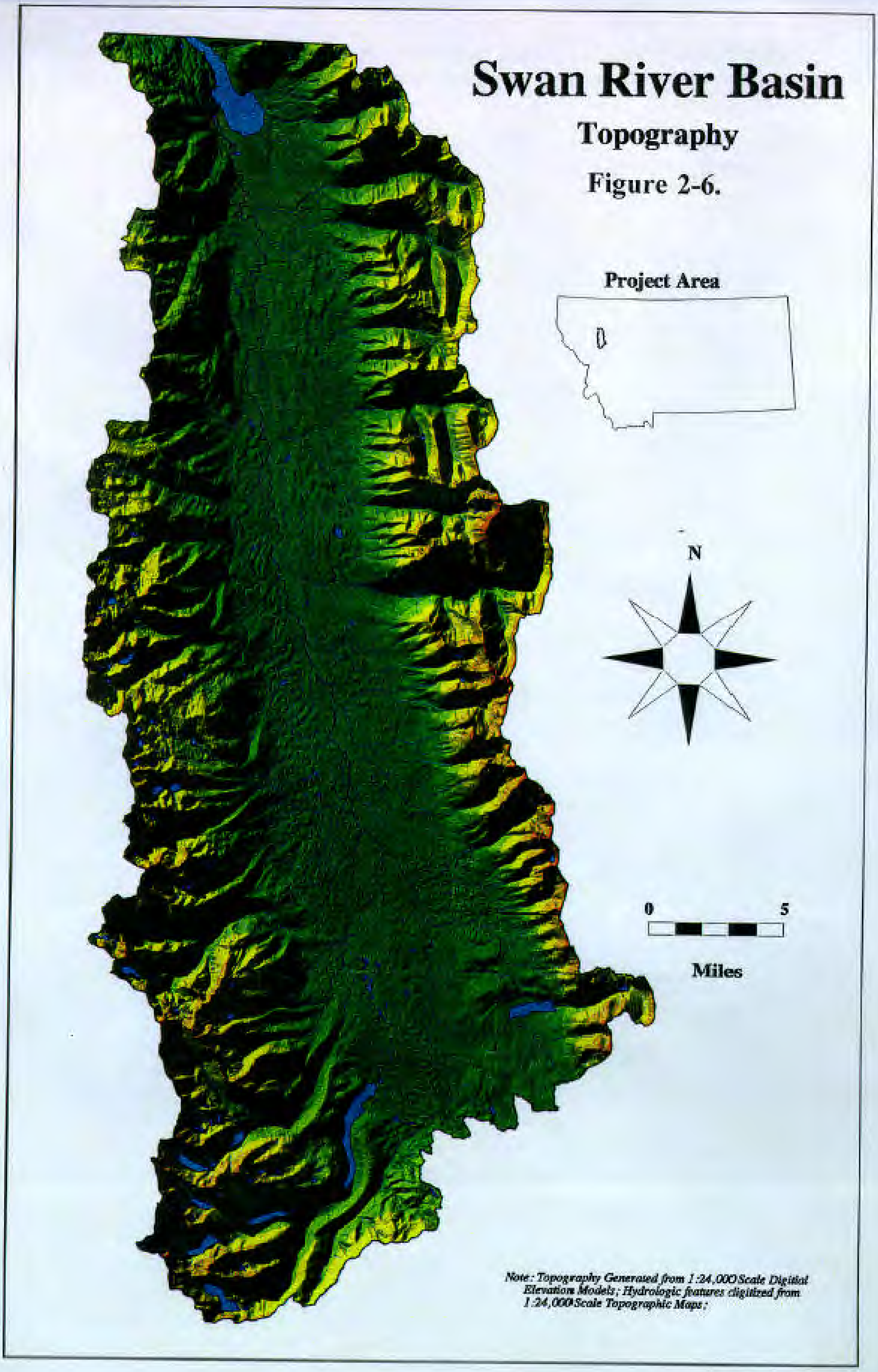
Figure 2-2. Elevation, slope and aspect distributions, Swan River basin.

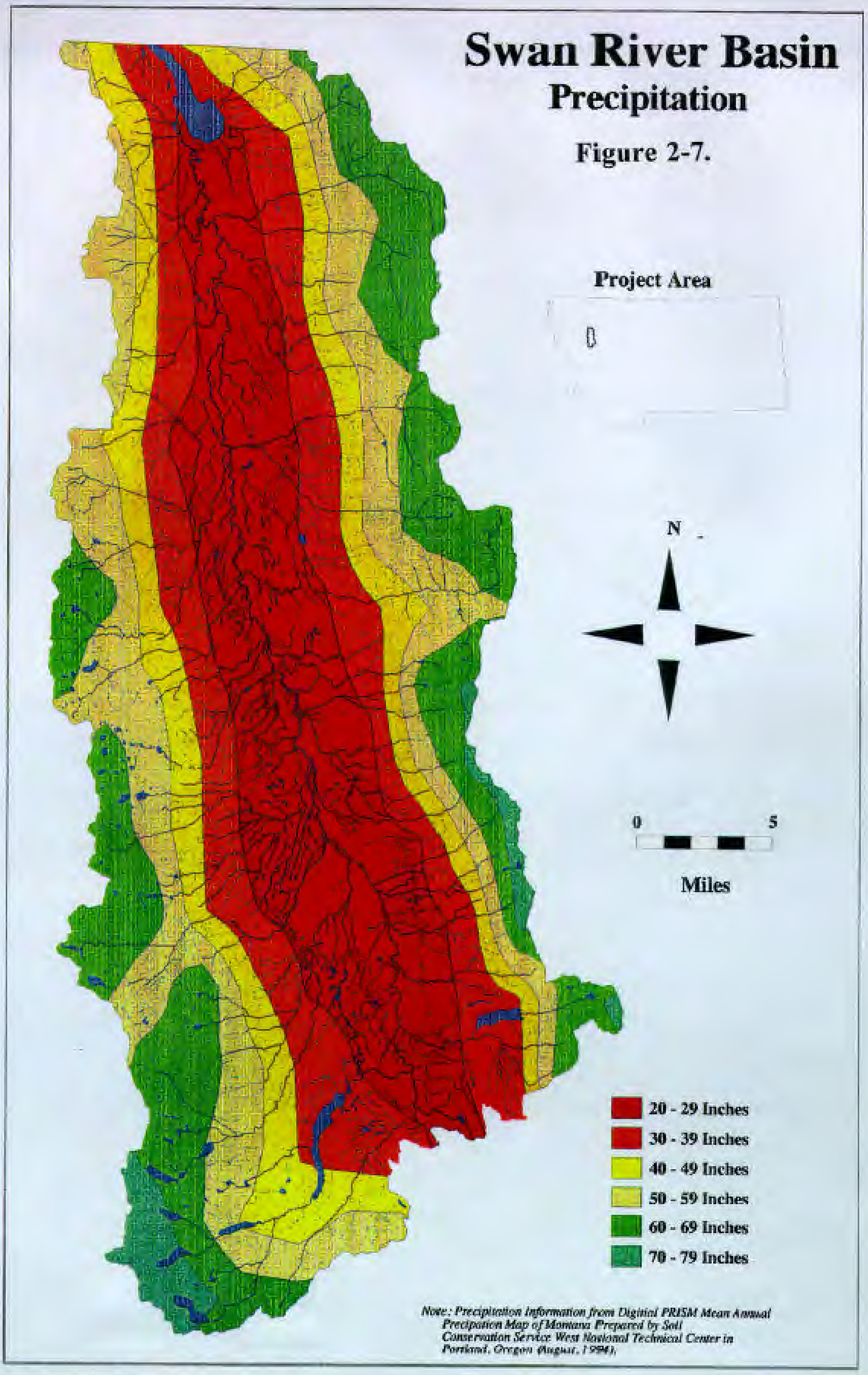

Swan River Basin
Elevation Classes
Figure 2-3.
3000 - 3999 Feet
4000 - 4999 Feet
5000 - 5999 Feet
6000 - 6999 Feet
7000 - 7999 Feet
8000 - 8999 Feet
9000 - 9999 Feet
N
0
5
Miles
Note: Elevation Classes Generated from 1:24,000 Scale DEM's


Swan River Basin
Slope Classes
Figure 2-4.
Project Area
N
0
5
Miles
Less than 1 %
1 - 2 %
2 - 5 %
5 - 10 %
10 - 22 %
22 - 46 %
46 - 100 %
Greater than 100 %
Note: Slope Classes Generated from 1:24,000 and 1:250,000 Scale
Digital Elevation Models, resampled to 90meter pixels.



Swan River Basin
Aspect Classes
Figure 2-5.
Project Area
N
0
5
Miles
Flat
North
Northeast
East
Southeast
South
Southwest
West
Northwest
Note: Slope Classes Generated from 1:24,000 and 1:250,000 Scale Digitial Elevation Models, resampled to 90meter pixels;


Swan River Basin
Topography
Figure 2-6.
Project Area
N
0
5
Miles
Note: Topography Generated from 1:24,000 Scale Digital Elevation Models; Hydrologic features digitized from 1:24,000 Scale Topographic Maps;


Swan River Basin
Precipitation
Figure 2-7.
Project Area
N
0
5
Miles
20 - 29 Inches
30 - 39 Inches
40 - 49 Inches
50 - 59 Inches
60 - 69 Inches
70 - 79 Inches
Note: Precipitation Information from Digital PRISM Mean Annual Precipation Map of Montana Prepared by Soil Conservation Service West National Technical Center in Portland, Oregon (August, 1994).

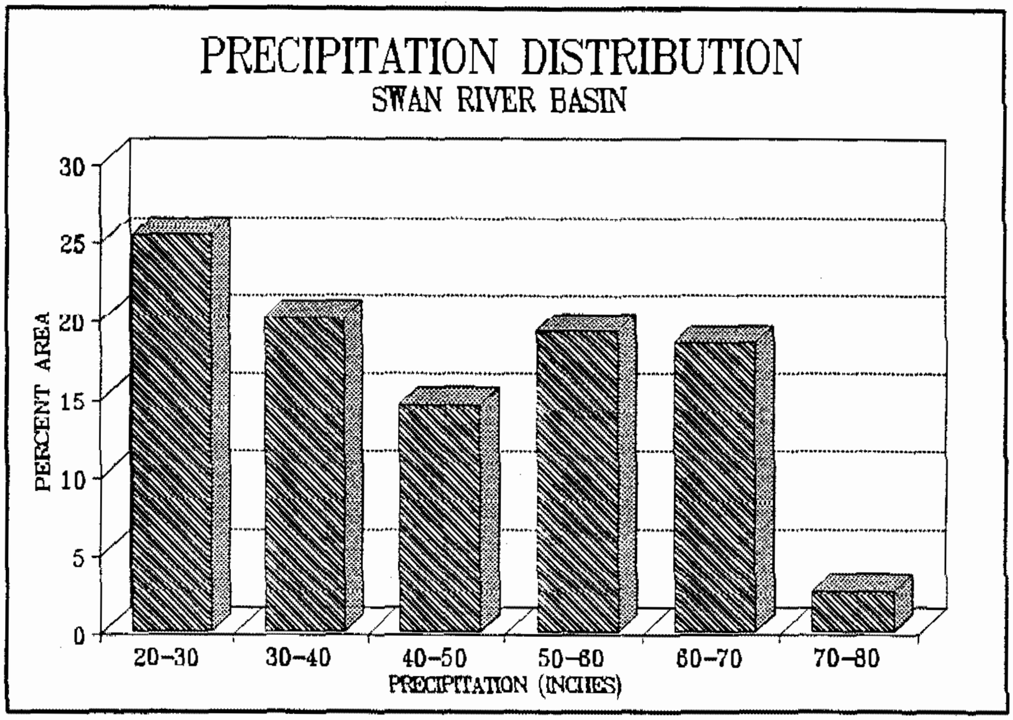


Figure 2-8. Distribution of precipitation classes.

The stream courses marked on Figure 2-1 are from the 1:24,000 scale quads. The upstream and downstream elevations of stream reaches were estimated from 1:24,000 scale DEMs. Grade was calculated as:

$$((E_u - E_d)/L) * 100$$

where: E_u = Upstream elevation of reach
E_d = Downstream elevation of reach
L = Length of reach

A stream order based on Strahler (1957) was assigned to each reach. The headwater tributaries marked on 1:24,000 scale are Order 1. The convergence of two Order 1 streams makes an Order 2 stream. The convergence of two Order 2 streams makes an Order 3; etc. At Swan Lake, the Swan River is Order 6. Streamflow regime (intermittent versus perennial) was also assigned to each reach, as marked on the 1:24,000 scale quads. Stream attributes are summarized in Table 2-1. About 46 percent of the total stream length is perennial with an average gradient of 7.9 percent. Intermittent streams are much steeper with an average grade of 18.3 percent. Also included in Swan River basin are about 554 lakes and ponds with a total area of 7,656 acres and 311 linear miles of shoreline.

Table 2-1. Stream attribute summary[1].

ORDER	-----INTERMITTENT-----			------PERENNIAL------			--------TOTAL--------		
	N	Length (mi)	Grade (%)	N	Length (mi)	Grade (%)	N	Length (mi)	Grade (%)
1	839	580.0	20.0	140	109.0	15.9	979	689.0	19.3
2	186	78.9	10.2	261	199.8	9.6	447	278.7	9.8
3	25	12.5	5.9	200	126.6	5.8	225	139.0	5.8
4	4	1.2	3.3	104	75.1	2.0	108	76.3	2.0
5	1	0.4	1.3	41	18.5	0.8	42	18.9	0.8
6	16	7.8	0.5	77	46.9	0.4	93	54.6	0.4
TOTAL	1071	680.7	18.3	823	575.9	7.9	1894	1256.6	13.6

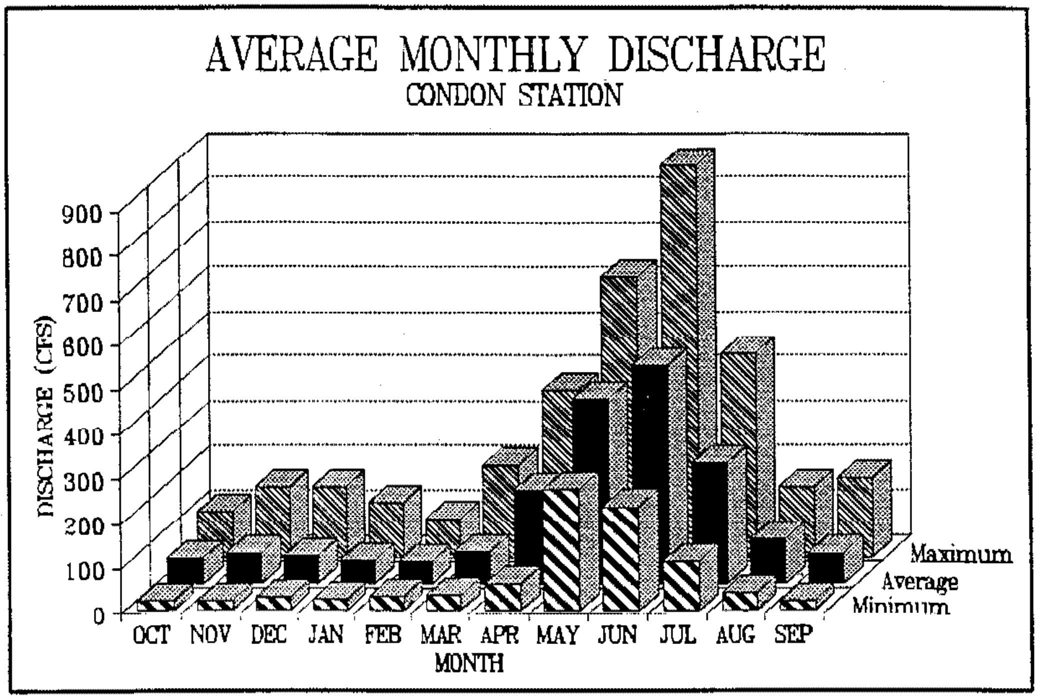
[1] data compiled from 1:24,000 scale quads and 1:24,000 scale DEMs.

Stream gaging stations are monitored by USGS on the Swan River at Condon (20 year period of record from 1973 to 1992), located in the upper part of the Swan River Valley and at Big Fork (72 year period of record from 1922 to 1993), just above Flathead Lake. Average monthly flows (minimum, mean, and maximum) are compared for each gaging station in Figure 2-9. Average annual yields at Big Fork are 841,941 acre-feet. About 640,643 acre-feet (43 percent of average annual precipitation) is lost to evapotranspiration and percolation to deep groundwater.

Lands are managed by the U.S. Forest Service, Plum Creek and other private owners (see Figure 2-10 and Table 2-2).

Table 2-2. Land ownership summary.

OWNERSHIP	AREA			STREAM LENGTH			
				Perennial		Intermittent	
	N	(ac)	(%)	(miles)	(%)	(miles)	(%)
Forest Service	81	256152	62.7	303.5	52.7	421.9	62.0
Plum Creek	123	82718	20.2	137.7	23.9	145.6	21.4
Private	48	27874	6.8	72.6	12.6	47.9	7.0
State	29	39624	9.7	55.7	9.7	61.9	9.1
Wildlife Refuge	1	2261	0.6	6.4	1.1	3.4	0.5
TOTAL		408630	100	575.9	100.0	680.7	100.0



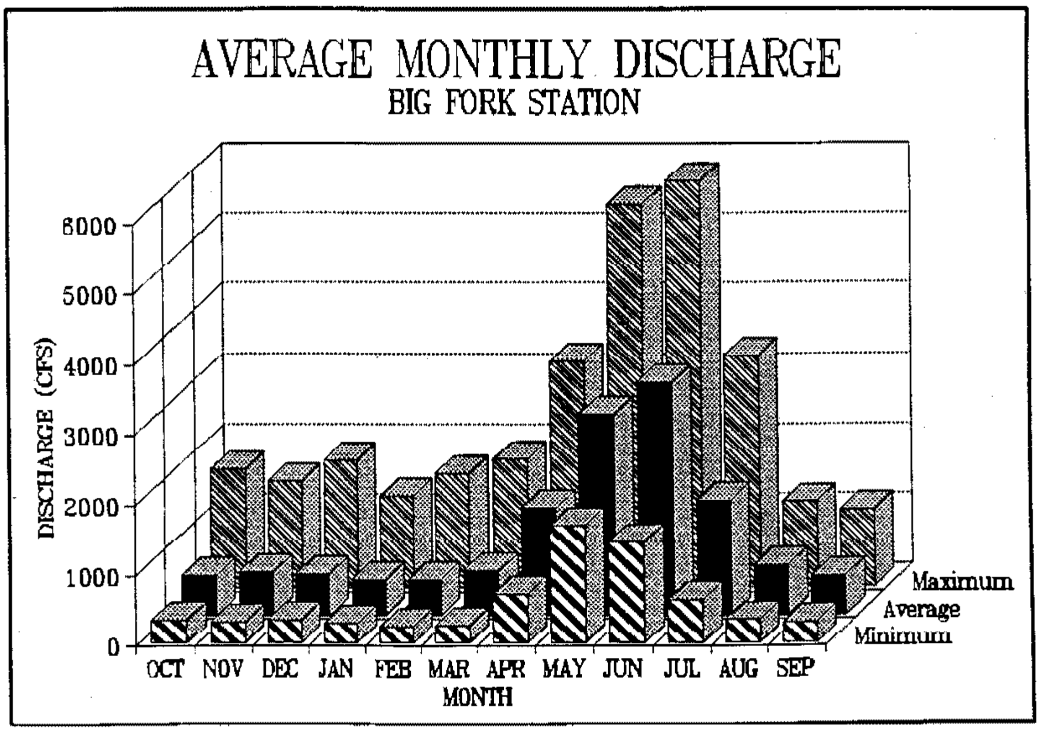
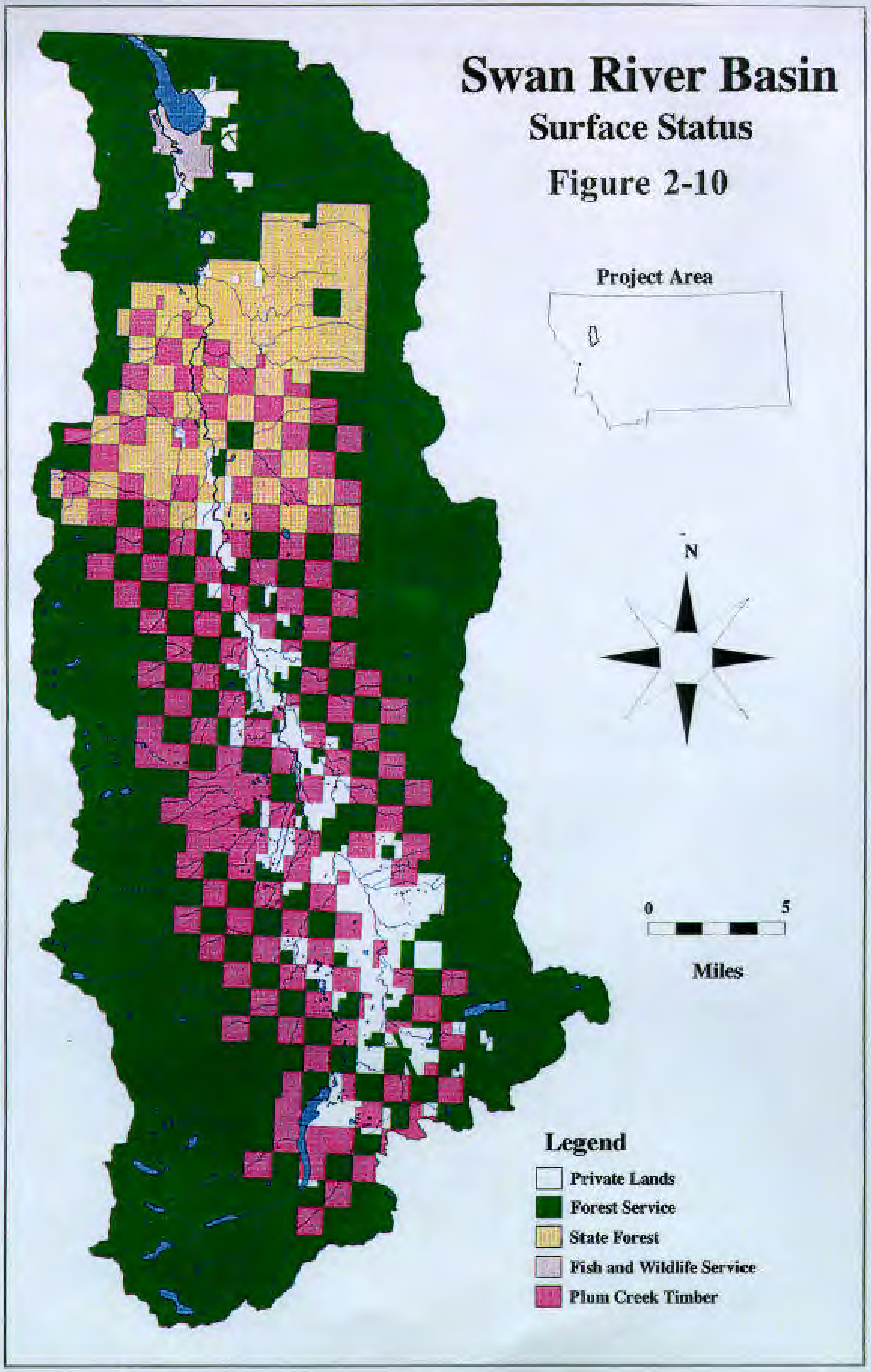


Figure 2-9. Average monthly flows, Swan River.


Swan River Basin
Surface Status
Figure 2-10
Project Area
N
0
5
Miles
Legend
Private Lands
Forest Service
State Forest
Fish and Wildlife Service
Plum Creek Timber

3.0 CLASSIFICATION AND INVENTORY

The classification is hierarchical and consists of seven levels (Table 3.0-1). Classes of the top levels are based on regional criteria from small-scale maps and general information sources. Classes of the lower levels are based on information from large-scale maps and on more quantitative, site-specific criteria. The intent of the classification is to identify landscapes that evolved in response to distinctive processes that have resulted in distinctive structure, function and ecological potential. Landscapes have evolved in response to the interaction of climatic, geologic, geomorphic, hydrologic and biotic processes. From a "high-perspective" (e.g., 1:2,500,000 scale), differences in regional climate and geologic structure are apparent between the Columbia Plateau and the Northern Rocky Mountain Ecoregions. When viewed from a "mid-perspective" (e.g., 1:100,000 scale), differences in geologic districts (e.g., granite versus basalt) and landtype associations (e.g., glacial versus fluvial) become discernable, corresponding with landscapes of more distinctive structure, form and ecological potential. From a "low-perspective" (e.g., 1:24,000 scale) areas of still more distinctive form and position relative to environmental gradients are used to discern landtypes, habitat types and riparian landtypes.

Table 3.0-1. Hierarchical levels of classification.

Ecoregion	Areas of distinctive land-surface form, potential natural vegetation, land-use and soil (Omernik 1987); identified from small scale (1:2,500,000) maps, they may contain few to many geologic districts.
Geologic District	Areas of distinctive parent materials that differ from surrounding districts in structure, degree of weathering, dominant size-fractions of weathering products and water- handling characteristics (e.g., porosity, permeability, runoff potential); includes both uplands and bottom-lands; it may contain one to several landtype associations.
Subsection	A division of a geologic district, distinguished by geologic structure for the Swan River basin.
Landtype Association	A hierarchical level of the Land System Inventory applied by the USDA Forest Service. Sirucek (1995) reported that landtype associations were mapped for the Flathead River basin by grouping landtypes identified by Martinson and Basko (1983) with distinctive erosion potential and sediment delivery efficiency.
Landtype	A hierarchical level of the Land System Inventory applied by the USDA Forest Service. Martinson and Basko (1983) distinguished landtypes by landform, patterns of soil and climax plant community.
Habitat Type	Forested habitat types of Montana were described by Pfister et al. (1977) and identify climax plant communities, usually identified at a scale similar to landtypes.
Riparian Landtype	Riparian/wetland habitats that were described and mapped by the Flathead National Forest (Sirucek and Bachurski 1995). Riparian landtypes were distinguished by valley gradient, dominant stream substrate and dominant overstory vegetation.

Hierarchical levels may be thought of as layers of information. The top layers (e.g., ecoregion) consist of large polygons that are described in terms of general criteria. At successively lower levels, polygons are divided into smaller areas that are described in terms of more refined criteria, from which increasingly specific interpretations can be drawn. The classification is applied from the top level down, thus accounting for variance at the broadest level possible. The various scales used in the classification allow interpretation and generalization at perspectives ranging from regional to more specific. More specific information for lower levels can also be integrated to support interpretations for higher levels.

3.1 Ecoregion

Ecoregion (Omernik 1987) is the broadest level of classification. Ecoregions are based on factors that cause regional variation in ecosystems or on factors that integrate the causes of regional variations. Principal factors used to identify ecoregions are land surface form, potential natural vegetation, land use and soils. Ecoregions have been used to identify streams of similar potential to facilitate impact assessments (Hughes et al. 1986; Rohm et al. 1987) and for identifying streams with similar biotic and physicochemical characteristics (Hughes et al. 1987; Whittier et al. 1988).

The diversity within ecoregions is not consistent. Some are similar throughout; others encompass great variation. The range in elevation and topographic diversity are relative measures of the diversity within an ecoregion. The scale at which the diversity is apparent also varies. In the High Desert/Snake River Plain, comprised mainly of rather flat lava, the variance occurs over large areas and can be shown on small (e.g., 1:1,000,000) scale maps. In the Northern Basin and Range Ecoregion, with numerous high ranges separated by basins, the diversity occurs within comparatively small areas and must be indicated on larger (e.g., 1:500,000) scale maps. More inclusive analyses, at larger scales, are necessary to develop quantitative understanding of the variance within and between ecoregions (Omernik 1987).

The Swan River basin is within the Northern Rocky Mountain Ecoregion (Figure 3.1-1). This ecoregion is characterized as high mountains with cedar/hemlock/pine, western spruce/fir, grand fir/Douglas-fir and Douglas-fir potential natural vegetation. Major land uses include harvest of forest and woodland products. Soils are described as Eastern interior mountain soils with acidic rock types, mostly Inceptisols.

Ecoregions of the Western United States
(Omernik, 1993)

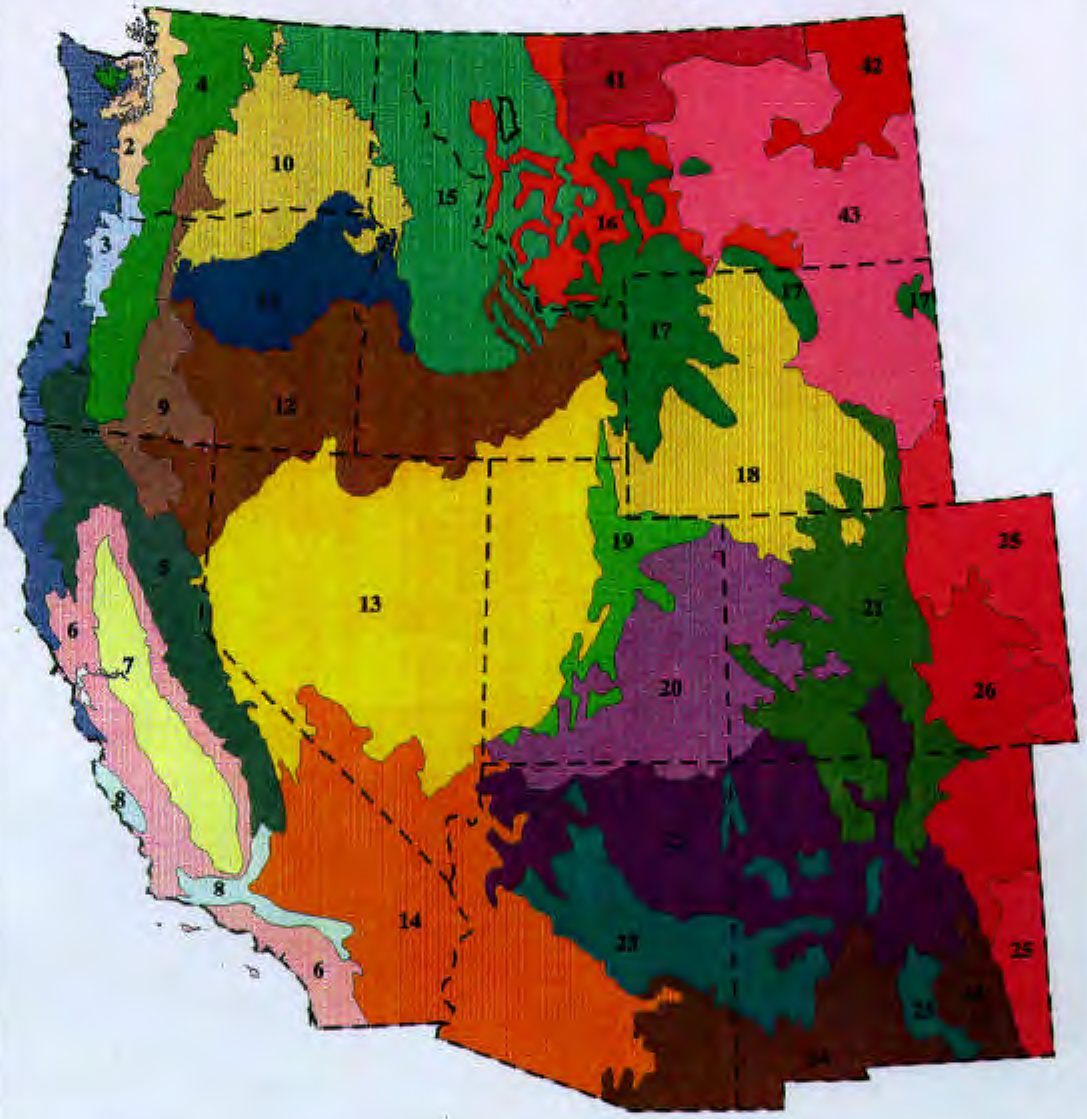
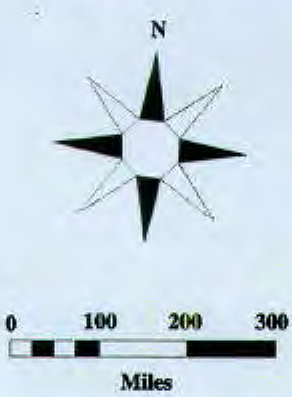


Figure 3.1-1.

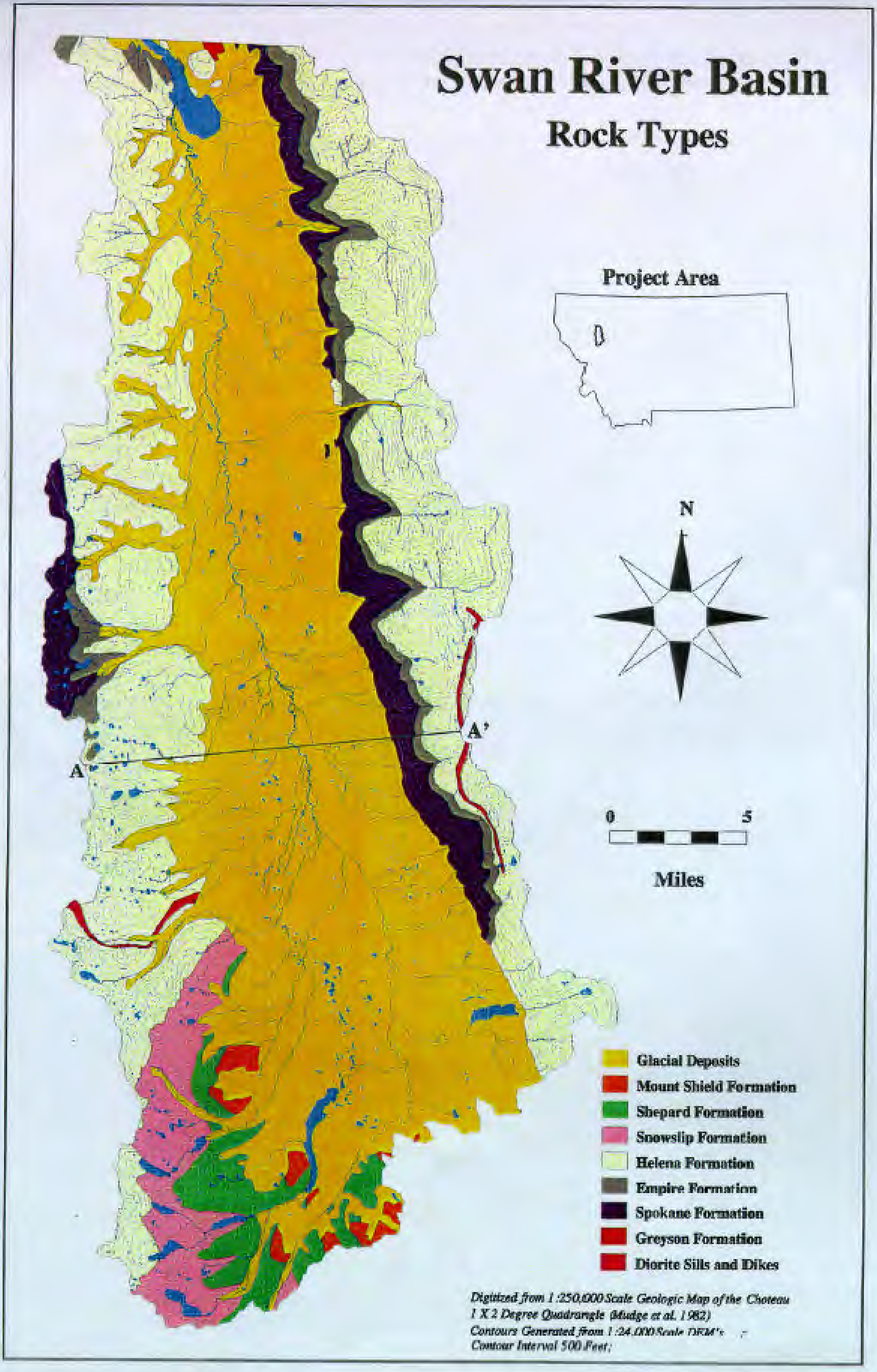


3.2 Geologic Districts

Geologic districts are areas of distinctive rock types or parent materials. They often correspond with distinctive assemblages of upland potential plant communities and areas of distinctive hydrologic character. The hydrologic character of landscapes is also influenced by the degree to which parent material has been weathered (producing sediment) and the water-handling characteristics (e.g., porosity, retention, etc.) of the parent rock and its weathering products. The hydrologic character of hard rock (e.g., quartzite) that weathers slowly to mixed sizes (e.g., silt, sand, gravel and cobble) is different from that of soft rock (e.g., tuff) that weathers rapidly to fine-textured sediment.

Geologic districts may be 10's to many 100's of square miles in size. They are identified at about the same scale as subsections identified in U.S. Forest Service Land System Inventories (Wertz and Arnold 1972). Geologic districts do not change (to other types) in response to cultural practices. They include both uplands and bottom-lands.

Swan Valley was created in response to block faulting, with the upthrust fault scarp forming the steep Swan Range on the east side of the valley and the dip slope forming the Mission Range along the west side of the valley. Surficial rock types identified in Figure 3.2-1 and 3.2-1b are from a 1:250,000 scale Geologic Map of the Choteau Quadrangle (Mudge et al. 1982). A legend of rock types is presented as Table 3.2-1. The areas of surficial rock types in Swan River basin are listed in Table 3.2-2. Because of the universal similarity of parent materials, a single geologic district was identified for the entire basin - the Precambrian Sedimentary geologic district.



Swan River Basin
Rock Types
Project Area
N
A
A'
0
5
Miles
Glacial Deposits
Mount Shield Formation
Shepard Formation
Snowslip Formation
Helena Formation
Empire Formation
Spokane Formation
Greyson Formation
Diorite Sills and Dikes
Digitized from 1:250,000 Scale Geologic Map of the Choteau 1 X 2 Degree Quadrangle (Mudge et al. 1982)
Contours Generated from 1:24,000 Scale DEM's
Contour Interval 500 Feet

Geologic Cross-section of Swan River Valley

Figure 3.2-1b.

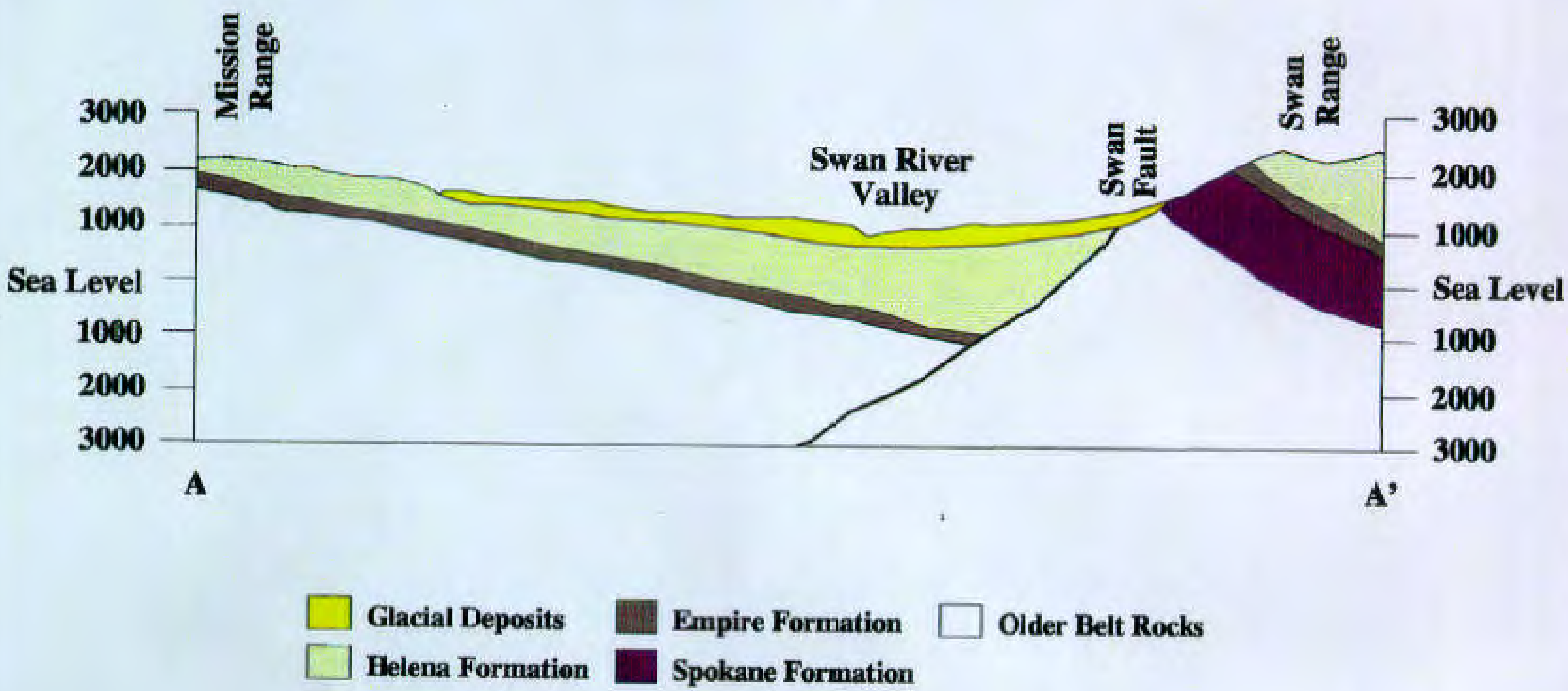


Table 3.2-1. Rock type legend, Swan River basin (Mudge et al. 1982).

ERA Period	SYMBOL	NAME	DESCRIPTION
RECENT			
Holocene/Pleistocene	Qg	Glacial deposits	Drift, heterogeneous mixture of rock fragments in silty clay matrix. Forms hummocky topography. Includes deposits from alpine and continental glaciations; as much as 100 meters thick in Swan River valley where thickness of mostly sand and gravel deposits exceeds 300 meters.
PRECAMBRIAN			
Proterozoic	Yms	Mount Shields Form.	Mostly bright reddish brown, thinly laminated, micaceous siltite, argillite, and thin-to-thick bedded quartzite. A grayish-green siltite unit with local interbedded dark-gray fissile shale is widespread in the upper part of the formation. The quartzite beds are mostly fine to medium grained and more common in the middle and lower pats of the formation.
Proterozoic	Ysh	Shepard Formation	Consists mostly of greenish-gray to grayish-yellow micaceous siltite and some silty limestone and argillite. Beds of maroon siltite and argillite widespread in the middle part and locally in the upper part.
Proterozoic	Ysn	Snowslip Formation	Consists of pale-red to reddish-brown beds and interbedded greenish-gray beds of argillite and siltite with some thin beds of very fine to fine-grained quartzite.
Proterozoic	Yh	Helena Formation	In most places the Helena is divisible into three units. The upper unit consists of beds of limestone interbedded with dolomite, siltite, and argillite. The middle unit, comprising most of the formation, consists of light to medium-gray, thin to thick-bedded silty limestone, dolomite and calcitic dolomite that weathers to a yellowish gray to grayish orange. The lower unit consists mostly of calcareous or dolomitic siltite with some beds of dolomite and quartzite.

Table 3.2-1. Continued.

ERA Period	SYMBOL	NAME	DESCRIPTION
PRECAMBRIAN (CONTINUED)			
Proterozoic	Ye	Empire Formation	A transitional unit between the Helena and Spokane Formations. Mostly greenish gray argillite and siltite with interbeds of quartzite, dolomite, and locally stromatolitic and oolitic carbonate rock.
Proterozoic	Ys	Spokane Formation	Mostly pale-purplish-red and grayish-red siltite and argillite interbedded with lithologically similarly greenish-gray beds.
Proterozoic	Yg	Greyson Formation	The oldest unit exposed in and near the map area. Consists of light-gray to greenish-gray, thinly bedded siltite with some quartzite, grading down into dark gray, greenish-gray, very thinly laminated argillite and siltite in the lower part.
Proterozoic	Zd	Diorite sills & dikes	Mostly diorite and quartz diorite, locally minor diorite-grabbro and monsonite. Dark gray, weathers grayish brown.

Table 3.2-2. Areas of surficial rock types. Swan River basin.

SYMBOL	NAME	N	ACRES	PERCENT
Qg	Glacial deposits	1	201150	49.2
Ye	Empire Formation	13	13193	3.2
Yg	Grayson Formation	1	260	0.1
Yh	Helena Formation	16	134587	32.9
Yms	Mount Shields Formation	10	3371	0.8
Ys	Spokane Formation	7	23028	5.6
Ysh	Shepard Formation	11	12652	3.1
Ysn	Snowslip Formation	2	18711	4.6
Zd	Diorite sills and dikes	5	1680	0.4
TOTAL		66	408630	100.0

Both the Mission Mountains on the west and the Swan Mountains on the east are Precambrian sedimentary formations. Dominant parent materials are siltite, argillite, limestone and quartzite of the Mount Shields, Shephard, Helena and Empire Formations. Nearly 50 percent of Swan River basin is mantled by secondary glacial deposits, most derived from these same dominant parent materials. These similar parent materials were combined as the Precambrian Sedimentary geologic district for the Swan River basin.

3.3 Subsections

Subsections were defined to distinguish parts of the geologic district with distinctive geologic structure and geomorphology. The Swan Valley was created in response to block faulting, with the upthrust fault scarp along the east side of the valley (Swan Range) and the dip slope along the west side of the valley (Mission Range). Nearly 50 percent of Swan River basin is mantled by secondary glacial deposits.

During the Bull Lake ice age that peaked roughly 100,000 years ago, the northern end of the Mission Range split the Cordilleran ice sheet that moved south from British Columbia, sending one lobe of the glacier through the Swan Valley (Alt and Hyndman 1986). That branch of the Cordilleran ice sheet plowed through the Swan Valley and continued south into the Clearwater River basin, which drains south. This glacier left moraines that form many of the hills just south of Clearwater Junction. Ice advanced through the Swan Valley again to the lower end of Salmon Lake during the Pinedale ice age, which reached a maximum about 15,000 years ago.

After the mass of ice that filled Swan Valley was gone, large glaciers repeatedly plowed down the valleys of the Mission and Swan Ranges. The later advances of these alpine glaciers left high moraines that now enclose Holland and Lindbergh Lakes, as well as others at the mouths of canyons in the Mission and Swan Ranges. Johns (1970) and Witkind (1977) suggest that the alpine glaciers may have merged to form a very large ice sheet in Swan Valley that flowed north to meet the Cordilleran ice sheet near Big Fork. These authors speculate that giant glacial grooves cut in the northern tip of the Mission Range and further south along the east flank of the Mission Mountains and the west flank of the Swan Range were scoured by the south flowing Cordilleran ice sheet and/or the north flowing Swan Valley glacier.

Three subsections were identified in the Swan River basin (Figure 3.3-1). The areas of subsections are listed in Table 3.3-1. Stream attributes for subsections are listed in Table 3.3-2. Stream gradients are compared for different subsections in Figure 3.3-2 and drainage density (linear miles stream/square miles) are compared in Figure 3.3-3. Descriptions of subsections follow.

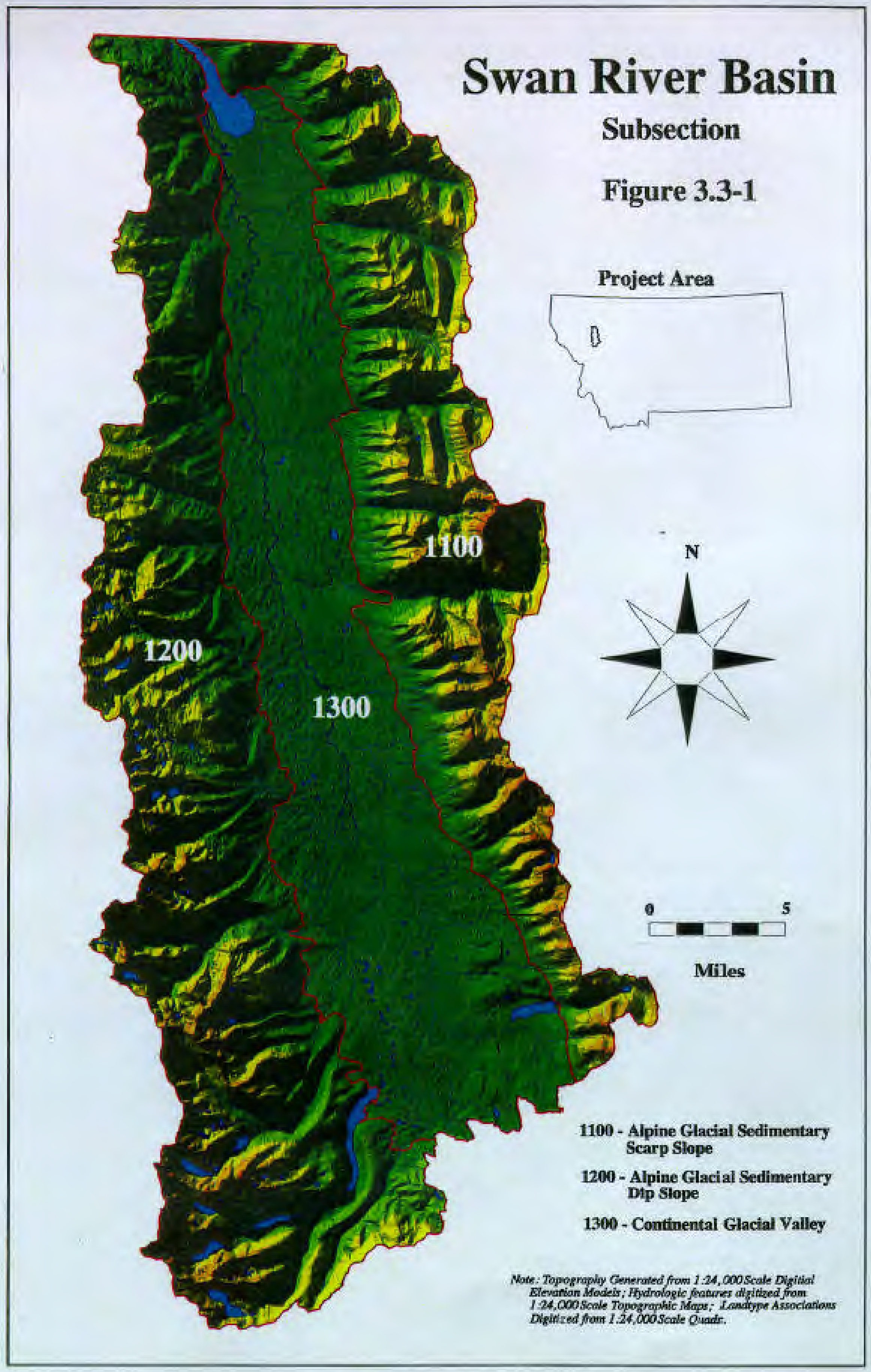
Table 3.3-1. Subsections, Swan River basin.

CODE	Subsection	AREA (acres)	AREA (%)
(1100)	Alpine Glacial Sedimentary Scarp Slope	109,948	26.9
(1200)	Alpine Glacial Sedimentary Dip Slope	166,140	40.7
(1300)	Continental Glacial Sedimentary Valley	132,542	32.4
	TOTAL	408,630	100.0

Table 3.3-2. Stream attributes for subsections[1].

SUBSECTION (CODE) Order	PERENNIAL		INTERMITTENT		TOTAL	
	Length (mi)	Grade (%)	Length (mi)	Grade (%)	Length (mi)	Grade (%)
ALPINE GLACIAL SEDIMENTARY SCARP SLOPE (1100)						
1	34.1	24.7	191.5	33.4	225.6	32.1
2	49.5	18.5	10.2	25.6	59.7	19.7
3	29.3	9.0	0		29.3	9.0
4	6.5	4.3	0		6.5	4.3
TOTAL	**119.4**	**17.1**	**201.8**	**33.0**	**321.2**	**27.1**
ALPINE GLACIAL SEDIMENTARY DIP SLOPE (1200)						
1	49.4	16.6	205.1	22.3	254.5	21.2
2	75.4	10.7	26.7	16.5	102.1	12.2
3	43.9	8.0	3.7	14.9	47.6	8.5
4	16.0	3.0			16.0	3.0
TOTAL	**184.8**	**11.0**	**235.5**	**21.5**	**420.3**	**16.9**
CONTINENTAL GLACIAL SEDIMENTARY VALLEY (1300)						
1	24.9	2.7	183.3	3.0	208.2	3.0
2	71.7	2.7	41.9	2.4	113.6	2.6
3	57.1	2.3	8.7	2.1	65.8	2.2
4	52.5	1.4	1.2	3.3	53.7	1.5
5	18.4	0.7	0.4	1.3	18.9	0.8
6	46.8	0.4	7.8	0.5	54.6	0.4
TOTAL	**271.5**	**1.8**	**243.3**	**2.8**	**514.7**	**2.3**

[1] Stream attributes generated from 1:24,000 scale quads and 1:24,000 scale DEMs.



Swan River Basin
Subsection
Figure 3.3-1
Project Area
1100
1200
1300
N
0
5
Miles
1100 - Alpine Glacial Sedimentary Scarp Slope
1200 - Alpine Glacial Sedimentary Dip Slope
1300 - Continental Glacial Valley
Note: Topography Generated from 1:24,000 Scale Digitial Elevation Models; Hydrologic features digitized from 1:24,000 Scale Topographic Maps; Landtype Associations Digitized from 1:24,000 Scale Quads.

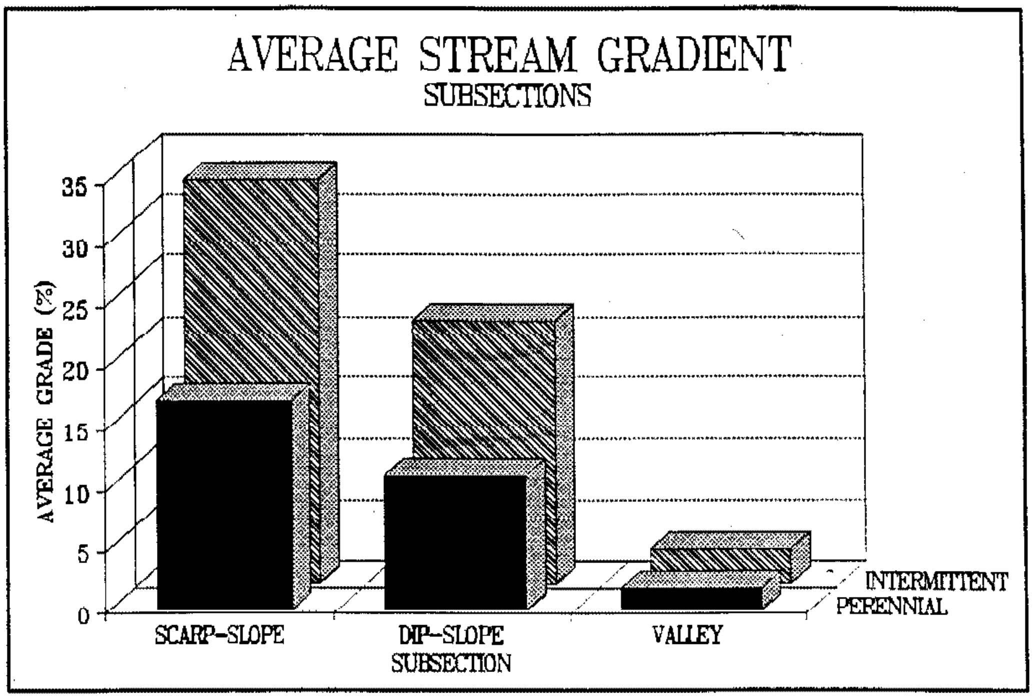


Figure 3.3-2. Stream gradients for subsections.

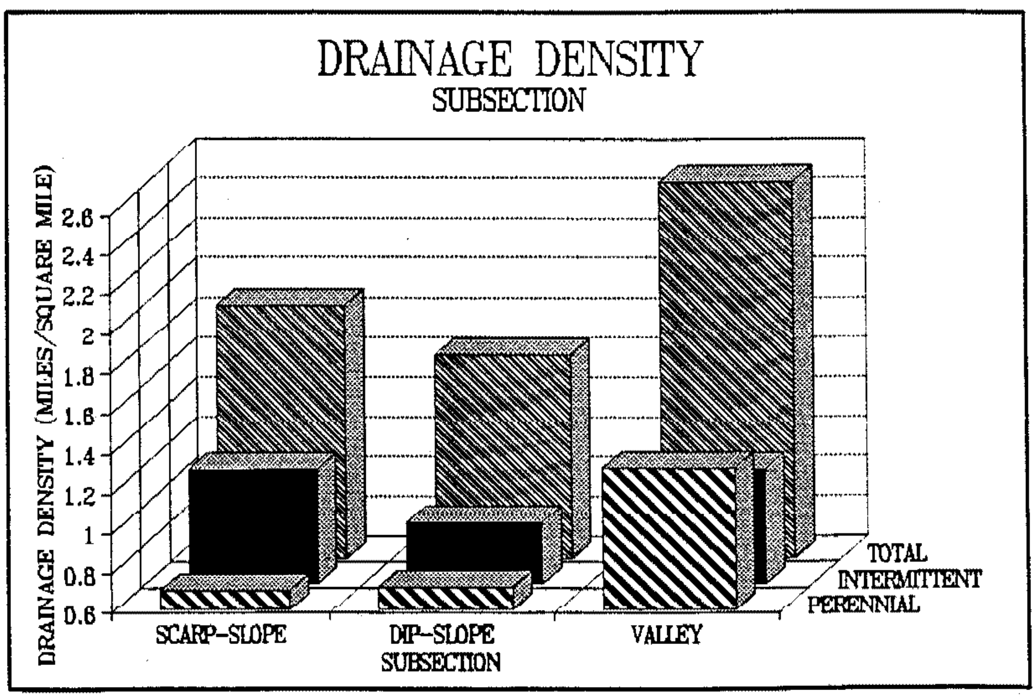


Figure 3.3-3. Drainage density for subsections.

3.3.1 Alpine Glacial Sedimentary Scarp Slope (1100)

As the name implies, this subsection is an up-thrust block (scarp slope) of sedimentary rock that has been scoured by alpine glaciation in the Swan Range. Also, the Cordilleran ice sheet covered lower elevations of this subsection. One polygon of this subsection comprises 109,949 (27 percent) of the Swan River basin.

The distributions of elevation, slope and aspect for the 1100 subsection are illustrated in Figure 3.3.1-1. Elevations are mostly from 4,000 to 8,000 feet. The dominant slopes are 22 to 100 percent. Given the general north-to-south orientated fault scarp, western aspects are prevelent.

This subsection includes 321 miles of Order 1 through 4 streams of which 119 miles (37 percent) is perennial. The weighted average stream grade for perennial streams is 17.1 percent for perennial streams and 33.0 percent for intermittent streams (see Table 3.3-2). This subsection includes 24 lakes with a total area of 186 acres.

This subsection is differentiated from the Continental Glacial Sedimentary Valley (1300) by higher elevations, steeper slopes and more rugged topography. It is different from the Alpine Glacial Sedimentary Dip Slope (1200) subsection in having a higher proportion of very steep (46 to 100%) slopes, steeper perennial and intermittent streams in narrower valley-bottoms and higher intermittent drainage density, in addition to having fewer lakes.

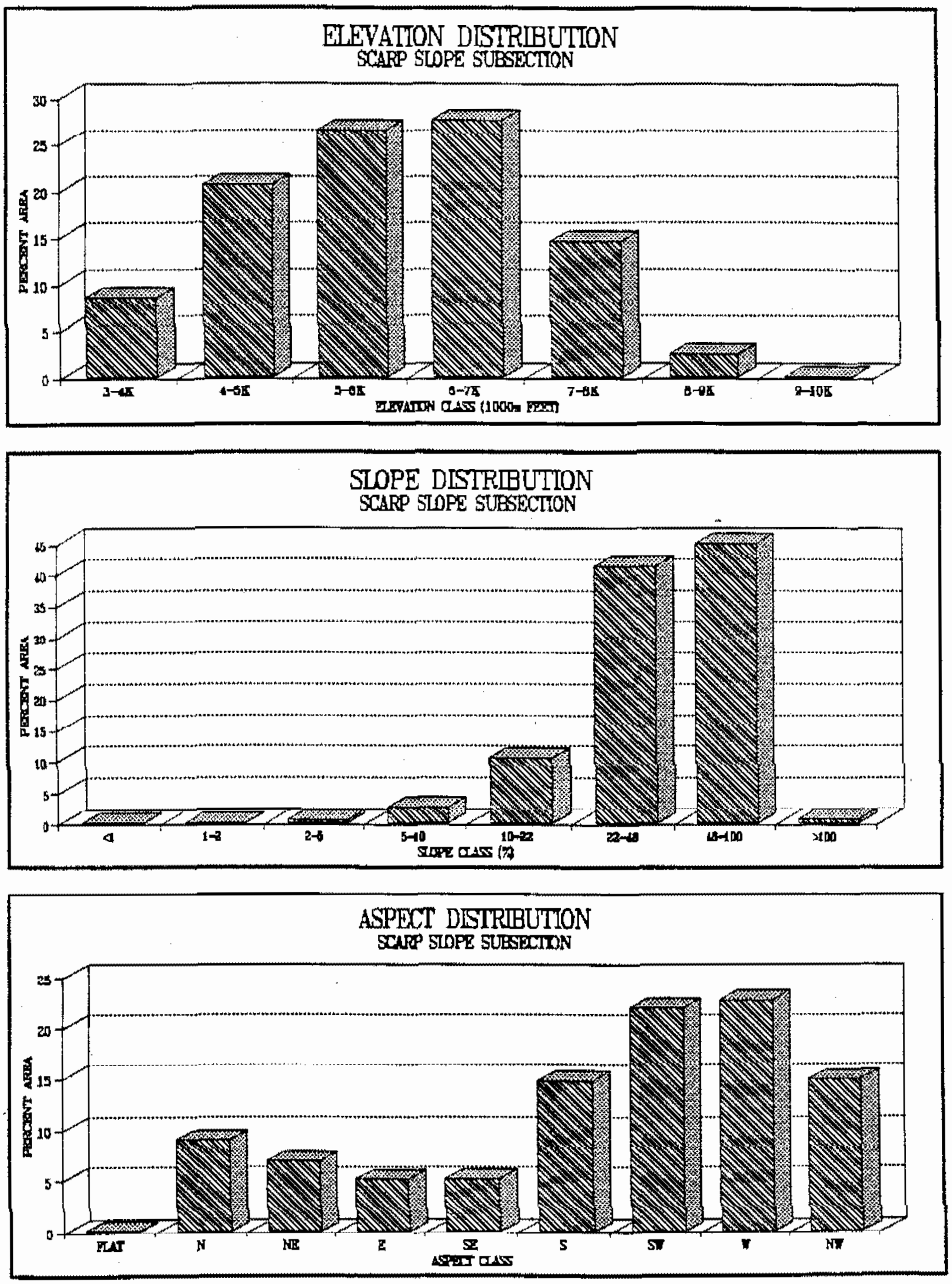


Figure 3.3.1-1. Elevation, slope and aspect distributions, scarp-slope subsection.

3.3.2 Alpine Glacial Sedimentary Dip Slope (1200)

This subsection is an down-thrust block (dip slope) of sedimentary rock that has been scoured by alpine glaciation in the Mission Range. Also, the Cordilleran ice sheet covered lower elevations of this subsection. It comprises 166,140 acres (41 percent) of the Swan River basin (Figure 3.3-1).

The distribution of elevation, slope and aspect is presented as Figure 3.3.2-1. Dominant elevations are similar to the 1100 subsection, from 4,000 to 8,000 feet. Dominant slopes are more gradual and range from 10 to 46 percent. Given the general north-to-south orientated fault scarp, eastern aspects are prevelent.

This subsection includes 420 miles of Order 1 through 4 streams of which 185 miles (44 percent) are perennial. The weighted average stream grade for perennial streams is 11.0 percent for perennial streams and 21.5 percent for intermittent streams (see Table 3.3-2). This subsection includes 243 lakes with a total area of 3,421 acres.

This subsection is differentiated from the Continental Glacial Sedimentary Valley (1300) in having dramatically higher elevations, greater slopes and more rugged topography. It is different from the Alpine Glacial Sedimentary Scarp Slope (1100) subsection in having a lower proportion of very steep (46 to 100%) slopes, streams with lower average gradient, wider valley-bottoms and more lakes.

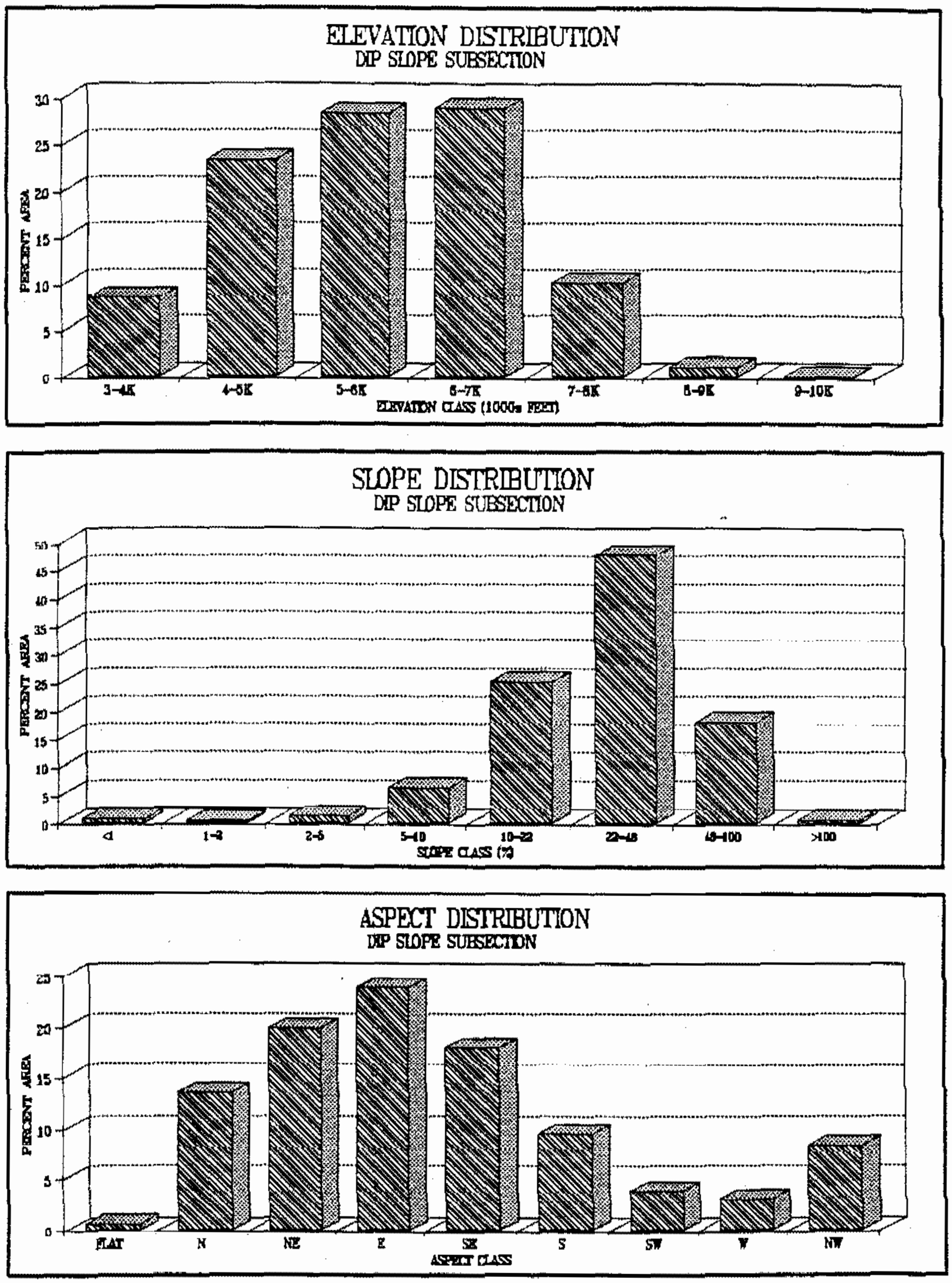


Figure 3.3.2-1. Elevation, slope and aspect distributions, dip-slope subsection.

3.3.3 Continental Glaciated Sedimentary Valley (1300)

This subsection is a block-fault valley underlain by sedimentary rock and mantled with thick deposits of glacial debris left by continental glaciers that moved generally south from British Columbia. This subsection comprises Swan Valley and is 132,542 acres or 32 percent of Swan River basin (Figure 3.3-1).

The distributions of elevation, slope and aspect are illustrated in Figure 3.3.3-1. Dominant elevations range from 3,000 to 5,000 feet. Dominant slopes are less than 22 percent. It is interesting to note that south and southeast aspects, the direction the continental glacier flowed, are minimized. Glacial deposits tend to be elongated ridges oriented parallel to the direction of glacial flow.

This subsection includes 515 miles of Order 1 through 6 streams of which 272 miles (53 percent) are perennial. The weighted average stream grade for perennial streams is 1.8 percent for perennial streams and 2.8 percent for intermittent streams (see Table 3.3-2). Excluding Swan Lake, this subsection includes 275 lakes with a total area of 1,483 acres. The portion of Swan Lake in the study area is 2,034 acres.

This subsection is differentiated from the Alpine Glacial Sedimentary Scarp Slope (1100) and the Alpine Glacial Sedimentary Dip Slope (1200) subsections in having dramatically lower elevations, more gentle slopes and topography, and lower gradient streams.

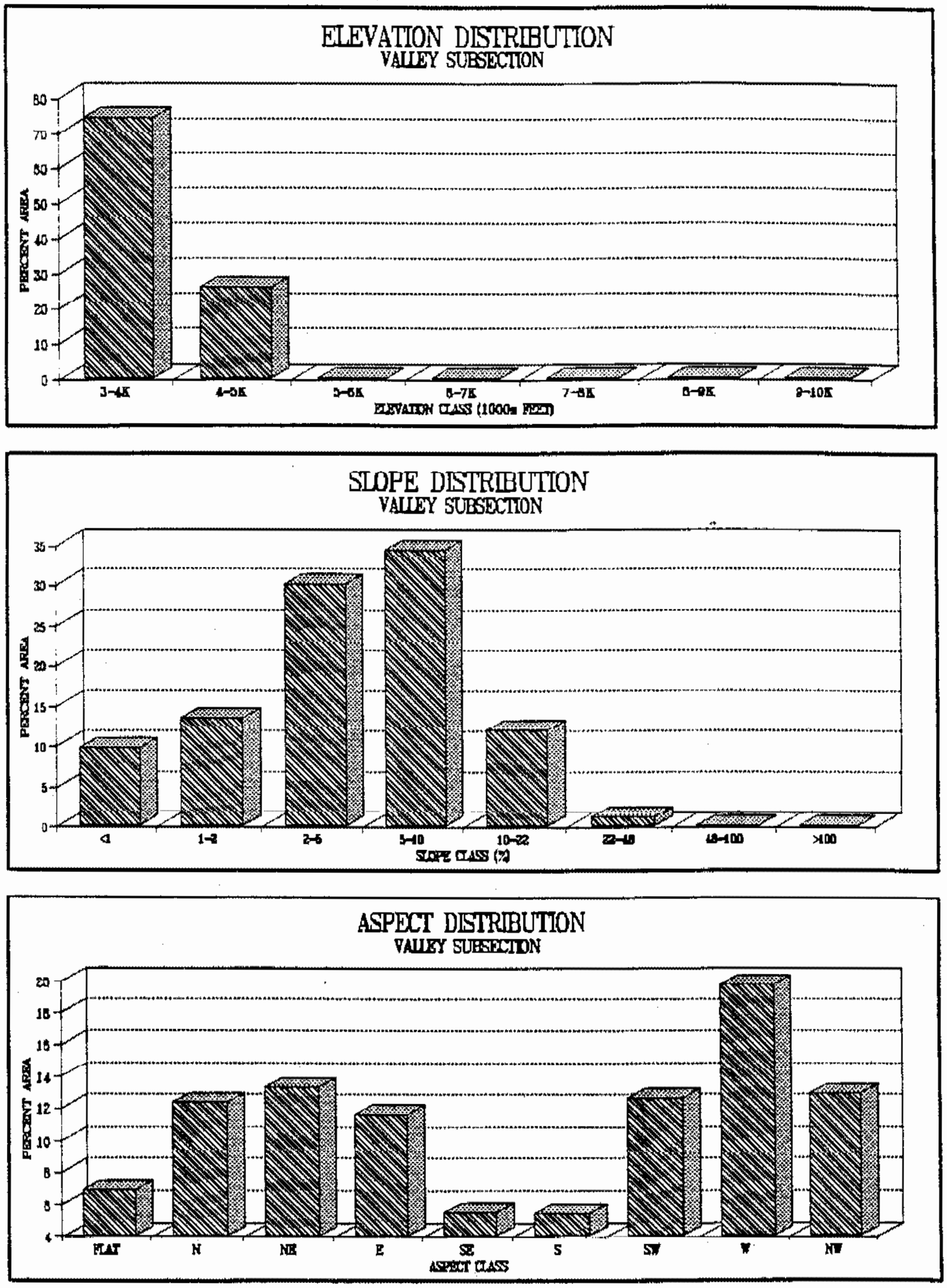


Figure 3.3.3-1. Elevation, slope and aspect distributions, valley subsection.

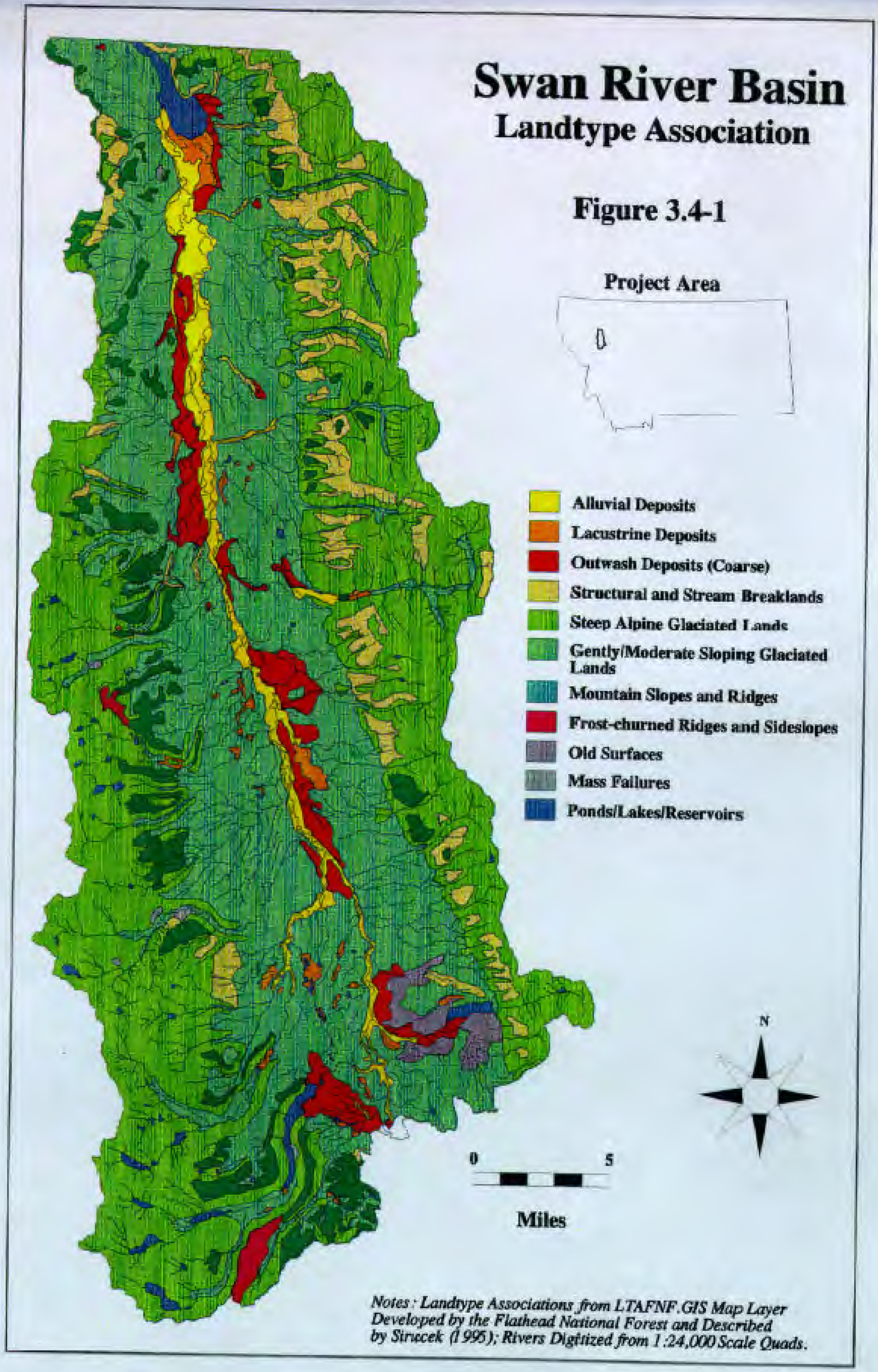
3.4 Landtype Association

In 1994 the Flathead National Forest compiled a landtype association map layer as part of a region-wide Columbia River Basin assessment. Landtype association mapping was done at a scale of 1:100,000 with a minimum map unit size of 80 to 100 acres. The landtype associations were defined to group landtypes with distinctive erosion potential and sediment delivery efficiency. The differentiating criteria for the map units were landform classes that were further subdivided by classes of bedrock lithology. For lands in the Flathead National Forest, landtypes identified in a previous inventory (Martinson and Basko 1983) were grouped and then subdivided by bedrock lithology to create the landtype association map units. A map of landtype associations for the Swan River basin is presented as Figure 3.4-1. The areas of landtype associations identified in the Swan River basin are listed in Table 3.4-1.

Table 3.4-1. Landtype association legend.

CODE	LANDTYPE ASSOCIATION	N	-----AREA------ (ac)	(%)
10	Alluvial Deposits (Coarse)	6	14111	3.5
11	Lacustrine Deposits	43	4536	1.1
12	Outwash Deposits (Coarse)	19	16191	4.0
20	Structural and Stream Breaklands[1]	48	23773	5.8
40	Steep Alpine Glaciated Lands[1]	52	158394	38.8
50	Gently/Moderate Sloping Glaciated Lands[1]	32	156625	38.3
60	Mountain Slopes and Ridges[1]	76	22135	5.4
70	Frost-churned Ridges and Sideslopes[1]	4	1816	0.4
80	Old Surfaces[1]	3	4067	1.0
90	Mass Failures	6	493	0.1
99	Miscellaneous (Ponds/Lakes/Reservoirs)	89	6004	1.5
	TOTAL	**541**	**408660**	**100.0**

[1] Metasedimentary parent material;

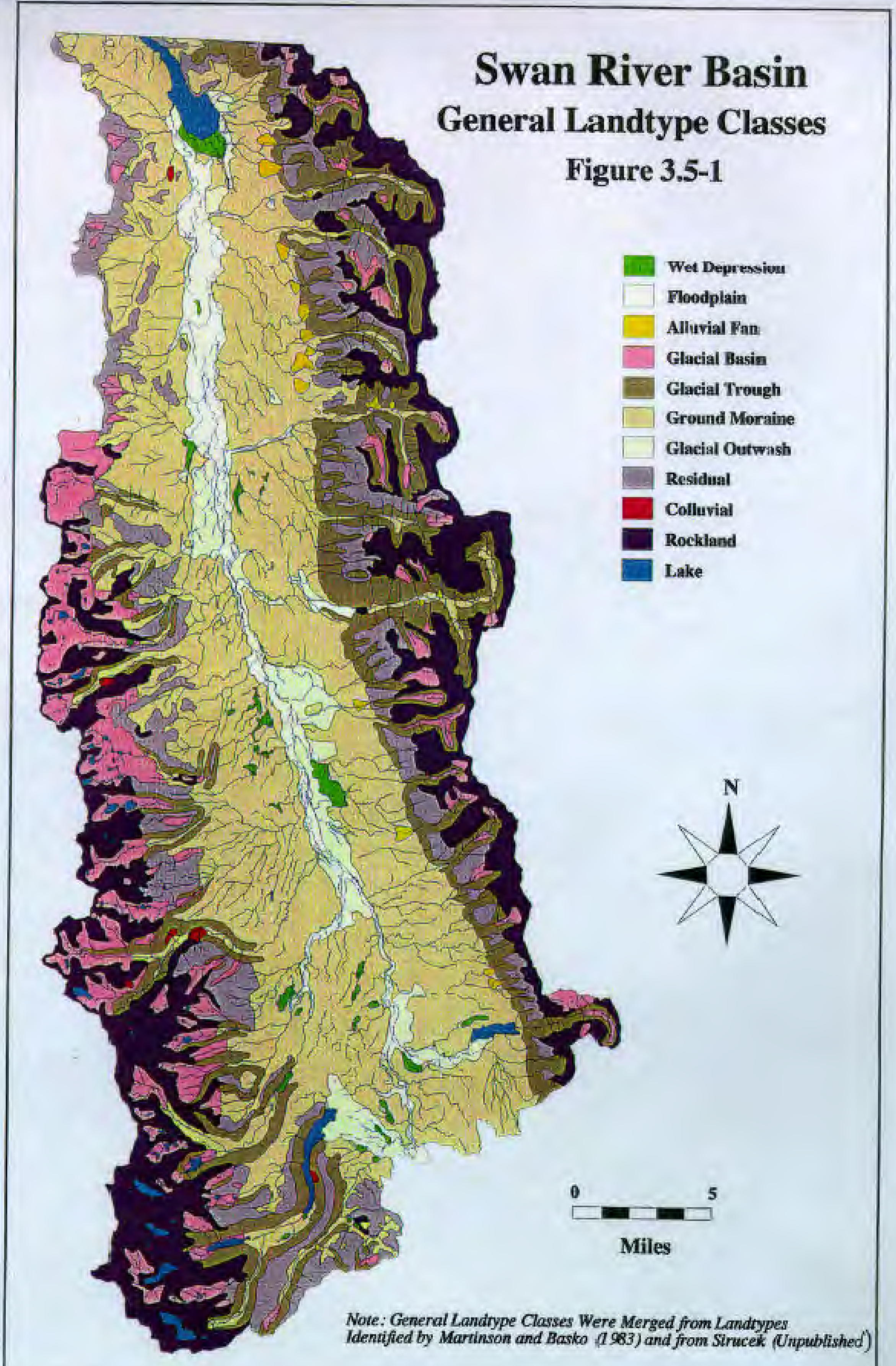

Swan River Basin
Landtype Association
Figure 3.4-1
Project Area
Alluvial Deposits
Lacustrine Deposits
Outwash Deposits (Coarse)
Structural and Stream Breaklands
Steep Alpine Glaciated Lands
Gently/Moderate Sloping Glaciated Lands
Mountain Slopes and Ridges
Frost-churned Ridges and Sideslopes
Old Surfaces
Mass Failures
Ponds/Lakes/Reservoirs
N
0
5
Miles
Notes: Landtype Associations from LTAFNF.GIS Map Layer Developed by the Flathead National Forest and Described by Sirucek (1995); Rivers Digitized from 1:24,000 Scale Quads.

3.5 Landtypes

Landtypes have distinctive landform, soil patterns and climax plant community. Landtypes were identified as part of an Order III Land System Inventory in the northern Rocky Mountains of northwest Montana (Martinson and Basko 1983). The Order III survey included most of the Swan River basin, but excluded the Mission Mountain Wilderness. Sirucek (unpublished) extended an Order IV survey of landtypes for the Mission Mountain Wilderness and provided "cross-walks" between the Order III landtypes and the more general Order IV landtypes.

Local landforms were used to develop landtype map units. Soils were classified using criteria adopted by the National Cooperative Soil Survey and documented in Soil Taxonomy (USDA SCS 1975). Potential vegetation was classified using Habitat Types of Montana (Pfister et al. 1977).

A total of 46 Order III and IV landtypes were identified in the Swan River basin. These 46 different landtypes were combined into 11 general **landtype classes**. A map of general landtype classes is presented as Figure 3.5-1. The area of landtypes are listed in Table 3.5-1 by general landtype class. A descriptive legend of landtypes is presented as Table 3.5-2. The distribution of landtype classes by subsection is listed in Table 3.5-3. Because this version of the Ecological Classification is abriged, the reader is referred to Martinson and Basko (1983) and Sirucek (Unpublished) for detailed map unit descriptions.



Swan River Basin
General Landtype Classes
Figure 3.5-1
Wet Depression
Floodplain
Alluvial Fan
Glacial Basin
Glacial Trough
Ground Moraine
Glacial Outwash
Residual
Colluvial
Rockland
Lake
N
0
5
Miles
Note: General Landtype Classes Were Merged from Landtypes Identified by Martinson and Basko (1983) and from Strucek (Unpublished)

Table 3.5-1. Distribution of Order III and IV landtypes, Swan River basin.

GENERAL CLASS	ORDER	LANDTYPE	LANDFORM	N	ACRES	PERCENT
Lake	III	Lake	Lake	114	5653	1.4
Wet Depression	III	12	Depression in ground moraine/lacustrine deposit	19	2073	0.5
Wet depression	III	14-3	Low basin/depression in rolling ground moraine	14	1295	0.3
Wet Depression	IV	Ia	Wet, grass/sedge meadow	2	57	0.0
Wet Depression		**TOTAL**		**35**	**3425**	**0.8**
Floodplain	III	10-2	Well drained floodplain	10	2408	0.6
Floodplain	III	10-3	Poorly drained floodplain	5	14183	3.5
Floodplain		**TOTAL**		**15**	**16591**	**4.1**
Alluvial Fan	III	16	Alluvial fan	22	1976	0.5
Glacial Basin	III	21-8	Alpine glaciated basin, 20-40% slope	47	9219	2.3
Glacial Basin	III	21-9	Alpine glaciated basin, 40-60% slope	15	3331	0.8
Glacial Basin	IV	II	Glacial cirque basin	38	15978	3.9
Glacial Basin	IV	VIa	Scoured glacial basin	7	4498	1.1
Glacial Basin		**TOTAL**		**107**	**33026**	**8.1**
Glacial Trough	III	73	Glacial troughwalls (Subalpine fir series)	57	39923	9.8
Glacial Trough	III	78	Glacial troughwalls (Douglas-fir series)	10	7139	1.7
Glacial Trough	IV	VII	Forested, cool aspect breakland	27	7842	1.9
Glacial Trough		**TOTAL**		**94**	**54904**	**13.4**

Table 3.5-1. Continued.

GENERAL CLASS	ORDER	LANDTYPE	LANDFORM	N	ACRES	PERCENT
Ground Moraine	III	14-2	Well drained depression in moraine	4	1110	0.3
Ground Moraine	III	23-8	Moraine from argillite, linestone and siltite, 20-40% slope	5	4376	1.1
Ground Moraine	III	23-9	Moraine from argillite, linestone and siltite, 40-60% slope	9	14925	3.7
Ground Moraine	III	26A-7	Moraine from limestone, 0-20% slope	15	13057	3.2
Ground Moraine	III	26A-8	Moraine from limestone, 20-40% slope	16	9931	2.4
Ground Moraine	III	26A-9	Moraine from limestone, 40-60% slope	5	3452	0.8
Ground Moraine	III	26C-7	Moraine from argillite and siltite, 0-20% slope	19	50619	12.4
Ground Moraine	III	26C-8	Moraine from argillite and siltite, 20-40% slope	29	22175	5.4
Ground Moraine	III	26C-9	Moraine from argillite and siltite, 40-60% slope	9	4606	1.1
Ground Moraine	III	26D-7	Moraine from quartzite, 0-20% slope	9	20544	5.0
Ground Moraine	III	26D-8	Moraine from quartzite, 20-40% slope	19	9132	2.2
Ground Moraine	III	26D-9	Moraine from quartzite, 40-60% slope	2	449	0.1
Ground Moraine	III	26G-7	Moraine from Tertiary sediment, 0-20% slope	1	38	0.0
Ground Moraine	III	26L-7	Moraine from old surface material, 0-20% slope	2	1420	0.3
Ground Moraine	III	26L-8	Moraine from old surface material, 20-40% slope	1	2196	0.5
Ground Moraine	III	74	Fluvial breaklands in moraine	10	1730	0.4
Ground Moraine	IV	III	Forested ground moraine	17	4115	1.0
Ground Moraine		**TOTAL**		**172**	**163875**	**40.1**
Glacial Outwash	III	27-7	Kame/stream terraces/pit and kettle topography, 0-20% slope	14	7039	1.7
Glacial Outwash	III	27-8	Kame/stream terraces/pit and kettle topography, 40-60% slop	5	3529	0.9
Glacial Outwash	III	28-7	Outwash plain, stream terrace and bench, 0-20% slope	6	3475	0.9
Glacial Outwash		**TOTAL**		**25**	**14043**	**3.4**
Residual	III	57-8	Glacial scoured hillsides and ridgetop, 20-40% slope	48	13163	3.2
Residual	III	57-9	Glacial scoured hillsides and ridgetop, 40-60% slope	29	7472	1.8
Residual	III	76	Extremely steep structural breaklands, >60% slope	24	14194	3.5
Residual	III	77	Extremely steep structural breaklands, >60% slope	7	3936	1.0
Residual	IV	Va	Forested high elevation ridge	4	2131	0.5
Residual	IV	Vb	Forested smooth residual slope	14	4360	1.1
Residual		**TOTAL**		**126**	**45256**	**11.1**

Table 3.5-1. Continued.

GENERAL CLASS	ORDER	LANDTYPE	LANDFORM	N	ACRES	PERCENT
Colluvial	III	32	Block glides with dipping bedrock	3	299	0.1
Colluvial	IV	IV	Slump land	3	206	0.1
Colluvial		TOTAL		6	506	0.1
Rockland	III	55	Rockland on low-to-mid elevation hillside, 40-60% slope	3	176	0.0
Rockland	III	72	Rockland on over-steepened cirque headwall & alpine ridge	14	31702	7.8
Rockland	III	75	Rockland on cliffs	12	3259	0.8
Rockland	IV	VI	Peaks and alpine ridge	6	34238	8.4
Rockland		TOTAL		35	69375	17.0
TOTAL		TOTAL	TOTAL	751	408630	100.0

Table 3.5-2. Descriptive legend for landtypes.

Landtype[1]	Landform	Geology	Map Unit Component	Soil Classification	Vegetative Series[2]	Slope (%)
GENERAL LANDTYPE CLASS						
WET DEPRESSION						
12	Depression in moraine and lacustrine deposits	Undifferentiated	Poorly drained organic deposits	Borosaprists	Wet herbaceous, shrubs	0-2
14-3	Basins and depressions in moraine	Undifferentiated	Somewhat poorly drained lacust. dep.	Aquepts	ABLA	0-5
Ia	Wet, Grass-sedge Meadows	Alluvium	Alluvial and lacustrine deposits	Aquepts and Aquolls	Water tolerant shrubs	NA
FLOODPLAIN						
10-2	Floodplain	Undifferentiated	Well drained formed in alluvium	Complex of Ochrepts and Fluvents	ABLA, PSME	0-5
10-3	Floodplain	Undifferentiated	Poorly drained alluvial deposits	Aquents	ABLA	0-5
ALLUVIAL FAN						
16	Alluvial fan	Undifferentiated	Coarse textured in colluvium	Ochrepts and Orthents	ABLA	5-30
GLACIAL BASIN						
21-8	Alpine glaciated basin	Undifferentiated	Ash loess over glacial till	Andic Cryochrepts & Entic Cryandepts	ABLA, PIAL	20-40
21-9	Alpine glaciated basin	Undifferentiated	Ash loess over glacial till	Andic Cryochrepts & Entic Cryandepts	ABLA, PIAL	40-60
II	Glacial cirque basins	Undifferentiated	Ash loess over till & residuum	Andic Cryochrepts & Cryorthods, Typic Cryandepts	ABLA, PIAL, PICEA	NA
VIa	Glacial scoured basins	Undescribed	Undescribed	Undescribed	Undescribed	NA
GLACIAL TROUGH						
73	Glacial troughwalls	Undifferentiated	Ash loess over residuum & till	Ochrepts and Boralfs	ABLA	>60
78	Glacial troughwalls	Undifferentiated	Ash loess over residuum	Dystrochrepts	PSME	>60
VII	Forested, cool aspect breaklands	Undifferentiated	Residuum, drift & colluvium	Andic Cryochrepts and Lithic Cryandepts	PICO, ABLA, PICEA	>60

[1] Landtype Codes that are Roman Numerals (Ia, II, III, IV, Va, Vb, VI, VIa) are from an Order 4 survey of the Mission Mountain Wilderness in Swan River basin (Sirucek, unpublished). The other landtype codes are from an Order 3 survey (Martinson and Basco 1983).

[2] Vegetation Series are from Habitat Types of Montana (Pfister 1977). Acronyms are the first two letters of the genus and the first two letters of the species: ABLA = subalpine fir (*Abies lasiocarpa*); ABGR = grand fir (*Abies grandis*); LAOC = larch (*Larix occidentalis*); PIAL = whitebark pine (*Pinus albicaulis*); PICO = lodgepole pine (*Pinus contorta*); PICEA = spruce (*Picea spp.*); POTR = aspen (*Populus tremuloides*); PSME = Douglas-fir (*Pseudotsuga menziesii*); THPL = Western red cedar (*Thuja plicata*).

Table 3.5-2. Continued.

LANDTYPE CLASS Landtype[1]	Landform	Geology	Map Unit Component	Soil Classification	Vegetative Series[2]	Slope (%)
GROUND MORAINE						
14-2	Basins and depressions in moraine	Undifferentiated	Well drained lacustrine deposits	Glossic Cryoboralfs	ABLA, PSME	0-20
23-8	Ground moraine	Argillite, limestone and siltite	Ash loess over till & silt loam	Andeptic Cryoboralfs & Andic Cryochrepts	ABLA, ABGR, THPL	20-40
23-9	Ground moraine	Argillite, limestone and siltite	Ash loess over till & silt loam	Andeptic Cryoboralfs & Andic Cryochrepts	ABLA, ABGR, THPL	40-60
26A-7	Ground moraine	Limestone	Ash loess over till & silt loam	Andeptic Cryoboralfs	ABLA, ABGR, THPL	0-20
26A-8	Ground moraine	Limestone	Ash loess over till & silt loam	Andeptic Cryoboralfs	ABLA, ABGR, THPL	20-40
26A-9	Ground moraine	Limestone	Ash loess over till & silt loam	Andeptic Cryoboralfs	ABLA, ABGR, THPL	40-60
26C-7	Ground moraine	Argillite, siltite	Ash loess over silty till	Andeptic Cryoboralfs	ABLA, ABGR, THPL	0-20
26C-8	Ground moraine	Argillite, siltite	Ash loess over silty till	Andeptic Cryoboralfs	ABLA, ABGR, THPL	20-40
26C-9	Ground moraine	Argillite, siltite	Ash loess over silty till	Andeptic Cryoboralfs	ABLA, ABGR, THPL	40-60
26D-7	Ground moraine	Quartzite	Ash loess over sandy loam till	Dystric Cryochrepts	ABLA, PSME	0-20
26D-8	Ground moraine	Quartzite	Ash loess over sandy loam till	Dystric Cryochrepts	ABLA, PSME	20-40
26D-9	Ground moraine	Quartzite	Ash loess over sandy loam till	Dystric Cryochrepts	ABLA, PSME	40-60
26G-7	Ground moraine	Tertiary sediments	Ash loess over silt loam till	Typic Eutroboralfs	PSME	0-20
26L-7	Ground moraine	Old surface material	Ash loess over vg SiL and g SiCL	Glossic Cryoboralfs	ABLA	0-20
26L-8	Ground moraine	Old surface material	Ash loess over vg SiL and g SiCL	Glossic Cryoboralfs	ABLA	20-40
74	Fluvial breaklands in ground moraines & uplands	Undifferentiated	Glacial till & residuum	Ochrepts and Orthents	PSME, ABLA	>60
III	Forested ground moraine	Undifferentiated	Loamy drift & residuum	Typic and Andic Cryoboralfs	PICO, POTR	NA
GLACIAL OUTWASH						
27-7	Kame, stream terrace & pit and kettle topography	Undifferentiated	Loam in loess over glacial outwash	Dystric Eutrochrepts	ABLA, PSME	0-20
27-8	Kame, stream terrace & pit and kettle topography	Undifferentiated	Loam in loess over glacial outwash	Dystric Eutrochrepts	ABLA, PSME	20-40
28-7	Outwash plains, stream terraces and benches	Undifferentiated	Sandy soils in glacial outwash	Dystric Eutrochrepts	ABLA, PSME	0-20
RESIDUAL						
57-8	Glacial scoured hillsides and ridgetops	Undifferentiated	Ash loess over residuum	Andic Cryochrepts	ABLA	20-40
57-9	Glacial scoured hillsides and ridgetops	Undifferentiated	Ash loess over residuum	Andic Cryochrepts	ABLA	40-60
76	Extremely steep structural breaklands	Undifferentiated	Ash loess over residuum	Cryochrepts	ABLA	>60
77	Extremely steep structural breaklands	Undifferentiated	Ash loess over residuum	Cryochrepts	ABLA	>60
Va	Forested high elevation ridges	Undifferentiated	Ash loess over residuum	Andic Cryochrepts	PIAL, PICO	25-50
Vb	Forested smooth residual slopes	Undifferentiated	Ash loess over residuum	Andic Cryochrepts	PICO, LAOC	25-60
COLLUVIAL						
32	Block glides associated with dipping bedrock	Undifferentiated	Colluvium & residuum	Boralfs and Ochrepts	ABLA	30-50
IV	Slump land	Undifferentiated	Fine slump material with boulders	Typic and Andic Cryoboralfs	PICO, PSME, ABLA, PICEA	NA
ROCKLAND						
55	Low to mid-elevation hillsides	Undifferentiated	Rockland	Rockland	Herbaceous, shrub, trees	40-60
72	Cirque headwalls and narrow alpine ridges	Undifferentiated	Rockland, talus, ash loess & residuum	Rockland and Andepts	ABLA, PIAL	>60
75	Rock cliffs	Undifferentiated	Rockland	Rockland	Shrub, grass, small tree	>60
VI	Peaks and alpine ridges	Undifferentiated	Rockland, talus & scree	Rockland	Sparse small trees	NA
MISCELLANEOUS LANDTYPE						
Lake	Lake	Undifferentiated	Not applicable	Not applicable	Not applicable	NA

Table 3.5-3. Distribution of Landtype Classes (LTC) by Subsection.

SUBSECTION	LTC	------AREA------	
		(ac)	(%)
Scarp Slope	Wet Depression	0	0.0
Dip Slope	Wet Depression	242	7.1
Valley	Wet Depression	3183	92.9
TOTAL	**Wet Depression**	**3425**	**100.0**
Scarp Slope	Floodplain	29	0.2
Dip Slope	Floodplain	497	3.0
Valley	Floodplain	16063	96.8
TOTAL	**Floodplain**	**16589**	**100.0**
Scarp Slope	Alluvial Fan	1096	55.5
Dip Slope	Alluvial Fan	18	0.9
Valley	Alluvial Fan	862	43.6
TOTAL	**Alluvial Fan**	**1975**	**100.0**
Scarp Slope	Glacial Basin	6783	20.5
Dip Slope	Glacial Basin	26227	79.5
Valley	Glacial Basin	0	0.0
TOTAL	**Glacial Basin**	**33010**	**100.0**
Scarp Slope	Glacial Trough	36781	67.0
Dip Slope	Glacial Trough	17921	32.6
Valley	Glacial Trough	195	0.4
TOTAL	**Glacial Trough**	**54896**	**100.0**
Scarp Slope	Ground Moraine	13362	8.2
Dip Slope	Ground Moraine	54527	33.3
Valley	Ground Moraine	95955	58.6
TOTAL	**Ground Moraine**	**163844**	**100.0**
Scarp Slope	Glacial Outwash	0	0.0
Dip Slope	Glacial Outwash	216	1.5
Valley	Glacial Outwash	13825	98.5
TOTAL	**Glacial Outwash**	**14041**	**100.0**
Scarp Slope	Residual	18390	40.6
Dip Slope	Residual	26829	59.3
Valley	Residual	32	0.1
TOTAL	**Residual**	**45250**	**100.0**

Table 3.5-3. Continued.

SUBSECTION	LTC	------AREA------ (ac)	(%)
Scarp Slope	Colluvial	0	0.0
Dip Slope	Colluvial	506	100.0
Valley	Colluvial	0	0.0
TOTAL	**Colluvial**	**506**	**100.0**
Scarp Slope	Rockland	33501	48.3
Dip Slope	Rockland	35863	51.7
Valley	Rockland	0	0.0
TOTAL	**Rockland**	**69364**	**100.0**
Scarp Slope	Lake	7	0.1
Dip Slope	Lake	3245	57.3
Valley	Lake	2411	42.6
TOTAL	**Lake**	**5663**	**100.0**

3.6 Habitat Types

Habitat types described by Pfister et al. (1977) were identified by Sirucek (1994) for the Flathead National Forest. The map of habitat types in the Swan River basin (Figure 3.6-1) was developed from: 1) empirical models; 2) forest stand data; and 3) an existing map layer of forest structure classes.

Statistical analyses of ECODATA plots served as a basis for the empirical models (Sirucek 1994).. Primary parameters for distinguishing habitat types were elevation, slope, aspect and geographical subdivision. A few habitat types were also distinguished by landtype. Criteria listed in Table 3.6-1 were used to predict habitat types for the Swan Lake Ranger District. A map layer of "modelled" habitat types was generated.

Next Sirucek (1994) listed all timber stands where the habitat type had been field identified. Where several habitat types were identified in a timber stand, the most frequently sampled habitat type was identified for the stand. A digital map of habitat types for timber stands was developed and inset to the modelled map layer. Timber stands were primarily at low to middle elevations in areas suitable for commercial harvest.

Finally, Sirucek (1994) used a forest structure map to identify forb/grass, bare/rock and lakes/rivers and inset it to the modelled/stand map layer. These procedures yielded a forest-wide habitat type map layer on 50 by 50 meter pixels. The accuracy of the habitat map layer has not been reported, but an assessment is anticipated. The author lists the primary limitation of the habitat type map layer is that modelling parameters were generalized for a typical situation and do not account for variation in site characteristics. Also, only the most frequently sampled habitat of a timber stand was identified. Habitat types identified in the Swan River basin by empirical modelling, from timber stand data and from existing maps of forest structure are listed in Table 3.6-2.

Major habitat types comprising more than 0.5 percent of Swan River basin are those that were predicted by the empirical model, some of which were also identified for timber stands. Minor habitat types comprise less than 0.5 percent of Swan River basin, were not predicted by the empirical model, but were identified for timber stands. Minor habitat types were combined with the adjacent major habitat type sharing the longest common boundary. A map of major habitat types, Swan River basin is presented as Figure 3.6-1.

Brief descriptions excerpted from Pfister et al. (1977) follow. More comprehensive descriptions of both major and minor habitat types are presented in Forest Habitat Types of Montana (Pfister et al. 1977).

Table 3.6-1. Criteria for modeled habitat types, Swan Lake Ranger District (Sirucek 1994).

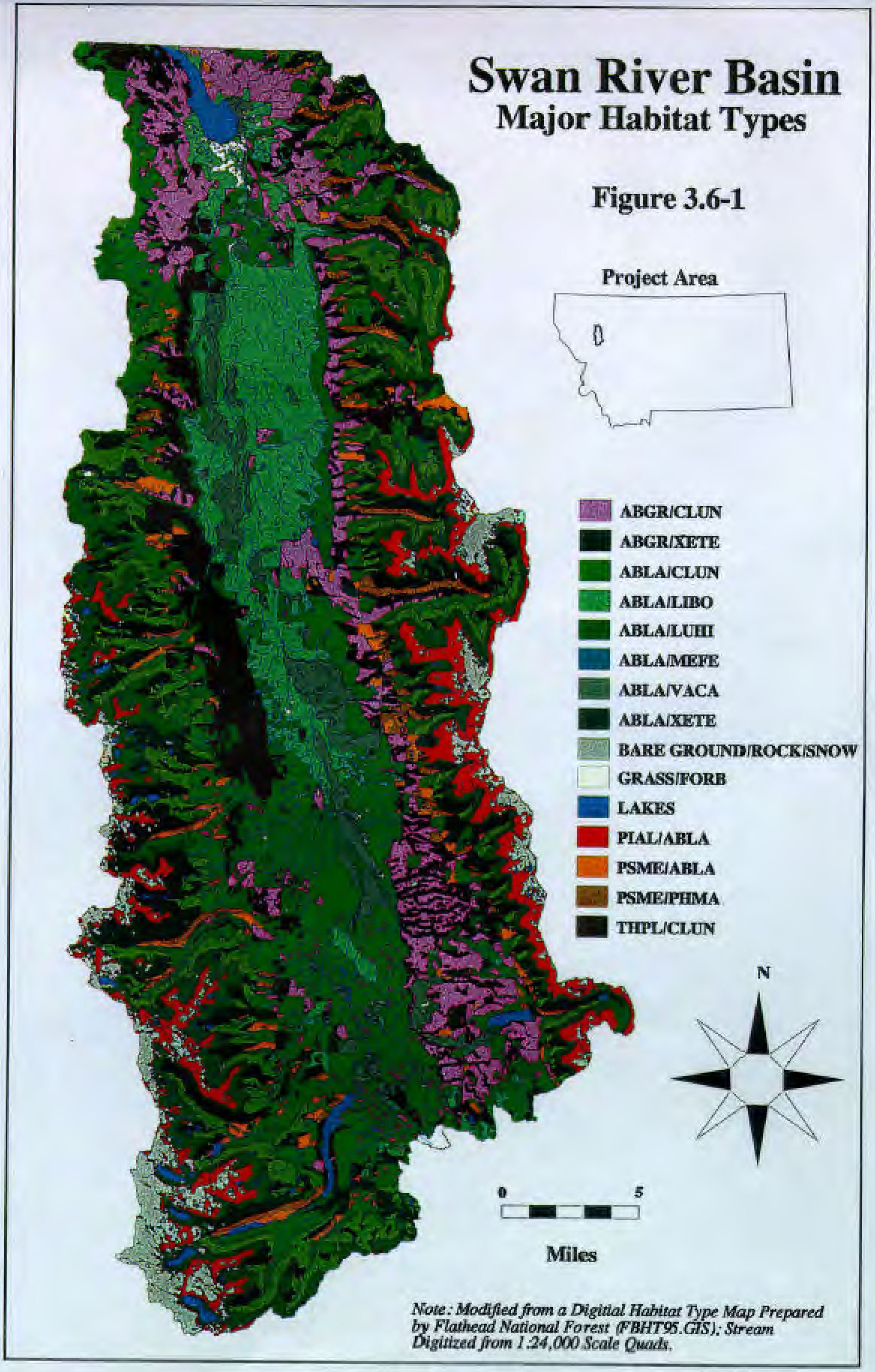
HT	ELEVATION (ft)	ASPECT	SLOPE (%)	OTHER
ABGR/CLUN	3800 to 4599	SE,W,NW,N,NE,E,F	None	Swan Range
	3800 to 4599	S,SW	None	Mission Range
ABGR/XETE	3800 to 4599	S,SW	None	Swan Range
ABLA/CLUN	3600 to 3799	All	All	None
	3800 to 4599	W,NW,N,NE,E,SE,F	<15	Mission Range
	4600 to 5399	W,NW,N,NE,E,F	All	Swan Range
ABLA/LIBO	2800 to 3599	All	All	None
ABLA/LUHI	6200 to 6899	W,NW,N,NE,E,F	All	None
	6500 to 6899	SW,S,SE	ALL	None
ABLA/MEFE	5400 to 6199	W,NW,N,NE,E,F	All	None
ABLA/VACA	>2800	All	All	LTs 10-2, 27-7, 28-7
ABLA/XETE	5400 to 6499	SW,S,SE	All	None
LALY-ABLA	>7200	N	ALL	None
PIAL-ABLA	6900 to 7199	N	ALL	None
	>6900	NE,E,SE,S,SW,W,NW,F	ALL	None
PICEA/CLUN	3200 to 4399	All	10 to 20	None
PSME/PHMA	4600 to 5399	SE,S,SW	>40	None
PSME/SYAL	4600 to 5399	SW,S,SE	<40	None
THPL/CLUN	3800 to 4599	All	All	200 m wide along streams; Swan Range
	3800 to 4599	SE,W,NW,NE,E	>15	Mission Range

Table 3.6-2. Habitat types, Swan River basin.

HABITAT	N	------AREA------- (ac)	(%)
Major Habitat Types from Empirical Modelling			
ABGR/CLUN	624	35463	8.7
ABGR/XETE	388	6227	1.5
ABLA/CLUN	549	95816	23.4
ABLA/LIBO	229	39392	9.6
ABLA/LUHI	270	42647	10.4
ABLA/MEFE	324	33930	8.3
ABLA/VACA	122	13677	3.3
ABLA/XETE	425	30755	7.5
PIAL/ABLA	1011	24536	6.0
PSME/SYAL	418	8672	2.1
PSME\PHMA	257	8097	2.0
THPL/CLUN	382	30350	7.4
SUBTOTAL	4999	369560	90.4
Minor Habitat Types from Timber Stands			
ABGR/LIBO	24	848	0.2
ABLA-PIAL/VASC	1	178	0.0
ABLA/ALSI	18	898	0.2
ABLA/ARCO	2	23	0.0
ABLA/CACA	15	343	0.1
ABLA/GATR	3	104	0.0
ABLA/OPHO	11	317	0.1
ABLA/VAGL	3	58	0.0
LALY/ABLA	199	835	0.2
PICEA/CLUN	47	1677	0.4
PICEA/EQAR	13	358	0.1
PICEA/GATR	1	7	0.0
PICEA/LIBO	3	40	0.0
PICEA/VACA	15	423	0.1
PIPO	4	72	0.0
PSME/ARUV	2	62	0.0
PSME/CARU	15	550	0.1
PSME/FEID	4	214	0.1
PSME/LIBO	13	388	0.1
PSME/VACA	27	1018	0.2
PSME/VAGL	22	1029	0.3
THPL/OPHO	14	524	0.1
TSME/CLUN	7	134	0.0
TSME/LUHI	3	136	0.0
TSME/MEFE	8	618	0.2
TSME/XETE	2	122	0.0
SUBTOTAL	476	10974	2.7

Table 3.6-2. Continued

HABITAT	N	AREA (ac)	AREA (%)
Miscellaneous Types from Forest Structure Map			
BARE/ROCK/SNOW	497	18244	4.5
GRASS/FORB	864	2483	0.6
LAKES	787	7369	1.8
SUBTOTAL	**2148**	**28096**	**6.9**
TOTAL	**7623**	**408630**	**100.0**


Swan River Basin
Major Habitat Types
Figure 3.6-1
Project Area
ABGR/CLUN
ABGR/XETE
ABLA/CLUN
ABLA/LIBO
ABLA/LUHI
ABLA/MEFE
ABLA/VACA
ABLA/XETE
BARE GROUND/ROCK/SNOW
GRASS/FORB
LAKES
PIAL/ABLA
PSME/ABLA
PSME/PHMA
THPL/CLUN
N
0
5
Miles
Note: Modified from a Digitial Habitat Type Map Prepared by Flathead National Forest (FBHT95.GIS); Stream Digitized from 1:24,000 Scale Quads.

The grand fir series is climax on low to middle elevations with maritime influenced climate in northwestern and west-central Montana. The series is bounded on drier sites by the Douglas fir series and on cooler sites by the subalpine fir series. The boundary between grand fir and subalpine fir may be diffuse. Three grand fir habitat types were identified in the Swan River basin:

ABGR/CLUN (*Abies grandis/Clintonia uniflora;* grand fir/queencup beadily): Found on relatively moist sites from 2,400 to 5,000 feet elevation on valley bottoms and benches; all aspects. Grand fir is the dominant climax component but subalpine fir may persist as a minor climax component. Seral trees include Douglas-fir, western Larch, spruce and lodgepole pine. Moist-site herbs, western twinflower (*Linnaea borealis*) and are prominent in the understory.

ABGR/XETE (*Abies grandis/Xerophyllum tenax*; grand fir/beargrass): Found on well-drained slopes between 4,700 and 5,300 feet. It is the driest of the grand fir habitat types in Montana. Grand fir is predicted to be the dominant climax component of the overstory. Seral stands often dominated by Douglas-fir, western Larch and lodgepole pine. Undergrowth is sparse.

ABLA/CLUN (*Abies lasiocarpa/Clintonia uniflora;* subalpine fir/queencup beadily): Occurs at lower elevations (3,200 to 5,500 feet) on relatively warm and moist sites, on all but the driest southern aspects. Subalpine fir is the dominant climax species with spruce, Douglas-fir, western Larch, lodgepole pine and western white pine associated in seral stands.

The subalpine fir series includes all climax forests potentially dominated by subalpine fir, mountain hemlock, whitebark pine or alpine larch. This is the dominant series at higher elevations in the Rocky Mountains of Montana. At lower elevations it often borders moist forests where shade-tolerant grand fir, western red cedar and western hemlock are the climax species. At its upper limits this series is bordered by alpine tundra. Lightning-caused fires have allowed Douglas-fir, western larch and lodgepole pine to dominant most stands at lower elevations. Five habitat types in the subalpine fir series were identified in Swan River basin:

ABLA/LIBO (*Abies lasiocarpa/Linnaea borealis;* subalpine fir/twinflower): Occurs at 5,000 to 7,000 feet on moist, north aspects and benches. Seral stands are dominated by Douglas-fir, lodgepole pine and spruce. Understory composition is variable.

ABLA/LUHI (*Abies lasiocarpa/Luzula hitchcockii*; subalpine fir/wood-rush): a major upper subalpine forest habitat type with a 700 feet elevation zone between ABLA/XETE or ABLA/MEFE below and PIAL-ABLA above. Whitebark pine, Engelmann spruce and lodgepole pine are the principal seral species.

ABLA/MEFE (*Abies lasiocarpa/Menziesia ferruginea*; subalpine fir/menziesia): occurs in moist, higher elevation forests of western Montana with maritime climate. In northwestern Montana it occurs on all cool aspects between about 5,300 and 6,500 feet. Subalpine fir is usually dominant in old-growth stands, but Engelmann spruce may be more conspicuous. Lodgepole pine and Douglas-fir are usually present.

ABLA/VACA (*Abies lasiocarpa/Vaccinium caespitosum;* subalpine fir/dwarf huckleberry): confined largely to well-drained sites on benchlands and in cold air sinks. Elevations range from 6,000 to 7,200 feet. Pinus contorta is dominant in nearly all stands and is the persistent seral dominant.

ABLA/XETE (*Abies lasiocarpa/Xerophyllum tenax;* subalpine fir/beargrass): makes up a major portion of the subalpine fir series west of the Continental Divide in Montana, on seep dry exposures between 5,200 and 7,000 feet. Subalpine fir is dominant at climax but spruce is a minor component of most stands. Lodgepole pine and Douglas-fir typically dominant seral stands.

PIAL/ABLA (*Pinus albicaulis-Abies lasiocarpa;* whitebark pine-subalpine fir): Occurs at timberline where stunted forms of whitebark pine, subalpine fir and Engelmann spruce occur with variable under-stories.

Douglas fir habitat types are associated with well-drained mountain slopes and valleys and extend from the lower elevations of forest growth up to about 5,500 feet on southern aspects. The Douglas-fir series is bordered on warmer, drier sites by ponderosa pine, limber pine or grassland series. Spruce and grand fir series are usually adjacent along more moist boundaries. Two Douglas fir habitat types were identified in the Swan River basin:

PSME/SYAL (*Pseudotsuga menziesii/Symphoricarpos albis:* Douglas-fir/snowberry): a common habitat on warm slopes and benches in Montana. Seral stands at lower elevations are frequently dominated by ponderosa pine. At higher elevations Douglas-fir is dominant through most successional stages.

PSME/PHMA (*Pseudotsuga menziesii/Physocarpus malvaceous;* Douglas fir/ninebark): occurs mostly on cool and moist aspects at elevations from 2,000 to 5,700 feet. The overstory is dominated by Douglas fir. Ponderosa pine, western larch and lodgepole pine are minor seral components.

The western red cedar and western hemlock series occupy moist areas with maritime climate. In Montana these habitats are generally confined to bottomland or northerly aspects between 2,000 and 5,000 feet where annual precipitations is 32 inches or more. A single habitat type was identified in the Swan River basin:

THPL/CLUN (*Thuja plicata/Claytonia uniflora;* western redcedar/queencup beadily): Relatively common in northwestern Montana typically associated with bottomlands, benches and north aspects from about 2,000 to 5,000 feet. Western redcedar is the indicated climax species and is dominant in most stands. Subdominant seral components include grand fir, Douglas-fir, larch and subalpine fir.

3.7 Riparian Landtypes

Riparian landtypes are map units with distinctive valley bottom gradient, dominant streambed materials size-class and dominant vegetation community type. Riparian Landtypes were mapped and described for Forest Service lands in the Flathead National Forest (Sirucek and Bachurski 1995)[1]. Subsequent mapping of riparian landtypes for private and state lands in the Swan River basin was conducted by Flathead National Forest personnel (unpublished). A legend of riparian landtypes identified in Swan River basin is presented as Table 3.7-1. The first two letters of the riparian landtype code denote the valley bottom gradient glass (FL = flat; NL = nearly level; SL = slightly sloping; MS = moderately steep; VS = very steep). The third digit of the code denotes the dominant streambed substrate (1 = clay, silt, fine sand and medium sand; 2 = coarse sand, gravel and cobble; 3 = stone and boulder; 4 = bedrock; 5 = undifferentiated). The last letter of the code denotes the dominant vegetation community types (A = subalpine fir habitat types; B = grand fir habitat types; C = Engelmann spruce habitat types; D = black cottonwood habitat types; E = willow and sedge community or habitat types; G = snow avalanche chute plant communities). Maps denoting valley bottom gradient classes, stream substrate classes and dominant vegetation types are presented as Figures 3.7-1, 3.7-2 and 3.7-3, respectively.

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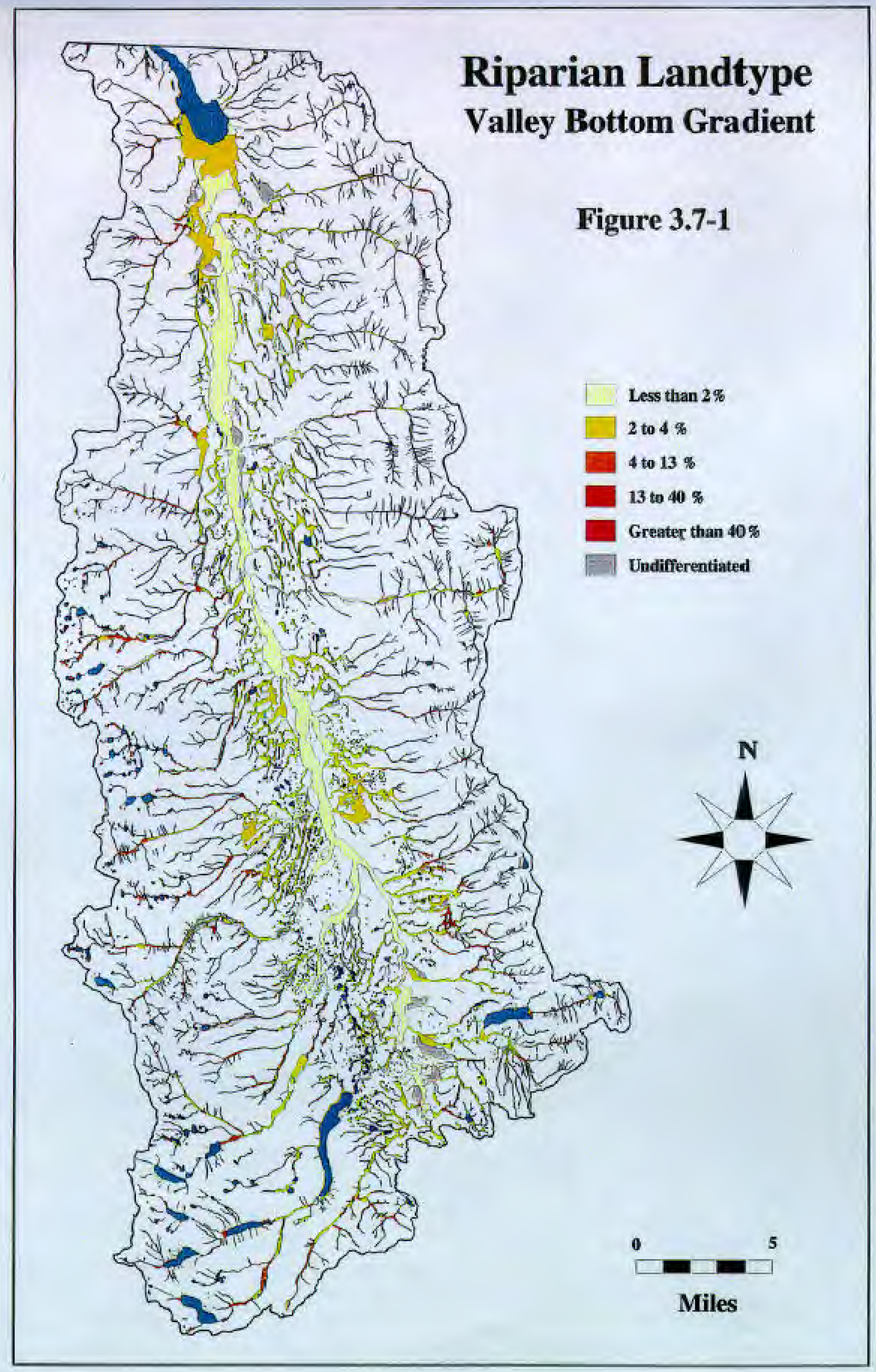
[1] Forest Service riparian landtype digital map files were modified to include stream arcs digitized from 1:24,000 scale quads. The stream often crossed in and out along the boundary of a riparian landtype with upland. A small buffer was placed on the stream to merge it with the adjacent riparian landtype - riparian landtypes in modified map files are slightly larger than riparian landtypes in the Forest Service digital map file.

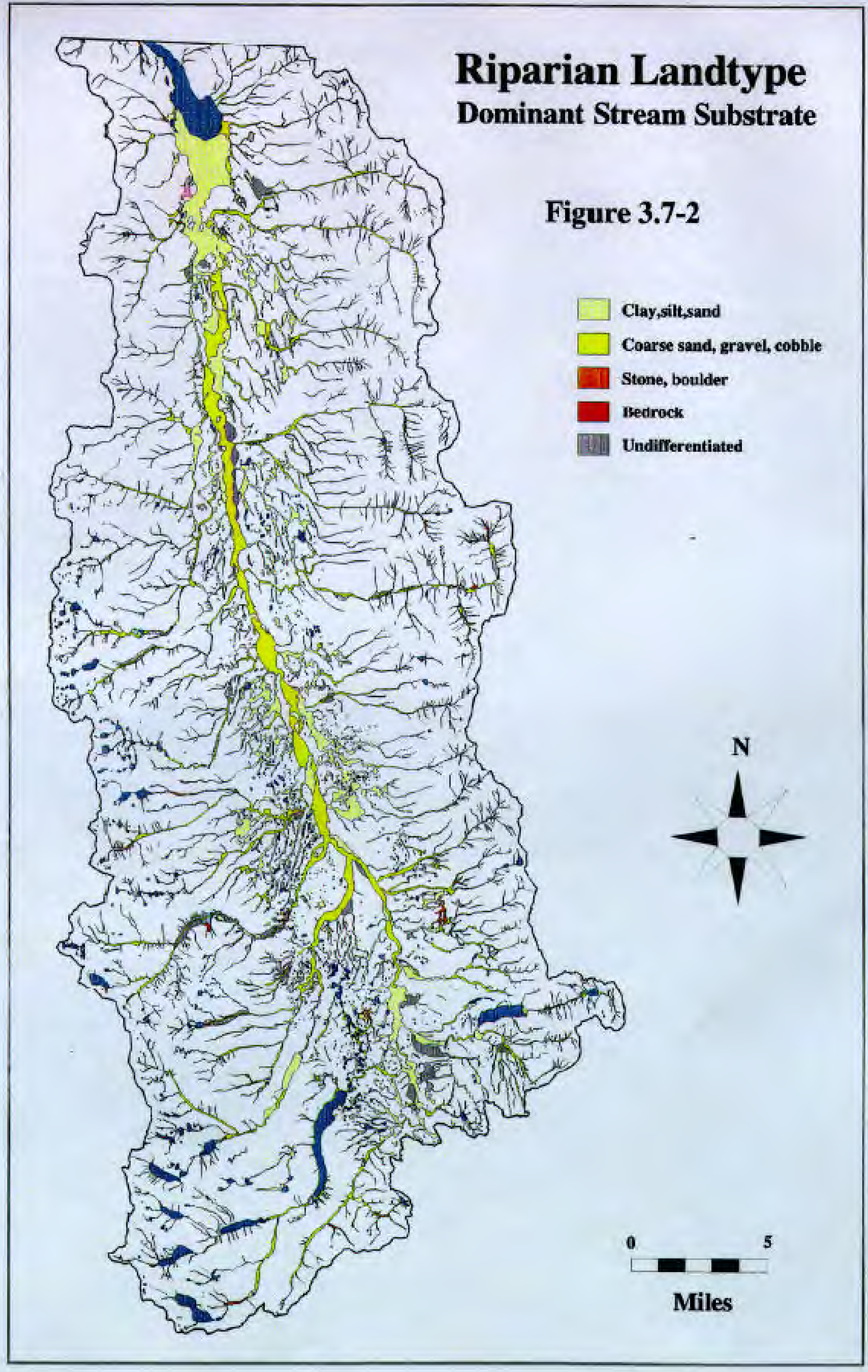
The Forest Service mapped some very narrow riparian landtypes as lines. These were converted to polygons by placing a buffer on each side of the stream course. The width of the buffer is that specified by Sirucek and Bachurski (1995) as the typical width of the riparian landtype on each side of the stream.

Table 3.7-1. Riparian Landtype (RLT) legend.

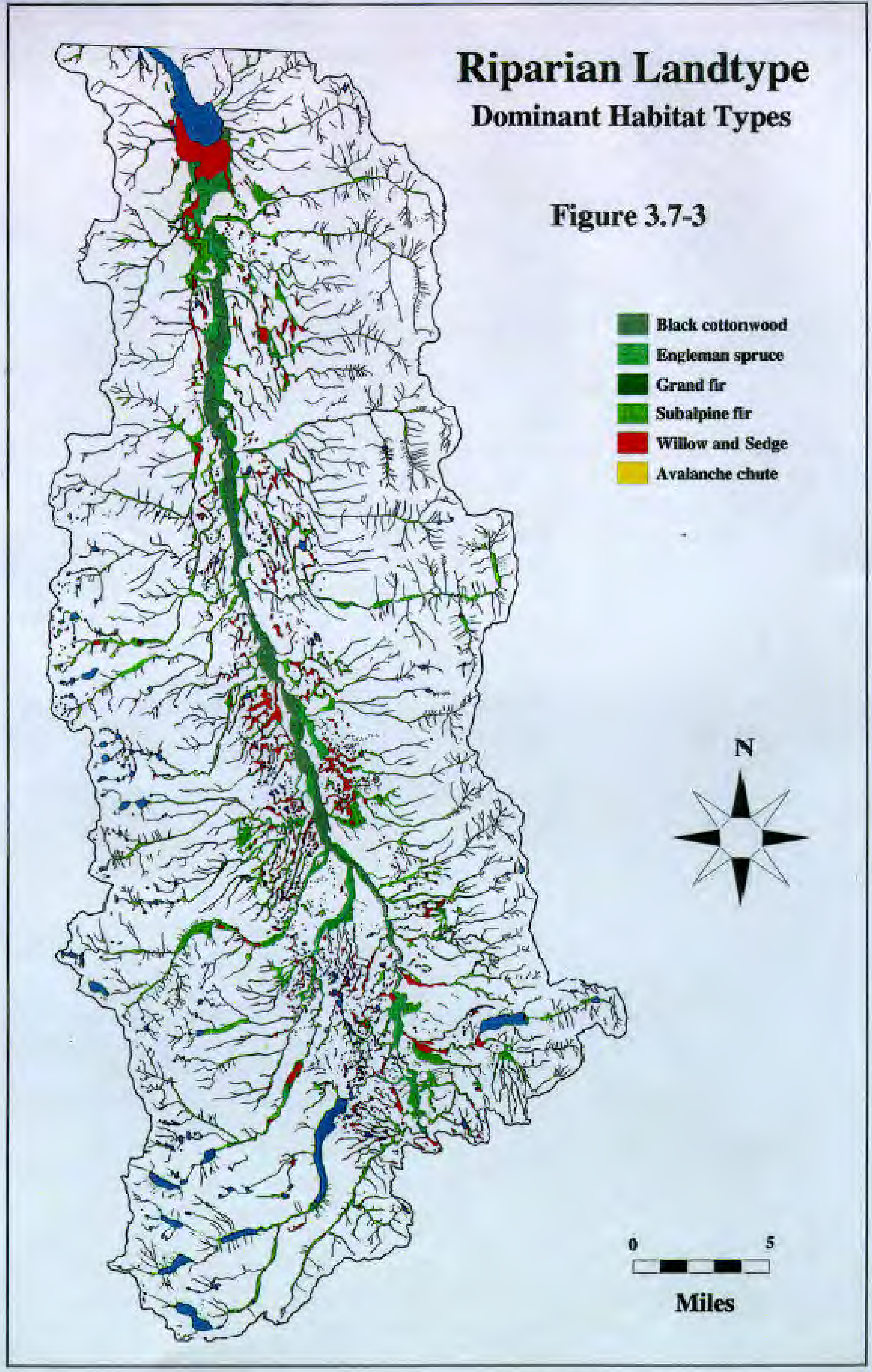
RLT CODE	VALLEY BOTTOM GRADIENT (%)	DOMINANT SUBSTRATE	DOMINANT HABITATS
FL1C	<2	clay, silt, sand	Engelmann spruce
FL2C	<2	coarse sand, gravel, cobble	Engelmann spruce
FL2D	<2	coarse sand, gravel, cobble	cottonwood/Engelmann spruce
NL1A	2 to 4	clay, silt, sand	subalpine fir
NL1E	2 to 4	clay, silt, sand	willow and sedge
NL2A	2 to 4	coarse sand, gravel, cobble	subalpine fir
SL2A	4 to 13	coarse sand, gravel, cobble	subalpine fir
SL2B	4 to 13	coarse sand, gravel, cobble	grand fir
SL3A	4 to 13	stone, boulder	subalpine fir
SL3B	4 to 13	stone, boulder	grand fir
SL5A	4 to 13	undifferentiated	subalpine fir
MS3A	13 to 40	stone, boulder	subalpine fir
MS3B	13 to 40	stone, boulder	grand fir
MS4A	13 to 40	bedrock	subalpine fir
MS5A	13 to 40	undifferentiated	subalpine fir
VS3A	>40	stone, boulder	subalpine fir
VS4A	>40	bedrock	subalpine fir
VS4G	>40	bedrock	avalanche chute
WL5A	undifferentiated	undifferentiated	subalpine fir
WS5A	undifferentiated	undifferentiated	subalpine fir

The areas of riparian landtypes in the Swan River basin are listed in Table 3.7-2. Stream length and grade are listed by stream order for riparian landtypes in Table 3.7-3. The riparian landtype map and legend is presented as Figure 3.7-4. The 21 individual quad map sheets outlined in Figure 3.7-4 were removed for this abridged version of the Swan River Basin Ecological Classification.


Riparian Landtype
Valley Bottom Gradient
Figure 3.7-1
Less than 2 %
2 to 4 %
4 to 13 %
13 to 40 %
Greater than 40 %
Undifferentiated
N
0
5
Miles



Riparian Landtype
Dominant Stream Substrate
Figure 3.7-2
Clay,silt,sand
Coarse sand, gravel, cobble
Stone, boulder
Bedrock
Undifferentiated
N
0
5
Miles



Riparian Landtype
Dominant Habitat Types
Figure 3.7-3
Black cottonwood
Engleman spruce
Grand fir
Subalpine fir
Willow and Sedge
Avalanche chute
N
0
5
Miles

Table 3.7-2. Areas of Riparian Landtypes (RLT), Swan River basin.

RLT	N	AREA acres)	AREA (%)
FL1C	72	5005.0	9.3
FL2C	22	2592.7	4.8
FL2D	12	5675.6	10.6
TOTAL	**106**	**13273.3**	**24.8**
NL1A	390	5384.1	10.0
NL1E	1667	10868.0	20.3
NL2A	120	4745.8	8.9
TOTAL	**2177**	**20997.8**	**39.2**
SL2A	228	2925.6	5.5
SL2B	42	590.7	1.1
SL3A	66	476.1	0.9
SL3B	17	150.2	0.3
SL5A	515	4196.4	7.8
TOTAL	**868**	**8339.0**	**15.6**
MS3A	391	1543.8	2.9
MS3B	64	254.6	0.5
MS4A	438	976.2	1.8
MS5A	20	336.0	0.6
TOTAL	913	3110.5	5.8
VS3A	75	96.8	0.2
VS4A	287	378.0	0.7
VS4G	432	561.7	1.0
TOTAL	**794**	**1036.4**	**1.9**
WL5A	287	5420.6	10.1
WS5A	797	1408.4	2.6
TOTAL	**1084**	**6829.0**	**12.7**
GRAND TOTAL	**5942**	**53586.1**	**100.0**

Table 3.7-3. Stream lengths and grades by flow and order for Riparian Landtypes (RLT).

RLT	ORDER	-PERENNIAL- Length (mi)	Grade (%)	-INTERMITTENT- Length (mi)	Grade (%)	----TOTAL----- Length (mi)	Grade (%)
FL1C	1	0.00	NA	6.74	1.8	6.74	1.8
FL1C	2	1.97	2.5	5.18	1.1	7.15	1.5
FL1C	3	3.45	1.1	0.79	1.3	4.24	1.1
FL1C	4	9.00	0.9	0.00	NA	9.00	0.9
FL1C	5	3.75	0.4	0.00	NA	3.75	0.4
FL1C	6	12.82	0.4	1.88	0.7	14.70	0.5
FL1C	TOTAL	30.99	0.8	14.60	1.4	45.58	1.0
FL2C	1	4.12	2.1	3.47	2.2	7.59	2.2
FL2C	2	4.85	1.9	0.00	NA	4.85	1.9
FL2C	3	16.03	1.8	0.00	NA	16.03	1.8
FL2C	4	23.46	1.4	0.88	2.7	24.35	1.5
FL2C	5	8.35	1.0	0.42	1.3	8.77	1.0
FL2C	6	0.00	NA	0.00	NA	0.00	NA
FL2C	TOTAL	56.81	1.6	4.78	2.2	61.59	1.6
FL2D	1	0.00	NA	0.00	NA	0.00	NA
FL2D	2	2.47	1.1	0.73	1.5	3.20	1.2
FL2D	3	4.77	1.1	0.72	0.9	5.50	1.1
FL2D	4	1.59	0.8	0.00	NA	1.59	0.8
FL2D	5	6.39	0.8	0.00	NA	6.39	0.8
FL2D	6	31.58	0.5	5.89	0.4	37.47	0.5
FL2D	TOTAL	46.80	0.7	7.34	0.6	54.14	0.7
NL1A	1	6.49	2.8	36.71	2.2	43.20	2.3
NL1A	2	16.46	3.4	15.13	2.4	31.58	2.9
NL1A	3	9.51	2.2	3.07	1.9	12.59	2.2
NL1A	4	3.60	1.6	0.00	NA	3.60	1.6
NL1A	5	0.00	NA	0.00	NA	0.00	NA
NL1A	6	0.00	NA	0.00	NA	0.00	NA
NL1A	TOTAL	36.06	2.8	54.91	2.2	90.97	2.5
NL1E	1	0.00	NA	11.79	5.5	11.79	5.5
NL1E	2	22.56	1.2	6.26	1.9	28.82	1.4
NL1E	3	6.37	1.7	1.25	2.5	7.62	1.8
NL1E	4	7.45	0.7	0.00	NA	7.45	0.7
NL1E	5	0.00	NA	0.00	NA	0.00	NA
NL1E	6	1.91	0.1	0.00	NA	1.91	0.1
NL1E	TOTAL	38.28	1.2	19.30	4.1	57.58	2.2

Table 3.7-3. Continued.

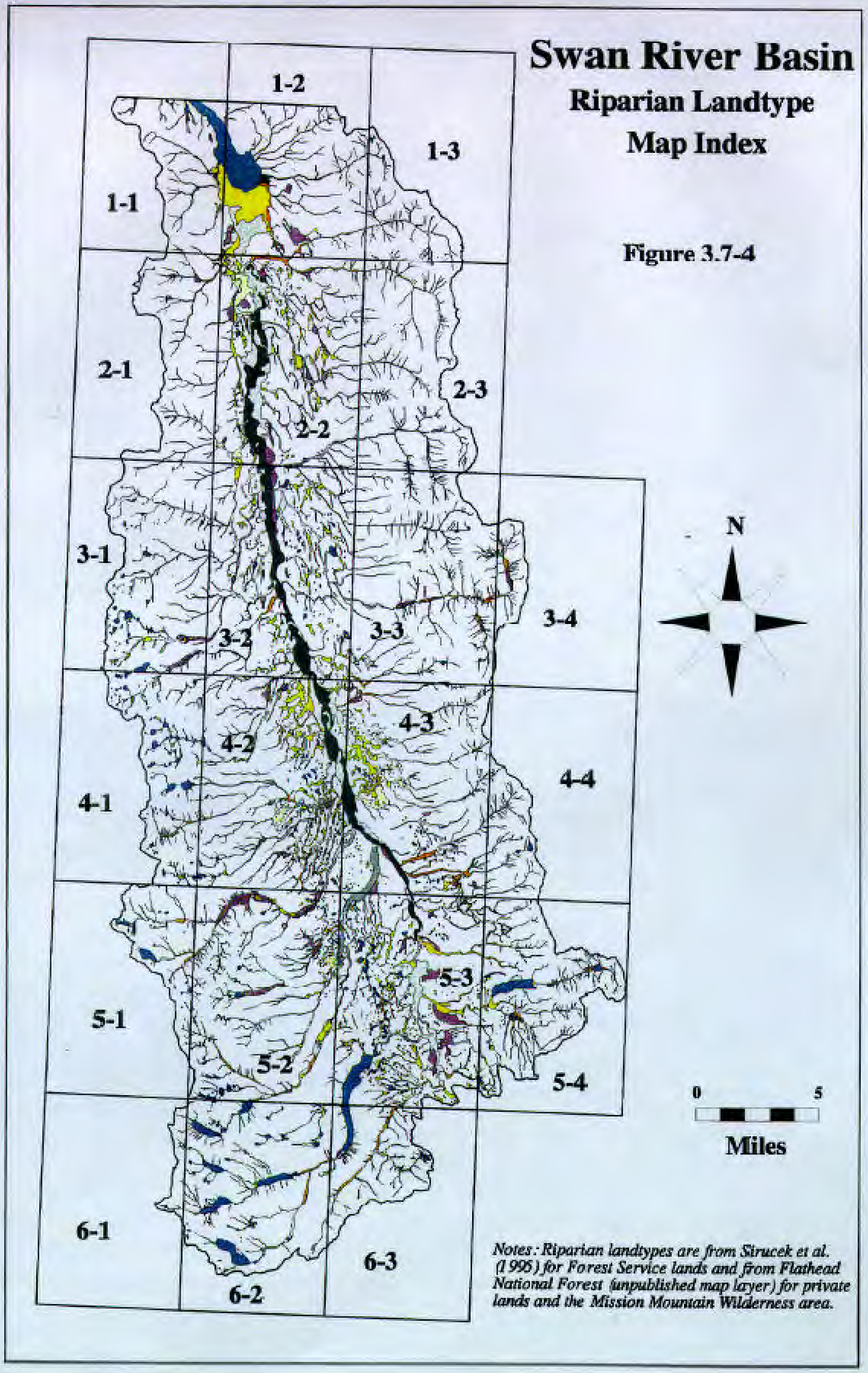
RLT	ORDER	-PERENNIAL- Length (mi)	Grade (%)	-INTERMITTENT- Length (mi)	Grade (%)	----TOTAL----- Length (mi)	Grade (%)
NL2A	1	18.52	7.2	37.51	8.5	56.04	8.1
NL2A	2	23.27	3.8	2.70	4.4	25.97	3.8
NL2A	3	25.58	3.1	0.47	4.7	26.05	3.2
NL2A	4	21.32	2.7	0.10	0.9	21.42	2.7
NL2A	5	0.00	NA	0.00	NA	0.00	NA
NL2A	6	0.00	NA	0.00	NA	0.00	NA
NL2A	TOTAL	88.70	4.1	40.77	8.2	129.47	5.4
SL2A	1	0.45	9.1	8.36	8.6	8.81	8.7
SL2A	2	39.15	8.3	4.72	11.4	43.87	8.6
SL2A	3	28.28	7.3	1.43	8.0	29.71	7.3
SL2A	4	2.21	4.6	0.19	8.1	2.40	4.9
SL2A	5	0.00	NA	0.00	NA	0.00	NA
SL2A	6	0.00	NA	0.00	NA	0.00	NA
SL2A	TOTAL	70.09	7.7	14.70	9.4	84.78	8.0
SL2B	1	2.16	9.9	9.28	13.5	11.44	12.8
SL2B	2	7.32	8.7	1.00	6.2	8.32	8.4
SL2B	3	7.30	6.6	0.51	3.6	7.80	6.4
SL2B	4	0.94	7.1	0.00	NA	0.94	7.1
SL2B	5	0.00	NA	0.00	NA	0.00	NA
SL2B	6	0.00	NA	0.00	NA	0.00	NA
SL2B	TOTAL	17.72	7.9	10.79	12.3	28.50	9.6
SL3A	1	2.12	13.3	18.27	11.6	20.39	11.8
SL3A	2	10.36	10.1	2.52	9.7	12.88	10.0
SL3A	3	3.35	8.6	1.07	4.8	4.42	7.6
SL3A	4	0.40	8.6	0.00	NA	0.40	8.6
SL3A	5	0.00	NA	0.00	NA	0.00	NA
SL3A	6	0.00	NA	0.00	NA	0.00	NA
SL3A	TOTAL	16.23	10.2	21.86	11.1	38.08	10.7
SL3B	1	4.47	7.8	0.00	NA	4.47	7.8
SL3B	2	2.31	10.1	0.00	NA	2.31	10.1
SL3B	3	2.49	8.3	0.00	NA	2.49	8.3
SL3B	4	0.00	NA	0.00	NA	0.00	NA
SL3B	5	0.00	NA	0.00	NA	0.00	NA
SL3B	6	0.00	NA	0.00	NA	0.00	NA
SL3B	TOTAL	9.27	8.5	0.00	ERR	9.27	8.5

Table 3.7-3. Continued.

RLT	ORDER	-PERENNIAL- Length (mi)	Grade (%)	-INTERMITTENT- Length (mi)	Grade (%)	----TOTAL----- Length (mi)	Grade (%)
SL5A	1	1.67	34.5	7.34	39.3	9.01	38.4
SL5A	2	3.48	6.8	5.22	7.4	8.70	7.1
SL5A	3	1.59	9.2	0.58	21.7	2.18	12.5
SL5A	4	0.00	NA	0.00	NA	0.00	NA
SL5A	5	0.00	NA	0.00	NA	0.00	NA
SL5A	6	0.00	NA	0.00	NA	0.00	NA
SL5A	TOTAL	6.74	14.2	13.14	25.8	19.89	21.9
MS3A	1	24.49	20.6	94.28	22.3	118.77	22.0
MS3A	2	29.33	18.2	5.51	20.0	34.84	18.5
MS3A	3	6.88	14.6	0.00	NA	6.88	14.6
MS3A	4	0.00	NA	0.00	NA	0.00	NA
MS3A	5	0.00	NA	0.00	NA	0.00	NA
MS3A	6	0.00	NA	0.00	NA	0.00	NA
MS3A	TOTAL	60.70	18.7	99.80	22.2	160.50	20.9
MS3B	1	19.59	18.2	93.92	22.8	113.50	22.0
MS3B	2	3.23	18.1	0.26	4.8	3.49	17.1
MS3B	3	1.88	17.0	0.00	NA	1.88	17.0
MS3B	4	0.44	14.9	0.00	NA	0.44	14.9
MS3B	5	0.00	NA	0.00	NA	0.00	NA
MS3B	6	0.00	NA	0.00	NA	0.00	NA
MS3B	TOTAL	25.13	18.1	94.18	22.7	119.31	21.8
MS4A	1	2.76	9.4	0.15	5.1	2.91	9.2
MS4A	2	11.59	15.3	12.35	20.1	23.93	17.8
MS4A	3	6.87	16.7	0.07	14.2	6.94	16.7
MS4A	4	0.90	11.4	0.00	NA	0.90	11.4
MS4A	5	0.00	NA	0.00	NA	0.00	NA
MS4A	6	0.00	NA	0.00	NA	0.00	NA
MS4A	TOTAL	22.11	14.9	12.57	19.9	34.67	16.7
MS5A	1	10.09	3.4	60.92	2.4	71.01	2.5
MS5A	2	4.53	5.4	0.02	22.4	4.56	5.5
MS5A	3	3.43	4.1	0.00	NA	3.43	4.1
MS5A	4	3.27	2.5	0.00	NA	3.27	2.5
MS5A	5	0.00	NA	0.00	NA	0.00	NA
MS5A	6	0.00	NA	0.00	NA	0.00	NA
MS5A	TOTAL	21.33	3.8	60.94	2.4	82.27	2.8

Table 3.7-3. Continued.

RLT	ORDER	-PERENNIAL- Length (mi)	Grade (%)	-INTERMITTENT- Length (mi)	Grade (%)	----TOTAL----- Length (mi)	Grade (%)
VS3A	1	6.71	33.8	48.65	46.6	55.36	45.0
VS3A	2	3.09	37.3	0.50	30.8	3.59	36.4
VS3A	3	0.01	38.6	0.00	NA	0.01	38.6
VS3A	4	0.00	NA	0.00	NA	0.00	NA
VS3A	5	0.00	NA	0.00	NA	0.00	NA
VS3A	6	0.00	NA	0.00	NA	0.00	NA
VS3A	TOTAL	9.80	34.9	49.15	46.4	58.95	44.5
VS4A	1	4.59	34.7	52.34	46.0	56.93	45.1
VS4A	2	4.27	34.6	2.23	41.7	6.51	37.0
VS4A	3	0.28	32.1	0.47	30.3	0.75	30.9
VS4A	4	0.00	NA	0.00	NA	0.00	NA
VS4A	5	0.00	NA	0.00	NA	0.00	NA
VS4A	6	0.00	NA	0.00	NA	0.00	NA
VS4A	TOTAL	9.14	34.6	55.04	45.7	64.18	44.1
VS4G	1	3.25	14.9	18.63	8.7	21.88	9.6
VS4G	2	1.94	26.9	2.06	40.0	4.00	33.6
VS4G	3	0.00	NA	0.31	36.6	0.31	36.6
VS4G	4	0.00	NA	0.00	NA	0.00	NA
VS4G	5	0.00	NA	0.00	NA	0.00	NA
VS4G	6	0.00	NA	0.00	NA	0.00	NA
VS4G	TOTAL	5.19	19.4	21.00	12.2	26.19	13.6
WL5A	1	9.31	17.4	59.39	19.3	68.70	19.0
WL5A	2	2.21	11.5	3.83	1.6	6.04	5.2
WL5A	3	1.80	6.7	1.08	2.3	2.88	5.0
WL5A	4	0.48	6.2	0.00	NA	0.48	6.2
WL5A	5	0.00	NA	0.00	NA	0.00	NA
WL5A	6	0.00	NA	0.00	NA	0.00	NA
WL5A	TOTAL	13.81	14.6	64.30	17.9	78.10	17.4
WS5A	1	0.00	NA	0.01	3.3	0.01	3.3
WS5A	2	4.84	16.1	5.05	9.7	9.89	12.9
WS5A	3	0.37	17.7	0.34	1.9	0.71	10.2
WS5A	4	0.00	NA	0.00	NA	0.00	NA
WS5A	5	0.00	NA	0.00	NA	0.00	NA
WS5A	6	0.00	NA	0.00	NA	0.00	NA
WS5A	TOTAL	5.22	16.3	5.39	9.2	10.61	12.7


Swan River Basin
Riparian Landtype
Map Index
Figure 3.7-4
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5-2
5-3
5-4
6-1
6-2
6-3
N
0
5
Miles
Notes: Riparian landtypes are from Sirucek et al. (1995) for Forest Service lands and from Flathead National Forest (unpublished map layer) for private lands and the Mission Mountain Wilderness area.

Riparian Landtypes Legend

- LAKE
- FL1C
- FL2C
- FL2D
- MS3A
- MS3B
- MS4A
- MS5A
- NL1A
- NL1E
- NL2A
- SL2A
- SL2B
- SL3A
- SL3B
- SL5A
- VS3A
- VS4A
- VS4G
- WL5A
- WS5A
- UPLAND

The distribution of riparian landtype by subsections (see chapter 3.3) is illustrated in Figure 3.7-5. The scarp slope subsection (Swan Range) has the lowest proportion of riparian landtype (4 percent). The dip slope subsection (Mission Range) has about 8 percent riparian landtype. Most of the riparian landtype is found in the valley subsection, which is about 28 percent riparian landtype. The distributions of riparian landtypes for general landtype classes are listed in Table 3.7-4. About 69 percent of the riparian landtype in the Swan River basin is associated with ground moraine and floodplain landtypes. Riparian landtypes are major components of wet depression (65 percent), floodplain (75 percent), glacial outwash (24 percent) and colluvial (29 percent) landtypes.

The reader is referred to Sirucek and Bachurski (1995), for more detailed unit descriptions. For more detailed descriptions of survey methods and map units, refer to Riparian Landtype Inventory of the Flathead National Forest (ibid.). A legend of riparian community and habitat types mentioned in riparian landtype descriptions is presented as Table 3.7-5. Those interested in more detailed description of riparian types are referred to Classification and Management of Montana's Riparian and Wetland Sites (Hansen et al. 1995).

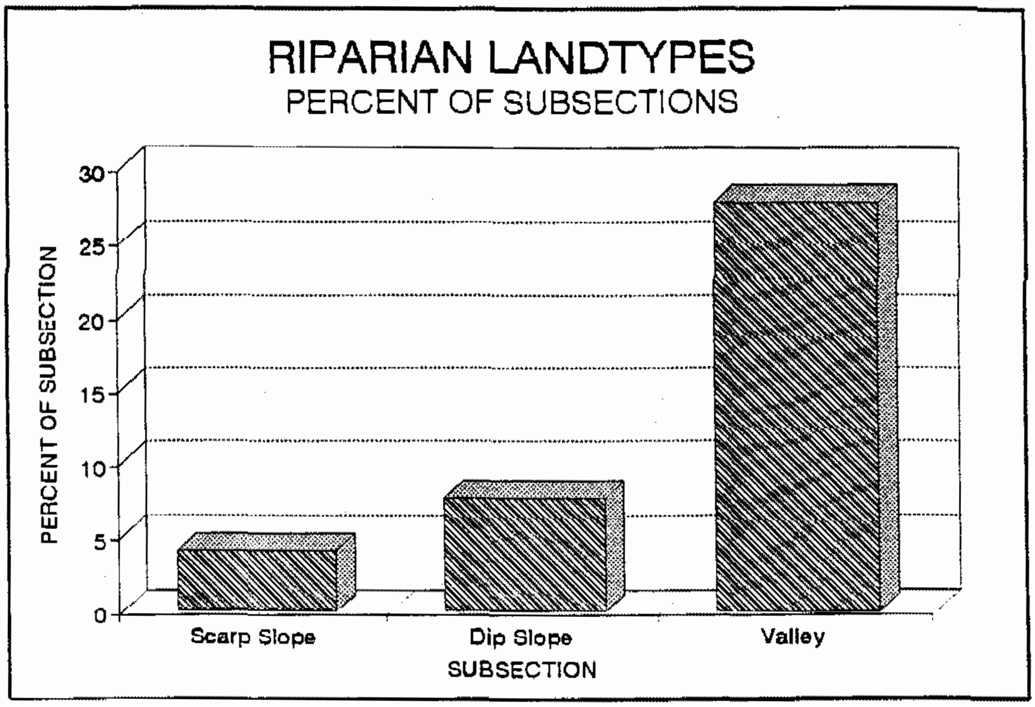

Figure 3.7-5. Proportion of subsections that are riparian landtypes.

Table 3.7-4. Distribution of Riparian Landtypes (RLTs) for Landtype Classes (LTCs).

LANDTYPE CLASS	DISTRIBUTION OF RLTs (ac) (1)	(%) (2)	LTC (ac) (3)	RLT/LTC (%) (4)
Lake	3319	6.1	5653	58.7
Wet Depression	2216	4.1	3425	64.7
Floodplain	12381	22.9	16591	74.6
Alluvial Fan	130	0.2	1976	6.6
Glacial Basin	2975	5.5	33026	9.0
Glacial Trough	2710	5.0	54904	4.9
Ground Moraine	24679	45.7	163875	15.1
Glacial Outwash	3360	6.2	14043	23.9
Residual	739	1.4	45256	1.6
Colluvial	146	0.3	506	28.8
Rockland	1349	2.5	69375	1.9
TOTAL	54003	100.0	408630	

[1] Total area of riparian landtype in respective landtype class.

[2] Percent of the total riparian landtype for Swan River basin in respective landtype class.

[3] Total acres of landtype class.

[4] Percent of landtype class that is riparian landtype.

Table 3.7-5. Riparian community and habitat type legend.

ACRONYM	SCIENTIFIC NAME	COMMON NAME
ABGR/ATFI	*Abies grandis/Athyrium filix-femina*	Grand fir/lady fern
ABGR/OPHO	*Abies grandis/Oplopanax horridum*	Grand fir/devils club
ABLA/ACRU	*Abies lasiocarpa/Actea rubra*	Subalpine fir/baneberry
ABLA/CACA	*Abies lasiocarpa/Calamagrostis canadensis*	Subalpine fir/bluejoint reedgrass
ABLA/LEGL	*Abies lasiocarpa/Ledum glandulosum*	Subalpine fir/Labrador tea
ABLA/LIBO	*Abies lasiocarpa/Linnaea borealis*	Subalpine fir/twinflower
ABLA/OPHO	*Abies lasiocarpa/Oplopanax horridum*	Subalpine fir/devils club
ABLA/STAM	*Abies lasiocarpa/Streptopus amplexifolius*	Subalpine fir/twisted stalk
ABLA/VACA	*Abies lasiocarpa/Vaccinium caespitosum*	Subalpine fir/
ALIN	*Alnus incana*	Mountain alder
ALSI	*Alnus sinuata*	Sitka alder
CARO	*Carex rostrata*	Beaked sedge
COST	*Cornus stolonifera*	Red-osier dogwood
PICEA/COST	*Picea/Cornus stolonifera*	Spruce/red-osier dogwood
PICEA/EQAR	*Picea/Equisetum arvense*	Spruce/field horsetail
PICEA/GATR	*Picea/Galium triflorum*	Spruce/sweetscented bedstraw
PICEA/LIBO	*Picea/Linnaea borealis*	Spruce/twinflower
POTR/COST	*Populus tremuloides/Cornus stolonifera*	Aspen/red-osier dogwood
PSME/COST	*Pseudotsuga menziesii/Cornus stolonifera*	Douglas-fir/red-osier dogwood
SADR	*Salix drummondiana*	Drummond willow
SADR/CACA	*Salix drummondiana/Calamagrostis canadensis*	Drummond willow/blue-joint reedgrass
SADR/CARO	*Salix drummondiana/Carex rostrata*	Drummond willow/beaked sedge
SAEX	*Salix exigua*	Sandbar willow
SAPL	*Salix planifolia*	Plainleaf willow
THPL/GYDR	*Thuja plicata/Gymnocarpium dryopteris*	Western red cedar/oak fern
THPL/OPHO	*Thuja plicata/Oplopanax horridum*	Western red cedar/devils club

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APPENDIX D:
MAPPING CHLOROPHYLL DISTRIBUTION OVER LAKES OF NORTHWEST MONTANA

Mapping chlorophyll distribution over lakes of northwest Montana

10/01

Satellite Data

The distribution of the chlorophyll was estimated and mapped over lakes of northwest Montana, specifically around the flathead lake region using Landsat/Thematic Mapper. Landsat TM (Thematic Mapper) and ETM+(Enhanced Thematic Mapper Plus) have been widely used for monitoring of inland water quality parameters both because of the sufficient spatial resolution and because of the suitable spectral range of data acquisition. For this analysis we acquired 5 satellite images during the months of July/August from 1984 through 1999. The scenes for the years 1984, 1986, 1991 and 1996 are from the TM sensor onboard the Landsat 5 satellite, while the image for year 1999 is from the ETM+ onboard the Landsat 7 satellite.

Atmospheric corrections:

Atmospheric conditions play a key role in determining the amount of reflected radiation reaching the satellite sensors. In order to estimate lake quality parameters such as chlorophyll, one must remove the atmospheric contribution before converting the reflectances to measures of lake quality. The atmosphere affects the radiance leaving the water bodies through scattering caused by molecules and aerosols. In general, the water-leaving radiance detected by the sensor is very low with respect to the contribution of the atmosphere. There are numerous atmospheric models for accounting for the atmospheric contribution. To atmospherically correct the images used in our analysis, we used the atmospheric correction provided for TM data calibration with the image processing software ENVI 3.2. The ETM+ scene for 1999 was corrected independently by applying the correction suggested by the Landsat-7 Science Data User's Handbook.

Estimation of chlorophyll distribution from water reflectance

The estimation of the chlorophyll concentration makes use of the spectral properties of the water bodies within the optical and near infrared portion of the electromagnetic spectrum. Bands 1 to 4 (from 450 nm to 900 nm) are in the spectral range where light penetrates the water to a sufficient depth to extract information about the water quality. The presence of chlorophyll *a* and aquatic humus determines attenuation in the reflectance in band 1 (blue) and 3 (red), and an increase in reflectance in band 2 (green). The attenuation of reflectance in band 3 is lower than in band 1 due to the counteracting backscattering of suspended sediments. To develop an algorithm for chlorophyll estimation using TM data, the effect of the total suspended sediment on reflectance should therefore be taken into consideration. By subtracting band 3 from the reflectance in band 1, a correction for the additional radiance caused by scattering of non-organic sediment is introduced. For our analysis we adopted a model suggested by Brivio et al (2001), where the atmospherically corrected reflectances in band 1 and 3 are normalized by the reflectance in band2:

$$chl = 0.098 \bullet \frac{band1 - band3}{band2} \qquad \textbf{(1)}$$

This model was applied to all the 5 Landsat scenes to estimate the spatial distribution of chlorophyll in the Flathead Lake.

Registration and land masking

In order to facilitate the comparison of the chlorophyll distribution in the Flathead and Swan lakes, the 5 Landsat scenes were co-registered to the UTM projection, zone 11, datum Clarke 1866. A mask to isolate the water bodies was obtained through an unsupervised classification of band 4 (near-infrared). In the near infrared the absorption by the water is very high in contrast to the surrounding land areas. This characteristic makes the creation of a mask to isolate the water bodies relatively easy task. In the image of July 20 1991 some clouds where present in the western part of the scene during its acquisition. Since clouds also absorb in the near-infrared, they where included into the mask.

Results and Discussion

Figure 1 presents the distribution of the chlorophyll concentration in µg/l predicted for the five Landsat scenes. Table 1 presents the areal extents of flathead lake in various categories of chlorophyll concentration. In general, 1980s show higher chlorophyll concentrations compared to the 1990s.:

Chlorophyll concentration mg/l	**July 16, 1984 %**	**July 27, 1988 %**	**July 20, 1991 %**	**July 1, 1996 %**	**August 3, 1999 %**
0 – 1	0.00	0.15	10.17	0.00	33.25
1 – 2	2.82	4.86	89.83	7.74	66.75
2 – 3	35.62	69.73	0.00	88.84	0.0
4 – 4.4	61.55	25.25	0.05	3.41	0.0

Table 1 – Percent of surface area in chlorophyll concentration classes as estimated from the five Landsat scenes.

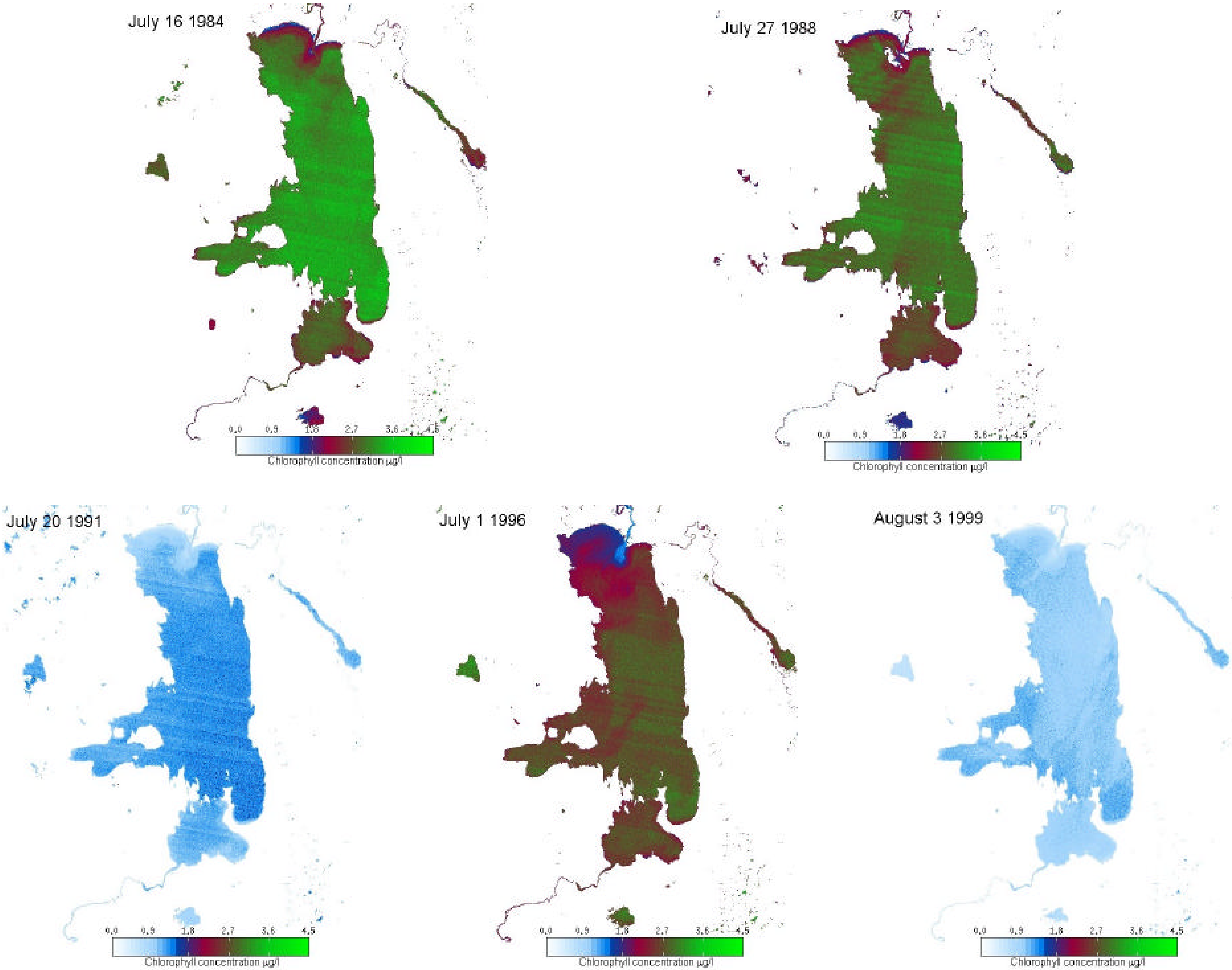

Figure 1 – Maps of chlorophyll concentration in mg/l estimated from the atmospherically corrected Landsat TM and ETM+ data using the model presented in equation 1.

Both Figure 1 and Table 1 show that the chlorophyll concentration was predicted to be the highest in 1984, followed by 1988 and 1996. In the years 1991 and 1999 the lake's chlorophyll concentration was estimated to be the lowest.

We explain this lower prediction of chlorophyll concentration as a result of higher streamflow and lower lake temperature in the years 1991 and 1999. In Table 2 we report the monthly streamflow in cubic feet/second recorded for the Flathead River near Columbia Falls for the different years of our analysis. In the month of July streamflow was the lowest in 1988 and in 1984, which show the highest predicted chlorophyll concentrations. Years 1991 and 1999, which have the lowest predicted chlorophyll concentrations, have the highest streamflows in the months of satellite data acquisition.

month	**1984**	**1988**	**1991**	**1996**	**1999**
1	1101	398	995	1456	710
2	853	395	1161	2017	602
3	820	546	1018	1574	1101
4	2848	3537	4147	5155	3340
5	5966	7430	12530	8932	7799
6	9004	5924	12720	14410	11360
7	3439	1739	6697	5470	5855
8	1440	858	2156	2124	2531
9	1142	662	1049	1306	1148
10	947	1175	727	1474	1435
11	877	1269	712	1103	3435
12	588	836	615	697	1419
total	29025	24769	44527	45718	40735

Table 2 – Monthly streamflow of the Flathead River near Columbia Falls in cubic feet/second.

In Figure 2 we show the temperature map of the lake surface for 1984 and 1991 as estimated from the thermal bands from the Landsat TM scenes. The temperature in 1991 was considerably lower than in 1984, and it can be expected that lower temperatures affect the magnitude of the algal blooms.

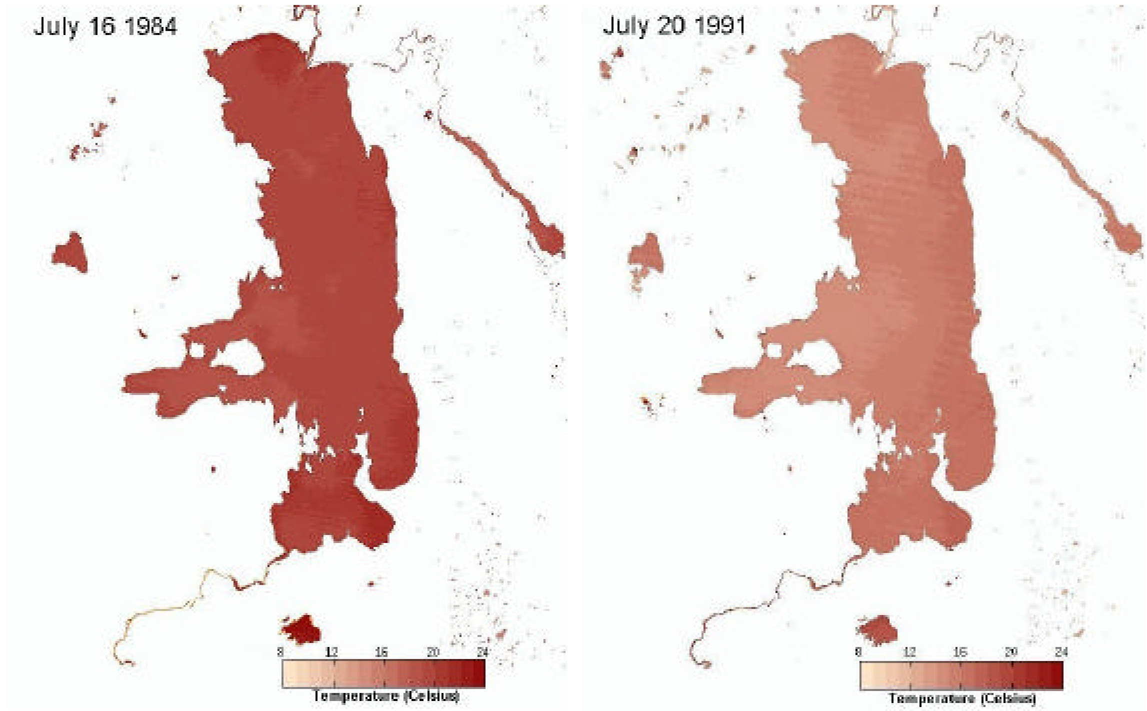

Figure 2 - Temperature map of the lake surface for 1984 and 1991 as estimated from the thermal bands of the Landsat TM scenes.

A more accurate estimation of the distribution of the chlorophyll concentration in the Flathead Lake could be obtained if geo-referenced ground measurements of the parameter (chlorophyll) are available. We suggest that water sampling should be performed at 5-6 locations around the lake. These measurements would allow a better calibration of the model presented in equation 1.

Conclusions

Landsat TM and ETM+ data have been used in a number of studies to estimate quality of inland waters. The advantages of this type of data are:

- suitable spatial resolution
- suitable spectral range of data acquisition
- long data record (1982 to present)
- affordable cost

The analysis of Landsat satellite data to map chlorophyll concentration in inland waters may provide a useful tool for gaining periodical information on the spatial distribution of algae.

Nevertheless, we suggest that ground measurements be available to improve the accuracy of the estimation of the chlorophyll distribution.

References

Brivio P.A., C. Giardino and E. Zilioli (2001) – Determination of chlorophyll concentration changes in Lake Garda using an image-based radiative transfer code for Landsat TM images. International Journal of remote sensing 22:2: 487-502.

APPENDIX E:
FOREST ROAD SEDIMENT ASSESSMENT METHODOLOGY

FOREST ROAD
SEDIMENT ASSESSMENT METHODOLOGY

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1.0 INTRODUCTION

This document describes a method of analysis for calculation of sedimentation rates from both natural background and forest roads (including road tread as well as cut and fill slopes).

This process is repeatable, rigorous, and defensible, but it does rely on a substantial amount of professional judgement. An integral part of this assessment methodology is concise and careful notation in the field of rationale behind judgement calls as they are made. These should be included in the final assessment report and can serve as valuable documentation during scrutiny of the process and the values derived.

2.0 NATURAL RATES OF SEDIMENTATION

There are numerous ways to calculate a natural background erosion rate. Two are presented here as examples. Depending on available data, more reliable methods may be derived.

2.1 Soil Creep Estimate

The soil creep calculations described here are from the *Washington Forest Practices Board* (WFPB) manual (1995). Annual erosion rates are calculated using the following equation:

$$\text{Annual Erosion Volume } (m^3/yr) = (L*2) * D * C$$

where:
L = length of stream channel in meters (this is doubled to account for both sides of stream).
D = soil depth in meters.
C = creep rate in meters per year.

Based on information provided in WFPB (1995) the creep rate was assigned as 0.001 m/yr for basins with average slope of <35% and 0.002 m/yr for basins with average slope of >35%. Stream length may be determined by planimeter or GIS, if available. The hydrography layers should be checked for accuracy by direct observations.

Soil depth information is often available from a local USDA office or other government office depending on the location. In many cases, soils inventories provide erosion rates for a combination of both coarse and fine sediment. If this is the case, one must apply a factor for the percent fines in the soil types in the study area.

2.2 Landtype Estimate

A second common method for estimating natural erosion rates is with Forest Service landtype estimates of base surface erosion rates. A watershed erosion rate may be calculated as a weighted average by area of landtype. This may be done manually with a planimeter or with GIS.

The values of natural background sedimentation are then compared to road sedimentation to determine the percentage of total sediment load that is coming from forest roads.

3.0 RATE OF SEDIMENTATION FROM ROAD SURFACES

3.1 Collecting Data and Applying Mitigation Factors

The assessment of erosion and fine sediment delivery from roads is essentially an accounting procedure that involves actual field observations of erosion and delivery of sediment to streams. Streams are defined as “any drainage depression containing a defined bed and banks extending continuously below the drainage site. Flow regime can be ephemeral, intermittent, or perennial”. Therefore, erosion that was delivered to a drainage feature known to be discontinuous below (i.e. no connection to downstream waterbodies) should not be counted in the sediment budget presented below.

The contributing area associated with stream crossings is considered to be all areas of road tread, cut slope, and fill slope, from which water could flow to the stream. In other words, if the road tread and cut slope were relieved by a drain dip 100 feet from the culvert, then only that 100 feet between the dip and the culvert would be considered in the sediment budget. In some cases, road drainage features such as drain dips are not 100% effective. That is, they do not capture all runoff from the uphill sections of road. In these instances, the observer must take this into account when characterizing the ultimate delivery ratio for any given site.

Several mitigating factors were applied to this measurement of actual eroding surface area. These were applied as average factors over each individual eroding area.

The factors are shown in **Table 1**.

Table 1. ***Factors Applied in Road Surface Sedimentation Assessment***

Factor	Definition
Cover	Percent of non-soil cover
Gravel	A categorical factor accounting for mitigating resulting in gravel road surfacing
Traffic	Factor accounting for higher erosion from higher traffic roads
Snow	Percent of the year when snow or ice mitigates surface erosion (applied directly to traffic factor)
Delivery	Percent of displaced fine sediment which is delivered into a waterbody

Cover Factor

The cover factor is the percent of non-erodible cover on each of the three road features (tread, cutslope, and fillslope). Cover percent translates into the following factors applied in the sediment calculations:

Table 2. ***Factor for Percent Cover Values***

Cover Percent	Factor
>80%	0.18
50%	0.37
30%	0.53
20%	0.63
10%	0.77
0%	1.00

Gravel Factor

The gravel factor accounts for reduced erosion from roads with gravel applications. With a gravel lift of 2” to 6” depth the factor is 0.50. With a gravel lift of >6” the factor is 0.20.

Traffic and Snow Factors

The traffic multiplier accounts for the fact that roads which receive heavy truck traffic have higher erosion rates. This factor ranges from 1 to 50 as shown in **Table 3**. The value assigned depends on the use that the road experiences. Greater traffic results in a greater multiplier. The actual factor one uses should be a judgment call.

Table 3. ***Traffic Factors***

Traffic use / Road Category	Annual Precipitation	
	<1200 mm	1200 mm-3000 mm
Heavy Traffic / Active Mainline	20	50
Moderate Traffic / Active Secondary	2	4
Light Traffic / Not Active	1	1

The snow factor is the estimated percent of the year that the road feature being assessed is under snow and/or ice. The factor works counter to the traffic multiplier. It accounts for the fact that when a road is covered with snow or ice, the traffic is not dislodging soil particles.

Percent Delivery

The determination of the percent of eroded fine sediment which is delivered to a stream is perhaps the most challenging part of this assessment methodology. This factor must take into account the observer’s sense of sediment delivery over time and, without an accurate way to characterize historical or potential future sedimentation, it becomes a judgment call.

It is also easy to “double mitigate” with the percent delivery. In other words, one could reduce the calculated amount of sediment being generated at a given location by using the gravel factor and on top of that, claim that the *delivery* was very low due to the lack of sediment *generation*.

This is double mitigation for the gravel. The amount of fine sediment generated and the amount of fine sediment delivered are two different factors. To avoid this pitfall, one should be careful to consider "delivery" as the *potential* for sediment to be carried to a stream once it is eroded. If there is no sediment being eroded, take that into account with the cover factor, gravel factor, etc.

Table 4 shows the descriptions for delivery categories. These can be adjusted based on the experience and judgment of the observer.

Table 4. ***Categories of Sediment Delivery to Streams***

Percent Category	Description
100%	Chronic direct delivery under most erosional scenarios.
75%	Direct delivery evident but not chronic, effective buffer (provided by distance, gentle topography, or vegetation) during low intensity erosional events.
50%	Direct sediment delivery but minor amounts or older events.
25%	Direct delivery unlikely except in moderate to major erosional events.
5%	Effective buffer, but proximity of road to stream makes 5% necessary.

3.2 Sedimentation Calculation

To calculate the volume of sediment contribution from each road location take the following steps:

1. Assign a base (natural) erosion rate from roads in tons/acre/year. This commonly comes from a combination of published values and professional knowledge of the soils in the watershed.
2. Calculate the area of erosion (length times width) for the tread, cut and fill slopes, and covert it to acres.
3. Apply each multiplier (cover, gravel, traffic, snow (applied to traffic factor directly), and percent delivery).
4. Multiply all of these together for the road tread, cut slope, and fill slope individually to derive the sediment volume from each of these features.
5. Sum these three values for the total delivery for that location, in tons of sediment per year.

Location totals thus derived are then summed for the entire watershed to arrive at a total fine sediment contribution from roads.

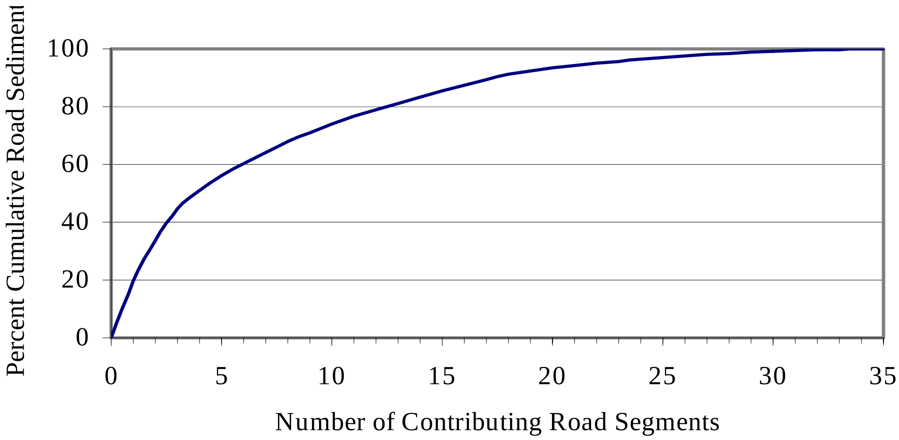
4.0 APPLICATION OF DATA TO WATERSHED RESTORATION PROCESS

The tabulated data for sedimentation from road surfaces can be used to plan and account for sediment reductions in a watershed. For most watersheds, a small number of road segments will be responsible for a large portion of the total sedimentation load. **Figure 1** shows a typical distribution of watershed-scale sedimentation volumes for road segments. The road sediment data can be used for the following purposes, depending on the ultimate objectives of the assessment project:

- Comparison to natural background rates to determine a quantitative impact.

- By ranking road segments in terms of total fine sediment delivered, one can determine where restoration or mitigation activities would most efficiently reduce sediment delivery to streams. By addressing the erosion from these segments, a quantitative reduction in sediment delivery may be achieved.
- Proposed restoration activities can be "modeled" in the spreadsheet to show projected sediment reduction volumes.
- As improvements are made to specific road segments (e.g., better drainage, improved sediment buffers, etc.) the total volume of sediment coming from roads in the basin is reduced and this can be used in a TMDL.

Figure 1. ***Typical Cumulative Frequency Distribution of Road Segments Contributing Fine Sediment***



Applying the data from the culvert failure assessment is a qualitative exercise. As improvements are made to specific stream crossings (e.g., larger pipes installed, better rock armoring, better alignment, replacement of pipes with a bridge, etc.) the total volume of sediment at risk of failure in the watershed is reduced and this, although qualitative, can be used in a TMDL.

Using this assessment methodology, managers can more efficiently focus their restoration dollars and can document improvements. This planning process and the subsequent mitigation activities are likely going to be a strong foundation in the development of a TMDL for waterbodies impaired by fine sediment resulting from forest management.

APPENDIX F: FOREST ROADS SEDIMENT RESULTS

List of Tables

List of Maps

Table F-1. Swan River Basin Road Sediment Assessment Data.

Final Map Code	Location Code	Tread Length	Tread Width	Acres of Tread	Base Erosion Rate (tons/yr)	Gravel Factor	Traffic Factor	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Tread Delivered Load (tons/yr)	Cutslope Length	Avg Cutslope Width	Acres of Cutslope	Base Erosion Rate (tons/yr)	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Cutslope Delivered Load (tons/yr)	Fillslope Length	Avg Fillslope Width	Acres of Fillslope	Base Erosion Rate (tons/yr)	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Fillslope Delivered Load (tons/yr)	Location Delivered Load (tons/yr)
SWC1	Beaver	162	14	0.05	30	1	1	85	0.16	5	0.05	0.01	143	5	0.02	30	70	0.23	5	0.05	0.01	55	5	0.01	30	95	0.12	5	0.05	0.00	0.019
SWC2	Beaver	0	0	0.00	30	1	1	0	0.00	0	0.00	0.00	286	4	0.03	30	95	0.12	10	0.10	0.01	44	4	0.00	30	90	0.14	50	0.50	0.01	0.018
SWC3	Beaver	385	19	0.17	30	1	1	55	0.34	50	0.50	0.86	0	0	0.00	30	0	0.00	0	0.00	0.00	88	5	0.01	30	95	0.12	5	0.05	0.00	0.858
SWC4	Beaver	885	17	0.35	30	1	1	80	0.18	5	0.05	0.09	852	6	0.12	30	95	0.12	60	0.60	0.25	50	8	0.01	30	100	0.10	5	0.05	0.00	0.348
SWC5	Beaver	368	17	0.14	30	1	1	50	0.37	50	0.50	0.80	280	12	0.08	30	90	0.14	25	0.25	0.08	176	15	0.06	30	90	0.14	50	0.50	0.13	1.005
SWC6	Beaver	236	19	0.10	30	1	1	70	0.23	5	0.05	0.04	121	8	0.02	30	90	0.14	5	0.05	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.040
SWC7	Beaver	0	0	0.00	30	1	1	0	0.00	0	0.00	0.00	253	7	0.04	30	95	0.12	5	0.05	0.01	0	0	0.00	30	0	0.00	0	0.00	0.00	0.007
SWC8	Beaver	0	0	0.00	30	1	1	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	38	3	0.00	30	95	0.12	25	0.25	0.00	0.002
SWC9	Beaver	412	17	0.16	30	1	1	35	0.49	5	0.05	0.12	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.118
SWC10	Beaver	220	17	0.09	30	1	1	85	0.16	15	0.15	0.06	0	0	0.00	30	0	0.00	0	0.00	0.00	28	4	0.00	30	95	0.12	15	0.15	0.00	0.063
SWC11	Beaver	0	0	0.00	30	1	1	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	66	6	0.01	30	95	0.12	5	0.05	0.00	0.002
SWC12	Beaver	385	16	0.14	30	1	1	50	0.37	5	0.05	0.08	0	0	0.00	30	0	0.00	0	0.00	0.00	49	6	0.01	30	100	0.10	5	0.05	0.00	0.079
SWC13	Beaver	25	16	0.01	30	1	1	40	0.45	5	0.05	0.01	0	0	0.00	30	0	0.00	0	0.00	0.00	10	2	0.00	30	100	0.10	5	0.05	0.00	0.006
SWC14	Beaver	1529	18	0.63	30	1	2	20	0.63	25	0.25	5.97	1919	5	0.22	30	100	0.10	5	0.05	0.03	649	6	0.09	30	100	0.10	5	0.05	0.01	6.017
SWC15	Beaver	852	19	0.37	30	1	2	40	0.45	10	0.10	1.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	1.003
SWC16	Beaver	1809	22	0.91	30	1	2	15	0.70	10	0.10	3.84	165	5	0.02	30	95	0.12	10	0.10	0.01	1122	5	0.13	30	95	0.12	10	0.10	0.05	3.890
SWC17	Beaver	1370	17	0.53	30	1	1	25	0.58	25	0.25	2.33	429	6	0.06	30	90	0.14	5	0.05	0.01	176	7	0.03	30	100	0.10	5	0.05	0.00	2.342
SWC18	Holland	750	19	0.33	30	1	1	40	0.45	10	0.10	0.44	330	4	0.03	30	95	0.12	5	0.05	0.01	605	6	0.08	30	100	0.10	5	0.05	0.01	0.460
SWC19	(Unnamed)	1300	25	0.75	30	1	1	0	1.00	100	1.00	22.38	0	0	0.00	30	0	0.00	0	0.00	0.00	40	1	0.00	30	10	0.77	100	1.00	0.02	22.404
SWC20	(Unnamed)	1700	30	1.17	30	1	1	0	1.00	90	0.90	31.61	300	1	0.01	30	0	1.00	100	1.00	0.21	30	2	0.00	30	15	0.70	100	1.00	0.03	31.847
SWC21	(Unnamed)	3000	25	1.72	30	1	1	5	0.90	60	0.60	27.89	550	10	0.13	30	75	0.21	50	0.50	0.40	300	8	0.06	30	100	0.10	50	0.50	0.08	28.373
SWC22	Holland	900	16	0.33	30	1	1	40	0.45	10	0.10	0.45	0	0	0.00	30	0	0.00	0	0.00	0.00	150	4	0.01	30	100	0.10	5	0.05	0.00	0.448
SWC23	Holland	540	19	0.24	30	1	1	50	0.37	10	0.10	0.26	980	4	0.09	30	90	0.14	5	0.05	0.02	265	6	0.04	30	100	0.10	5	0.05	0.01	0.286
SWC24	Holland	320	14	0.1	30	1	1	50	0.37	5	0.05	0.06	286	2	0.01	30	90	0.14	5	0.05	0.00	550	3	0.04	30	100	0.10	5	0.05	0.01	0.066
SWC25	Holland	250	12	0.07	30	1	1	30	0.53	30	0.30	0.33	0	0	0.00	30	0	0.00	0	0.00	0.00	100	5	0.01	30	85	0.16	20	0.20	0.01	0.340
SWC26	Holland	0	0	0.00	30	1	1	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	80	3	0.01	30	40	0.45	35	0.35	0.03	0.026
SWC27	Holland	350	18	0.14	30	1	1	20	0.63	5	0.05	0.14	500	2	0.02	30	99	0.10	15	0.15	0.01	220	6	0.03	30	95	0.12	10	0.10	0.01	0.158
SWC28	Holland	50	16	0.02	30	1	1	75	0.21	90	0.90	0.10	200	1	0.00	30	40	0.45	5	0.05	0.00	88	5	0.01	30	100	0.10	5	0.05	0.00	0.109
SWC29	(Unnamed)	720	20	0.33	30	1	1	10	0.77	75	0.75	5.73	0	0	0.00	30	0	0.00	0	0.00	0.00	60	5	0.01	30	100	0.10	100	1.00	0.02	5.748
SWC30	(Unnamed)	920	20	0.42	30	1	1	10	0.77	75	0.75	7.32	870	12	0.24	30	95	0.12	70	0.70	0.60	60	5	0.01	30	100	0.10	100	1.00	0.02	7.943
SWC31	Beaver	82	17	0.03	30	1	1	40	0.45	5	0.05	0.02	0	0	0.00	30	0	0.00	0	0.00	0.00	82	3	0.01	30	50	0.37	10	0.10	0.01	0.028
SWC32	Beaver	385	19	0.17	30	1	1	50	0.37	5	0.05	0.09	0	0	0.00	30	0	0.00	0	0.00	0.00	82	6	0.01	30	100	0.10	5	0.05	0.00	0.095
SWC33	(Unnamed)	1160	20	0.53	30	1	1	10	0.77	75	0.75	9.23	250	12	0.07	30	100	0.10	75	0.75	0.15	95	12	0.03	30	100	0.10	100	1.00	0.08	9.461
SWC34	(Unnamed)	170	25	0.10	30	1	1	0	1.00	40	0.40	1.17	0	0	0.00	30	0	0	0	0.00	0.00	110	2	0.01	30	75	0.21	20	0.20	0.01	1.177
SWC35	(Unnamed)	175	25	0.10	30	1	1	5	0.90	10	0.10	0.27	0	0	0.00	30	0	0	0	0.00	0.00	240	3	0.02	30	50	0.37	15	0.15	0.03	0.299
SWC36	(Unnamed)	150	25	0.09	30	1	1	60	0.30	80	0.80	0.62	100	7	0.02	30	50	0.37	50	0.50	0.09	100	2	0.00	30	75	0.21	80	0.80	0.02	0.732
SWC37	(Unnamed)	120	25	0.07	30	1	1	5	0.90	10	0.10	0.19	120	8	0.02	30	50	0.37	10	0.10	0.02	140	5	0.02	30	90	0.14	10	0.10	0.01	0.217
SWC38	(Unnamed)	600	15	0.21	30	1	1	70	0.23	15	0.15	0.21	150	2	0.01	30	90	0.14	15	0.15	0.00	40	40	0.04	30	95	0.12	10	0.10	0.01	0.231
SWC39	(Unnamed)	370	20	0.17	30	1	1	10	0.77	75	0.75	2.94	350	10	0.08	30	90	0.14	50	0.50	0.17	75	4	0.01	30	95	0.12	95	0.95	0.02	3.135
SWC40	(Unnamed)	400	15	0.14	30	1	1	40	0.45	15	0.15	0.28	400	3	0.03	30	75	0.21	15	0.15	0.03	95	4	0.01	30	90	0.14	25	0.25	0.01	0.314
SWC41	(Unnamed)	250	25	0.14	30	1	1	30	0.53	65	0.65	1.48	0	0	0.00	30	0	0.00	0	0.00	0.00	100	1	0.00	30	80	0.18	50	0.50	0.01	1.489
SWC42	Kraft	450	19	0.20	30	1	1	65	0.26	10	0.10	0.08	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.077
SWC43	(Unnamed)	80	25	0.05	30	1	1	40	0.45	25	0.25	0.15	0	0	0.00	30	0	0.00	0	0.00	0.00	120	2	0.01	30	75	0.21	60	0.60	0.02	0.176
SWC44	Kraft	138	16	0.05	30	1	1	95	0.12	5	0.05	0.01	116	6	0.02	30	100	0.10	5	0.05	0.00	100	8	0.02	30	100	0.10	5	0.05	0.00	0.014
SWC45	Kraft	0	0	0.00	30	1	1	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	40	4	0.00	30	25	0.58	100	1.00	0.06	0.064
SWC46	Kraft	525	19	0.23	30	1	1	50	0.37	20	0.20	0.25	0	0	0.00	30	0	0.00	0	0.00	0.00	100	6	0.01	30	100	0.10	5	0.05	0.00	0.256
SWC47	Kraft	0	0	0.00	30	1	1	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	22	3	0.00	30	90	0.14	5	0.05	0.00	0.000
SWC48	Kraft	465	20	0.21	30	1	1	50	0.37	20	0.20	0.47	385	5	0.04	30	95	0.12	5	0.05	0.01	150	6	0.02	30	100	0.10	5	0.05	0.00	0.485
SWC49	Kraft	715	17	0.28	30	1	1	50	0.37	25	0.25	0.39	700	3	0.05	30	100	0.10	5	0.05	0.01	192	5	0.02	30	95	0.12	10	0.10	0.01	0.402
SWC50	(Unnamed)	300	20	0.14	30	1	1	20	0.63	50	0.50	1.30	0	0	0.00	30	0	0.00	0	0.00	0.00	30	4	0.00	30	50	0.37	50	0.50	0.02	1.317
SWC51	Kraft	110	14	0.04	30	1	1	95	0.12	5	0.05	0.01	0	0	0.00	30	0	0.00	0	0.00	0.00	33	4	0.00	30	100	0.10	5	0.05	0.00	0.007
SWC52	Kraft	400	16	0.15	30	1	1	95	0.12	5	0.05	0.03	360	3	0.02	30	95	0.12	5	0.05	0.00	110	9	0.02	30	100	0.10	5	0.05	0.00	0.034
SWC53	Holland	35	17	0.01	30	1	1	80	0.18	30	0.30	0.02	0	0	0.00	30	0	0.00	0	0.00	0.00	500	6	0.07	30	95	0.12	10	0.10	0.02	0.047
SWC54	(Unnamed)	250	20	0.11	30	1	1	70	0.23	25	0.25	0.20	250	4	0.02	30	70	0.23	25	0.25	0.04	115	6	0.02	30	90	0.14	25	0.25	0.02	0.254
SWC55	(Unnamed)	100	20	0.05	30	1	1	10	0.77	25	0.25	0.27	100	8	0.02	30	10	0.77	10	0.10	0.04	0	0	0.00	30	0	0	0	0.00	0.00	0.308
SWC56	(Unnamed)	380	25	0.22	30	1	1	5	0.90	90	0.90	5.30	130	6	0.02	30	5	0.90	90	0.90	0.44	140	4	0.01	30	100	0.10	90	0.90	0.03	5.769
SWC57	Barber	407	18	0.17	30	1	1	20	0.63	10	0.10	0.32	0	0	0.00	30	0	0.00	0	0.00	0.00	66	3	0.00	30	100	0.10	5	0.05	0.00	0.319
SWC58	Barber	1677	19	0.73	30	1	1	25	0.58	10	0.10	1.27	1300	10	0.30	30	90	0.14	10	0.10	0.13	341	4	0.03	30	100	0.10	5	0.05	0.00	1.403
SWC59	Barber	731	22	0.37	30	1	2	15	0.70	50	0.50	7.75	620	10	0.14	30	65	0.26	25	0.25	0.28	247	6	0.03	30	95	0.12	15	0.15	0.02	8.049

Table F-1. Swan River Basin Road Sediment Assessment Data.

Final Map Code	Location Code	Tread Length	Tread Width	Acres of Tread	Base Erosion Rate (tons/yr)	Gravel Factor	Traffic Factor	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Tread Delivered Load (tons/yr)	Cutslope Length	Avg Cutslope Width	Acres of Cutslope	Base Erosion Rate (tons/yr)	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Cutslope Delivered Load (tons/yr)	Fillslope Length	Avg Fillslope Width	Acres of Fillslope	Base Erosion Rate (tons/yr)	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Fillslope Delivered Load (tons/yr)	Location Delivered Load (tons/yr)
SWC60	Barber	192	19	0.08	30	1	1	20	0.63	10	0.10	0.16	0	0	0.00	30	0	0.00	0	0.00	0.00	88	4	0.01	30	90	0.14	10	0.10	0.00	0.162
SWC61	(Unnamed)	325	30	0.22	30	1	1	35	0.48	35	0.35	1.13	0	0	0.00	30	0	0.00	0	0.00	0.00	130	5	0.01	30	95	0.12	50	0.37	0.02	1.148
SWC62	(Unnamed)	600	30	0.41	30	1	1	20	0.63	25	0.25	1.95	80	8	0.01	30	80	0.18	75	0.75	0.06	180	5	0.02	30	95	0.12	50	0.37	0.03	2.040
SWC63	Buck	1210	16	0.44	30	1	1	30	0.53	5	0.05	0.35	429	10	0.10	30	60	0.30	5	0.05	0.04	143	6	0.02	30	85	0.16	5	0.05	0.00	0.402
SWC64	Rumble	3250	16	1.19	30	1	1	35	0.49	75	0.75	13.16	0	0	0.00	30	0	0.00	0	0.00	0.00	30	5	0.00	30	100	0.10	5	0.05	0.00	13.162
SWC65	Rumble	28	17	0.01	30	1	1	30	0.53	80	0.80	0.14	203	8	0.04	30	50	0.37	5	0.05	0.02	82	6	0.01	30	90	0.12	10	0.10	0.00	0.164
SWC66	Rumble	1336	16	0.49	30	1	1	35	0.49	50	0.50	3.61	121	6	0.02	30	75	0.21	50	0.50	0.05	0	0	0.00	30	0	0.00	0	0.00	0.00	3.659
SWC67	Rumble	1397	16	0.51	30	1	1	35	0.49	5	0.05	0.38	0	0	0.00	30	0	0.00	0	0.00	0.00	30	5	0.00	30	100	0.10	5	0.05	0.00	0.378
SWC68	(Unnamed)	200	25	0.11	30	1	1	40	0.45	25	0.25	0.39	200	8	0.04	30	70	0.23	25	0.25	0.06	60	4	0.01	30	100	0.10	25	0.25	0.00	0.455
SWC69	Glacier	1925	17	0.75	30	1	2	15	0.70	20	0.20	6.31	1727	7	0.28	30	85	0.16	5	0.05	0.07	616	8	0.11	30	100	0.10	5	0.05	0.02	6.394
SWC70	Kraft	125	15	0.04	30	1	1	30	0.53	5	0.05	0.03	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.034
SWC71	(Unnamed)	775	25	0.44	30	1	1	5	0.90	60	0.60	7.21	70	5	0.01	30	30	0.53	60	0.60	0.08	120	3	0.01	30	100	0.10	5	0.05	0.00	7.283
SWC72	(Unnamed)	800	30	0.55	30	1	1	0	1.00	75	0.75	12.40	580	7	0.09	30	10	0.77	75	0.75	1.61	190	5	0.02	30	80	0.18	75	0.75	0.09	14.100
SWC73	(Unnamed)	200	20	0.09	30	1	1	5	0.90	25	0.25	0.62	0	0	0.00	30	0	0.00	0	0.00	0.00	40	3	0.00	30	100	0.10	10	0.10	0.00	0.621
SWC74	(Unnamed)	360	25	0.21	30	1	1	5	0.90	10	0.10	0.56	0	0	0.00	30	0	0.00	0	0.00	0.00	90	2	0.00	30	100	0.10	50	0.50	0.01	0.564
SWC75	(Unnamed)	1400	30	0.96	30	1	1	10	0.77	40	0.40	8.91	600	2	0.03	30	80	0.18	25	0.25	0.04	200	5	0.02	30	80	0.18	50	0.50	0.06	9.008
SWC76	(Unnamed)	650	25	0.37	30	1	1	5	0.90	25	0.25	2.52	250	5	0.03	30	40	0.45	35	0.35	0.14	130	2	0.01	30	80	0.18	50	0.50	0.02	2.670
SWC77	Glacier	798	22	0.40	30	1	2	30	0.53	25	0.25	3.20	0	0	0.00	30	0	0.00	0	0.00	0.00	192	3	0.01	30	75	0.21	20	0.20	0.01	3.218
SWC78	(Unnamed)	1200	25	0.69	30	1	1	0	1.00	75	0.75	15.50	0	0	0.00	30	0	0.00	0	0.00	0.00	30	2	0.00	30	95	0.12	95	0.95	0.00	15.501
SWC79	(Unnamed)	590	30	0.41	30	1	1	5	0.90	60	0.60	6.58	0	0	0.00	30	0	0.00	0	0.00	0.00	75	2	0.00	30	90	0.14	35	0.35	0.01	6.588
SWC80	(Unnamed)	350	30	0.24	30	1	1	0	1.00	80	0.80	5.79	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	5.785
SWC81	Swan	1331	22	0.67	30	1	2	10	0.77	10	0.10	3.11	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	3.106
SWC82	(Unnamed)	820	30	0.56	30	1	1	10	0.77	40	0.40	5.22	0	0	0.00	30	0	0.00	0	0.00	0.00	150	4	0.01	30	90	0.14	40	0.40	0.02	5.241
SWC83	Glacier	396	21	0.19	30	1	2	40	0.45	10	0.10	0.52	0	0	0.00	30	0	0.00	0	0.00	0.00	280	10	0.06	30	100	0.10	5	0.05	0.01	0.525
SWC84	Elk	275	20	0.13	30	1	2	25	0.58	5	0.05	0.22	0	0	0.00	30	0	0.00	0	0.00	0.00	380	8	0.07	30	90	0.14	5	0.05	0.01	0.234
SWC85	(Unnamed)	1120	25	0.64	30	1	1	10	0.77	75	0.75	11.14	1050	5	0.12	30	80	0.18	25	0.25	0.16	300	6	0.04	30	90	0.14	80	0.80	0.14	11.438
SWC86	(Unnamed)	270	25	0.15	30	1	1	70	0.23	25	0.25	0.27	200	12	0.06	30	90	0.14	15	0.00	0.03	300	8	0.06	30	100	0.10	10	0.10	0.02	0.319
SWC87	(Unnamed)	0	0	0.00	30	1	1	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.000
SWC88	(Unnamed)	300	25	0.17	30	1	1	85	0.16	5	0.05	0.04	250	8	0.05	30	90	0.14	5	0.05	0.01	150	6	0.02	30	95	0.12	30	0.30	0.02	0.073
SWC89	Glacier	0	0	0.00	30	1	1	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	440	5	0.05	30	95	0.12	10	0.10	0.02	0.018
SWC90	(Unnamed)	850	30	0.59	30	1	1	90	0.14	5	0.05	0.12	825	12	0.23	30	100	0.10	10	0.10	0.07	60	5	0.01	30	100	0.12	10	0.10	0.00	0.194
SWC91	(Unnamed)	380	25	0.22	30	1	1	85	0.16	15	0.15	0.16	170	10	0.04	30	60	0.30	15	0.05	0.02	150	6	0.02	30	100	0.10	30	0.30	0.02	0.193
SWC92	Cooney	15	12	0.00	30	1	1	50	0.37	25	0.25	0.01	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.000	0.00	0.011
SWC93	Cooney	1512	16	0.56	30	1	1	45	0.41	5	0.05	0.34	798	6	0.11	30	85	0.16	5	0.05	0.03	38	3	0.00	30	100	0.10	5	0.05	0.00	0.368
SWC94	Cooney	193	17	0.08	30	1	1	35	0.49	25	0.25	0.28	275	5	0.03	30	75	0.21	20	0.20	0.04	110	5	0.01	30	100	0.10	5	0.05	0.00	0.318
SWC95	(Unnamed)	180	25	0.10	30	1	1	50	0.37	25	0.25	0.29	0	0	0.00	30	0	0.00	0	0.00	0.00	40	1	0.00	30	50	0.37	75	0.75	0.01	0.294
SWC96	(Unnamed)	180	20	0.08	30	1	1	50	0.37	75	0.75	0.69	0	0	0.00	30	0	0.00	0	0.00	0.00	100	40	0.09	30	90	0.14	90	0.90	0.35	1.035
SWC97	(Unnamed)	125	25	0.07	30	1	1	50	0.37	75	0.75	0.60	0	0	0.00	30	0	0.00	0	0.00	0.00	40	1	0.00	30	80	0.18	50	0.50	0.00	0.600
SWC98	McKay	187	16	0.07	30	1	1	30	0.53	25	0.25	0.27	121	2	0.01	30	60	0.30	25	0.25	0.01	82	3	0.01	30	90	0.12	10	0.10	0.00	0.288
SWC99	(Unnamed)	350	25	0.20	30	1	1	40	0.45	30	0.30	0.81	0	0	0.00	30	0	0.00	0	0.00	0.00	80	1	0.00	30	90	0.14	50	0.50	0.00	0.817
SWC100	(Unnamed)	600	25	0.34	30	1	1	25	0.58	75	0.75	4.49	0	0	0.00	30	0	0.00	0	0.00	0.00	40	7	0.01	30	90	0.14	80	0.80	0.02	4.515
SWC101	Smith	126	22	0.06	30	1	2	25	0.58	5	0.05	0.11	0	0	0.00	30	0	0.00	0	0.00	0.00	99	4	0.01	30	100	0.10	5	0.05	0.00	0.112
SWC102	(Unnamed)	290	22	0.15	30	1	1	5	0.90	15	0.15	0.59	0	0	0.00	30	0	0.00	0	0.00	0.00	60	2	0.00	30	100	0.10	75	0.75	0.01	0.599
SWC103	Smith	313	16	0.11	30	1	1	30	0.53	5	0.05	0.09	484	5	0.06	30	95	0.12	5	0.05	0.01	137	8	0.03	30	100	0.10	5	0.05	0.00	0.105
SWC104	(Unnamed)	800	20	0.37	30	1	1	10	0.77	60	0.60	5.09	800	14	0.26	30	70	0.23	50	0.50	0.89	70	5	0.01	30	100	0.10	90	0.90	0.02	6.000
SWC105	Falls	285	22	0.14	30	1	1	5	0.90	10	0.10	0.39	0	0	0.00	30	0	0.00	0	0.00	0.00	40	2	0.00	30	100	0.10	70	0.70	0.00	0.392
SWC106	Falls	400	16	0.15	30	1	1	30	0.53	10	0.10	0.23	370	8	0.07	30	100	0.10	10	0.10	0.02	28	8	0.01	30	95	0.12	10	0.10	0.00	0.256
SWC107	Falls	589	19	0.26	30	1	2	25	0.58	10	0.10	0.89	137	3	0.01	30	100	0.10	10	0.10	0.00	28	3	0.00	30	100	0.10	10	0.10	0.00	0.897
SWC108	Falls	192	16	0.07	30	1	1	20	0.63	10	0.10	0.13	192	4	0.02	30	100	0.10	10	0.10	0.01	38	6	0.01	30	100	0.10	5	0.05	0.00	0.139
SWC109	Condon	280	17	0.11	30	1	1	25	0.58	5	0.05	0.10	0	0	0.00	30	0	0.00	0	0.00	0.00	70	6	0.01	30	100	0.10	5	0.05	0.00	0.097
SWC110	(Unnamed)	260	15	0.09	30	1	1	50	0.37	220	2.20	2.19	150	16	0.06	30	70	0.23	20	0.20	0.08	60	4	0.01	30	100	0.10	50	0.50	0.01	2.271
SWC111	Simpson	55	16	0.02	30	1	1	85	0.16	5	0.05	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	12	3	0.00	30	100	0.10	5	0.05	0.00	0.005
SWC112	(Unnamed)	1050	20	0.48	30	1	1	75	0.21	25	0.25	0.76	1050	15	0.36	30	0	0.00	0	0.00	0.00	230	2	0.01	30	100	0.10	75	0.75	0.02	0.783
SWC113	Simpson	687	17	0.27	30	1	1	20	0.63	10	0.10	0.51	687	3	0.05	30	100	0.10	10	0.10	0.01	17	5	0.00	30	100	0.10	5	0.05	0.00	0.521
SWC114	Dog	248	17	0.10	30	1	1	40	0.45	25	0.25	0.33	181	6	0.02	30	85	0.16	10	0.10	0.01	88	8	0.02	30	100	0.10	5	0.05	0.00	0.341
SWC115	Elk	715	20	0.33	30	1	2	5	0.90	5	0.05	0.89	200	8	0.04	30	70	0.23	25	0.25	0.06	50	6	0.01	30	100	0.10	5	0.05	0.00	0.951
SWC116	Elk	385	18	0.16	30	1	2	5	0.90	5	0.05	0.43	275	4	0.03	30	50	0.37	25	0.25	0.07	100	8	0.02	30	100	0.10	5	0.05	0.00	0.502
SWC117	Cold	764	13	0.23	30	1	1	75	0.21	20	0.20	0.29	759	3	0.05	30	90	0.14	5	0.05	0.01	0	0	0.00	30	0	0.00	0	0.00	0.00	0.298
SWC118	(Unnamed)	75	25	0.04	30	1	1	60	0.30	25	0.25	0.10	0	0	0.00	30	0	0.00	0	0.00	0.00	130	2	0.01	30	95	0.12	30	0.30	0.01	0.103

Table F-1. Swan River Basin Road Sediment Assessment Data.

Final Map Code	Location Code	Tread Length	Tread Width	Acres of Tread	Base Erosion Rate (tons/yr)	Gravel Factor	Traffic Factor	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Tread Delivered Load (tons/yr)	Cutslope Length	Avg Cutslope Width	Acres of Cutslope	Base Erosion Rate (tons/yr)	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Cutslope Delivered Load (tons/yr)	Fillslope Length	Avg Fillslope Width	Acres of Fillslope	Base Erosion Rate (tons/yr)	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Fillslope Delivered Load (tons/yr)	Location Delivered Load (tons/yr)
SWC119	Cold	1210	18	0.50	30	1	1	25	0.58	5	0.05	0.44	0	0	0.00	30	0	0.00	0	0.00	0.00	126	6	0.02	30	100	0.10	5	0.05	0.00	0.438
SWC120	Cold	280	19	0.12	30	1	1	65	0.26	50	0.50	0.48	77	4	0.01	30	90	0.14	5	0.05	0.00	60	6	0.01	30	90	0.14	10	0.10	0.00	0.481
SWC121	(Unnamed)	500	15	0.17	30	1	1	60	0.30	10	0.10	0.15	0	0	0.00	30	0	0.00	0	0.00	0.00	35	2	0.00	30	95	0.12	30	0.30	0.00	0.157
SWC122	Cold	952	20	0.44	30	1	1	25	0.58	5	0.05	0.38	1072	4	0.10	30	100	0.10	5	0.05	0.01	264	8	0.05	30	100	0.10	5	0.05	0.01	0.402
SWC123	Cold	825	17	0.32	30	1	1	20	0.63	5	0.05	0.30	0	0	0.00	30	0	0.00	0	0.00	0.00	83	10	0.02	30	100	0.10	5	0.05	0.00	0.307
SWC124	Cold	358	17	0.14	30	1	1	25	0.58	10	0.10	0.24	0	0	0.00	30	0	0.00	0	0.00	0.00	83	7	0.01	30	100	0.10	5	0.05	0.00	0.245
SWC125	Cold	3200	25	1.84	30	1	1	10	0.90	75	0.75	37.19	40	3	0.00	30	75	0.21	25	0.25	0.00	100	7	0.02	30	100	0.10	5	0.05	0.00	37.197
SWC126	Cold	450	21	0.22	30	1	1	30	0.53	25	0.25	0.86	429	4	0.04	30	90	0.14	5	0.05	0.01	77	8	0.01	30	100	0.10	5	0.05	0.00	0.873
SWC127	Cold	30	50	0.03	30	1	1	95	0.12	5	0.05	0.01	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.006
SWC128	Cold	605	17	0.24	30	1	1	40	0.45	10	0.10	0.32	1045	5	0.12	30	80	0.18	10	0.10	0.06	60	4	0.01	30	100	0.10	5	0.05	0.00	0.384
SWC129	Cold	192	17	0.07	30	1	1	30	0.53	5	0.05	0.06	0	0	0.00	30	0	0.00	0	0.00	0.00	200	5	0.02	30	100	0.10	5	0.05	0.00	0.063
SWC130	(Unnamed)	400	30	0.28	30	1	1	50	0.37	25	0.25	0.76	0	0	0.00	30	0	0.00	0	0.00	0.00	200	2	0.01	30	95	0.12	40	0.40	0.01	0.778
SWC131	(Unnamed)	5	25	0.00	30	1	1	40	0.45	30	0.30	0.01	0	0	0.00	30	0	0.00	0	0.00	0.00	100	2	0.00	30	80	0.18	25	0.25	0.01	0.018
SWC132	(Unnamed)	1075	25	0.62	30	1	1	10	0.77	75	0.75	10.69	928	15	0.32	30	70	0.23	65	0.65	1.43	100	12	0.03	30	95	0.12	50	0.50	0.05	12.172
SWC133	Smith	655	19	0.29	30	1	1	15	0.70	25	0.25	1.50	0	0	0.00	30	0	0.00	0	0.00	0.00	335	3	0.02	30	100	0.10	5	0.05	0.00	1.503
SWC134	(Unnamed)	319	25	0.18	30	1	1	10	0.77	75	0.75	3.17	220	12	0.06	30	70	0.23	75	0.75	0.31	180	15	0.06	30	95	0.12	50	0.50	0.11	3.597
SWC135	(Unnamed)	180	15	0.06	30	1	1	15	0.70	25	0.25	0.33	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.325
SWC136	(Unnamed)	1300	25	0.75	30	1	1	10	0.77	75	0.75	12.93	600	15	0.21	30	50	0.37	50	0.50	1.15	110	15	0.04	30	95	0.12	75	0.75	0.10	14.175
SWC137	Condon	180	15	0.06	30	1	1	15	0.70	25	0.25	0.33	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.325
SWC138	Simpson	209	14	0.07	30	1	1	95	0.12	5	0.05	0.01	0	0	0.00	30	0	0.00	0	0.00	0.00	33	3	0.00	30	100	0.10	5	0.05	0.00	0.012
SWC139	(Unnamed)	900	25	0.52	30	1	1	10	0.77	50	0.50	5.97	250	6	0.03	30	75	0.21	25	0.25	0.05	45	10	0.01	30	100	0.10	75	0.75	0.02	6.043
SWC140	(Unnamed)	200	25	0.11	30	1	1	10	0.77	25	0.25	0.66	0	0	0.00	30	0	0.00	0	0.00	0.00	50	12	0.01	30	90	0.14	75	0.75	0.04	0.706
SWC141	(Unnamed)	280	15	0.10	30	1	1	50	0.37	25	0.25	0.27	0	0	0.00	30	0	0.00	0	0.00	0.00	40	5	0.00	30	100	0.10	50	0.50	0.01	0.274
SWC142	(Unnamed)	2000	25	1.15	30	1	1	10	0.77	30	0.30	7.95	1900	10	0.44	30	10	0.77	25	0.25	2.52	50	4	0.00	30	95	0.12	75	0.75	0.01	10.486
SWC143	(Unnamed)	100	25	0.06	30	1	1	0	1.00	50	0.50	0.86	0		0.00	30	0	0.00	0	0.00	0.00	200	2	0.01	30	10	0.77	10	0.10	0.02	0.882
SWC144	Jim	145	11	0.04	30	1	1	30	0.53	20	0.20	0.12	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.116
SWC145	(Unnamed)	1800	25	1.03	30	1	1	10	0.77	40	0.40	9.55	350	10	0.08	30	90	0.14	25	0.25	0.08	65	12	0.02	30	100	0.10	75	0.75	0.04	9.670
SWC146	Jim	115	7	0.02	30	1	1	30	0.53	10	0.10	0.03	0	0	0.00	30	0	0.00	0	0.00	0.00	20	10	0.00	30	20	0.63	80	0.80	0.07	0.099
SWC147	Jim	225	24	0.12	30	1	1	10	0.77	50	0.50	0.14	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.140
SWC148	Jim	250	10	0.06	30	1	1	40	0.45	10	0.10	0.08	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.077
SWC149	Cat	165	17	0.06	30	1	1	40	0.45	5	0.05	0.04	110	10	0.03	30	70	0.23	5	0.05	0.01	44	12	0.01	30	100	0.10	5	0.05	0.00	0.054
SWC150	Dog	704	17	0.27	30	1	1	70	0.23	5	0.05	0.09	0	0	0.00	30	0	0.00	0	0.00	0.00	115	6	0.02	30	100	0.10	5	0.05	0.00	0.097
SWC151	Swan	330	17	0.13	30	1	1	15	0.70	25	0.25	0.34	0	0	0.00	30	0	0.00	0	0.00	0.00	99	3	0.01	30	100	0.10	10	0.10	0.00	0.340
SWC152	Swan	1139	19	0.50	30	1	2	10	0.77	50	0.50	5.74	1017	5	0.12	30	70	0.23	50	0.50	0.40	1001	3	0.07	30	100	0.10	10	0.10	0.02	6.162
SWC153	(Unnamed)	830	25	0.48	30	1	1	10	0.77	75	0.75	8.25	800	8	0.15	30	90	0.14	25	0.25	0.15	200	15	0.07	30	100	0.10	75	0.75	0.15	8.562
SWC154	Jim	410	15	0.14	30	1	1	50	0.37	25	0.25	0.39	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.392
SWC155	Pony	297	17	0.12	30	1	1	65	0.26	5	0.05	0.05	242	3	0.02	30	100	0.10	5	0.05	0.00	22	3	0.00	30	100	0.10	5	0.05	0.00	0.048
SWC156	Pony	220	21	0.11	30	1	1	30	0.53	10	0.10	0.17	148	4	0.01	30	100	0.10	20	0.20	0.01	121	8	0.02	30	100	0.10	5	0.05	0.00	0.180
SWC157	Pony	451	22	0.23	30	1	1	30	0.53	5	0.05	0.18	0	0	0.00	30	0	0.00	0	0.00	0.00	165	4	0.02	30	100	0.10	5	0.05	0.00	0.183
SWC158	Jim	630	22	0.32	30	1	1	50	0.37	50	0.50	1.77	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	1.766
SWC159	Alder	770	22	0.39	30	1	2	0	1.00	90	0.90	21.00	319	3	0.02	30	60	0.30	30	0.30	0.06	121	6	0.02	30	50	0.37	90	0.90	0.17	21.226
SWC160	Alder	430	30	0.30	30	1	1	25	0.58	75	0.75	3.86	0	0	0.00	30	0	0.00	0	0.00	0.00	90	5	0.01	30	85	0.16	75	0.75	0.04	3.902
SWC161	Piper	0	0	0.00	30	1	1	0	0.00	0	0.00	0.00	70	40	0.06	30	25	0.58	90	0.90	1.01	0	0	0.00	30	0	0.00	0	0.00	0.00	1.007
SWC162	Lion	300	20	0.14	30	1	1	50	0.37	50	0.50	0.76	300	10	0.07	30	75	0.21	75	0.75	0.33	60	20	0.03	30	90	0.14	5	0.05	0.01	1.096
SWC163	Lion	175	15	0.06	30	1	1	40	0.45	40	0.40	0.33	0	0	0.00	30	0	0.00	0	0.00	0.00	400	15	0.14	30	40	0.45	90	0.90	1.67	1.999
SWC164	Lion	450	18	0.19	30	1	1	40	0.45	5	0.05	0.13	35	8	0.01	30	90	0.14	50	0.50	0.01	50	10	0.01	30	90	0.14	5	0.05	0.00	0.141
SWC165	Piper	180	20	0.08	30	1	1	50	0.37	75	0.75	0.69	0	0	0.00	30	0	0.00	0	0.00	0.00	100	40	0.09	30	90	0.14	90	0.90	0.35	1.035
SWC166	Piper	20	15	0.01	30	1	1	25	0.58	75	0.75	0.09	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.090
SWC167	Fatty	280	30	0.19	30	1	1	25	0.58	65	0.65	2.18	200	25	0.11	30	50	0.37	25	0.25	0.32	240	40	0.22	30	100	0.10	75	0.75	0.50	2.995
SWC168	Fatty	2600	25	1.49	30	1	1	10	0.77	35	0.35	12.06	2400	15	0.83	30	75	0.23	15	0.15	0.86	120	2	0.01	30	100	0.10	50	0.50	0.01	12.928
SWC169	Fatty	400	25	0.23	30	1	1	10	0.77	35	0.35	1.86	500	5	0.06	30	90	0.14	50	0.50	0.12	350	8	0.06	30	100	0.10	75	0.75	0.14	2.121
SWC170	Fatty	100	25	0.06	30	1	1	10	0.77	50	0.50	0.66	900	10	0.21	30	40	0.45	25	0.25	0.70	180	50	0.21	30	100	0.10	75	0.75	0.46	1.825
SWC171	Fatty	110	25	0.06	30	1	1	10	0.77	25	0.25	0.36	1100	10	0.25	30	40	0.45	65	0.65	2.22	120	4	0.01	30	50	0.37	50	0.50	0.06	2.642
SWC172	Fatty	650	25	0.37	30	1	1	5	0.90	75	0.75	7.55	500	6	0.07	30	50	0.37	25	0.25	0.19	200	30	0.14	30	30	0.53	75	0.75	1.64	9.388
SWC173	Fatty	950	25	0.55	30	1	1	10	0.77	25	0.25	3.15	1400	5	0.16	30	90	0.14	60	0.60	0.40	100	4	0.01	30	90	0.14	75	0.75	0.03	3.583
SWC174	Squeezer	0	0	0.00	30	1	1	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	15	15	0.01	30	75	0.21	50	0.50	0.02	0.016
SWC175	Cedar	210	20	0.10	30	1	1	0	1.00	75	0.75	2.17	110	12	0.03	30	75	0.21	75	0.75	0.14	0	0	0.00	30	0	0.00	0	0.00	0.00	2.313
SWC176	Squeezer	265	20	0.12	30	1	1	15	0.70	50	0.50	1.28	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	1.278
SWC177	Squeezer	425	20	0.20	30	1	1	15	0.70	50	0.50	2.05	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	2.049

Table F-1. Swan River Basin Road Sediment Assessment Data.

Final Map Code	Location Code	Tread Length	Tread Width	Acres of Tread	Base Erosion Rate (tons/yr)	Gravel Factor	Traffic Factor	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Tread Delivered Load (tons/yr)	Cutslope Length	Avg Cutslope Width	Acres of Cutslope	Base Erosion Rate (tons/yr)	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Cutslope Delivered Load (tons/yr)	Fillslope Length	Avg Fillslope Width	Acres of Fillslope	Base Erosion Rate (tons/yr)	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Fillslope Delivered Load (tons/yr)	Location Delivered Load (tons/yr)
SWC178	Squeezer	260	18	0.11	30	1	1	20	0.63	50	0.50	1.02	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	1.015
SWC179	Squeezer	120	15	0.04	30	1	1	20	0.63	40	0.40	0.31	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.312
SWC180	Squeezer	70	15	0.02	30	1	1	20	0.63	50	0.50	0.23	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.228
SWC181	Squeezer	95	20	0.04	30	1	1	10	0.77	20	0.20	0.20	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.202
SWC182	Squeezer	140	15	0.05	30	1	1	50	0.37	20	0.20	0.11	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.107
SWC183	Goat	260	20	0.12	30	1	1	0	1.00	50	0.50	1.79	230	25	0.13	30	5	0.90	90	0.90	3.21	260	20	0.12	30	80	0.18	50	0.50	0.32	5.321
SWC184	Goat	220	15	0.08	30	1	1	5	0.90	90	0.90	1.84	50	15	0.02	30	5	0.90	90	0.90	0.42	140	30	0.10	30	50	0.37	100	1.00	1.07	3.330
SWC185	Goat	150	15	0.05	30	1	1	25	0.58	25	0.25	0.22	0	0	0.00	30	0	0.00	0	0.00	0.00	50	10	0.01	30	95	0.12	5	0.05	0.00	0.227
SWC186	Goat	0	0	0.00	30	1	1	0	0.00	0	0.00	0.00	400	20	0.18	30	75	0.21	75	0.75	0.87	0	0	0.00	30	0	0.00	0	0.00	0.00	0.868
SWC187	Goat	0	0	0.00	30	1	1	0	0.00	0	0.00	0.00	350	20	0.16	30	75	0.21	75	0.75	0.76	0	0	0.00	30	0	0.00	0	0.00	0.00	0.759
SWC188	Goat	800	12	0.22	30	1	1	5	0.90	90	0.90	5.36	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	5.355
SWC189	Goat	475	15	0.16	30	1	1	5	0.90	75	0.75	3.31	475	10	0.11	30	75	0.21	25	0.25	0.17	60	6	0.01	30	75	0.21	75	0.75	0.04	3.523
SWC190	S. Woodward	7366	22	3.72	30	1	1	30	0.53	85	0.85	50.28	825	14	0.27	30	100	0.10	85	0.85	0.68	0	0	0.00	30	0	0.00	0	0.00	0.00	50.955
SWC191	S. Woodward	90	20	0.04	30	1	1	100	0.10	10	0.10	0.01	0	0	0.00	30	0	0.00	0	0.00	0.00	110	18	0.05	30	100	0.10	50	0.50	0.07	0.081
SWC192	S. Woodward	400	18	0.17	30	1	1	25	0.58	80	0.80	2.30	310	12	0.09	30	90	0.14	25	0.25	0.09	65	20	0.03	30	100	0.10	75	0.75	0.07	2.458
SWC193	S. Woodward	210	20	0.10	30	1	1	0	1.00	75	0.75	2.17	210	16	0.08	30	0	1.00	75	0.75	1.74	130	35	0.10	30	0	1.00	75	0.75	2.35	6.255
SWC194	S. Woodward	30	15	0.01	30	1	1	5	0.90	50	0.50	0.14	0	0	0.00	30	0	0.00	0	0.00	0.00	80	15	0.03	30	100	0.10	50	0.50	0.04	0.181
SWC195	S. Woodward	30	15	0.01	30	1	1	50	0.37	100	1.00	0.11	125	12	0.03	30	75	0.21	100	1.00	0.22	110	15	0.04	30	75	0.21	100	1.00	0.24	0.570
SWC196	S. Woodward	30	15	0.01	30	1	1	50	0.37	100	1.00	0.11	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.115
SWC197	S. Woodward	630	22	0.32	30	1	1	15	0.70	80	0.80	5.35	0	0	0.00	30	0	0.00	0	0.00	0.00	85	12	0.02	30	100	0.10	100	1.00	0.07	5.416
SWC198	S. Woodward	470	20	0.22	30	1	1	20	0.63	75	0.75	3.06	0	0	0.00	30	0	0.00	0	0.00	0.00	70	10	0.02	30	100	0.10	100	1.00	0.05	3.107
SWC199	S. Woodward	320	18	0.13	30	1	1	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	30	16	0.01	30	50	0.37	100	1.00	0.12	0.122
SWC200	S. Woodward	550	25	0.32	30	1	1	25	0.58	75	0.75	4.12	75	20	0.03	30	30	0.53	75	0.75	0.41	60	10	0.01	30	100	0.10	100	1.00	0.04	4.571
SWC201	S. Woodward	90	22	0.05	30	1	1	5	0.90	50	0.50	0.61	0	0	0.00	30	0	0.00	0	0.00	0.00	45	10	0.01	30	50	0.37	100	1.00	0.11	0.728
SWC202	(Unnamed)	730	25	0.42	30	1	1	0	1.00	100	1.00	12.57	550	18	0.23	30	40	0.45	100	1.00	3.07	70	12	0.02	30	100	0.10	100	1.00	0.06	15.695
SWC203	(Unnamed)	120	25	0.07	30	1	1	0	1.00	75	0.75	1.55	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	1.550
SWC204	S. Woodward	670	20	0.31	30	1	1	25	0.58	75	0.75	4.01	0	0	0.00	30	0	0.00	0	0.00	0.00	35	10	0.01	30	100	0.10	100	1.00	0.02	4.039
SWC205	S. Woodward	280	20	0.13	30	1	1	20	0.63	50	0.50	1.21	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	1.215
SWC206	S. Woodward	330	20	0.15	30	1	1	50	0.37	50	0.50	0.84	0	0	0.00	30	0	0.00	0	0.00	0.00	20	10	0.00	30	70	0.23	100	1.00	0.03	0.873
SWC207	Woodward	325	15	0.11	30	1	1	100	0.10	25	0.25	0.08	0	0	0.00	30	0	0.00	0	0.00	0.00	125	0	0.00	30	100	0.10	25	0.25	0.00	0.084
SWC208	Woodward	150	20	0.07	30	1	1	30	0.53	25	0.25	0.27	0	0	0.00	30	0	0.00	0	0.00	0.00	100	0	0.00	30	90	0.14	25	0.25	0.00	0.274
SWC209	Woodward	370	15	0.13	30	1	1	90	0.14	25	0.25	0.13	350	15	0.12	30	90	0.14	25	0.25	0.13	60	10	0.01	30	90	0.14	50	0.50	0.03	0.289
SWC210	Woodward	120	25	0.07	30	1	1	0	1.00	70	0.70	1.45	150	6	0.02	30	90	0.14	50	0.50	0.04	30	4	0.00	30	100	0.10	100	1.00	0.01	1.498
SWC211	Woodward	330	25	0.19	30	1	1	5	0.90	40	0.40	2.05	310	15	0.11	30	35	0.50	40	0.40	0.64	50	5	0.01	30	50	0.45	100	1.00	0.08	2.763
SWC212	(Unnamed)	725	16	0.27	30	1	1	20	0.70	75	0.75	4.19	0	0	0.00	30	0	0.00	0	0.00	0.00	80	8	0.01	30	100	0.10	100	1.00	0.04	4.238
SWC213	(Unnamed)	420	22	0.21	30	1	1	10	0.77	70	0.70	3.43	160	10	0.04	30	90	0.14	60	0.60	0.09	65	8	0.01	30	100	0.10	100	1.00	0.04	3.558
SWC214	Nape	50	20	0.02	30	1	1	20	0.63	15	0.15	0.07	0		0.00	30	0	0.00	0	0.00	0.00	50	8	0.01	30	100	0.10	90	0.90	0.02	0.090
SWC215	Soup	550	20	0.24	30	1	1	10	0.77	70	0.70	4.90	520	12	0.14	30	100	0.10	40	0.50	0.23	140	14	0.03	30	100	0.10	90	0.90	0.12	5.265
SWC216	Soup	1400	25	0.80	30	1	1	60	0.30	75	0.75	5.42	1200	80	2.20	30	50	0.37	75	0.75	18.35	120	20	0.06	30	100	0.10	75	0.75	0.12	23.895
SWC217	Soup	660	20	0.30	30	1	1	10	0.77	70	0.70	4.90	590	12	0.16	30	100	0.10	50	0.50	0.24	140	14	0.04	30	100	0.10	90	0.90	0.12	5.265
SWC218	Soup	40	12	0.01	30	1	1	70	0.23	20	0.20	0.02	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.015
SWC219	(Unnamed)	500	25	0.29	30	1	1	10	0.77	10	0.10	0.66	0	0	0.00	30	0	0.00	0	0.00	0.00	40	6	0.01	30	80	0.18	90	0.90	0.03	0.690
SWC220	Cilly	210	14	0.07	30	1	1	50	0.37	25	0.25	0.19	60	18	0.02	30	30	0.53	50	0.50	0.20	30	15	0.01	30	100	0.10	50	0.50	0.02	0.400
SWC221	Cilly	490	16	0.18	30	1	1	10	0.77	25	0.25	1.04	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	1.039
SWC222	(Unnamed)	47	15	0.02	30	1	1	20	0.63	25	0.25	0.08	0	0	0.00	30	0	0.00	0	0.00	0.00	47	80	0.09	30	90	0.14	90	0.90	0.33	0.403
SWC223	Cilly	740	14	0.24	30	1	1	50	0.37	25	0.25	0.66	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.660
SWC224	S. Lost Creek	105	15	0.04	30	1	1	75	0.21	25	0.25	0.06	60	16	0.02	30	75	0.21	25	0.25	0.03	0	0	0.00	30	0	0.00	0	0.00	0.00	0.092
SWC225	Whitetail	600	20	0.28	30	1	1	5	0.90	75	0.75	5.58	600	14	0.19	30	90	0.14	25	0.25	0.20	600	20	0.28	30	90	0.14	25	0.25	0.29	6.070
SWC226	Whitetail	800	15	0.28	30	1	1	25	0.58	75	0.75	3.60	725	14	0.23	30	90	0.14	25	0.25	0.24	550	25	0.32	30	90	0.14	30	0.30	0.40	4.237
SWC227	Whitetail	100	20	0.05	30	1	1	10	0.77	30	0.30	0.32	150	15	0.05	30	50	0.37	30	0.30	0.17	90	35	0.07	30	90	0.14	75	0.75	0.23	0.718
SWC228	Whitetail	705	20	0.32	30	1	1	0	1.00	75	0.75	7.28	700	15	0.24	30	50	0.37	25	0.25	0.67	700	15	0.24	30	90	0.14	25	0.25	0.25	8.205
SWC229	(Unnamed)	95	22	0.05	30	1	1	5	0.90	50	0.50	0.65	100	12	0.03	30	50	0.37	50	0.50	0.15	45	12	0.01	30	50	0.37	75	0.75	0.10	0.904
SWC230	Whitetail	825	15	0.28	30	1	1	5	0.90	75	0.75	5.75	750	18	0.31	30	90	0.14	25	0.25	0.33	625	18	0.26	30	90	0.14	30	0.30	0.33	6.404
SWC231	(Unnamed)	380	22	0.19	30	1	1	25	0.63	45	0.45	1.63	380	6	0.05	30	100	0.10	40	0.40	0.06	50	10	0.01	30	100	0.10	100	1.00	0.03	1.730
SWC232	Porcupine	0	0	0.00	30	1	1	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	10	6	0.00	30	90	0.14	25	0.25	0.00	0.001
SWC233	Porcupine	407	22	0.21	30	1	2	40	0.45	10	0.10	0.28	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.278
SWC234	Porcupine	247	19	0.11	30	1	1	40	0.45	15	0.15	0.22	0	0	0.00	30	0	0.00	0	0.00	0.00	60	4	0.01	30	95	0.12	15	0.15	0.00	0.221
SWC235	Gildart	198	17	0.08	30	1	1	40	0.45	25	0.25	0.26	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.261
SWC236	Gildert	570	25	0.33	30	1	1	25	0.58	65	0.65	3.70	480	10	0.11	30	90	0.14	50	0.50	0.23	130	15	0.04	30	100	0.10	100	1.00	0.13	4.066

Table F-1. Swan River Basin Road Sediment Assessment Data.

Final Map Code	Location Code	Tread Length	Tread Width	Acres of Tread	Base Erosion Rate (tons/yr)	Gravel Factor	Traffic Factor	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Tread Delivered Load (tons/yr)	Cutslope Length	Avg Cutslope Width	Acres of Cutslope	Base Erosion Rate (tons/yr)	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Cutslope Delivered Load (tons/yr)	Fillslope Length	Avg Fillslope Width	Acres of Fillslope	Base Erosion Rate (tons/yr)	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Fillslope Delivered Load (tons/yr)	Location Delivered Load (tons/yr)
SWC237	Gildert	230	20	0.11	30	1	1	70	0.23	20	0.20	0.15	200	2	0.01	30	100	0.10	25	0.25	0.01	40	2	0.00	30	100	0.10	50	0.50	0.00	0.155
SWC238	Bug	400	30	0.28	30	1	1	10	0.77	25	0.25	1.59	700	5	0.08	30	75	0.21	25	0.25	0.13	180	10	0.04	30	90	0.14	90	0.90	0.16	1.874
SWC239	Goat	10	12	0.00	30	1	1	75	0.21	5	0.05	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	15	10	0.00	30	75	0.21	5	0.05	0.00	0.002
SWC240	S. Lost Creek	200	20	0.09	30	1	1	25	0.58	25	0.25	0.40	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.399
SWC241	N. Lost Creek	430	14	0.14	30	1	1	25	0.58	25	0.25	0.60	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.601
SWC242	N. Lost Creek	310	14	0.10	30	1	1	25	0.58	25	0.25	0.43	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.433
SWC243	(Unnamed)	1200	14	0.39	30	1	1	25	0.58	50	0.50	3.36	1200	8	0.22	30	95	0.12	50	0.50	0.40	40	2	0.00	30	100	0.10	90	0.90	0.00	3.757
SWC244	Spring	110	14	0.04	30	1	1	20	0.70	40	0.40	0.30	0	0	0.00	0	0	0	0	0.00	0.00	220	5	0.03	30	100	0.10	90	0.90	0.07	0.365
SWC245	Stopher	390	22	0.20	30	1	1	50	0.37	5	0.05	0.05	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.055
SWC246	(Unnamed)	600	14	0.19	30	1	1	15	0.70	40	0.40	1.62	550	10	0.13	30	90	0.14	75	0.75	0.40	20	2	0.00	30	90	0.14	95	0.95	0.00	2.021
SWC247	Lime	110	22	0.06	30	1	1	50	0.37	5	0.05	0.02	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.015
SWC248	Little Yew	115	19	0.05	30	1	1	40	0.45	25	0.25	0.08	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.085
SWC249	Yew	137	17	0.05	30	1	1	40	0.45	10	0.10	0.04	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.036
SWC250	Hall	950	25	0.55	30	1	1	10	0.77	40	0.40	5.04	670	18	0.28	30	85	0.16	50	0.50	0.66	115	6	0.02	30	100	0.10	90	0.90	0.04	5.745
SWC251	Hall	1350	25	0.77	30	1	1	15	0.70	85	0.85	13.83	1140	15	0.39	30	70	0.23	50	0.50	1.35	120	4	0.01	30	100	0.10	90	0.90	0.03	15.214
SWC252	Hall	590	20	0.27	30	1	1	15	0.70	70	0.70	3.98	630	15	0.22	30	90	0.14	50	0.50	0.46	55	6	0.01	30	100	0.10	85	0.85	0.02	4.457
SWC253	Yew	690	30	0.48	30	1	1	25	0.63	75	0.75	6.74	630	8	0.12	30	100	0.10	35	0.35	0.12	55	6	0.01	30	100	0.10	90	0.90	0.02	6.878
SWC254	Yew	230	25	0.13	30	1	1	10	0.77	60	0.60	1.83	230	10	0.05	30	50	0.37	50	0.50	0.29	160	5	0.02	30	100	0.10	85	0.85	0.05	2.169
SWC255	Kraft	0	0	0.00	30	1	1	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	14	4	0.00	30	90	0.14	10	0.10	0.00	0.001
SWC256	Kraft	100	15	0.03	30	1	1	75	0.21	10	0.10	0.02	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.022
SWC257	Cold	440	17	0.17	30	1	1	25	0.58	25	0.25	0.75	319	4	0.03	30	80	0.18	20	0.20	0.03	66	6	0.01	30	100	0.10	5	0.05	0.00	0.780
SWC258	Cold	506	22	0.26	30	1	1	25	1.00	30	0.30	1.33	132	5	0.02	30	85	0.00	10	0.10	0.01	28	6	0.00	30	95	0.00	5	0.05	0.00	1.342
SWC259	Falls	99	21	0.05	30	1	1	25	0.58	5	0.05	0.04	270	5	0.03	30	95	0.12	5	0.05	0.01	22	3	0.00	30	95	0.12	5	0.05	0.00	0.047
SWC260	Glacier	55	19	0.02	30	1	2	10	0.77	50	0.50	0.55	0	0	0.00	30	0	0.00	0	0.00	0.00	165	4	0.02	30	95	0.12	10	0.10	0.01	0.560
SWC261	Beaver	0	0	0.00	30	1	1	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	40	4	0.00	30	75	0.21	75	0.75	0.02	0.017
SWC262	Beaver	797	17	0.31	30	1	1	50	0.37	5	0.05	0.17	797	5	0.09	30	75	0.21	15	0.15	0.09	0	0	0.00	30	0	0.00	0	0.00	0.00	0.259
SWC263	Beaver	115	17	0.04	30	1	1	50	0.37	5	0.05	0.02	115	9	0.02	30	30	0.53	5	0.05	0.02	0	0	0.00	30	0	0.00	0	0.00	0.00	0.044
SWC264	Beaver	60	16	0.02	30	1	1	60	0.30	5	0.05	0.01	330	9	0.07	30	90	0.14	5	0.05	0.01	33	6	0.00	30	90	0.14	5	0.05	0.00	0.025
SWC265	Beaver	0	0	0.00	30	1	1	0	0.00	0	0.00	0.00	412	6	0.06	30	90	0.14	10	0.10	0.02	0	0	0.00	30	0	0.00	0	0.00	0.00	0.024
SWC266	Beaver	0	0	0.00	30	1	1	0	0.00	0	0.00	0.00	275	5	0.03	30	100	0.10	20	0.20	0.02	0	0	0.00	30	0	0.00	0	0.00	0.00	0.019
SWC267	Beaver	940	17	0.37	30	1	2	25	0.58	5	0.05	0.64	940	6	0.13	30	90	0.14	5	0.05	0.03	0	0	0.00	30	0	0.00	0	0.00	0.00	0.666
SWC268	Beaver	0	0	0.00	30	1	1	0	0.00	0	0.00	0.00	20	25	0.01	30	20	0.63	25	0.25	0.05	50	25	0.03	30	90	0.14	10	0.10	0.01	0.066
SWC269	Beaver	346	17	0.14	30	1	1	85	0.16	10	0.10	0.06	0	0	0.00	30	0	0.00	0	0.00	0.00	30	5	0.00	30	85	0.16	10	0.10	0.00	0.066
SWC270	Gildart	660	22	0.33	30	1	2	30	0.53	50	0.50	2.65	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	2.650
SWC271	Gildart	291	20	0.13	30	1	2	25	0.58	40	0.40	0.93	0	0	0.00	30	0	0.00	0	0.00	0.00	27	5	0.00	30	80	0.18	50	0.50	0.01	0.938
SWC272	Gildart	115	20	0.05	30	1	2	25	0.58	30	0.30	0.28	0	0	0.00	30	0	0.00	0	0.00	0.00	11	3	0.00	30	90	0.14	25	0.25	0.00	0.276
SWC273	Gildart	115	20	0.05	30	1	2	25	0.58	50	0.50	0.46	22	6	0.00	30	85	0.16	30	0.30	0.00	15	5	0.00	30	90	0.14	25	0.25	0.00	0.466
SWC274	Gildart	346	22	0.17	30	1	2	30	0.53	25	0.25	0.69	187	6	0.03	30	100	0.10	25	0.25	0.02	0	0	0.00	30	0	0.00	0	0.00	0.00	0.714
SWC275	Porcupine	572	16	0.21	30	1	1	40	0.45	20	0.20	0.57	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.567
SWC276	S. Lost Creek	225	14	0.07	30	1	1	10	0.77	90	0.90	1.50	0	0	0.00	30	0	0.00	0	0.00	0.00	20	10	0.00	30	5	0.90	100	1.00	0.12	1.627
SWC277	S. Lost Creek	195	18	0.08	30	1	1	5	0.90	60	0.60	1.31	0	0	0.00	30	0	0.00	0	0.00	0.00	70	12	0.02	30	90	0.14	90	0.90	0.07	1.378
SWC278	S. Lost Creek	270	20	0.12	30	1	1	5	0.90	50	0.50	1.67	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	1.674
SWC279	S. Lost Creek	3138	15	1.08	30	1	1	5	0.90	50	0.50	14.59	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	14.588
SWC280	Cilly	0	15	0.00	30	1	1	40	0.45	25	0.25	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.000
SWC281	S. Woodward	45	20	0.02	30	1	1	75	0.21	25	0.25	0.03	0	0	0.00	30	0	0.00	0	0.00	0.00	60	10	0.01	30	75	0.21	75	0.75	0.07	0.098
SWC282	Whitetail	90	15	0.03	30	1	1	20	0.63	50	0.50	0.29	50	10	0.01	30	90	0.14	40	0.40	0.02	50	15	0.02	30	90	0.14	50	0.50	0.04	0.348
SWC283	Whitetail	325	20	0.15	30	1	1	10	0.77	25	0.25	0.86	275	12	0.08	30	75	0.21	25	0.25	0.12	80	30	0.06	30	90	0.14	50	0.50	0.12	1.097
SWC284	Holland	40	15	0.01	30	1	1	30	0.53	30	0.30	0.07	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.066
SWC285	Holland	350	20	0.16	30	1	1	40	0.45	30	0.30	0.33	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.325
SWC286	Beaver	121	25	0.07	30	1	1	30	0.53	5	0.05	0.06	93	3	0.01	30	60	0.30	10	0.10	0.01	0	0	0.00	30	0	0.00	0	0.00	0.00	0.061
SWC287	Beaver	165	19	0.07	30	1	2	30	0.53	5	0.05	0.11	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.114
SWC288	Stopher	215	25	0.12	30	1	1	40	0.45	10	0.10	0.08	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.083
SWC289	Swan	495	25	0.28	30	1	1	50	0.37	10	0.10	0.16	495	2	0.02	30	100	0.10	25	0.25	0.02	22	3	0.00	30	70	0.23	50	0.50	0.01	0.180
SWC290	Swan	132	21	0.06	30	1	1	40	0.45	10	0.10	0.04	104	2	0.00	30	100	0.10	25	0.25	0.00	30	5	0.00	30	95	0.12	5	0.05	0.00	0.047
SWC291	Swan	429	19	0.19	30	1	1	40	0.45	10	0.10	0.13	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.126
SWC292	Swan	0	0	0.00	30	1	1	0	0.00	0	0.00	0.00	55	5	0.01	30	100	0.10	20	0.20	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.004
SWC293	Swan	192	21	0.09	30	1	1	40	0.45	10	0.10	0.06	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.062
SWC294	Bug	291	17	0.11	30	1	1	30	0.53	5	0.05	0.05	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.045
SWC295	Goat	0	0	0.00	30	1	1	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	75	20	0.03	30	65	0.26	50	0.50	0.13	0.134

Table F-1. Swan River Basin Road Sediment Assessment Data.

Final Map Code	Location Code	Tread Length	Tread Width	Acres of Tread	Base Erosion Rate (tons/yr)	Gravel Factor	Traffic Factor	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Tread Delivered Load (tons/yr)	Cutslope Length	Avg Cutslope Width	Acres of Cutslope	Base Erosion Rate (tons/yr)	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Cutslope Delivered Load (tons/yr)	Fillslope Length	Avg Fillslope Width	Acres of Fillslope	Base Erosion Rate (tons/yr)	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Fillslope Delivered Load (tons/yr)	Location Delivered Load (tons/yr)
SWC296	Goat	200	15	0.07	30	1	1	0	1.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	250	35	0.20	30	75	0.21	75	0.75	0.95	0.949
SWC297	N. Lost Creek	210	15	0.07	30	1	1	25	0.58	50	0.50	0.63	210	20	0.10	30	100	0.10	50	0.50	0.14	30	80	0.06	30	100	0.10	50	0.50	0.08	0.856
SWC298	N. Lost Creek	140	14	0.04	30	1	1	20	0.63	25	0.25	0.21	0	0	0.00	30	0	0.00	0	0.00	0.00	20	90	0.04	30	90	0.14	90	0.90	0.16	0.369
SWC299	Squeezer	225	15	0.08	30	1	1	70	0.23	45	0.45	0.24	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.241
SWC300	Goat	450	15	0.15	30	1	1	5	0.90	90	0.90	3.77	450	20	0.21	30	25	0.58	90	0.90	3.24	130	40	0.12	30	25	0.58	100	1.00	2.08	9.078
SWC301	N. Lost Creek	900	15	0.31	30	1	1	25	0.58	20	0.20	1.08	0	0	0.00	30	0	0.00	0	0.00	0.00	900	20	0.41	30	100	0.10	50	0.50	0.62	1.698
SWC302	(Unnamed)	230	16	0.08	30	1	1	25	0.63	75	0.75	1.20	0	0	0.00	30	0	0	0	0.00	0.00	120	12	0.03	30	100	0.10	100	1.00	0.10	1.297
SWC303	(Unnamed)	115	16	0.04	30	1	1	10	0.77	50	0.50	0.49	0	0	0.00	30	0	0	0	0.00	0.00	75	12	0.02	30	100	0.10	100	1.00	0.06	0.550
SWC304	(Unnamed)	850	25	0.49	30	1	1	10	0.77	50	0.50	5.63	850	10	0.20	30	75	0.21	30	0.30	0.37	80	12	0.02	30	95	0.12	75	0.75	0.06	6.063
SWC305	(Unnamed)	630	20	0.29	30	1	1	10	0.77	75	0.75	5.01	610	10	0.14	30	95	0.12	50	0.50	0.25	60	4	0.01	30	95	0.12	95	0.95	0.02	5.282
SWC306	(Unnamed)	415	20	0.19	30	1	1	10	0.77	75	0.75	3.30	405	10	0.09	30	95	0.12	50	0.50	0.17	45	5	0.01	30	100	0.10	100	1.00	0.02	3.484
SWC307	(Unnamed)	270	20	0.12	30	1	1	10	0.77	60	0.60	1.72	165	14	0.05	30	75	0.21	60	0.60	0.20	105	10	0.02	30	100	0.10	100	0.10	0.07	1.991
SWC308	(Unnamed)	400	15	0.14	30	1	1	30	0.53	25	0.25	0.55	250	5	0.03	30	40	0.45	25	0.25	0.10	100	8	0.02	30	90	0.14	75	0.75	0.06	0.702
SWC309	(Unnamed)	50	30	0.03	30	1	1	25	0.58	25	0.25	0.15	75	20	0.03	30	10	0.77	35	0.35	0.28	35	4	0.00	30	90	0.14	50	0.50	0.01	0.435
SWC310	(Unnamed)	300	25	0.17	30	1	1	25	0.58	25	0.25	0.75	50	3	0.00	30	75	0.21	25	0.25	0.01	30	2	0.00	30	90	0.14	50	0.50	0.00	0.757
SWC311	(Unnamed)	410	15	0.14	30	1	1	75	0.21	50	0.50	0.44	225	12	0.06	30	75	0.21	50	0.50	0.20	0	0	0.00	30	0	0.00	0	0.00	0.00	0.640
SWC312	(Unnamed)	90	25	0.05	30	1	1	20	0.70	25	0.25	0.27	110	8	0.02	30	100	0.10	20	0.20	0.01	70	8	0.01	30	100	0.10	100	1.00	0.04	0.322
SWC313	Cilly	130	15	0.04	30	1	1	90	0.14	25	0.25	0.05	0	0	0.00	30	0	0.00	0	0.00	0.00	70	10	0.02	30	90	0.14	50	0.50	0.02	0.081
SWC314	(Unnamed)	225	0	0.00	30	1	1	25	0.58	50	0.50	0.00	200	15	0.07	30	75	0.21	50	0.50	0.22	200	15	0.07	30	75	0.21	50	0.50	0.22	0.434
SWC315	(Unnamed)	85	15	0.03	30	1	1	25	0.58	25	0.25	0.13	0	0	0.00	30	0	0.00	0	0.00	0.00	0	0	0.00	30	0	0.00	0	0.00	0.00	0.127
SWC316	(Unnamed)	230	25	0.13	30	1	1	5	0.90	35	0.35	1.25	400	40	0.37	30	70	0.23	50	0.50	1.27	300	40	0.28	30	100	0.10	75	0.75	0.62	3.134
SWC317	(Unnamed)	300	25	0.17	30	1	1	10	0.77	50	0.50	1.99	150	15	0.05	30	25	0.58	25	0.25	0.22	60	2	0.00	30	95	0.12	50	0.50	0.00	2.218
SWC318	(Unnamed)	50	25	0.029	30	1	1	0	1.00	90	0.90	0.77	230	6	0.03	30	75	0.21	75	0.75	0.15	30	2	0.00	30	50	0.37	90	0.90	0.01	0.938

Table F-2. Ranking of Road Crossing Sites.

Rank	Map Code	Tons/year
1	SWC190	50.955
2	SWC125	37.197
3	SWC20	31.847
4	SWC21	28.373
5	SWC216	23.895
6	SWC19	22.404
7	SWC159	21.226
8	SWC202	15.695
9	SWC78	15.501
10	SWC251	15.214
11	SWC279	14.588
12	SWC136	14.175
13	SWC72	14.100
14	SWC64	13.162
15	SWC168	12.928
16	SWC132	12.172
17	SWC85	11.438
18	SWC142	10.486
19	SWC145	9.670
20	SWC33	9.461
21	SWC172	9.388
22	SWC300	9.078
23	SWC75	9.008
24	SWC153	8.562
25	SWC228	8.205
26	SWC59	8.049
27	SWC30	7.943
28	SWC71	7.283
29	SWC253	6.878
30	SWC79	6.588
31	SWC230	6.404
32	SWC69	6.394
33	SWC193	6.255
34	SWC152	6.162
35	SWC225	6.070
36	SWC304	6.063
37	SWC139	6.043
38	SWC14	6.017
39	SWC104	6.000
40	SWC80	5.785
41	SWC56	5.769
42	SWC29	5.748
43	SWC250	5.745
44	SWC197	5.416
45	SWC188	5.355
46	SWC183	5.321
47	SWC305	5.282
48	SWC217	5.265

Table F-2. Ranking of Road Crossing Sites.

Rank	Map Code	Tons/year
49	SWC215	5.265
50	SWC82	5.241
51	SWC200	4.571
52	SWC100	4.515
53	SWC252	4.457
54	SWC212	4.238
55	SWC226	4.237
56	SWC236	4.066
57	SWC204	4.039
58	SWC160	3.902
59	SWC16	3.890
60	SWC243	3.757
61	SWC66	3.659
62	SWC134	3.597
63	SWC173	3.583
64	SWC213	3.558
65	SWC189	3.523
66	SWC306	3.484
67	SWC184	3.330
68	SWC77	3.218
69	SWC39	3.135
70	SWC316	3.134
71	SWC198	3.107
72	SWC81	3.106
73	SWC167	2.995
74	SWC211	2.763
75	SWC76	2.670
76	SWC270	2.650
77	SWC171	2.642
78	SWC192	2.458
79	SWC17	2.342
80	SWC175	2.313
81	SWC110	2.271
82	SWC317	2.218
83	SWC254	2.169
84	SWC169	2.121
85	SWC177	2.049
86	SWC62	2.040
87	SWC246	2.021
88	SWC163	1.999
89	SWC307	1.991
90	SWC238	1.874
91	SWC170	1.825
92	SWC158	1.766
93	SWC231	1.730
94	SWC301	1.698
95	SWC278	1.674
96	SWC276	1.627
97	SWC203	1.550

Table F-2. Ranking of Road Crossing Sites.

Rank	Map Code	Tons/year
98	SWC133	1.503
99	SWC210	1.498
100	SWC41	1.489
101	SWC58	1.403
102	SWC277	1.378
103	SWC258	1.342
104	SWC50	1.317
105	SWC302	1.297
106	SWC176	1.278
107	SWC205	1.215
108	SWC34	1.177
109	SWC61	1.148
110	SWC283	1.097
111	SWC162	1.096
112	SWC221	1.039
113	SWC165	1.035
114	SWC96	1.035
115	SWC178	1.015
116	SWC161	1.007
117	SWC5	1.005
118	SWC15	1.003
119	SWC115	0.951
120	SWC296	0.949
121	SWC271	0.938
122	SWC318	0.938
123	SWC229	0.904
124	SWC107	0.897
125	SWC143	0.882
126	SWC126	0.873
127	SWC206	0.873
128	SWC186	0.868
129	SWC3	0.858
130	SWC297	0.856
131	SWC99	0.817
132	SWC112	0.783
133	SWC257	0.780
134	SWC130	0.778
135	SWC187	0.759
136	SWC310	0.757
137	SWC36	0.732
138	SWC201	0.728
139	SWC227	0.718
140	SWC274	0.714
141	SWC140	0.706
142	SWC308	0.702
143	SWC219	0.690
144	SWC267	0.666
145	SWC223	0.660
146	SWC311	0.640

Table F-2. Ranking of Road Crossing Sites.

Rank	Map Code	Tons/year
147	SWC73	0.621
148	SWC241	0.601
149	SWC97	0.600
150	SWC102	0.599
151	SWC195	0.570
152	SWC275	0.567
153	SWC74	0.564
154	SWC260	0.560
155	SWC303	0.550
156	SWC83	0.525
157	SWC113	0.521
158	SWC116	0.502
159	SWC48	0.485
160	SWC120	0.481
161	SWC273	0.466
162	SWC18	0.460
163	SWC68	0.455
164	SWC22	0.448
165	SWC119	0.438
166	SWC309	0.435
167	SWC314	0.434
168	SWC242	0.433
169	SWC222	0.403
170	SWC63	0.402
171	SWC49	0.402
172	SWC122	0.402
173	SWC220	0.400
174	SWC240	0.399
175	SWC105	0.392
176	SWC154	0.392
177	SWC128	0.384
178	SWC67	0.378
179	SWC298	0.369
180	SWC93	0.368
181	SWC244	0.365
182	SWC282	0.348
183	SWC4	0.348
184	SWC114	0.341
185	SWC151	0.340
186	SWC25	0.340
187	SWC137	0.325
188	SWC285	0.325
189	SWC135	0.325
190	SWC312	0.322
191	SWC57	0.319
192	SWC86	0.319
193	SWC94	0.318
194	SWC40	0.314
195	SWC179	0.312

Table F-2. Ranking of Road Crossing Sites.

Rank	Map Code	Tons/year
196	SWC55	0.308
197	SWC123	0.307
198	SWC35	0.299
199	SWC117	0.298
200	SWC95	0.294
201	SWC209	0.289
202	SWC98	0.288
203	SWC23	0.286
204	SWC233	0.278
205	SWC272	0.276
206	SWC141	0.274
207	SWC208	0.274
208	SWC235	0.261
209	SWC262	0.259
210	SWC46	0.256
211	SWC106	0.256
212	SWC54	0.254
213	SWC124	0.245
214	SWC299	0.241
215	SWC84	0.234
216	SWC38	0.231
217	SWC180	0.228
218	SWC185	0.227
219	SWC234	0.221
220	SWC37	0.217
221	SWC181	0.202
222	SWC90	0.194
223	SWC91	0.193
224	SWC157	0.183
225	SWC194	0.181
226	SWC156	0.180
227	SWC289	0.180
228	SWC43	0.176
229	SWC65	0.164
230	SWC60	0.162
231	SWC27	0.158
232	SWC121	0.157
233	SWC237	0.155
234	SWC164	0.141
235	SWC147	0.140
236	SWC108	0.139
237	SWC295	0.134
238	SWC315	0.127
239	SWC291	0.126
240	SWC199	0.122
241	SWC9	0.118
242	SWC144	0.116
243	SWC196	0.115
244	SWC287	0.114

Table F-2. Ranking of Road Crossing Sites.

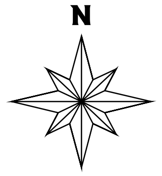
Rank	Map Code	Tons/year
245	SWC101	0.112
246	SWC28	0.109
247	SWC182	0.107
248	SWC103	0.105
249	SWC118	0.103
250	SWC146	0.099
251	SWC281	0.098
252	SWC150	0.097
253	SWC109	0.097
254	SWC32	0.095
255	SWC224	0.092
256	SWC214	0.090
257	SWC166	0.090
258	SWC248	0.085
259	SWC207	0.084
260	SWC288	0.083
261	SWC313	0.081
262	SWC191	0.081
263	SWC12	0.079
264	SWC148	0.077
265	SWC42	0.077
266	SWC88	0.073
267	SWC269	0.066
268	SWC268	0.066
269	SWC284	0.066
270	SWC24	0.066
271	SWC45	0.064
272	SWC10	0.063
273	SWC129	0.063
274	SWC293	0.062
275	SWC286	0.061
276	SWC245	0.055
277	SWC149	0.054
278	SWC155	0.048
279	SWC259	0.047
280	SWC290	0.047
281	SWC53	0.047
282	SWC294	0.045
283	SWC263	0.044
284	SWC6	0.040
285	SWC249	0.036
286	SWC52	0.034
287	SWC70	0.034
288	SWC31	0.028
289	SWC26	0.026
290	SWC264	0.025
291	SWC265	0.024
292	SWC256	0.022
293	SWC1	0.019

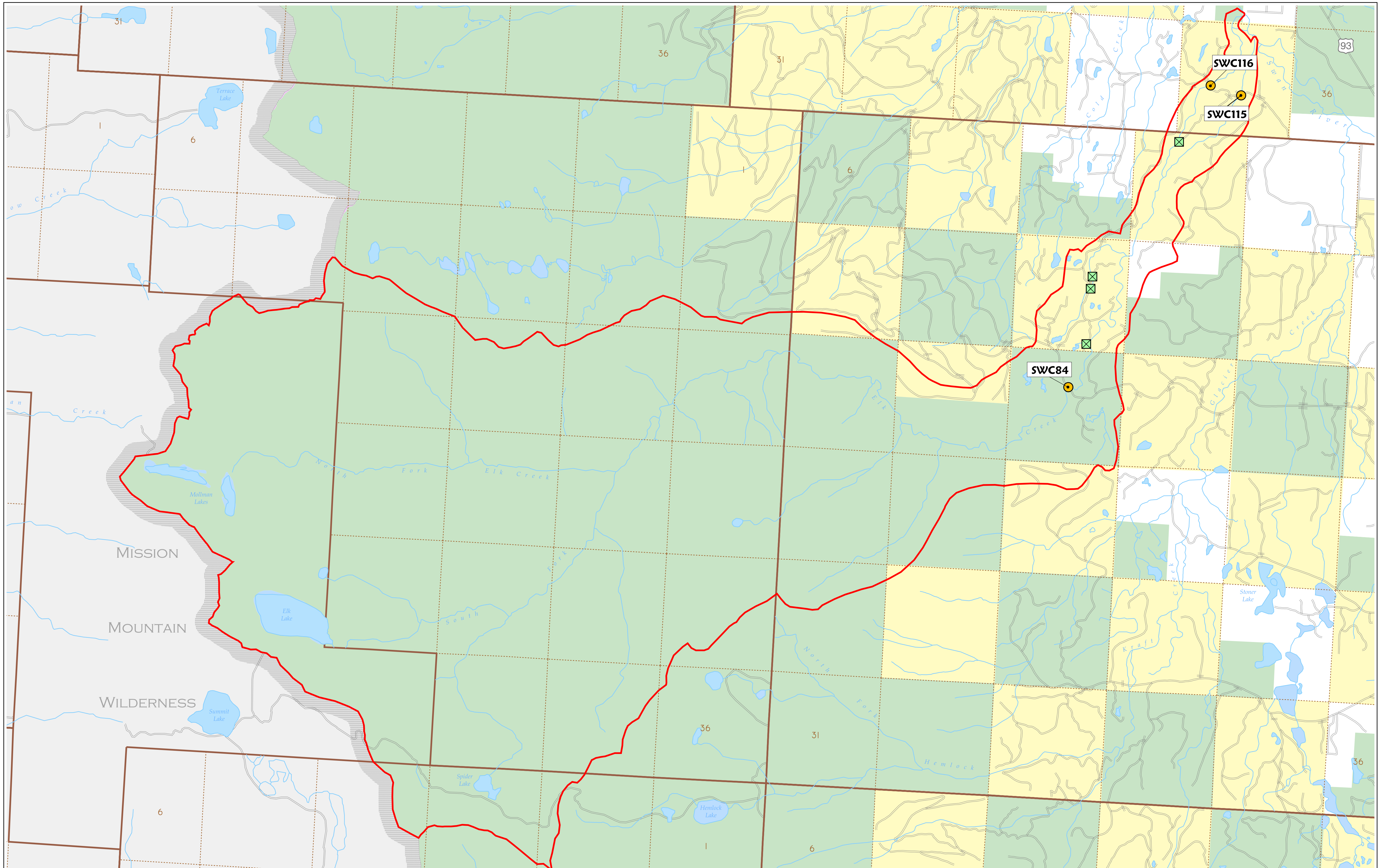
Table F-2. Ranking of Road Crossing Sites.

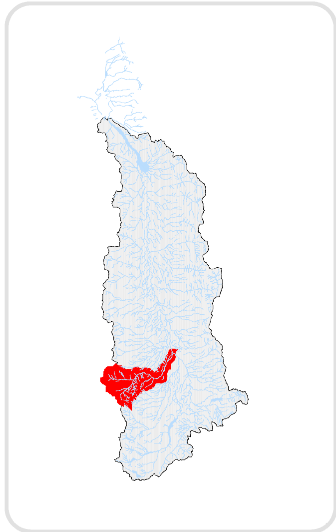
Rank	Map Code	Tons/year
294	SWC266	0.019
295	SWC89	0.018
296	SWC2	0.018
297	SWC131	0.018
298	SWC261	0.017
299	SWC174	0.016
300	SWC247	0.015
301	SWC218	0.015
302	SWC44	0.014
303	SWC138	0.012
304	SWC92	0.011
305	SWC7	0.007
306	SWC51	0.007
307	SWC13	0.006
308	SWC127	0.006
309	SWC111	0.005
310	SWC292	0.004
311	SWC8	0.002
312	SWC239	0.002
313	SWC11	0.002
314	SWC232	0.001
315	SWC255	0.001
316	SWC280	0.000
317	SWC47	0.000
318	SWC87	0.000
319		

Road Sediment Inventory

Elk Creek







Stream Crossings

- Not Contributing
- Contributing

Watershed Boundary
This boundary was delineated by L&W and may not match HUC boundaries used by Flathead National Forest.

- Streams
- Township and Range
- PLSS Lines
- Roads

Land Ownership

- Wilderness
- Flathead Tribal lands
- Montana Fish, Wildlife, and Parks
- Montana State Trust Lands -DNRC
- Plum Creek Timber lands
- The Nature Conservancy
- U.S. Fish and Wildlife Service
- U.S. Forest Service
- Undifferentiated Bureau of Indian Affairs trust
- Undifferentiated Private lands
- Water

0.5 0 0.5 1 Miles

1 0 1 Kilometers

LAND & WATER CONSULTING, INC.
1120 Cedar
PO Box 8254
Missoula, MT 59807

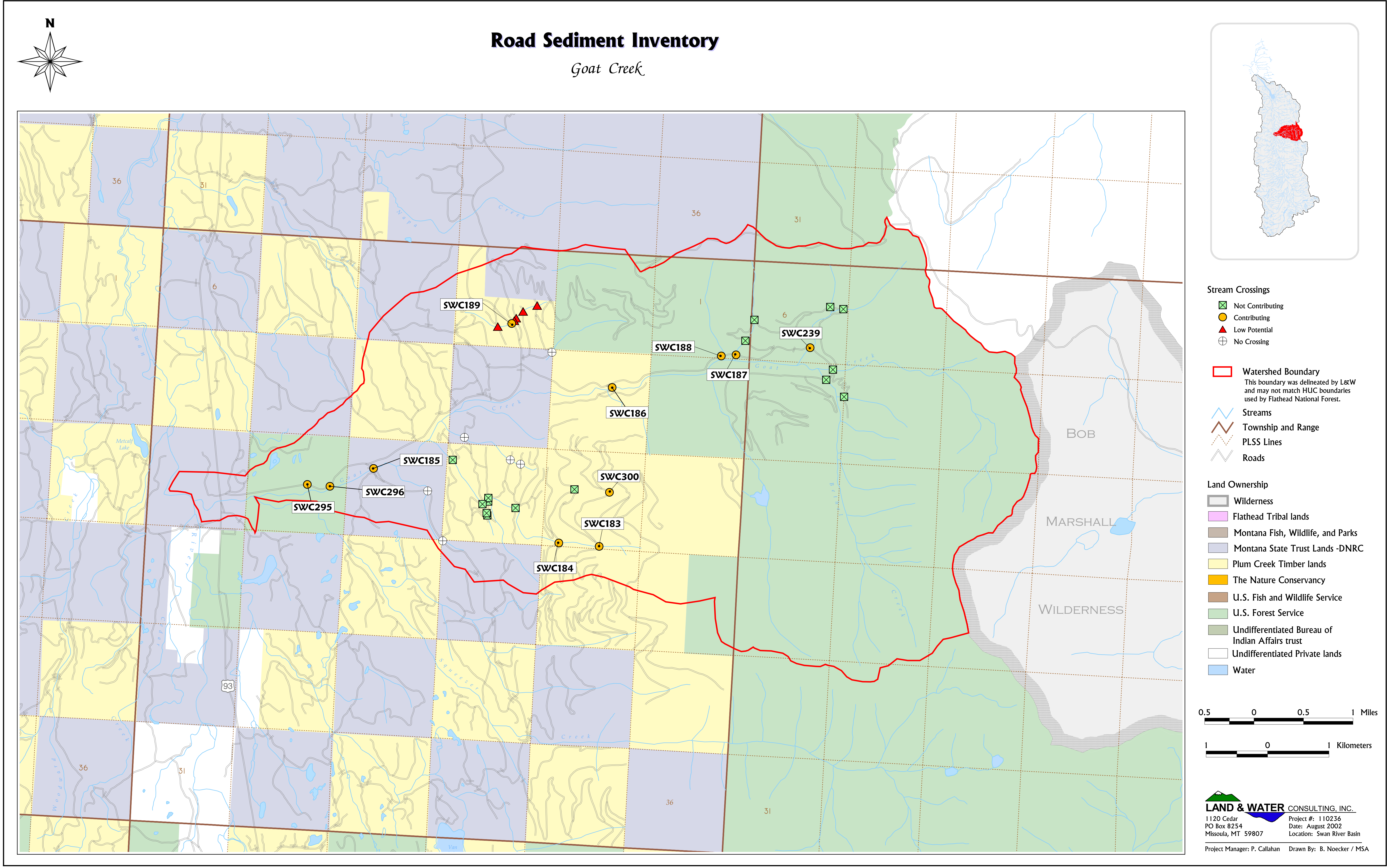
Project #: 110236
Date: August 2002
Location: Swan River Basin

Project Manager: P. Callahan Drawn By: B. Noecker / MSA

Note: Data is provisional. Maps are subject to revision.

Road Sediment Inventory

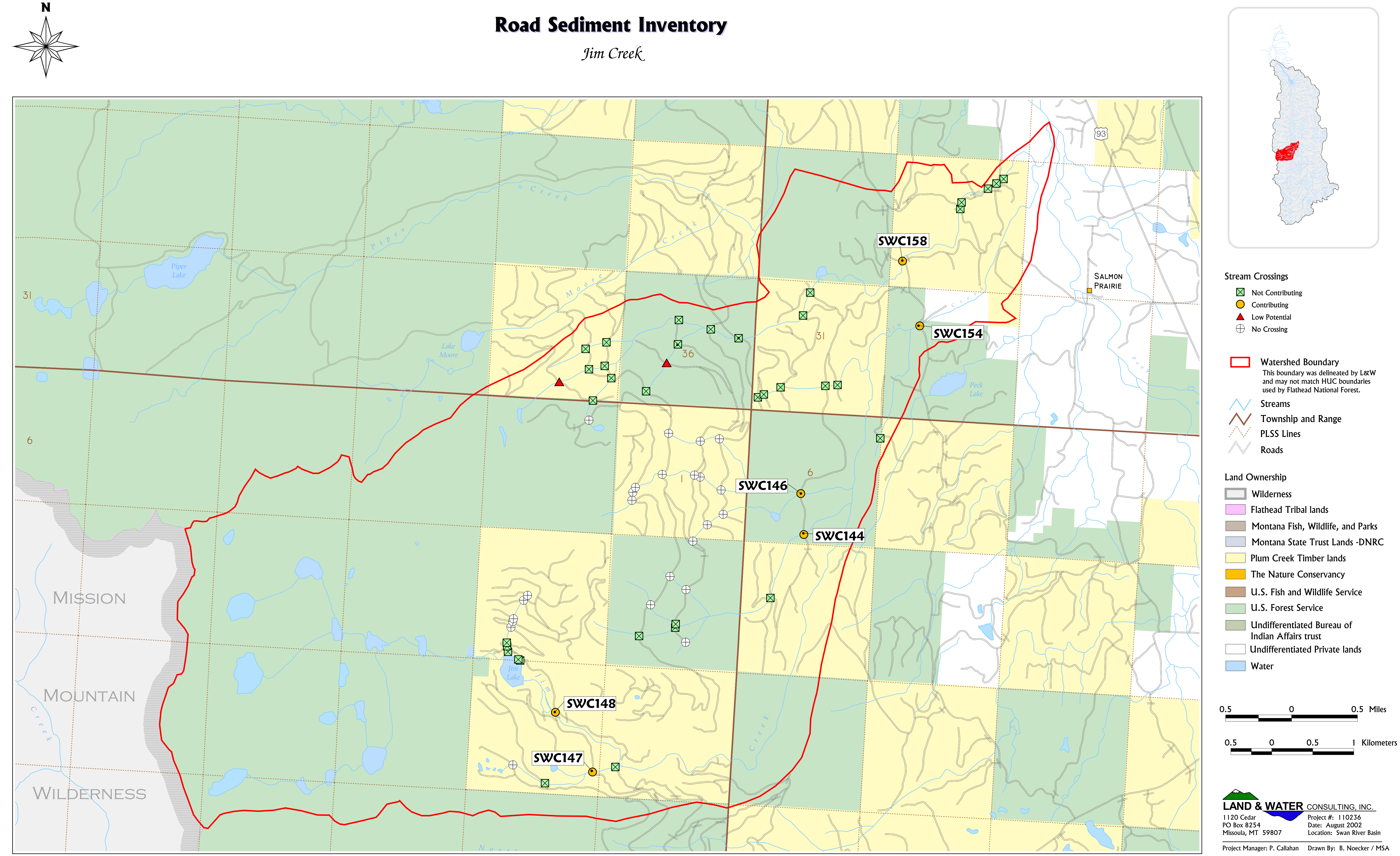
Goat Creek



Note: Data is provisional. Maps are subject to revision.

Road Sediment Inventory

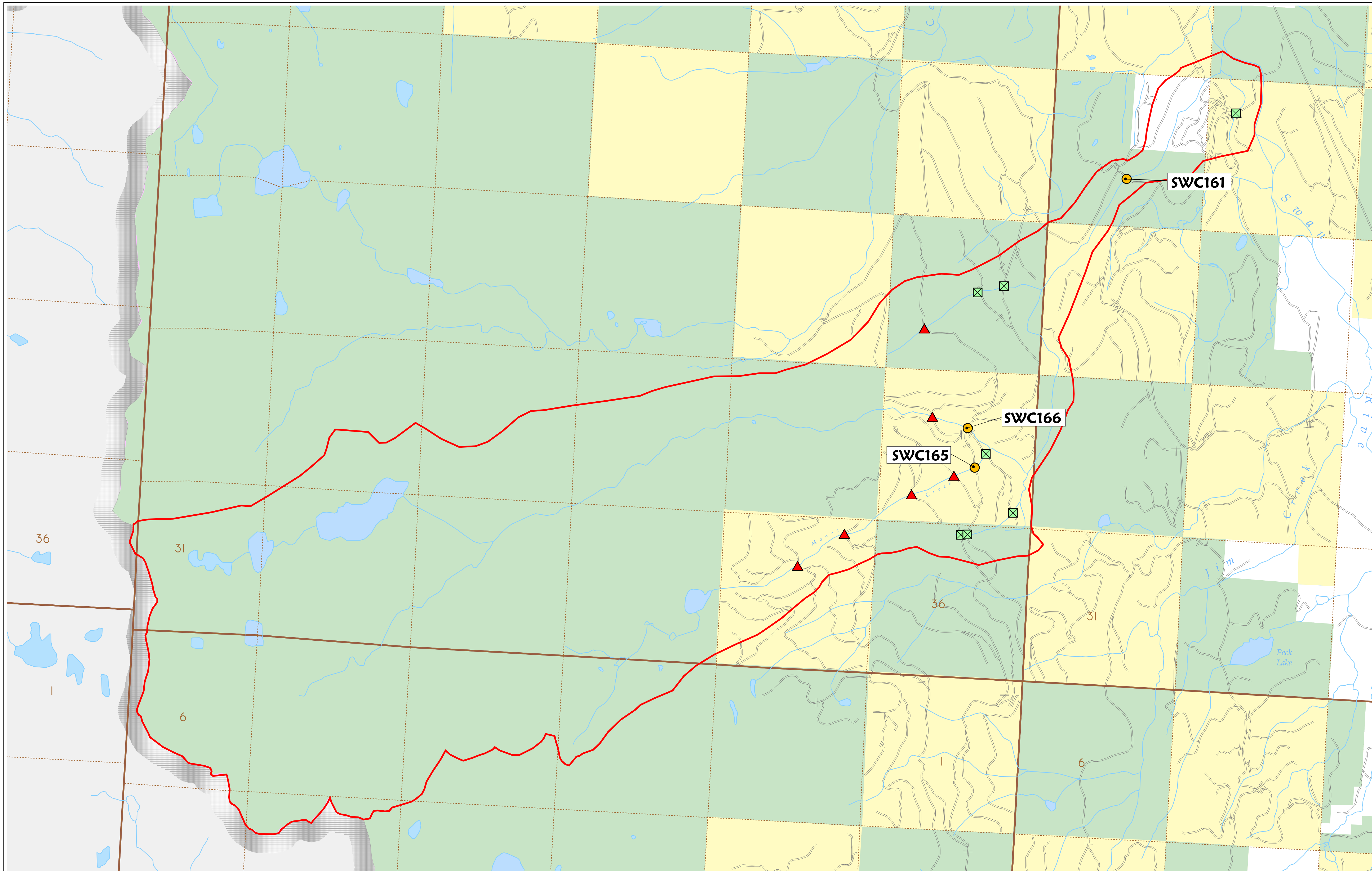
Jim Creek

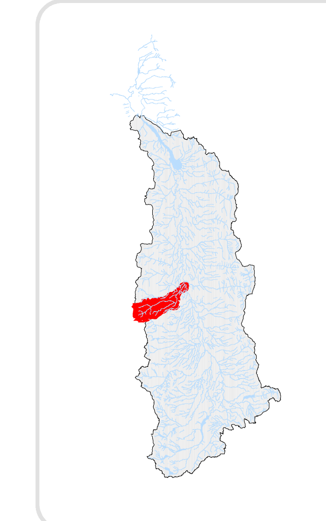


Note: Data is provisional. Maps are subject to revision.

Road Sediment Inventory

Piper Creek





Stream Crossings

- Not Contributing
- Contributing
- Low Potential

Watershed Boundary
This boundary was delineated by L&W and may not match HUC boundaries used by Flathead National Forest.

Streams

Township and Range

PLSS Lines

Roads

Land Ownership

- Wilderness
- Flathead Tribal lands
- Montana Fish, Wildlife, and Parks
- Montana State Trust Lands -DNRC
- Plum Creek Timber lands
- The Nature Conservancy
- U.S. Fish and Wildlife Service
- U.S. Forest Service
- Undifferentiated Bureau of Indian Affairs trust
- Undifferentiated Private lands
- Water

0.5 0 0.5 1 Miles

0.5 0 0.5 1 1.5 Kilometers

LAND & WATER CONSULTING, INC.
1120 Cedar
PO Box 8254
Missoula, MT 59807

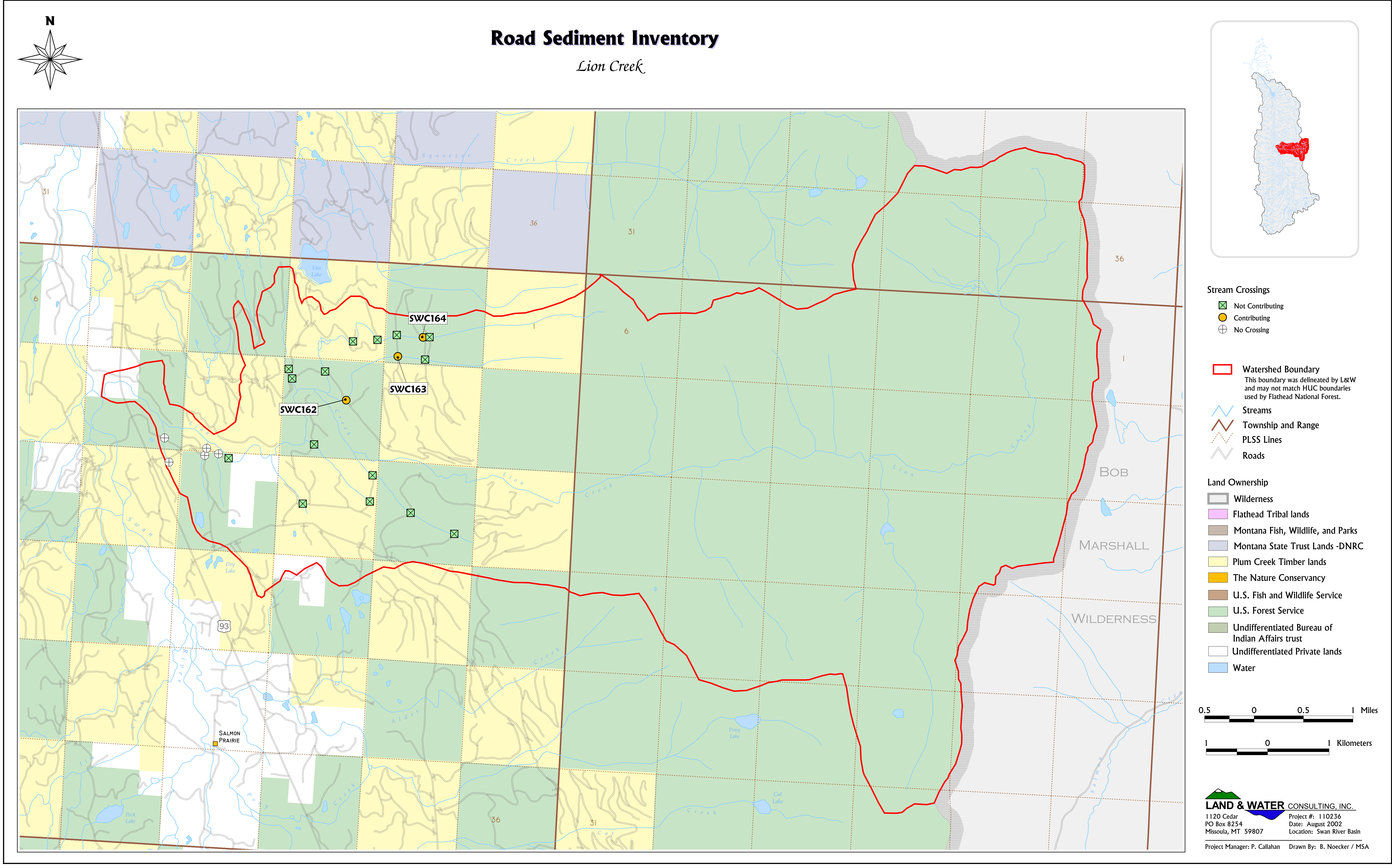
Project #: 110236
Date: August 2002
Location: Swan River Basin

Project Manager: P. Callahan
Drawn By: B. Noecker / MSA

Note: Data is provisional. Maps are subject to revision.

Road Sediment Inventory

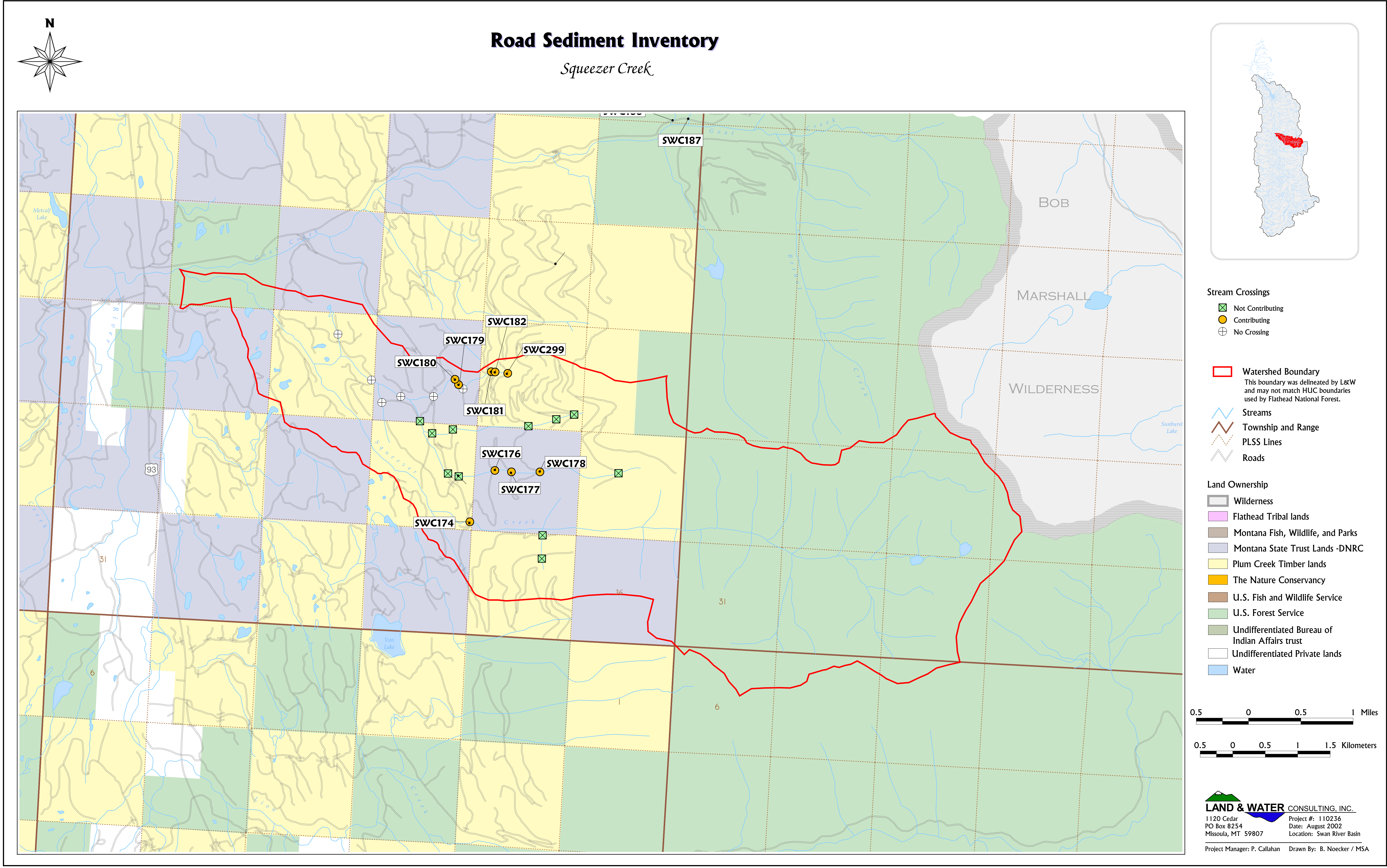
Lion Creek



Note: Data is provisional. Maps are subject to revision.

Road Sediment Inventory

Squeezer Creek



NOTE: DATA IS PROVISIONAL. MAPS ARE SUBJECT TO REVISION.


Road Sediment Inventory
Northeast Swan Lake Watershed
N
Stream Crossings & Road Segments
Contributing
No Crossing
Low Potential / Not Inventoried
Private
Non-contributing
HUC Boundaries
These boundaries were provided by Flathead National Forest.
Swan Lake Watershed
Streams
Township and Range
PLSS Lines
Roads
Land Ownership
Wilderness
Flathead Tribal lands
Montana Fish, Wildlife, and Parks
Montana State Trust Lands -DNRC
Plum Creek Timber lands
The Nature Conservancy
U.S. Fish and Wildlife Service
U.S. Forest Service
Undifferentiated Bureau of Indian Affairs trust
Undifferentiated Private lands
Water
1 0 1 2 Miles
2 0 2 Kilometers
Scale = 1:55000
LAND & WATER CONSULTING, INC.
1120 Cedar
PO Box 8254
Missoula, MT 59807
Project #: 110236
Date: November 2002
Location: Swan River Basin
Project Manager: P. Callahan
Drawn By: B. Noecker / MSA
170102110401
170102110306
170102110307
170102110305
170102110303
170102110302
170102110207
170102110206
170102110205

Road Sediment Inventory
Northwest Swan Lake Watershed
N
Stream Crossings & Road Segments
Contributing
No Crossing
Low Potential / Not Inventoried
Private
Non-contributing
HUC Boundaries
These boundaries were provided by Flathead National Forest.
Swan Lake Watershed
Streams
Township and Range
PLSS Lines
Roads
Land Ownership
Wilderness
Flathead Tribal lands
Montana Fish, Wildlife, and Parks
Montana State Trust Lands -DNRC
Plum Creek Timber lands
The Nature Conservancy
U.S. Fish and Wildlife Service
U.S. Forest Service
Undifferentiated Bureau of Indian Affairs trust
Undifferentiated Private lands
Water
1 0 1 2 Miles
2 0 2 Kilometers
Scale = 1:55000
LAND & WATER CONSULTING, INC.
1120 Cedar
PO Box 8254
Missoula, MT 59807
Project #: 110236
Date: November 2002
Location: Swan River Basin
Project Manager: P. Callahan
Drawn By: B. Noecker / MSA
Flathead Lake
Swan Lake
170102110401
170102110308
170102110306
170102110307
170102110305
170102110303
170102110304
170102110302
170102110301
170102110207
170102110206

Road Sediment Inventory
Southeast Swan Lake Watershed
N
Stream Crossings & Road Segments
Contributing
No Crossing
Low Potential / Not Inventoried
Private
Non-contributing
HUC Boundaries
These boundaries were provided by Flathead National Forest.
Swan Lake Watershed
Streams
Township and Range
PLSS Lines
Roads
Land Ownership
Wilderness
Flathead Tribal lands
Montana Fish, Wildlife, and Parks
Montana State Trust Lands -DNRC
Plum Creek Timber lands
The Nature Conservancy
U.S. Fish and Wildlife Service
U.S. Forest Service
Undifferentiated Bureau of Indian Affairs trust
Undifferentiated Private lands
Water
1 0 1 2 Miles
2 0 2 Kilometers
Scale = 1:55000
LAND & WATER CONSULTING, INC.
1120 Cedar
PO Box 8254
Missoula, MT 59807
Project #: 110236
Date: November 2002
Location: Swan River Basin
Project Manager: P. Callahan
Drawn By: B. Noecker / MSA
CONDON

Road Sediment Inventory
Southwest Swan Lake Watershed
Stream Crossings & Road Segments
Contributing
No Crossing
Low Potential / Not Inventoried
Private
Non-contributing
HUC Boundaries
These boundaries were provided by Flathead National Forest.
Swan Lake Watershed
Streams
Township and Range
PLSS Lines
Roads
Land Ownership
Wilderness
Flathead Tribal lands
Montana Fish, Wildlife, and Parks
Montana State Trust Lands -DNRC
Plum Creek Timber lands
The Nature Conservancy
U.S. Fish and Wildlife Service
U.S. Forest Service
Undifferentiated Bureau of Indian Affairs trust
Undifferentiated Private lands
Water
1 0 1 2 Miles
2 0 2 Kilometers
Scale = 1:55000
N
Mission Mountain Wilderness
LAND & WATER CONSULTING, INC.
1120 Cedar
PO Box 8254
Missoula, MT 59807
Project #: 110236
Date: November 2002
Location: Swan River Basin
Project Manager: P. Callahan
Drawn By: B. Noecker / MSA

APPENDIX G: SWAN BANK INVENTORY RESULTS

List of Tables

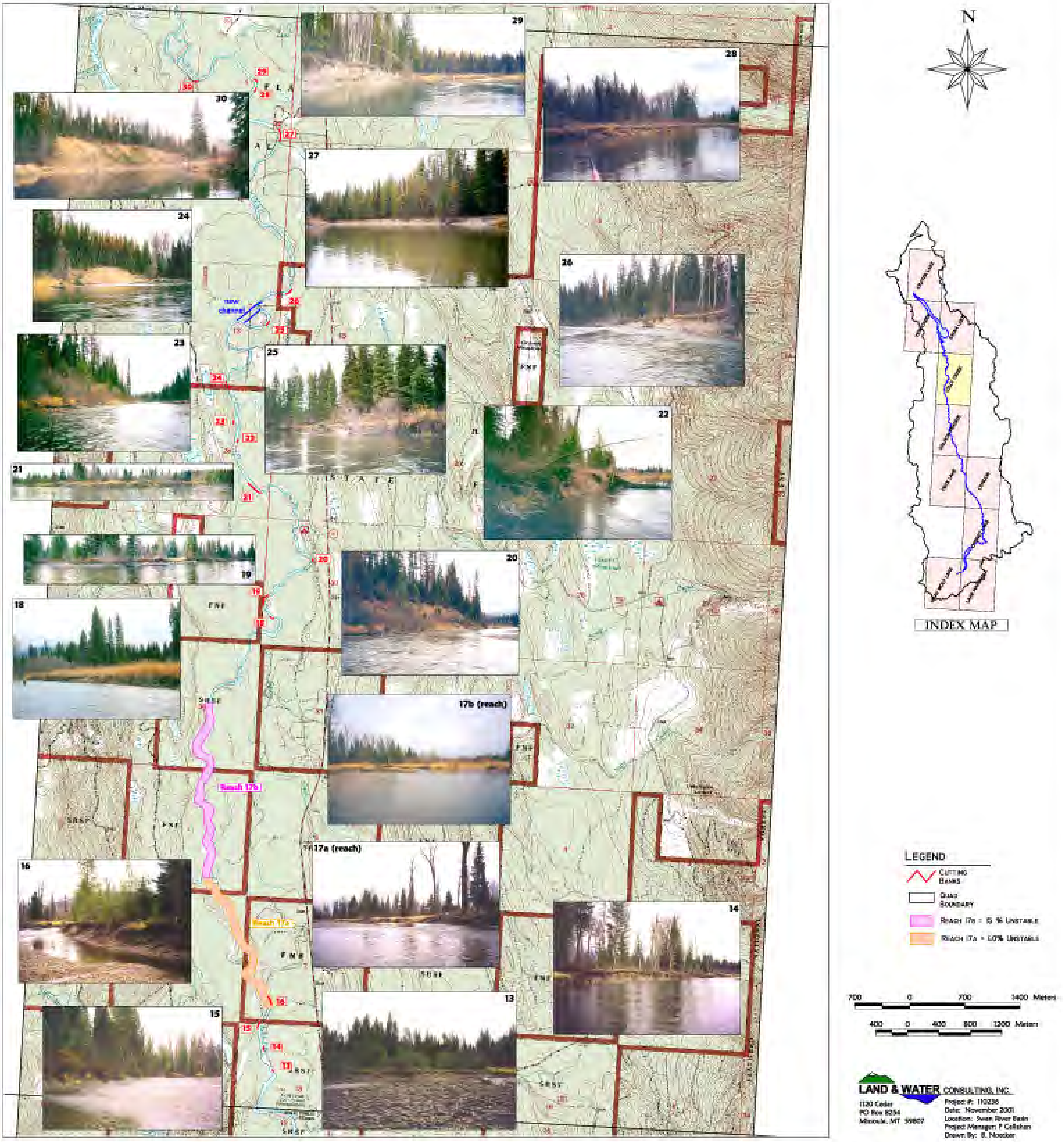
List of Maps

Swan River Bank Stability Assessment Results

Bank ID #	Length in ft (Bold text indicates anthropogenic cause)	Average Bank Heigth (ft)
1	**150**	5
2	350	25
3	400	35
4	**350**	5
5	**450**	3
6	150	60
7	250	10
8	400	12
9	250	12
10	200	7
11	150	10
12	100	4
13	100	4
14	150	7
15	300	9
16	200	6
*18	200	3.5
19	500	4
20	150	60
21	700	5
22	150	5
23	150	35
24	250	45
25	250	5
26	350	8
27	550	8
28	150	4
29	200	7
30	200	60
31	1300	8
32	200	4
33	700	4
34	150	4
35	150	4
36	400	4
37	150	4
38	400	4
39	900	5
40	1000	5
41	150	5
42	250	4
43	250	4
44	150	5
45	300	4
sub total	*14200*	
Reach 17a	5470.1	
Reach 17b	2588.3	
Total ft unstable	**22258.4**	

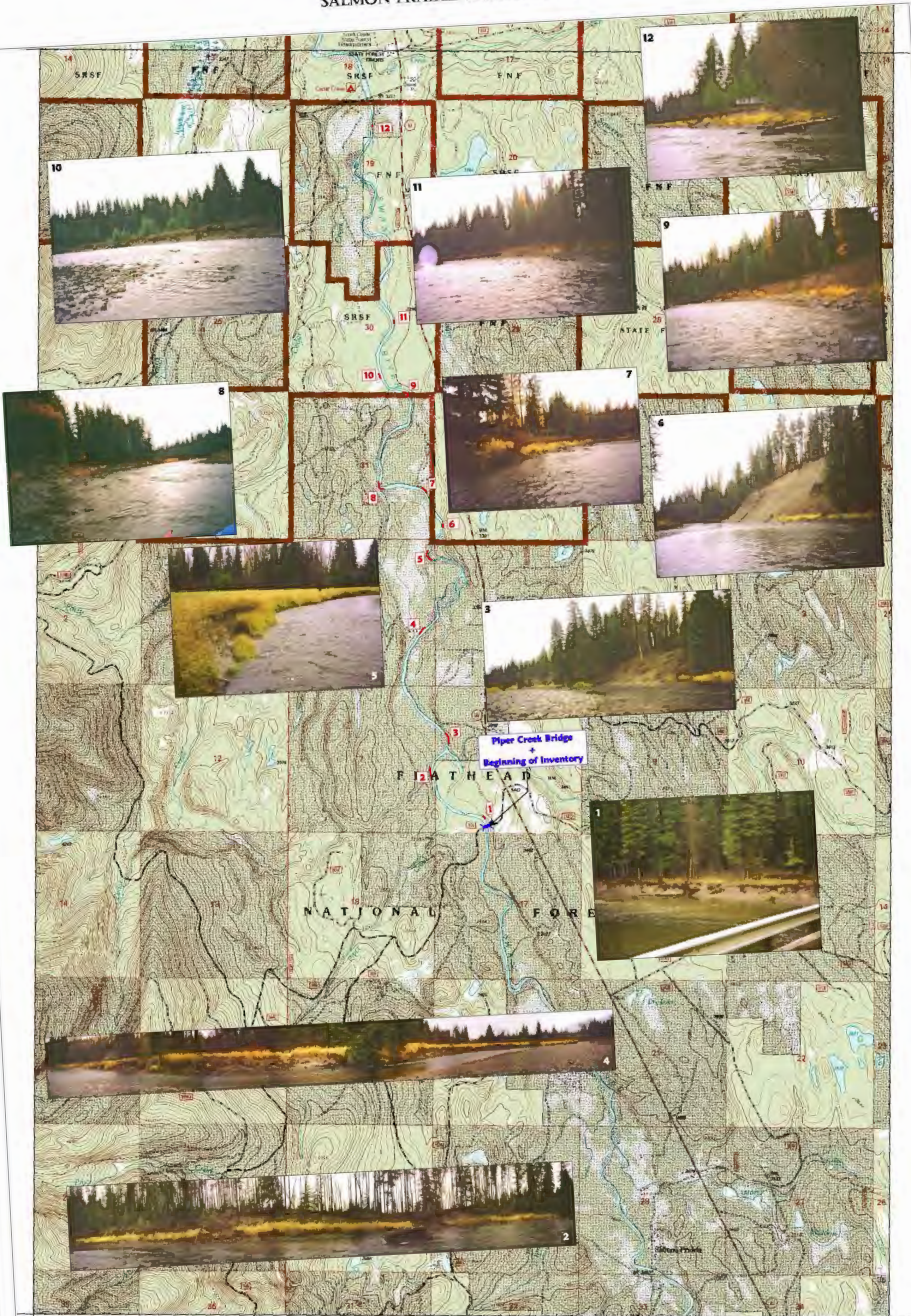
IN – CHANNEL EROSION

CILLY CREEK QUADRANGLE

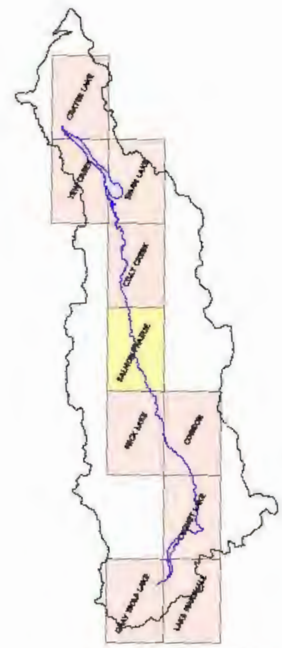


IN - CHANNEL EROSION

SALMON PRAIRIE QUADRANGLE



N


INDEX MAP

LEGEND

CUTTING BANKS

QUAD BOUNDARY

700 0 700 1400 Meters

400 0 400 800 1200 Meters

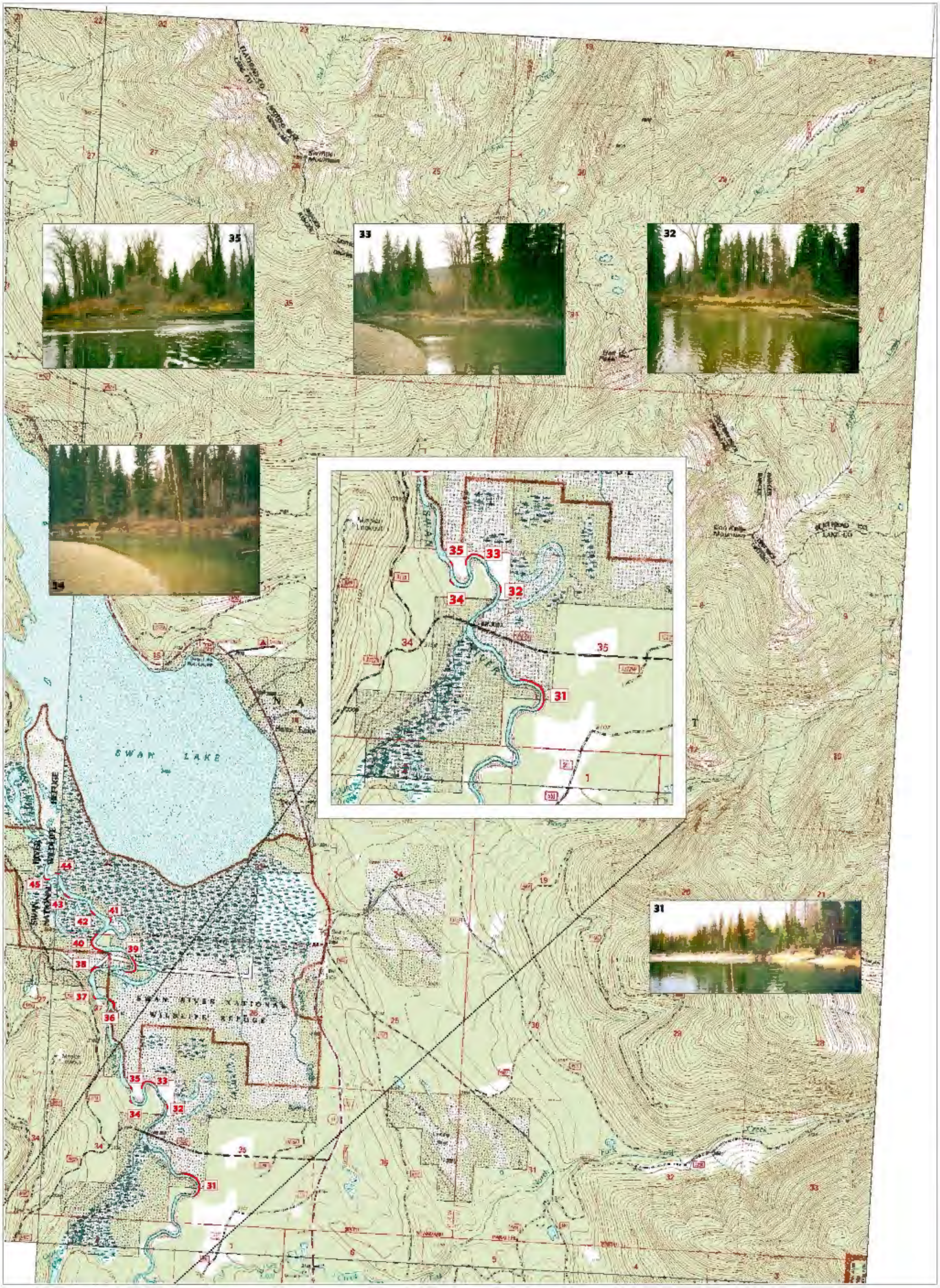
LAND & WATER CONSULTING, INC.

1120 Cedar
PO Box 8254
Missoula, MT 59807

Project #: 110236
Date: December 2001
Location: Swan River Basin
Project Manager: P. Callahan
Drawn By: B. Noecker

IN - CHANNEL EROSION

SWAN LAKE QUADRANGLE



N

INDEX MAP

LEGEND

Cutting Banks

Quad Boundary

700 0 700 1400 Meters

400 0 400 800 1200 Meters

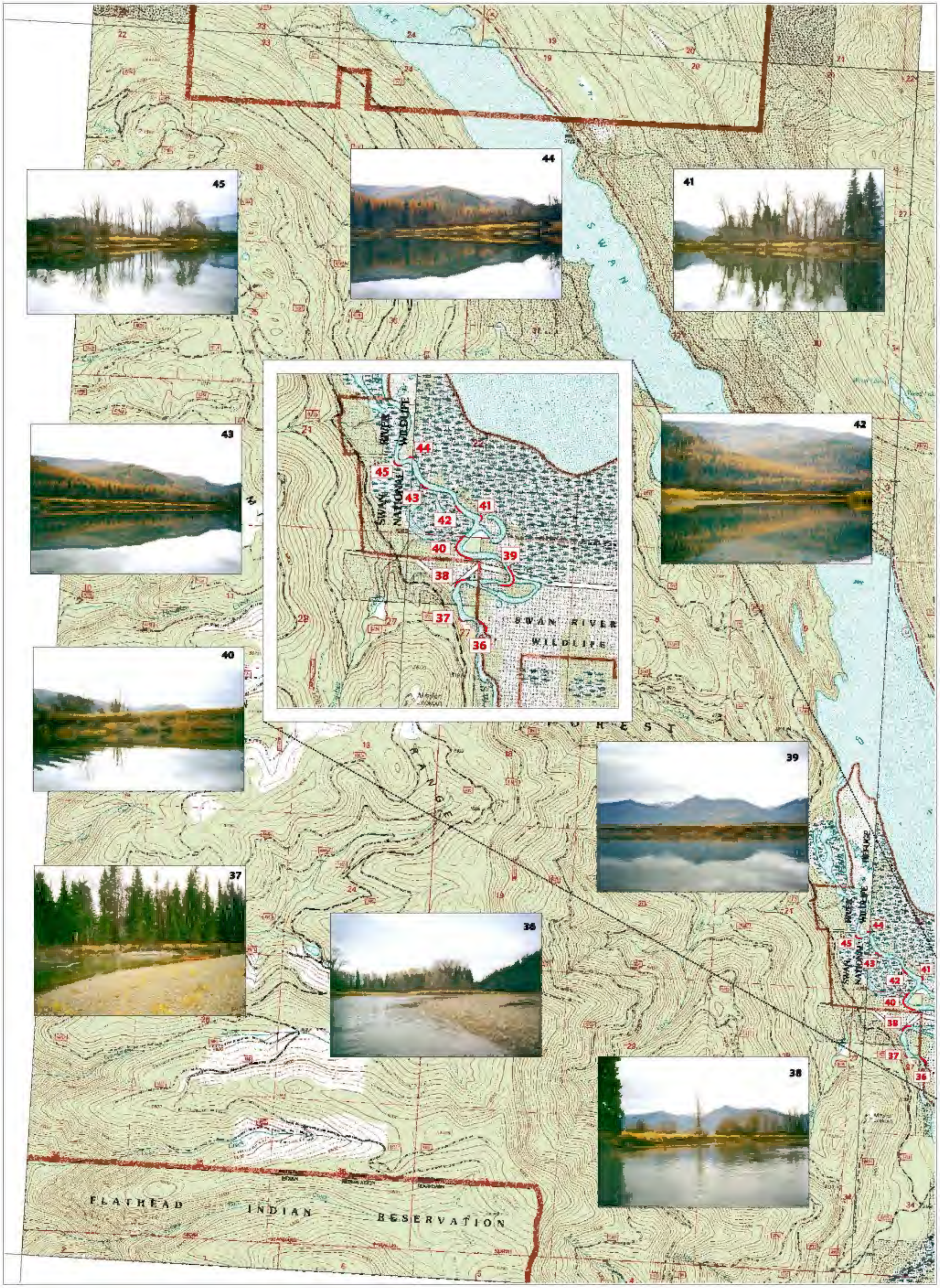
LAND & WATER CONSULTING, INC.

1120 Cedar
PO Box 8254
Missoula, MT 59807

Project #: 110236
Date: November 2001
Location: Swan River Basin
Project Manager: P. Callahan
Drawn By: B. Noecker

IN - CHANNEL EROSION

YEW CREEK QUADRANGLE



N

INDEX MAP

LEGEND

CUTTING BANKS

QUAD BOUNDARY

700 0 700 1400 Meters

400 0 400 800 1200 Meters

LAND & WATER CONSULTING, INC.
1120 Cedar
PO Box 8254
Missoula, MT 59807

Project #: 110236
Date: November 2001
Location: Swan River Basin
Project Manager: P. Callahan
Drawn By: B. Noecker

APPENDIX H:
LOCAL STREAM CORRIDOR PROTECTIVE REGULATIONS AND COVENANTS

H-1 Missoula County Subdivision Design Standards

3-13 AREAS OF RIPARIAN RESOURCE:

(1) PURPOSE: The intent of this section is to ensure that no subdivision shall be approved which is determined by the governing body to be unsuitable by reason of flooding, erosion, inadequate drainage, or impact in areas of riparian resources or any other feature likely to be harmful to the health, safety and welfare of the future residents of the proposed subdivision and the residents of Missoula County. More specifically, it is the intent of these regulations to ensure the following:

(A) That areas of riparian resource remain available to support diverse and productive aquatic and terrestrial riparian systems and habitats and to protect water quality;

(B) That stream channels, banks and lakeshores are protected;

(C) That areas of riparian resource are preserved to act as an effective sediment filters which help to maintain water quality;

(D) That areas of riparian resource shall be protected to preserve large, woody debris that is eventually recruited into a stream to maintain riffles, pools and other elements of channel structure and further to provide shade to regulate stream temperature;

(E) That the area of riparian resource shall be preserved to promote floodplain stability;

(F) That the public interest in the quality and quantity of surface and ground waters shall be protected; and

(G) That standards for development of land in areas of riparian resource are site-specific, allowing for flexibility for development while maintaining the integrity of these areas.

(2) DESIGNATION AS AREAS OF RIPARIAN RESOURCE: Areas of riparian resource means a stream, lake, wetland or other body of water and land containing any of the habitat or community types listed in Appendix V and an adjacent area of varying width where development may have significant negative impacts on wildlife habitat or water quality and quantity, fish, or other aquatic resources.

(3) MANAGEMENT PLAN: In order to meet the purposes outlined in Section 3-13 (1), a management plan for areas of riparian resource must be submitted with the subdivision proposal. Approval of the management plan by the governing body is required as a condition of subdivision approval. The plan shall include, but not be limited to the following:

(A) Proposed access to or through the area;

(B) Proposed low-impact use of the area;

(C) Planned restoration of the area with native species;

(D) Planned mitigation of impacts from all proposed uses; and

(E) Planned buffer to mitigate development adjacent to areas of riparian resources.

(4) SUBDIVISION PROHIBITION:

(A) Except as provided in Sections 5 and 6 below, no subdivision shall be approved which is determined to be wholly within areas of riparian resource. Subdivisions which encompass portions of areas of riparian resource shall provide for protection of the resource specific to the area, as outlined in the management plan and as approved by the governing body; and

(B) Subdivisions which encompass areas of riparian resource shall place development outside the areas of riparian resource. Except for road construction as provided for in (5) below, areas of "no improvements" of any kind shall be approved within the area of riparian resource, including fencing, except for those improvements which are outlined in the management plan and as approved by the governing body. The area of riparian resource may be available to the subdivision proposal for purposes of determining density allocations or number of lots and to satisfy the parks and open space requirements.

(5) ROAD CONSTRUCTION IN AREAS OF RIPARIAN RESOURCE: No proposed road shall be approved for construction if located in an area of riparian resource unless the road is for the purpose of crossing an area of riparian resource in order to access a body of water or stream and is outlined in a management plan approved by the governing body. The following restrictions shall apply to all road construction.

(A) The intentional sidecasting of road material into a stream, lake, wetland, or other body of water during road construction or maintenance is prohibited. The following additional standards shall apply to roads in these areas:

(i) Effective erosion and sedimentation control practices shall be conducted during all clearing, construction or reconstruction operations; and

(ii) Road fill material shall not be deposited in the areas of riparian resource or in such a location or manner so that adverse impacts will result to the area.

(B) The following guidelines for placement and construction of roads shall be considered in areas of riparian resource but may be waived with the consent of the governing body.

(i) In the event it is necessary to route a road through an area of riparian resource, then open areas should be utilized in order to minimize impact on vegetated areas;

(ii) Roads should not be constructed in areas where soils have a high susceptibility to erosion which would create sedimentation and pollution problems during and after construction; and

(iii) Roads should not intrude into areas adjacent to open exposures of water and should avoid scenic intrusion by building below ridge crests and high points.

(6) VARIANCE PROCEDURE: The governing body may grant variances from the following requirements of this section if it determines that strict compliance will result in undue hardship and when compliance with the regulations is not essential to the public welfare.

(A) Designation of an area as a riparian resource;

(B) Restriction of the development, improvement or road construction in an area of riparian resource;

(C) Restrictions on the location or standards applied to the construction of roads; and

(D) The governing body shall apply the following criteria to the habitat and community types found in Appendix V, as well as those contained in Sections 3-130) and 6-1 in determining whether to grant a variance to this section:

(i) Abundance of the type;

(ii) The restoration potential of the site after disturbance and whether the type is threatened by or is the result of human disturbance;

(iii) The structural layers present in the type (short, medium or tall);

(iv) The stage of the type (early, mid or late);

(v) The contribution of the type to stream bank stabilization;

(vi) The susceptibility of the soil in the type to compaction;

(vii) The contribution of the type in offering protection from erosion;

(viii) The contribution of the type to big game habitat (forage, thermal, security cover) of the type;

(ix) The contribution of the type to upland game bird, waterfowl and small animal habitat (forage and cover);

(x) The contribution of the type to non-game bird habitat (forage, thermal and security cover and nesting, including neo-tropical migrant species);

(xi) The contribution of the type to fisheries, especially native species and species of special concern; and

(xii) The contribution of the type to wide-ranging species of limited distribution, particularly threatened or endangered species and species of special concern.

H-2 Lake County Floodplain Regulations

Lake County floodplain regulations include the following pertinent sections regarding protection of waterbodies:

IV-A-4. *Floodplain Provisions*
1. Land located in the floodway of a flood of 100-year frequency as defined by Title 76, Chapter 5, MCA, or land deemed subject to flooding as determined by the governing body shall not be subdivided for building or residential purposes, or other uses that may increase or aggravate flood hazards to life, health, or property.

2. If any portion of a proposed subdivision is within 2,000 horizontal feet and 20 vertical feet of a live stream draining an area of 25 square miles or more, and no official floodway delineation or floodway studies of the stream have been made, the subdivider must furnish survey data to the Floodplain Management Section of the Water Resources Division of the Montana Department of Natural Resources and Conservation. Survey data must comply with the Standards for Flood Hazard Evaluations as contained in Appendix F of these regulations. After the Floodplain Management Section of the Water Resources Division has prepared a report delineating the floodway, the subdivider must submit it to the subdivision administrator along with the Environmental Assessment required for the preliminary plat.

3. The governing body must waive this requirement where the subdivider contacts the Water Resources Division and that agency states in writing that available data indicated that the proposed subdivision is not in a flood hazard area.

IV-A-21. *Buffer Strips Along Waterways*
The subdivider will define buffer strips along streams, rivers, or lakes by identifying buffer strip width and a plan for protection of vegetation within the buffer strip. The plan shall promote infiltration of run-off and wildlife habitat. The buffer strip plan will be included in the required information for review and be incorporated in the covenants for the proposed division.

H-3 Applicable Covenants for Land Sold by Plum Creek

Below is relevant covenant language for the PSA if the Property is within a Tier 1 Watershed or abuts a Key Migratory River.

Seller and Purchaser acknowledge and agree that Seller is subject to an "Incidental Take Permit" issued by the United States Fish and Wildlife Service ("USFWS") pursuant to that certain Native Fish Habitat Conservation Plan dated ______________, (the "NFHCP"), as such NFHCP may be updated and amended from time to time. Pursuant to the NFHCP, at such time as Seller conveys the Property, Seller is required to place restrictive deed covenants on a portion of the Property as follows:

1. The portion of the Property which is affected by these restrictive covenants is described as an area [50] [100] [in the case of 100 feet, may be less if it reaches a flat bench of

15% slope or less] feet wide, slope distance, as measured from the channel migration zone (“CMZ”), and shall be extended to include associated wetlands [located within the Property]. The CMZ is defined as [_______________]. The area so described is hereinafter referred to as the “Restricted Zone.”

2. Within the Restricted Zone, the following restrictions shall apply:

a. No buildings shall be constructed within the Restricted Zone.

b. No new roads shall be constructed within the Restricted Zone except where such construction is necessary to obtain access or to cross a stream or wetland. All new road construction shall be in compliance with forestry road Best Management Practices then in effect to minimize the delivery of sediment to streams.

c. No gravel pits shall be developed within the Restricted Zone.

d. The amount of impervious surface area (such as paving) shall not exceed ten percent (10%) of the total land area within the Restricted Zone.

e. No timber shall be harvested within the Restricted Zone. Shrubs and submerchantable trees must be protected and retained in the Restricted Zone to the extent practical.

f. Cultivated areas such as lawns, gardens and pastures shall not exceed twenty-five percent (25%) of the total area within the Restricted Zone. Lawns may not be created or maintained within the CMZ.

g. Broadcast burning within the Restricted Zone is prohibited.

h. The handling, storage, application, or disposal of hazardous or toxic materials within the Restricted Zone in a manner that pollutes streams, lakes or wetlands or that may cause damage or injury to humans, land, animals or plants is prohibited.

i. Any application of herbicides, pesticides, or fertilizers within the Restricted Zone must be done in a manner that such materials are not introduced into streams, lakes, wetlands, or other bodies of water through surface runoff or subsurface flow.

j. Development of private ponds for fish stocking is prohibited within the Restricted Zone.

3. In addition to the provisions set forth above to be applied within the Restricted Zone, any drain field for a septic system installed on the Property adjacent to the Restricted Zone shall be a minimum of 200 feet, slope distance, from a stream, and shall otherwise comply with all applicable sanitation standards; provided, however, that if an alternative can be developed and approved by the appropriate department of health or sanitation that is a lower-risk alternative for stream pollution, then the lower risk alternative may be used.

APPENDIX I: RIPARIAN ASSESSMENT & CHARACTERIZATION OF THE SWAN RIVER & SELECT TRIBUTARIES

RIPARIAN ASSESSMENT & CHARACTERIZATION of the SWAN RIVER & SELECT TRIBUTARIES

Michael Pipp
Water Quality Specialist/Modeler

Montana Department of Environmental Quality
Helena, MT

September 5, 2002

OVERVIEW

Analysis of the current riparian environment and stream channel characteristics is an essential element to support TMDL development, and subsequent five-year target evaluation, for the Swan River Watershed. The analysis used here quantifies riparian and stream channel parameters and actual or potential threats to the riparian environment or channel stability. Waterbodies assessed included Goat/Squeezer, Jim, Piper, and Elk Creeks - the four streams currently listed as water quality limited by the Montana DEQ 303(d) list and, in addition, the Swan River main stem above Swan Lake. The assessment, using standard photometric, GIS, and mapping analytical techniques, allowed a suite of parameters to be evaluated with reasonable speed, accuracy, and repeatability. The process is documented herein and all assessment data have been entered into a spreadsheet database. Reaches delineated during this assessment have been annotated on 7½-minute USGS quadrangle maps and are on file at the Montana DEQ office in Helena, MT. In addition, the NHD streams layer for the Swan River HUC may be attributed with reach level assessment conditions.

PHOTO INTERPRETATION, MAPPING, & CONDITION ASSESSMENT

Aerial photo interpretation and mapping was performed using 1997 color aerial photos at 1:15,840 scale and 7½' USGS quadrangle maps. The assessment extended from the mouth of the streams to the wilderness boundary (west-side streams) or to where Flathead National Forest (FNF) lands comprised all contributing area and little management, if any, was evident.

Streams were delineated into assessment reaches using the following criteria: 1) ownership boundaries as identified by the NRIS Stewardship Map, 2) significant changes in channel slope and/or valley type, 3) functional change in riparian vegetation, and 4) county line. Each reach was assigned a unique alphanumeric identification using three letters of the stream name followed by a number. Reaches were numbered sequentially from the mouth upstream to the end of the analysis area. Reach breaks were manuscripted on hard copy 7½' USGS quadrangles and may be transferred onto a GIS streams layer employing the NHD stream coverage.

Photo interpretation (PI) and map work allowed for the determination of following parameters: county, ownership, land use, impervious surfaces, riparian structures, active channel width, canopy density (LB/RB), buffer width (LB/RB), vegetation composition (LB/RB), bank condition (LB/RB), and channel confinement (Table 1). The PI work focused on a 300' width along the riparian corridor for buffer width while impervious surfaces and riparian structures were limited to 100' corridors. Initially, the PI work intended to include estimates of tree-to-channel distance, tree-to-channel slope, percent vegetation overhang, and an integrated evaluation of riparian vegetation along both banks. The ability to discern this information from photos at this scale (1:15,840) proved impractical and the first three listed parameters were dropped from the assessment. It was also decided that it would be advantageous to record riparian and stream bank information individually for each the left and right banks. **(Note: left and right banks are defined as facing downstream.)**

Estimation of bank condition proved very difficult with a 1:15,840 photo scale. Banks without obvious signs of instability were noted as “natural” while banks with obvious bare slopes, cut banks, or were otherwise in suspect condition were noted as “bare”.

Subsequent analysis employed GIS tools and coverages provided by the Flathead National Forest including Rosgen channel types, Riparian Land Types (RLT), Grizzly bear linkage zones, and 2001 satellite imagery with 5 meter resolution. The computer-based analysis provided “reach-level” information for Level 1 stream type, sinuosity, and channel slope (from the Rosgen coverage), riparian land types, location inside/outside grizzly bear linkage zones, reach length (measured using ArcView’s measure tool and digital topographic maps - DRGs), and stream order (7½’ quadrangles). In addition, the satellite imagery was a used to look for areas/reaches that have had a significant change in riparian forest cover within 300 feet of the stream channel since 1997 – the vintage of the aerial photos.

Refinements to the PI/map reach delineations were made while recording riparian land types. Eight reaches were sub-divided to account for, and align with, RLT delineations defined by the FNF. All other reach breaks delineated from photo interpretation aligned with forest’s RLT designations. Also, the riparian land type designation contains more detailed information concerning valley slope range, channel substrate material, and the potential natural vegetation communities (Sirucek and Bachurski, 1995). An example of a RLT designation is FL2D and the RLT nomenclature is provided in Table 2. Appendix A, Table A1 presents all assessment data.

Table 1. Assessment Parameters.

Assessment Parameter	Resolution	**Comments**
Canopy Density	10%	Photo estimated; if current riparian trees have CD < 10%, then CD = 0 %
Grizzly Bear Linkage	Yes/No	FNF GIS coverage
Riparian Land Type	Nominal class	FNF Riparian Land Type GIS coverage
Active Channel Width	5 ft.	Photo estimated / measured
Reach Length	25 ft.	GIS measured (ArcView measure tool)
Buffer Width	25 ft.	Photo estimated; 300’ max. (Horizontal Dist.)
Vegetation Composition	Nominal class	Photo estimated; Herbaceous, Deciduous, Conifer, Wetland, Woody
Stream Order (Strahler)	1:24k streams	USGS 7½’ quadrangles
Channel Sinuosity	0.01	FNF Rosgen GIS coverage
Rosgen Channel Type	Level 1	FNF Rosgen GIS coverage
Channel Confinement	Nominal class	Photo/map estimated; Unconfined, Moderate, Confined
Bank Condition	Nominal class	Photo estimated; Natural, Bare, Rip Rap
Land Use Class	Nominal class	Photo & map estimated
Impervious Surface	Yes / No	Photo; within a 100’ corridor of the stream
Riparian Structures	N/A	Count of visible structures with ~100 ft of the channel. Accounting included all visible structures regardless of “footprint” or potential structure type

Table 2. Flathead National Forest Riparian Land Types (Sirucek and Bachurski, 1995)

Differential	Unit Symbol	Definition
Gradient	FL	Flat valley bottoms; 0 – 2 % gradients
Gradient	NL	Nearly level valley bottoms; 2 – 4 % gradients
Gradient	SL	Slightly sloping valley bottoms; 5 – 12 % gradients
Gradient	MS	Moderately steep valley bottoms; 13 – 39 % gradients
Gradient	VS	Very steep valley bottoms; 40 + % gradients
Bed material	1	Clays, silts, fine and medium sand materials
Bed material	2	Coarse sand, gravels, and cobble materials
Bed material	3	Stones and boulder materials
Bed material	4	Bedrock
Bed material	5	Undifferentiated
Potential natural vegetation	A	Subalpine fir habitat types
Potential natural vegetation	B	Grand fir and western red cedar habitat types
Potential natural vegetation	C	Engelmann spruce habitat types
Potential natural vegetation	D	Black cottonwood habitat types
Potential natural vegetation	E	Willow and sedge community or habitat types
Potential natural vegetation	G	Snow avalanche chute plant communities
	UP	Upland habitats surrounded by riparian communities

Parameter Definitions

General

Stream Name

Reach ID – three letters of the stream name and a reach number set sequentially upstream from the mouth

County

- **Msla** – Missoula
- **Lake** – Lake County

Owner

- **PC** – Plum Creek Timber Co. lands or parcels
- **PC1** – Plum Creek Timber Co. parcels identified for transfer to federal management
- **PVT** – other, undifferentiated private lands
- **PVT-C** – private lands under a conservation management strategy
- **USFS** – Forest Service system lands
- **DNRC** – MT Dept. of Natural Resource Conservation (Swan River State Forest)
- **DUAL** – ownership split between left/right banks

Reach Length – linear stream distance; computed using the ArcView measure tool and USGS digital topographic maps (i.e. DRGs)

Grizzly Bear Linkage – inside/outside of identified zones using the Flathead National Forest Grizzly Bear Linkage GIS coverage.

Riparian Area

Canopy Density – percent shade quality or the effectiveness of vegetation to block sunlight

Land Use

- **PFOR –** Private forest lands
- **SFOR –** State-managed forest lands
- **NFOR –** Federally-managed forest lands
- **NR –** Private Non-Resource Lands (i.e. rural residential; floodplain/wetland)
- **RS –** Apparent resource land, non-forestry
- **MIX –** Mixed private land uses

Impervious Surface – presence/absence of impervious surface(s) within ~ 100' of the stream

Riparian Structures – count of visible structures/building within ~100' of the channel

Buffer Width – averaged width of riparian vegetation (non-herbaceous vegetation only), maximum distance recorded: 300 feet. Measured as horizontal distance, not slope distance.

Vegetation Composition – existing riparian vegetation composition

- **HB –** herbaceous
- **WDY –** woody or shrub (refined to type/genus if possible, i.e. willow)
- **MD –** mixed deciduous stand (refined to type/genus if possible, i.e. cottonwood)
- **MC –** mixed conifer stand (refined to type/genus if possible, i.e. Doug fir)
- **MD/HB –** mixed deciduous and herbaceous
- **MD/C –** mixed deciduous/conifer stand; deciduous dominant
- **MC/D –** mixed deciduous/conifer stand; conifer dominant
- **WET –** wetland species

Riparian Land Type - Flathead National Forest RLT GIS coverage, nominal class ID

Stream Channel

Active Channel – approximate measure of bankfull channel width or channel disturbance area using an engineering scale.

Stream Order – Strahler's numeric ranking system of relative stream size where exterior streams are labeled as "1" and are defined as those that "carry wet weather streams and are normally dry" (Gordon, et. al. 1992, pg. 104) and are identified as blue lines on 1:24,000 USGS quadrangle maps.

Rosgen Level 1 – stream channel classification based on channel slope, sinuosity, valley type, and stream pattern and form. The source of this data is from the Flathead National Forest's Rosgen GIS coverage. Note: Level 1 designation was adjusted to maintain stream types within their designated slope ranges. This coverage was found to have variances where stream types were classified as a particular type even though it's slope exceeded it's normal range. This was most often the case on C-type channels with reported sloped greater than 2%. These streams were reclassified as B-type channels. In addition, where the reaches delineated in this process covered several stream types on the GIS, the GIS values were averaged for the reach.

Bank Condition

- **NAT –** vegetated banks, no evidence of erosion or mass wasting
- **BR –** vegetation reduced or absent; erosion or channel widening evident
- **RR –** presence of riprap or unnatural bank stabilization materials

Channel Confinement

U – Unconfined; floodplain width > 4X bankfull width
M – Moderate Confinement; floodplain width 4X > bankfull width > 2X floodplain width
C – Confined; floodplain width < 2X bankfull width

CURRENT CONDITION VERIFICATION

Given that the vintage of aerial photographs used for this assessment was five years old an effort was made to verify that 1997 riparian conditions had not change dramatically. To achieve this, black and white panchromatic satellite imagery from 2000 or 2001 was used to evaluate the riparian areas of all streams assessed in this report. The source imagery had a five-meter (269 ft^2) pixel resolution taken by the Indian Remote Sensing Satellite. Although this is considered high resolution by satellite imagery standards is was still too course to identify, with confidence, any riparian features other than gross canopy removal. Reaches identified as having potential reduction in riparian cover between 1997 and 2000/2001 were limited to the Swan River and include reaches 56, 59, 60, 61, 62, 70, and 71.

In addition to alteration in riparian conditions, there were several shifts in channel location noted from the 1997 aerial photos that occurred subsequent to the USGS mapping. Initial topographic maps were compiled from 1964 photos with selected updates in the early 1990's. Reaches that had (primary) channel migration during this period include Swan River 63, 83, 92-93, 103-105, 109, and 110 and Elk Creek reaches 9 and 10. Slope and sinuosity values for these reaches were calculated from the "old channel" by the Flathead National Forest's Rosgen GIS coverage while the reach lengths were measured by estimating the new primary channel's course in GIS using the ArcView measure tool.

FIELD ASSESSMENTS

Field assessments will be conducted during the summer of 2002. To facilitate fieldwork, reaches were noted during the PI that might warrant on-the-ground measurement. Sampling reaches were identified that would provide surveys of reaches where human activities have had an obvious impact on either riparian vegetation or stream channel stability, as well as, reaches without any obvious human activities. Reaches were also selected to represent all ownerships and Rosgen channel types (Tables 3 and 4). Three reaches were specifically identified for reference condition evaluation and/or ground truthing the PI work. However, limited ground truthing is believed to be necessary since most of the parameters derived from photo interpretation can be cross-referenced using the Flathead National Forest's GIS coverage's, and specifically, the RLT data which under went extensive ground truthing and field validation during it's development (Sirucek and Bachurski, 1995). Furthermore, the data collected from this effort is not destine to be used in any way to model water quality in the basin, but solely as a tool by which to evaluate current conditions and conditions at a later date using a repeatable method.

Field assessments of Elk, Goat/Squeezer, Jim, and Piper Creeks will use accepted field measurement protocols and procedures determined by Montana DEQ. Where ground truthing is conducted, specific to the PI work, it should consist of reaches 200 feet in length were PI values were determined specifically for that area. Measurements should be conducted at three transects (bottom, middle, and top) along the ~ 200 foot reach. The reach value for each parameter is computed by averaging all measurements taken. Field measurements should then be compared to photo-interpreted or map derived values and adjustments made to existing conditions if indicated. The only parameters that need to be ground truthed are active channel width and canopy density (LB/RB). Channel width measurements will be taken using either a standard engineering tape or range finder at bank full indicators. Canopy density measurements should be taken with a densiometer following the protocol outlined in Platts et al., 1987 pg. 58.

Table 3. 2002 Field Assessment Reach Identification.

Stream	Reach	Length (ft)	Owner	RLT	Rosgen	Comments
Piper Cr	2	2450	PVT	NL2A	B	Developed – reduced vegetation, RRT
Piper Cr	3	900	PVT	NL2A	B	Developed with better buffer/vegetation, RRT
Piper Cr	5	950	USFS	NL2A	B	d/s of Rd 966 to reach end
Piper Cr	6	1100	USFS	NL2A	A	Full buffer, mature trees
Piper Cr	10	1575	PCTC	MS5A	B	Landslide RLF; bare right bank?
Piper Cr	14	1375	PCTC	MS5A	A	Large buffers **(Reference / Ground Truth)**
Jim Cr	4	2425	PCTC	FL2C	C	Riparian mosaic
Jim Cr	5	2675	PVT	FL2C	B	FS access via Rd 888; start u/s → d/s
Jim Cr	11	550	USFS	NL2E	A	Access via Rd 9798
Jim Cr	14	2475	USFS	SL2A	A	No harvest
Jim Cr	15	3225	PCTC	SL2A	A	Access to middle of reach – Rd 10296 → PC road
Jim Cr	24	2575	PCTC	SL2A	A	CC's minimal buffers; erosion/accumulation?
Elk Cr	2	1275	PCTC	FL2C	C	Access on PCT Rd via Condon; road crossing d/s; **GT site:** top of 1st bend d/s → u/s ~500'
Elk Cr	3	2450	PCTC	FL2C	C	Survey 1000' u/s of road crossing
Elk Cr	6	3275	PCTC	FL2C	C	Channel bars, wide channel area; post '97 harvests
Elk Cr	9	850	PVT	FL2C	C	"New" channel
Elk Cr	13	1250	USFS	NL2A	C	Good buffers / no harvest; access via Rd 2591
Goat Cr	3	1450	SRSF	FL2C	C	u/s of Hwy 83
Goat Cr	7	775	USFS	FL2C	B	Riparian harvest; off of Rd 554
Goat Cr	9	3700	SRSF	FL2C	C	u/s of Rd 568 stream crossing; **Reference? / Ground truth segment**
Goat Cr	10	2000	PCTC	FL2C	B	Harvested; access off of Rd 554
Goat Cr	11	1050	SRSF	FL2C	C	Access off of Rd 554
Goat Cr	16	1925	PCTC	WS5A	B	Measure u/s ½ of reach (possible reference)

Table 4. Reaches identified and selected for field assessment in 2002. Reaches have been sorted by: 1st - Rosgen channel type, 2nd - owner, and 3rd – evidence of human activities impacting the channel/riparian area.

Stream/Reach #	Length (ft)	Rosgen	Owner	Human Impacts	RLT	1997 Photo #	USGS Quadrangle
Jim Cr / 14	2475	A	USFS	No	SL2A	697-28	Peck Lake
Piper Cr / 6	1100	A	USFS	No	NL2A	697-33	Salmon-Prairie
Jim Cr / 11	550	A	USFS	Yes	NL2E	697-29	Peck Lake
Piper Cr / 14	1375	A	PCTC	No	MS5A	197-148	Salmon-Prairie
Jim Cr / 15	3225	A	PCTC	Yes	SL2A	697-28	Peck Lake
Jim Cr / 24	2575	A	PCTC	Yes	SL2A	1397-116	Peck Lake
Goat Cr / 7	775	B	USFS	Yes	FL2C	197-38	Cilly Creek
Piper Cr / 5	950	B	USFS	Yes	NL2A	697-33	Salmon-Prairie
Goat Cr / 16	1925	B	PCTC	No	WS5A	1397-26	Thunderbolt Mtn
Goat Cr /10	2000	B	PCTC	Yes	FL2C	197-39	Cilly Creek
Piper Cr / 10	1575	B	PCTC	Yes	MS5A	197-148	Salmon-Prairie
Jim Cr / 5	2675	B	PVT	No	FL2C	697-30	Salmon-Prairie
Piper Cr / 2	2450	B	PVT	Yes	NL2A	697-34	Salmon-Prairie
Piper Cr / 3	900	B	PVT	Yes	NL2A	697-34	Salmon-Prairie
Elk Cr / 13	1250	C	USFS	No	NL2A	197-19	Hemlock Lake
Elk Cr / 2	1275	C	PCTC	No	FL2C	197-64	Condon
Elk Cr / 3	2450	C	PCTC	No	FL2C	197-64	Condon
Jim Cr / 4	2425	C	PCTC	No	FL2C	197-30	Salmon-Prairie
Elk Cr / 6	3275	C	PCTC	Yes	FL2C	197-65	Peck Lake
Elk Cr / 9	850	C	PVT	No	FL2C	197-65	Peck Lake
Goat Cr / 3	1450	C	SRSF	No	FL2C	697-39	Salmon-Prairie
Goat Cr / 9	3700	C	SRSF	No	FL2C	197-39	Cilly Creek
Goat Cr / 11	1050	C	SRSF	No	FL2C	1397-12	Cilly Creek

REFERENCES

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Sirucek, D. and V. Bachurski, 1995. *Riparian Landtype Survey of the Flathead National Forest Area, Montana*. USDA Forest Service, Kalispell, MT. 56 p.

APPENDIX A

Assessment Data Tables

Table A1. 2001 Stream Channel and Riparian Condition Reach Assessment Data

Stream Name	Reach Name	County	Owner	Land Use	Grizzly Bear Linkage	Impervious Surface	Riparian Structures	Reach Length (ft)	Active Channel (ft)	LB Canopy Density	LB Buffer (ft)	LB Vegetation	LB Bank Condition	RB Canopy Density	RB Buffer (ft)	RB Vegetation	RB Bank Condition	Stream Order	Riparian Land Type	Channel Sinuosity	Stream Slope	Rosgen Level 1 Channel	Channel Confinement	COMMENTS / DISTURBANCE
Elk Cr	Elk1	Msla	PC	PFOR	N	N		1075	100	0.1	50	MC/D	NAT	0.1	50	MC/D	NAT	4	FL2D	1.09	1.38	C	U	Riparian Mosaics; Channel & Point Bars; Swan River has shifted onto the lower 600 feet of Elk Creek as depicted on USGS quadrangle
Elk Cr	Elk2	Msla	PC	PFOR	N	Y		1275	60	0.2	100	MC	NAT	0.7	200	MC	NAT	4	FL2C	1.09	1.38	C	M	Riparian Mosaic-RLF
Elk Cr	Elk3	Msla	PC	PFOR	N	N		2450	60	0.2	100	MC	NAT	0.4	100	MC	NAT	4	FL2C	1.09	1.38	C	M	Riparian Mosaic; Harvest; Road Crossing
Elk Cr	Elk4	Msla	PC	PFOR	N	N		775	40	0.1	50	MC	NAT	0.8	300	MC	NAT	4	FL2C	1.09	1.38	C	M	Riparian Harvest-RLF; Channel Bars?
Elk Cr	Elk5	Msla	PC	PFOR	N	N		2675	100	0.3	100	MC	BR	0.7	50	MC/D	BR	4	FL2C	1.09	1.38	C	M	Narrow Buffer; Braided / Bars; Distributary Channel
Elk Cr	Elk6	Msla	PC	PFOR	N	N		3275	100	0.2	50	MC/D	BR	0.5	300	MC/D	BR	4	FL2C	1.13	1.60	C	M	Riparian Mosaics; Channel Bars; post-97 harvest RLF
Elk Cr	Elk7	Msla	PC	PFOR	N	N		575	60	0.3	50	MC	NAT	0.6	300	MC	NAT	4	FL2C	1.14	1.78	C	M	Narrowing Channel; No Bars; post-97 harvest RLF
Elk Cr	Elk8	Msla	PVT	NR	N	N	1	400	60	0.5	250	MC/D	NAT	0.7	300	MC	NAT	4	FL2C	1.14	1.78	C	M	Small Homesite On Sect. Line-25' Buffer
Elk Cr	Elk9	Msla	PVT	NR	N	N		850	80	0.2	250	MC/D	BR	0.6	300	MC	BR	4	FL2C	1.05	1.20	C	M	New Channel (Length = EST); Large Bar; Mosaic RLF; Sinuosity & Slope = Old Channel #'s
Elk Cr	Elk10	Msla	PC	PFOR	N	N		800	60	0.1	250	MC/D	NAT	0.6	300	MC	NAT	4	FL2C	1.37	2.37	B	M	Riparian Harvest / Mosaic-RLF
Elk Cr	Elk11	Msla	PC	PFOR	N	N		6025	60	0.4	200	MC/D	NAT	0.5	200	MC/D	NAT	4	FL2C	1.36	2.61	C	C	Old Riparian Harvests; Sinuosity & Slope Averaged
Elk Cr	Elk12	Msla	USFS	NFOR	N	Y		2800	60	0.3	50	MC/D	NAT	0.8	250	MC	NAT	4	FL2C	1.35	1.70	C	C	Harvest w/ Small Buffer-RLF; Road Crossing
Elk Cr	Elk13	Msla	USFS	NFOR	N	N		1250	40	0.6	300	MC/D	NAT	0.8	300	MC	NAT	4	NL2A	1.35	1.70	C	C	Some Mosaic RLF; Improving Channel
Elk Cr	Elk14	Msla	USFS	NFOR	Y	N		5975	60	0.8	300	MC	NAT	0.8	300	MC	NAT	4	NL2A	1.12	2.21	C	C	Intact Forest; No Channel Bar Evidence; Sinuosity & Slope Averaged
Elk Cr	Elk15	Msla	USFS	NFOR	Y	N		1375	60	0.0	100	WDY	NAT	0.0	150	WDY	NAT	4	NL2A	1.50	0.02	E	M	Open Riparian Meadow; Forest Beyond Meadow
Elk Cr	Elk16	Msla	USFS	NFOR	Y	N		1175	40	0.7	300	MC	NAT	0.6	300	MC	NAT	4	NL2A	1.03	1.56	C	C	Forested

Table A1. 2001 Stream Channel and Riparian Condition Reach Assessment Data

Stream Name	Reach Name	County	Owner	Land Use	Grizzly Bear Linkage	Impervious Surface	Riparian Structures	Reach Length (ft)	Active Channel (ft)	LB Canopy Density	LB Buffer (ft)	LB Vegetation	LB Bank Condition	RB Canopy Density	RB Buffer (ft)	RB Vegetation	RB Bank Condition	Stream Order	Riparian Land Type	Channel Sinuosity	Stream Slope	Rosgen Level 1 Channel	Channel Confinement	COMMENTS / DISTURBANCE
Elk Cr	Elk17	Msla	USFS	NFOR	Y	N		2175	60	0.0	200	WDY	NAT	0.0	200	WDY	NAT	4	NL1E	1.36	0.20	E	M	Braided Upper 1/3; Large Meander Bends
Elk Cr	Elk17.1	Msla	USFS	NFOR	Y	N		400	40	0.8	300	MC	NAT	0.7	300	MC	NAT	4	NL1E	1.07	4.68	A	C	Falls / Cataracts
Elk Cr	Elk18	Msla	USFS	NFOR	Y	N		1300	40	0.8	300	MC	NAT	0.7	300	MC	NAT	4	NL2A	1.07	4.68	A	C	Falls / Cataracts
Elk Cr	Elk19	Msla	USFS	NFOR	Y	N		2275	60	0.4	300	WDY	NAT	0.4	300	WDY	NAT	4	NL1E	1.63	0.84	E	M	Large Meander Bends; Riparian Mosaic
Elk Cr	Elk19.1	Msla	USFS	NFOR	Y	N		750	60	0.6	300	MC	NAT	0.8	300	MC	NAT	4	NL1E	1.32	0.84	E	C	
Elk Cr	Elk20	Msla	USFS	NFOR	Y	N		1725	60	0.6	300	MC	NAT	0.8	300	MC	NAT	4	NL1A	1.32	0.84	E	C	
Elk Cr	Elk20.1	Msla	USFS	NFOR	Y	N		1900	60	0.5	300	MC	NAT	0.2	200	MC	NAT	4	NL1E	1.32	0.84	E	M	Large Meander Bends; Riparian Mosaics
Elk Cr	Elk21	Msla	USFS	NFOR	Y	N		550	60	0.5	300	MC	NAT	0.2	200	MC	NAT	4	NL2A	1.32	0.84	E	M	Large Meander Bends; Riparian Mosaics
Elk Cr	Elk22	Msla	USFS	NFOR	Y	N		1075	40	0.5	300	MC	NAT	0.7	300	MC	NAT	4	NL2A	1.16	5.39	A	C	Steep Channel / Cataract
Elk Cr	Elk23	Msla	USFS	NFOR	Y	N		4725	60	0.7	300	MC	NAT	0.7	300	MC	NAT	4	NL2A	1.07	2.74	B	C	Sinuosity & Slope Averaged
Elk Cr	Elk24	Msla	USFS	NFOR	Y	N		850	60	0.4	300	MC	NAT	0.6	300	MC	NAT	4	NL2A	1.02	0.51	C	C	
Goat Cr	Got1	Lake	DNRC	SFOR	N	N		625	40	0.1	100	MC/D	NAT	0.2	200	MC	NAT	4	FL2D	1.25	0.95	C	U	SRSF HQ Compound
Goat Cr	Got2	Lake	DNRC	SFOR	N	Y	6	1625	40	0.6	300	MC	NAT	0.7	250	MC	NAT	4	FL2D	1.25	0.95	C	U	SRSF HQ Buildings-Southside; Hwy 83
Goat Cr	Got3	Lake	DNRC	SFOR	N	N		1450	40	0.7	300	MC	NAT	0.6	300	MC/D	NAT	4	FL2C	1.25	0.95	C	M	Gravel Pit(s); Forest Rd 554 (N) Beyond Buffer
Goat Cr	Got4	Lake	USFS	NFOR	N	N		525	40	0.5	50	MC/D	NAT	0.6	300	MC	NAT	4	FL2C	1.25	0.95	C	M	Harvest-RLF; Squeezer Cr. Confluence

Table A1. 2001 Stream Channel and Riparian Condition Reach Assessment Data

Stream Name	Reach Name	County	Owner	Land Use	Grizzly Bear Linkage	Impervious Surface	Riparian Structures	Reach Length (ft)	Active Channel (ft)	LB Canopy Density	LB Buffer (ft)	LB Vegetation	LB Bank Condition	RB Canopy Density	RB Buffer (ft)	RB Vegetation	RB Bank Condition	Stream Order	Riparian Land Type	Channel Sinuosity	Stream Slope	Rosgen Level 1 Channel	Channel Confinement	COMMENTS / DISTURBANCE
Goat Cr	Got5	Lake	USFS	NFOR	N	N		3275	30	0.2	100	MC	NAT	0.5	300	MC/D	NAT	3	FL2C	1.03	1.25	C	M	Harvest-RLF
Goat Cr	Got6	Lake	USFS	NFOR	N	Y		1225	30	0.6	150	MC	NAT	0.6	250	MC	NAT	3	FL2C	1.07	1.00	C	C	Road Impinging-RRT
Goat Cr	Got7	Lake	USFS	NFOR	N	N		775	30	0.7	100	MC	NAT	0.1	25	MC	BR	3	FL2C	1.02	2.53	B	M	Riparian Harvest-RRT
Goat Cr	Got8	Lake	DNRC	SFOR	Y	Y		1525	30	0.7	300	MC	NAT	0.5	300	MC	NAT	3	FL2C	1.02	2.53	B	M	Roads w/in Riparian
Goat Cr	Got9	Lake	DNRC	SFOR	Y	N		3700	30	0.3	300	MC/D	NAT	0.4	300	MC/D	NAT	3	FL2C	1.04	1.30	C	M	Riparian Mosaic-Conifer / Shrubs
Goat Cr	Got10	Lake	PC	PFOR	Y	N		2000	40	0.3	100	MC	NAT	0.1	50	MC/D	NAT	3	FL2C	1.02	2.36	B	M	Harvested; Bar Formation
Goat Cr	Got11	Lake	DNRC	SFOR	Y	N		1050	40	0.5	150	MC	NAT	0.5	50	MC	NAT	3	FL2C	1.07	1.97	C	M	Bank Status?; Sinuosity & Slope Averaged
Goat Cr	Got12	Lake	DNRC	SFOR	Y	Y		1850	40	0.8	300	MC	NAT	0.6	150	MC	NAT	3	FL2C	1.09	5.13	A	C	Road-RRT; Sinuosity & Slope Averaged
Goat Cr	Got13	Lake	DNRC	SFOR	Y	N		3125	30	0.8	300	MC	NAT	0.8	300	MC	NAT	3	WS5A	1.04	3.61	B	C	Enters "Canyon"; Channel Size?; Sinuosity & Slope Averaged
Goat Cr	Got14	Lake	PC	PFOR	Y	N		3200	30	0.7	150	MC	NAT	0.4	50	MC	NAT	3	WS5A	1.06	6.21	A	C	Riparian Harvests; Sinuosity & Slope Averaged
Goat Cr	Got15	Lake	PC	PFOR	Y	Y		900	30	0.8	150	MC	NAT	0.8	100	MC	NAT	3	WS5A	1.09	5.72	A	C	Road Crossing; Riparian Harvest; Landing; Sinuosity & Slope Averaged
Goat Cr	Got16	Lake	PC	PFOR	Y	N		1925	30	0.7	250	MC	NAT	0.7	250	MC	NAT	3	WS5A	1.07	4.41	B	C	Road to Section Line ~ Edge of 300' Riparian
Goat Cr	Got17	Lake	USFS	NFOR	Y	N		3150	30	0.7	300	MC	NAT	0.7	300	MC	NAT	3	WS5A	1.03	6.69	A	C	Road RRT- Lower 1/3 of Hill slope; Scout Cr. Confluence; Sinuosity & Slope Averaged
Goat Cr	Got18	Lake	USFS	NFOR	Y	Y		1050	25	0.6	300	MC	NAT	0.6	250	MC	NAT	3	WS5A	1.03	5.93	A	C	Road RRT- Lower 1/3 of Hill slope; Sinuosity & Slope Averaged
Goat Cr	Got19	Lake	USFS	NFOR	Y	N		1850	25	0.6	300	MC	NAT	0.6	125	MC	NAT	3	WS5A	1.00	6.93	A	C	Harvest RRT
Goat Cr	Got20	Lake	USFS	NFOR	Y	N		2675	25	0.3	300	MC	NAT	0.4	300	MC	NAT	3	WS5A	1.00	6.45	A	C	Jammer Roads / Harvest RLF

Table A1. 2001 Stream Channel and Riparian Condition Reach Assessment Data

Stream Name	Reach Name	County	Owner	Land Use	Grizzly Bear Linkage	Impervious Surface	Riparian Structures	Reach Length (ft)	Active Channel (ft)	LB Canopy Density	LB Buffer (ft)	LB Vegetation	LB Bank Condition	RB Canopy Density	RB Buffer (ft)	RB Vegetation	RB Bank Condition	Stream Order	Riparian Land Type	Channel Sinuosity	Stream Slope	Rosgen Level 1 Channel	Channel Confinement	COMMENTS / DISTURBANCE
Goat Cr	Got21	Lake	USFS	NFOR	Y	N		2450	25	0.3	150	MC	NAT	0.2	150	MC	NAT	3	NL2A	1.01	1.38	C	M	Riparian Harvest; Jammer Rd Harvest
Goat Cr	Got22	Lake	USFS	NFOR	Y	N		1400	25	0.6	200	MC	NAT	0.6	200	MC	NAT	3	NL2A	1.08	4.57	A	M	Riparian Harvest; Bethel Cr. Confluence; Sinuosity & Slope Averaged
Goat Cr	Got23	Lake	USFS	NFOR	Y	Y		850	15	0.6	300	MC	NAT	0.6	150	MC	NAT	2	SL2B	1.01	7.14	A	M	Road Crossing
Goat Cr	Got24	Lake	USFS	NFOR	Y	N		850	15	0.7	100	MC	NAT	0.7	300	MC	NAT	2	MS3B	1.00	14.96	Aa	C	Riparian Harvest-Both Sides
Squeezer Cr	Squ1	Lake	USFS	NFOR	N	N		3450	40	0.4	100	MC/D	NAT	0.4	100	MC/D	NAT	3	FL2C	1.06	2.19	B	M	Harvest w/ Narrow Riparian Buffer
Squeezer Cr	Squ2	Lake	USFS	NFOR	N	N		2375	40	0.5	200	MC	NAT	0.4	200	MC	NAT	3	FL2C	1.12	2.22	B	C	"Canyon"; Harvested Beyond Buffer
Squeezer Cr	Squ3	Lake	DNRC	SFOR	N	N		400	40	0.7	300	MC	NAT	0.7	100	MC	NAT	3	FL2C	1.12	2.22	B	C	RRT Buffer Reduced by Harvest on Adjoining Parcels (FNF, PCTC)
Squeezer Cr	Squ4	Lake	PC	PFOR	N	N		2775	40	0.1	250	WDY	NAT	0.2	200	MC/D	NAT	3	FL2C	1.03	1.50	C	U	Riparian Mosaics; Harvested Section
Squeezer Cr	Squ5	Lake	PC	PFOR	N	N		2350	40	0.3	250	MC/D	NAT	0.2	100	MC/D	NAT	3	FL2C	1.05	1.12	C	U	Riparian Mosaic; Harvested Sect
Squeezer Cr	Squ6	Lake	PC	PFOR	N	N		2075	40	0.5	300	MC	NAT	0.2	50	MC	BR	3	FL2C	1.04	2.19	B	U	Riparian Harvest RRT; Bank Condition?; Sinuosity & Slope Averaged
Squeezer Cr	Squ7	Lake	DNRC	SFOR	N	N		850	30	0.7	300	MC	NAT	0.7	300	MC	NAT	3	FL2C	1.04	2.79	B	C	No Harvest DNRC Sect; Sinuosity & Slope Averaged
Squeezer Cr	Squ7.1	Lake	DNRC	SFOR	N	N		500	30	0.7	300	MC	NAT	0.7	300	MC	NAT	3	NL2A	1.04	2.79	B	C	No Harvest DNRC Sect; Sinuosity & Slope Averaged
Squeezer Cr	Squ8	Lake	PC	PFOR	N	N		2250	30	0.7	300	MC	NAT	0.7	300	MC	NAT	3	NL2A	1.05	1.94	C	M	Nice Riparian Stand
Squeezer Cr	Squ9	Lake	PC	PFOR	N	Y		1400	30	0.7	250	MC	NAT	0.7	100	MC	NAT	3	NL2A	1.05	1.94	C	M	Old Riparian Road & Harvest
Squeezer Cr	Squ10	Lake	PC	PFOR	N	N		1750	20	0.7	150	MC	NAT	0.7	150	MC	NAT	3	NL2A	1.07	4.92	A	C	Harvests; Select RRT; CC RLF; Road Crossing; Sinuosity & Slope Averaged

Table A1. 2001 Stream Channel and Riparian Condition Reach Assessment Data

Stream Name	Reach Name	County	Owner	Land Use	Grizzly Bear Linkage	Impervious Surface	Riparian Structures	Reach Length (ft)	Active Channel (ft)	LB Canopy Density	LB Buffer (ft)	LB Vegetation	LB Bank Condition	RB Canopy Density	RB Buffer (ft)	RB Vegetation	RB Bank Condition	Stream Order	Riparian Land Type	Channel Sinuosity	Stream Slope	Rosgen Level 1 Channel	Channel Confinement	COMMENTS / DISTURBANCE
Squeezer Cr	Squ10.1	Lake	PC	PFOR	N	N		1850	20	0.7	150	MC	NAT	0.7	150	MC	NAT	3	SL2A	1.07	4.92	A	C	Harvests; Select RRT; CC RLF; Road Crossing; Sinuosity & Slope Averaged
Squeezer Cr	Squ11	Lake	DNRC	SFOR	N	N		1575	20	0.6	300	MC	NAT	0.6	300	MC	NAT	3	SL2A	1.04	10.33	A	C	
Squeezer Cr	Squ12	Lake	DNRC	SFOR	N	N		3150	20	0.8	300	MC	NAT	0.8	250	MC	NAT	3	SL2A	1.00	9.72	A	C	Dense Riparian; Road & Harvested-RLF
Squeezer Cr	Squ13	Lake	DNRC	SFOR	N	N		925	15	0.8	300	MC	NAT	0.8	200	MC	NAT	3	MS4A	1.00	20.65	Aa	C	Nick Point; Steep Channel; Talus Slopes RRT
Squeezer Cr	Squ14	Lake	PC	PFOR	N	N		2530	15	0.8	300	MC	NAT	0.8	250	MC	NAT	3	SL2A	1.00	6.83	A	C	Talus Slope RRT
Squeezer Cr	Squ15	Lake	PC	PFOR	N	N		2775	15	0.8	300	MC	NAT	0.8	300	MC	NAT	3	SL2A	1.00	8.14	A	C	
Jim Cr	Jim1	Lake	PVT	NR	N	N		2550	80	0.1	300	WET	NAT	0.1	300	WET	NAT	3	FL2D	1.43	0.53	E	U	No Development / Intrusion (97); Riparian Mosaic
Jim Cr	Jim2	Lake	PVT	NR	N	N		2250	80	0.1	300	WET	NAT	0.1	300	WET	NAT	3	FL2D	1.13	0.69	C	U	No Development / Intrusion (97); Riparian Mosaic
Jim Cr	Jim3	Lake	PC	PFOR	N	N		1750	80	0.1	100	MC/D	NAT	0.1	100	MC/D	NAT	3	FL2D	1.13	0.69	C	U	No Obvious Riparian Management; Old Bridge Site
Jim Cr	Jim4	Lake	PC	PFOR	N	Y		2425	60	0.1	100	MC/D	NAT	0.1	100	MC/D	NAT	3	FL2C	1.13	0.69	C	U	Old Access Road RRT; Riparian Mosaics (Old Harvest?)
Jim Cr	Jim5	Lake	PVT	NR	N	Y	6	2675	40	0.4	150	MC	NAT	0.6	300	MC	NAT	3	FL2C	1.08	2.26	B	M	Residential Development RLF; Sinuosity & Slope Averaged
Jim Cr	Jim6	Lake	USFS	NFOR	N	Y		850	40	0.5	300	MC	NAT	0.6	300	MC	NAT	3	MS5A	1.04	3.14	B	M	System Road Crossing; Private Access Rd-RLF
Jim Cr	Jim7	Lake	USFS	NFOR	N	N		1350	30	0.5	300	MC	NAT	0.8	300	MC	NAT	3	MS5A	1.30	2.91	B	M	No Intrusions
Jim Cr	Jim8	Lake	PC	PFOR	N	N		1375	30	0.6	250	MC	NAT	0.7	300	MC	NAT	3	MS5A	1.15	2.25	B	M	
Jim Cr	Jim9	Lake	PC	PFOR	N	N		1000	30	0.7	300	MC	NAT	0.7	200	MC	NAT	3	MS5A	1.09	2.52	B	M	

Table A1. 2001 Stream Channel and Riparian Condition Reach Assessment Data

Stream Name	Reach Name	County	Owner	Land Use	Grizzly Bear Linkage	Impervious Surface	Riparian Structures	Reach Length (ft)	Active Channel (ft)	LB Canopy Density	LB Buffer (ft)	LB Vegetation	LB Bank Condition	RB Canopy Density	RB Buffer (ft)	RB Vegetation	RB Bank Condition	Stream Order	Riparian Land Type	Channel Sinuosity	Stream Slope	Rosgen Level 1 Channel	Channel Confinement	COMMENTS / DISTURBANCE
Jim Cr	Jim10	Lake	PC	PFOR	N	N		1700	25	0.0	0	WET	NAT	0.5	150	MC/D	NAT	3	MS5A	1.15	0.81	C	U	Riparian Meadow-RLF; Sinuosity & Slope Averaged
Jim Cr	Jim11	Lake	USFS	NFOR	N	Y		550	25	0.2	300	MC/D	NAT	0.2	300	MC/D	NAT	3	NL1E	1.06	5.63	A	U	Riparian Meadows / Mosaic
Jim Cr	Jim12	Lake	USFS	NFOR	N	N		1750	25	0.7	300	MC	NAT	0.7	300	MC	NAT	3	NL2A	1.03	6.52	A	M	
Jim Cr	Jim13	Lake	USFS	NFOR	N	N		750	20	0.7	150	MC	NAT	0.7	300	MC	NAT	3	NL2A	1.04	7.66	A	M	CC w/ Buffer-RLF
Jim Cr	Jim14	Lake	USFS	NFOR	N	N		2475	20	0.7	300	MC	NAT	0.7	300	MC	NAT	3	SL2A	1.02	5.85	A	M	Sinuosity & Slope Averaged
Jim Cr	Jim15	Msla	PC	PFOR	N	Y		3225	15	0.6	150	MC	NAT	0.3	50	MC	NAT	3	SL2A	1.09	6.20	A	M	CC's Both Sides w/ Narrow Buffers; Sinuosity & Slope Averaged
Jim Cr	Jim16	Msla	PC	PFOR	N	Y		1600	15	0.6	50	MC	NAT	0.5	50	MC	NAT	3	SL2A	1.03	9.81	A	C	CCs RLF/RRT; Thin Buffer; Sinuosity & Slope Averaged
Jim Cr	Jim17	Msla	PC	PFOR	N	N		1000	15	0.7	100	MC	NAT	0.7	100	MC	NAT	3	SL2A	1.01	5.90	A	C	CC's w/ Buffers
Jim Cr	Jim18	Msla	USFS	NFOR	Y	N		2950	15	0.8	300	MC	NAT	0.8	300	MC	NAT	3	SL2A	1.02	8.27	A	C	Intact Forest Stand; Sinuosity & Slope Averaged
Jim Cr	Jim19	Msla	USFS	NFOR	Y	N		950	15	0.8	300	MC	NAT	0.8	300	MC	NAT	3	MS4A	1.01	20.42	Aa	C	Steeps / Cataract; Change in Gradient
Jim Cr	Jim20	Msla	USFS	NFOR	Y	N		1025	15	0.5	300	WET	NAT	0.5	300	WET	NAT	3	SL5A	1.14	0.40	C	M	Riparian Meadow / Mosaic; Sinuosity & Slope Averaged
Jim Cr	Jim21	Msla	USFS	NFOR	Y	N		375	15	0.7	300	MC	NAT	0.7	300	MC	NAT	3	MS4A	1.10	15.61	Aa	C	Steeps / Cataract; Change in Gradient
Jim Cr	Jim22	Msla	PC	PFOR	Y	Y		3975	15	0.2	50	MC	BR	0.2	50	MC	BR	3	NL2A	1.14	2.43	B	M	Riparian Harvest; Possible Bank Erosion / Sediment Accumulation; Sinuosity & Slope Averaged
Jim Cr	Jim23	Msla	PC	PFOR	Y	N		675	15	0.2	100	MC	NAT	0.1	50	MC	NAT	3	MS3A	1.00	29.82	Aa	C	Steeps / Cataract; CC; Rip Harvests
Jim Cr	Jim24	Msla	PC	PFOR	Y	N		2575	25	0.2	100	MC	BR	0.2	100	MC	BR	3	SL2A	1.07	7.54	A	C	Riparian Harvests; Old Ghost Roads; Channel Widening?
Jim Cr	Jim25	Msla	PC	PFOR	Y	Y		2525	40	0.1	25	MC	BR	0.1	25	MC	BR	3	SL2A	1.05	0.95	C	C	Riparian Harvest; Non-FPA Buffer; Blown Channel; Sinuosity & Slope Averaged

Table A1. 2001 Stream Channel and Riparian Condition Reach Assessment Data

Stream Name	Reach Name	County	Owner	Land Use	Grizzly Bear Linkage	Impervious Surface	Riparian Structures	Reach Length (ft)	Active Channel (ft)	LB Canopy Density	LB Buffer (ft)	LB Vegetation	LB Bank Condition	RB Canopy Density	RB Buffer (ft)	RB Vegetation	RB Bank Condition	Stream Order	Riparian Land Type	Channel Sinuosity	Stream Slope	Rosgen Level 1 Channel	Channel Confinement	COMMENTS / DISTURBANCE
Jim Cr	Jim26	Msla	PC	PFOR	Y	N		900	400	0.1	50	MC	NAT	0.1	50	MC	NAT	3	NL1E	N/A	0.00		U	Unnamed Lake - CC w/ Minimal Buffer
Jim Cr	Jim27	Msla	PC	PFOR	Y	N		625	20	0.1	50	MC	BR	0.2	100	MC/D	BR	3	SL2A	1.12	0.06	C	M	Channel Bottom Influenced by fluctuating Lake Elevation
Jim Cr	Jim28	Msla	PC	PFOR	Y	N		500	15	0.3	50	MC	NAT	0.4	100	MC/D	NAT	3	SL2A	1.30	2.11	B	C	Harvests and Ghost Roads
Jim Cr	Jim29	Msla	PC	PFOR	Y	Y		1225	1300	0.6	200	MC	NAT	0.2	50	MC	NAT	3	NL1E	N/A	0.00		U	Jim Lake- Clear Cut & Roaded; Delta
Jim Cr	Jim30	Msla	PC	PFOR	Y	N		1150	40	0.0	0	HB	BR	0.1	25	WDY	BR	3	SL5A	1.30	2.11	B	C	No Buffer; Clear Cut; Blown Channel-Lake Delta
Jim Cr	Jim31	Msla	USFS	NFOR	Y	N		1625	20	0.2	25	MC	NAT	0.5	300	MC	NAT	3	SL5A	1.30	2.11	B	C	N-Side-Riparian Harvest on PCT Parcel
Piper Cr	Pip1	Lake	USFS	NFOR	Y	N		800	25	0.4	300	MC	NAT	0.3	300	MC	NAT	3	FL2D	1.02	0.54	C	M	Riparian Mosaic (Tree / Meadow)
Piper Cr	Pip1.1	Lake	USFS	NFOR	Y	N		375	25	0.4	300	MC	NAT	0.3	300	MC	NAT	3	NL2A	1.02	0.54	C	M	Riparian Mosaic (Tree / Meadow)
Piper Cr	Pip2	Lake	PVT	NR	Y	Y	5	2450	25	0.4	300	MC/D	NAT	0.2	25	MC/D	BR	3	NL2A	1.12	2.12	B	M	Road Crossing; RRT Developed; Minimal Veg; Slope Averaged
Piper Cr	Pip3	Lake	PVT	NR	Y	Y	8	900	25	0.5	300	MC/D	NAT	0.4	300	MC/D	NAT	3	NL2A	1.12	2.12	B	M	Developed RRT; Better Veg; Slope Averaged
Piper Cr	Pip4	Lake	USFS	NFOR	Y	N		575	25	0.5	300	MC	NAT	0.5	300	MC	NAT	3	NL2A	1.12	2.77	B	M	Harvested w/ Buffer
Piper Cr	Pip5	Lake	USFS	NFOR	Y	Y		1925	25	0.5	150	MC	NAT	0.5	150	MC	NAT	3	NL2A	1.01	2.80	B	M	Road Crossing; Harvest w/ Minimal Buffer; Sinuosity & Slope Averaged
Piper Cr	Pip6	Lake	USFS	NFOR	Y	N		1100	25	0.7	300	MC	NAT	0.7	300	MC	NAT	3	NL2A	1.01	5.87	A	M	
Piper Cr	Pip7	Lake	PC	PFOR	Y	N		2875	25	0.4	25	MC	NAT	0.6	200	MC	NAT	3	SL2A	1.02	5.74	A	M	CC Beyond Buffer; Sinuosity & Slope Averaged
Piper Cr	Pip8	Lake	USFS	NFOR	Y	N		1575	30	0.7	150	MC	NAT	0.8	300	MC	NAT	3	SL2A	1.01	6.59	A	M	CC Beyond Buffer

Table A1. 2001 Stream Channel and Riparian Condition Reach Assessment Data

Stream Name	Reach Name	County	Owner	Land Use	Grizzly Bear Linkage	Impervious Surface	Riparian Structures	Reach Length (ft)	Active Channel (ft)	LB Canopy Density	LB Buffer (ft)	LB Vegetation	LB Bank Condition	RB Canopy Density	RB Buffer (ft)	RB Vegetation	RB Bank Condition	Stream Order	Riparian Land Type	Channel Sinuosity	Stream Slope	Rosgen Level 1 Channel	Channel Confinement	COMMENTS / DISTURBANCE
Piper Cr	Pip9	Lake	USFS	NFOR	Y	N		725	30	0.8	300	MC	NAT	0.8	300	MC	NAT	3	SL2A	1.17	4.15	A	M	CC Just u/s on PCTC Parcel
Piper Cr	Pip10	Lake	PC	PFOR	Y	N		1575	40	0.5	100	MC/D	NAT	0.2	25	MC/D	BR	3	MS5A	1.13	2.93	B	M	FPA Buffer; Mass Failure-Left Slope; Sinuosity & Slope Averaged
Piper Cr	Pip11	Lake	USFS	NFOR	Y	N		3175	40	0.7	300	MC	NAT	0.7	300	MC	NAT	3	MS5A	1.06	0.67	C	M	Riparian Mosaics; Sinuosity & Slope Averaged
Piper Cr	Pip11.1	Lake	PC	PFOR	Y	N		1950	25	0.3	50	MC	NAT	0.8	300	MC	NAT	3	MS5A	1.02	7.10	A	C	CC N-Side; Buffer S-Side; Sinuosity & Slope Averaged
Piper Cr	Pip12	Lake	PC	PFOR	Y	N		1950	25	0.3	50	MC	NAT	0.8	300	MC	NAT	3	SL3B	1.02	7.10	A	C	CC N-Side; Buffer S-Side; Sinuosity & Slope Averaged
Piper Cr	Pip13	Lake	PC	PFOR	Y	Y		1125	20	0.3	50	MC	NAT	0.7	300	MC	NAT	2	SL3B	1.06	9.76	A	C	CC N-Side; Buffer w/ Road S-Side; Sinuosity & Slope Averaged
Piper Cr	Pip14	Lake	PC	PFOR	Y	N		1375	20	0.6	300	MC	NAT	0.6	300	MC	NAT	2	MS5A	1.02	5.17	A	U	Good Riparian Stand
Piper Cr	Pip15	Lake	PC	PFOR	Y	Y		3225	20	0.3	100	MC	NAT	0.6	50	MC	NAT	2	MS5A	1.08	7.09	A	C	FPA Buffers w/ Harvests; Road S-Side; Sinuosity & Slope Averaged
Piper Cr	Pip15.1	Lake	USFS	NFOR	Y	N		1275	15	0.7	300	MC	NAT	0.8	300	MC	NAT	2	MS5A	1.04	7.99	A	C	No Intrusive Management; Sinuosity & Slope Averaged
Piper Cr	Pip16	Lake	USFS	NFOR	Y	N		2925	15	0.7	300	MC	NAT	0.8	300	MC	NAT	2	SL2A	1.04	7.99	A	C	No Intrusive Management; End @ Wilderness; Sinuosity & Slope Averaged
Swan River	Swn1	Lake	FWS	CONS.	N	N		9550	350			WET	NAT			WET	NAT		NL1E	1.06	0.41	C	U	Refuge
Swan River	Swn2	Lake	Dual	MIX	N	N		1425	350			WET	NAT			MC	NAT		NL1E	1.19	0.29	C	U	RLF-Refuge; RRT Private
Swan River	Swn3	Lake	Dual	MIX	N	N		2225	350			WET	NAT			MC	NAT		NL1E	1.19	0.29	C	U	RLF-Private; RRT Refuge
Swan River	Swn4	Lake	PVT	NR	N	N		1200	300	0.6	300	MC	NAT	0.4	300	MC	NAT		FL1C	1.13	0.09	C	U	
Swan River	Swn5	Lake	USFS	NFOR	N	N		2425	300	0.4	300	MC/D	NAT	0.4	300	MC/D	NAT		FL1C	1.13	0.09	C	U	Mosaic of Meadow & Conifer Stands

Table A1. 2001 Stream Channel and Riparian Condition Reach Assessment Data

Stream Name	Reach Name	County	Owner	Land Use	Grizzly Bear Linkage	Impervious Surface	Riparian Structures	Reach Length (ft)	Active Channel (ft)	LB Canopy Density	LB Buffer (ft)	LB Vegetation	LB Bank Condition	RB Canopy Density	RB Buffer (ft)	RB Vegetation	RB Bank Condition	Stream Order	Riparian Land Type	Channel Sinuosity	Stream Slope	Rosgen Level 1 Channel	Channel Confinement	COMMENTS / DISTURBANCE
Swan River	Swn6	Lake	Dual	MIX	N	N		1525	300	0.3	250	MC/D	NAT	0.4	250	MC/D	NAT		FL1C	1.13	0.09	C	U	RLF Private; RRT Refuge
Swan River	Swn7	Lake	USFS	NFOR	N	N		3675	300	0.6	300	MC/D	NAT	0.6	300	MC/D	NAT		FL1C	1.13	0.09	C	U	Large Meander Bends; Point Bars
Swan River	Swn8	Lake	PVT	NR	N	Y		1100	300	0.2	300	MC/D	NAT	0.3	300	MC/D	NAT		FL1C	1.13	0.09	C	U	Bridge Crossing; River Access; Gildart Cr Confluence
Swan River	Swn9	Lake	PVT	NR	N	N		1675	300	0.2	300	MC/D	NAT	0.5	300	MC/D	NAT		FL1C	1.11	0.40	C	U	
Swan River	Swn10	Lake	PVT-C	CONS.	N	N		1400	250		200	HB	NAT	0.1	250	MC	NAT		FL1C	1.11	0.40	C	U	RLF-HB Veg w/ Conifer Beyond; RRT Mosaic
Swan River	Swn11	Lake	USFS	NFOR	N	N		10250	250	0.4	300	MC	NAT	0.4	300	MC	NAT		FL1C	1.16	0.82	Da	U	Old Harvest Units?; Lost Cr. Confluence
Swan River	Swn12	Lake	USFS	NFOR	N	Y		4575	250		300	WET	NAT		300	MC	NAT		FL1C	1.08	0.15	C	U	Picnic Area RRT
Swan River	Swn13	Lake	PVT	NR	N	Y		1275	250	0.5	300	MC/D	NAT	0.7	100	MC	NAT		FL1C	1.08	0.16	C	U	Private Access Road-RRT; Wetland Behind Buffer-RRT
Swan River	Swn14	Lake	USFS	NFOR	N	N		3900	300	0.4	300	MC/D	NAT	0.5	150	MC/D	NAT		FL1C	1.08	0.16	C	U	Forest / Wetland Mosaics
Swan River	Swn15	Lake	USFS	NFOR	N	N		1875	300	0.6	300	MC/D	NAT	0.6	300	MC/D	NAT		FL2D	1.08	0.16	C	U	
Swan River	Swn16	Lake	DNRC	SFOR	N	N		1350	300	0.6	300	MC/D	NAT	0.6	300	MC/D	NAT		FL2D	1.08	0.16	D	U	
Swan River	Swn17	Lake	USFS	NFOR	N	N		1225	300	0.4	300	MC/D	NAT	0.6	300	MC/D	NAT		FL2D	1.28	0.30	D	U	
Swan River	Swn18	Lake	PVT	RS	N	Y	1	1850	300	0.3	150	MC/D	NAT	0.2	100	MC	NAT		FL2D	1.28	0.30	C	U	RLF-Point Bar; RRT Airstrip
Swan River	Swn19	Lake	USFS	NFOR	N	N		2575	300	0.6	300	MC	NAT	0.3	300	MC/D	NAT		FL2D	1.15	0.05	Da	U	
Swan River	Swn20	Lake	Dual	MIX	N	N		800	600	0.7	300	MC	NAT	0.3	50	MC	BR		FL2D	1.18	0.05	Da	U	RLF-FNF; RRT-PVT; Eroding Bank
Swan River	Swn21	Lake	USFS	NFOR	N	N		1525	300	0.7	300	MC	NAT	0.7	300	MC	NAT		FL2D	1.08	1.32	Da	U	Channel Disturbance Zone ≈ 1600 ft

Table A1. 2001 Stream Channel and Riparian Condition Reach Assessment Data																								
Stream Name	Reach Name	County	Owner	Land Use	Grizzly Bear Linkage	Impervious Surface	Riparian Structures	Reach Length (ft)	Active Channel (ft)	LB Canopy Density	LB Buffer (ft)	LB Vegetation	LB Bank Condition	RB Canopy Density	RB Buffer (ft)	RB Vegetation	RB Bank Condition	Stream Order	Riparian Land Type	Channel Sinuosity	Stream Slope	Rosgen Level 1 Channel	Channel Confinement	COMMENTS / DISTURBANCE
Swan River	Swn22	Lake	DNRC	SFOR	Y	N		4825	300	0.5	300	MC	NAT	0.6	300	MC	NAT		FL2D	1.17	0.49	C	U	RRT-Forest / Wetland Mosaic
Swan River	Swn23	Lake	DNRC	SFOR	Y	Y		4425	300			MC/D	NAT			MC/D	NAT		FL2D	1.17	0.49	Da	U	Forest / Wetland Mosaic
Swan River	Swn24	Lake	DNRC	SFOR	Y	N		725	200	0.6	150	MC/D	NAT				BR		FL2D	1.17	0.49	C	U	RRT-Steep, Bare Cut Bank
Swan River	Swn25	Lake	DNRC	SFOR	Y	N		4925	250			MC/D	NAT			MC/D	NAT		FL2D	1.16	0.32	Da	U	Forest / Wetland Mosaic
Swan River	Swn26	Lake	PC	PFOR	Y	N		1000	250			MC/D	NAT			MC/D	NAT		FL2D	1.02	1.03	Da	U	Forest / Wetland Mosaic
Swan River	Swn27	Lake	DNRC	SFOR	Y	N		6500	250			MC/D	NAT			MC/D	NAT		FL2D	1.08	0.49	Da	U	Forest / Wetland Mosaic
Swan River	Swn28	Lake	PC1	PFOR	Y	N		5200	250			MC/D	NAT			MC/D	NAT		FL2D	1.20	0.43	Da	U	Forest / Wetland Mosaic; Woodward Cr. Confluence
Swan River	Swn29	Lake	PC1	PFOR	Y	N		1025	25			MC/D	NAT			MC/D	NAT		FL2D	1.14	0.28	Da	U	
Swan River	Swn30	Lake	DNRC	SFOR	Y	N		2550	250			MC/D	NAT			HB	BR		FL2D	1.14	0.28	Da	U	RRT-Few Conifers; Bare, Vertical Bank
Swan River	Swn31	Lake	PC1	PFOR	Y	N		4425	300			MC/D	NAT			MC/D	NAT		FL2D	1.08	0.66	Da	U	Forest / Meadow Mosaic
Swan River	Swn32	Lake	DNRC	SFOR	N	N		825	250	0.3	300	MC/D	NAT	0.6	100	MC/D	NAT		FL2D	1.03	1.40	C	U	Forest / Meadow Mosaic
Swan River	Swn33	Lake	DNRC	SFOR	N	N		1475	250	0.2	200	MC/D	NAT	0.1	100	MC/D	NAT		FL2D	1.01	0.05	C	U	RRT-SRSF HQ
Swan River	Swn34	Lake	DNRC	SFOR	N	N		1750	250	0.3	300	MC/D	NAT	0.6	300	MC/D	NAT		FL2D	1.25	0.98	C	U	RRT-SRSF HQ
Swan River	Swn35	Lake	DNRC	SFOR	N	N		1700	200	0.5	300	MC/D	NAT	0.5	250	MC	NAT		FL2D	1.48	0.98	C	U	RRT-SRSF HQ
Swan River	Swn36	Lake	DNRC	SFOR	N	Y		1475	200	0.5	300	MC	NAT	0.4	100	MC/D	NAT		FL2D	1.01	0.53	C	U	RLF-Campground; River Access; Bridge Crossing
Swan River	Swn37	Lake	PVT	NR	N	N		1350	200	0.5	50	MC	NAT	0.6	50	MC	NAT		FL2D	1.01	0.53	C	U	RRT-Homesite Development within 1000'

Table A1. 2001 Stream Channel and Riparian Condition Reach Assessment Data

Stream Name	Reach Name	County	Owner	Land Use	Grizzly Bear Linkage	Impervious Surface	Riparian Structures	Reach Length (ft)	Active Channel (ft)	LB Canopy Density	LB Buffer (ft)	LB Vegetation	LB Bank Condition	RB Canopy Density	RB Buffer (ft)	RB Vegetation	RB Bank Condition	Stream Order	Riparian Land Type	Channel Sinuosity	Stream Slope	Rosgen Level 1 Channel	Channel Confinement	COMMENTS / DISTURBANCE
Swan River	Swn38	Lake	USFS	NFOR	N	N		575	200	0.2	100	MC	BR	0.8	300	MC	NAT		FL2D	1.23	0.37	C	U	RLF-Narrow Buffer; Large Meadow
Swan River	Swn39	Lake	PVT	NR	N	N		1375	200	0.7	300	MC/D	NAT	0.8	300	MC	NAT		FL2D	1.23	0.37	C	U	Large River Bend / Point Bar
Swan River	Swn40	Lake	USFS	NFOR	N	N		1800	200	0.6	100	MC/D	NAT	0.6	300	MC	BR		FL2D	1.23	0.37	C	U	Channel Migration Toward RRT
Swan River	Swn41	Lake	Dual	MIX	N	N	4	600	200			HB	BR	0.4	300	MC	NAT		FL2D	1.23	0.37	Da	U	RLF-PVT; Meadow / Homesite; RRT-FNF
Swan River	Swn42	Lake	USFS	NFOR	N	N		1300	250		200	WDY	BR	0.5	300	MC	NAT		FL2D	1.23	0.37	C	U	
Swan River	Swn43	Lake	DNRC	SFOR	N	N		1300	200	0.6	300	MC	NAT	0.7	300	MC	NAT		FL2D	1.23	0.37	C	U	
Swan River	Swn44	Lake	PVT	NR	N	N	4	825	200		50	HB	NAT	0.7	300	MC	NAT		FL2D	1.23	0.37	D	U	RLF; Bank Veg herbaceous but Appears Intact
Swan River	Swn45	Lake	DNRC	SFOR	N	N		4300	200	0.4	300	MC/D	NAT	0.7	300	MC/D	NAT		FL2D	1.08	0.38	C	U	
Swan River	Swn46	Lake	PVT	NR	N	Y	11	2925	200	0.3	300	MC/D	NAT	0.3	300	MC	NAT		FL2D	1.12	0.34	C	U	RRT-Development; RLF - 2 Structures
Swan River	Swn47	Lake	PVT	NR	N	Y		1075	200	0.8	300	MC	NAT	0.5	300	MC/D	NAT		FL2D	1.12	0.30	C	U	RLF-Second Growth Forest
Swan River	Swn48	Lake	PVT	NR	N	N		1225	200	0.6	150	MC/D	NAT	0.5	300	MC/D	NAT		FL2D	1.12	0.30	C	U	RLF-Forest / Wetland Mosaic
Swan River	Swn49	Lake	PVT	NR	N	N	4	1325	250	0.5	100	MC/D	NAT	0.2	100	MC	BR		FL2D	1.12	0.30	C	U	RRT-Structures Near Unprotected Bank
Swan River	Swn50	Lake	DNRC	SFOR	N	N		1100	200	0.8	300	MC	NAT				BR		FL2D	1.12	0.30	C	U	RRT-Steep Eroding Cutbank (Outside Bend)
Swan River	Swn51	Lake	PVT	NR	N	N		1050	250				BR				BR		FL2D	1.12	0.30	Da	U	Forested / Wetland Anastomosed Area; Cut Banks
Swan River	Swn52	Lake	PC	PFOR	N	N		3700	250				BR				BR		FL2D	1.12	0.30	Da	U	Forested / Wetland Anastomosed Area; Cut Banks
Swan River	Swn53	Lake	PVT	NR	Y	N	3	3025	250				BR	0.2	300	MC/D	NAT		FL2D	1.12	0.30	C	U	RLF-Ranch Houses; Exposed Banks?

Table A1. 2001 Stream Channel and Riparian Condition Reach Assessment Data

Stream Name	Reach Name	County	Owner	Land Use	Grizzly Bear Linkage	Impervious Surface	Riparian Structures	Reach Length (ft)	Active Channel (ft)	LB Canopy Density	LB Buffer (ft)	LB Vegetation	LB Bank Condition	RB Canopy Density	RB Buffer (ft)	RB Vegetation	RB Bank Condition	Stream Order	Riparian Land Type	Channel Sinuosity	Stream Slope	Rosgen Level 1 Channel	Channel Confinement	COMMENTS / DISTURBANCE
Swan River	Swn54	Lake	PC1	PFOR	Y	N		1875	200	0.4	300	MC/D	NAT	0.3	300	MC/D	NAT		FL2D	1.12	0.30	C	U	
Swan River	Swn55	Lake	PVT	PFOR	Y	N		1550	200	0.3	100	MC/D	NAT	0.7	300	MC	BR		FL2D	1.11	0.38	C	U	RLF - Vegetating Point Bar; RRT – second Growth
Swan River	Swn56	Lake	Dual	MIX	Y	N		1175	200	0.7	100	MC/D	NAT	0.6	300	MC/D	NAT		FL2D	1.05	0.90	C	U	RRT: FNF; RLF: PCTC, Post '97 Harvest, Reduced Buffer Width & Destiny?
Swan River	Swn57	Lake	USFS	NFOR	Y	N		675	200	0.7	300	MC/D	NAT	0.7	300	MC/D	NAT		FL2D	1.04	0.73	C	U	Piper Cr. Confluence
Swan River	Swn58	Lake	USFS	NFOR	Y	N		1925	200	0.7	250	MC/D	NAT	0.7	300	MC/D	NAT		FL2D	1.13	0.40	C	U	Bridge Crossing
Swan River	Swn59	Lake	PC	PFOR	Y	N		850	275	0.3	300	MC/D	BR	0.2	300	MC/D	NAT		FL2D	1.13	0.40	C	U	Thin Buffer; Riparian Harvest?; Post '97 Harvests
Swan River	Swn60	Lake	PC	PFOR	Y	N		700	275	0.0			BR	0.3	300	MC/D	NAT		FL2D	1.13	0.40	C	U	Riparian Harvest: RLF; Post '97 Harvests
Swan River	Swn61	Lake	PC	PFOR	Y	Y		1650	275	0.6	300	MC	NAT	0.4	300	MC/D	NAT		FL2D	1.13	0.40	Da	U	High Flow Side Channel; Channel Bars; Post '97 Harvests
Swan River	Swn62	Lake	PC	PFOR	Y	N		4050	275	0.5	300	MC	NAT	0.1	100	MC	NAT		FL2D	1.13	0.40	C	U	Riparian Harvest: RRT; Post '97 Harvest
Swan River	Swn63	Lake	PC	PFOR	Y	N		850	300	0.3	200	MC	NAT	0.3	200	MC	NAT		FL1C	1.07	0.67	Da	U	New Channel (Post 1990); Distance is New Channel Est.
Swan River	Swn64	Lake	PVT	RS	N	N		1475	300	0.0		HB	BR	0.3	300	MC/D	NAT		FL1C	1.07	0.67	C	U	Field w/ High Flow Channel: RRT
Swan River	Swn65	Lake	PVT	RS	N	N		1025	300	0.1	50	MC/D	BR	0.0			BR		FL2D	1.07	0.67	C	U	Bare Cut Bank: RRT
Swan River	Swn66	Lake	PVT	RS	N	N		1900	325	0.0		HB	NAT	0.3	150	MC	NAT		FL2D	1.21	0.08	Da	U	Large Channel Island & Migration Zone
Swan River	Swn67	Lake	PVT	RS	N	N		475	325	0.0		WDY	NAT	0.0			BR		FL2D	1.09	0.49	Da	U	Bare Cut Bank: RRT; Channel Bars; Jim Cr.
Swan River	Swn68	Lake	PVT	RS	N	N		1900	325	0.2	300	MD/C	BR	0.2	300	MD/C	BR		FL2D	1.09	0.49	Da	U	Large Channel Bars, Shifting Channel
Swan River	Swn69	Lake	PVT	NR	N	N		3050	350	0.3	300	MD/C	BR	0.4	300	MD/C	BR		FL2D	1.13	0.41	Da	U	Large Channel Bars, Shifting Channel

Table A1. 2001 Stream Channel and Riparian Condition Reach Assessment Data

Stream Name	Reach Name	County	Owner	Land Use	Grizzly Bear Linkage	Impervious Surface	Riparian Structures	Reach Length (ft)	Active Channel (ft)	LB Canopy Density	LB Buffer (ft)	LB Vegetation	LB Bank Condition	RB Canopy Density	RB Buffer (ft)	RB Vegetation	RB Bank Condition	Stream Order	Riparian Land Type	Channel Sinuosity	Stream Slope	Rosgen Level 1 Channel	Channel Confinement	COMMENTS / DISTURBANCE
Swan River	Swn70	Lake	PVT	RS	N	N	1	1750	325	0.0	300	HB	BR	0.4	300	MD/C	NAT		FL2D	1.17	0.32	C	U	Meadow/ Field RLF; Post '97 Harvest-RRT
Swan River	Swn71	Lake	PVT	NR	N	N	3	650	275	0.7	300	MD/C	BR	0.5	300	MC	BR		FL2D	1.17	0.32	C	U	Bare Banks; Salmon Prairie, Post '97 Harvest?-RLF
Swan River	Swn72	Lake	PVT	RS	N	Y	2	1200	300	0.1	20	MC	BR	0.4	300	MC/D	NAT		FL2D	1.17	0.32	C	U	Bare Outside Bend w/ Farm Road On Top
Swan River	Swn73	Lake	PVT	NR	N	Y	6	1225	300	0.3	300	MC	BR	0.0			BR		FL2D	1.03	0.93	C	U	Riparian Roads/ Structures; Steep, Bare Banks?
Swan River	Swn74	Lake	PVT	NR	N	N	1	1075	300	0.5	300	MC	BR	0.3	100	MC	NAT		FL2D	1.05	0.96	C	U	Large Outside Cut Bank-Vegetated
Swan River	Swn75	Lake	PVT	NR	N	N		700	225	0.0			BR	0.7	300	MC/D	NAT		FL2D	1.05	0.96	C	U	Bare Cut Bank: RLF
Swan River	Swn76	Lake	PVT	NR	N	N		2550	225	0.4	300	MC/D	NAT	0.5	300	MC/D	NAT		FL2D	1.08	1.19	C	U	Riparian Harvests/ Thinning
Swan River	Swn77	Lake	USFS	NFOR	Y	N		1225	225	0.2	300	MC	NAT	0.7	300	MC	BR		FL2D	1.08	1.49	C	U	Bare Cut Bank: RRT
Swan River	Swn78	Lake	USFS	NFOR	Y	N		750	275	0.8	300	MC	NAT	0.8	300	MC	NAT		FL2D	1.08	1.49	C	U	Vegetated Point Bar and Outside Bank
Swan River	Swn79	Lake	USFS	NFOR	Y	N		950	300	0.8	300	MC	NAT	0.1	300	MC	NAT		FL2D	1.16	0.15	C	U	Riparian Meadow
Swan River	Swn80	Lake	USFS	NFOR	Y	N		350	300	0.8	300	MC	NAT	0.1	300	MC	NAT		FL2D	1.11	1.15	C	U	Large Meander Bend w/ High Flow Channels
Swan River	Swn81	Lake	PVT	NR	Y	N		700	300	0.1	300	MC	BR	0.0		WDY	BR		FL2D	1.11	1.15	C	U	Large Meander Bend w/ High Flow Channels
Swan River	Swn82	Lake	PVT	NR	Y	N		925	250	0.6	150	MC	BR	0.6	300	MC	NAT		FL2D	1.11	1.15	Da	U	Partially Vegetated Point Bar; High Flow Channel
Swan River	Swn83	Lake	PVT	NR	Y	N		2050	250	0.1	300	MC/D	NAT	0.1	300	MC/D	NAT		FL2D	1.13	0.67	Da	U	New Primary Channel (Post 1990)
Swan River	Swn84	Lake	PC1	PFOR	Y	N		2100	150	0.1	100	MC/D	NAT	0.0	300	WDY	NAT		FL2D	1.13	0.67	Da	U	Riparian Mosaic
Swan River	Swn85	Lake	PC1	PFOR	Y	N		925	150	0.6	100	MC	NAT	0.3	300	MC/D	NAT		FL2D	1.13	0.67	Da	U	Riparian Mosaic

Table A1. 2001 Stream Channel and Riparian Condition Reach Assessment Data

Stream Name	Reach Name	County	Owner	Land Use	Grizzly Bear Linkage	Impervious Surface	Riparian Structures	Reach Length (ft)	Active Channel (ft)	LB Canopy Density	LB Buffer (ft)	LB Vegetation	LB Bank Condition	RB Canopy Density	RB Buffer (ft)	RB Vegetation	RB Bank Condition	Stream Order	Riparian Land Type	Channel Sinuosity	Stream Slope	Rosgen Level 1 Channel	Channel Confinement	COMMENTS / DISTURBANCE
Swan River	Swn86	Msla	PVT	RS	Y	N	8	2150	100	0.0		WET	NAT	0.1	300	MC	NAT		FL2D	1.13	0.67	Da	U	Wetland: RLF; Riparian Harvest: RRT
Swan River	Swn87	Msla	PVT	NR	Y	N		1775	200	0.0		WET	NAT	0.0		WET	NAT		FL2D	1.13	0.67	C	U	Wetland Characteristics
Swan River	Swn88	Msla	PVT	NR	Y	N		1525	200	0.1	50	MC/D	BR	0.3	50	MD/C	NAT		FL2D	1.16	0.17	Da	U	Cut Bank: RLF
Swan River	Swn89	Msla	PVT	RS	N	N		1825	225	0.0		HB	NAT	0.0	100	WDY	NAT		FL2D	1.18	0.48	Da	U	Meadow: RLF
Swan River	Swn90	Msla	PVT	NR	N	N		1075	225	0.2	100	MC/D	NAT	0.0	300	WDY	NAT		FL2D	1.13	0.53	Da	U	Large Channel Bars; Multi-thread Channel
Swan River	Swn91	Msla	PC1	PFOR	N	Y		1475	475	0.5	300	MC	NAT	0.4	300	MC/D	BR		FL2D	1.13	0.53	D	U	Bridge crossing; Large Channel Bars!
Swan River	Swn92	Msla	PC1	PFOR	N	N		1725	250	0.2	300	MC/D	NAT	0.2	150	MD/C	BR		FL2D	1.13	0.53	Da	U	New Primary Channel; Large Exposed Bars/ Banks: RRT
Swan River	Swn93	Msla	PC1	PFOR	N	N		1975	250	0.2	300	MC/D	NAT	0.4	300	MD/C	BR		FL2D	1.13	0.53	Da	U	New Primary Channel
Swan River	Swn94	Msla	PVT	NR	N	Y		1550	300	0.4	300	WDY	BR	0.6	150	WDY	BR		FL2D	1.13	0.53	Da	U	Hwy 83 RRT, Large Channel Bars
Swan River	Swn95	Msla	PVT	NR	N	N		1775	200	0.3	300	MC	BR	0.3	300	MD	BR		FL2D	1.13	0.53	Da	U	Large Channel Bars; Migration zone
Swan River	Swn96	Msla	PC1	PFOR	Y	N		3500	300	0.2	50	MC	BR	0.2	300	MC	BR		FL2D	1.13	0.53	D	U	Riparian Harvests
Swan River	Swn97	Msla	Dual	MIX	Y	N		1000	300	0.3	300	MC	NAT	0.1	300	MC	NAT		FL2D	1.13	0.53	D	U	PC1-RRT; FNF-RLF; Lg Bars
Swan River	Swn98	Msla	PVT	PFOR	Y	N		1050	150	0.6	300	MC	NAT	0.2	300	MC/D	NAT		FL2D	1.15	0.12	C	U	Large Point Bars
Swan River	Swn99	Msla	Dual	MIX	Y	N		1300	200	0.6	300	MC	NAT	0.4	300	MC/D	NAT		FL2D	1.08	0.63	C	U	Large Point Bars
Swan River	Swn100	Msla	PVT	NR	Y	N		750	475	0.6	300	MC/D	NAT	0.3	200	MC/D	NAT		FL2D	1.18	0.59	Da	U	Large Channel Bars; Side Channel
Swan River	Swn101	Msla	USFS	NFOR	N	N		2550	300	0.6	300	MC/D	NAT	0.7	300	MC	NAT		FL2D	1.05	0.54	Da	U	Large Channel Bars; Side Channel

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Stream Name	Reach Name	County	Owner	Land Use	Grizzly Bear Linkage	Impervious Surface	Riparian Structures	Reach Length (ft)	Active Channel (ft)	LB Canopy Density	LB Buffer (ft)	LB Vegetation	LB Bank Condition	RB Canopy Density	RB Buffer (ft)	RB Vegetation	RB Bank Condition	Stream Order	Riparian Land Type	Channel Sinuosity	Stream Slope	Rosgen Level 1 Channel	Channel Confinement	COMMENTS / DISTURBANCE
Swan River	Swn102	Msla	PVT	RS	N	Y	2	1025	200	0.3	300	MC	NAT	0.6	300	MC	BR		FL2D	1.15	0.48	Da	U	Potential Riprap RRT
Swan River	Swn103	Msla	PC	PFOR	N	N		1225	225	0.1	300	MC	NAT	0.1	300	MC	NAT		FL2D	1.11	0.98	Da	U	Primary Channel Shift; Elk Cr. Confluence
Swan River	Swn104	Msla	PC	PFOR	N	N		3075	225	0.1	50	MC	BR	0.2	300	MC	NAT		FL2D	1.29	0.67	Da	U	Primary Channel Shift; Riparian Harvest-RLF
Swan River	Swn105	Msla	USFS	NFOR	N	N		3100	175	0.7	300	MC	NAT	0.1	300	MC	NAT		FL2D	1.29	0.67	Da	U	Primary Channel Shift; Post '97 Harvests-RLF
Swan River	Swn106	Msla	PVT	NR	N	N		2225	175	0.6	300	MD/C	NAT	0.1	300	MC/D	NAT		FL2D	1.05	0.85	Da	U	Riparian Mosaics
Swan River	Swn107	Msla	PVT	NR	N	Y	13	450	125		100	HB	NAT	0.4	300	MC	NAT		FL2D	1.06	0.31	C	U	Potential Riprap; Bridge Crossing
Swan River	Swn108	Msla	PVT	NR	N	N		600	125	0.6	300	MC	NAT	0.6	100	MC	NAT		FL2D	1.20	0.89	C	U	Potential Riprap on Bridge Abutement
Swan River	Swn109	Msla	PVT	NR	N	N		300	125		300	HB	BR	0.6	300	MC/D	NAT		FL2D	1.33	1.73	Da	U	Homesite/ Field-RLF; Channel Island-RRT
Swan River	Swn110	Msla	PVT	NR	N	N		475	125	0.3	300	MC	NAT	0.4	300	MC/D	NAT		FL2D	1.33	1.73	Da	U	Riparian Mosaic
Swan River	Swn111	Msla	PVT	NR	N	Y		1900	125	0.2	300	MC/D	NAT	0.7	200	MC	NAT		FL2D	1.33	1.73	Da	U	Hwy 83-RRT; Riparian Mosaic-RLF
Swan River	Swn112	Msla	PVT	NR	N	N	10	2825	125	0.2	300	MC/D	NAT	0.4	300	MC	NAT		FL2D	1.06	0.77	C	U	Residences-RRT; Riparian Mosaic-RLF
Swan River	Swn113	Msla	PVT	NR	N	N	1	5100	125	0.2	300	MC/D	NAT	0.2	300	MC/D	NAT		FL2D	1.21	1.40	C	U	Riparian Mosaic
Swan River	Swn114	Msla	PVT	NR	N	Y	3	525	125	0.3	300	MC/D	NAT	0.5	300	MC	NAT		FL2D	1.14	0.79	C	U	Bridge Crossing; Side Channel
Swan River	Swn115	Msla	PVT	NR	N	Y	5	975	125	0.4	300	MD/C	NAT	0.2	225	MC/D	BR		FL2D	1.14	0.79	C	U	Riparian Mosaic-RLF; Homesites-RRT
Swan River	Swn116	Msla	PVT	NR	N	N		1900	125	0.7	300	MC	NAT	0.7	300	MC/D	NAT		FL2D	1.02	1.31	C	U	Riparian Forest
Swan River	Swn117	Msla	PVT	PFOR	N	N		700	125	0.2	300	MC	NAT	0.7	250	MC	NAT		FL2D	1.01	0.90	C	U	Riparian Harvest-RLF; CC w/ Buffer- RRT

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Stream Name	Reach Name	County	Owner	Land Use	Grizzly Bear Linkage	Impervious Surface	Riparian Structures	Reach Length (ft)	Active Channel (ft)	LB Canopy Density	LB Buffer (ft)	LB Vegetation	LB Bank Condition	RB Canopy Density	RB Buffer (ft)	RB Vegetation	RB Bank Condition	Stream Order	Riparian Land Type	Channel Sinuosity	Stream Slope	Rosgen Level 1 Channel	Channel Confinement	COMMENTS / DISTURBANCE
Swan River	Swn118	Msla	PVT	RS	N	N		1400	125	0.1	300	MC	NAT	0.1	300	MC	NAT		FL2D	1.11	0.89	C	U	Floodplain; Buck Creek Alluvial Fan-RRT
Swan River	Swn119	Msla	PVT	PFOR	N	N		775	125	0.2	300	MC	NAT	0.7	100	MC	NAT		FL2D	1.15	0.65	C	U	Floodplain-RLF; CC w/ Thin Buffer-RLF
Swan River	Swn120	Msla	PVT	NR	N	N	1	3675	125	0.2	300	MC/D	NAT	0.5	300	MC/D	RR		FL2D	1.15	0.65	C	U	Residential DW on Floodplain; Bridge Crossing
Swan River	Swn121	Msla	PC	PFOR	N	N		1975	100	0.4	300	MC	NAT	0.2	300	MC/D	BR		FL2D	1.15	0.65	C	U	Riparian Mosaic
Swan River	Swn122	Msla	PC	PFOR	N	N		350	100	0.8	300	MC	BR	0.4	200	MC	NAT		FL2D	1.15	0.65	C	U	Riparian Mosaic-RRT; "Timber Stand" RLF
Swan River	Swn123	Msla	PC	PFOR	N	N		2350	100	0.6	300	MC/D	NAT	0.2	200	MC	BR		FL2D	1.15	0.65	Da	U	CC Slope-RRT
Swan River	Swn124	Msla	PC	PFOR	N	N		1275	125	0.6	300	MC/D	BR			HB	BR		FL2D	1.04	1.52	C	U	Cut Bank-RLF; Riparian Pasture-RRT
Swan River	Swn125	Msla	PVT	RS	N	N	1	600	125	0.8	300	MC	NAT	0.6	300	MC	NAT		FL2C	1.27	0.47	C	U	Farmstead/ Pastures-RRT; Forest-RLF
Swan River	Swn126	Msla	PVT	RS	N	N	1	700	100	0.8	300	MC	NAT	0.5	300	MC/D	BR		FL2C	1.27	0.47	C	U	Cut bank-RRT
Swan River	Swn127	Msla	PVT	RS	N	Y	2	1350	100	0.7	300	MC/D	NAT	0.4	300	MC/D	BR		FL2C	1.27	0.47	Da	M	Secondary Channel Against Road; Cut bank below
Swan River	Swn128	Msla	PVT	NR	N	N	2	2025	125	0.1	300	MD/C	BR	0.4	300	MC	NAT		FL2C	1.27	0.47	C	M	Riparian Mosaic; Cut Bank-RLF
Swan River	Swn129	Msla	PVT	NR	N	Y		1325	125	0.7	300	MC	NAT	0.7	300	MC	NAT		FL2C	1.27	0.47	C	M	Forested Riparian
Swan River	Swn130	Msla	PVT	NR	N	Y		975	125	0.8	300	MC	NAT	0.6	300	MC	NAT		FL1C	1.27	0.47	C	M	Bridge Crossing
Swan River	Swn131	Msla	PVT	NR	N	Y		925	125	0.6	300	MC	NAT		300	HB	RR		FL1C	1.27	0.47	C	U	Road-RRT; Potential Riprap Area
Swan River	Swn132	Msla	PVT	NR	N	N		3850	100		300	WET	NAT		300	WET	NAT		FL1C	1.30	0.25	E	U	Riparian Mosaic/ Wetland
Swan River	Swn133	Msla	PVT	NR	N	N		1100	100		300	WET	NAT	0.7	300	MC	NAT		FL1C	1.30	0.25	C	U	Forest-RRT; Wetland-RLF

Table A1. 2001 Stream Channel and Riparian Condition Reach Assessment Data

Stream Name	Reach Name	County	Owner	Land Use	Grizzly Bear Linkage	Impervious Surface	Riparian Structures	Reach Length (ft)	Active Channel (ft)	LB Canopy Density	LB Buffer (ft)	LB Vegetation	LB Bank Condition	RB Canopy Density	RB Buffer (ft)	RB Vegetation	RB Bank Condition	Stream Order	Riparian Land Type	Channel Sinuosity	Stream Slope	Rosgen Level 1 Channel	Channel Confinement	COMMENTS / DISTURBANCE
Swan River	Swn134	Msla	PVT	NR	N	N		3300	100	0.2	300	WET	NAT	0.4	300	MC	NAT		FL1C	1.26	0.37	E	U	Wetlands; Floodplain Activity-RRT
Swan River	Swn135	Msla	Dual	MIX	N	N		2175	100	0.3	150	MC	NAT	0.7	300	MC	NAT		FL1C	1.26	0.37	Da	U	FNF-RRT; Wetlands, PVT-RLF
Swan River	Swn136	Msla	PVT	RS	N	N		1475	100	0.2	300	MC/D	NAT	0.3	300	MC/D	NAT		FL1C	1.11	0.75	C	U	Riparian Harvests
Swan River	Swn137	Msla	PVT	NR	N	Y	1	1675	100	0.7	300	MC	NAT	0.7	300	MC	NAT		FL1C	1.13	0.87	C	U	Homesite; Bridge Crossing
Swan River	Swn138	Msla	USFS	NFOR	Y	N		1475	100	0.7	300	MC	NAT	0.7	300	MC	NAT		FL1C	1.15	0.99	C	M	One Small CC Impacting Buffer
Swan River	Swn138.1	Msla	USFS	NFOR	Y	N		1625	100	0.7	300	MC	NAT	0.7	300	MC	NAT		FL2C	1.15	0.99	C	M	Intact Riparian Forest
Swan River	Swn139	Msla	USFS	NFOR	Y	N		1225	100	0.8	300	MC	NAT	0.7	300	MC	NAT		FL2C	1.03	0.49	C	M	Harvests Beyond Buffers
Swan River	Swn140	Msla	USFS	NFOR	Y	N		1100	100	0.8	300	MC	NAT	0.4	175	MC	BR		FL2C	1.43	0.54	C	M	Cut Bank, Thin Buffer-RRT
Swan River	Swn141	Msla	USFS	NFOR	Y	Y		1325	100	0.7	300	MC	NAT	0.7	300	MC	NAT		FL2C	1.43	0.54	C	M	Bridge Crossing, River Access-RRT
Swan River	Swn142	Msla	USFS	NFOR	Y	N		1550	75		300	WET	NAT	0.7	300	MC	NAT		FL1C	1.43	0.54	E	U	Forest-RRT; Wetland Mix-RLF
Swan River	Swn143	Msla	USFS	NFOR	Y	N		1800	75		300	WET	NAT		300	WET	NAT		FL1C	1.45	0.67	E	U	Wetlands w/ Scattered MC
Swan River	Swn144	Msla	USFS	NFOR	Y	N		1450	75	0.4	200	MC	NAT	0.6	300	MC/D	NAT		FL1C	1.23	1.48	Da	U	Riparian Harvest-RLF
Swan River	Swn145	Msla	USFS	NFOR	Y	N		2400	75	0.7	300	MC	NAT	0.6	300	MC	NAT		FL1C	1.23	1.48	Da	U	Broad Floodplain Area; Multi-thread Channels
Swan River	Swn146	Msla	PVT	RS	Y	N		750	75	0.6	300	MC/D	NAT	0.8	300	MC	NAT		FL1C	1.05	0.38	Da	M	Intact Riparian
Swan River	Swn147	Msla	PVT	RS	Y	N	3	2200	50	0.7	300	MC/D	NAT	0.8	300	MC	NAT		FL1C	1.29	1.76	C	C	Intact Riparian
Swan River	Swn148	Msla	PVT	RS	Y	Y		3825	75	0.5	300	MC	NAT	0.8	175	MC	NAT		FL1C	1.28	2.62	B	M	CC Beyond Buffer-RRT

Table A1. 2001 Stream Channel and Riparian Condition Reach Assessment Data

Stream Name	Reach Name	County	Owner	Land Use	Grizzly Bear Linkage	Impervious Surface	Riparian Structures	Reach Length (ft)	Active Channel (ft)	LB Canopy Density	LB Buffer (ft)	LB Vegetation	LB Bank Condition	RB Canopy Density	RB Buffer (ft)	RB Vegetation	RB Bank Condition	Stream Order	Riparian Land Type	Channel Sinuosity	Stream Slope	Rosgen Level 1 Channel	Channel Confinement	COMMENTS / DISTURBANCE
Swan River	Swn149	Msla	USFS	NFOR	Y	Y		4000	50	0.7	300	MC	NAT	0.8	300	MC	NAT		FL1C	1.46	1.65	C	M	Riparian Road in Part of Reach-RLF
Swan River	Swn150	Msla	Dual	MIX	Y	N		900	50	0.7	300	MC	NAT	0.7	100	MC	NAT		FL1C	1.20	2.79	B	M	FNF-RLF & 100' RRT; CC-RRT
Swan River	Swn151	Msla	Dual	MIX	Y	N		1225	50	0.7	300	MC	NAT	0.7	300	MC	NAT		FL1C	1.20	2.79	B	M	FNF-RLF; PVT-RRT
Swan River	Swn152	Msla	PVT	NR	N	Y		875	50	0.6	300	MC/D	NAT	0.8	175	MC	NAT		FL1C	1.20	2.79	B	C	Harvests (Thinning)-RRT; Bridge; Cygnet Lake Outlet

APPENDIX J:
TRIBUTARY PHYSICAL ASSESSMENT FOR TMDL DEVELOPMENT SUPPORT

J.1 Stream Assessment Methodology

Physical assessments on the 2002 303(d)-listed tributaries (Goat, Piper, Elk, and Jim Creeks) of the Swan River were conducted according to a two-part methodology. In the first part of the assessment, DEQ personnel conducted an aerial photo analysis of the listed streams (reference Appendix I and Section 5.11). Streams were divided, into assessment reaches according to ownership boundaries, change in slope or valley type, change in riparian vegetation, and county lines. Reaches were numbered beginning with 1 at the mouth of each creek. A suite of parameters was evaluated in each reach to evaluate riparian and streambank conditions.

In the second part of the assessment, several reaches from each stream were selected for evaluation on the ground. Based on the preliminary aerial assessment results, these reaches were classified as either indications of human impact or not having indications of human impacts, so that the effect of human impacts could be evaluated by comparing results from the two reach types. However, because the Swan Lake Watershed has been heavily logged in these drainages, few true lower elevation reference reaches could be found. Instead, non-impacted reaches were defined as those that contained few impervious surfaces or riparian structures and that appeared in the air photos to contain channels that remained in a relatively natural condition: i.e., the channel was bordered by a wide vegetated buffer strip, the banks appeared to be stable, and no evidence of excessive sediment deposition or channel adjustments were observed.

Field crews visited the selected reaches and evaluated their physical condition using a modified version of the Environmental Protection Agencies EMAP protocols (EPA, 1999b). Assessment reaches were either 1000 or 800 feet in length depending on conditions identified in the aerial photo assessment. Within each reach, three transects were established, at 250, 500, and 750 feet in the 1,000-foot reaches, and at 200, 400 and 600 feet in the 800-foot reaches. At each transect, field crews determined bank full width and average bankfull depth, maximum bankfull depth, and flood prone width (the width of the flood prone area at twice the maximum bankfull depth) using a measuring tape and staff gage. This approach did not allow for very accurate flood prone width measurements in most cases. These data were used to calculate width-to-depth ratios based on the bankfull width divided by the average bankfull depth, and entrenchment ratios based on the flood prone width divided by the maximum bankfull depth. Width to depth and entrenchment ratios from the three transects were averaged to provide a single measurement for each reach. At the tail-out of the pool closest to the 250 and 750-foot transects (or the 200 and 600-foot transects), Wolman pebble counts (Wolman, 1954) were conducted on a minimum of 100 particles (with one exception).

Along the entire length of each assessment reach, field crews took measurements of number and depth of pools, pieces of large woody debris, riparian plant coverage and reproduction, eroding bank locations and length, and indicators of human impacts to the streams. For each reach, crews also calculated a stability rating designed to help evaluate whether the channel was aggrading, stable, or degrading. Example field forms are provided as attachments to this appendix. In general, this method was intended to identify areas of anthropogenic habitat alteration and/or sediment delivery, which were the primary causes of the impairment listings in the Swan Lake Watershed. Another major goal was to characterize a wide range of sediment and habitat indicators that could be used to help validate impairment conditions and develop sediment and habitat related TMDL targets.

In several reaches, modified assessments were conducted and there was some minor follow-up field reconnaissance work in 2003. In these assessments, field crews simply walked the reaches, making notes on the conditions they encountered and looking for evidence of instability and/or human impacts to the streams. Where significant degradation was found, the full assessment was conducted. If no sign of degradation was found, then no additional assessment took place. In this way, crews were able to evaluate a greater length of each stream than if they had conducted full source assessments in streams with little to no evidence of significant anthropogenic impacts.

J.2 Assessment Results

J.2.1 Goat Creek

Goat Creek was divided into 24 reaches for the aerial photo analysis and 6 of these reaches were selected for field assessment. Selected results of the aerial photo analysis for these 6 reaches are presented in Table J-1. In general, the aerial photo analysis indicated that although some level of timber harvest had occurred in the vicinity of most reaches, Goat Creek appeared to be in relatively stable condition, with wide riparian vegetation buffers, streambanks in seemingly natural condition, and few areas of active channel adjustment. Notable exceptions to this were found in Reach 7 where the riparian buffer on the right bank was only 25 feet wide and the bank condition was rated as “reduced” (indicating vegetation was reduced or absent and that erosion and/or channel widening were evident), and Reach 10, where the vegetation buffer on the right bank was only 50 feet and some channel bar formation was noted, which can be an indicator of instability. These reaches appeared to be among the most heavily impacted and were included in the field assessment to help evaluate the effects of anthropogenic activities in the watershed.

Reaches 2, 3, 9, and 16 appeared to be among the least impacted in Goat Creek, characterized by relatively wide riparian buffer zones, streambanks in apparent stable condition, and few significant human impacts to the stream channel. These reaches were selected as potential reference conditions against which to compare conditions in the more heavily impacted reaches.

Table J-1. Select Aerial Photo Analysis Results for Assessed Goat Reaches.

Location	Stream Type (Rosgen)	Left Veg. Buffer	Left Bank Canopy Density (%)	Right Veg. Buffer	Right Bank Canopy Density (%)	Evidence of Potentially Significant Human Impacts
Reach 2	C	300	60	250	70	No
Reach 3	C	300	70l	300	60	No*
Reach 7	B	100	70	25	10	Yes
Reach 9	C	300	30	300	40	No
Reach 10	B	100	30	50	10	Yes
Reach 16	B	250	70	250	70	No*

*Results of the field assessment did find evidence of limited human impacts to the riparian area (Table J-2).

Selected results of the field stream assessments are provided in Table J-2. In Reaches 3, 7, 9, and 16, the full field assessment was conducted; in Reaches 2 and 10, the modified assessment was conducted. Observed human impacts ranged from limited riparian harvest probably consistent with state SMZ law, to significant riparian harvest that apparently occurred prior to implementation of the SMZ law. All of the reaches of Goat Creek that were assessed in the field appeared to be in stable condition, with sediment inputs and stream energy near equilibrium. Most reaches were only slightly entrenched, as indicated by entrenchment ratios consistently greater than 2.2. Reach 16 was moderately entrenched, with an entrenchment ratio of 1.5, consistent with the Rosgen "B" stream type (Rosgen, 1996). In fact, the entrenchment ratio for Reach 7 indicates that the assessed portion of this stream may be more indicative of a "C" vs. "B" stream type, although potential variations in flood prone width and other measurements may also account for this inconsistency. The width-to-depth ratio for Reach 7, the most impacted reach with a full assessment, was consistent with the ratios in less impacted reaches.

Table J-2. Goat Creek Stream Assessment Results.

Location	Field Stability Rating	Width/Depth ratio	Entrenchment Ratio	Observed Human Impacts
Reach 2	Stable	NC	NC	None
Reach 3	Stable	18	>2.2	Limited Riparian Harvest
Reach 7	Stable	12	>2.2	Significant Riparian Harvest
Reach 9	Stable	12	>2.2	Limited Riparian Harvest
Reach 10	Stable	NC	NC	Significant Riparian Harvest
Reach 16	Stable	14	1.5	Limited Riparian Harvest

Table J-3 presents additional results of the Goat Creek assessment. No actively eroding banks were observed in any of the reaches evaluated in Goat Creek. Woody debris, both single pieces and aggregates, was common throughout most of the reaches; with a total woody debris count that was slightly lower in Reaches 7 and 2, possibly due to historic riparian harvest and reduced woody debris inputs, although the somewhat mobile nature of woody debris, once in a stream channel, must be taken into account when evaluating woody debris numbers and trying to link these numbers to local riparian impacts. Pools were also common throughout all of the reaches; with deeper pools over 3 feet in depth (bankfull depth) comprising 50 to 74 percent of the total number of pools.

Particle size distributions were determined by Wolman pebble counts at two locations in each reach. Particle size distributions refer to the percentage of the bed materials of the bankfull channel that are finer than a designated size. For example, at Reach 3, the D_{15} indicates that 15 percent of the particles are 0.25 mm or smaller at the lower cross section, and 15 percent are 16 mm or smaller at the upper cross section. The results of these pebble counts revealed tremendous variability in the particle distributions throughout Goat Creek; however, it does not appear that there were significantly more fines at the most impacted reach (Reach 7) than in the other, non-impacted reaches. It is worth noting that given sediment transport and depositional characteristics, percent fines may not represent a good methodology for identifying impacts from localized impairment indicators such as riparian removal.

Although field crews found evidence of significant riparian harvest along the banks of some reaches of Goat Creek, they consistently commented that the stream channel appeared to have recovered, or was in the process of recovering, from impacts that might have occurred from this riparian harvest. When visited on the ground, reaches that were identified in the aerial photo analysis as impacted by human activities did not appear to differ significantly from reaches that were identified as least impacted, with the possible exception of a reduction in woody debris in Reach 7. If Reach 7 is used as an example reach for other reaches with evidence of riparian harvest (see aerial assessment comments and canopy density results in Appendix I for Reaches 5, 9, 10, 20 and 21), then it would appear that as much as 25% of the lower 8 miles of Goat Creek may have some level of reduced woody debris, and the lower portion of the stream as a whole may have reduced numbers of large woody debris due to the mobile nature of woody debris.

No obvious anthropogenic sediment sources or other major indicators of water quality problems were located within these reaches (note that road crossings were excluded from the assessed reaches). In the qualitative assessment of Reach 2, the field crew found no evidence of the bank erosion and logging debris that were mentioned in the 1989 DEQ assessment (Appendix B) as a sign of impairment. Additional field reconnaissance work in 2003 was done for a longer stretch of this particular reach, and one significant LWD aggregate with some minor levels of localized bank erosion and stream widening was noted further down. This aggregate did not appear to include significant amounts of logging debris and was likely providing positive habitat in the form of pools and cover and was, therefore, not considered an indicator of impairment conditions. Overall, any significant levels of logging debris have probably been washed downstream and out of Goat Creek and any significant levels of bank erosion have healed naturally similar to other areas of historical impact.

Additional 2003 field reconnaissance work was also done along a portion of Goat Creek located in Section 7. Impacts along this portion of Goat Creek provided some of the rationale for originally listing Goat Creek for siltation and other habitat alterations based on evidence of elevated sediment, equipment crossings, and other indicators associated with timber harvest (reference Appendix B). The portion visited corresponds to Reach 21 of the aerial assessment, with evidence of riparian harvest and canopy densities of 20% and 30%. As was the case in other areas of historical harvest, a healthy riparian with essentially no eroding banks was observed and at least one old stream crossings was distinguishable with minimal remaining impact. The stream appeared stable with good pool numbers, although the LWD and pool cover values seemed depressed, and the riparian trees greater than one foot in diameter were essentially non-existent. Nearby timber harvest waste consisting of tree sections of possibly more than 3 feet in diameter, and the lack of such trees along the riparian and within the stream provide evidence of the long-term types of potential impacts that removal of riparian trees can have. It could be several decades or more before this section of the stream can produce LWD and related habitat and shade to the degree that it was once capable of.

The aerial assessment work was also performed for Squeezer Creek, which is a tributary stream that enters Goat Creek at the upstream end of Goat Creek Reach 4. Although determined to be fully supporting of aquatic life based on the 2000 303(d) list, it is worth noting that the lower 2.5 miles have of Squeezer Creek have low canopy density numbers providing evidence of potential riparian harvest (Appendix I). The upper 4 to 5 miles analyzed have significantly higher canopy density numbers and less evidence of potential riparian harvest. Right and Left Bank Buffer values in Squeezer Creek are consistently high and there are few other indications of human impacts, similar to Goat Creek and other streams assessed.

Table J-3. Goat Creek Stream Assessment Results.

Location	Large Woody Debris		Pools		Particle size distribution (mm)			Number of eroding banks/ 1000 feet
	Single #/1000 feet	Aggregates/ 1000 feet	#/1000 Feet	% pools > 3 feet deep	D_{15} Lower/ Upper	D_{50} Lower/ Upper	D_{84} Lower/ Upper	
Reach 2	NC	NC	NC	NC	NC	NC	NC	0
Reach 3	20	7	9	56	0.25/16	32/27	144/49	0
Reach 7*	20	11	18	71	7/7	26/30	52/56	0
Reach 9	49	13	15	50	7/0.2	26/28	61/79	0
Reach 10*	NC	NC	NC	NC	NC	NC	NC	0
Reach 16	32	23	19	74	11/0.24	39/140	81/464	0

*Reaches with significant (historical) riparian harvest.

J.2.2 Piper Creek

Piper Creek was divided into 16 reaches for the aerial photo analysis and 6 of these reaches were selected for field assessment. Selected results of the aerial photo analysis for these 6 reaches are presented in Table J-4. In general, the aerial photo analysis indicated that although some level of timber harvest had occurred in the vicinity of most reaches, Piper Creek appeared to be in stable condition, with relatively wide riparian vegetation buffers, streambanks in seemingly natural condition, and few areas of active channel adjustment. Notable exceptions to this were found in reaches 2 and 10, where the riparian buffers on the right banks were only 25 feet wide and the bank condition was rated as “reduced” (indicating that vegetation was reduced or absent and that erosion and/or channel widening were evident), and in Reaches 3 and 5 where the riparian canopy density appeared to have been reduced by timber harvest. These reaches appeared to be among the most heavily impacted and were included in the field assessment to help evaluate the effects of anthropogenic activities in the watershed.

Reaches 6 and 14 appeared to be among the least impacted in Piper Creek, characterized by relatively wide riparian buffer zones, streambanks in apparently stable condition, and few significant human impacts to the stream channel. These reaches were selected as potential reference conditions against which to compare conditions in the more heavily impacted reaches.

Table J-4. Select aerial photo analysis results for Assessed Piper Creek Reaches.

Location	Stream Type (Rosgen)	Left Veg. Buffer	Left Bank Canopy Density (%)	Right Veg. Buffer	Right Bank Canopy Density (%)	Evidence of Potentially Significant Human Impacts
Reach 2	B	300	40	25	20	Yes
Reach 3	B	300	50	300	40	Yes
Reach 5	B	150	50	150	50	Yes
Reach 6	A	300	70	300	70	No
Reach 10	B	100	50	25	20	Yes
Reach 14	A*	300	60	300	60	No

*Field assessment and map reconnaissance indicate that this stream classification, at least in a significant portion of the area assessed, is likely in error.

Selected results of the field stream assessment in Piper Creek are shown in Table J-5. In Reaches 2, 5, 6, 10, and 14, the full field assessment was conducted; in Reach 3 the modified assessment was conducted. All of the reaches of Piper Creek that were assessed in the field appeared to be in stable condition, with little if any evidence of active channel aggradation or degradation, with the exception of Reach 14 where aggradation and multiple channels existed. This condition was not linked to human disturbances and appears to be a naturally occurring condition. None of the reaches were entrenched, as indicated by entrenchment ratios consistently near or exceeding 2.2, indicating that possible variations in the Rosgen stream types noted in Table J-4, at least in the areas assessed. This is especially true for part of Reach 14. Width to depth ratios did not provide evidence of significant channel widening in the reaches with observed human impacts.

Table J-5. Piper Creek Stream Assessment Results.

Location	Field Stability Rating	Width/Depth Ratio	Entrenchment Ratio	Observed Human Impacts
Reach 2	Stable	16	>2.2	Private Home Development Encroachment, Bridge
Reach 3	Stable	NC	NC	Limited Private Lot Development
Reach 5	Stable	8	>2.2	Limited Riparian Harvest; Recent Harvest Near Streambanks; Small campsite
Reach 6	Stable	16	2.1	None
Reach 10	Stable	12	>2.2	Significant Riparian Harvest
Reach 14	Aggrading	16	>2.2	Timber Harvest in Vicinity, Good Buffer

As is shown in Table J-6, eroding banks were observed in Reaches 2 and 5. One of the eroding banks in Reach 2 was a high terrace. The erosion at this site appeared to be natural; although a bridge that crosses the creek approximately 50 yards upstream could be exacerbating the erosion. The other two banks were clearly unstable as a result of human activities. One was a steep bank adjacent to a house on the banks of Piper Creek. The bank had been partially armored with rock, but some erosion was still occurring. The other bank had been partially cleared of vegetation to accommodate a small pump house for irrigation water. The total length of the 3 eroding banks was approximately 60 feet, out of a total bank length in the reach of 2,000 feet. The eroding bank in Reach 5 was located at an informal campsite where campers accessing the creek have cleared the vegetation. The length of eroding bank was 20 feet; total bank length in the reach was 2000 feet. No other eroding banks were observed in any of the reaches visited in the Piper Creek field assessment. Overall these eroding bank numbers represent a very low overall percentage of the total bank lengths.

Large woody debris, both single pieces and aggregates, was common throughout most of the surveyed reaches of Piper Creek. Woody debris numbers appeared to be slightly reduced in Reaches 2 and 5, particularly when compared to the LWD count in Reach 6, immediately upstream of Reach 5. Pools were also common throughout all reaches, but like LWD, appeared to be slightly less common in Reaches 2 and 5 – reaches showing potential obvious impacts from human activities. Particle size distributions revealed highly variable conditions, but provided no evidence of increased fine sediment deposition in the impacted reaches. Only the upper transect of Reach 5 stands out as having a noticeably high proportion of fines (D_{15} = 0.41mm). This transect is located approximately 125 feet upstream of a bridge over Piper Creek, which could be the source of the additional fines. The fines may also be the result of natural forces, as the slope of Piper Creek decreases noticeably between the upper and lower ends of Reach 5, which could result in the deposition of fine materials.

Table J-6. Piper Creek Stream Assessment Results.

Location	Large Woody Debris		Pools		Particle size distribution (mm)			Number of eroding banks/ 1000 feet
	Single #/1000 feet	Aggregates/ 1000 feet	#/1000 Feet	% pools > 3 feet deep	D_{15} Lower/ Upper	D_{50} Lower/ Upper	D_{84} Lower/ Upper	
Reach 2*	30	5	15	53	16/15	47/46	87/90	3
Reach 3*	NC	NC	NC	NC	NC	NC	NC	0
Reach 5*	32	12	11	64	25/0.41	70/11	129/41	1
Reach 6	115	26	16	46	11/12	38/57	68/123	0
Reach 10*	139	33	23	72	6/12	32/30	56/58	0
Reach 14	70	19	28	41	9/19	47/45	142/86	0

*Verified evidence of potentially significant human impacts from field assessment, although relatively minor for the Reach 3 section evaluated.

In general, field crews found evidence of historic logging activity in several reaches of Piper Creek, but consistently commented that the stream appeared to either have recovered or be recovering from many of the impacts that might have occurred as a result of timber harvest. Even Reach 10, which perhaps had the greatest indicators of riparian harvest, had good numbers of woody debris, although as previously mentioned the mobile nature of woody debris must always be considered when making these types of analyses. In Reach 2, several instances of human bank alteration were noted; however these impacts were localized, comprising a small fraction of the total reach length, and no systemic degradation of the stream was observed. Reach 6, and perhaps portions of Reach 3, were noted as the most likely potential reference conditions for the assessed portions of Piper Creek.

Although there was significant focus on some of the stream reaches with evidence of human impacts, the assessment results do not reveal significant indicators of problem conditions. A few reaches with evidence of clearcuts on the stream banks (Reaches 11, 12, and 13) were not assessed although their total length in comparison the whole stream length is relatively low and the opposite banks have good canopy density numbers. Based on the results of the aerial and stream assessment, it would seem that a significantly high percentage of Piper Creek would have field assessment results consistent with the results documented in Tables J-5 and J-6.

J.2.3 Elk Creek

Elk Creek was divided into 24 reaches for the aerial photo analysis and 4 of these reaches were selected for field assessment. Selected results of the aerial photo analysis for these 4 reaches are presented in Table J-7. In general, the aerial photo analysis indicated that although some level of timber harvest was evident in the vicinity of most reaches, Elk Creek appeared to be in stable condition, with relatively wide riparian vegetation buffers, streambanks in seemingly natural condition, and few areas of active channel adjustment. Exceptions to this were found in Reach 6, which showed signs of recent timber harvest and where the condition of both banks was rated as “reduced” (indicating that vegetation was reduced or absent and that erosion and/or channel widening were evident). This reach appeared to be among the most heavily impacted and was included in the field assessment to evaluate the effects of anthropogenic activities in the watershed.

Reaches 2, 3, and 13 appeared to be among the least impacted in Elk Creek, characterized by relatively wide riparian buffer zones, streambanks in apparent stable condition, and few apparent human impacts to the stream channel. These reaches were selected as potential reference conditions against which to compare conditions in the more heavily impacted reaches, although subsequent field assessment determined that low levels of canopy density in Reaches 2 and 3 were due to riparian harvest versus natural conditions. Conversely, the section of Reach 6 assessed in the field showed little to no obvious human impacts and was identified as a potential reference reach. Reach 13 is the lower part of the segment of Elk Creek that has been identified as fully supporting aquatic life and cold water fish (reference Table J-1), and ultimately represents the best potential reference reach not only for Elk Creek, but also for the other three assessed streams.

Table J-7. Select Aerial Photo Analysis Results for Assessed Elk Creek Reaches.

Location	Stream Type (Rosgen)	Left Veg. Buffer	Left Bank Canopy Density (%)	Right Veg. Buffer	Right Bank Canopy Density (%)	Evidence of Potentially Significant Human Impacts
Reach 2	C	100	20	200	70	No*
Reach 3	C	100	20	100	40	No*
Reach 6	C	50	20	300	50	Yes**
Reach 13	C	300	60	300	80	No

*Results of the field assessment revealed potentially significant impacts associated with riparian harvest. This area of riparian harvest was initially determined to be a natural riparian mosaic conditions via the aerial assessment.
** Results of the field assessment revealed very little indication of potentially significant impacts associated with human activities in the assessed section of this reach.

Selected results of the field stream assessments are provided in Table J-8. In Reaches 3, 6, and 13, the full field assessment was conducted; in Reach 2 the modified assessment was conducted. All of the reaches of Elk Creek that were assessed in the field appeared to be in stable condition, with little if any evidence of active channel aggradation or degradation. None of the reaches were entrenched, as indicated by entrenchment ratios consistently greater than 2.2. The width-to-depth ratios were consistent for most reaches, although slightly higher in Reach 3, the most obviously impacted reach, suggesting the possibility of some channel widening as a result of human impacts.

Table J-8. Elk Creek Stream Assessment Results.

Location	Field Stability Rating	Width/Depth ratio	Entrenchment Ratio	Observed Human Impacts
Reach 2	Stable	NC	NC	Significant Riparian Harvest
Reach 3	Stable	21	>2.2	Significant Riparian Harvest
Reach 6	Stable	17.3	>2.2	None
Reach 13	Stable	14.6	>2.2	None

Additional stream assessment results are shown in Table J-9**.** Only one actively eroding bank was observed in the assessment of Elk Creek. In Reach 3, a bank 15 feet in length was rated as moderately unstable due to erosive forces created by a log jam on a bank that may have had additional protection if the riparian harvest had not occurred. None of the logs showed evidence of having been cut. Large woody debris, both single pieces and aggregates, was common throughout all of the reaches. Similar results were noted for pools.

Particle size distributions revealed a high diversity of substrate materials, but provided no evidence of fines accumulation in the impacted reaches. The D_{15} in Reach 13 appears to be significantly smaller than in the other reaches. Fifteen percent of the particles were smaller than 0.11 mm at the lower transect and smaller than 0.19 mm at the upper transect. The source of these fine materials is likely to be natural, as minimal human activity has taken place in the watershed upstream of this site.

Table J-9. Elk Creek Stream Assessment Results.

Location	Large Woody Debris		Pools		Particle size distribution (mm)			Number of eroding banks/ 1000 feet
	Single #/1000 feet	Aggregates/ 1000 feet	#/1000 Feet	% pools > 3 feet deep	D_{15} Lower/ Upper	D_{50} Lower/ Upper	D_{84} Lower/ Upper	
Reach 2*	NC	NC	NC	NC	NC	NC	NC	0
Reach 3*	19	10	11	100	24/10	51/35	102/77	1
Reach 6	96	19	17	65	23/37	56/76	138/108	0
Reach 13	21	10	14	79	.11/.19	84/41	285/104	0

***Verified evidence of potentially significant human impacts from field assessment.

In general, field crews found evidence of historic logging activity in much of Elk Creek, but consistently commented that the stream appeared to have recovered, or was in the process of recovering, from any impacts that may have occurred. Field crews noted old riparian harvests that probably occurred prior to implementation of the SMZ law in several reaches, but no significant signs of channel degradation in these reaches were observed. No significant in-stream anthropogenic sediment sources were located. Elk Creek was placed on the 303(d) list in part because cut logs, bridge parts, and potential cattle impacts identified during a 1989 DEQ assessment; no such impairment conditions were observed in the assessment described here and no evidence of grazing were noted.

The Elk Creek reaches where field assessment work was done appear to be a good representation of conditions in the portion of Elk Creek that had been identified as being impaired. No indications of problems were noted, with the possible exception of a minor increase in width-to-depth ratio in the section where there were obvious indicators of riparian harvest. It is worth noting that there is good pool development in this lower reach area (Reach 3), with all pool indicators comparing favorably against the Reach 13 potential reference condition (Table J-9).

J.2.4 Jim Creek

Jim Creek was divided into 31 reaches for the aerial photo analysis and four of these reaches were selected for field assessment. Selected results of the aerial photo analysis for these 4 reaches are presented in Table J-10. Reach 24 was selected to represent a section of Jim Creek where potentially significant human impacts were evident in the aerial photos. In Reach 24, the bank condition was rated as reduced, indicating that vegetation was reduced or absent and that erosion and/or channel widening were evident. Similar conditions were identified in the air photo assessment in Reaches 22, 25, 27, and 30. Reach 11 was selected because of the riparian meadows and mosaic conditions which indicated an area of potential human impacts from riparian harvest.

Reaches 4 and 5 were initially both selected for assessment, but a map review and GPS data indicate that the lower part of Reach 5 was actually assessed versus Reach 4, in addition to assessment that was done on the upper part of Reach 5. Reach 5 has indicators of limited residential development via the aerial assessment work, with perhaps some indication of past logging activities. Subsequent field assessment work revealed limited riparian harvest and limited private home development impacts in the assessed portions of Reach 5 (denoted as Reach 5U for the upper assessed reach and Reach 5L for the lower assessed reach), and significant riparian harvest along Reach 24 that occurred prior to implementation of the SMZ law. There was no evidence of riparian harvest along Reach 11.

Table J-10. Select Aerial Photo Analysis Results for Assessed Jim Creek Reaches.

Location	Stream Type	Left Veg. Buffer	Left Bank Canopy Density (%)	Right Veg. Buffer	Right Bank Canopy Density (%)	Evidence of Potentially Significant Human Impacts
Reach 5L	B	150	40	300	60	No**
Reach 5U	B	150	40	300	60	No**
Reach 11	A*	300	20	300	20	No
Reach 24	A	100	20	100	20	Yes

*Field assessment and map reconnaissance indicates the assessed section may be more representative of an E or other stream type.
** Field assessment identified limited riparian impacts from human activities.

Selected results of the field assessment are provided in Table J-11. In Reaches 5L, 11, and 24, the full assessment was conducted; in Reach 5U the modified assessment was conducted. All of the reaches of Jim Creek that were assessed in the field appeared to be in stable condition, with little if any evidence of either aggradation or degradation. Reaches 5L and 11 were not entrenched, as indicated by the entrenchment ratios greater than 2.2, whereas Reach 24 was entrenched with a ratio of 1.2. The width-to-depth ratio for Reach 5L appears to be within the range of width to depth ratios found within the three other streams evaluated, and the entrenchment ratio and field observations indicated that this assessed portion of Reach 5 may be more of a “C” vs. “B” stream type. The low width to depth ratios for Reaches 11 and 24 are indications of E and A channel types (Rosgen, 1996), with the entrenchment ration values indicating an E type channel for Reach 11, and an A type channel in Reach 24.

Table J-11. Jim Creek Stream Assessment Results.

Location	Field Stability Rating	Width/Depth ratio	Entrenchment Ratio	Observed Human Impacts
Reach 5L	Stable	12	>2.2	Limited Riparian Removals, Older Nearby Harvest
Reach 5U	Stable	NC	NC	Limited Riparian Removals
Reach 11	Stable	9	>2.2	None
Reach 24*	Stable	8	1.2	Significant Riparian Harvest

Additional stream assessment results are presented in Table J-11. No eroding banks were observed in any of the reaches evaluated in Jim Creek. Woody debris was common in Reaches 5L and 11, but relatively scarce in Reach 24. Field crews noted that in Reach 24, woody debris recruitment appeared to be reduced by heavy riparian logging. Pools followed a similar pattern, and field crews noted that few pools in Reach 24 had significant fish cover, probably a result of the relative scarcity of LWD. Even though Reach 24 was dry, pool measurements were obtained given the approach of using bankfull conditions for determining pool measures.

Particle size distributions revealed a great deal of diversity in substrate composition. Fine material was least common at the upstream site (Reach 24), increased in proportion at the middle site (Reach 11), and further increased in proportion at Reach 5L, the lowest surveyed site in the watershed. Woody debris helps establish streambed stability, dissipates energy, and directly influences sediment storage (Rosgen, 1996). The relatively large particle size distribution in Reach 24 is an indicator of a lack of sediment storage and increased transport of fine material. In fact, the D_{15} values in Jim Creek Reach 24 are consistently higher in comparison to the values for all other A or B stream types in Piper and Goat Creeks (Elk Creek had only C stream types evaluated). The location of a lake upstream of Reach 24 is a possible confounding factor that should also be considered when evaluating some of the data for this reach, although additional 2003 field reconnaissance over a longer portion of this reach verifies that significant storage of finer materials is only occurring in areas where the relatively scarce large woody debris aggregates exist.

Table J-12. Jim Creek Stream Assessment Results.

Location	Large Woody Debris		Pools		Particle size distribution (mm)			Number of eroding banks/ 1000 feet
	Single #/1000 feet	Aggregates/ 1000 feet	#/1000 Feet	% pools > 3 feet deep	D_{15} Lower/ Upper	D_{50} Lower/ Upper	D_{84} Lower/ Upper	
Reach 5L	96	6	19	100	NC/0.23	NC/17	NC/39	0
Reach 5U	78	23	NC	NC	NC	NC	NC	0
Reach 11	186	129	30	88	10/4	26/28	40/48	0
Reach 24*	13	0	20	0	35/32	68/81	118/167	0

***Verified evidence of potentially significant human impacts from field assessment.

Field crews found some evidence of historic logging activity in Reaches 5L and 5U. Although it appeared as though the creek had recovered from most impacts that may have occurred from this logging and was not significantly impacted by private development in the assessed sections. No impacts were noted in Reach 11. In Reach 24, however, riparian harvest appeared to be more extensive and more recent than in the other reaches, and, as described above, this harvest appears to have impacted the channel by reducing LWD recruitment and perhaps pool development, particularly regarding the development of potential spawning gravels at the downstream ends of these pools. Similar conditions were identified on aerial photographs for other nearby reaches such as Reaches 22 through 31. This essentially represents an upstream portion of Jim Creek where there has been significant reduction of stream side trees and woody debris over a length of as much as 2.5 miles (about 25% of the stream length that underwent aerial assessment), in addition to significant reduction of trees along the lake shore of Jim Lake and the small lake downstream from Jim Lake.

J.2.5 Comparison of Field Results to Aerial Assessment Results

There was good match between the aerial assessment canopy density determinations and field observations. Reaches where the aerial assessment showed low canopy density (less than or equal to 30%) were subsequently found to have low canopy density in the field. As noted above, the field evaluations were important in providing final verification at most reaches concerning whether the low canopy density was due to natural conditions versus riparian harvest or other human impacts. Also, areas with very high canopy density (greater than or equal to 70%) via aerial assessment also were found in the field to have high canopy density with high quality riparian cover and shade. Reaches were the canopy density varied from about 40 to 60% also matched field observations but with greater variability likely due to the fact that the physical assessment reach canopy information was typically averaged over a much shorter length than the length of stream reach for determining canopy density via aerial assessment.

A comparison of field width data with aerial assessment width data showed good correlation. Table J-13 is a representative comparison of the field reach width average measures with the aerial assessment width measures. Given the photo scale (1:15840), the fact that all but one measure is within 15 feet and many are less than 10 feet indicates good correlation. The one measure that was off by 62 feet is likely due to a miscommunication of where the photo estimate was taken relative to where the field assessment was performed or due to a significant channel change between the date when the aerial photo was taken and performance of the field assessment.

Table J-13. Comparison Between Aerial and Field Width Measures.

Aerial Assessment Reach Width Measure	Field Assessment Width Measure	Difference
20	21	(1)
25	24	1
25	24	1
25	24	1
25	20	5
25	18	7
30	23	7
30	19	11
30	19	11
40	30	10
40	35	5
40	36	4
60	45	15
100	38	62

Swan River Tributaries TMDL Development
Phase II Physical Assessment
Modified EMAP Field Parameters (X Section)

Date: ________

Stream: ______________________________ Observers: ______________

____

____

____

Reach ________ Units:(circle one) English (feet) Metric (meters)

River Miles: ______________

Transect	Bankfull Width	Bankfull Depth	Bar Width	Wet Width	Flood Prone Width	Channel Unit Type	Canopy Cov.	Comments*

WOLMAN PEBBLE COUNT

Stream:	**Channel Elevation:**
Reach:	**Channel Type:**
Survey Date:	**Surveyors:**

	Size Class (mm)	Dot Tally	Total #	Total %	Cum %	Description
	<0.062					Silt/Clay
	0.062 - 0.125					V. Fine Sand
	0.125 - 0.25					Fine Sand
	0.25 - 0.5					Med. Sand
	0.5 - 1					Coarse Sand
1)	1 - 2					V. Coarse Sand
2)	2 - 4					V. Fine Gravel
3)	4 - 6					Fine Gravel
4)	6 - 8					Fine Gravel
5)	8 -12					Med. Gravel
6)	12 - 16					Med. Gravel
7)	16 - 24					Coarse Gravel
8)	24 - 32					Coarse Gravel
9)	32 - 48					V. Coarse Gravel
10)	48 - 64					V. Coarse Gravel
11)	64 - 96					Small Cobble
12)	96 - 128					Small Cobble
13)	128 - 192					Large Cobble
14)	192 - 256					Large Cobble
15)	256 - 384					Small Boulder
16)	384 - 512					Small Boulder
17)	512 - 1024					Med. Boulder
18)	1024 - 2048					Large Boulder
19)	2048 - 4096					2048.0 - 4096.0
		TOTAL # =				

Conduct pebble count at lower and upper transects in tailout of nearest pool.
Min 100 particles

Swan River Tributaries TMDL Development
Phase II Physical Assessment
Pool Information

Date: ____________

Stream: ______________________________ Observers: ______________

____

Reach ____________ Units: (circle one) English (feet) Metric (meters) ______________

____

____

Tansect Sub-reach	Pool Number	Length of Pool	Cover (Yes or No)	Max. Bankfull depth of pools		Comments		

NOTES:
Pools are defined as areas with defined increase in thalwag depth and very low gradient
Cover is defined as LWD or undercut banks that can provide refugia for fish

Comments:

Swan River Tributaries TMDL Development
Phase II Physical Assessment
LWD Tally

Date: ____________

Stream: ________________________________ Observers: ________________

Reach ________

River Miles: ________________

LARGE WOODY DEBRIS (≥ 4 inch small end diameter; ≥ 5 ft length)

Transect A-B							
Diameter	Pieces All/part in Bankfull Channel			Pieces Bridge Above Bankfull Channel			Comments
Large End	5' to 16'	16' to 50'	> 50'	5' to 16'	16' to 50'	> 50'	
4" to < 1'							
1' to < 2'							
> 2.0'							
aggregates							

Transect B-C							
Diameter	Pieces All/part in Bankfull Channel			Pieces Bridge Above Bankfull Channel			Comments
Large End	5' to 16'	16' to 50'	> 50'	5' to 16'	16' to 50'	> 50'	
4" to < 1'							
1' to < 2'							
> 2.0'							
aggregates							

Transect C-D							
Diameter	Pieces All/part in Bankfull Channel			Pieces Bridge Above Bankfull Channel			Comments
Large End	5' to 16'	16' to 50'	> 50'	5' to 16'	16' to 50'	> 50'	
4" to < 1'							
1' to < 2'							
> 2.0'							
aggregates							

Transect E-D							
Diameter	Pieces All/part in Bankfull Channel			Pieces Bridge Above Bankfull Channel			Comments
Large End	5' to 16'	16' to 50'	> 50'	5' to 16'	16' to 50'	> 50'	
4" to < 1'							
1' to < 2'							
> 2.0'							
aggregates							

NOTE:
Aggregates are defined as two or more LWD pieces contributing to one habitat/pool feature; if LWD pieces overlap at angles and contribute to unique cover, then they can be counted as individual LWD pieces vs. as an aggregate

Swan River Tributaries TMDL Development
Phase II Physical Assessments
Modified EMAP Visual Riparian Estimates

Date: ________

Stream: ______________________________ Observers: ______________ Page: ________ of ________

Reach ________

EMAP Site Reference (eg BR22-1) River Miles: ______________

Codes: 0=absent (0%), 1= sparse (<10%), 2=mod (10-40%), 3=heavy (40-75%), 4=very heavy (> 75%)

		Canopy (> 5 m high)		Understory (0.5 to 5		Ground Cover (< 0.5 m high)			
Reach	Bank	BIG trees (trunk > 1' dbh)	SMALL trees (trunk < 1' dbh)	Woody shrubs and saplings	non-woody herbs, grasses and forbs	woody shrubs and seedlings	non-woody herbs, grasses, and forbs	barren, bare dirt, or duff	Comments (Observations such as riparian community composition, health and vigor, trend, human influence, livestock and wildlife influence). Also provide estimate of condition: PFC, FAR, NF
A-B									
	right 10m								
	right total								
	left 10m								
	left total								
B-C									
	right 10m								
	right total								
	left 10m								
	left total								
C-D									
	right 10m								
	right total								
	left 10m								
	left total								
E-F									
	right 10m								
	right total								
	left 10m								
	left total								

Stream
Reach #
Transects: A-B, B-C etc.

Swan River Tributaries Physical Assessment

Bank Erosion Inventory (modified from Zaroban and Sharp, 2001)
Bank Stability Rating Sheet

Site:

Bank Stability
0 = no erosion
1 = erosion evident
2 = erosion/cracking
3 = slumps/block failure

Bank Condition
0 = some bare, no overhang
1 = moderate overhang
2 = overhang/exposed roots
3 = bare, rills, overhang, falling trees

Vegetation/Bank Cover
0= Perennials/rocks
1= annuals/perennials/40% bare
2= annuals/70% bare
3= predominanatly bare

Bank/Channel Shape
0= v-shaped, sloped banks
1= steep V- near vertical banks
2= Vertical banks-U-shaped
3= u-shaped, undercut bks

Channel Bottom
0= noneroding bedrock
1= soil, grvl, cbbls; minor erosion
2= Silt bottom, active downcutting

Deposition
0= Recent deposits, silt bars
1= no evidence recent dpstn

Cumulative Rating
0-4 = Slight
5-8 = Moderate
9+ = Severe

Swan River Tributaries TMDL Development
Phase II Physical Assessment
bank description

Stream: ______________________ **Observers:** __________

____

Reach: ________ __________

River Miles: ________ **Date:** __________

Erosion Site (BR23-EI1)	Bank (TRB or TLB)	Length of Eroding Bank (ft)	Average Bank Height (ft)	Rating condition (slight, moderate, severe)	Do human activities appear to imapact the site	If yes, how?

Swan River Tributaries TMDL Development
Phase II Physical Assessment
Human Influence

Date: __________

Stream: ______________________________ Observers: ____________________

____

____

____

Reach __________

River Miles: ____________________

Codes: 0 = not present, P = > 30 feet, C = within 30 feet, B = on bank

Beginning distance from transect	Ending distance from transect	Wall/Dike/Revetment/Riprap/dam	buildings	pavement	road/ railroad	pipes (inlet/ outlet	landfill/ trash	park/lawn	row crops	pasture/ range/hayfield	logging operations	weeds	mining activity	Other

Swan River Tributaries Physical Assessment

applies to the entire 1000 ft (or less) reach

Channel Stability Indicators (Johnson, et.al., Rosgen, Thorne)

Stream: ____________________ **Observers:** ____________________

Reach __________ ____________________

____

River Miles: ____________________ **Date:** ____________________

Reach Stability: circle appropriate indicator	***1-2: Degrading***	***3: Stable***	***4-5: Aggrading***
Substrate Consolidation	Strong Gravels	Strong Gravels	Weak Gravels/Sands
Bank Failure Mechanism	High banks; gravitational collapse; variable channel width	Localized surficial erosion constant width	Low banks; overflows; surficial erosion
Bar Development	Poorly formed	Narrow; Vegetated	Wide (>1/2 Channel width); unvegetated
Bank Erosion Extent	Extensive both banks	Local erosion @ pools	Extensive bar pressure
Width:Depth Ratio	Low <6	Average (6-20)	High (>20)
Channel Pattern	Single thread	Single thread	Multiple threads
Average Bank Slope	<3:1	>3:1	n/a
Vegetative Bank Protection	Poor	Extensive	Poor

Field Stability Rating (circle one) ***1*** ***2*** ***3*** ***4*** ***5***

Boundary Conditions

Confinement (circle one) ***High*** (canyon) ***Moderate*** ***Low*** (broad floodplain)

Channel Perimeter (approximate % of total bankline) ***Bedrock*** ***Alluvium*** ***Revetment***

Channel Classification __________ **Aerial Assessment**

__________ **Field Assessment** (Add Substrate Value)

Sediment Source or Sink: ***source*** ***sink*** ***neither***

PFC trend (if possible) ***upward*** ***downward*** ***n/a***

Swan River Tributaries Physical Assessment

Impairments/Solutions/Reference Reach Potential/ Photo Log

Date: ______

Stream: ______________________ Observers: ______________

Reach ______

River Miles: ______________

Identified human influence (notes)

Potential Remedies (e.g. off-channel watering, culvert replacement, grazing BMP's, erosion control, channel reconfiguration, revegetation)

Does this reach have potential reference sites? Where? Why?

Photo Log

Photo Number	View	Notes

APPENDIX K:
DEQ RESPONSE TO PUBLIC COMMENT

This appendix provides the comments, or in some cases a summary of one or more comments, received during the public comment period. After each comment is DEQ's response. Similar comments that can be handled via one response have been combined.

Comments Focused on Assessment (Sections 4 & 5)

Comment: Section 4.1, Par. 2. Regarding the Carlson Trophic State Index (TSI), the document states that the TSI range for mesotrophic lakes is between 35-45 and cites EPA as the reference. However, a review of http://www.epa.gov/bioindicators/aquatic/carlson.html indicates that the range of mesotrophic conditions is between 40 and 50.

> **DEQ Response:** The language has been modified, with updated references, to note that the TSI values that range between 40 and 50 indicate mesotrophic conditions.

Comments:
- Photo 4-1: The fine print says the photo is from the Stillwater River. It should not be in a document that discusses the Swan Lake Watershed.
- Section 4.1.2.1. Regarding historic logging practices, there was a splash dam and log drive in the lower Swan River Area in the vicinity of Lost Creek in the early 1900's. However, this is the only one I am aware of in the Swan. As such, I would not characterize this effect as "common."
- Photo 4-1. An extended caption should be added to this photo to explain that this pre-dates environmental regulation.

> **DEQ Response:** The photo provides a relevant example of the type of impacts from this type of activity since there was apparently no similarly documentation of impacts like this within the Swan River drainage. The photo caption has been modified as suggested, and the word "common" has been removed from the text.

Comment: Section 4.1.2.2, Par. 4. Rather than mention Haur (1991) research on the North Fork, it would be better to reference his work for the Swan in this same report. He examined long-term trends in peak flows in the Swan and did not find evidence of increased peak flows associated with long-term timber harvest records.

> **DEQ Response:** We see no need to make any changes to the document based on this comment. The point made in the Section 4.1.2.2 paragraph is that harvest has the potential to increase peak flows in some cases, not just in the Swan River, but also in its tributaries, and that historic harvest levels may have increased flows within one or more streams within the Swan Lake Watershed. The North Fork results are relevant to the Swan because they suggest a detectable peak flow increase in a relatively large river as a result, presumably, of harvest in its tributary streams. A measurable peak flow increase in a large stream such as the North Fork suggests an even greater magnitude peak flow

increase in some of the tributaries. Thus, the North Fork results suggest that increased peak flows possibly/probably have occurred in tributaries to the Swan as well given the similar levels of past management, even if the peak flow increases were not detectable in the mainstem of the Swan River. These increased peak flows could have increased erosion and increased the rate of transport of pollutants to Swan Lake as discussed in the document. Significant future harvest in a tributary watershed can still lead to these pollutant transport conditions due to increases in peak flows.

Comment: Table 5-1. This table well encapsulates the relevant studies that have been completed in the Swan. One significant study that DEQ failed to identify was included in Stanford et al. (1997), which included a 1995 synoptic study of low flow nutrient concentrations for eight tributaries to the Swan River (see pages 113-116 of Stanford et al. 1997). In examining these data, what strikes me is that Woodward Creek has the highest concentration of NDOC, and it also contains an extensive wetland habitat in its lower reaches that is not common to the other tributaries inventoried. It may well be that Woodward Creek also contributes a disproportionately high percentage of the NDOC load during higher flow periods.

DEQ Response: A new Section 5.6.7 has been added to include discussion of the Stanford et al (1997) study, including the author's conclusion that "the data strongly suggests that nutrient loads are substantially elevated in streams with significant timber management activities".

The above referenced link to wetland habitat is not included within the document for several reasons. For example, the author (Stanford) does not specifically discuss the elevated NDOC loads in Woodward Creek. Funding limitations did not allow for a full analysis of the significant road network and related timber harvest levels in Woodward Creek that could impact NDOC levels. Also, review of the Stanford et al. (1997) data indicates a correlation between the flow of each Swan tributary and higher levels of NDOC as well as other pollutants, consistent with studies that show higher levels of these pollutants with increased spring flows. It is interesting that Woodward Creek has what appears to be an uncharacteristically high summer flow similar to the spring runoff levels measured at about the same location during 2003 (M. Vessar, unpublished data 2003), whereas other streams do not show this same high flow condition. It almost appears as though there was a recent rain event at the time of the Stanford study sampling or a problem with the sampling effort.

Comment: A good point was made at the meeting last night about the Swan highway maintenance and snowplowing. Sidecasting of gravel mixed with magnesium chloride into Swan Lake and tributaries that intersect the Swan Highway is a potential cumulative threat to the watershed that should be addressed by the stakeholder group and perhaps incorporated into the TMDL.

DEQ Response: We agree that pollutant loading from road sanding along Highway 83 represents a significant pollutant load to Swan Lake and therefore must be added to the document. This includes a new source assessment section (Section 5.3.3) to determine pollutant loading values to Swan Lake, the addition of an allocation in Section 8.2 to address the road sand load, and the addition of Section 9.2.5 to discuss water quality protection strategies as they relate to this road sanding.

Comment: Photo 5-3. It is not clear if this photograph was taken in the Swan River drainage or not. The caption should include a note about the general location of the washout. If it is not taken in the Swan, it should be removed from the document.

DEQ Response: It is an example of what a typical culvert failure can look like and how sediment loading can be significant from this source category. The text does not imply otherwise. It is difficult to use a photo from the Swan since there has been a lack of effort to track and document culvert failures within the watershed over time. Given the extensive number of culverts and documented failures in other watersheds, this picture is representative of the types of sediment loading that has probably occurred within the Swan Lake drainage over time.

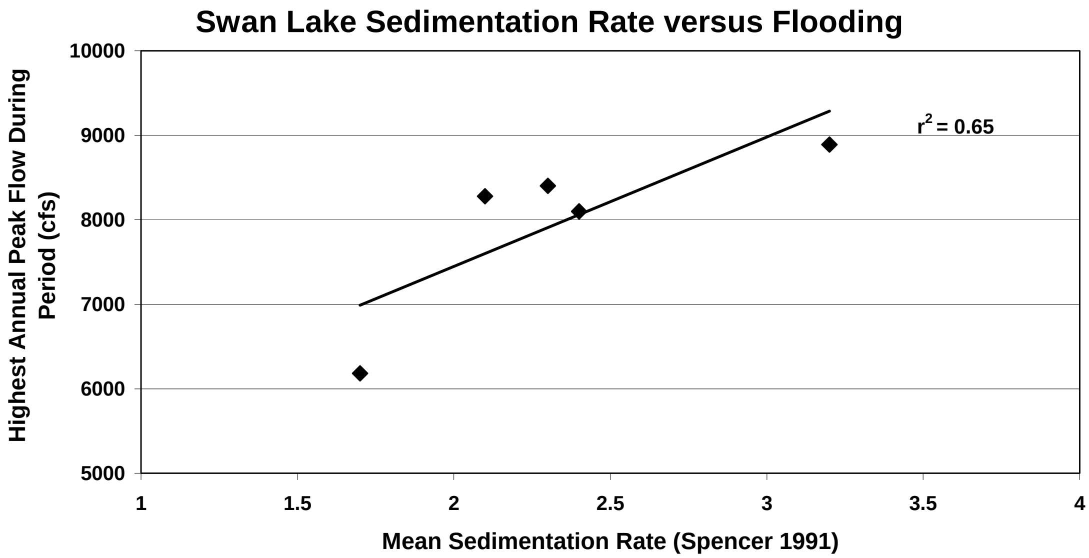
Comment: Section 5.7. The discussion would be strengthened by putting the results into context with the annual peak flow. During the EPA study, the annual peak flow in 1975 was 5410 cfs, which corresponds to about a 2- year recurrence interval. During the Butler study, the annual peak flow in 1993 was 5050 cfs, which also corresponds to about a 2-year recurrence interval. During the Ellis study, the annual peak flow in 1997 was 8520cfs, which corresponds to a 25-50 year recurrence interval.

DEQ Response: We agree that this is good information to include within Section 5.7 and have incorporated it.

Comment: Section 5.6.2. Par. 2. It is not correct to say that the changes in sediment levels were "attributed" to timber harvest. Rather, they were correlated with timber harvest. What Spencer did not thoroughly explore was the relationship of his sedimentation rates to peak flows. For each period that he examined sediment deposition, I determined what the peak flow was during that same period. I found that maximum peak flows explained 65% of the variability in mean sedimentation during his sampling period. This analysis is included below.

Time Period	Mean Sedimentation Rate (Spencer 1991)	Highest Recorded Discharge During Period (cfs)*
1922-1933	2.1	8280
1934-1946	1.7	6180
1947-1957	2.3	8400
1958-1972	2.4	8100
1973-1990	3.2	8890

* USGS Station on Swan River (near Bigfork)



DEQ Response: One of the primary mechanisms for sediment and other pollutant loading is increased flows. This applies to natural background sediment loading as well as sediment loading (erosion) from land management activities, particularly those lacking BMPs as would be anticipated for the years plotted. Therefore, it would be of no surprise that higher flows would lead to higher sediment loading, a substantial amount likely due to roads and other timber harvest activities where BMPs were lacking. DEQ, therefore, sees no need for any document changes based on this comment.

Comments Focused on Water Quality Goals, Targets, TMDLs and Allocations (Sections 7 & 8)

Comments:

- The stated goal for Swan Lake is to prevent any deterioration in water quality. However, the TMDL calls for a dramatic 40% reduction in sediment loading from roads. The document fails to document whether or not this huge reduction is feasible, and why it is necessary to achieve a goal of maintaining the existing condition of the lake.
- 40% Road Sediment Reduction TMDL Target Not Justified: TMDLs must be set at a minimum level to ensure protection of the beneficial use. In the case of Swan Lake, beneficial uses are currently supported. By logical extension, the existing level of loading is protecting the uses (it certainly has not been demonstrated otherwise). In light of this, for the Department to suggest a 40% reduction is needed is not appropriate. The TMDL target should be revised to reflect no additional increase in loading from forest roads.

DEQ Response: Although the Swan Lake POC and nutrient TMDLs are based on no reduction in loading, the Section 8.2.1 allocations for “road erosion” as well as “riparian and streambank protection” represent loading reductions as important component of the margin of safety identified in the Executive Summary (Table E-1 and Section 11.0). It seems appropriate to pursue erosion protection where best management practices are apparently lacking and then apply this reduction as a margin of safety. The allocation for road crossings represents anticipated reductions due to BMP implementation for the top 70 sediment producing road crossings as discussed in Section 8.2.1.1. There is also the potential for additional reductions at other road crossings instead of, or in addition to, reductions from the top 70 sediment producing road crossings. This represents a reasonable and prudent allocation and TMDL development approach that is not at all dramatic.

Based on these comments, a sentence has been added to Section 8.2 to link these load reduction allocations to the margin of safety for the Swan Lake POC and nutrient TMDLs.

Comment: Swan Lake secondary target #2 should include road decommissioning in addition to just using BMPs. On page 34 culverts were considered a significant unmanaged sediment loading risk throughout the drainage. The draft documents the problems associated with culverts and road failures especially in areas with high road densities such as the Swan but stops short by not suggesting that road decommissioning is a viable option to reduce this risk.

DEQ Response: We agree that road decommissioning, including removal of culverts, is a viable option. Language has been added to the Swan Lake Secondary Target #2 discussion to suggest this as an option. This option is also noted within the undersized culvert discussion in Section 8.2.1.3, the Section 9.2.2 Bullet #1 recommendation for road sediment reductions, and within the Section 9.2.3 discussion for culvert failures.

Comments:

- DEQ states “no decreasing percent saturation DO in the bottom waters of Swan Lake and no increase in the spatial extent of the low DO area”. This does not allow for natural variations in the DO content. We should not limit variation more than what could happen naturally.
- Swan Lake primary target #2 is no increasing trend of nutrient and chlorophyll a concentrations, no increasing trophic state index trends and no decreasing trends in Secchi Depth values in Swan Lake. Secondary target #1 is no increasing trend in phosphorus, nitrogen, TSS and organic carbon loads associated with human impacts entering Swan Lake from the Swan River. Please explain what constitutes an increasing trend and how many years of data are required to determine a trend. For example, the Bull Trout Restoration Team found that at least 15 years of data was necessary to determine trends in bull trout populations. The way these targets are worded seems to allow for increases in those parameters in some years which is probably not the intent.

DEQ Response: We agree that the DO target, as presented in the public comment document, could imply no changes even due to natural variability. To address this concern, a “Target Applicability Considerations” sub-section has been added for the Swan Lake DO target (Primary Targets #1) as well as for the Primary Target #2 parameters. This additional language will note that any final target compliance considerations must take natural variability into account, while at the same time also considering land use changes throughout the watershed

An increasing trend is typically considered a statistically significant change in one or more of the parameters of concern indicating a reduction in water quality. An analysis of nutrient trend detection capabilities of a water quality sampling network in the Clark Fork River revealed that the detection of statistically significant trends would require 5 to 10 years of monthly monitoring (Land and Water, 1995). The detection of trends in nutrient loading is, in part, a function of the variability in nutrient concentration. Unfortunately, this variability cannot be reliably estimated in Swan Lake and Swan River with the existing data. However, the Clark Fork example probably provides a reasonable approximation of what will be required to detect water quality trends in the Swan Watershed.

Additional language added to Section 7.0 Swan Lake primary targets applicability also states that the number of years needed to make a claim concerning target compliance will be a function of the level of sampling and the desired level of certainty in making such a determination. As suggested in the above paragraph, the effort should also include tracking land use indicators and significant natural disturbance events such as large fires within the watershed. Input from stakeholders can help with these decisions about the extent of sampling and desired certainty. Until more data is available to make trend related conclusions, Swan Lake will be considered a threatened waterbody. This approach is protective of water quality and does not hinder land use activities within the watershed since the Table 8-1 allocations are reasonable water quality protection expectations.

Comments:

- The TMDL fails to include an allotment for future growth in the planning area. With the demonstrated trend in increasing human habitation around the lake and in the watershed, this would seem to be a mandatory inclusion in the TMDL.
- We believe that the TMDL must include an allotment for future growth, which is inevitable in the Swan Valley and along Swan Lake. We believe that this can be accommodated in the existing TMDL load allocation because the goal for the lake is no further declining trend in water quality (i.e., not improvement), and because trends in riparian and upland conditions in the Swan Lake watershed trends are for improvement (e.g., recovery of riparian areas impacted by historic unregulated activities, Plum Creek’s efforts to get critical lands into public ownership, little or no activity on Forest Service). In consideration of all these factors, we believe there is room in the allocation for future growth and still meet the TMDL goal of no declining trend in water quality.

DEQ Response: The allocations in Section 8.0 effectively address future growth considerations since they limit existing pollutant loading impacts and effectively set upper limits for future pollutant loading impacts for the identified sources of concern. This language has been added to the Section 8.0 allocations for Swan Lake, Jim Creek and Goat Creek.

Comment: The TMDL target for Swan Lake titled "Other Timber Harvest Impacts" should be removed because it is vague, the existing condition relative to this loading source is unquantified (though believed small), and landowners cannot clearly demonstrate compliance.

> **DEQ Note:** There are not any targets in the document with this title; it appears that the comment is geared toward a TMDL allocation and the below response is, therefore, based on this assumption.
>
> **DEQ Response:** There are a significant number of pollutant-loading pathways represented by this allocation as identified in Table 8-1. These "other timber harvest impacts" have been significant sources in the past, such as in Jim Creek (Appendix B). Existing contributions may be relatively small and possibly within the range of "naturally occurring" in many drainages. Given that this is a major land use activity with significant potential for pollutant loading, it is required that an allocation is in place to at least address future growth potential, consistent with some of the above comments and responses. Unfortunately, it can be difficult to demonstrate compliance with most allocations, not just the allocation for this particular source. We believe that large landowners can help demonstrate compliance through methods such as monitoring water quality, tracking harvest activities, documenting implementation of BMPs and other water quality protection measures, documenting success of these management efforts, and documenting corrective approaches where unexpected pollutant loading occurs due to BMP failure or other circumstances.

Comment: The TMDL target for Swan Lake related to road erosion should be revised to state the reduction is applied over the entire Swan Lake watershed. Otherwise, it could be construed to apply to every given road segment, most of which are fully meeting BMPs and are not significant sediment sources.

> **DEQ Response:** The only target associated with roads is Swan Lake Secondary Target #2 that specifically applies to given road segments found to be a problem. Assuming that the comment is actually geared toward the "road erosion" TMDL *allocation* in Table 8-1, we agree that the above clarification is desirable and have changed the wording in Table 8-1. The new wording applies the allocation to road stream crossings (as defined by Section 5.2.1) to avoid the type of misinterpretation identified by the comment.

Comments:

- Some of the secondary targets for Swan Lake are for parameters that are not direct measures of beneficial uses or aquatic habitat, but rather are very closely tied to implementation. This includes requirements that action be taken at very specific locations, and defining a threshold level of riparian impact. We believe this unduly treads on the non-regulatory mechanism the state has in its Nonpoint Source Management Plan and is inconsistent with state law that requires the Department recognize established programs and practices for controlling nonpoint source pollution. Both of these targets should be eliminated.
- Targets" in Section 7.1 Should Only Be Set for Inlake or Instream Conditions: Targets are appropriate for instream conditions (e.g., percent fines, nutrient export trends, etc.) as a means to articulate a "goal" condition that may provide an expectation about how narrative

water quality criteria will be evaluate in the future. However, the road sediment loading and riparian streambank vegetative health "secondary targets" for Swan Lake proposed in Section 7.1.2 are inappropriate because they appear to nearly dictate an implementation threshold that may not be well correlated with the underlying beneficial uses. The state Nonpoint Source Management Plan is the implementation vehicle for this water quality restoration plan, not DEQ and EPA's dictated "targets."

DEQ Response: The use of these parameters or indicators for target development is consistent with EPA guidance (EPA, 1999a), where riparian and hillslope indicators are discussed within the context of target development for sediment TMDLs. As defined in the introduction to Section 7.0, the main purpose of these secondary targets is to "help track progress toward meeting primary targets and as additional indicators of watershed and lake health". These secondary targets are not applied as primary targets and do not represent a regulatory requirement. Because of the uncertainty around even the primary targets, these secondary targets are important to track as part of the adaptive management. The consequences of not meeting any of these targets are defined in such a way that does not unduly tread on the voluntary approach that applies to many land use practices and the selection of the secondary targets is consistent with and recognizes established programs and practices for controlling nonpoint sources. These existing programs and practices include or should include application of BMPs on forest roads and protection of riparian areas.

Comment: Riparian health indicators are defined in the document as "no reductions in overall average canopy density for significant stream segment, and no increases in the spatial extent of the riparian zone in which canopy density is less than 50%". Is there an exception for salvage? The SMZ law allows removal of more than 50 percent of a canopy in the case of salvage logging and on all operations along Class 3 streams. The DEQ target for canopy cover is more restrictive in some cases than the SMZ law which has worked well to protect streams. This also presents the problem of measuring the canopy coverage along a burned stream where there is no canopy.

DEQ Response: In responding to this comment, it is important to recognize the implications of not meeting this Swan Lake Secondary Target #3. As stated in the document "not meeting this target, especially in major streams or multiple streams, represents a potential increased threat to Swan Lake water quality and represents the need to investigate the land use activities that have led to this condition." Salvage work focused on burned streams would probably result in negligible change to a stream's average canopy density, especially where burned trees lacking canopy or soon to be lacking canopy are involved. In fact, the document further states: "potential canopy density impacts from natural events such as fire will need to be taken into account."

Since many segments with canopy densities less than 50% have increasing canopy densities due to recovery from riparian harvest, and since the target is based on 1997 conditions, there is built-in allowance for some canopy density reductions. To trigger the secondary target indicator, a stream segment that is above 50% would need to be reduced to less than 50% due solely to human activities – these types of efforts should be closely scrutinized. Because the canopy density is also an indicator of LWD recruitment, salvage efforts should take localized impacts into account as well as considering overall stream impacts and continued recovery from potential upstream historical riparian harvest. Where a stream has had significant reductions in canopy cover due to human activities or due to a fire, the rate of harvest along this stream where the canopy is healthier, as allowed by the SMZ law, will need to consider cumulative impacts to ensure full protection of beneficial uses and to assist with stream recovery.

We do agree that there could be some salvage activities, such as thinning of small trees to reduce fuels or removal of some trees where it is necessary to control a beetle infestation, which would seem inconsistent with the language in the document. Under these conditions, it is worth remembering that the target only triggers additional investigation and possible assessment of potential impacts to the stream's water quality. Nevertheless, we have added language that specifically notes that certain salvage work may help prevent larger water quality impacts even though the activity appears inconsistent with the Swan Lake Secondary Target #3.

Comments:

- Proposed instream habitat targets for Jim Creek are inappropriate. The target relating to fine sediment in spawning gravel is unattainable given that conditions in Jim Creek identically mirror those of the reference stream Lion Creek over the past decade. The target relating to woody debris and pools are inappropriate because these parameters are widely variable in nature. Available information on woody debris levels in undisturbed streams indicates that half of reference streams would fail to meet the target. Information on reference conditions for pools is not provided, so an evaluation of attainability is not possible.
- Jim Creek Targets Inappropriate: As we demonstrated above, all evidence suggests that Jim Creek is fully supporting its uses. The percent fines target is unattainable because Jim Creek is at its physical potential as evidenced by how closely it mirrors Lion Creek conditions. Regarding the LWD target, we believe LWD is well within the range of natural variability in un-managed systems and the unique circumstances of the reach that DEQ surveyed. Based on Light et al. (1999), DEQ proposes a target that 50% of reference streams cannot achieve which is simply not justifiable.

DEQ Response: DEQ agrees that the achievable levels of fines in Jim Creek could be consistent with Lion Creek as discussed in Sections 7.2, 7.5.1, and 10.1.1. Removing Jim Creek from the sediment impairment listing will require a higher level of certainty from additional years of data since there is a record of high fines in Jim Creek that could take several years or more to flush through the system. This is consistent with Watson et al. (1998) conclusions that high levels of sediment loading could take years or decades to flush through these streams. Macroinvertebrate results also need to show full support in the lower sections of Jim Creek where high levels of fines from past harvest activities could be contributing to impairment conditions.

- Many of the pollutant parameters that this document has to deal with are highly variable in nature, but the data from the upper portion of Jim Creek supports an impairment determination due to low levels of woody debris and impacts to pool and habitat quality. Table 5-6 provides sufficient data for % pools with cover for all other streams assessed, including those that could be used as a reference. The 50% target value was purposely chosen as a value that all other stream reaches assessed currently meet (reference Table 5-6 and Section 5.14.2.2 discussion).

- The Appendix J data on large woody debris shows that all higher elevation “B” or “B/C” type streams reaches (Goat 16, Piper 14 and Piper 10) have large woody debris and/or aggradate totals in excess of 50, with median and average values above the public review draft target level of 80. Based on the results of similar stream types in the watershed, the target has been reduced to “greater than 50 pieces of large woody debris and/or aggregates” to address variability between streams and overall target achievability. The current level of 13 pieces and 0 aggragates per 1000 feet in the upper part of Jim Creek is still well below this new target condition.

Comments:

- The proposed target for Goat Creek relating to suspended sediment does not directly relate to any beneficial use as they do not respond to instantaneous levels of suspended sediment. As the current target is worded, it could be exceeded for only one minute on a single day and that would constitute it remaining on the list. This is not right.
- Goat Creek Targets Inappropriate: It is inappropriate to set an absolute instantaneous threshold for a non-toxic pollutant such as TSS. TMDLs are designed to control “loads” not instantaneous concentrations. Additionally, there is no evidence that the one observation of 45 mg/L TSS in 1997 had any impact whatsoever on beneficial uses in Goat Creek.

DEQ Response: The target is linked to aquatic life beneficial uses and is consistent with Montana’s Water Quality Standard as well as water quality standards in several other western states (Rowe et al., 2003). Sufficient linkages to standards and impairment determination are provided in Section 6.4.1. Data is representative of what are arguably several weeks of elevated TSS concentrations (Ellis 1999b), which may have been even higher than the 45 mg/l measurement if more sampling had occurred.

- There are rarely enough resources to support continuous sampling during runoff, and a given sample must be used as an indicator of water quality for the time period between samples. The 1997 data supports a conclusion that suspended sediment values were elevated for several weeks during runoff. It is anticipated that any further data showing a value exceeding the 30 mg/l target could represent several days of elevated suspended sediment load depending on the sample design. Nevertheless, wording has been added to the “Target Applicability Considerations” part that allows for consideration of duration and magnitude of any sample results greater than 30 mg/l under circumstances where a very large data set indicates values less than 35 mg/l occur over a duration of less than one week, or values less than 40 mg/l occur over a duration of less than two days.

Comment: Targets and Allocations for other drainages not on the 303(d) list: The DEQ establishes targets and allocations for drainages not on the 303d list at this time. I think this is outside the scope of this TMDL, which should only deal with the currently listed streams.

DEQ Response:

Targets:
Only primary targets are applied to 303(d) listed stream segments and waterbodies. Secondary targets are applied to some individual streams as a method to help track progress toward meeting primary targets and to help with adaptive management decisions, consistent with EPA guidance (1999a) for the application of hillslope indicators for target development.

The "Additional Target Conditions" are defined as "indicator parameters or conditions that can be used as the basis for additional impairment determinations in Swan Lake and in tributary streams within the Swan Lake Watershed." Given the high percentage of available nonpoint source resources going toward TMDL development, it is reasonable to identify potential water quality protection goals that could apply throughout the watershed. Providing this information represents a prudent use of taxpayer's money to share information learned as part of the TMDL and water quality planning effort in a way that could help identify and possibly prevent future water quality problems and provide further guidance toward Clean Water Act compliance. This is consistent with the State's nonpoint source program, for which the TMDL and water restoration planning process is a major component.

Allocations:
Allocations are only applied to existing or potential future pollutant loading sources that are linked to the TMDL. The TMDLs are only applied to the 303(d) listed waterbodies impaired or threatened by a pollutant. This necessitates applying allocations at a watershed scale where a downstream waterbody is impaired or threatened. This can be done by source categories or at the tributary scale consistent with EPA guidance (1999a). Both approaches are used within Section 8.0.

Comments Addressing Multiple Sections

Comments:
- The document does not discuss state regulatory mechanisms for reviewing proposed septic tanks. While the document does summarize some existing county floodplain regulations, the omission of any discussion regarding regulatory mechanisms for septic tanks is glaring.
- TMDL Should Better Document Existing Regulatory Mechanisms: The document fails to describe provisions under state law for evaluating impacts of septic systems under the non-degradation statute and possibly other state laws. A description of these existing regulatory mechanisms should be added to Sections 5.12, Table 8-1, and Section 9.2.4. These existing regulations should be cited in Table 8-1 as the mechanism for achieving the TMDL load allocation for septic systems.

DEQ Response: Language referring to state laws that address septic systems has been added to the document in Sections 5.11, 8.0, and 9.2.4. This language is consistent with the above comments, although Table 8-1 still includes other methods, such as septic maintenance, to help achieve allocations.

Comments:
- The document fails to describe Montana's Streamside Management Zone (SMZ) law. This law is the implementation tool for forest landowners to ensure protection of streams and achievement of the TMDL.
- TMDL Should Better Document Existing Regulatory Mechanisms: Additionally, the document fails to mention or describe Montana's Streamside Management Zone (SMZ) law, which is a primary TMDL implementation tool for forest landowners.

  DEQ Response: The SMZ law is discussed in several locations of the public comment document, including Sections 4.1.2.2, 5.5.1, 5.13.3, 6.6, and 9.2.1. Some additional descriptive language has been added to Section 4.1.2.2 to better describe this law as suggested in the comments. Based on this comment, the SMZ law has been added as a "Method to Achieve Allocation" for the "Riparian and Streambank Protection" allocation within Tables 8-1, 8-2, and 8-3. Language has also been added to the Section 8.2.1.2 discussion for this allocation.

Comments Focused on Jim Creek Impairment Determination

Comment: Available macroinvertebrate data indicate the stream is fully supporting aquatic life. Table 5-9 indicates that the Jim Creek macroinvertebrate sample was collected just below the Wilderness boundary, but this is not the case. As provided by Plum Creek to the Department, this site was sampled at the 888 Road Crossing of Jim Creek in the SE1/4, NW1/4, Sec. 32, T22N, R17W, Lake County. This sample reach is located 2 miles above the mouth of Jim Creek and below most forest management activity.

> **DEQ Response:** Regarding the macroinvertebrate sampling location, the document has been corrected in Section 5.19, Section 6.3.1 and Section 7.2. The macroinvertebrate data, even taking the corrected sample location into account, does not appear to represent conditions along the whole stream segment. Until further analysis is performed, Jim Creek will remain impaired for both cold water fish and aquatic life consistent with other impairment determinations within the Swan Lake Watershed

Comments:
- The available long-term record of spawning gravel quality (1988 to present) indicates that Jim Creek has virtually identical fine sediment levels as Lion Creek (which DEQ has previously determined to be fully supporting its uses). This is not particularly surprising since the inventory of road sediment sources by Land and Water in 2001 found that sediment delivery rates in Jim Creek were only 2% above background.
- Much of the discussion on Jim Creek (especially Section 8.2.2.1.1) appear to make a good case that the stream meets all beneficial uses and is not impaired. It is hard to imagine a problem when the road related sediment is only 2 percent above natural background.

> **DEQ Response:** Sediment transport can take years or decades from the time it enters a stream and is transported from the system (Watson et al, 1998). Therefore, it would not be unusual to have a low existing input of sediment load and still be dealing with

historical loads that are causing impairment to beneficial uses. This condition is specifically recognized within the Table 8-2 and Section 8.2.2.1.1 road sediment delivery allocation.

Comment: In examining DEQ's report titled Riparian Assessment and Characterization of the Swan River and Select Tributaries (Pipp 2002), about 2 miles of upper Jim Creek riparian area (in the vicinity of Jim Lakes) was identified as being impacted by historic timber harvest. Only one of these segments was selected for field review in 2002 (Segment 24). In examining this reach, DEQ found relatively low levels of LWD (13 pieces per 1000 feet). While the mid-1970's harvesting by Plum Creek certainly reduced recruitment rates, it should be recognized that this reach has a gradient of 8%, a bankfull width of 18 feet, and drains 8 square miles of high elevation alpine terrain that receives tremendous annual snowfall. This translates to tremendous stream power in this reach and would make it very difficult for wood to accumulate. Additionally, because this reach is located just below a series of natural lakes, it is unlikely that it receives much LWD input from upstream sources. As such, we do not believe that historic LWD levels were likely very high in this reach. And this level of LWD is not outside the range of natural variability. Data summarized by Light et al. (1999) 1 found that about 15% of unmanaged streams have LWD levels below 20 pieces/1000 feet.

DEQ Response: The assessed portion of this reach was in a lower gradient section of the overall reach, and the LWD and pool cover was lacking when compared to other similar assessed reaches within the watershed. Riggers et al. (1998) found significant quantities of woody debris in the steeper Rosgen "A" type channels across the Lolo National Forest in western Montana streams. Table 4 from Light et al. (1999) identifies Cascade type streams with gradients greater than 6% as having low channel sensitivity relative to LWD, but then also notes the following: "pool-forming processes are significant in the absence of LWD, although there is evidence that LWD can increase pool frequency and provide other significant habitat elements". It is the loss of these significant habitat elements attributed to historic harvest and supported by adequate reference condition information that supports the impairment determination in upper Jim Creek.

Nevertheless, Section 7.5.1 does acknowledge that "it is possible that the natural potential of some streams will preclude achievement of a target". Furthermore, the target monitoring compliance criteria within Section 10.1.1 states: "Future monitoring should evaluate upper impacted reaches above and below Jim Lake. This data can be used to evaluate potential natural impacts that Jim Lake may have on downstream woody debris recovery." Based on this comment, there is no need for significant document changes, although language addressing target achievability and Jim Lake considerations, similar to the language in Sections 7.5.1 and 10.1.1, has been added to the Section 7.2 "Target

1 Light, J., M. Holmes, M. O'Connor, E.S. Toth, D. Berg, D. McGreer, and K. Doughty. 1999. Design of effective riparian management strategies for stream resource protection in Montana, Idaho and Washington. Native Fish Habitat Conservation Plan Technical Report No. 7. Plum Creek Timber Company, Columbia Falls, MT.

Applicability Considerations" sub-section for the pools and LWD target (Jim Creek Primary Target #2).

Comment: DEQs field assessment of Upper Jim Creek (Segment 24) found very low levels of fine sediment (<10% fines). This is not surprising since this reach is 8% gradient and is located immediately below a large sediment sink (i.e., Jim Lake). DEQ also noted that stream banks were stable. As a final observation, this reach of Jim Creek goes dry as it traverses a coarse glacial moraine (Flathead NF Landtype 23-8) at the foot of the Jim Lakes cirque basin and thus naturally provides little or no fish habitat (and certainly no bull trout habitat). However, it is fortuitous that it does go subsurface so that it can re-emerge as cool groundwater at bull trout spawning and rearing areas downstream.

Regarding the Jim Creek fishery, it supports a good population of bull trout. Data since 1991 average about 60 bull trout redds per year. Redd counts were lower in the late 1980's because bull trout could not access habitat due to a beaver dam in the lower reaches of the stream. FWP removed this dam in the late 1980's to allow upstream passage. Recently, the beaver dam has come back and is believed by FWP to be inhibiting upstream migration. They are currently considering removing it again (Tom Weaver [FWP] Personal Communication with Ron Steiner [PCTC]).

Development of a TMDL should logically "connect the dots" between an activity, delivery of a pollutant, impact to habitat, and impairment of a use. In the case of Jim Creek, DEQ has found that mid-1970's logging was identified as a potential impact. However, based on the data in the TMDL document this potential source has **not** manifested itself in unstable streambanks, delivery of sediment from roads, impact to surface or intergravel fines, unexplainably low levels of LWD, impacts to macroinvertebrates, or fish. The data that have been provided indicate full support of fisheries and aquatic life. Current regulatory mechanisms (BMPs, SMZ Law) and Plum Creek's Native Fish Habitat Conservation Plan will ensure that it continues to fully support its uses.

The data presented in the document fail to demonstrate impairment of Jim and Goat Creeks. Rather, the available information strongly suggests otherwise. In evaluating the available data for Jim Creek, we cannot follow the Department's technical argument that this stream is impaired. The data simply do no support this conclusion.

DEQ Response: Section 6.3 provides adequate rationale for an impairment determination for Jim Creek, including the fact that percent fines in bull trout spawning gravels, pools with cover in upper reaches, and large woody debris numbers in upper reaches all deviate from reference/target conditions. This determination is supported by land use impacts linked to the impairment conditions throughout the document. The above arguments only support the fact that there are limited impairment causes and in some cases the impairment is limited to a given reach. We agree that this is a close call, similar to the close calls for the conditions where we determined that Piper was no longer impaired and that most of the pollutant and habitat alteration conditions in Goat Creek were no longer significant enough to justify an impairment determination.

Comments Focused on Goat Creek Impairment Determination

Comments:

- Available Data do not Support an Impairment Determination for Goat Creek. In reviewing DEQs impairment determination for Goat Creek, it appears that the sole reason for listing is that during the Ellis et al. (1999b) study they observed a maximum TSS concentration of 45 mg/L whereas Lion Creek had a maximum concentration of around 20. DEQ's explanation for this difference is that Goat Creek has had 22% of its watershed harvested in the past 40 years (which is characterized as "extensively harvested" by DEQ in Section 5.6.4) whereas Lion Creek above the sample site was unharvested. We are troubled by the apparent use of this snapshot measurement of TSS for several reasons.

- First, suspended sediment concentrations can vary dramatically over short time periods. Bunte and MacDonald (1999)2 reported that: "…short term fluctuations commonly extend over a factor of three or more." Second, inspection of Ellis et al. (1999b) Figure 11 shows that Goat Creek was sampled near it's annual peak discharge (or far up the rising limb of the hydrograph), while Lion Creek was sampled on the falling limb of it's first spring peak. Because of this, it is likely that the Lion Creek peak TSS was missed. Third, except for that one observation on Goat Creek, other TSS concentrations throughout the spring runoff period are remarkably similar between Goat Creek and Lion Creek. Lastly, Ellis et al. (1999b) state "*The only biophysical factors that we measured that could explain the differences observed in the water quality attributes were the harvest legacy in Goat Creek*." The authors evidently forgot that earlier in their report (See page 2 paragraph 1) they stated that "….*Goat Creek traverses more of the glacial deposits than does Lion Creek. In addition, the glacial deposits on Goat Creek extend up the stream corridor a greater distance than in Lion Creek*." It is interesting that this possible factor was overlooked by the authors, since their concurrent study on the Swan River (Ellis et al 1999a) found that the amount of glacial deposits within a catchment was a significant factor in explaining TP concentrations (which is usually highly correlated with TSS).
- It is inappropriate to rely on a single snapshot measurement of TSS in 1997, a year that the Swan experienced a 25-50 year recurrence interval flood, and over-ride information we know about the status of beneficial uses in this watershed.
- A fine suspended sediment reduction of 33 percent during peak flows is based on the readings in 1997. This was a high water year and that could represent an extremely high reading for Goat Creek. It is difficult to know if this is a reasonable TMDL.

> **DEQ Response:** DEQ notes many of the above concerns and realizes that not only do suspended solids concentrations vary naturally, but are also sensitive to land management activities such as timber harvest, which have the potential to significantly increase suspended sediment concentrations. DEQ decided that Goat Creek would remain listed as

2 K. Bunte and L. MacDonald. 1999. Scale considerations and the detectability of cumulative watershed effects. Technical Bulletin No. 776. National Council of the Paper Industry for Air and Stream Improvement, Inc., Research Triangle Park, N.C.

impaired for suspended sediment to ensure protection of the resource, and feels that proper justification, including consideration of natural background conditions, was provided. This justification includes the following considerations not fully explored in the above comments: (l) all data for a two-month period showed TSS values higher in Goat Creek than Lion Creek, even though Lion Creek had significantly higher flow conditions; (2) elevated suspended sediment concentrations in Goat Creek are not only higher than Lion Creek, but also higher than other potential reference streams of Dog and Cat Creek (Section 5.6.4); and (3) with the existing timber harvest sources such as road sediment (Section 5.2.3) and others discussed throughout Section 5.0, it is probable that a watershed with a higher level of erodable soils would be more susceptible to impacts from roads and other timber harvest activities, especially under high runoff conditions.

Nevertheless, we have set targets in a manner that could be satisfied if sampling continues to indicate TSS runoff concentrations similar to the 2003 results which showed that, in spite of the high amount of glacial deposits noted above, Goat Creek has the potential for low suspended solids results similar to reference streams. The allocations are consistent with the Swan Lake allocations and application of forestry BMPs and other practices consistent with water quality protection. Therefore, no changes are made to the document based on the above comments.

Comment: Information we have on beneficial use support in the Goat Creek watershed indicates full support. Available macroinvertebrate data score very well (see Table 5-9). Goat Creek is a premier bull trout stream (~60 redds per year over past decade). And spawning gravel quality is good.

DEQ Response: The impairment determination for Goat Creek was based on a suspended sediment condition where water quality standards were not satisfied. Previously listed causes of impairment, such as habitat alterations, nutrients, and siltation were no longer considered a significant concern for some of the above noted reasons.

Comments Focused on Implementation and Monitoring Strategies (Sections 9.0 and 10.)

Comments:

- I suggest that a database be set up that tracks new road construction and logging activities. This would help identify potential areas to monitor and could possibly be some sites to test the effectiveness of BMPs. Because of the Swan Valley Conservation Agreement for grizzly bears logging and road construction are concentrated into three bear management subunits at a time that are rotated every three years. The effects of doing this on water quality and bull trout were not fully known when this Agreement was developed so this might be a good opportunity to test it. This could also be why in watersheds such as Woodward/South Woodward road problems were found because that bear management subunit was open for concentrated activities between 2000 and 2002.
- I suggest that a schedule of priorities be developed which would include the 70 worst road sediment contributing sites, the agency/entity responsible, the monitoring to be done and when the repairs were made. This would help to track that target to see whether the goal is

being reached. This information may already be in the draft TMDL but the appendix containing the road assessment data was not operating on DEQ's website.

> **DEQ Response:** The above concepts are essentially captured via the recommendations for complying with the "Other Timber Harvest Impacts" allocation within Section 8.2.1.3, and within the Section 10.1.2 implementation monitoring recommendations. Language consistent with the above recommendations, and similar to language in Sections 8.2.1.3 and 10.1.2, has also been added as part of the recommended strategy for timber harvest activities (Section 9.2.1) and reducing forest road sediment loading (Section 9.2.2). Wording has also been added to Section 6.5, which discusses the potential for impairments in other tributaries in the watershed. This additional Section 6.5 wording stresses the importance of tracking land use activities throughout the watershed.
>
> We stress the fact that the additional language within Sections 6.0 and 9.0 provides recommendations, versus requirements, for TMDL implementation and water quality protection within the watershed.

Comment: There does need to be a mechanism for concerned citizens to report violations of lakeshore protection and other regulations that is acted on by the enforcement agencies.

> **DEQ Response:** A DEQ enforcement division handles citizen complaints where potential state water quality regulations are violated. Also, citizens can report potential violations of local regulations to the appropriate county authority.

Comment: Blatant violations of Lake County Lakeshore Protections Regulations and the Montana Streamside Management Zone Law are being allowed to take place on the west Shore of Swan Lake in the Bug Creek area. These violations are having a significant negative impact on Swan Lake water quality and need to be addressed by the Department of Environmental Quality.

Specifically, two recent incidents illustrate the problems. A road cut was constructed on Swan Shores Estates Tract 2 (Easton) in or about 2002. We understand that Lake County initiated enforcement action and required remediation after the fact in this case. A similar road cut was constructed on adjacent Tract 3 (Zac) last Fall-apparently in connection with other onsite excavation for the building foundation, utility trenching and installation of the well and septic system. In the latter case, Lake County Planning apparently issued the septic construction permit as well as a Zoning Conformance Permit for the development of the property. We have contacted Don Wood of Lake County Planning, and Mr. Wood visited the site yesterday, March 23.

We recommended that DEQ require Lake County to take proactive action in connection with all future lakeshore projects as follows:

- As part of any Permitting activity (including but not limited to septic and zoning conformance permits) each property owner and contractor working on site be required to sign an affidavit acknowledging their receipt of copies of all relevant regulations affecting protection of the lakeshore and adjacent lands-and, acknowledge the likely enforcement consequences of any violations.

- Each property owner and contractor at time of any permits being granted should be required to clearly and prominently mark (and maintain throughout the course of development of the site) the appropriate lakeshore protection, “setback”, “buffer zone”, Streamside Management Zone (SMZ), or other boundaries against which regulatory conformance can be measured. Specifically stakes with pre-printed signs provided by Lake County should be placed at intervals of no less than fifty (50) feet, including at each property line.
- A sign should be installed at the start of West Swan Shores Road containing a message similar to the following:

Lakeshore Protection Regulations Strictly Enforced

Properties In This Area Are Subject To:
Lake County Lakeshore Protection Regulations
Bug Creek Zoning Regulations
Montana Streamside Management Zone Law
And other regulations

Attention Property Owners and Contractors
You Will Be Held Personally Financially Liable
For Any Violations, Including Fines and Remediation Cost
For Requirement and Permits Contact:

Lake County Planning Department
(406) 883-7240

DEQ Response: Lake County Planning personnel have appropriately addressed the above two noted incidents. There are significant efforts underway in Lake County, as well as other counties, to address the above noted violations along Swan Lake as well as preventing similar violations or water quality threats along any stream or lake. In Lake County, these efforts specifically include educating realtors and equipment operators on zoning requirements as well as the licensing of septic contractors.

Unfortunately, violations do still sometimes occur. DEQ however, has no authority to force a local authority to enforce their zoning regulations. In addition, DEQ has no authority to enforce the requirements of the state’s Streamside Management Zone (SMZ) act, as that authority rests exclusively with the Montana Department of Natural Resources and Conservation. Although the above comment implies that the SMZ law applies to private property development, the law only applies to commercial “timber sales” as defined in Section 77-5-302(9), MCA.

Many of the recommendations, including the sign, are consistent with Lake County efforts to educate the appropriate personnel about water quality protection, and are taken into consideration. Given stretched resources, a local watershed group can sometimes help accomplish many of the water quality educational and awareness goals represented by the above suggestions.

The concerns brought out by this comment are consistent with the document's focus on subdivision and other private land development as a significant future growth concern potentially affecting water quality. We hope that these future growth issues can be resolved with the help of concerned citizens and voluntary efforts, along with adherence to Lake County zoning requirements, the Natural Streambed and Land Preservation Act (310 Law), and state and federal water quality protection regulations. Education will be an important part of this effort.

Comment: In order to determine whether the goal of reducing sediment into Swan Lake is being met a coring should be done now and in an appropriate time frame (perhaps 5 years).

DEQ Response: This suggested monitoring is part of the Section 10.2.2 "Medium Priority Monitoring and Assessment Recommendations." Input from the Swan Lake TAG or other circumstances could lead to a higher priority rating for this or other medium priority recommendations, as suggested within Section 10.2.2.

Comments Noted

- In general, we think this draft TMDL and watershed protection plan represents an improvement over what was presented to stakeholders in late 2002. We appreciate that many of our earlier concerns were heard by the Department and incorporated into the public review draft. In the current document, DEQ does a good job of reviewing the available information and rendering reasoned and defensible arguments for delisting some previously listed stream segments, including Elk and Piper Creeks and some pollutants for Goat Creek. We also believe that DEQ has acknowledged the significant uncertainties in our scientific understanding of the linkages between land management activities and the low DO levels present in a portion of Swan Lake. We also applaud DEQ for documenting that naturally low DO levels have been observed in other low-productivity mountain lakes, and recognizing that the low DO in Swan Lake may be an entirely natural phenomenon. Lastly, we support the proposal that the goal for Swan Lake is one of preventing further degradation rather than requiring improvement. It is clear from everything we know about Swan Lake that it currently fully supports its beneficial uses.

- We do not have many substantial concerns about the content of the water quality protection plan. It is a good document that should provide improved water quality within the watershed.

- Section 5.2. We appreciate DEQ funding such a detailed road sediment inventory in the basin.

- Section 6.1. We agree that Elk Creek is an excellent resource and that it is fully supporting its beneficial uses. Elk Creek is one of the premiere bull trout streams in the United States. In recognition of this, Plum Creek is actively working to get company land along Elk Creek into Public ownership.

- Section 6.2. We support the Departments decision that Piper Creek is not impaired. Plum Creek conducted an extensive watershed analysis in the Piper Creek drainage and found it to be in excellent condition. Information we learned in Piper Creek analysis included the importance of protecting not only where the stream is today, but where it might be tomorrow (e.g., channel migration zones). We have since incorporated this concept into our Native Fish Habitat Conservation Plan on all of our lands in Montana.

- The first review draft that went out to the stakeholders suggested that DEQ would use water yield as a target or allocation. This caused concern because modeling results are only approximations of what is going on in a watershed and because of the lack of good data to set thresholds. Fortunately, water yield is not a part of the target or allocation in the draft document.