United States Environmental Protection Agency
Region 10
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Total Maximum Daily Load (TMDL) for Sediments in the Waters of Lake Creek in Coeur d'Alene Lake Subbasin, Idaho

February 2004

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Acronyms

APHA	American Public Health Association
BMP	Best management practice
BURP	Beneficial Use Reconnaissance Project
CDAT	Coeur d'Alene Tribe
CFR	Code of Federal Regulations
CRP	Conservation Reserve Program
EIFAC	European Inland Fisheries Advisory Council
GIS	Geographic information system
IDEQ	Idaho Department of Environmental Quality
IFIM	Instream Flow Incremental Methodology
KSSWCD	Kootenai-Shoshone Soil and Water Conservation District (formerly Kootenai-Shoshone Soil Conservation District [KSSCD])
LA	Load allocation
MOS	Margin of safety
NAS	National Academy of Sciences
NAE	National Academy of Engineering
NTU	Nephelometric turbidity units
RASI	Riffle armor stability index
RSI	Riffle stability index
SAWQP	State Agricultural Water Quality Program
SCS	Soil Conservation Service
SFI	Stream Fish Index
SHI	Stream Habitat Index
SMI	Stream Macroinvertebrate Index
STORET	USEPA's STOrage and RETrieval database
TDS	Total dissolved solids
TMDL	Total maximum daily load
TSS	Total suspended solids
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USLE	Universal Soil Loss Equation
WFPB	Washington Forest Practices Board
WLA	Wasteload allocation
WQPA	Water Quality Program for Agriculture

Total Maximum Daily Load for

Sediments in the Waters of Lake Creek

in Coeur d'Alene Lake Subbasin, Idaho

TMDL AT A GLANCE:

Water Quality Limited?	Yes
Hydrologic Unit Code:	17010303
Criteria of Concern:	Sediments
Designated Uses Affected:	Cold water aquatic life
Environmental Indicators:	Instream total suspended solids (TSS) concentration
Major Source(s):	Cropland erosion and mass wasting
Loading Capacity:	276.1 tons/year
Wasteload Allocation:	0 tons/year
Load Allocation:	276.1 tons/year
Margin of Safety:	0 tons/year (included implicitly)

Executive Summary

Lake Creek is on the 1996 303(d) list of impaired waters in Indian country because of impairments from sediments. Excess sediments in the creek can degrade and decrease the available habitat for aquatic life. Although Beneficial Use Reconnaissance Project (BURP) surveys demonstrate habitat impairment, it is difficult to quantitatively link habitat measures, such as percent fines and pool characteristics, to sediment loading. However, instream measures of sediment concentration can be linked directly to sediment loading. Therefore, the Total Maximum Daily Load (TMDL) is based on numeric instream total suspended solids (TSS) targets and will incorporate future habitat monitoring to assess improvements in aquatic habitat quality. A numeric TSS target of 40 mg/L was established for the TMDL based on literature values to represent desired instream sediment conditions and meet designated uses in the tribal and state water quality standards. Statistical analyses were conducted using the TSS target and observed flows at the Godde monitoring station in Lake Creek to calculate an overall sediment loading capacity for the watershed.

In addition, TSS loadings and necessary reductions were evaluated over a range of flows in Lake Creek to evaluate the times of increased sediment loading and focus future control actions. Observed flows were distributed based on their frequency of occurrence to establish a flow regime for the watershed, and 10 distinct flow ranges were established. The TSS target and observed flows were then used to calculate loading capacities for each flow range.

To identify the load reductions needed to meet the loading capacities, it was necessary to determine the existing TSS loadings in Lake Creek. Because instream TSS data are limited and turbidity data have been available almost daily since 1996 and for a wider range of flows, turbidity data were used along

with flow as the basis for identifying the existing sediment loadings. For each of the 10 flow ranges, a representative existing turbidity concentration was identified. These turbidity concentrations were then converted to TSS concentrations based on a correlation equation determined by using observed monitoring data. The TSS concentrations for each flow percentile range were used to establish existing TSS loadings for the Lake Creek watershed.

Using observed flow, turbidity, and TSS data, the Lake Creek sediment TMDL was calculated with an overall load allocation to nonpoint sources of 276.1 tons/year. This load allocation corresponds to a 71 percent reduction in existing nonpoint source sediment loadings. Because no permitted point sources are discharging in the watershed of the impaired segment of Lake Creek, the wasteload allocation for this TMDL is zero.

An implementation plan for the Lake Creek TMDL will likely be developed by the Coeur d’Alene Tribe and other local agencies and will evolve as the TMDL is finalized. The main focus of the implementation plan will likely be to reduce sediment inputs from agricultural sheet and rill erosion, restore riparian zones, augment base flow with storage reservoirs, and mitigate flow disturbance and sedimentation due to forest roads. Follow-up monitoring in Lake Creek is planned to track water quality improvement. The Coeur d'Alene Tribe seeks to continue its ongoing water quality sampling and monitoring in the Lake Creek watershed.

1. Overview

Section 303(d)(1)(C) of the Clean Water Act and the U.S. Environmental Protection Agency's (USEPA) implementing regulations (40 CFR Part 130) require the establishment of a Total Maximum Daily Load (TMDL) for the achievement of water quality standards and designated beneficial uses when a waterbody is water quality limited. A TMDL identifies the total amount of a pollutant that can be assimilated by a receiving water while still achieving water quality standards and includes an appropriate margin of safety. The focus of the TMDL is reduction of pollutant inputs to a level (or "load") that fully supports the designated uses of a given waterbody. The mechanisms used to address water quality problems after the TMDL is developed can include a combination of best management practices and/or effluent limits and monitoring required through National Pollutant Discharge Elimination System permits.

On the 1998 303(d) list, Lake Creek is identified as ID3549-1998, with the listed segment starting at Kruse Creek and extending 6.32 miles downstream. The listed segment is located in the Coeur d'Alene Indian Reservation. Idaho identified Lake Creek as water quality limited because increased sediment loadings to the stream reduced the quality of pools necessary for fish spawning and winter survival.

1.1 General Background[1]

Lake Creek is located in the Coeur d'Alene basin, with portions located in the Coeur d'Alene Indian Reservation, Kootenai County, Idaho, and Spokane County, Washington (Figure 1-1). Lake Creek drains into Windy Bay on the western side of Lake Coeur d'Alene (Figure 1-2). The watershed of the impaired segment of Lake Creek is approximately 21,560 acres (33.7 mi^2), with 27 percent (5,748 acres [9 mi^2]) located in Spokane County, Washington, and the remainder (15,812 acres [24.7 mi^2]) on the Coeur d'Alene Reservation and in Kootenai County, Idaho. Approximately 57 percent of the impaired watershed is located on the Coeur d'Alene Indian Reservation (7,415 acres [19.2 mi^2]).

The Coeur d'Alene Tribe (CDAT) reports current land uses as agriculture (36 percent), forest (60 percent), urban (<1 percent), and land enrolled in the Natural Resources Conservation Service Conservation Reserve Program (CRP) (4 percent), which is primarily grassland (CDAT, 2000). The CRP is a national program that provides funds to farmers not to farm their land and to allow the native plants and trees to grow, reducing the loss of highly erodible soils. Land uses have remained steady, with agricultural conversion balanced by reforestation of former agricultural lands. Figure 1-3 presents the distribution of watershed land use, based on U.S. Geological Survey (USGS) Land Use and Land Cover data, indicating similar land use percentages as CDAT (2000).

Elevations in the watershed range from approximately 5,100 feet at the headwaters on Mica Peak, Washington, to approximately 2,200 feet at the downstream point of the impaired segment. The watershed experiences flashy hydrology, with high runoff events and low summer flows, and is strongly influenced by rain-on-snow events in late winter and early spring (CDAT, 2000). Stream geometry varies with the flow, with widths between 10 and 40 feet and depths between 0.5 and 3 feet.

[1]KSSCD (1998) and CDAT (2000) are recommended as sources of background information on the basin.

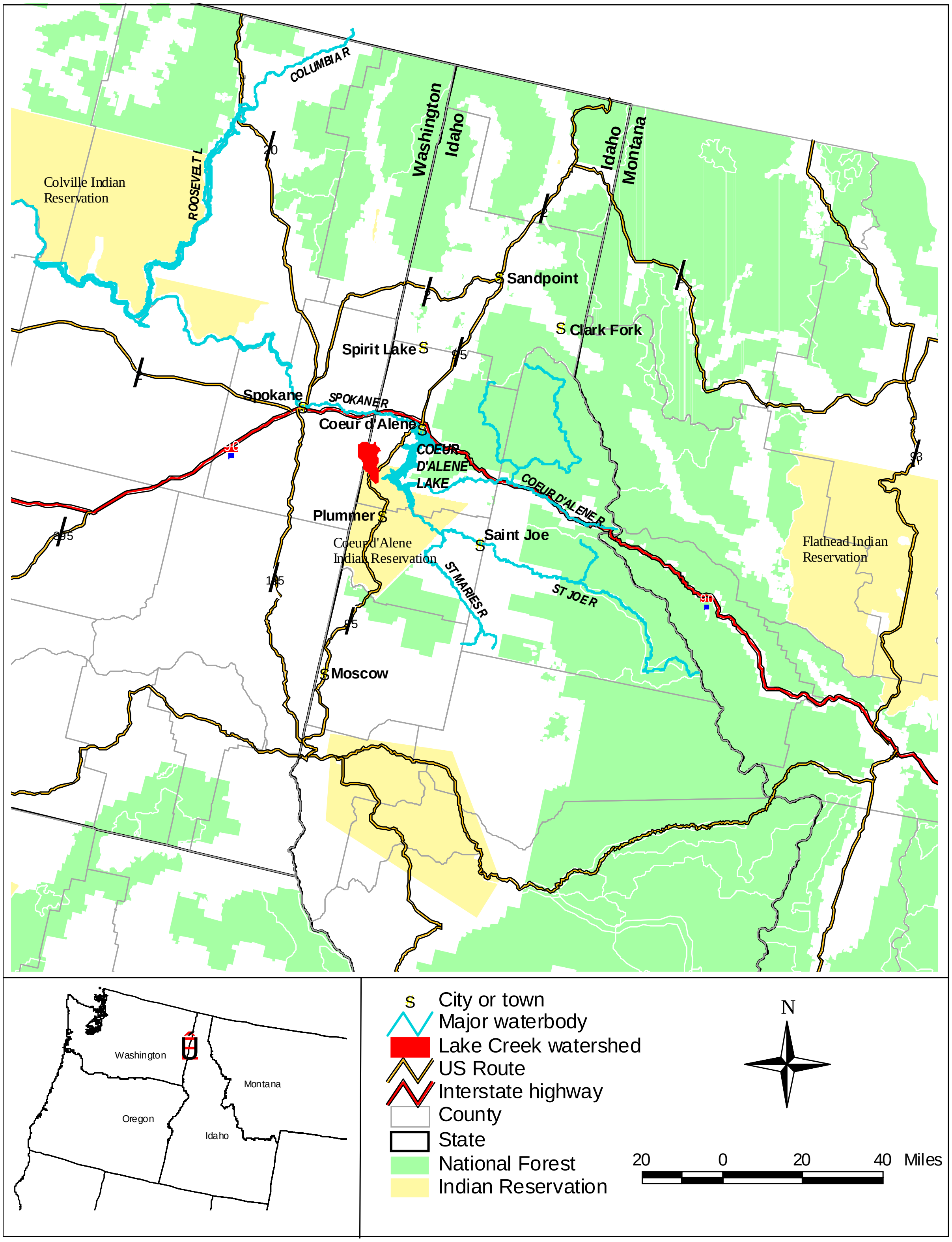


Figure 1-1. Regional setting of the Lake Creek watershed.

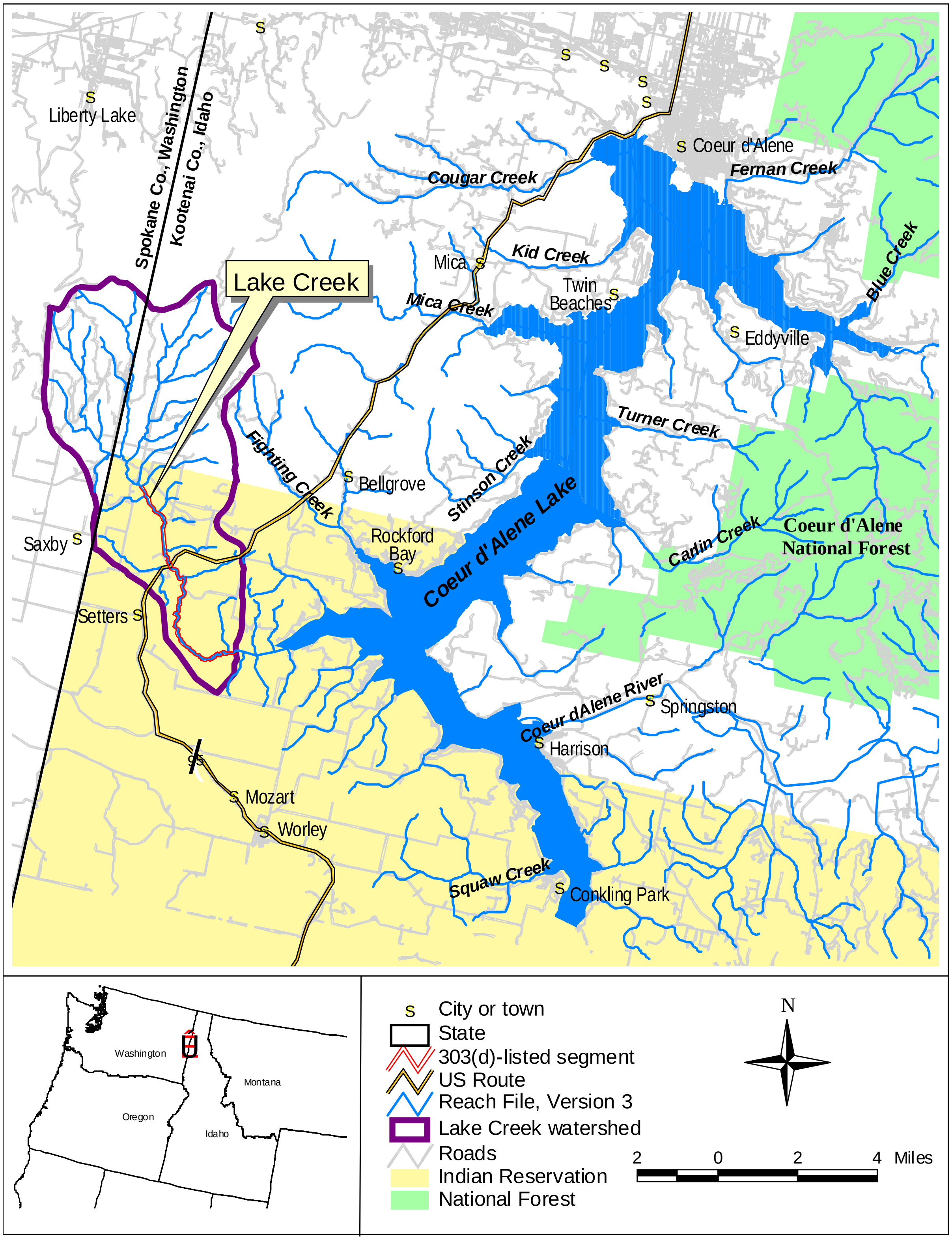


Figure 1-2. Location of the Lake Creek watershed.

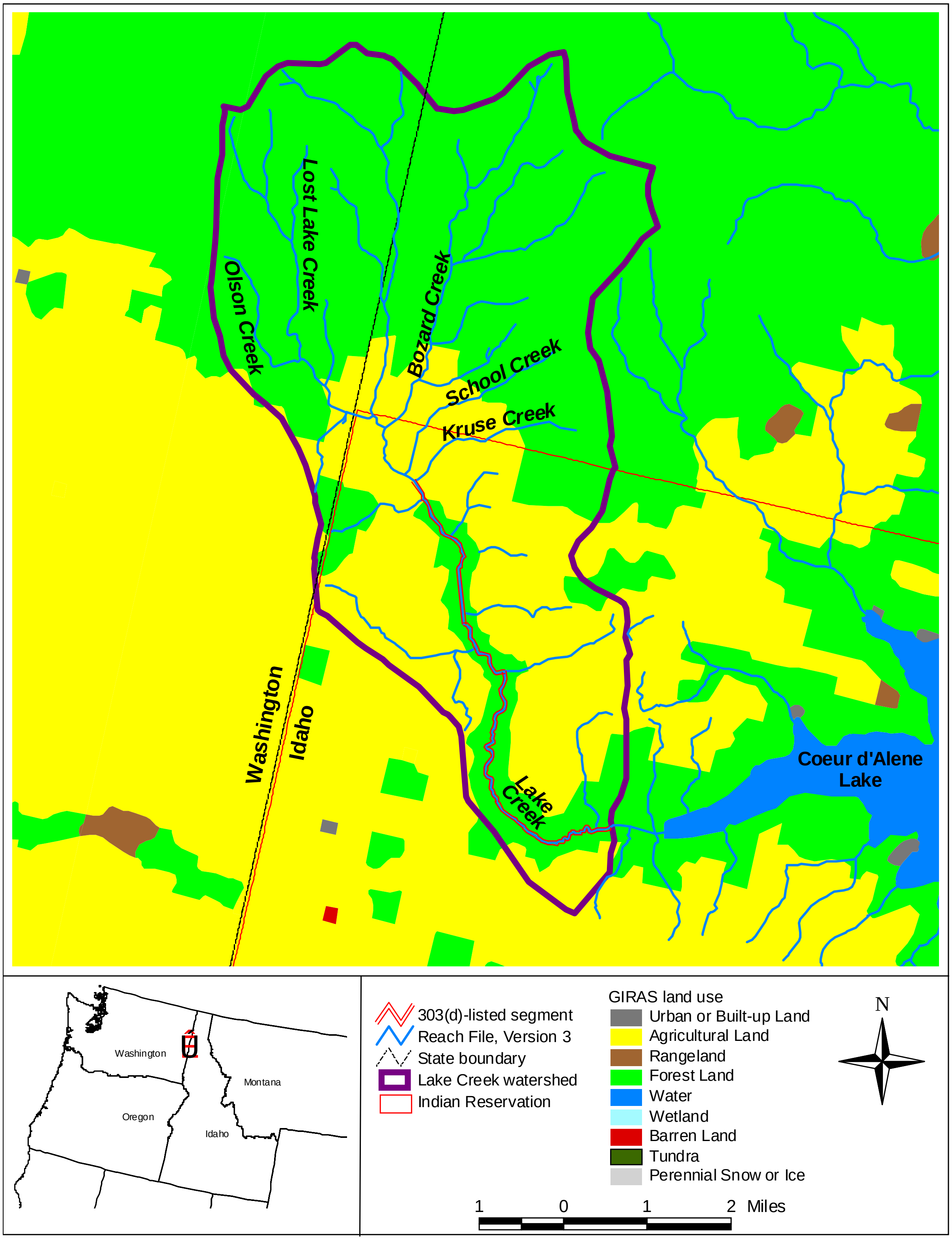


Figure 1-3. Land use in the Lake Creek watershed.

The Lake Creek watershed has a subhumid climate, with warm, dry summers and cool, wet winters. The average daily maximum temperature in July is 85 degrees, while the average daily minimum temperature in January is 21 degrees. The upper elevations receive 35 inches of precipitation, with two-thirds of the annual precipitation falling between October and March, primarily as snow (KSSCD, 1991).

1.2 Designated Use Impacts

Sediment can affect aquatic life uses in several ways, including the following:

R Sediment deposition can fill pools, reducing aquatic habitat, particularly for refuge and rearing.
R Sediment deposition can fill interstitial spaces between gravel, reducing spawning habitat by trapping the emerging fish and reducing the exchange of oxygen necessary for fish embryos.
R Suspended sediment and turbidity can prevent fish from seeing food in the water and can clog their gills.
R High levels of suspended sediment can also result in fish avoiding the stream.

Data available for Lake Creek from the CDAT and Idaho Department of Environmental Quality (DEQ) indicate that Lake Creek is impaired because of sediment that has reduced its use for aquatic life, particularly fish spawning.

The CDAT's Water Resource Program completed the draft *Lake Creek Watershed Assessment* in July 2000. The watershed assessment indicated that Lake Creek only partially supports its use for salmonid spawning and cold water biota and that its use by salmonids is limited by suspended sediment, turbidity, and excessive summer temperatures. The assessment indicated that sediment inputs to Lake Creek will likely be deposited in the channel and that the present response of the creek is fine sediment aggradation, with the system experiencing degradation of salmonid spawning conditions. Percent of fine sediment in the channel substrate and riffle:pool ratios exceeded the optimal limits for salmonid spawning and rearing. Fish populations surveys indicated limited usage of Lake Creek by cutthroat trout, likely due to fine sediment, lack of plunge pool habitat, and high summer water temperatures.

In 1999, Idaho DEQ completed a Sub-basin Assessment for the Coeur d'Alene Lake and River (IDEQ, 1999). The Sub-basin Assessment reviews existing data for waterbodies in the sub-basin that were included on the 303(d) list as water quality limited. Data reviewed for Lake Creek include instream water quality data collected for a study of baseline water quality for the Lake Creek Agricultural Project, pool measurements, and fish population data. Based on the data reviewed, the Sub-basin Assessment indicates that Lake Creek experiences turbidity levels that exceed the sight feeding criterion for cold water aquatic life, has diminished residual pool volumes, and has measured fish populations an order of magnitude below reference streams. The Sub-basin Assessment concludes that Lake Creek is impaired by sediment and requires a sediment TMDL. The Lake Creek Watershed was also assessed using Idaho DEQ's Beneficial Use Reconnaissance Project (BURP) data. BURP data and results are included in the Appendix.

2. TMDL Target

Water quality standards designate the "uses" to be protected (e.g., aquatic life, recreation, secondary contact recreation, cold water aquatic community, drinking water, recreation, fish and wildlife habitat) and the "criteria" for their protection (e.g., how much of a pollutant can be present in a waterbody without impairing its designated uses). TMDLs are developed to meet water quality standards. Standards may be expressed as numeric water quality targets or narrative standards for the support of designated uses. The numeric target identifies the specific goals or endpoints for the TMDL that equate to attainment of the water quality standard. The numeric target may be equivalent to a numeric water quality standard where one exists, or it may represent a quantitative interpretation of a narrative standard. This section reviews the water quality standards and identifies an appropriate indicator and numeric target for the calculation of the TMDL for sediment in Lake Creek. This TMDL is developed to meet water quality criteria and protect the uses of Lake Creek described in both state and tribal water quality standards.

2.1 Water Quality Standards

The CDAT has adopted water quality standards for the waters within its Reservation. Both the tribal and state water quality standards contain narrative criteria for the protection of waters from excess sediment.

The tribe's water quality criteria for sediments are as follows:

> *All surface waters of the tribe shall be free from anthropogenic contaminants that may settle and have a deleterious effect on the aquatic biota or that will significantly alter the physical and chemical properties of the water or the bottom sediments.* (CDAT, 1999)

The state's water quality criteria for sediments are as follows:

> *Sediment shall not exceed quantities specified in Section 250, or, in the absence of specific sediment criteria, quantities which impair designated beneficial uses. Determinations of impairment shall be based on water quality monitoring and surveillance and the information utilized as described in Subsection 350.02.b.* (IDEQ, 2003a)

This TMDL is developed to meet these criteria and protect designated uses in Lake Creek, based upon agreement from the involved agencies (CDAT, USEPA Region 10, Idaho DEQ). Designated uses include domestic water supply, agricultural water supply, recreational and cultural use, bull trout aquatic life use (Upper Lake Creek), and cutthroat trout aquatic life use (Lower Lake Creek).

2.2 Parameter of Concern

The 1998 303(d) list of impaired waters identified Lake Creek as water quality limited because of sediment.

2.3 TMDL Endpoints

The TMDL is developed to meet an instream TSS target concentration representing levels acceptable for designated use support.

The TSS target was established from a range of values typically maintaining good or moderate fisheries (EIFAC, 1965). The European Inland Fisheries Advisory Commission report (EIFAC, 1965) reviewed literature on suspended solids effects on fisheries in an attempt to define water quality criteria for suspended solids and fisheries. The report indicated that a relationship between solids concentration and risk of fisheries damage could not be precisely defined, but the available information could be used to establish categories of risk to fisheries with associated typical ranges of concentrations. Based on the information included in EIFAC (1965), the Environmental Studies Board of the National Academy of Sciences (NAS and NAE, 1973) recommended the following ranges of TSS concentrations and the corresponding effects on aquatic communities:

R <25 mg/L = No harmful effect on fisheries
R 25–80 mg/L = Slight effect on production
R 80–400 mg/L = Significant reduction in fisheries
R >400 mg/L = Poor fisheries

Based on these ranges, a TSS target of 40 mg/L was selected for Lake Creek. The ranges identified in EIFAC (1965) and NAS and NAE (1973) represent a persistent instream concentration that occurs frequently, rather than a maximum instantaneous concentration that may occur infrequently and present less of a risk to the aquatic communities. Because the Lake Creek TMDL uses a constant, instantaneous concentration of 40 mg/L under all flows for the identification of loading capacities, the 40-mg/L concentration is assumed acceptable, and even conservative, for resulting in typical or “average” instream TSS between 25 and 80 mg/L.

2.4 Secondary Monitoring Targets

In addition to an instream TSS target concentration, the Lake Creek TMDL implementation plan will establish monitoring targets for aquatic habitat measures. Because it is difficult to link such water column measurements as TSS to aquatic life habitat quality, measures of channel and habitat conditions are more useful in directly gauging the availability and quality of aquatic life habitat and support. These indicators include measurements such as riffle:pool ratios, channel substrate composition, and amount of large woody debris. If an evaluation of habitat measures indicates that Lake Creek is supporting designated uses prior to meeting load reductions or TSS targets established in the TMDL, the TMDL will be reevaluated and revised accordingly.

The Lake Creek Watershed Assessment (CDAT, 2000) previously evaluated streambank and habitat measures in the Lake Creek watershed. It is expected that additional monitoring of these measures will be conducted to track the improvement of habitat quality in response to the sediment load reductions implemented by this TMDL. Potential habitat measures to be monitored and proposed targets are included in Tables 2-1 and 2-2. The specific targets associated with each habitat measure are proposed and will be further defined in the Lake Creek TMDL implementation plan.

Table 2-1. Proposed Targets for Habitat Indicators

Indicator	Proposed Target	Source
Percent fines (<4 mm) in channel substrates	No more than 10 percent of particles <4 mm	CDAT (2000) [Hickman and Raleigh (1982)]
Riffle:pool ratio	1:1	CDAT (2000) [Hickman and Raleigh (1982)]
Residual pool depth	1.0 m	Personal communication, CDAT, July 2003
Riffle stability index	RSI<70	IDEQ (2003b) [Kappesser (1993)]; CDAT (2000) [Kappesser (1992)]
Fish counts	Phased targets of juvenile fish/m^2 (See Table 2-2)	Personal communication, CDAT, Department of Natural Resources, October 2003
Cobble embeddedness	Targets are not established at this time but will be considered in future monitoring. If future monitoring provides sufficient information on reference levels, quantitative targets will be established at that time.	
Large woody debris		

Table 2-2. Proposed Targets for the Lake Creek Fishery[1]

Segment[2]	Phased Target (juvenile fish/m^2)				
	1998	2007	2012	2016	Beyond
Lower Lake Creek	0.020	0.023	0.061	0.069	0.224
Upper Lake Creek	0.128	0.128	0.178	0.283	0.393

[1] Personal communication, CDAT, Department of Natural Resources, October 2003.
[2] Lower Lake Creek extends from the Emtman gauging station to the mouth. Upper Lake Creek extends from the Emtman gauging station to the headwaters.

3. Data Analysis

Several sources of water quality and watershed information were reviewed to characterize the condition of Lake Creek with respect to sediments and turbidity; however, some data were used for general and background information and were not used directly in the calculation of the TMDL. This section includes the following information:

- Data inventory—describes the available data and information used to evaluate water quality conditions in Lake Creek.
- Data analyses—presents results of various data analyses evaluating trends and relationships in instream data.

3.1 Data Inventory

Table 3-1 and the following sections summarize the data and information evaluated.

Table 3-1. Data Available for the Lake Creek Watershed

Date	Source	Relevant Data
Instream monitoring data		
1996–2001	Kootenai-Shoshone Soil Conservation District	Continuous monitoring, including turbidity with some TSS samples. (Majority of these data were collected for and presented in KSSCD [1998])
1997–2002	CDAT	Water quality monitoring data, including TSS and turbidity
1989	STORET (Idaho Department of Health and Welfare)	Turbidity data
Other watershed information		
2000	CDAT draft *Lake Creek Watershed Assessment*	General background, watershed/stream conditions, and sediment loading estimates
1996, 1997	Idaho DEQ	BURP field sheets

Kootenai-Shoshone Soil Conservation District

During the initial stages of the Lake Creek Agricultural Project, the Kootenai-Shoshone Soil and Water Conservation District[2] (KSSWCD) collected water quality and hydrologic data during 1996, 1997, and 1998 at two sites within the Lake Creek watershed—Emtman and Godde stations (Figure 3-1). The Emtman station is located at river mile 7.4, just below the confluence of Lake Creek and Bozard Creek. The Godde station is located at river mile 3.4, 0.75 mile downstream of the Highway 95 bridge.

[2]Kootenai-Shoshone Soil and Water Conservation District was formerly the Kootenai-Shoshone Soil Conservation District (KSSCD).

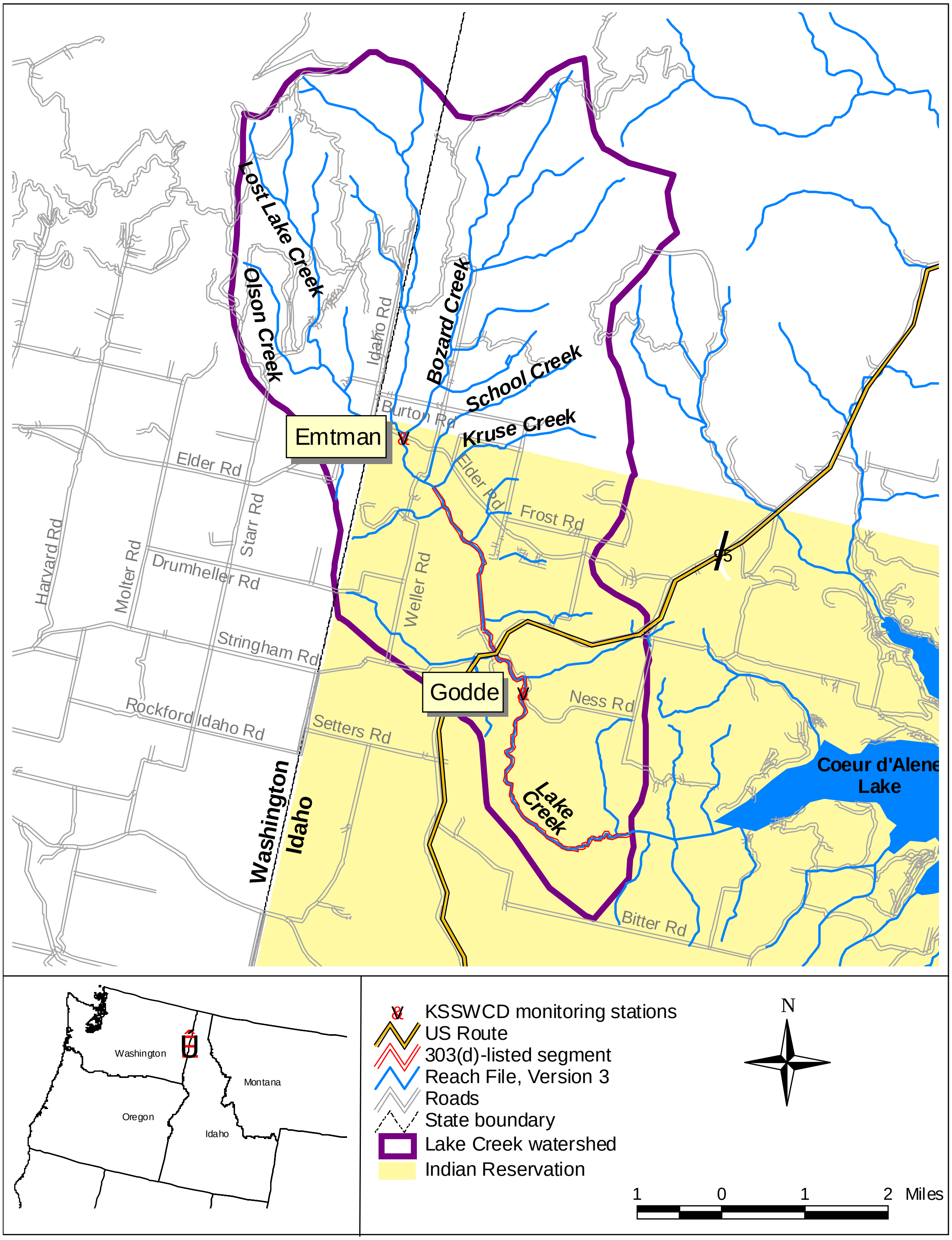


Figure 3-1. Location of KSSWCD monitoring stations on Lake Creek.

The monitoring was initiated to evaluate the effectiveness of best management practices (BMPs) planned for the watershed. Data collected from January 1996 through April 1998 are presented in *Lake Creek Agricultural Project: Summary of Baseline Water Quality Data* (KSSCD, 1998) and represent water quality under minimal BMP implementation. KSSWCD discontinued water quality monitoring at the two sites in 2001, and data are available from January 1996 through August 2001.

The monitoring includes continuous readings of water stage, turbidity, conductivity, and precipitation as well as air, ground, and water temperature. Readings were recorded every 15 minutes and are presented in data files as hourly readings. Turbidity is measured in millivolts using an optical particle sensor and converted to turbidity in nephelometric turbidity units (NTU) based on calibration to laboratory-analyzed turbidity samples. Corresponding continuous flows are also available, recorded as stage heights and converted to flows based on calibration rating curves. Several manual samples were also collected and analyzed for TSS, turbidity, and nutrients to provide data for calibration of field equipment.

Manual Samples

During 1996 KSSWCD collected manual samples at the two Lake Creek stations to provide data for development of calibration curves. KSSWCD collected additional manual samples in 1997 and 1998. Table 3-2 provides a summary of data collected manually by KSSWCD at the Emtman and Godde stations, and Figures 3-2 and 3-3 present the values grouped by month. As shown in Figures 3-2 and 3-3, sampling occurred mainly in February and March, with no data collected between May and October.

Table 3-2. Summary of KSSWCD Grab Samples Collected at the Emtman and Godde Stations

	Emtman Station		Godde Station	
	TSS (mg/L)	Turbidity (NTU)	TSS (mg/L)	Turbidity (NTU)
Minimum	3.00	6.00	2.90	8.00
Maximum	330.00	360.00	1,450.00	1,020.00
Average	105.76	67.41	327.35	183.92
Start date	2/1/96	2/1/96	1/18/96	1/18/96
End date	3/2/98	3/2/98	3/2/98	3/2/98
Number of samples	26	23	36	36

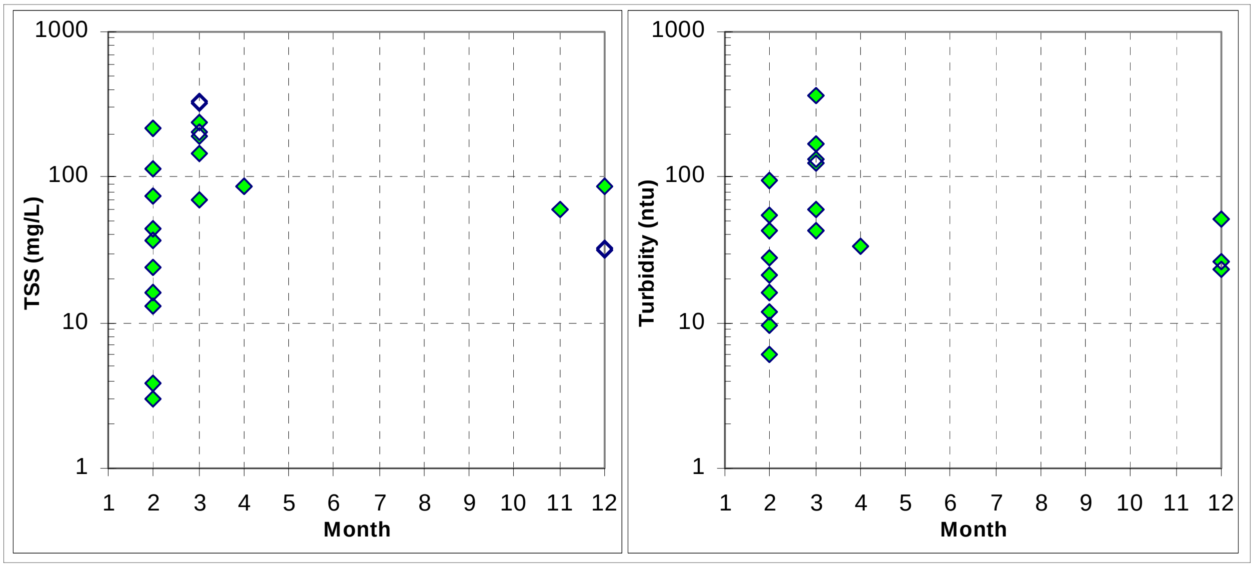


Figure 3-2. Monthly distribution of TSS and turbidity data collected by KSSWCD at the Emtman site.

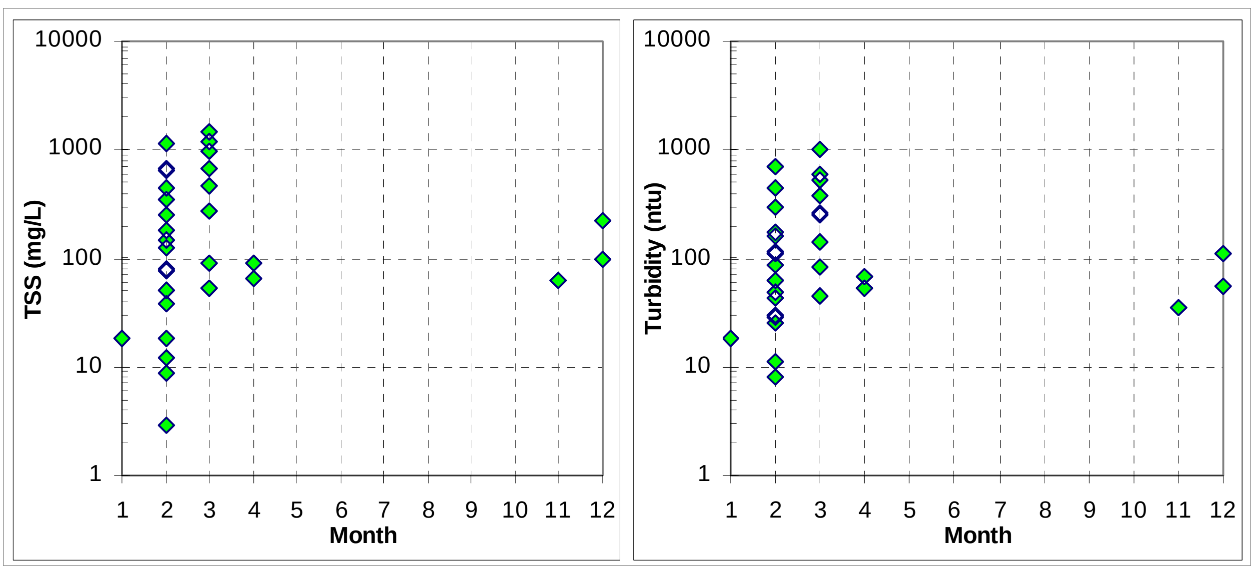


Figure 3-3. Monthly distribution of TSS and turbidity data collected by KSSWCD at the Godde site.

Continuous Samples

KSSWCD has conducted continuous monitoring of water stage, turbidity, conductivity, and precipitation as well as air, ground, and water temperature at the Emtman and Godde stations on Lake Creek since 1996. Automated readings are recorded every 15 minutes and are presented in data files as hourly values. Average daily turbidity values were calculated for every day sampled in the period of record at the two stations, using the hourly data. Table 3-3 provides a summary of the daily average turbidity values over the period of record for both the Emtman and Godde stations.

Table 3-3. Summary of Daily Average Turbidity Readings at KSSWCD's Emtman and Godde Sites

	Turbidity (NTU)	
	Emtman Station	Godde Station
Minimum	3	1
Maximum	145	2,161
Average	19	113
Start date	2/4/96	1/16/96
End date	4/30/00	8/31/01
Number of samples	731	1,314

Coeur d'Alene Tribe

The CDAT has collected several grab samples in the Lake Creek watershed. They have monitored the Lower Lake Creek station (Godde) since 1997 and have since begun sampling at the Upper Lake Creek station (Emtman) and on Bozard Creek. Table 3-4 provides a summary of these data. These data were combined with KSSWCD manual samples to establish a relationship between TSS and turbidity for use in the TMDL analysis.

Table 3-4. Summary of CDAT TSS and Turbidity Data

Station	Start Date	End Date	Count	Minimum	Average	Maximum
TSS						
Lower Lake Creek	6/30/97	9/10/02	32	2	16.1	154
Upper Lake Creek	2/23/01	2/22/02	6	2	12.5	35.8
Bozard	4/29/98	9/10/02	28	2	5.5	20
Turbidity						
Lower Lake Creek	4/29/98	9/10/02	32	0.961	8.6	76.8
Upper Lake Creek	2/23/01	2/22/02	6	3.12	10.4	21.3
Bozard	3/17/99	9/10/02	28	0.994	4.1	13.6

STORET

USEPA's STORET database was searched for water quality data for Lake Creek. No turbidity, TSS, or sediment data were available in STORET for the Lake Creek watershed in the last 10 years. However, turbidity data were collected by the Idaho Department of Health and Welfare at 14 stations throughout the watershed from January through November 1989. Given the availability of a more recent and robust data set (i.e., continuous monitoring by the KSSWCD), these data were not used in the TMDL analysis.

Coeur d'Alene Tribe Watershed Assessment

The CDAT's Water Resource Program developed the draft *Lake Creek Watershed Assessment* (CDAT, 2000) in July 2000. The report provides background on the watershed's physiographic setting; information on stream hydrology, streambank and streambed conditions, and water quality; and estimates of watershed sediment loading. This section summarizes the information in CDAT (2000) related to the instream conditions in Lake Creek and the impairment to designated uses by sediment.

In 1993 and 1994, the tribe conducted channel and habitat surveys in Lake Creek. A study of Lake Creek's channel morphology indicated that sediment inputs to Lake Creek will likely be deposited within the channel and will not be transported under the majority of stream flows. Based on this and the sediment budget results, the assessment indicates that the present response of Lake Creek to sediment loading is the aggradation of fine sediment and a decrease in salmonid spawning conditions.

The watershed assessment evaluated indicators of aquatic habitat related to the composition of the channel substrate, as well as the presence and measure of pools and riffles in the stream. Because fine sediments can fill interstitial gravel spaces or bind with other sediments to create a hard surface that prevents egg laying and brooding, measures of sediment size distribution can indicate the quality of salmonid habitat. CDAT (2000) identifies optimal cutthroat trout habitat as less than 10 percent of the particles being smaller than 4 millimeters (mm) in size. The lower reaches of Lake Creek generally had less than 20 percent of particles smaller than 4 mm (but greater than the 10 percent criteria). Percentage of particles smaller than 4 mm was generally greater than 30 percent in the middle reaches. No assessment of the upper forested reaches was conducted. Based on the 1993 and 1994 surveys, four of the nine surveyed reaches had good pool habitat frequency. Average riffle:pool ratios were 2.7:1 in 1993 and 2.8:1 in 1994. None of the surveyed reaches attained the 1:1 ratio identified as optimum. The optimum residual pool depth for salmonid habitat is identified as 2.0 meters. Average residual pool depth for Lake Creek was 0.5 meter, with no individual pool measurements meeting the 2.0-meter criteria.

Channel stability was also estimated for Lake Creek, using the channel stability index of Pfankuch (1975). The index is based on scores for a variety of stability factors, including mass wasting potential, debris jam potential, bank vegetation density, channel capacity, in-channel erosion and deposition, and bottom substrates. Most of the ratings for Lake Creek and West Lake Creek were "fair," with reaches not meeting "good" or "excellent" ratings because of observed bank cutting and lack of bank vegetation.

The Riffle Armor Stability Index (RASI) was measured at seven reaches in Lake Creek and West Lake Creek to evaluate the stream stability. The evaluation resulted in 37 RASI scores, including the following:

R 20 scores indicating that the system is entering a period of instability (70–90)
R 13 scores indicating geomorphic stability (<70)
R 4 scores indicating instability

The tribe's watershed assessment also included electrofishing surveys in an attempt to quantify the populations, age distributions, and habitat of salmonids in Lake Creek. Based on the data, the cutthroat trout population in the Lake Creek drainage is estimated as 1,457. Fish density measured during the survey ranged from 0.3 to 18.2 fish/100 m^2. Fisheries data indicate that cutthroat spawning activity occurs in the Lake Creek mainstem and the upper tributaries.

Beneficial Use Reconnaissance Project

Idaho DEQ conducted biological assessments of fish habitat at two sites in 1996. The upper site coincides with KSSWCD's Emtman monitoring station. The lower site is 1.25 miles upstream from the stream mouth and 0.75 mile downstream of KSSWCD's Godde monitoring site. A 1997 survey was conducted at a third site, 200 meters below Elder Road bridge, near KSSWCD's Emtman monitoring station. During these surveys, widths, depths, and bank stability were measured and Wolman pebble counts were conducted. This section summarizes information contained on the Beneficial Use Reconnaissance Project field forms.

Streambanks with higher percentages of rooted vegetation and overhead cover can resist erosion and can provide stable pools for fish habitat. The 1997 survey of Lake Creek found 95 percent of the streambank to be covered and stable and 5 percent to be covered but unstable. These findings agree with those of the 1996 survey, which rated the upper streambanks as 95 to 97 percent covered and stable and the lower site streambanks as 92 to 97 percent covered and stable. This level of covered, stable streambank would significantly reduce sediment loss through streambank erosion.

Sediment size distribution is a measure used to evaluate the condition of aquatic habitat. Fine sediments can fill interstitial gravel spaces or bind with other sediments to create a hard surface that prevents egg laying and brooding. The *Lake Creek Watershed Assessment* report (CDAT, 2000) defined optimal cutthroat trout habitat as 10 percent of particles below 4 mm in size. This target value was used to assess the particle counts from the Idaho DEQ surveys. In 1996 the upper site had one riffle, while the lower site had two riffles where pebble counts were performed. The 1996 results are summarized in Table 3-5. Neither the upper nor lower site meets the targets from the *Lake Creek Watershed Assessment* report. By 1997 Idaho DEQ was using a modified pebble count procedure. The modified procedure divides each site into a "wetted zone" and "outside the wetted zone." For each site, the 1996 pebble counts by particle size were similar to the 1997 totals (wetted zone plus outside wetted zone counts) for the corresponding particle size.

Another assessment metric is the quantity and quality of pools that provide habitat for fish and other aquatic life. Pool quantity and quality are evaluated in several ways, including percent pools, riffle:pool ratio, and pool depth. The 1996 survey found that the upper site was 43 percent pools and the lower site was 14 percent pools. The optimal riffle:pool ratio identified by CDAT (2000) is 1:1. The upper site had 4 meters in riffles and 49 meters in pools, resulting in a ratio of 0.08:1, and the lower site had 35 meters in riffles and 21 meters in pools, with a ratio of 1.7:1. CDAT (2000) identified optimal residual pool depth as 2 meters. Maximum residual pool depths measured in 1996 were 0.45 meter at both the upper and lower sites.

Table 3-5. Pebble Counts for 1996 Beneficial Use Reconnaissance Project

Size (mm)	Upper Riffle Count	Upper Riffle Percent	Lower Riffle 1 Count	Lower Riffle 1 Percent	Lower Riffle 2 Count	Lower Riffle 2 Percent	Lower Riffles Mean	Lower Mean Percent
0–1	8	11.1	15	25.4	15	24.6	15	25.0
1–2.5	21	29.2	1	1.7	1	1.6	1	1.7
2.5–6	0	0.0	1	1.7	0	0.0	0.5	0.8
6–15	5	6.9	0	0.0	1	1.7	0.5	0.8
15–31	12	16.7	2	3.3	1	3.3	1.5	3.3
31–64	22	30.6	5	8.5	13	21.3	9	15.0
64–128	2	2.8	9	15.3	18	29.5	13.5	22.5
128–256	2	2.8	18	30.6	10	16.4	14	23.3
256–512	0	0.0	5	8.5	2	3.3	3.5	5.8
512–1,024	0	0.0	2	3.4	0	0.0	1	1.7
1,024+	0	0.0	1	1.7	0	0.0	0.5	0.8
Total	72	100.0	59	100.0	61	100.0	60	100.0

3.2 Data Analysis

To better understand water quality and flow conditions in Lake Creek, various data analyses were conducted to identify trends and relationships in instream data. The following sections summarize the results of these analyses, including a comparison of observed TSS values to the TMDL target, an evaluation of the relationship between instream sediment measures (i.e., TSS and turbidity), an evaluation of temporal water quality and flow trends, and an evaluation of spatial variations in water quality.

Relationship Between Instream TSS and Turbidity

Local TSS data provide a measure of the amount of sediment suspended in the stream at a given moment in time. However, instream TSS data are limited, whereas turbidity data have been available almost daily since 1996 and for a wider range of flows. Therefore, turbidity and TSS data were evaluated to identify a relationship between the two parameters. If a relationship exists, turbidity data can be used to indirectly evaluate instream TSS trends or relationships that could not be conducted with the limited TSS data set.

Both TSS and turbidity provide measures of the amount of sediment in the stream. Turbidity is an optical measure of water related to light transmission and is a measure of the total amount of light-scattering particles in a water sample. TSS refers to solids that are not in true solution and can be removed by filtration. TSS accounts for both organic and mineral particles. Such suspended solids typically contribute to the turbidity of the water column.

Turbidity and flow data were collected in Lake Creek during KSSWCD's long-term monitoring program beginning in 1996, and TSS data are available sporadically throughout the period of record. In addition, the CDAT has collected turbidity and TSS data at three watershed stations. The paired TSS and turbidity data available from KSSWCD and the CDAT were used to establish a relationship between the two parameters. That relationship is illustrated in Figure 3-4 and is represented by the equation in Figure 3-4.

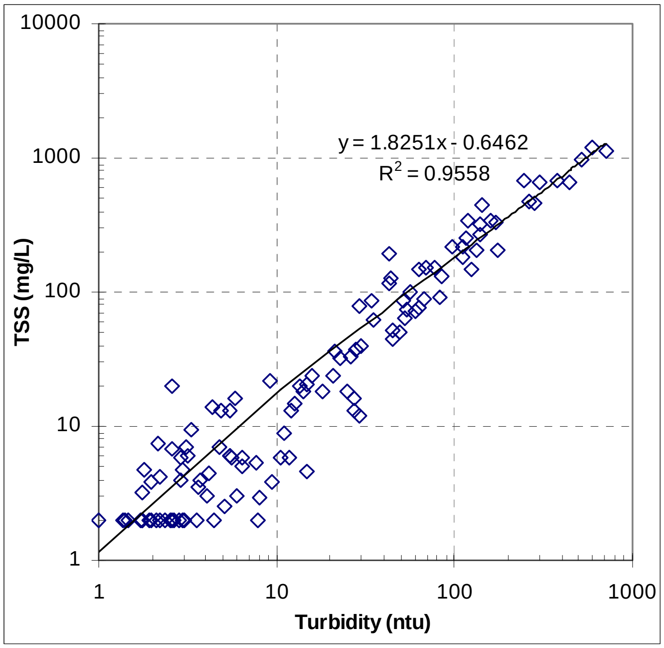


Figure 3-4. TSS versus turbidity for Lake Creek monitoring data.

Because of the availability of continuous turbidity measurements and the strong correlation between turbidity and TSS, the turbidity data set was evaluated to gain an understanding of temporal and spatial patterns in TSS conditions, as discussed in the following sections.

Comparison of TSS to TMDL Target

Available TSS data were compared to the TMDL target of 40 mg/L to evaluate the magnitude of deviation of current water quality conditions from desired conditions. Table 3-6 summarizes the data, and Figure 3-5 presents the observed data in comparison to the TMDL target. Because the recent TSS data available are limited, KSSWCD continuous turbidity data were converted to TSS values based on the TSS-turbidity correlation for comparison to the TMDL TSS target. Evaluation of the converted TSS values against the TMDL target is summarized in Table 3-6 and Figure 3-6.

Table 3-6. Summary of TSS Data Exceeding the TMDL Target (40 mg/L)

Station	Data Source	Number of Samples	Exceedances	Percent Exceeding
Observed TSS				
Lower (Godde)	KSSWCD	36	30	83
Upper (Emtman)	KSSWCD	26	16	62
Bozard	CDAT	28	0	0
Lower	CDAT	32	2	6
Upper	CDAT	6	0	0
Converted TSS				
Upper (Emtman)	KSSWCD	1,005	232	23
Lower (Goode)	KSSWCD	1,310	1,016	78

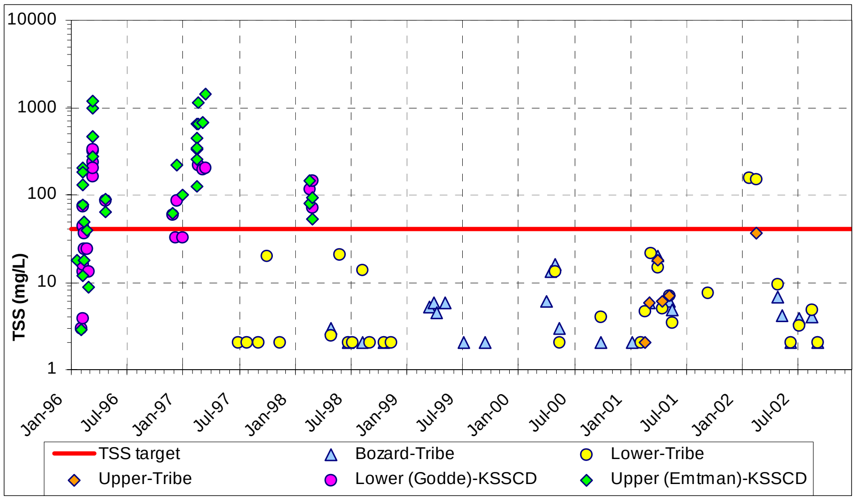


Figure 3-5. Comparison of observed TSS data to TMDL target.

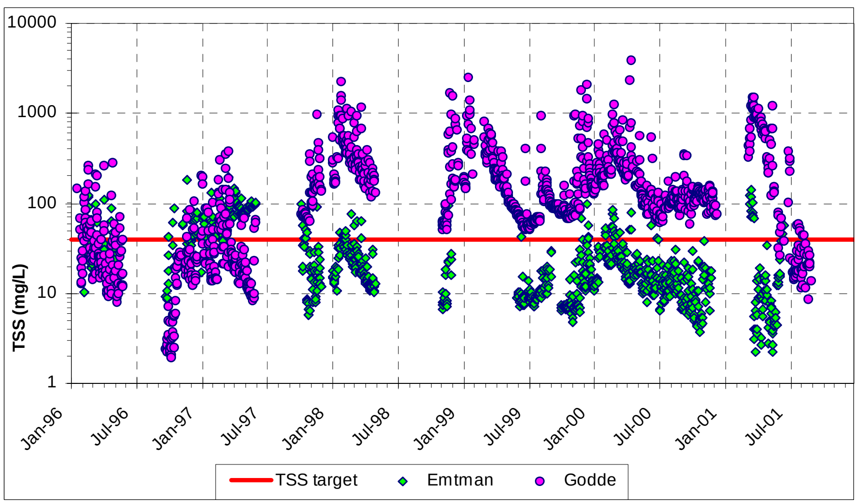


Figure 3-6. Comparison of converted TSS data to TMDL target.

Spatial Variation

Evaluating the spatial variations in instream turbidity can also help to identify areas of increased sediment loading and the location of potential sources. Figure 3-7 presents turbidity data collected at the Emtman (upstream) and Godde (downstream) stations throughout the period of record. As shown in Figure 3-1, the Emtman station is located on Lake Creek at river mile 7.4, just downstream of the confluence of Lake Creek and Bozard Creek, and the Godde station is located at river mile 3.4, about 2 miles upstream of where Lake Creek enters Windy Bay. Turbidity data collected during 1996 and 1997 are relatively consistent between the two stations. However, from mid-1997 through 2000, turbidity levels at the downstream Godde station are much higher than those recorded at the Emtman station. Because flows during this time remained comparable between the two stations (Figure 3-8), the increased turbidity downstream indicates a new source of sediment or increased source activity between the stations. Investigation of the discrepancies between the stations and their consideration in the TMDL analysis is discussed in later sections.

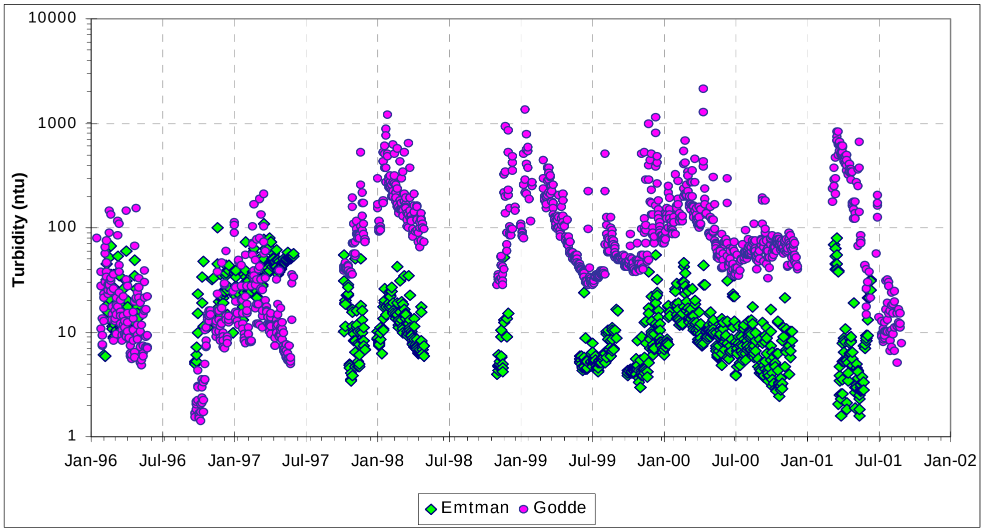


Figure 3-7. Turbidity at Emtman and Godde stations.

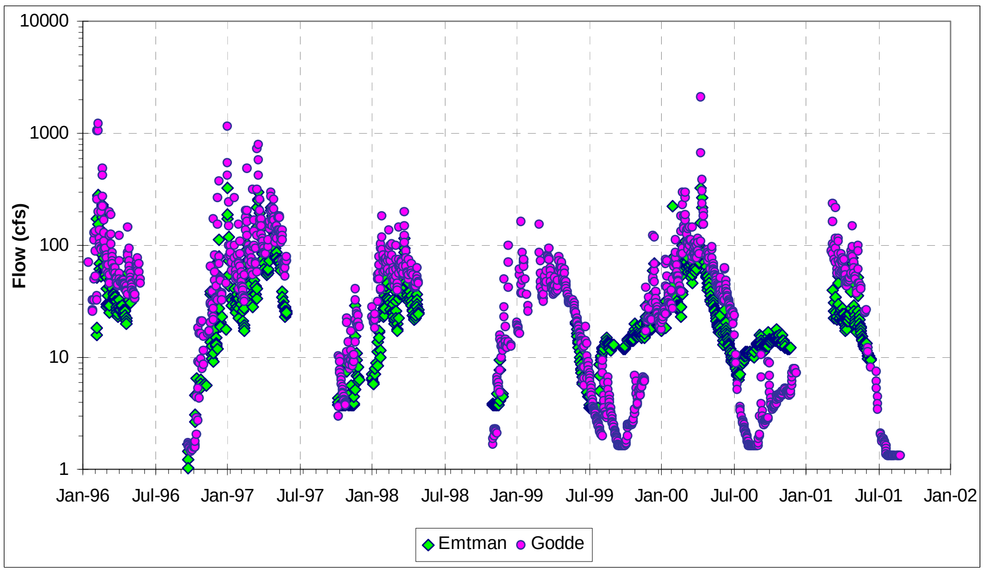
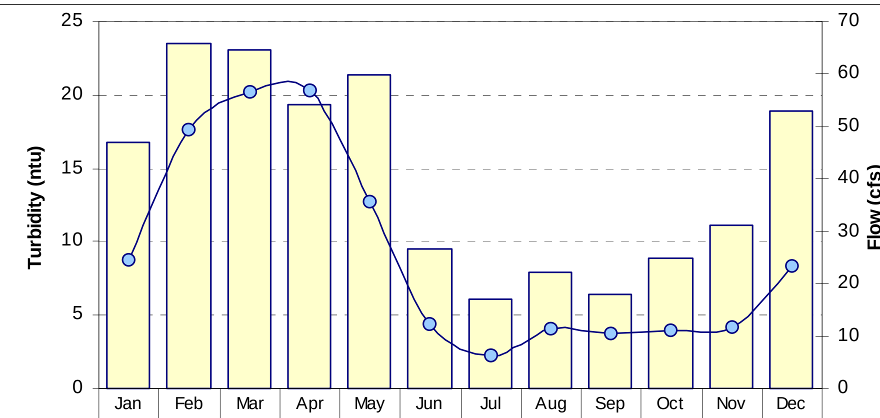


Figure 3-8. Flow at Emtman and Godde stations.

Temporal Variation

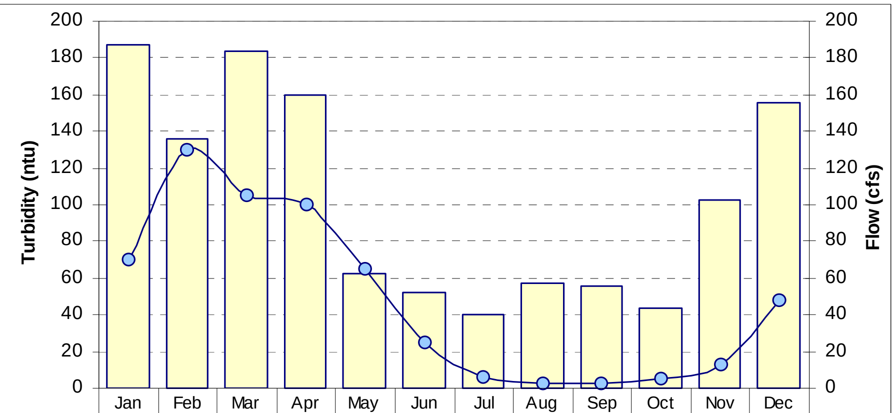
Temporal variations (e.g., monthly, seasonally) in instream conditions can provide insight into the types of sources contributing to the sediment impairment and the periods of loading and impairment. Monthly or seasonal variations in turbidity can also be due to variations in weather patterns rather than in source activity and sediment loading. Flow and turbidity at the Lake Creek stations were used to evaluate any identifiable patterns in turbidity and between turbidity and flow. Evaluation of relationships between instream flow and turbidity can indicate conditions under which loading and impairment occur. The continuous flow data collected by KSSWCD provide a robust set of turbidity and associated flow data. Figures 3-9 and 3-10 present monthly average flow and turbidity over the period of record at Emtman and Godde stations. Typically, turbidity levels, as well as flows, are higher between November and April. Flow and turbidity tend to follow similar patterns, with higher turbidity during times of higher flow; however, as shown in Figures 3-11 and 3-12, the relationship between flow and turbidity is not strong. (Figures 3-9 through 3-12 represent data only from days with observations of both turbidity and flow.) Figures 3-11 and 3-12 include paired flow and turbidity data over the entire period of record at the Lake Creek stations. However, as noted in the previous section, turbidity concentrations at Godde dramatically increased in mid-1997 through 2000, while flow remained comparable throughout the period of record. Figure 3-13 isolates the data before and after the turbidity increase and after June 2001, when turbidity concentrations appear to be returning to lower levels, in an attempt to establish a relationship between turbidity and flow during periods of similar water quality. As shown in Figure 3-13, there is not a strong correlation between flow and turbidity during any of the isolated time periods, reinforcing the assumption that the relationship between flow and turbidity is not strong in Lake Creek.

Because of the hydrologic and climatic patterns of the Lake Creek watershed, it is difficult to directly relate flow and turbidity. Sediment loading and therefore instream turbidity levels likely increase when flows increase as a result of storm events. However, when storms occur as rain-on-snow events, the sediment loading is low related to discharge because the soils are frozen and the ground is covered, and somewhat protected, by snow. In these cases, flow increases with a minimal increase in turbidity. Spring storms could occur when soils have begun to thaw and do not have a protective snow cover, providing the opportunity for erosion and sediment transport to streams, resulting in elevated instream turbidity levels. Therefore, although higher flows typically indicate the occurrence of higher instream sediment and turbidity, not all storm events are conducive to sediment delivery, making it difficult to establish a strong relationship between flow and turbidity.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average turbidity	17	23	23	19	21	10	6	8	6	9	11	19
Average flow	24	49	56	57	36	12	6	11	10	11	12	23
No. of samples	1323	2300	3285	3290	1867	1306	1261	933	865	1988	2462	1100

Figure 3-9. Monthly average flow and turbidity at Emtman station.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average turbidity	188	136	183	160	62	52	40	57	55	43	103	155
Average flow	70	130	105	100	65	24	6	2	2	5	13	48
No. of samples	115	110	175	156	132	67	77	87	66	117	134	74

Figure 3-10. Monthly average flow and turbidity at Godde station.

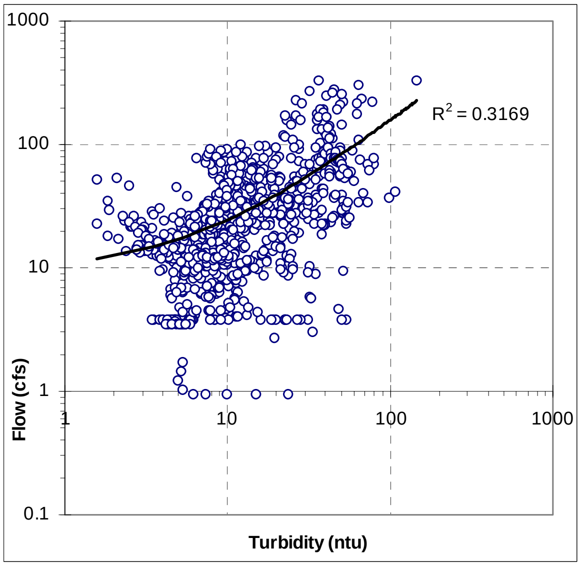


Figure 3-11. Turbidity versus flow at the Emtman site.

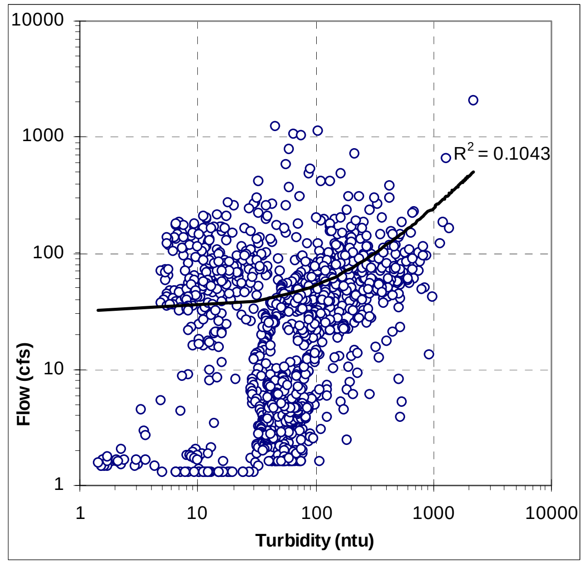


Figure 3-12. Turbidity versus flow at the Godde site.

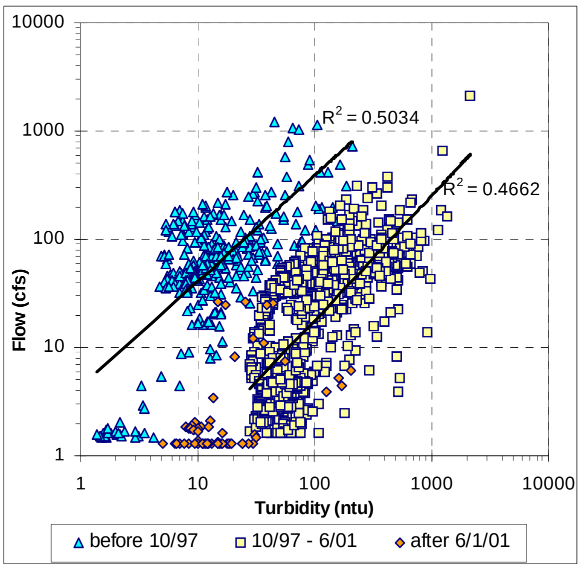


Figure 3-13. Turbidity versus flow at the Godde site—various time periods.

4. Pollutant Sources

This section discusses the potential sources of sediment loading to Lake Creek, including point and nonpoint sources.

4.1 Point Sources

No permitted point sources discharge in the watershed of the impaired segment of Lake Creek.

4.2 Nonpoint and Natural Sources

The CDAT Water Resource Program produced a watershed assessment report (CDAT, 2000) that estimated contributions from the various nonpoint sources of sediments in the Lake Creek basin. The sediment loading was calculated using accepted practices from the Washington Forest Practices Board (WFPB, 1997) to account for the major contributing sources. The watershed assessment identified gully erosion, roads, soil creep, erosion from cropland, and mass movement of soils as the major sources of sediment in the Lake Creek watershed. The following source summaries are based on information in CDAT (2000).

Soils in the Lake Creek watershed fall mainly into three general categories:

1. Alluvial soils in lowlands. These soils are usually found on 0 to 2 percent slopes and have a low erosion potential.
2. Loess-derived soils on lower elevation hills. These soils are usually found on 3 to 25 percent slopes and have a moderate to high erosion potential.
3. Colluvial and residual soils. These soils are usually found on 5 to 65 percent slopes and have a high to very high erosion potential.

The loess-based soils and colluvial soils are frequently underlain by an impermeable layer that results in 97 percent of cropland in the Idaho portion of the basin being highly erodible (KSSCD, 1991). Two methods are usually used to estimate the amount of sediment available for movement in the watershed—the yield approach and the budget approach. The yield approach is based on sediment passing a monitoring station, which would not account for sediment storage in the stream, also called aggradation. Aggradation typically has a negative impact on cold water biota and lengthens the recovery time of a stream. For shallow stream sections, the sandbars show the instream sediment storage which is subject to transport when the water velocity increases. In deeper sections, the impact of aggradation is not seen until the pools fill with sediment or stream measurements reveal the habitat changes. On the other hand, the budget approach accounts for the total sediment loading from the different sources and estimates the percentage of the different loadings that is likely to be transported to the stream.

The CDAT conducted a sediment budget in the Lake Creek watershed (CDAT, 2000), including measurements and estimates for soil creep, mass wasting, sheet and rill erosion, gully erosion, and road erosion. Sediment exiting the system was estimated using established sediment budget research and limited yield data from the Lake Creek watershed. Soil creep and mass wasting provide an estimate of the natural sedimentation in the absence of soil and vegetation disturbances. Information in the following sections is based on this sediment budget and is provided to identify possible sources of sediment in the Lake Creek watershed and their relative magnitude.

Soil Creep

The effects of gravity result in the gradual movement, or creep, of soil down a slope, even in the absence of water. This movement is difficult to measure, but its effects can be readily observed in the tilt of telephone poles and curved tree trunks on hillsides. Increased slope and soil depth generally produce a higher creep rate. Soil creep terminates at the stream, so the delivery ratio for soil creep is 100 percent. Using the estimation methods of the WFPB (1997), the CDAT estimated a soil creep loading of 709 tons/year of sediment.

Mass Wasting

Mass wasting, or mass movement, is the rapid movement of soil from one location to another. The instability resulting in the movement is frequently caused by water. Mudslides and landslides are large-scale mass wasting events. The mass wasting load includes the effect of saturated and unsaturated soil movement. When saturated sediment at the head of a channel detaches, the sediment flows through the channel. As a result, portions of the channel are filled and a new channel forms. These are usually single episode events that happen intermittently. The unsaturated soil movement is characterized by sediment masses that detach multiple times during the period of instability. The soil movements rarely result in new channels and are the result of undercutting of slopes, low-level seismic activity, or multiple years of higher-than-normal precipitation.

The soil loss from mass wasting was developed using approved methods from Ritter et al. (1995). The surface area of the soil slides was used to estimate the soil volume. This volume in cubic yards was converted to cubic feet, and multiplied by a conservative soil density of 100 pounds per cubic feet to obtain a weight. Based on estimated tree ages, the recurrence interval for the slides is 50 years. This gave an average annual input of 14,000 tons/year. By multiplying the 14,000 tons/year by the relief ratio, or average slope, of 0.06, the estimated loading is 840 tons/year.

Road Systems

Contributions of sediment from roads (especially unimproved roads) are a significant component of sediment budgets. Sediment loads were estimated using the methods of WFPB (1997) and total road mileage in the tribe’s geographic information system (GIS) database. The major factors for the sediment loading are vegetation, road surface, travel frequency, and total mileage by road type. Four road types were used to derive a total loading of 5,600 tons/year and a stream delivery of 336 tons/year based on average slope. The four road types and their estimated sediment loads are shown in Table 4-1.

Table 4-1. Sediment Loadings from Road Surfaces

Road Type	Total Load (tons/yr)	Stream Load (tons/yr)
4-wheel drive roads	4,180	251
Secondary roads	880	53
Main roads (Hwy 95)	350	21
Gravel improved roads	188	11

Ephemeral Gully Erosion

Ephemeral gully erosion is the ongoing process by which ditches and gullies become deeper and wider with rainfall. Gully erosion was estimated from direct measurements at several sites. The sites provided a mix of slopes, uses, and direction of the slope faces (aspect). Field measurements were entered into a spreadsheet designed for the Soil Conservation Service (SCS) gully measurement approach (SCS, 1990), resulting in an average erosion of 1.42 tons/acre or 12,100 tons from 8,518 acres susceptible to gully erosion. Applying the relief ratio of 0.06 yields a stream delivery rate of 726 tons/year.

Sheet and Rill Erosion from Cropland

Rill erosion is the result of water contained in many small channels. These are the miniature gullies found in a field, which will become gullies if not corrected. When a sheet of water flows across the land surface, unattached soil is transported, resulting in sheet erosion. Using the Universal Soil Loss Equation (USLE) (SCS, 1975), sheet and rill erosion was estimated in KSSCD (1991). The equation considers topography, climate, crop type, and soil types. The 1991 estimates were not expected to change significantly in the past decade. Estimates were derived for three units: crops in flat bottoms with 0 to 2 percent slopes, crops on 3 to 7 percent slopes, and crops on 3 to 25 percent slopes. The total loading was 115,070 tons/year, with 10,615 tons/year reaching the stream. The estimated sediment loading from croplands is summarized in Table 4-2.

Table 4-2. Erosion from Croplands

Unit	Slope	Acres	Yield (tons/ac)	Total Load (tons/yr)	Delivery Ratio	Stream Load (tons/yr)
1	0–2%	276	4.8	1,370	20%	265
2	3–7%	2,060	9.9	20,400	5%	1,020
3	3–25%	6,182	15.1	93,300	10%	9,330
Total				115,070		10,615

Streambank Erosion

The tribe was not able to estimate the streambank erosion in their sediment budget, but field work in the basin did include notes about freshly cut banks. The WFPB methods for estimating streambank erosion use aerial photos or actual measurements. Lake Creek is too small for the aerial photo method, and the available time and resources did not allow for actual measurements. A study in an agricultural watershed (Trimble, 1983) reported channel erosion at 6 to 11 percent of total erosion.

Sediment Yield

Using the best available information and methods, the tribe developed estimates of the total sediment generated in the watershed and the loadings reaching the stream. The agricultural contribution is the predominant source, both in generation and delivery. The yield for each component is summarized in Table 4-3.

Not all the 13,226 tons/year of sediment reaching the stream will be transported out of the watershed. The sediment retained by the stream fills the slower backwaters to create new stream channels, sandbars or mudflats, and streambanks, thereby reducing the available fishery habitat. Some of the sediment also settles onto the stream channel, filling the interstitial spaces in the gravel or binding to the sediments to form a hard crust. A hardened stream bottom and the loss of interstitial spaces would affect the Lake Creek designated use of salmonid spawning. The CDAT's report cites sources that show that forested and agricultural watersheds generally export 5 to 20 percent of the generated sediments. Other studies cited in the report found that 50 percent of annual sediment yields result from three or four runoff events. Based on these studies, the limited sediment discharge information available, and graphical relationships of percent yield to basin area, the tribe estimated the yearly export to be approximately 11 percent, or 1,455 tons/year (CDAT, 2000).

Table 4-3. Summary of Sediment Loadings

Source	Total Load (tons/yr)	Stream Load (tons/yr)	Percent of Total
Soil creep	1,050	709	5.4
Mass wasting	14,000	840	6.4
Road system	5,600	336	2.5
Crop land erosion	115,070	10,615	80.3
Gully erosion	12,100	726	5.5
Total	147,820	13,226	100.0

As discussed in the following sections, existing monitoring data are used to establish the existing sediment loadings and loading capacity for the Lake Creek watershed, rather than the tribe's sediment budget. Instream observed data provide a direct measurement of the water quality conditions of the stream and tie sediment loading directly to instream conditions, which ultimately measure impairment. The tribe's sediment budget provides useful insight into the categories of nonpoint sediment sources and illustrates the relative magnitudes of the sources. The sediment budget will be helpful in prioritizing control efforts and focusing source reductions, but because it does not provide a link to the instream conditions, it was not used in the TMDL analysis.

5. Analytical Approach

Developing TMDLs requires a combination of technical analysis, practical understanding of important watershed processes, and interpretation of watershed loadings and receiving water responses to those loadings. In identifying the technical approach for development of the sediment TMDL for Lake Creek, the following core set of principles was identified and applied:

- ***The TMDLs must be based on scientific analysis and reasonable and acceptable assumptions.*** All major assumptions have been made based on available data and in consultation with appropriate agency staff.
- ***The TMDLs must use the best available data.*** All available data in the watershed were reviewed and were used in the analysis where possible or appropriate.
- ***Methods should be clear and as simple as possible to facilitate explanation to stakeholders.*** All methods and major assumptions used in the analysis are described. The TMDL document has been presented in a format accessible to a wide range of audiences, including the public and interested stakeholders.

The analytical approach used to estimate the loading capacity, existing loads, and load allocations presented below relies on these principles and provides a TMDL calculation that uses the best available information to represent watershed and instream processes.

5.1 Analysis Background

Instream solids concentrations are highly variable based on flow and antecedent conditions, and instream flows vary depending on weather and watershed conditions. To capture the inherent variability of flow and instream sediment conditions in Lake Creek, this TMDL uses observed flow data and a TSS target to statistically establish loading capacities for various flow ranges in Lake Creek.

Observed flows were distributed based on their frequency of occurrence to establish a flow regime for the watershed, and 10 distinct flow ranges were established. The TSS target and observed flows were then used to calculate loading capacities for each flow range. To identify the load reductions needed to meet the loading capacities, it was necessary to determine the existing TSS loadings in Lake Creek. Because instream TSS data are limited and turbidity data have been available almost daily since 1996 and for a wider range of flows, turbidity data were used along with flow as the basis for identifying the existing sediment loadings. For each of the 10 flow ranges, a representative existing turbidity concentration was identified. These turbidity concentrations were then converted to TSS concentrations based on a correlation equation determined by using observed monitoring data. The TSS concentrations for each flow percentile range were then used to establish existing TSS loadings for the Lake Creek watershed.

The following sections provide more detailed explanations of the methods and process used to calculate the existing loadings and the loading capacity for Lake Creek.

5.2 Evaluation of Existing Loads

It is necessary to determine the existing conditions in Lake Creek to evaluate the load reductions needed to meet TMDL allocations. The existing TSS loads in Lake Creek were calculated by establishing a load duration curve based on observed turbidity and flow data. Because TSS data are not available over a long period of time or for a wide range of flows, turbidity data were used to evaluate existing loads, which were then converted to TSS loads based on the TSS-turbidity correlation established from observed data. The calculation of the existing loads relies on identifying a turbidity level for each of the flow ranges that represents existing conditions. Therefore, the existing loading analysis is highly dependent on the underlying data used. The following sections discuss the data used for identifying existing turbidity conditions, and therefore the existing TSS loadings, and the method applied to calculate the loadings.

Data Used in the Analysis

All the data available for the Lake Creek watershed were evaluated for their appropriateness for use in this TMDL analysis, specifically for the identification of a TSS-turbidity relationship and the subsequent evaluation of existing loadings. The entire record of turbidity data was evaluated to identify the appropriate data and associated period of record to use in the analysis of loads in Lake Creek.

To evaluate the loading conditions within the Lake Creek watershed, it is important to have data that appropriately reflect the range of water quality and flow conditions that occur in the creek. Turbidity and flow data were evaluated for the entire period of record to evaluate any identifiable water quality trends. Evaluation of the data indicated an obvious increase in turbidity values in October 1997 at the Godde station (Figure 5-1). Corresponding turbidity and flow values were evaluated to investigate potential explanations for this variation in the data. A least-squares test was conducted to identify a running correlation of turbidity and flow. As shown in Figure 5-2, turbidity and flow follow a similar (and expected) pattern of turbidity increasing with flow throughout the majority of the period of record.

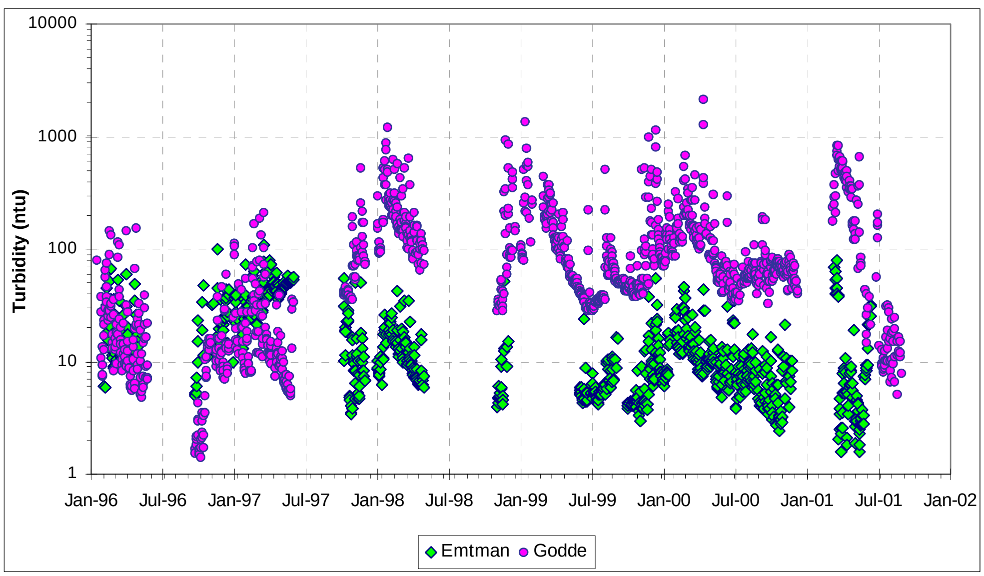


Figure 5-1. Daily average turbidity at the Emtman (upstream) and Godde (downstream) stations.

However, data collected after October 1997 show an increase in turbidity readings with flow remaining comparable to pre-October values. This shift in data is represented in the least-squares test with a reverse in the flow-turbidity pattern beginning around February 1997, with turbidity decreasing as flow increases. The pattern then returns to one where turbidity increases with increasing flows and decreases with decreasing flows. However, the turbidity values are significantly higher than the previous measurements.

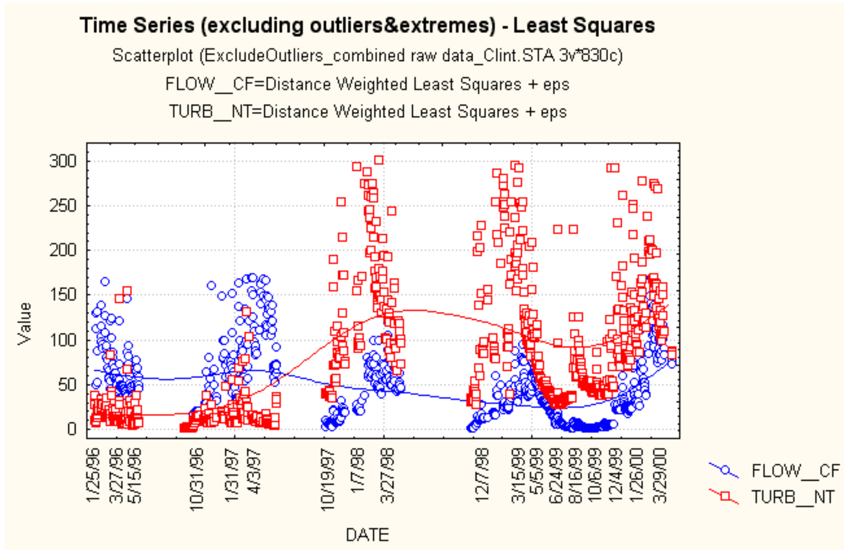


Figure 5-2. Correlation of flow and turbidity in Lake Creek.

Discussions with the Lake Creek TMDL Advisory Committee indicated that a major rain-on-snow event in the watershed produced flood conditions in early 1997. Logging at a parcel of forest property near the Godde station also occurred during the spring of 1997, likely increasing sediment runoff to the stream. The anomalies in the flow-turbidity relationship could be attributed to extreme flow conditions and the subsequent, temporary alteration of the environment due to the rain-on-snow events, as well as increased sediment runoff and delivery due to the isolated logging activities.

The monitoring equipment at the Godde station is located in a portion of the stream close to the culvert discharging the muddy runoff from the logging site. When the logging runoff enters the stream, it mixes with and likely becomes diluted by the stream flow with lower sediment concentrations. However, because of its location, the equipment was likely capturing unmixed conditions in the stream and was measuring concentrations dominated by the logging discharge and its elevated sediment concentrations. Because the data measured during these conditions are not considered representative of the actual stream conditions at the Godde site, data from October 1997 through June 2001 were excluded from the estimation of existing loading in the Lake Creek TMDL analysis.

Calculation of Existing Loads

To calculate the existing loadings, a representative existing turbidity concentration was needed for each of the flow ranges. Although the maximum stream loading would be obtained by using the maximum turbidity observations, these maximum concentrations are attributed to extreme events and are not expected in an average year; therefore, the 70th percentile turbidity reading for each flow range was used to establish the existing conditions. For calculating the existing TSS loadings, the 70th percentile turbidity concentrations were converted to an "existing" TSS concentration (Table 5-1) based on the relationship established between observed

Table 5-1. "Existing" Turbidity Values and Corresponding TSS Values

Flow Range	70th Percentile Turbidity (NTU)	Existing TSS (mg/L)
0–10%	12.8	22.7
10–20%	16	28.5
20–30%	9.8	17.3
30–40%	15	26.7
40–50%	20.4	36.6
50–60%	28.8	52.0
60–70%	24.4	43.8
70–80%	28.6	51.6
80–90%	47.7	86.4
90–100%	76.2	138.3

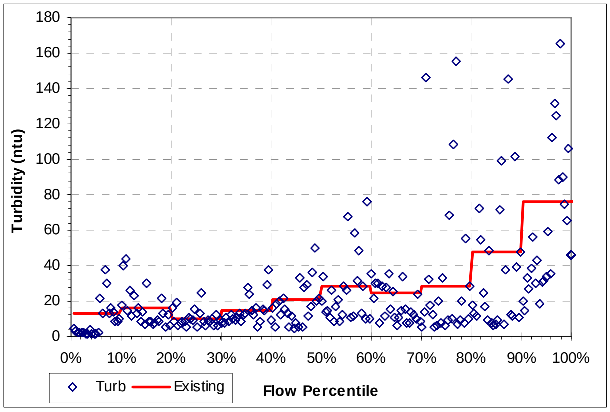


Figure 5-3. Observed average daily turbidity and representative "existing" levels.

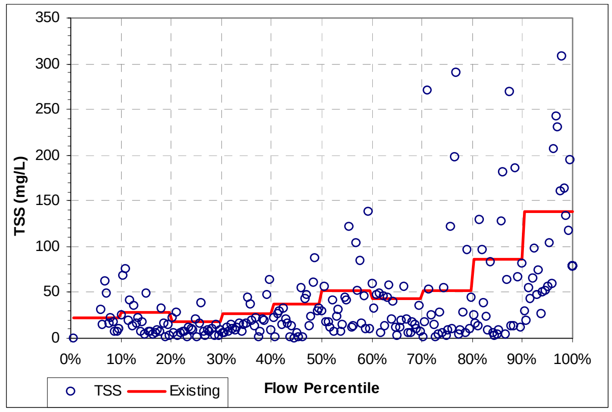


Figure 5-4. Converted TSS values and representative "existing" levels.

turbidity and TSS (Section 3.2). Figure 5-3 presents the observed average daily turbidity readings distributed by associated flow percentiles, with the 70th percentile levels representing existing conditions. Figure 5-4 presents the converted TSS concentrations based on observed turbidity and "existing" turbidity values.

A load was calculated at each flow percentile using the flow and the existing TSS for the flow range. This resulted in 100 TSS discrete loads that were plotted as a function of the cumulative flow distribution (Figure 5-5). The area under the load duration curve represents the total average annual loading.

The trapezoidal method was used to determine the area under the curve, representing the existing TSS load for Lake Creek. The flow and existing load were calculated at 1-percentile flow increments. The area of an incremental trapezoid is equal to the width (1 percentile) multiplied by the height (average loading). Therefore, the area for each incremental trapezoid was calculated as the average of the loading rate at the previous and current percentiles. For example, the existing loading for the 49th to 50th incremental percentile was the average of the 49th percentile existing load and the 50th percentile existing load. The 100 individual incremental loads were summed and divided by 100 percentile increments to get a total load in tons/year.

Because the TMDL is representative of the entire Lake Creek watershed, the flow rates were adjusted to reflect the additional drainage area between the Godde monitoring station and the mouth of Lake Creek at Windy Bay. Approximately 27 percent of the watershed area lies downstream of the Godde station. Therefore, the flows (and loading) were increased by 27 percent. Table 5-2 summarizes the existing load calculation for the entire Lake Creek watershed.

Table 5-2. Existing TSS Loads in Lake Creek

Flow Percentile	Flow (cfs)	Load[1] (tons/yr)	Cumulative Load[2] (tons/yr)
10	28.6	3.2	3.2
20	44.7	3.1	6.3
30	55.5	1.1	7.4
40	73.9	5.0	12.4
50	89.1	6.3	18.7
60	107.4	11.4	30.1
70	135.3	6.6	36.7
80	178.4	16.0	52.7
90	239.5	56.5	109.2
100	1404.9	853.5	962.7

[1] Represents loads for the flow range (e.g., 30th–40th percentile range).
[2] Represents cumulative loads through the maximum percentile of the range (e.g., 0–40th).

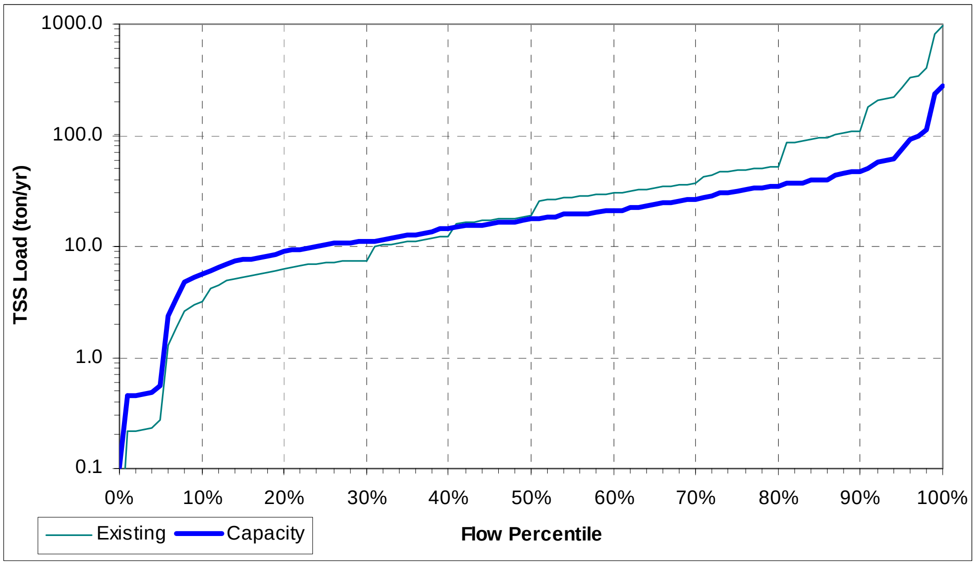


Figure 5-5. Loading capacity and existing loading curves for Lake Creek (at Godde).

5.3 Evaluation of Loading Capacity

One of the essential components of a TMDL is identifying and representing the relationship between the desired condition of the stream (expressed as the water quality target) and pollutant loadings. Once this relationship has been established, it is possible to determine the capacity of the waterbody to assimilate sediment loadings and still maintain acceptable sediment levels or aquatic habitat. Although the Beneficial Use Reconnaissance Project demonstrates habitat impairment, it is difficult to quantitatively link habitat measures to sediment loading. But it is assumed that reductions in sediment loading will ultimately result in improvements of habitat quality. For example, decreases in sediment loading will decrease the chances for sediment deposition in spawning habitat and will decrease water column sediment that can disturb fish visibility. Therefore, the TMDL is based on a numeric instream TSS target and will incorporate future habitat monitoring to assess improvements in habitat quality.

The loading capacity for Lake Creek was calculated using the same load duration method as the existing loading. However, because the loading capacity corresponds to desired conditions, calculation of the loads used observed flows and the TMDL TSS target as the instream concentration. To determine the overall loading capacity of Lake Creek, the TSS target of 40 mg/L was multiplied by the observed flows at the Godde station to determine individual sediment loading capacities for each flow percentile. The 100 individual capacities were plotted to establish a loading capacity curve, as shown in Figure 5-5 with the existing loading curve for Lake Creek. The representative total load corresponding to each of the 10 flow percentile ranges was calculated and is presented in Table 5-3.

Table 5-3. Summary of Existing Loads and Loading Capacities for TSS by Flow Range

Flow Percentile	Flow (cfs)	Load[1] (tons/yr)	Capacity[1] (tons/yr)	Cumulative Load[2] (tons/yr)	Cumulative Capacity[2] (tons/yr)
10	28.6	3.2	5.6	3.2	5.7
20	44.7	3.1	3.2	6.3	8.9
30	55.5	1.1	2.1	7.4	11.0
40	73.9	5.0	3.6	12.4	14.6
50	89.1	6.3	3.0	18.7	17.6
60	107.4	11.4	3.6	30.1	21.2
70	135.3	6.6	5.5	36.7	26.7
80	178.4	16.0	8.5	52.7	35.2
90	239.5	56.5	12.0	109.2	47.2
100	1404.9	853.5	228.9	962.7	276.1

[1] Represents loads for the flow range (e.g., 30th–40th percentile range).
[2] Represents cumulative loads through the maximum percentile of the range (e.g., 0–40th).

6. TMDL

A TMDL is composed of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is denoted by the equation

$$\text{TMDL} = \Sigma\ \text{WLAs} + \Sigma\ \text{LAs} + \text{MOS}$$

The TMDL is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality standards.

For some pollutants, TMDLs are expressed on a mass loading basis (e.g., pounds or kilograms per day). In some cases a TMDL is expressed as another appropriate measure that is the relevant expression for the reduction of loadings of the specific pollutant needed to meet water quality standards or goals. The TMDLs for sediment for Lake Creek are expressed in terms of TSS loading (tons/year). Table 6-1 presents a summary of the TMDL for sediments in Lake Creek, and the following sections provide more details on the individual elements of the TMDL.

Table 6-1. Sediment TMDL for Lake Creek

Source	Annual Existing TSS Load	Estimated Percent Reduction	Annual Allocated TSS Load
Nonpoint Sources:			
Lake Creek watershed	956.4 tons/yr	71%	276.1 tons/yr
Point Sources:			
N/A	0 tons/yr	0%	0 tons/yr
Total Existing Load	**956.4 tons/yr**	**Load Allocation**	**276.1 tons/yr**
Total Annual Load Reduction = 71%		**Wasteload Allocation**	**0 tons/yr**
		Margin of Safety[1]	**0 tons/yr**
		TMDL = Loading Capacity =	**276.1 tons/yr**

[1]MOS was included implicitly through conservative assumptions.

6.1 Margin of Safety

The MOS accounts for any uncertainty concerning the relationship between pollutant loading and water quality. The MOS can be implicit (e.g., incorporated into the TMDL analysis through conservative assumptions) or explicit (e.g., expressed in the TMDL as a portion of the loadings) or a combination of both.

The MOS was included in the Lake Creek TMDL implicitly through a series of conservative assumptions related to both the estimation of the existing loading and the establishment of the water quality target for the TMDL. The conservative assumptions include the following:

- The available flow record was assumed to be representative of a normal, long-term distribution. However, for several years turbidity was not measured in Lake Creek during the summer months. Therefore, because the analysis required paired turbidity and flow data points, the summer flows during those years were not included in the analysis. Because summer flows tend to be lower than those in the late winter and spring, the flow percentiles are biased toward higher flow rates, resulting in higher estimated loadings.

- The TSS target was established at 40 mg/L as an instantaneous maximum concentration. It was chosen from a range of recommended values (25 to 80 mg/L) representing maintenance of good fisheries. Because the recommended values represent typical concentrations that allow for some occasional elevated concentrations, the constant application of the 40-mg/L target is conservative.

- The 70^{th} percentile of the TSS readings was assumed as the existing condition. Although not the maximum possible TSS loading, using the 70^{th} percentile TSS concentrations to determine loading results in a higher than average existing loading. This results in larger associated load reductions, providing a margin of safety.

6.2 Wasteload Allocation

Because no permitted point sources are discharging in the watershed of the impaired segment of Lake Creek, the wasteload allocation for this TMDL is zero.

6.3 Load Allocation

The sediment load allocation is equal to the loading capacity calculated using observed monitoring data and represents the allowable load from watershed sources. The total load allocation is 276.1 tons/year and represents a gross allocation to the entire watershed. Table 6-2 presents the individual load allocations corresponding to each evaluated flow range.

Allocations by flow range were established to identify times of greatest loading and focus control efforts; however, because the loads are based on observed instream data, they represent an instream load from the entire watershed and do not provide information on specific sources in the watershed and their contribution to the sediment impairment in Lake Creek. Further evaluation of specific watershed sources (e.g., cropland runoff) and appropriate controls will be performed during development of the TMDL implementation plan.

6.4 Seasonal Variation

Instream sediment concentrations are often correlated with the flow conditions in a stream. For example, during times of higher flows due to spring runoff events, instream TSS concentrations are likely to be elevated compared to times of lower flows. Although this TMDL does not specifically establish seasonal TSS load allocations, it is based on a representative flow regime in the Lake Creek watershed. By using flow-based loadings, the TMDL inherently accounts for seasonal variation due to the seasonal influences on weather and, therefore, flow.

Table 6-2. Summary of Lake Creek TMDL TSS Load Allocations and Associated Load Reductions

Flow Percentile	Flow (cfs)	Load[1] (tons/yr)	Capacity[1] (tons/yr)	Percent Reduction[1]	Cumulative Load[2] (tons/yr)	Cumulative Capacity[2] (tons/yr)	Percent Reduction[2]
10%	28.6	3.2	5.6	-	3.2	5.7	0
20%	44.7	3.1	3.2	-	6.3	8.9	0
30%	55.5	1.1	2.1	-	7.4	11.0	0
40%	73.9	5.0	3.6	28	12.4	14.6	0
50%	89.1	6.3	3.0	53	18.7	17.6	6
60%	107.4	11.4	3.6	68	30.1	21.2	29
70%	135.3	6.6	5.5	17	36.7	26.7	27
80%	178.4	16.0	8.5	47	52.7	35.2	33
90%	239.5	56.5	12.0	79	109.2	47.2	57
100%	1,404.9	853.5	228.9	73	962.7	276.1	71

[1] Represents loads for the flow range (e.g., 30th–40th percentile range).
[2] Represents cumulative loads through the maximum percentile of the range (e.g., 0–40th).

7. Implementation

Although not legally required, an implementation plan is crucial to the success of a TMDL. An implementation plan for the Lake Creek TMDL will likely be developed by the CDAT and other local agencies and will evolve as the TMDL is finalized. This section identifies expected goals, control options, and timelines to be included in the implementation plan.

7.1 Implementation Focus and Target Reductions

Because it is difficult to directly link habitat quality to sediment loading, the Lake Creek TMDL is based on an instream TSS concentration assumed to represent conditions of good fisheries production. However, the implementation plan for restoring designated uses of Lake Creek will not focus simply on reducing TSS but rather on identifying control actions that will effectively and cost-efficiently restore aquatic habitat, reduce sediment loading and its detrimental effects, and ultimately result in improved water quality and designated use support. The CDAT, Idaho DEQ, and other responsible agencies will attempt to link watershed characteristics to past, present, and future pollution problems to identify and implement management practices that will most efficiently improve water quality and restore designated uses.

The Lake Creek TMDL establishes allocations by flow range to identify times of greatest loading and focus control efforts; however, because the loads are based on observed instream data, they represent an instream load from the entire watershed and do not provide information on specific sources in the watershed and their contribution to the sediment impairment in Lake Creek. Further evaluation of specific watershed sources (e.g., cropland runoff) and appropriate controls will be performed during development of the TMDL implementation plan to focus management efforts on controllable sources that significantly affect instream conditions. The CDAT's watershed assessment (CDAT, 2000) can be used to initially gain some insight into the sources needing control to restore designated uses. CDAT (2000) estimated sediment loads from major sources in the watershed. Table 7-1 uses the source load distribution established in CDAT (2000) to approximate the distribution of existing instream loads in Lake Creek. Table 7-1 also includes target load reductions for the watershed sources to meet the TMDL loading capacity, focusing reductions on more controllable sources.

Table 7-1. Target Load Reductions for Watershed Sediment Sources

Source	Percent of Total Load[1]	Estimated Existing Load (tons/yr)	Targeted Percent Reduction	Reduced Load (tons/yr)
Soil creep	5.4	51.6	0	51.6
Mass wasting	6.4	61.1	0	61.1
Road system	2.5	24.5	64	8.8
Cropland erosion	80.3	772.7	87	101.7
Gully erosion	5.5	52.8	0	52.8
TOTAL		962.7	71	276.1

[1] From CDAT (2000).

7.2 Proposed Control Actions

The implementation of the Lake Creek TMDL and associated control activities will be a locally driven effort, depending on the cooperation of the state, the tribe, local agencies, and area property owners. Although this section does not outline specific control efforts and responsibilities, it provides information on the elements and priorities that should be included in the Lake Creek TMDL implementation plan.

Reduce Sediment Inputs from Agricultural Sheet and Rill Erosion

Sediment budget analysis indicates that the Lake Creek drainage system is presently aggrading because of fine sediment input which exceeds the annual sediment discharge capacity. Suggested practices to reduce agricultural sediment input include the following:

R Conversion to permanent cover crops such as bluegrass. Measures to protect annual burning, or provide an economically viable alternative, are included as part of the conversion process.

R Establishment of buffer and filter strips along the Lake Creek mainstem, major tributaries, and major ephemeral drainages. Ephemeral drainages carry substantial sediment loads during runoff events, and should be managed similar to permanent reaches of the system. Buffer and filter strips also need to be employed along bluegrass fields, as substantial erosion is observed on the fields prior to the growing season, and within the fire breaks that often border drainages or road ditches which discharge to the drainage system.

R Agricultural BMPs, including strip cropping, no-till, and structural practices (gully plugs, sediment basins, grass waterways).

The Kootenai-Shoshone Soil and Water Conservation District enrolled 55 percent of the Lake Creek agricultural acreage within Idaho under the State Agricultural Water Quality Program (SAWQP) in 1993. This commits watershed producers to a variety of agricultural BMPs, including conversion to bluegrass. As the contracts are completed, the Lake Creek watershed should receive reduced sediment loads from sheet and rill erosion on cropland. In 1999, SAWQP was replaced with the Water Quality Program for Agriculture (WQPA) to provide financial incentives to owners and operators of agricultural lands to apply conservation practices to protect and enhance water quality and fish and wildlife habitat.

The majority of landowners inclined to cooperate with agricultural conservation measures were enrolled under SAWQP. Of approximately 680 acres of tribal allotted land in agriculture in the watershed, 480 acres (71 percent) are treated with a combination of permanent cover crop and structural BMPs. The tribe will continue to implement and evaluate BMPs on tribal land. Sheet and rill erosion reduction efforts by the tribe should be directed to the establishment of buffer and filter strips as described above.

Restore Riparian Zones and Increase Streambank Canopy Cover

Canopy cover along Lake Creek and its tributaries is less than the 75 percent closure recommended for salmonid habitat for most of the drainage system. Canopy restoration is critical to maintaining water temperatures suitable for salmonids. Practices should include the following:

R Tree and shrub planting along reaches that presently lack a riparian zone. Species selection should provide various canopy levels and include native species whenever possible. A conifer component is important to provide shade throughout the year and for recruitment of large woody debris. This process is under way, funded by various federal, state, and private grants.

- Enhancement of existing riparian zones. Planting in such areas should provide the missing components. Several reaches between U.S. Hwy 95 and the Lake/Bozard Creek confluence have riparian zones consisting of a single shrub row. Such areas should be planted to provide additional canopy levels and future large woody debris. Reaches below U.S. Hwy 95 would also benefit from supplemental planting, since a near-stream conifer component is presently lacking and large woody debris recruitment is poor.

- Restoration of upland canopy cover wherever possible. Canopy removal and thinning in the uplands has increased flash flooding by increasing snow accumulation and subsequent rain-on-snow events. Canopy losses also destroy cool microclimates typical of well-stocked coniferous forests in stream valleys. These function as cold air drains and remain cool even during hot summer days.

Augment Base Flow of Lake Creek and Tributaries with Storage Reservoirs

Summer low flows contribute to excess stream temperature and reduce available habitat for resident fish and rearing of adfluvial stock. A system of storage reservoirs for flow augmentation is presently being implemented and should remain a priority. The reservoirs have additional benefits of trapping suspended sediment and providing wildlife habitat.

Mitigate Flow Disturbance and Sedimentation Due to Forest Roads

Forest road surfaces and cut-and-fill slopes are the predominant sediment source from forested highlands. Also, forest road cutslopes convert water in ground storage to surface runoff, which exacerbates flash flooding and summer low flow conditions. Projects to mitigate these effects include the following:

- Road obliteration and revegetation. Roads treated with obliteration should be returned to original grade to restore natural slope hydrology. Older, highly compacted roads could require installation of French drains to draw water into the subsurface. Where return-to-grade projects are cost-prohibitive, road subsoiling and revegetation will restore some infiltration capacity and reduce channelization of sheet flow from hillsides.

- Permanent road closure and natural revegetation where access needs or cost prevents more aggressive treatments.

- Seasonal road closure for roads used for present or anticipated timber harvest. Closure from winter to the cessation of the runoff season will reduce sediment delivery from road surfaces. This will not, however, restore natural slope hydrology, which is necessary for base flow maintenance.

7.3 TMDL Implementation Timeline and Adaptive Management Approach

The implementation plan developed for Lake Creek will more specifically identify implementation activities and schedules. Table 7-2 provides a general recommended timeline for the implementation of the TMDL and associated control activities. The plan will also include a review schedule, recognizing that TMDL implementation may be an iterative process. The plan will include phased implementation of BMPs with monitoring designed to evaluate the BMPs' effectiveness and improvement in water quality.

Periodic reviews of monitoring results will be used to evaluate progress toward attaining TMDL goals and restoring water quality standards and designated uses. The monitoring results and reviews will provide a feedback loop to evaluate the appropriateness of the TMDL and its implementation plan. If necessary, the TMDL and/or implementation plan will be revised based on new information collected during the follow-up monitoring.

Table 7-2. General TMDL Implementation Plan Timeline

Activity	Lead Agency (Support Agencies)	Completion Date
Completion of *Lake Creek TMDL Implementation Plan*, including specific sediment load reduction practices, party responsible for their implementation, and deadlines for their implementation	CDAT (Idaho DEQ)	1 year from approval of TMDL
Implementation of Phase I Controls (to be specified in implementation plan)	To be specified in implementation plan	Within 1 to 3 years from TMDL approval
Implementation of Phase II Controls (to be specified in implementation plan)	To be specified in implementation plan	Within 3 to 5 years from TMDL approval
Monitoring	CDAT, Idaho DEQ	Ongoing as specified in the monitoring plan
Annual Progress Evaluations to track implementation of control efforts and to review monitoring results and effects on TMDL	USEPA (CDAT, Idaho DEQ)	Yearly from approval of TMDL
TMDL Updates or Revisions based on subsequent monitoring results	USEPA (CDAT, Idaho DEQ)	Within 5 to 7 years from TMDL approval, as necessary

8. Monitoring

Follow-up monitoring for a TMDL is important in tracking the progress of TMDL implementation and subsequent water quality response, as well as in evaluating any assumptions made during TMDL development. Monitoring results can be used to better characterize "unknowns" in the TMDL analysis (e.g., background concentrations, seasonal variations) and can provide support for any necessary future TMDL revisions. Most important, monitoring will track the water quality of Lake Creek to evaluate future attainment of TMDL targets and water quality standards. If future monitoring indicates that Lake Creek is supporting designated uses prior to meeting load reductions set in the TMDL, the TMDL will be reevaluated and revised accordingly.

The CDAT seeks to continue its ongoing water quality sampling and monitoring in the Lake Creek watershed, as described in this section. Idaho DEQ will collect additional water quality data during their routine monitoring schedules. The TMDL monitoring plan for Lake Creek will rely on three main elements—instream water quality monitoring, measurement of other habitat indicators, and the potential identification and monitoring of a reference site.

Monitoring will occur at the following three sites in the Lake Creek watershed:

Upper Lake Creek:
NW ¼ NE ¼ Sec. 12 T48N R6W
Downstream of crossing of Lake Creek and Elder Road

Bozard Creek:
NW ¼ NE ¼ Sec. 12 T48N R6W
Just upstream of the confluence with Lake Creek off of Elder Road

Lower Lake Creek:
NW ¼ SE ¼ Sec. 21 T48N R5W
Downstream of HWY 95 bridge about ½ mile on Lake Creek

8.1 Instream Water Quality Monitoring

Dissolved oxygen, pH, temperature, conductivity, total dissolved solids (TDS), nutrients, and turbidity will be measured at each site on a regular schedule. In addition, paired TSS and turbidity measurements will be taken during rain-on-snow events.

The sampling schedule is developed to capture water quality conditions during both peak and low-flow conditions. This is justified by the fact that the majority of pollutant loads delivered by streams are delivered by several discrete peak flow events. Summer low-flow conditions deliver very little pollutant load by comparison; temperature and discharge become the parameters of concern during dry months.

Dissolved oxygen, pH, temperature, conductivity, turbidity, and discharge will be sampled at the three sites biweekly from March 1 to October 31, and monthly the rest of the season. The schedule will be flexible and adjusted to incorporate a variety of flow conditions.

The two sites on the mainstem of Lake Creek will also be sampled for TSS and turbidity in conjunction with rain-on-snow events. Based on previous years, at least three such events are expected during the period from November 1 to June 1. Peak event sampling at these sites will include collection of discharge and Hydrolab parameters. This sampling is expected for the "frozen solid" period of January and February and again in mid-April, as TSS can change considerably with the degree of soil freezing.

Table 8-1 provides a summary of parameters to be measured and their frequency, and the following discussion provides details of the methods that will be used in their measurement.

Table 8-1. Coeur d'Alene Tribe Monitoring Plan

Site	Parameter	Frequency
Upper Lake Creek	Discharge, temperature, turbidity, pH, dissolved oxygen, conductivity (TDS)	Biweekly, March 1 through October 31, and peak flow events
	TSS and turbidity	Rain-on-snow events (three events between November 1 and June 1)
Bozard Creek (major tributary to upper Lake Creek)	Discharge, temperature, turbidity, pH, dissolved oxygen, conductivity (TDS)	Biweekly, March 1 through October 31, and peak flow events
Lower Lake Creek	Discharge, temperature, turbidity, pH, dissolved oxygen, conductivity (TDS)	Biweekly, March 1 through October 31, and peak flow events
	TSS and turbidity	Rain-on-snow events (three events between November 1 and June 1)

Regression analysis of stage and discharge measurements will produce rating curves for discharge monitoring points. Measurements are to be taken at low, medium, and high flows so that a complete curve can be obtained. High-capacity equipment will be used to monitor peak events. Previously, some sites had to be bypassed during peak events because of the hazard of wading during high discharge.

Stage readings will be taken from a fixed staff gauge located in the stream. Discharge measurements will be taken using Instream Flow Incremental Methodology (IFIM). Under this approach, the stream is divided into 20 equal-width cells. Velocity is measured in each cell and multiplied by cell area, and the volumes are summed to obtain the discharge measurement in cubic feet per second. Channel profiles will also be taken to monitor changes in stream morphology at the site.

A Hydrolab (trade name for a multi-parameter water quality testing probe) will be used to determine dissolved oxygen, pH, temperature, and conductivity. Total dissolved solids (TDS) will be calculated from conductivity readings. The unit will be calibrated prior to each use according to manufacturer specifications. A calibration log is maintained to ensure that required calibrations are being completed. In addition, calibration is verified monthly using scientific-grade reference solutions. Instrument drift will be checked at the end of each sampling day, and results will be recorded in the calibration log. Once calibrated, the unit is deployed by placing the underwater probe as close as practical to mid-stream and mid-depth. The transmitter is allowed to stabilize for 1 minute. An instantaneous reading is then taken and recorded in a data logger.

Nutrients, TSS, turbidity, total phosphate, and total kjeldahl nitrogen will be collected using methods described in the *Standard Methods for the Treatment of Water and Wastewater* (APHA, 1992). All analyses of this type will be conducted by an accredited (state- or USEPA-certified) contract laboratory. Nutrients will be analyzed using USEPA method 300.0 ion chromatography. TSS will be analyzed using U.S. Geological Survey (USGS) whole sample methodology. Turbidity will be analyzed using USEPA method 180.1. Total phosphate will be analyzed using USEPA method 200.7, Inductively Coupled Plasma. Total kjeldahl nitrogen will be analyzed using standard method 4500-N_{org}B.

8.2 Other Habitat Indicators

In addition to an instream TSS target concentration, the Lake Creek TMDL implementation plan will establish monitoring targets for aquatic habitat measures. Because it is difficult to link such water column measurements as TSS to aquatic life habitat quality, measures of channel and habitat conditions are more useful in directly gauging the availability and quality of aquatic life habitat and support. These indicators include measurements such as riffle:pool ratios, channel substrate composition, and amount of large woody debris. If evaluation of habitat measures indicates that Lake Creek is supporting designated uses prior to meeting load reductions or TSS targets established in the TMDL, the TMDL will be reevaluated and revised accordingly.

The Lake Creek Watershed Assessment (CDAT, 2000) previously evaluated streambank and habitat measures in the Lake Creek watershed. It is expected that additional monitoring of these measures will be conducted to track the improvement of habitat quality in response to the sediment load reductions implemented by this TMDL. Potential habitat measures to be monitored and proposed targets are included in Tables 8-2 and 8-3. The specific targets associated with each habitat measure are proposed and will be further defined in the Lake Creek TMDL implementation plan.

Table 8-2. Proposed Targets for Habitat Indicators

Indicator	Proposed Target	Source
Percent fines (<4 mm) in channel substrates	No more than 10 percent of particles <4 mm	CDAT (2000) [Hickman and Raleigh (1982)]
Riffle:pool ratio	1:1	CDAT (2000) [Hickman and Raleigh (1982)]
Residual pool depth	1.0 m	Personal communication, CDAT, July 2003
Riffle stability index	RSI<70	IDEQ (2003b) [Kappesser (1993)]; CDAT (2000) [Kappesser (1992)]
Fish counts	Phased targets of juvenile fish/m^2 (See Table 2-2)	Personal communication, CDAT, Department of Natural Resources, October 2003
Cobble embeddedness	Targets are not established at this time but will be considered in future monitoring. If future monitoring provides sufficient information on reference levels, quantitative targets will be established at that time.	
Large woody debris		

Table 8-3. Proposed Targets for the Lake Creek Fishery[1]

Segment[2]	Phased Target (juvenile fish/m^2)				
	1998	2007	2012	2016	Beyond
Lower Lake Creek	0.020	0.023	0.061	0.069	0.224
Upper Lake Creek	0.128	0.128	0.178	0.283	0.393

[1] Personal communication, CDAT, Department of Natural Resources, October 2003.
[2] Lower Lake Creek extends from the Emtman gauging station to the mouth. Upper Lake Creek extends from the Emtman gauging station to the headwaters.

8.3 Identification of a Reference Site

Another approach to evaluating the health or impairment of a watershed is comparison to a reference site that represents unimpaired conditions (i.e., designated uses are supported). A reference site allows for the identification of parameters and characteristics of desired, unimpaired conditions that can be set as targets for the impaired watershed. The identification of an appropriate reference site is dependent on a thorough evaluation of watershed characteristics of both the impaired and reference watersheds. It is important that the two watersheds be similar in terms of soil type, soil and subsurface characteristics, hydrology, land cover, and climate/weather patterns and events. The reference watershed should be as similar to the impaired watershed as possible; basically, it should represent the impaired watershed prior to disturbance or impairment.

During TMDL development for Lake Creek, no reference sites were identified. Waters in the upper watershed are considered to be of good quality; however, the geology and environment of the upper and lower watershed vary. Therefore, it would be inappropriate to set desired conditions for the lower watershed based on conditions in the upper watershed.

In addition to the collection of chemical, physical, and habitat monitoring, the Lake Creek TMDL follow-up monitoring plan will consider the further investigation of available reference sites for Lake Creek. Evaluation of regional water quality data and watershed coverages (e.g., soils and land use) can identify potential reference sites for the evaluation of impairment in Lake Creek, or it could indicate that an appropriate reference site does not exist.

If a reference site is identified, monitoring comparable to that of the Lake Creek sites will be conducted to support comparison of the two watersheds and the establishment of desired targets for the Lake Creek watershed. Water quality and habitat data collected at the reference site will aid in the evaluation of natural/background conditions of the Lake Creek watershed and the appropriateness of the TMDL load allocations and reductions.

9. Public Comments

This proposed TMDL is open for public comment from ______________ to ________________. People wishing to comment on the proposed TMDL should do so in writing by the close of the public comment period, __________. Written comments must be postmarked by the close of the comment period and sent to Jayne Carlin, USEPA Region 10 (OW-134), 1200 Sixth Avenue, Seattle, WA 98101. Comments may be faxed to EPA at 206-553-0165 (confirm delivery by calling Jayne Carlin at 206-553-8512) or e-mailed to carlin.jayne@epa.gov by the close of the public comment period. All comments should include the name, address, and telephone number of the commenter and a concise statement of the comment and the relevant facts upon which it is based.

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Appendix: Summary of Idaho DEQ BURP Data for Lake Creek

Idaho DEQ uses BURP data to calculate stream habitat indices for evaluation of aquatic life use support (Grafe, 2002). A Stream Macroinvertebrate Index (SMI), Stream Fish Index (SFI), and Stream Habitat Index (SHI) are generated for each surveyed stream, where possible, and each index is rated based on different condition categories related to reference conditions (Table A-1 and Table A-2). The individual scores are then averaged into one condition rating that is used to determine use support. An average score of greater than or equal to 2 is considered fully supporting while an average score of less than 2 is considered not fully supporting. Table A-3 summarizes the available indices for Lake Creek, indicating that the creek does not fully support its aquatic life use.

Table A-1. SMI Scoring Criteria for the Northern Mountains Region

Condition Category	SMI Scores	Condition Rating
Above the 25th percentile of reference condition	65–100	3
10th to 25th percentile of reference condition	57–64	2
Minimum to 10th percentile of reference condition	39–56	1
Below minimum of reference condition	<39	Minimum Threshold

Source: Grafe (2002).

Table A-2. SHI Scoring Criteria for the Northern Rockies Region

Condition Category	SHI Scores	Condition Rating
Above the 25th percentile of reference condition	66–100	3
10th to 25th percentile of reference condition	58–65	2
Below 10th percentile of reference condition	<58	1

Source: Grafe (2002).

Table A-3. Summary of Lake Creek Scores for Determination of Aquatic Life Use Support

Stream	Waterbody ID	BURP Site ID	SMI Score (0–100)	SMI Score (1–3)	SHI Score (0–100)	SHI Score (1–3)	Average Score	Support Status
Lake Creek (Lower)	17010303PN06	96NIRO0B18	42.05	1	50	1	1	Not fully supporting
Lake Creek (Upper)	17010303PN06	96NIRO0B19	39.4	1	50	1	1	Not fully supporting
Lake Creek (Upper)	17010303PN06	97NIRO0A01			54	1	1	Not fully supporting