Water Quality Protection Plan and TMDLs
for the
Swan Lake Watershed

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Land & Water Consulting, Inc.

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

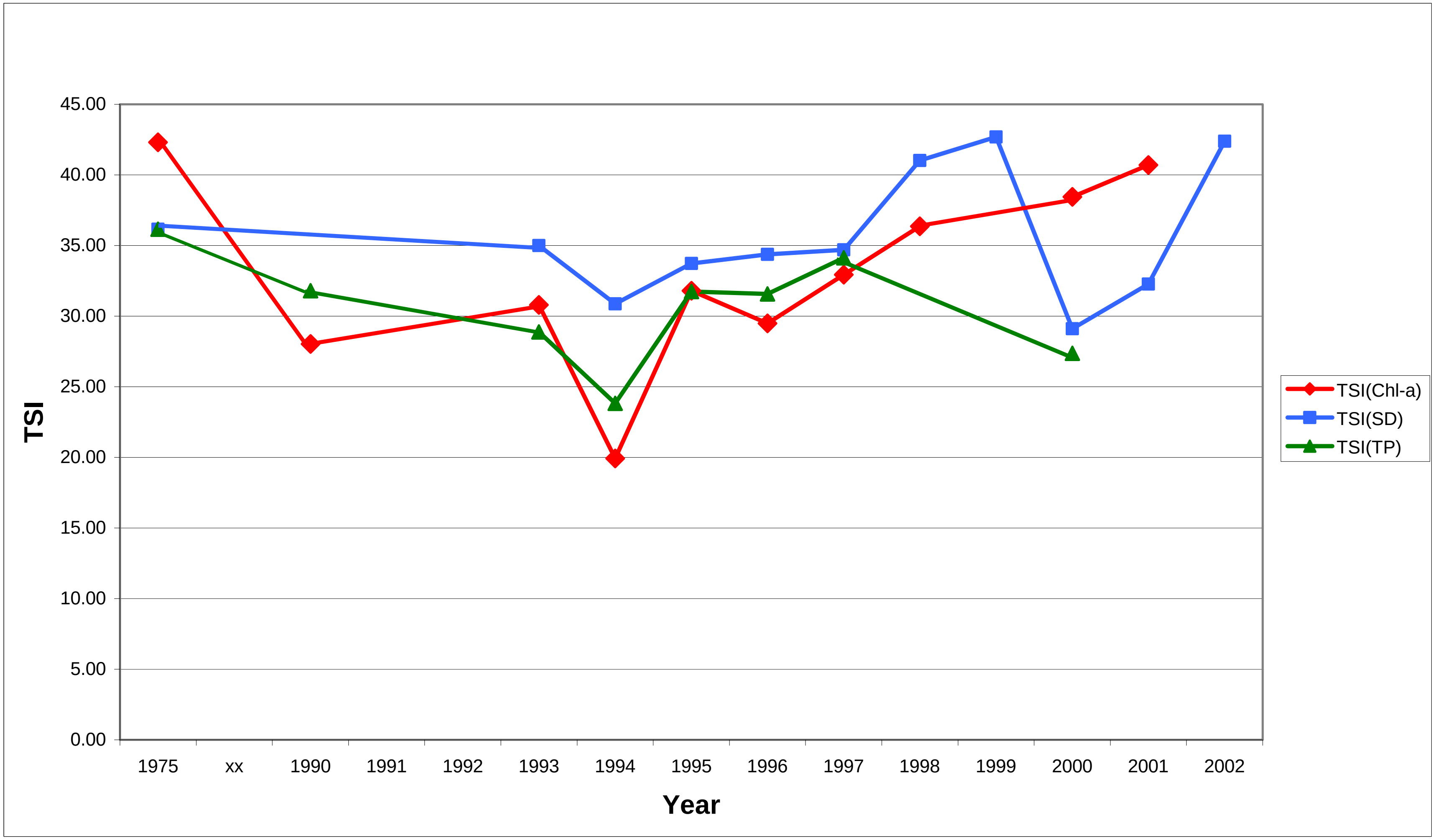
4.1 Water Quality Data and Dissolved Oxygen Concern

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.

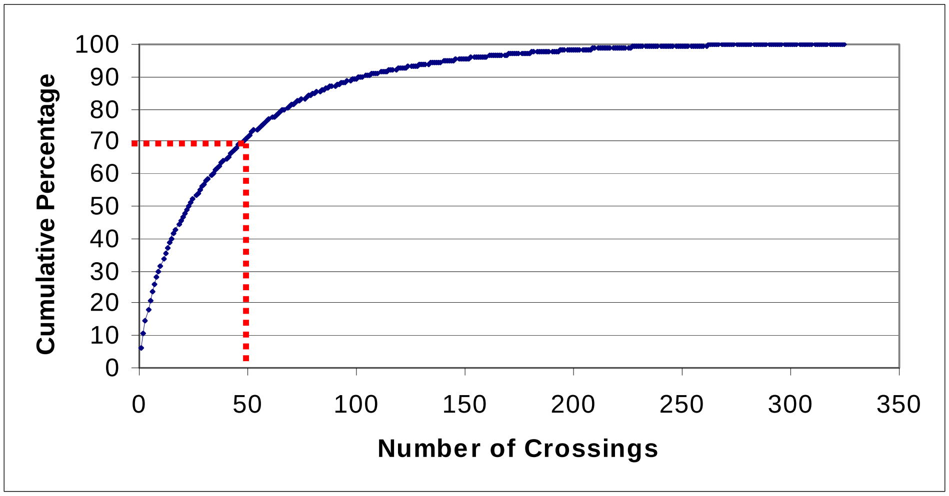


Table 5-3. Largest 20 Road Sediment Sources in Swan Lake Watershed.

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).

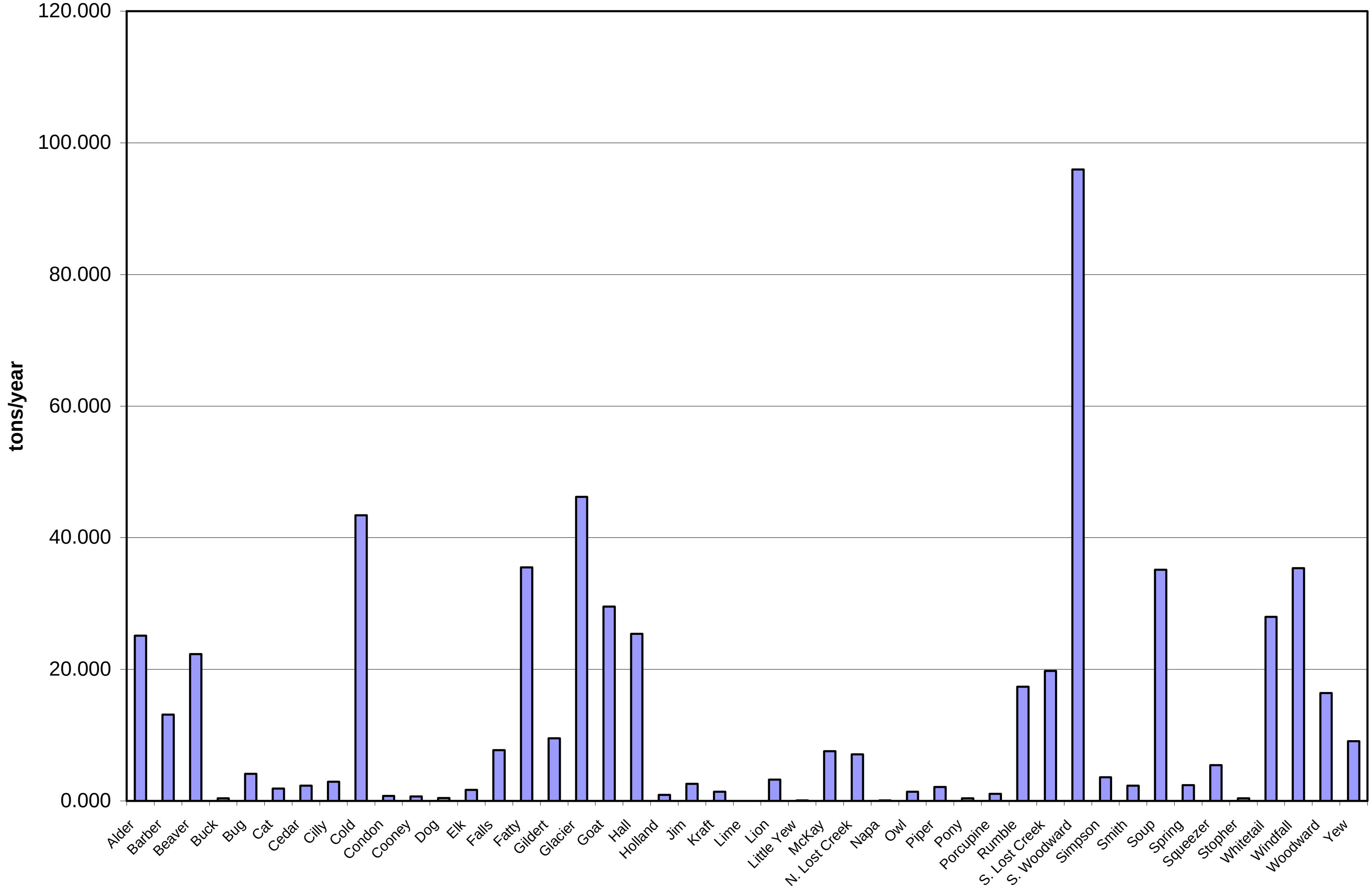
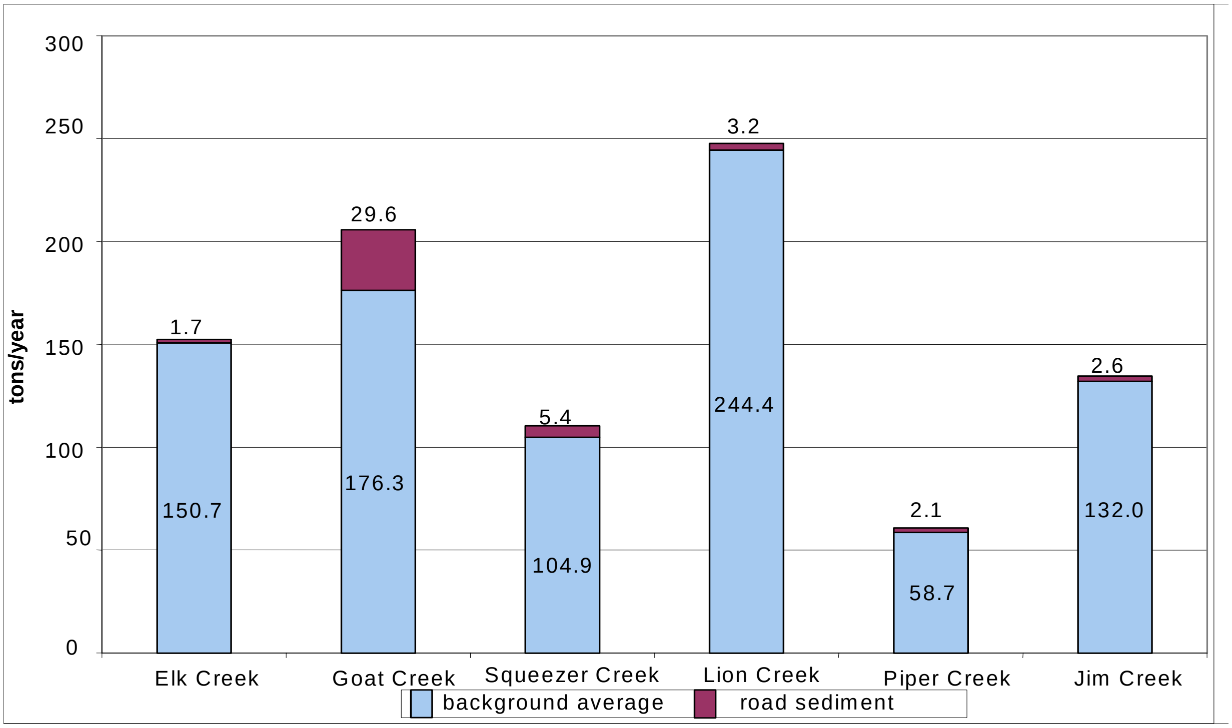


Figure 5-3 shows calculated road and background sediment load values for the six 1996 listed 303(d) streams. The road sediment loads in comparison to natural background loading is comparatively small in five of the six drainages. In the sixth drainage (Goat Creek), the estimated road sediment load is 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).

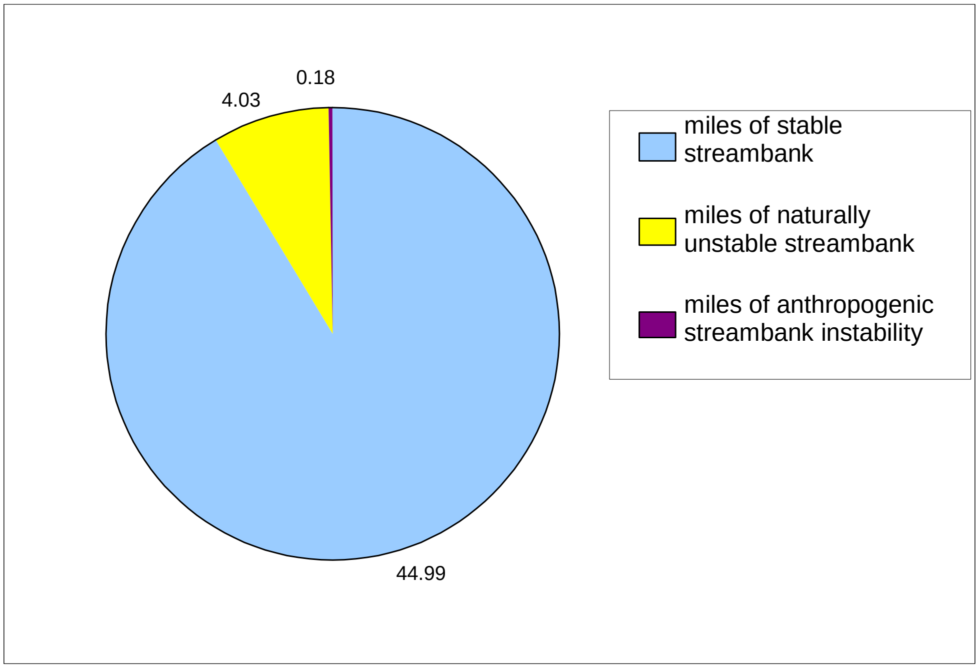


Photo 5-4. ***Example of Stable Bank on Swan River.***

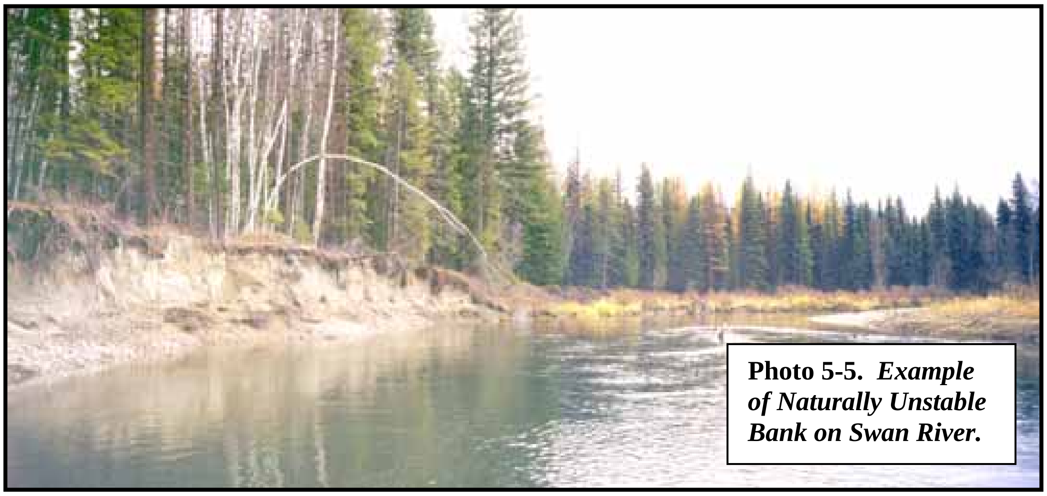


Photo 5-5. ***Example of Naturally Unstable Bank on Swan River.***

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.

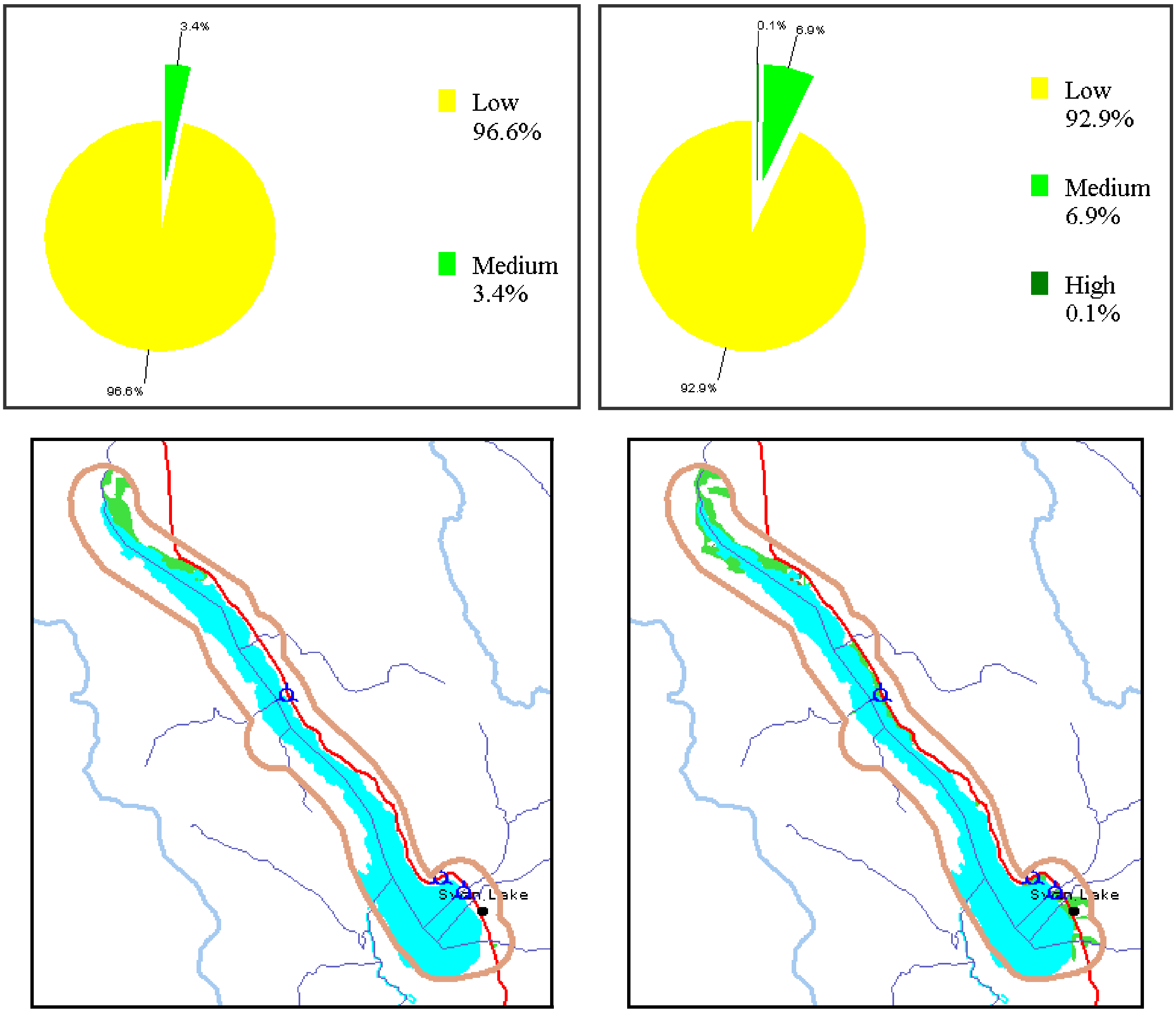
Figure 5-5. Septic Density Around Swan Lake.

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.

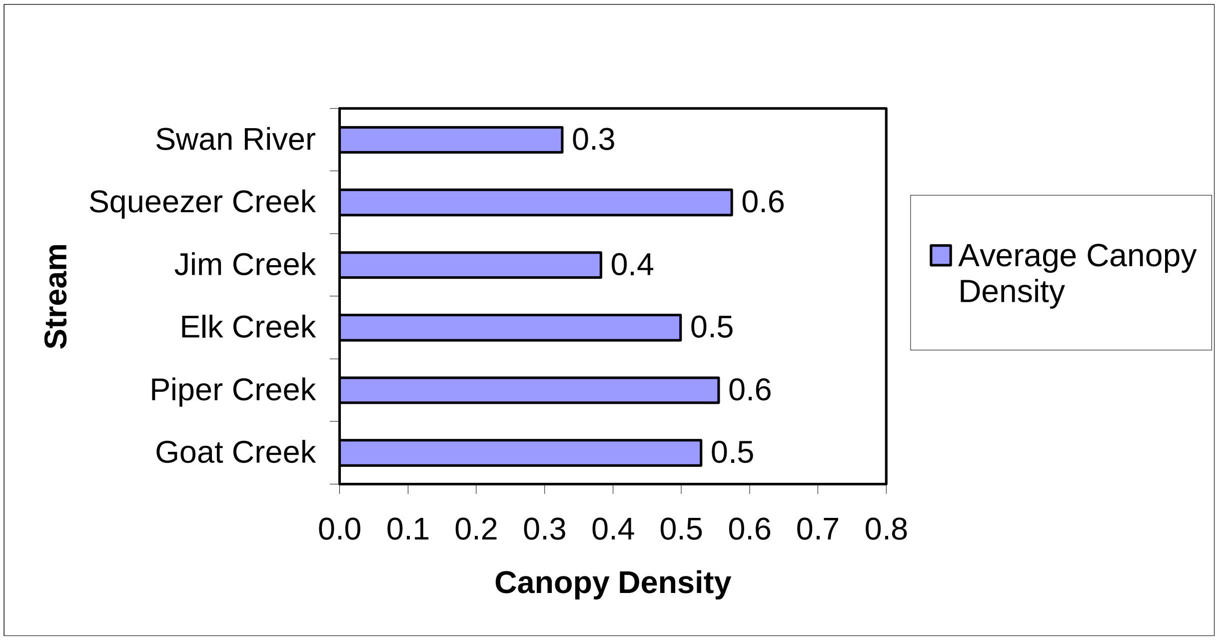


Figure 5-7. Swan River Aerial Canopy Density.

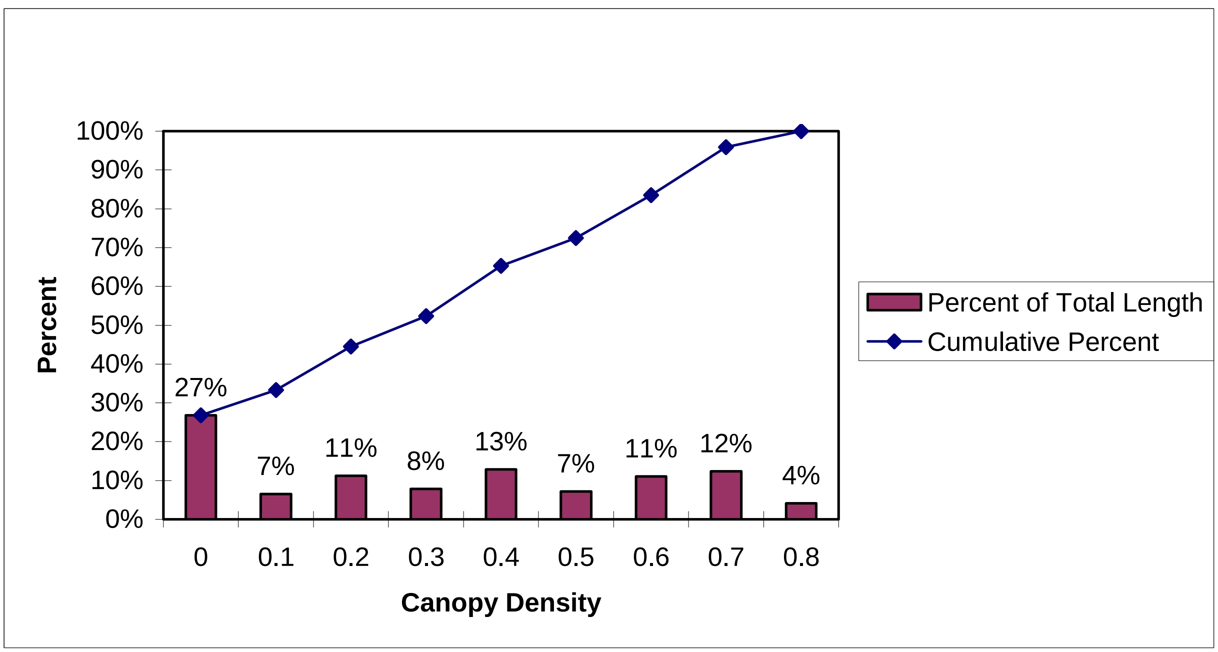


Figure 5-8. Goat Creek Aerial Canopy Density.

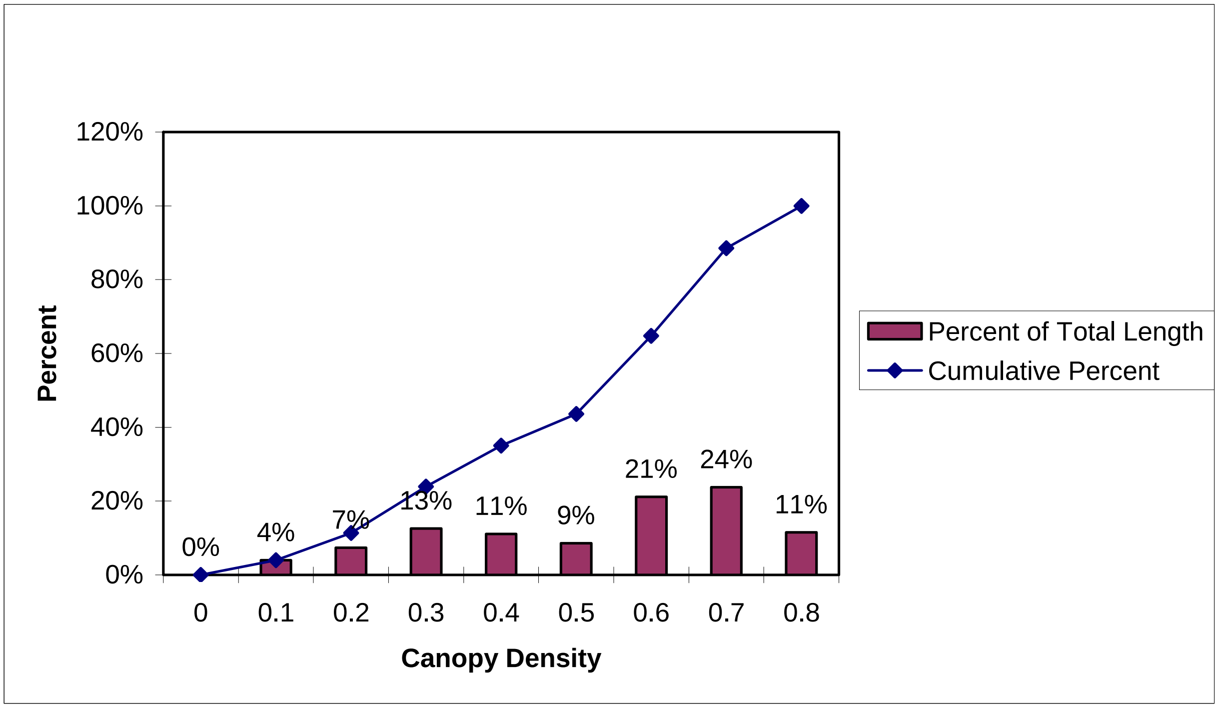


Figure 5-9. Piper Creek Aerial Canopy Density.

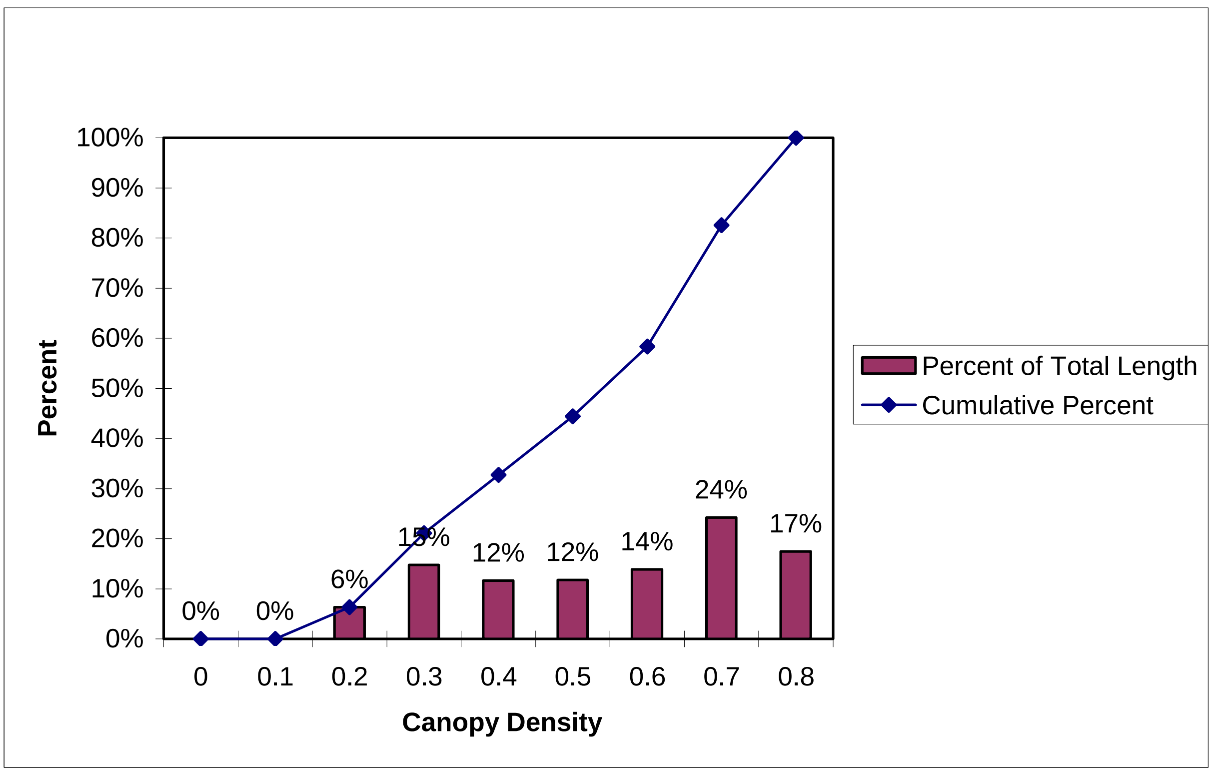


Figure 5-10. Elk Creek Aerial Canopy Density.

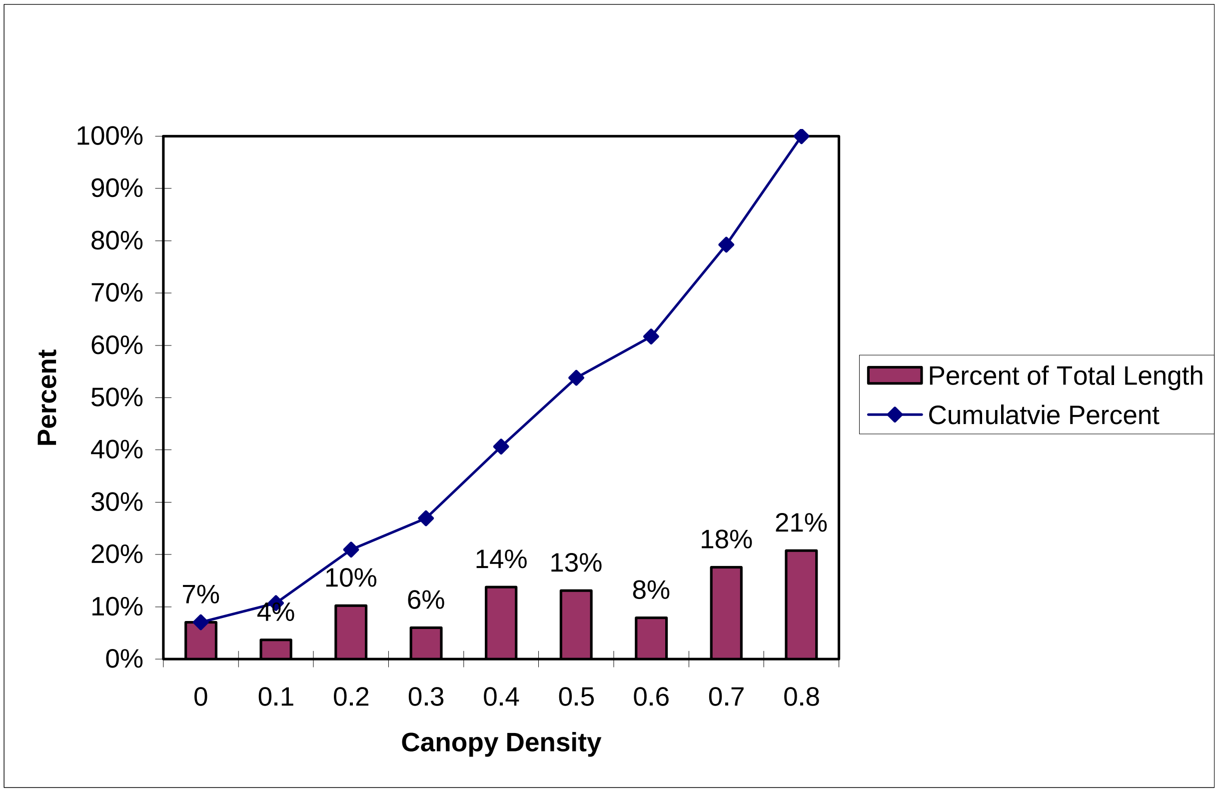
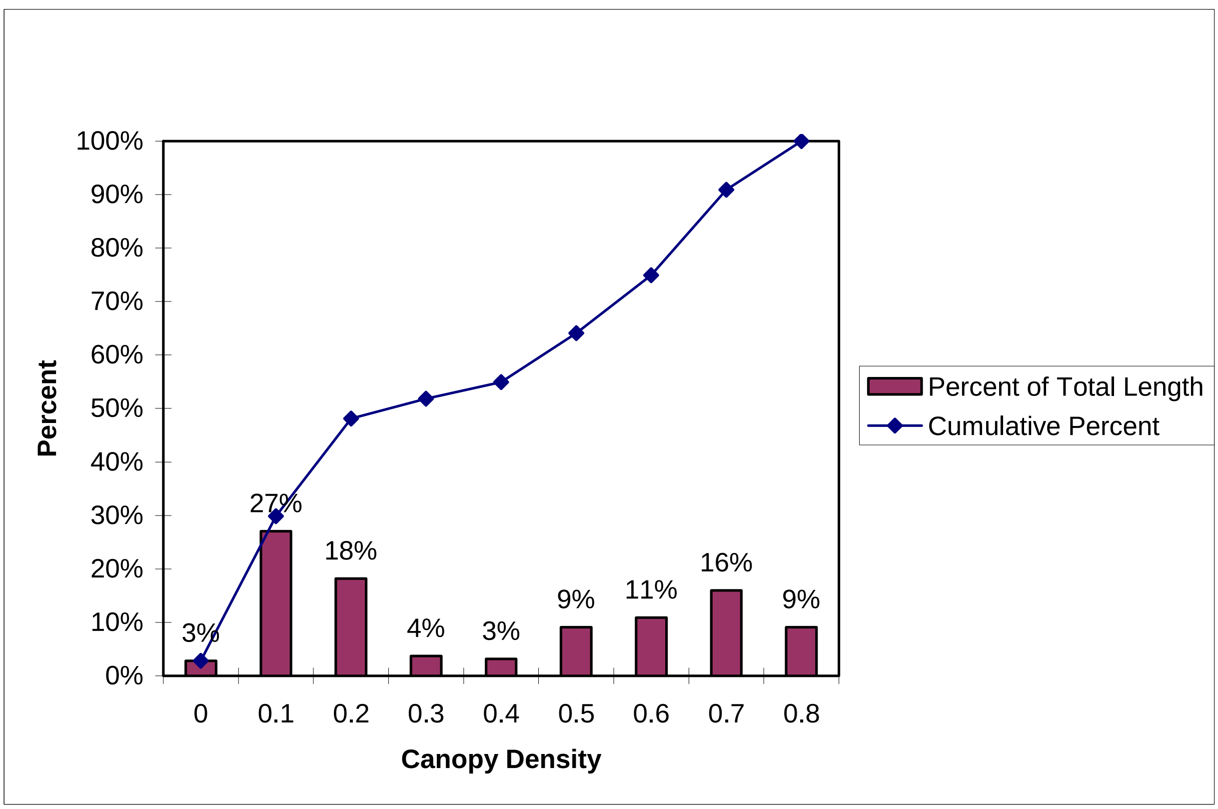


Figure 5-11. Jim Creek Aerial Canopy Density.



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.

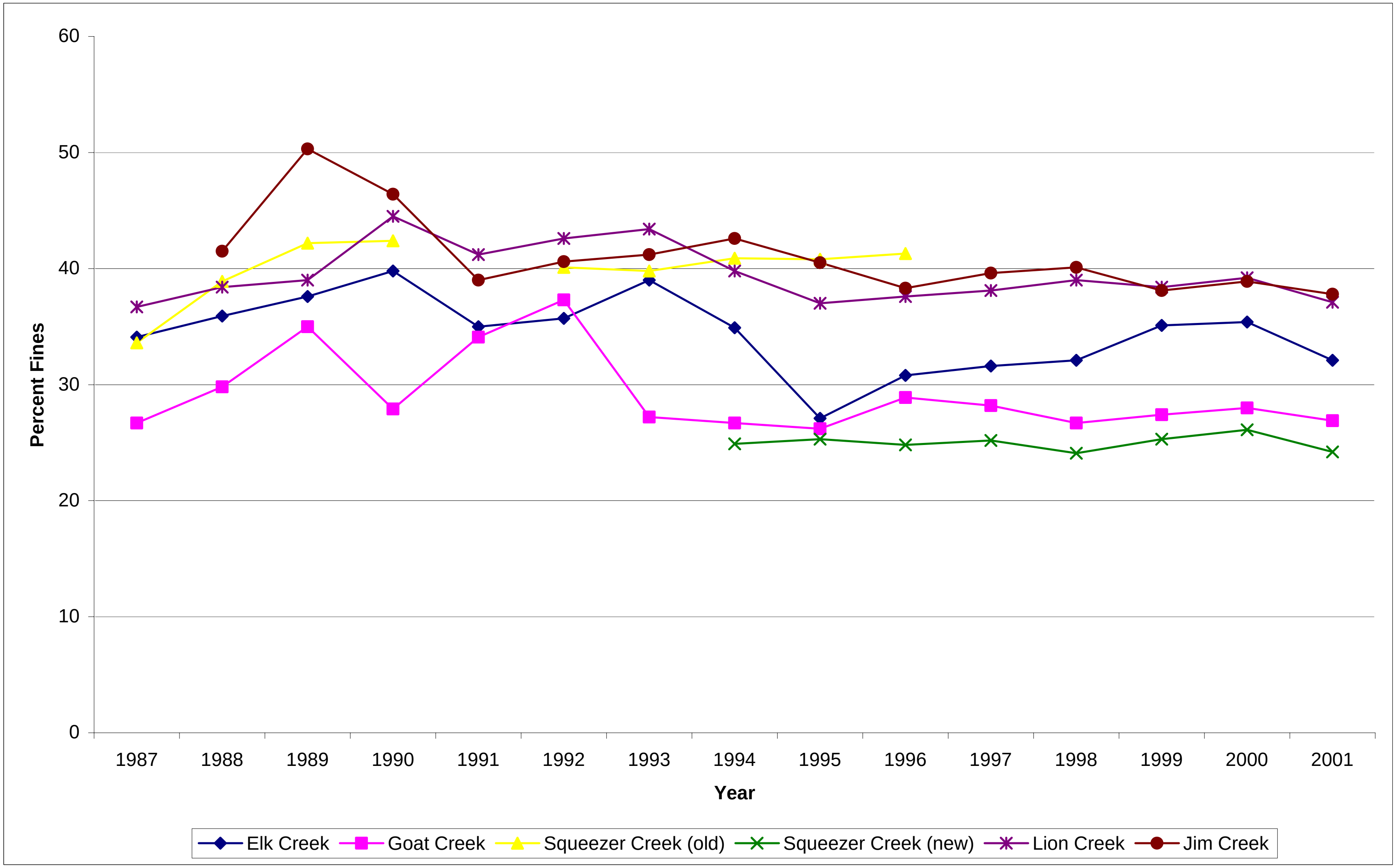
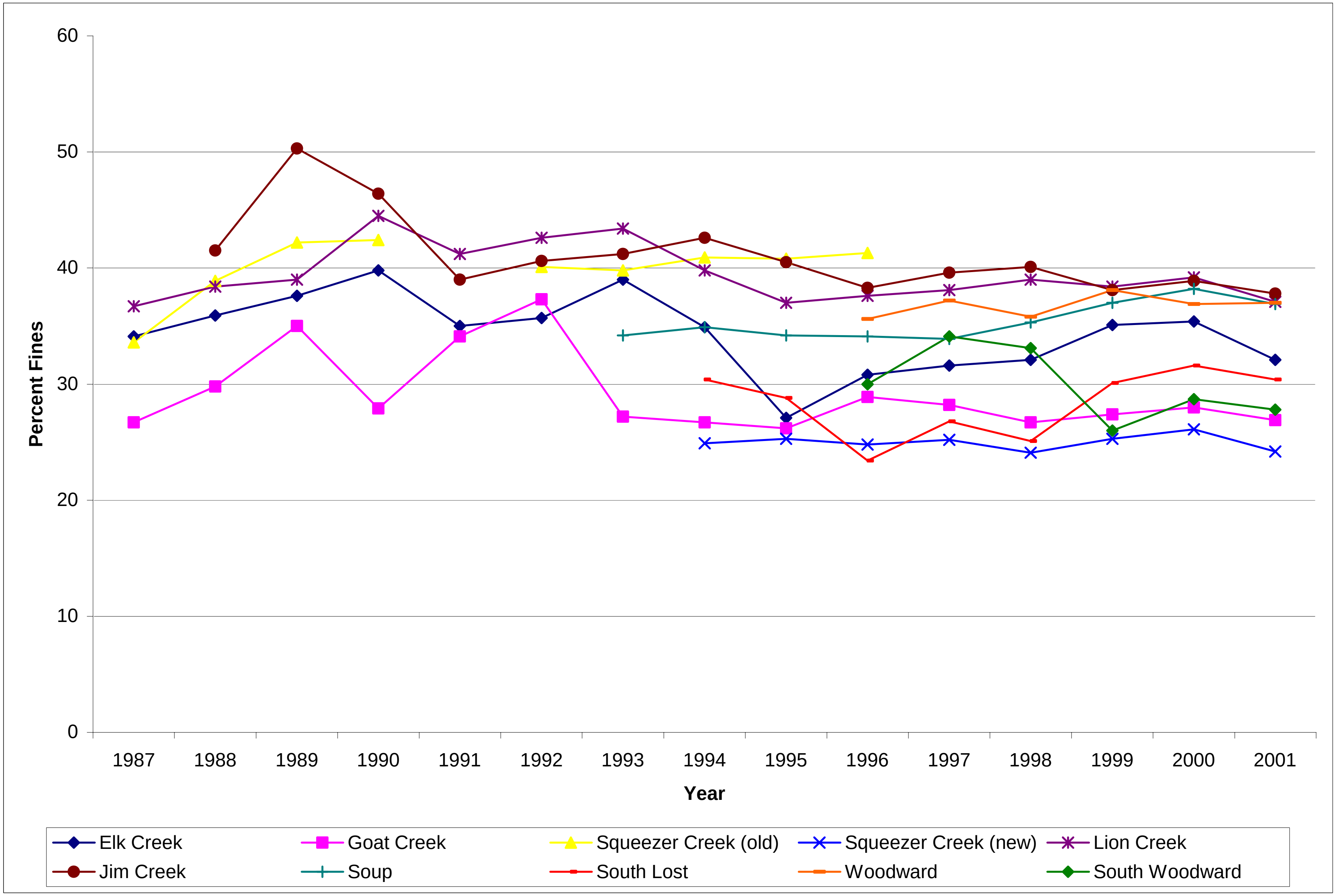


Figure 5-13. McNeil Core Sample Results for Tributaries in Swan Lake Watershed.



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 25th 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.

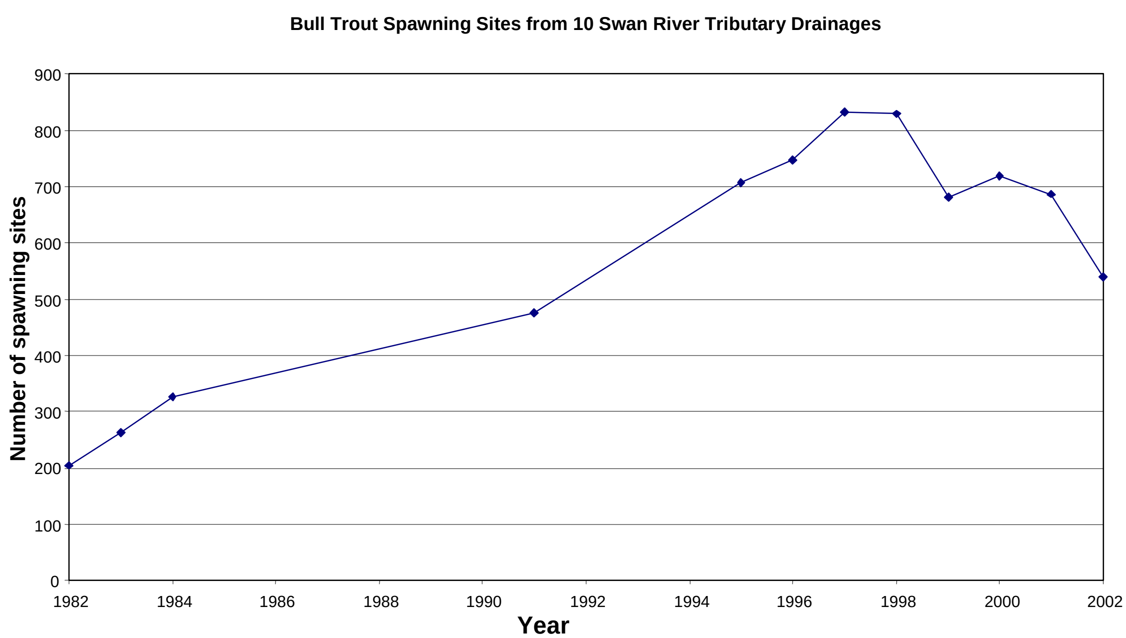
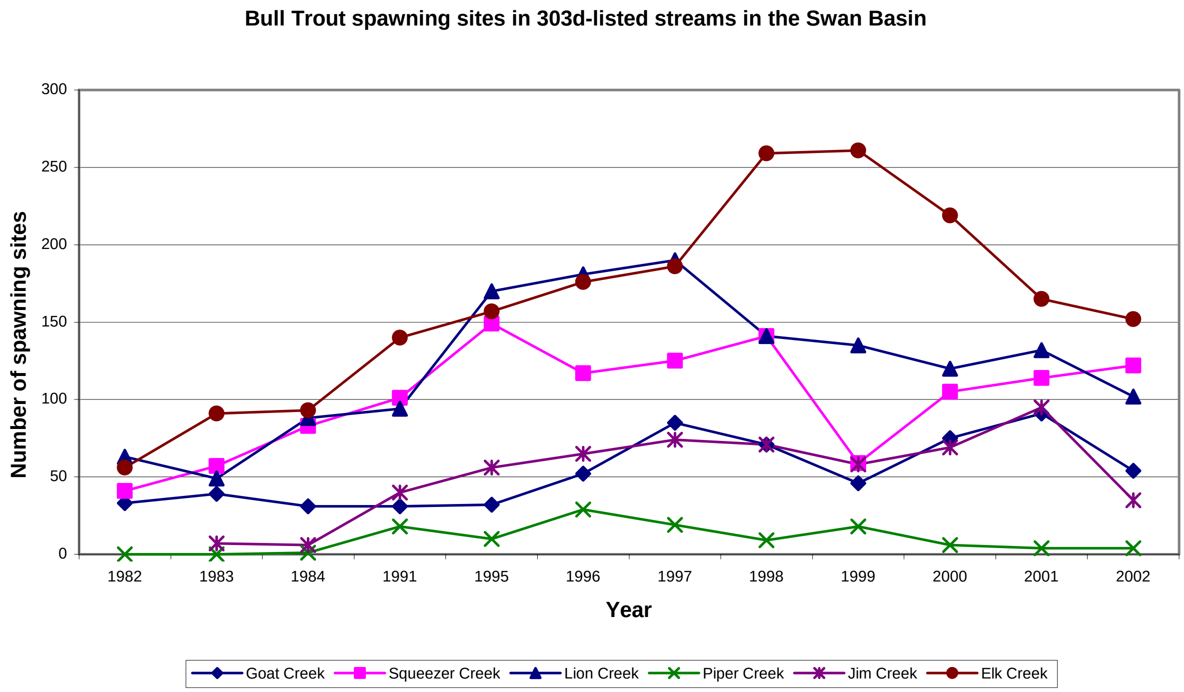


Figure 5-15. Bull Trout Spawning Sites in the Six 1996 303d-listed Swan Tributaries.



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.

<u>In-Lake Nutrient and Chlorophyll *a* Concentrations (Swan Lake Primary Target #2)</u>: ***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.

Percent Fines from Core Sampling (Jim Creek Primary Target #1): ***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.

Pools and Large Woody Debris (Jim Creek Primary Target #2): ***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.

Total Suspended Solids (Goat Creek Primary Target #1): ***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.

Macroinvertebrate Communities (Goat Creek Primary Target #2): ***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.

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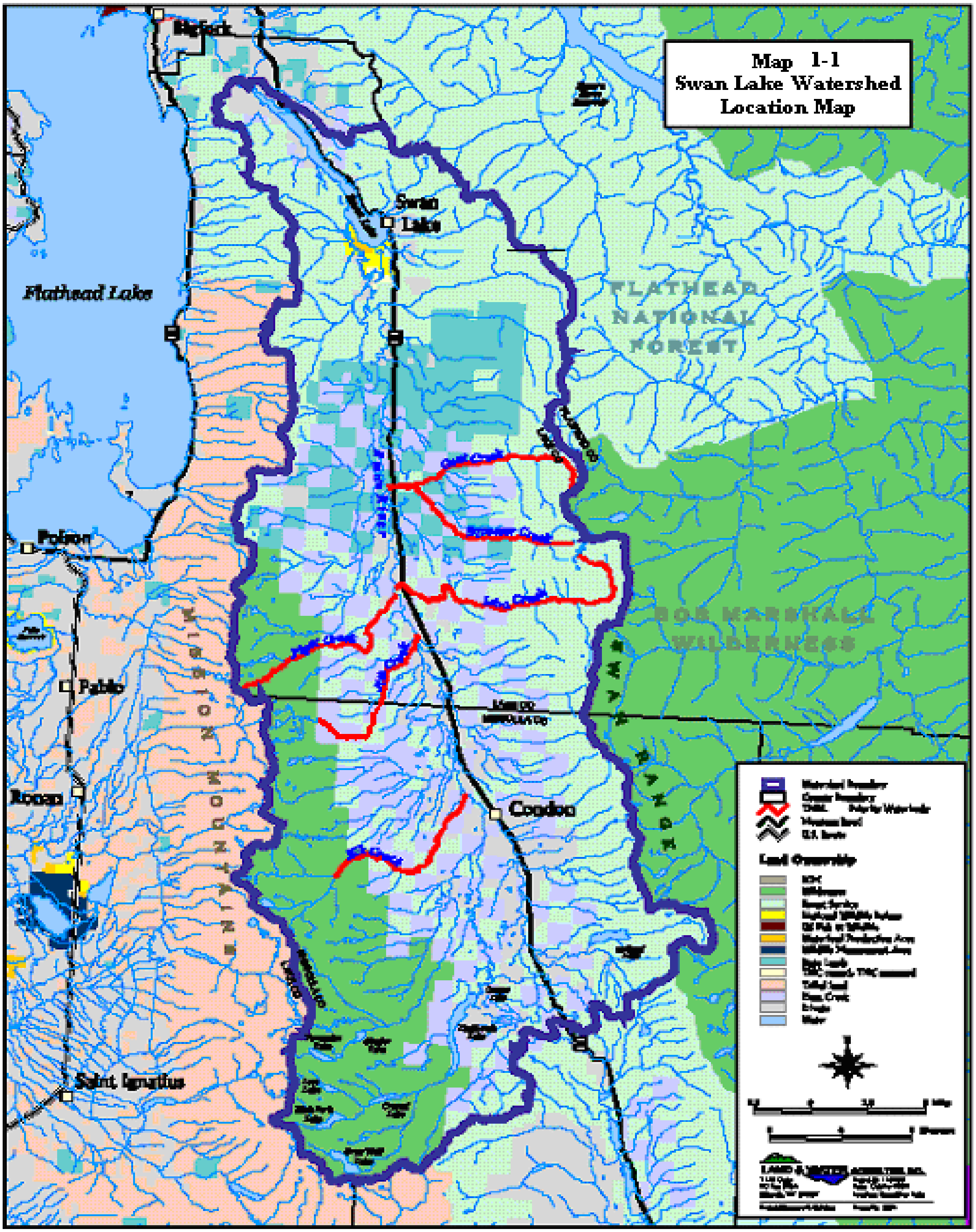
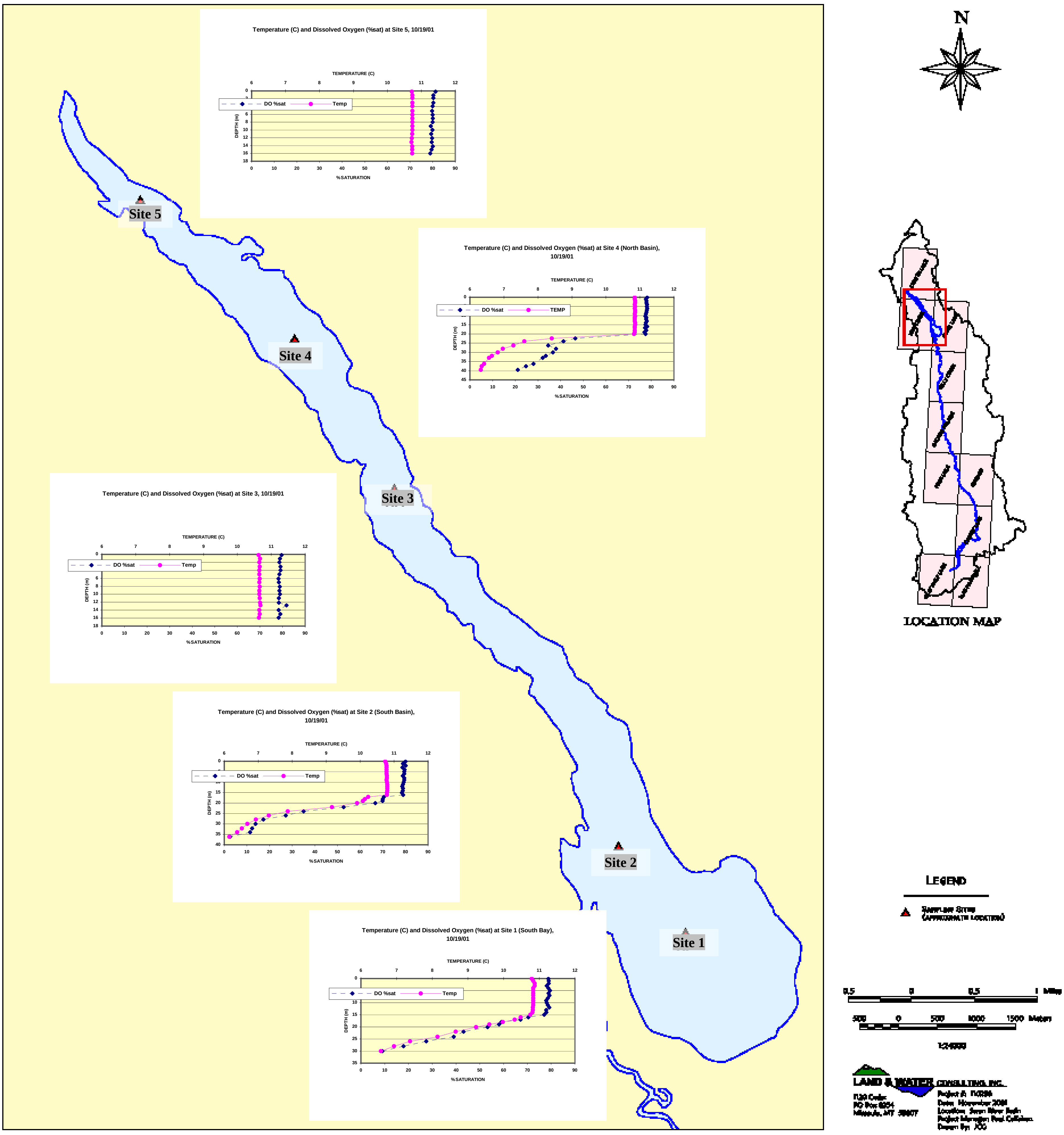
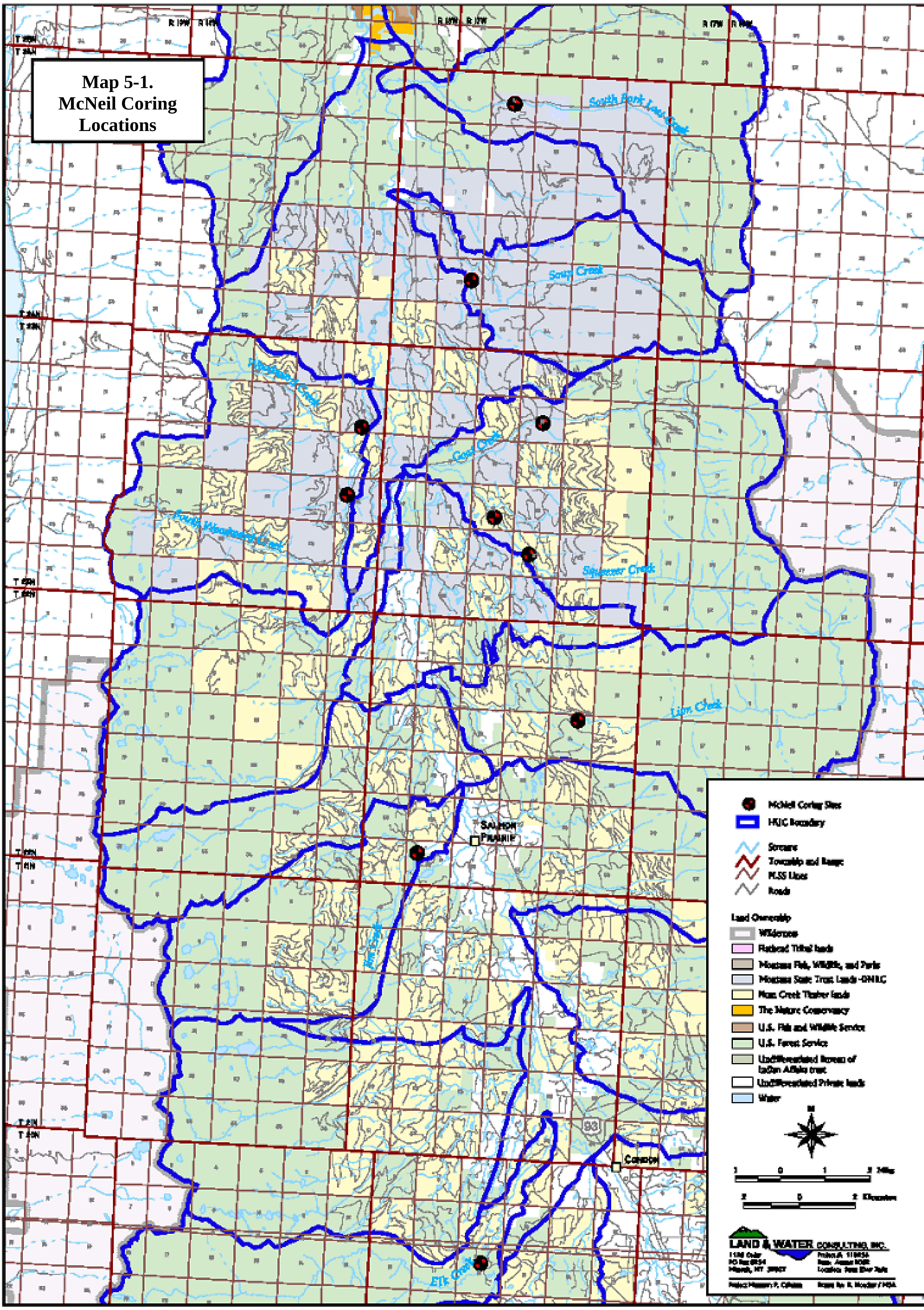


Map 1-1
Swan Lake Watershed
Location Map
Bigfork
Swan
Lake
Flathead Lake
FLATHEAD
NATIONAL
FOREST
Polson
BOB MARSHALL
WILDERNESS
MISSION MOUNTAINS
SWAN RANGE
Pablo
Ronan
Condon
Saint Ignatius
Land Ownership

Map 4-1
SWAN LAKE
DISSOLVED OXYGEN CONCENTRATION SAMPLING SITES





Map 5-1.
McNeil Coring
Locations