# Fernan Lake Subbasin Assessment and Total Maximum Daily Load

1st Draft

**Department of Environmental Quality**

**February 2013**

# Fernan Lake Subbasin Assessment and TMDL

**February 2013**

**Prepared by:**
**Idaho Department of Environmental Quality**
**Coeur d'Alene Regional Office**
**2110 Ironwood Parkway**
**Coeur d'Alene, ID 83814**

# Acknowledgments

This document was prepared by Kristin Larsen. It could not have been completed without the technical oversight of Bob Steed, DEQ and help of Craig Nelson of the Coeur d'Alene Regional Office. Thank you to the Fernan Lake Citizen Volunteer Monitoring Program (CVMP) for their hard work and dedication to protection of water quality in the lake. Their data was invaluable. Also, special thanks to Jim Szpara for his invaluable GIS expertise in making the bathymetry map that was the basis for the load calculations in the TMDL.

# Table of Contents

# List of Tables

# List of Figures

This page intentionally left blank for correct double-sided printing.

# Abbreviations, Acronyms, and Symbols

**§303(d)** Refers to section 303 subsection (d) of the Clean Water Act, or a list of impaired water bodies required by this section

**µ** micro, one-one millionth

**§** Section (usually a section of federal or state rules or statutes)

**AU** assessment unit

**AWS** agricultural water supply

**BAG** Basin Advisory Group

**BLM** United States Bureau of Land Management

**BMP** best management practice

**BOD** biochemical oxygen demand

**BURP** Beneficial Use Reconnaissance Program

**C** Celsius

**CFR** Code of Federal Regulations (refers to citations in the federal administrative rules)

**cfs** cubic feet per second

**cm** centimeters

**CWA** Clean Water Act

**CWAL** cold water aquatic life

**CWE** cumulative watershed effects

**DEQ** Department of Environmental Quality

**DO** dissolved oxygen

**DWS** domestic water supply

**EPA** United States Environmental Protection Agency

**F** Fahrenheit

**FPA** Idaho Forest Practices Act

**GIS** Geographical Information Systems

**HUC** Hydrologic Unit Code

**I.C.** Idaho Code

**IDAPA** Refers to citations of Idaho administrative rules

**IDFG** Idaho Department of Fish and Game

**IDL** Idaho Department of Lands

**IDWR** Idaho Department of Water Resources

**km** kilometer

**$km^2$** square kilometer

**LA** load allocation

**LC** load capacity

**m** meter

**m³** cubic meter

**mi** mile

**mi²** square miles

**mg/L** milligrams per liter

**mm** millimeter

**MOS** margin of safety

**n.a.** not applicable

**NA** not assessed

**NB** natural background

**nd** no data (data not available)

**NFS** not fully supporting

**NPDES** National Pollutant Discharge Elimination System

**NRCS** Natural Resources Conservation Service

**NTU** nephelometric turbidity unit

**ORV** off-road vehicle

**PCR** primary contact recreation

**ppm** part(s) per million

**RBP** rapid bioassessment protocol

**RHCA** riparian habitat conservation area

**SBA** subbasin assessment

**SCR** secondary contact recreation

**SRP** soluble reactive phosphorus

**SS** salmonid spawning

**STATSGO** State Soil Geographic Database

**TDG** total dissolved gas

**TDS** total dissolved solids

**T&E** threatened and/or endangered species

**TIN** total inorganic nitrogen

**TKN** total Kjeldahl nitrogen

**TMDL** total maximum daily load

**TOTAL PHOSPHORUS** total phosphorus

**TS** total solids

**TSS** total suspended solids

**t/y** tons per year

**U.S.** United States

**U.S.C.** United States Code

**USDA** United States Department of Agriculture

**USDI** United States Department of the Interior

**USFS** United States Forest Service

**USGS** United States Geological Survey

**WAG** Watershed Advisory Group

**WBAG** *Water Body Assessment Guidance*

**WBID** water body identification number

**WLA** wasteload allocation

**WQLS** water quality limited segment

**WQMP** water quality management plan

**WQRP** water quality restoration plan

**WQS** water quality standard

This page intentionally left blank for correct doubled-sided printing.

# Executive Summary

The federal Clean Water Act (CWA) requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters. States and tribes, pursuant to Section 303 of the CWA, are to adopt water quality standards necessary to protect fish, shellfish, and wildlife while providing for recreation in and on the nation's waters whenever possible. Section 303(d) of the CWA establishes requirements for states and tribes to identify and prioritize water bodies that are water quality limited (i.e., water bodies that do not meet water quality standards). States and tribes must periodically publish a priority list (a "§303(d) list") of impaired waters. Currently this list must be published every two years. For waters identified on this list, states and tribes shall develop a total maximum daily load (TMDL) for the pollutants, set at a level to achieve water quality standards.

This document addresses Fernan Lake within the Coeur d'Alene Lake Subbasin (hydrologic unit code (HUC) 17010303). The document contains a subbasin assessment (SBA) and TMDL analysis that have been developed to comply with Idaho's TMDL schedule. It describes the physical, biological, and cultural setting; water quality status; pollutant sources; and recent pollution control actions relevant to Fernan Lake, located in Kootenai County, North Idaho.

The SBA is an important first step in leading to the TMDL. It includes Idaho's current §303(d) list of water quality-limited water bodies, on which Fernan Lake is currently listed. The §303(d) list identifies Fernan Lake's recreational beneficial use as being impaired by excess nutrients/eutrophication which results in the occurrence of blue-green algae blooms. The SBA examines the status of Fernan Lake and its contributing watershed and defines the extent of impairment and causes of water quality limitation. The TMDL analysis quantifies pollutant sources and allocates responsibility for load reductions needed to return listed waters to a condition of meeting water quality standards and full support of beneficial uses.

## Subbasin at a Glance

Fernan Lake is located in Kootenai County, north Idaho in the Coeur d'Alene Lake subbasin (HUC 17010303) (Figure 2). It is 381 acres in size with 6.5 miles of shoreline and a maximum water depth of 27 feet. Due to its close proximity to north Idaho's largest community of Coeur d'Alene, Fernan Lake is a popular residential and recreational-use lake for boating, fishing, swimming, and aesthetics.

The Fernan Lake watershed is 5,579 ha (13,786 acres) in size of which 3,118 ha (7,704 acres) (556 percent) are steep, forested mountains within the U.S. Forest Service property boundaries. The private land in the watershed is 2,265 ha (5,596 acres) (41 percent). There are 32 ha (80 acres) of state lands in the watershed. On the northwest end of the lake is Fernan Lake Village, comprised of approximately 71 homes housing a mostly year-round population of 169 people.

Fernan Creek is the major perennial water input to Fernan Lake, and is currently listed as fully supporting all beneficial uses. Fernan Creek receives perennial inflow from Stacel Creek, and intermittent flow from Dry gulch, State Creek, upper Fernan Creek, Jungle Gulch, Smith Gulch, and Rondo Gulch. Other sources of water input to the lake are intermittent streams and groundwater.

While snowpack in the upper watershed drives much of the stream hydrology into Fernan Lake, rain-on-snow events in the low-mid elevations of the watershed provide big spikes in the flow during the months of November to February.

# Key Findings

Fernan Lake blue-green algae blooms generally occur during late summer and fall. These blooms impair the lake's recreational beneficial use by significantly reducing water clarity, and causing unsightly, thick green algal mats along shorelines. In addition, some species identified in Fernan Lake may produce toxins that are capable of causing illness and death to animals and illness to humans.

Citizen Volunteer Monitoring Program data has been valuable in understanding physical and chemical conditions in Fernan Lake, conditions important to phosphorus availability and algal blooms. The data has shown Fernan Lake is typically mixed, or isothermal, during the summer months. It appears that the overall average shallow depth and frequent winds cause enough wave action to mix the lake and prevent stratification. While thermal stratification may occur for periods, the duration of stratification seem to be short-lived. This thermal mixing sustains aerobic conditions in the lower depths of the lakes. The absence of thermal stratification, the shallow depth of Fernan Lake, and steep shoreline favoring less-abundant plant growth lends itself to Mesotrophic status of the lake, consistent with trophic status given to the lake by previous studies.

Discrepancies exist in previous literature regarding bathymetry of Fernan Lake. In 2011, DEQ collected new bathymetry data to create an updated map (Figure 5). This information was necessary for accurate phosphorus loading calculations and useful in calculating new morphometric information valuable in understanding limnology of Fernan Lake. The new data reveals the lake has steep shorelines with a depth of 20 to 21 feet throughout much of the lake. The deepest part of the lake is 27 feet near the southern shoreline of the lake.

Analysis of available total phosphorus data shows that annually there is time period of elevated total phosphorus concentrations between August 15 and September 15 with a typical concentration of 31 μg/L. This equates to an existing phosphorus load in Fernan Lake of 245 kg (530 lb) at any time during the critical period.

After evaluation of the different data sources (using DEQ nutrient data analysis of regionally similar lakes, and a TMDL for Black Lake and a shallow Mesotrophic lake in eastern Washington, and other sources) DEQ concluded that it is reasonable to establish a water quality target for Fernan Lake would be within the range that represented other Mesotrophic lakes which do not have frequent blue green algae blooms. As such, the total phosphorus water quality target established for the Fernan Lake TMDL is 20 μg/L. With a target concentration of 20 μg/L, the load capacity of Fernan Lake is 158 kg (348 lb) at any time during the critical period.

There are no NPDES-permitted facilities within or outside of the Fernan Lake watershed that discharge to Fernan Lake or its tributaries. Total phosphorus load allocations and a required 35 percent reduction was assigned to nonpoint sources in the watershed (Table 1). The primary non-point source of pollution into Fernan Lake is Fernan Creek. Other sources of nutrients are lawn/garden fertilizers and storm water runoff from Fernan Village, Fernan Lake Road, and developed areas on the northern and southern hillslopes above the lake. Sources within the lake are internal cycling and submerged macrophytes on the east and west shores of the lake.

**Table 1. TP Load Allocations and Percent Reduction Goals required for all Nonpoint Sources to Fernan Lake**

| Existing TP concentration[1] (ug/L) | Existing load[1] (kg) | Fraction of TP reduction needed to meet target concentration | Target concentration[1] (ug/L) | TP load at target concentration[1] (kg) |
|---|---|---|---|---|
| 31 | 245 | 35% | 20 | 158 |

| Source | Existing amount of TP contributed by source (kg/yr) | Existing TP Load[1] (kg/yr) | Fraction of TP reduction needed to meet target concentration[1] (load reduction) (percent) | Amount of TP reduction needed to meet target concentration[1] (load reduction) (kg/yr) | Amount of TP contributed by source after reductions (load allocation) (kg/yr) | TP load at target concentrations [1] (kg/yr) |
|---|---|---|---|---|---|---|
| **Fernan Creek** | 3200 | 160[2] | 35% | 1120 | 2080 | 104[2] |
| **Fernan Village Lawns** | 24 | 24 | 35% | 8.4 | 16 | 16 |
| **Fernan Village Stormwater** | 4 | 4 | 35% | 1.4 | 2.6 | 2.6 |
| **Fernan Lake Road** | 14 | 14 | 35% | 4.9 | 9.1 | 9.1 |
| **Septic** | 11 | 11 | 35% | 3.9 | 7.2 | 7.2 |
| **Internal Cycling** | 24 | 24 | 35% | -- | -- | -- |
| **French Gulch** | 1 | 1 | 35% | 0.4 | 0.7 | 0.7 |
| **Other** | 12 | 7.0 | 35% | 2.5 | 7.8 | 4.6 |
| **Total** | **3290** | **245** | | **1149.9** | **2139.4** | **160.2** |

[1]Concentrations and loads are during the critical time period between August 15th and September 15th.
[2]Load remaining after Spring flows flush through Fernan Lake. At high flows, much of the TP in Fernan Creek is flushed through the outlet of Fernan Lake and it does not remain in the lake.

This page intentionally left blank for correct double-sided printing.

# Subbasin Assessment – Watershed Characterization

The federal Clean Water Act (CWA) requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters. States and tribes, pursuant to Section 303 of the CWA, are to adopt water quality standards necessary to protect fish, shellfish, and wildlife while providing for recreation in and on the nation's waters whenever possible.

Section 303(d) of the CWA establishes requirements for states and tribes to identify and prioritize water bodies that are water quality limited (i.e., water bodies that do not meet water quality standards). States and tribes must periodically publish a priority list (a "§303(d) list") of impaired waters. Currently this list must be published every two years. For waters identified on this list, states and tribes must develop a total maximum daily load (TMDL) for the pollutants, set at a level to achieve water quality standards. In common usage, a TMDL also refers to the written document that contains the statement of loads and supporting analyses, often incorporating TMDLs for several water bodies and/or pollutants within a given watershed.

This document addresses Fernan Lake within the Coeur d'Alene Lake Subbasin (hydrologic unit code (HUC 17010303). Fernan Lake is currently on Idaho's current §303(d) list as not supporting its recreation beneficial use due to excessive nutrients that result in annual blue-green algae blooms on the lake.  Blue-green algae are microscopic bacteria also known as cyanobacteria. There are many species of blue-green algae that are naturally occurring in surface waters, and blooms generally occur in eutrophic conditions during late summer and fall. The physical appearance of blue-green algae blooms can be unsightly, often causing thick green mats along the shoreline. In addition, some species can produce toxins that may cause illness and death to animals and illness to humans (CDC 2008).

This document includes a subbasin assessment (SBA) and a TMDL which characterize and document pollutant loads to Fernan Lake.  The first portion of this document, the SBA, is partitioned into four major sections: watershed characterization, water quality concerns and status, pollutant source inventory, and a summary of past and present pollution control efforts (Sections 1 – 4). This information will then be used to develop a TMDL for each pollutant of concern for Fernan Lake (Section 5).

## Introduction

In 1972, Congress passed the Federal Water Pollution Control Act, more commonly called the Clean Water Act. The goal of this act was to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (Water Environment Federation 1987, p. 9). The act and the programs it has generated have changed over the years, as experience and perceptions of water quality have changed.

The CWA has been amended 15 times, most significantly in 1977, 1981, and 1987. One of the goals of the 1977 amendment was protecting and managing waters to insure "swimmable and fishable" conditions. This goal, along with a 1972 goal to restore and maintain chemical, physical, and biological integrity, relates water quality with more than just chemistry.

## Background

The federal government, through the U.S. Environmental Protection Agency (EPA), assumed the dominant role in defining and directing water pollution control programs across the country. The Department of Environmental Quality (DEQ) implements the CWA in Idaho, while the EPA oversees Idaho and certifies the fulfillment of CWA requirements and responsibilities.

Section 303 of the CWA requires DEQ to adopt water quality standards and to review those standards every three years (EPA must approve Idaho's water quality standards). Additionally, DEQ must monitor waters to identify those not meeting water quality standards. For those waters not meeting standards, DEQ must establish a TMDL for each pollutant impairing the waters. Further, the agency must set appropriate controls to restore water quality and allow the water bodies to meet their designated uses.

These requirements result in a list of impaired waters, called the "§303(d) list." This list describes water bodies not meeting water quality standards. Waters identified on this list require further analysis. A SBA and TMDL provide a summary of the water quality status and allowable TMDL for water bodies on the §303(d) list.

The SBA section of this document (Sections 1 – 4) includes an evaluation and summary of the current water quality status, pollutant sources, and control actions in the Fernan Lake watershed to date. While this assessment is not a requirement of the TMDL, DEQ performs the assessment to ensure impairment listings are up to date and accurate. The TMDL is a plan to improve water quality by limiting pollutant loads. Specifically, a TMDL is an estimation of the maximum pollutant amount that can be present in a water body and still allow that water body to meet water quality standards (Water quality planning and management, 40 CFR Part 130). Consequently, a TMDL is water body- and pollutant-specific. The TMDL also allocates allowable discharges of individual pollutants among the various sources discharging the pollutant.

Some conditions that impair water quality do not receive TMDLs. The EPA does consider certain unnatural conditions, such as flow alteration, human-caused lack of flow, or habitat alteration, that are not the result of the discharge of a specific pollutants as "pollution." However, TMDLs are not required for water bodies impaired by pollution, but not by specific pollutants. A TMDL is only required when a pollutant can be identified and in some way quantified.

## Idaho's Role

Idaho adopts water quality standards to protect public health and welfare, enhance the quality of water, and protect biological integrity. A water quality standard defines the goals of a water body by designating the use or uses for the water, setting criteria necessary to protect those uses, and preventing degradation of water quality through antidegradation provisions.

The state may assign or designate beneficial uses for particular Idaho water bodies to support. These beneficial uses are identified in the Idaho water quality standards and include the following:

- Aquatic life support–cold water, seasonal cold water, warm water, salmonid spawning, modified
- Contact recreation–primary (swimming), secondary (boating)
- Water supply–domestic, agricultural, industrial
- Wildlife habitats
- Aesthetics

The Idaho legislature designates uses for water bodies. Industrial water supply, wildlife habitats, and aesthetics are designated beneficial uses for all water bodies in the state. If a water body is unclassified, then cold water aquatic life and primary contact recreation are used as additional default designated uses when water bodies are assessed.

A SBA entails analyzing and integrating multiple types of water body data, such as biological, physical/chemical, and landscape data to address several objectives:

- Determine the degree of designated beneficial use support of the water body (i.e., attaining or not attaining water quality standards).
- Determine the degree of achievement of biological integrity.
- Compile descriptive information about the water body, particularly the identity and location of pollutant sources.
- Determine the causes and extent of the impairment when water bodies are not attaining water quality standards.

# Physical and Biological Characteristics

Watershed characteristics relevant to pollutants impairing beneficial uses are assessed by describing physical and biological characteristics of the watershed, including a description of the climate, hydrology, and unique characteristics of the individual streams in the watershed. To evaluate the Fernan Lake watershed for sensitivity to activities that may impair beneficial uses of the water bodies, the geology, soil, vegetation, and assemblages of aquatic life are identified and described.

The terms "subbasin" and "watershed" are used throughout this section and the rest of the document to describe specific areas on the land. The term "subbasin" in our case refers to the land area that drains into the Spokane River (Figure 1). "Subbasins" are larger in area than "watersheds" and contain many "watersheds" within them. "Subbasin" is also an accounting identification used by DEQ for tracking and sorting Idaho's waters. The term "watershed" in our case refers to the land area that drains into Fernan Lake and includes Fernan Lake. The Fernan Lake watershed is one of the many watersheds within the Coeur d' Alene subbasin.

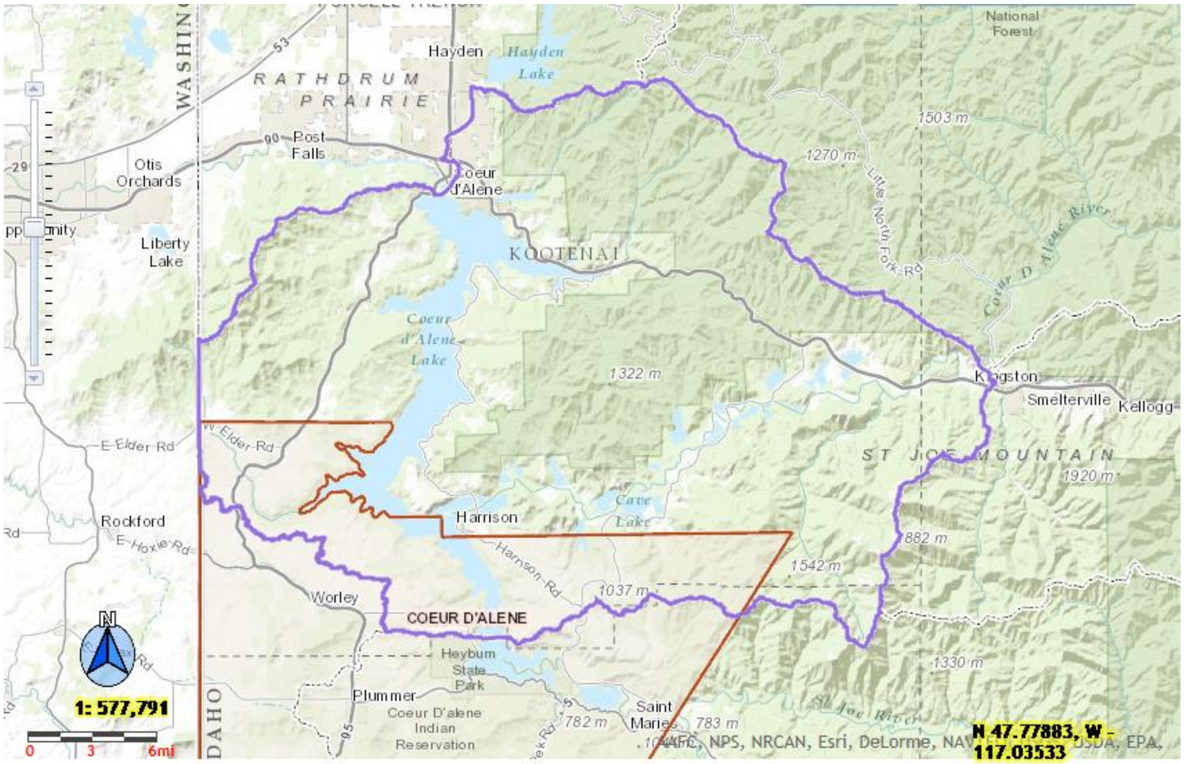



**Figure 1. Coeur d' Alene Subbasin**

## Climate

The climate in the region is characterized by relatively dry summers and cold, wet winters. Based on the US Weather Services 50-year average the average daytime temperatures in the summer range from 24 – 29 °C (75 – 85 °F). The average daytime temperatures in the winter range from 3 – 9 °C (37 – 48 °F). Average annual precipitation in the area is 74 cm (29 inches) with average seasonal snowfall of 150 cm (59 inches).

## Subbasin Characteristics

The Coeur d’Alene Lake Subbasin (hydrologic unit code [HUC] 17010303) is a 1683 km2 (650 square-mile) basin, which includes the Coeur d’Alene Lake, the Coeur d’Alene River, and the waters which drain directly to the Coeur d' Alene River and the Coeur d' Alene Lake (Figure 2). The Coeur d’Alene Lake Subbasin is located in Benewah, Kootenai and Shoshone counties of northern Idaho. A portion of the subbasin is also within the boundaries of the Coeur d’Alene Tribal Reservation. It lies within the Northern Rocky Mountain physiographic region to the west of the Bitterroot Mountains.

Because the subbasin is predominantly in the elevation range between 900 – 1400 m (3,000 – 4,500 feet), it is subject to winter “rain-on-snow” events. Such events create peaks in stream discharge that may exceed that observed during snow-melt during the spring months. In addition, the relative low elevation of the basin results in earlier maximum discharge during the period of snow-melt runoff.

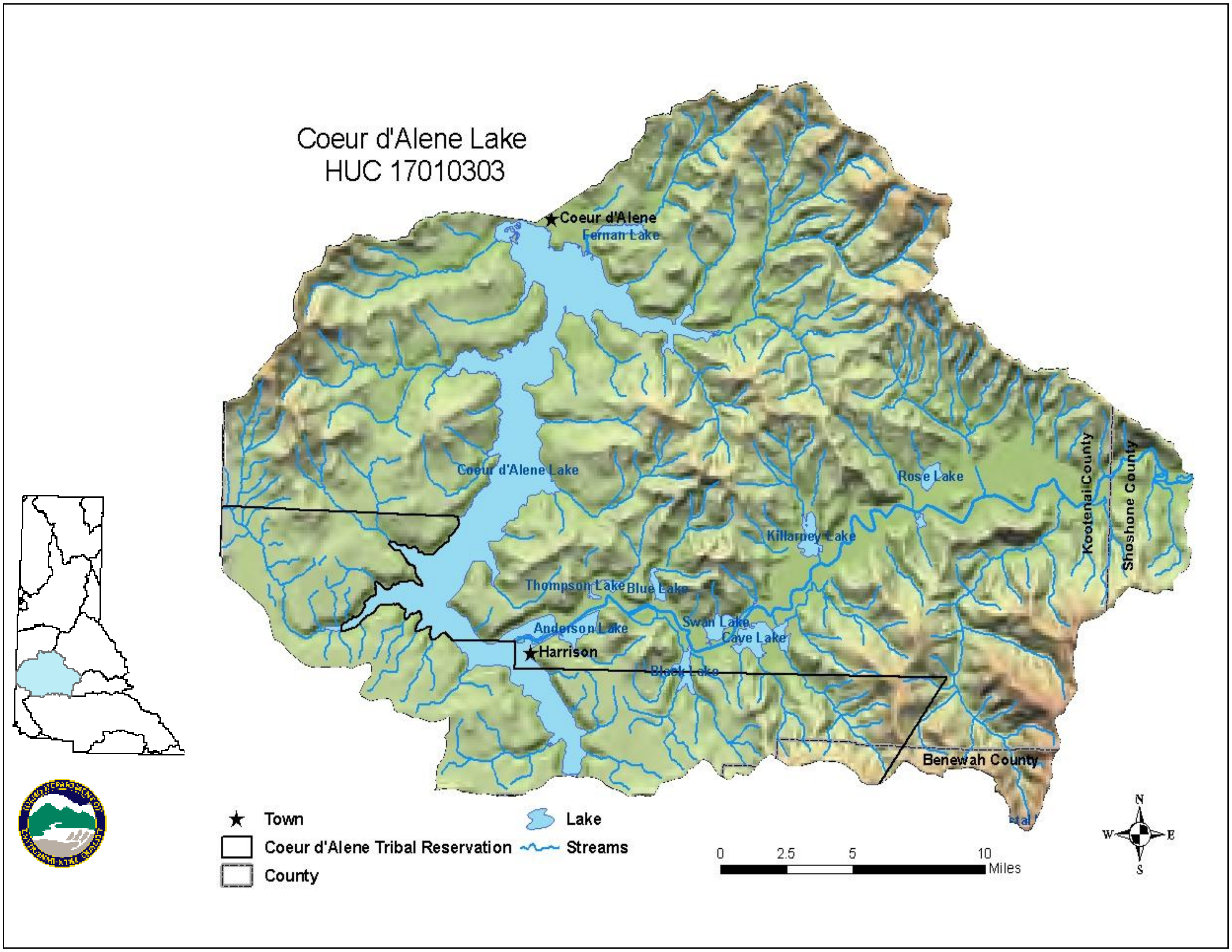
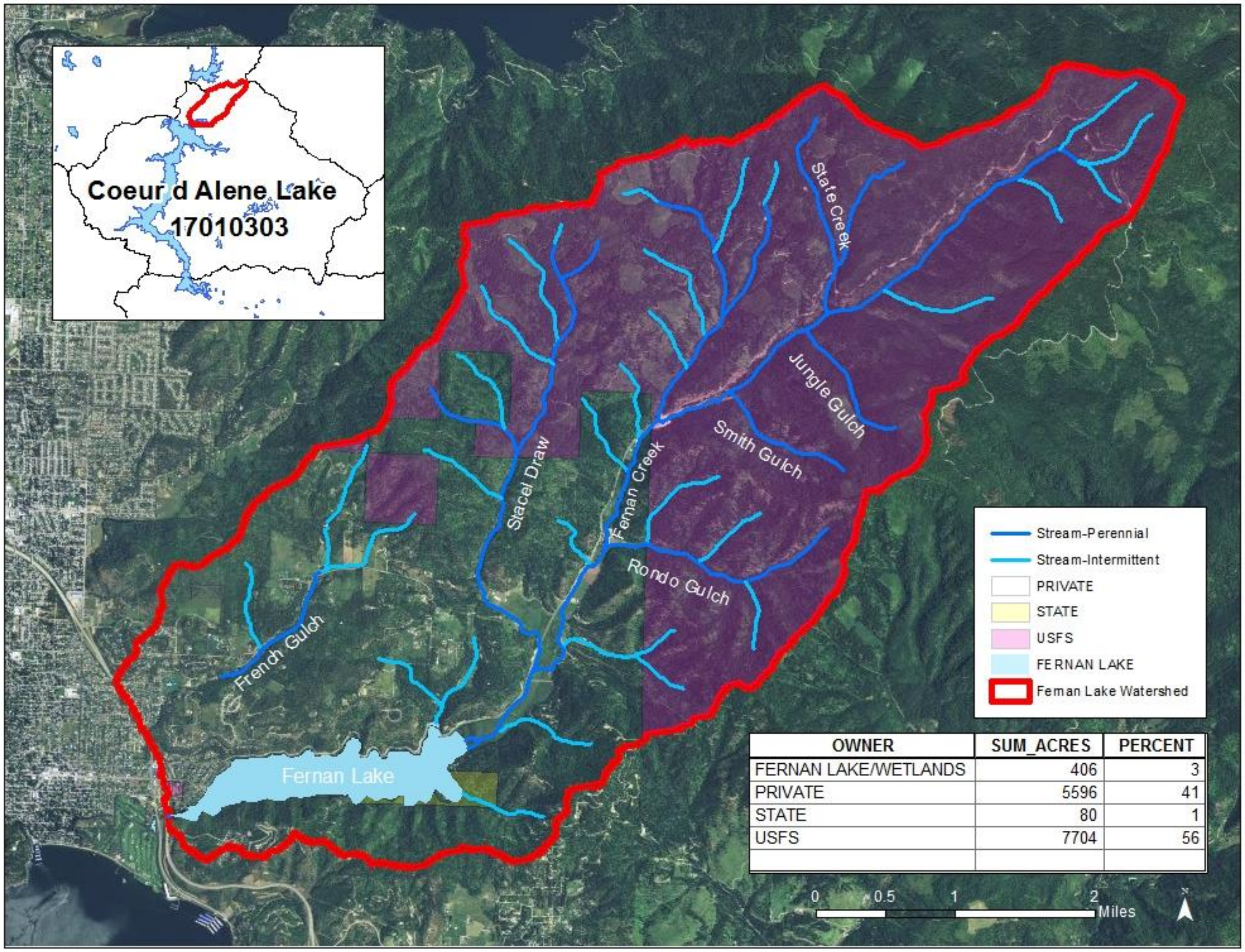



**Figure 2. Extent of Coeur d'Alene Lake Subbasin (HUC 17010303).**

## Watershed Characteristics

The Fernan Lake (Assessment Unit ID: 17010303PN33_03) is located in Kootenai County, in the Panhandle region of northern Idaho. Fernan Creek is the major intermittent water input to Fernan Lake. Fernan Creek receives perennial inflow from Stacel Creek, and intermittent flow from Dry gulch, State Creek, upper Fernan Creek, Jungle Gulch, Smith Gulch, and Rondo Gulch (Figure 3). There are no gage stations on Fernan Creek and as a result, there is a paucity of flow data available which affects historical hydrography of this tributary. To the north of Fernan Creek is an intermittent channel that drains into Fernan Creek near the mouth.




| OWNER | SUM_ACRES | PERCENT |
|---|---|---|
| FERNAN LAKE/WETLANDS | 406 | 3 |
| PRIVATE | 5596 | 41 |
| STATE | 80 | 1 |
| USFS | 7704 | 56 |
| | | |

**Figure** 3**. Map of Fernan Lake watershed.**

## Geology and Soils

While it is in close proximity to the City of Coeur d'Alene, much of the Fernan Lake watershed is covered by steep, forested mountains with typical gradients of 40 to 60 percent. Much of the watershed is comprised of Intermediate Precambrian sediments of siltite, argillite, and quartzite of the Middle Proterozoic Prichard Formation (Figure 4). This formation is about 80 percent silt and clay, 10 percent muddy graded sand, 5 percent hummocky silt association, and 5 percent quarzitic or dolomitic silt-mud microlamina association (USGS 2012). The hillslopes above the northern shore of Fernan Lake is of Miocene basalt flow. The western edge of the watershed is comprised of Pleistocene outwash fanglomerate flood and terrace gravels. This includes younger alluvial and older glacial-outwash and alluvial deposits.

Fernan Lake is one of several lakes formed in alluvial deposits of sand, gravel, cobbles, and boulders ringing the Rathdrum Prairie. As such, the lake contributes to the recharge to this sole-source aquifer.

The U.S. Department of Agriculture has identified 5 different soil types surrounding Fernan Lake. The very deep, very poorly drained *Ramsdell* silt loam is on the north and east portion of the lake. Within the vicinity of Fernan Village is the excessively-drained *McGuire-Marble* series which is volcanic ash/loess over glacial outwash. On the south side of the lake are three soil types: the moderately deep, well-drained *Huckleberry-Ardenvoir* soil, which is formed in loess and volcanic ash with material from metasedimentary origin. Also on the south side of the lake are the well-drained *McCrosket-Ardenvoir* and the *McCrosket-Tekoa* series formed from metasedimentary bedrock overlain by loess.

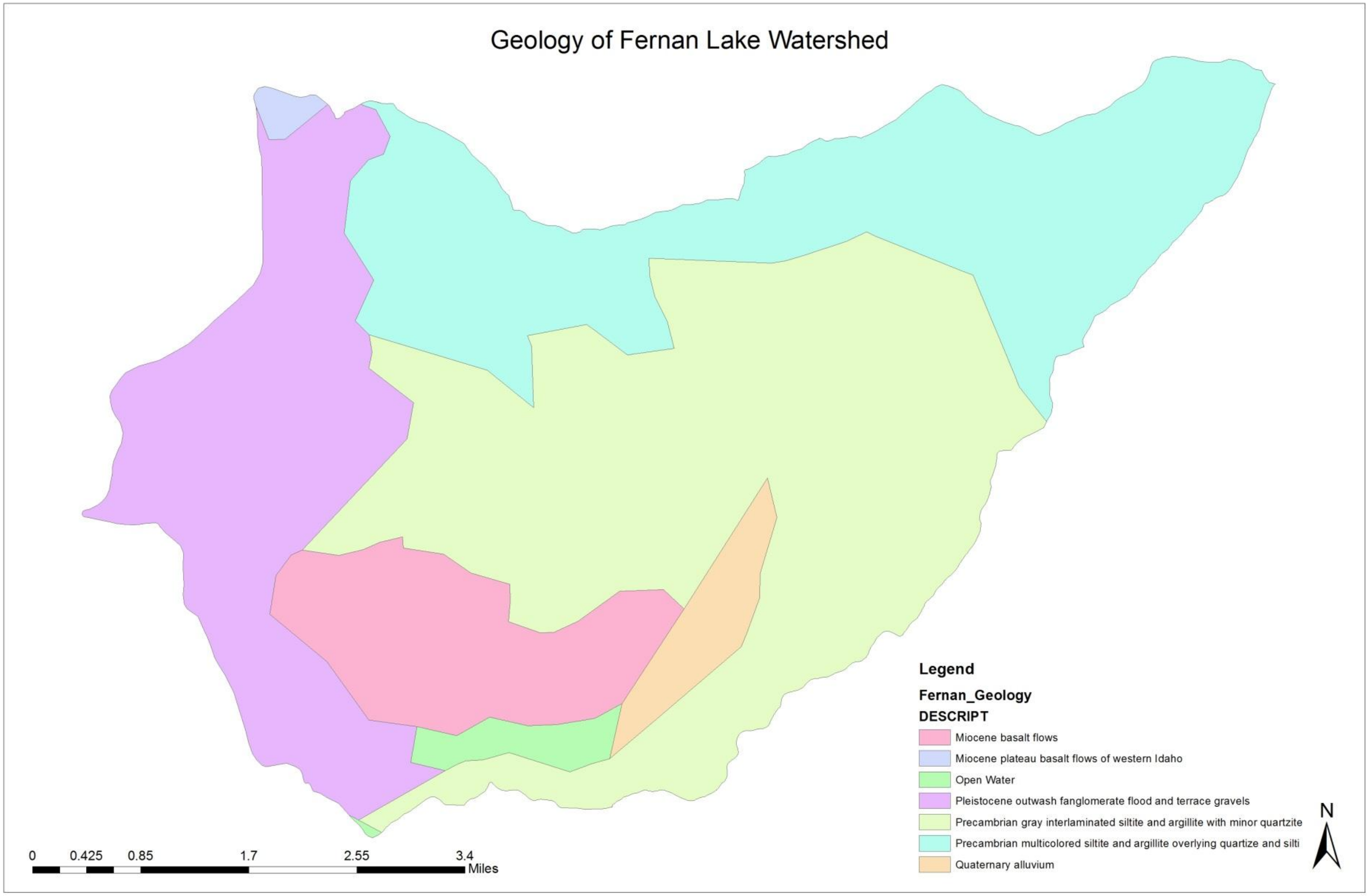



**Figure 4 Geology of the Fernan Lake watershed.**

## Lake Characteristics

Fernan Lake is a narrow lake, approximately 3.5 km (2.2 miles) long and 0.56 km (0.35 miles) wide extending west to east from the city of Coeur d'Alene. The watershed extends about 21 km (13 miles) to the northeast of the lake. Fernan Lake covers a surface area of 54 ha (381 acres). Shoreline bottom gradients are very steep on all sides of the lake except at the northwest shore near Fernan Village and the east shore at the Fernan Creek inlet. Fernan Creek is the main intermittent channel flowing into Fernan Lake. A smaller unnamed intermittent channel flows into Fernan Lake from the Northeast.

Due to the shallow depth of Fernan Lake, sufficient wind occurs almost on a diurnal basis to cause wave action resulting in mixing in the lake. While thermal stratification may occur, the duration of stratification is short-lived due to wind and wave action on this shallow lake (See section 2.4 for analysis of temperature data).

Due to the presence of Fernan Lake Village, the Fernan Lake Road, and steep hillslopes adjacent to the southern end lake, much of the shoreline of the lake does not have riparian vegetation. However, there remain well-established wetlands on the east side of the lake in the delta of Fernan Creek. There is also a smaller wetland on the west end of the lake near the outlet.

### *Bathymetry*

Falter (2001) explains in his previous study that discrepancies exist in historic Fernan Lake bathymetry data. In 2011, DEQ collected new bathymetry data to create an updated map (Figure 5). Using Spatial Analyst and 3D Analyst, a new total volume was established of 7,894,510 $m^3$ (6400 acre-feet).

### *Morphometry*

Morphometric characteristics of Fernan Lake have been determined from a number of sources (Mossier 1993, Miligan et al. 1983, and IDEQ 2001). While all agree the maximum depth of Fernan Lake is between 7.0 – 8.0 meters (23 -26 ft), Falter (2001) sites a discrepancy in mean depth across the sources. The new bathymetric data shows a mean depth of 5.1 m (16.8 feet) (Figure 5). The new bathymetry data verifies Falter's observation of the lake being mostly flat-bottomed at a depth of 6.1-6.4 meters (20-21 feet), which is different from the old bathymetric map, which indicated a gradual sloping of the lake from the shoreline. The new bathymetry data shows a maximum depth of 8.2 meters (27 feet) in a small area on the southern shore of the lake. An updated summary of morphometric characteristics is provided in Table 2.

**Table 2. Morphometric characteristics of Fernan Lake**

| MORPHOMETRY | |
|---|---|
| Elevation | 649 meters (2130 feet) |
| Area of Watershed or Drainage | 49.7 $km^2$ (19.2 $mile^2$) |
| Lake Volume | 7,894,510 $m^3$ (6400 acre-feet) |
| Surface Area | 1.5 $km^2$ (381 acres) |
| Mean Depth (volume/surface area) | 5.1 meter (16.8 feet) |
| Greatest Depth | 8.2 meter (27 feet) |

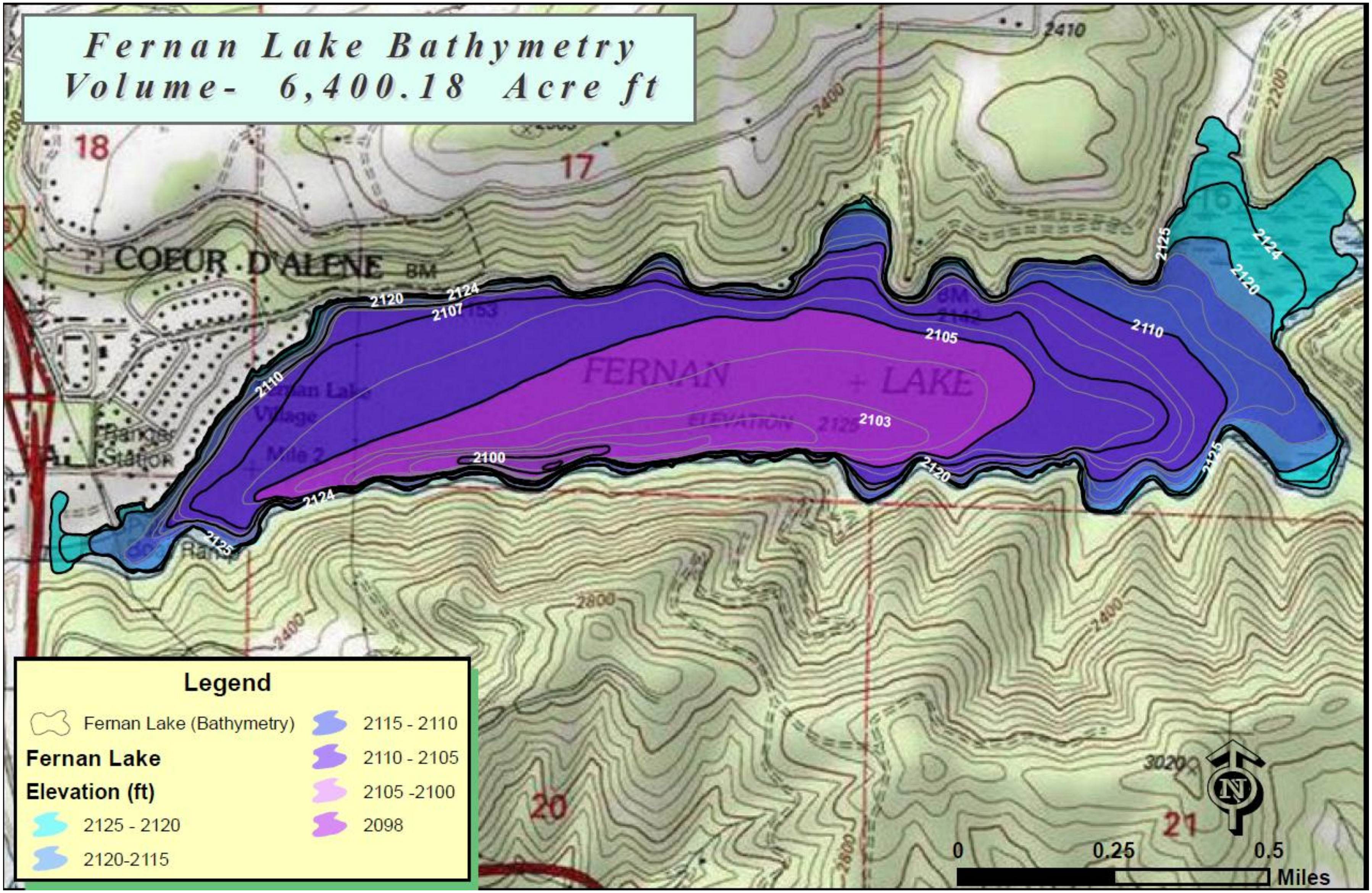



**Figure 5. Bathymetry map of Fernan Lake (created by DEQ 2012).**

### *Hydraulic Retention Time*

Hydraulic Retention Time (HRT) is the ratio of the lake's volume to annual outflow of the lake. Falter (2001) estimated a Hydraulic Retention Time (HRT) of 0.16 year using flow data collected by DEQ in 2000 and the old Bathymetric map. It was thought that a low (0.16) HRT would not support high algae production. It was also thought that the previous mean 3 meter depth was too shallow or the outflow estimate was too high for the lake productivity that was observed and that an assumed a mean depth of 6 meters was more appropriate and resulted in an estimated a HRT of 0.41 year (Falter 2001).

DEQ recalculated a new estimated the HRT of 0.32 years in Fernan Lake with the volume calculated from the new bathymetric data and flow data collected in Fernan Creek and French Gulch during 2008-2009 (DEQ 2010). Flow was measured during base flow, low flow, along the ascending limb, the peak, and descending limb of the hydrograph, and during rain-on-snow events. Flow from Fernan Creek was measured below the confluence with French Gulch which is at the outlet of Fernan Lake. Outflow from the lake was determined by subtracting flow from French Gulch from the flow in Fernan Creek. Outflow estimates are provided in Table 3.

**Table 3. Outflow estimates for Fernan Lake**

| | Number of days | Fernan Creek (below Fernan Lake) (cfs) | French Gulch (cfs) | Lake Outflow (cfs) | Lake Outflow (ft3/year) |
|---|---|---|---|---|---|
| **Rain-on-snow** | 7.0 | 69.2 | 8.4 | 60.7 | 37,000,000 |
| **Ascending limb** | 30 | 50.0 | 6.0 | 44.0 | 110,000,000 |
| **Peak flow** | 30 | 88.4 | 20.6 | 67.8 | 180,000,000 |
| **Descending limb** | 60 | 77.3 | 9.1 | 68.2 | 350,000,000 |
| **Low flow** | 60 | 34.2 | 0.0 | 34.2 | 180,000,000 |
| **Base Flow** | 178 | 0.3 | 0.0 | 0.3 | 5,000,000 |
| **Total** | | | | | 862,000,000 |

## Hydrology below Fernan Lake

Figure 6 illustrates the hydrology of Fernan Creek below the outlet of Fernan Lake. At the outlet of Fernan Lake, Fernan Creek is routed through a culvert under Interstate 90, then it immediately meets with French Gulch. French Gulch drains a portion of western Coeur d'Alene. Fernan Creek then is routed through another culvert that goes under a 4-lane road (Coeur d'Alene Lake Drive) and then meets a small-sized pond with a dam at the downstream end. This dam is used for flood control of Fernan Lake during seasonal high flows and it maintains Fernan Lake's elevation after run off. Figure 7 provides photographs of the dam during late fall when it is open and during early September when the flood gate is in place to control the elevation of Fernan Lake. The top of the dam is 5.6 feet above the elevation of Coeur d'Alene Lake at summer pool.

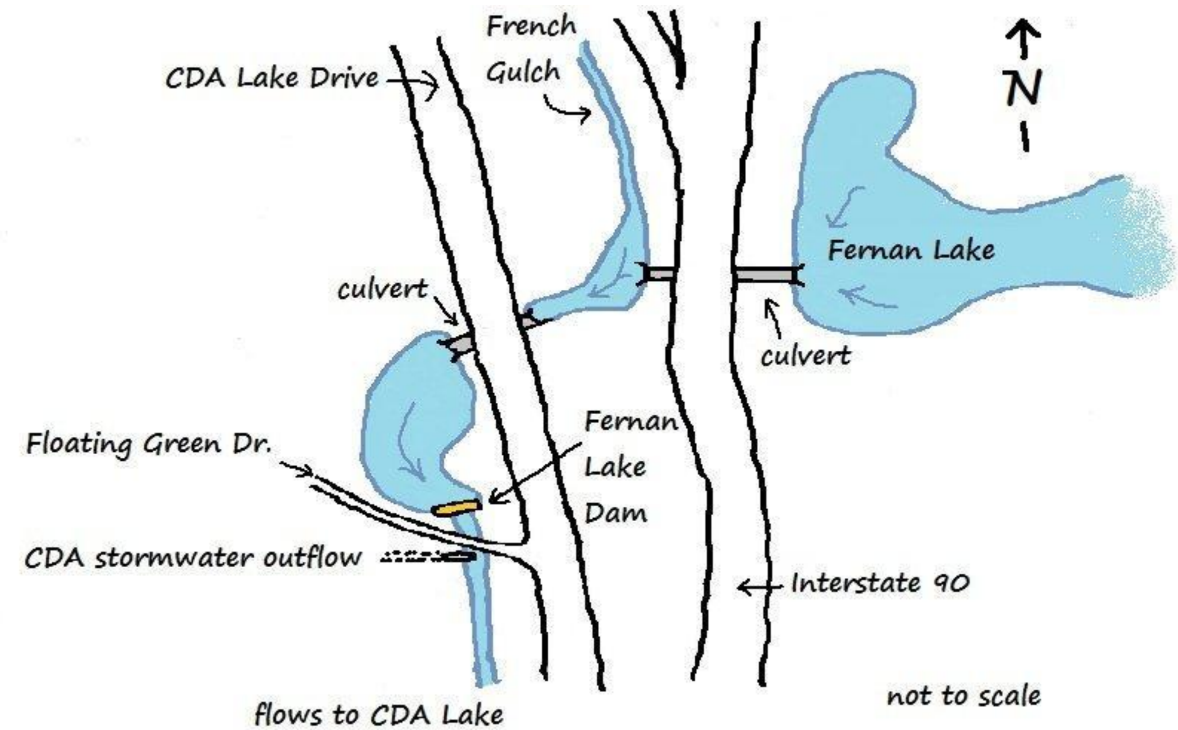



**Figure 6. Hydrology of Fernan Creek below Fernan lake**


**Figure 7. Fernan Lake Dam when flood gates are open (left) and closed (right).**

## Fisheries and Aquatic Life

Due to easy access and its close proximity to the city of Coeur d'Alene, Fernan Lake is heavily frequented by anglers and is a typical put-and-take fishery. It is managed with simple regulations to provide a consumptive fishery oriented towards family fishing (IDFG 2007). As such, the fishery is composed of: rainbow trout (*Oncorhynchus mykiss*), cutthroat trout (*Onchorhynchus clarki*), largemouth bass (*Micropterus dolomieui*), smallmouth bass (*Micropterus salmoides)*, crappie (*Pomoxis nigromaculatus*), perch (*Perca flavescens*), pumpkinseed *(Lepomis gibbosus*), bluegill (*Lepomis macrochirus*), northern pike (*Esox* *lucius*), channel catfish (*Ictalurus punctatus*), and bullhead catfish (*Ictaluras melas*). It is stocked annually with 3,000-5,000 channel catfish of catchable size, 19,000 triploid Kamloop rainbow trout of catchable size, and 5,000-7,000 westslope cutthroat trout fingerlings (IDFG 2011).

## Vegetation

Timber cover on the drier, south-facing slopes of the watershed is dominated by Ponderosa pine (*Pinus ponderosa*). North-facing slopes are dominated by Douglas fir (*Pseudostuga menziesii*). A complete list of species of trees, shrubs, herbs, and wetland species are described in detail in the draft Fernan Lake Watershed Management Plan (Fernan Lake Watershed Technical Advisory Committee 2003). There are very limited defined riparian zones around Fernan Lake; rather, the Douglas fir and Ponderosa pine communities extend down to the waterline.

Based on the presence of hydrophytic vegetation, hydric soils, and positive indicators of wetland hydrology, there are seven areas identified as wetlands around Fernan Lake and along Fernan Creek. These wetland areas and the hydrology feeding the wetlands are described in detail in the draft Fernan Lake Watershed Management Plan (Fernan Lake Watershed Technical Advisory Committee 2004).

# Cultural Characteristics

While much of the Fernan Lake watershed is undeveloped, the lake itself is on the western outskirts of the City of Coeur d'Alene. Therefore, it is a popular recreational destination for boating, fishing, and swimming.

The Fernan Lake watershed is 5,579 ha (13,786 acres) in size of which 3,118 ha (7,704 acres) (56 percent) are steep, forested mountains within the U.S. Forest Service property boundaries. The private land in the watershed is 2,265 ha (5,596 acres) (41 percent). There are 32 ha (80 acres) of state lands in the watershed, and less than 1 percent of the watershed is wetlands or "surveyed water" (Figure 8).

Much of the northern hillsides adjacent to Fernan Lake are developed as residential property. Most of the northern shoreline of Fernan Lake is developed with very low-density cabins and homes, except for Fernan Lake Village that occupies the northwest end of the lake. It is the only community in the watershed with approximately 71 homes housing a year-round population of 169 people (US Census Bureau 2010). The southern portion of the hillsides adjacent to the lake is largely undeveloped due to difficulty in access and to a Hillside Ordinance passed by the Coeur d'Alene City Council (City of Coeur d'Alene 2003). The southern shoreline is also largely undeveloped. From the mouth of Fernan Creek upstream for a few miles, is floodplain property historically used for grazing and agricultural purposes.

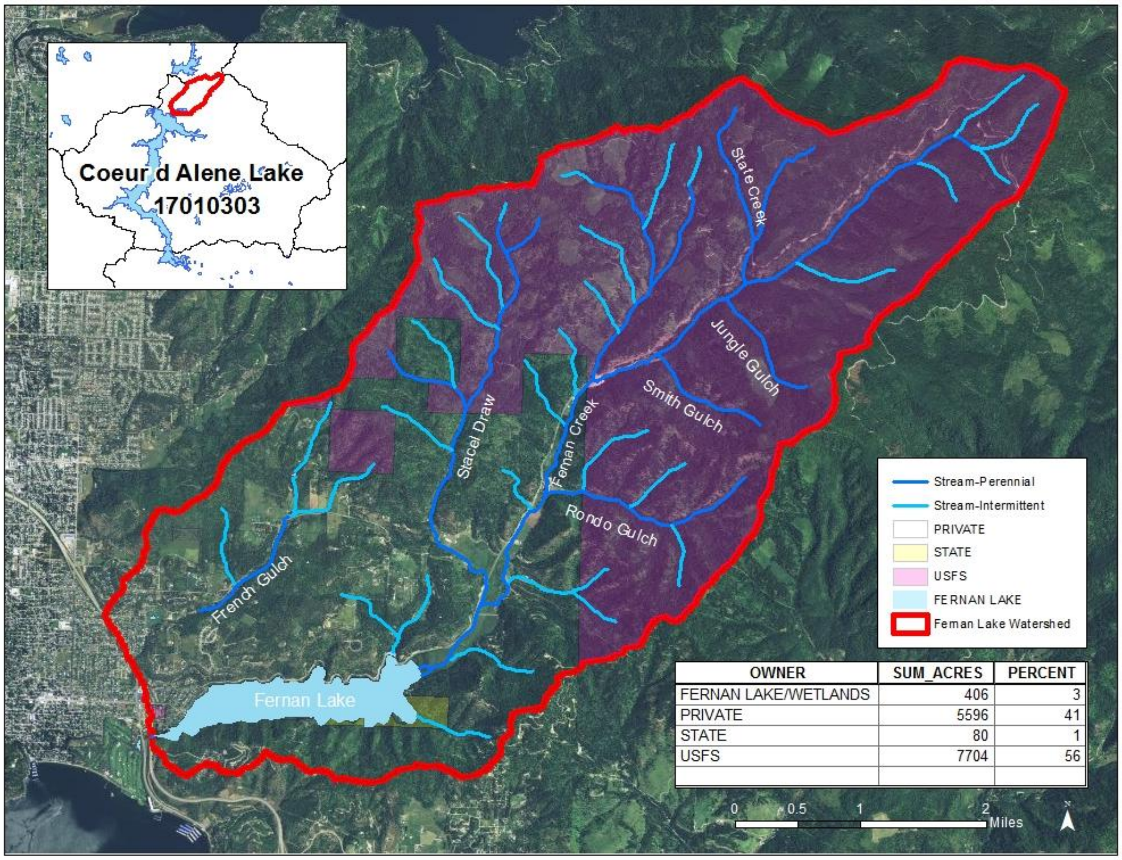



**Figure 8. Land ownership map of the Fernan Lake watershed**

The residents of Fernan Lake Village have a long history of community involvement in activities associated with the health of the Lake. The Fernan Conservation and Recreation Association is a citizen group that has taken a proactive approach to addressing issues and concerns of the lake. The mission of the Fernan Lake Conservation & Recreation Association (FLCRA) is to preserve the scenic and natural resource value of the Fernan Lake watershed and enhance its beneficial uses both public and private, utilizing sound conservational practices (Personal communication Susan Andrews, Fernan Lake Conservation and Recreation Association

# Subbasin Assessment – Water Quality Concerns and Status

Fernan Lake has a long history of blue-green algae blooms. Blue-green algae are microscopic bacteria also known as cyanobacteria. There are many species of blue-green algae. Blooms generally occur in eutrophic conditions during late summer and fall. The physical appearance of blue-green algae blooms can be unsightly, often causing thick green mats along shorelines. In addition, some species can produce toxins that may cause illness and death to animals and illness to humans (CDC 2008). These effects may impair beneficial uses such as agricultural water supply, drinking water supply, aesthetics, cold water aquatic life, and recreation. The recreation beneficial use of Primary Contact Recreation is the Beneficial Use that this Total Maximum Daily Load analysis is addressing.

## Water Quality Limited Assessment Units Occurring in the Subbasin

Section 303(d) of the CWA states that waters that are unable to support their beneficial uses and that do not meet water quality standards must be listed as water quality limited waters. Subsequently, these waters are required to have TMDLs developed to bring them into compliance with water quality standards.

### About Assessment Units

Assessment Units (AUs) now define all the waters of the state of Idaho. These units and the methodology used to describe them can be found in the WBAGII (Grafe et al 2002). Assessment units (AUs) are assigned to individual lakes and also groups of similar streams that have similar land use practices, ownership, or land management. Stream order, however, is the main basis for determining AUs—although ownership and land use can change significantly, the AU remains the same.

Using assessment units to describe water bodies offers many benefits, the primary benefit being that all the waters of the state are now defined consistently. In addition, using AUs fulfills he fundamental requirement of EPA's 305(b) report, a component of the Clean Water Act wherein states report on the condition of all the waters of the state. Because AUs are a subset of water body identification numbers, there is now a direct tie to the water quality standards for each AU, so that beneficial uses defined in the water quality standards are clearly tied to streams and lakes on the landscape.

### Listed Waters

New to the 2010 Integrated Report, Fernan Lake is listed as not supporting the recreational beneficial use due to nutrient/eutrophication resulting in annual blue-green algae blooms (Table 4).

**Table 4. §303(d) Segments in the Total Maximum Daily Load Subbasin.**

| Water Body Name | Assessment Unit ID Number | §303(d) Boundaries | Pollutants | Listing Basis |
|---|---|---|---|---|
| Fernan Lake | ID17010303PN033_03 | 2010 | Nutrient Eutrophication | Annual blue-green algae blooms |

# Applicable Water Quality Standards and Beneficial Uses

State water quality standards are established as the "yardstick" for the fishable and swimmable goal of the CWA. Water quality standards contain three key components: designated uses, water quality criteria (numeric and narrative), and an antidegradation policy. These components as defined by the Idaho Administrative Procedures Act 58 Title 01, Chapter 02 are summarized below.

## Beneficial Uses

Idaho water quality standards, defined in IDAPA 58.01.02, designate beneficial uses and set water quality goals for the waters of the state. Idaho water quality standards require that surface waters of the state be protected for *beneficial uses*, wherever attainable (IDAPA 58.01.02.050.02). These beneficial uses are interpreted as existing uses, designated uses, and presumed uses as briefly described below. The *Water Body Assessment Guidance*, second edition (Grafe et al. 2002), gives a more detailed description of beneficial use identification for use assessment purposes.

### Existing Uses

Existing uses under the CWA are "those uses actually attained in the waterbody on or after November 28, 1975, whether or not they are included in the water quality standards." The existing in-stream water uses and the level of water quality necessary to protect the uses shall be maintained and protected (IDAPA 58.01.02.050.02, .02.051.01, and .02.053). Existing uses include uses actually occurring, whether or not the level of quality to fully support the uses exists. A practical application of this concept would be to apply the existing use of salmonid spawning to water that could support salmonid spawning, but salmonid spawning is not occurring due to other factors, such as dams blocking migration.

### Designated Uses

Designated uses under the CWA are "those uses specified in water quality standards for each water body or segment, whether or not they are being attained." Designated uses are simply uses officially recognized by the state. In Idaho these include uses such as aquatic life support, recreation in and on the water, domestic water supply, and agricultural uses. Water quality must be sufficiently maintained to meet the most sensitive use. Designated uses may be added or removed using specific procedures provided for in state law, but the effect must not be to preclude protection of an existing higher-quality use such as cold water aquatic life or salmonid spawning. Designated uses are specifically listed for water bodies in Idaho in tables in the Idaho water quality standards (see IDAPA 58.01.02.003.27 and .02.109-.02.160 in addition to citations for existing uses).

Fernan Lake is listed in Idaho water quality standards as designated for the cold water aquatic life, salmonid spawning, primary contact recreation, and domestic water supply beneficial uses (Table 5).

**Table 5. Beneficial uses of Section 303(d) listed streams.**

| Water Body/Assessment Unit | Beneficial Uses[a] | Type of Use (state if designated, existing, etc.) |
|---|---|---|
| Fernan Lake ID17010303033_03 | CW, SS, PCR, DWS | Designated |

[a] CW – cold water, SS – salmonid spawning, PCR – primary contact recreation, SCR – secondary contact recreation, AWS – agricultural water supply, DWS – domestic water supply

### *Presumed Uses*

In Idaho, most water bodies listed in the tables of designated uses in the water quality standards do not yet have specific use designations. These undesignated uses are to be designated. In the interim, and absent information on existing uses, DEQ presumes that most waters in the state will support cold water aquatic life and either primary or secondary contact recreation (IDAPA 58.01.02.101.01). To protect these so-called "presumed uses," DEQ will apply the numeric cold water criteria and primary or secondary contact recreation criteria to undesignated waters. If in addition to these presumed uses, an additional existing use, (e.g., salmonid spawning) exists, because of the requirement to protect levels of water quality for existing uses, then the additional numeric criteria for salmonid spawning would additionally apply (e.g., inter-gravel dissolved oxygen, temperature). However, if for example, cold water aquatic life is not found to be an existing use, a use designation to that effect is needed before some other aquatic life criteria (such as seasonal cold) can be applied in lieu of cold water criteria (IDAPA 58.01.02.101.01).

## Criteria to Support Beneficial Uses

Beneficial uses are protected by a set of criteria, which include *narrative* criteria for pollutants such as sediment and nutrients and *numeric* criteria for pollutants such as bacteria, dissolved oxygen, pH, ammonia, temperature, and turbidity (IDAPA 58.01.02.250). Table 6 includes the most common numeric criteria used in TMDLs. Figure 7 provides an outline of the stream assessment process for determining support status of the beneficial uses of cold water aquatic life, salmonid spawning, and contact recreation.

Idaho's water quality standards do not directly address blue-green algae (cyanobacteria) or the toxins that the organisms may produce. The standards do address conditions when algae blooms impair beneficial uses (i.e. recreation, cold water aquatic life, and aesthetics). There are narrative criteria for excess nutrients: "Surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses (IDAPA 58.01.02.200.06)." There are also narrative criteria for floating, suspended or submerged matter: "Surface waters of the state shall be free from floating, suspended, or submerged matter of any kind in concentrations causing nuisance or objectionable conditions or that may impair designated beneficial uses (IDAPA 58.01.02.200.05)." Regarding toxic substances, Idaho code (IDAPA 58.01.02.200.02) states "surface waters of the state shall be free from toxic substances in concentrations that impair designated beneficial uses." Determination of nuisance algae blooms and narrative criteria exceedances are described in the Waterbody Assessment Guidance, Second Edition (Grafe, et al. January 2002). Section 5 specifically addresses the IDEQ narrative criteria evaluation policy.

DEQ's procedure to determine whether a water body fully supports designated and existing beneficial uses is outlined in IDAPA 58.01.02.053. The procedure relies heavily upon biological parameters and is presented in detail in the Water Body Assessment Guidance (Grafe et al. 2002). This guidance requires the use of the most complete data available to make beneficial use support status determinations.

Table 4 includes the most common numeric criteria used in TMDLs. Figure 9 provides an outline of the stream assessment process for determining support status of the beneficial uses of cold water aquatic life, salmonid spawning, and contact recreation.

**Table 6. Selected numeric criteria supportive of designated beneficial uses in Idaho water quality standards.**

| Designated and Existing Beneficial Uses | | | | |
|---|---|---|---|---|
| **Water Quality Parameter** | **Primary Contact Recreation** | **Secondary Contact Recreation** | **Cold Water Aquatic Life** | **Salmonid Spawning (During Spawning and Incubation Periods for Inhabiting Species)** |
| **Water Quality Standards: IDAPA 58.01.02.250** | | | | |
| **Bacteria, ph, and Dissolved Oxygen** | Less than 126 *E. coli*/100 ml[a] as a geometric mean of five samples over 30 days; no sample greater than 406 *E. coli* organisms/100 ml | Less than 126 *E. coli*/100 ml as a geometric mean of five samples over 30 days; no sample greater than 576 *E. coli*/100 ml | pH between 6.5 and 9.0<br>DO[b] exceeds 6.0 mg/L[c]<br>The standard does not apply a) for the bottom 20 percent of lakes or reservoirs less than 35 meters in depth, b)the bottom 7 meters of lakes and reservoirs greater than 35 meters in depth, and c) the hypolimnion of a stratified lake or reservoir . | pH between 6.5 and 9.5<br>Water Column DO: DO exceeds 6.0 mg/L in water column or 90% saturation, whichever is greater<br>Intergravel DO: DO exceeds 5.0 mg/L for a one day minimum and exceeds 6.0 mg/L for a seven day average |
| **Temperature[d]** | | | 22 °C or less daily maximum; 19 □°C or less daily average | 13 °C or less daily maximum; 9 °C or less daily average<br>Bull trout: not to exceed 13 °C maximum weekly maximum temperature over warmest 7-day period, June – August; not to exceed 9 °C daily average in September and October |
| | | | Seasonal Cold Water: Between summer solstice and autumn equinox: 26 °C or less daily maximum; 23 °C or less daily average | |
| **Turbidity** | | | Turbidity shall not exceed background by more than 50 NTU[e] instantaneously or more than 25 NTU for more than 10 consecutive days. | |
| **Ammonia** | | | Ammonia not to exceed calculated concentration based on pH and temperature. | |
| **EPA Bull Trout Temperature Criteria: Water Quality Standards for Idaho, 40 CFR Part 131** | | | | |
| **Temperature** | | | | 7 day moving average of 10 °C or less maximum daily temperature for June - September |

[a] *Escherichia coli* per 100 milliliters
[b] dissolved oxygen
[c] milligrams per liter
[d] Temperature Exemption - Exceeding the temperature criteria will not be considered a water quality standard violation when the air temperature exceeds the ninetieth percentile of the seven-day average daily maximum air temperature calculated in yearly series over the historic record measured at the nearest weather reporting station.
[e] Nephelometric turbidity units

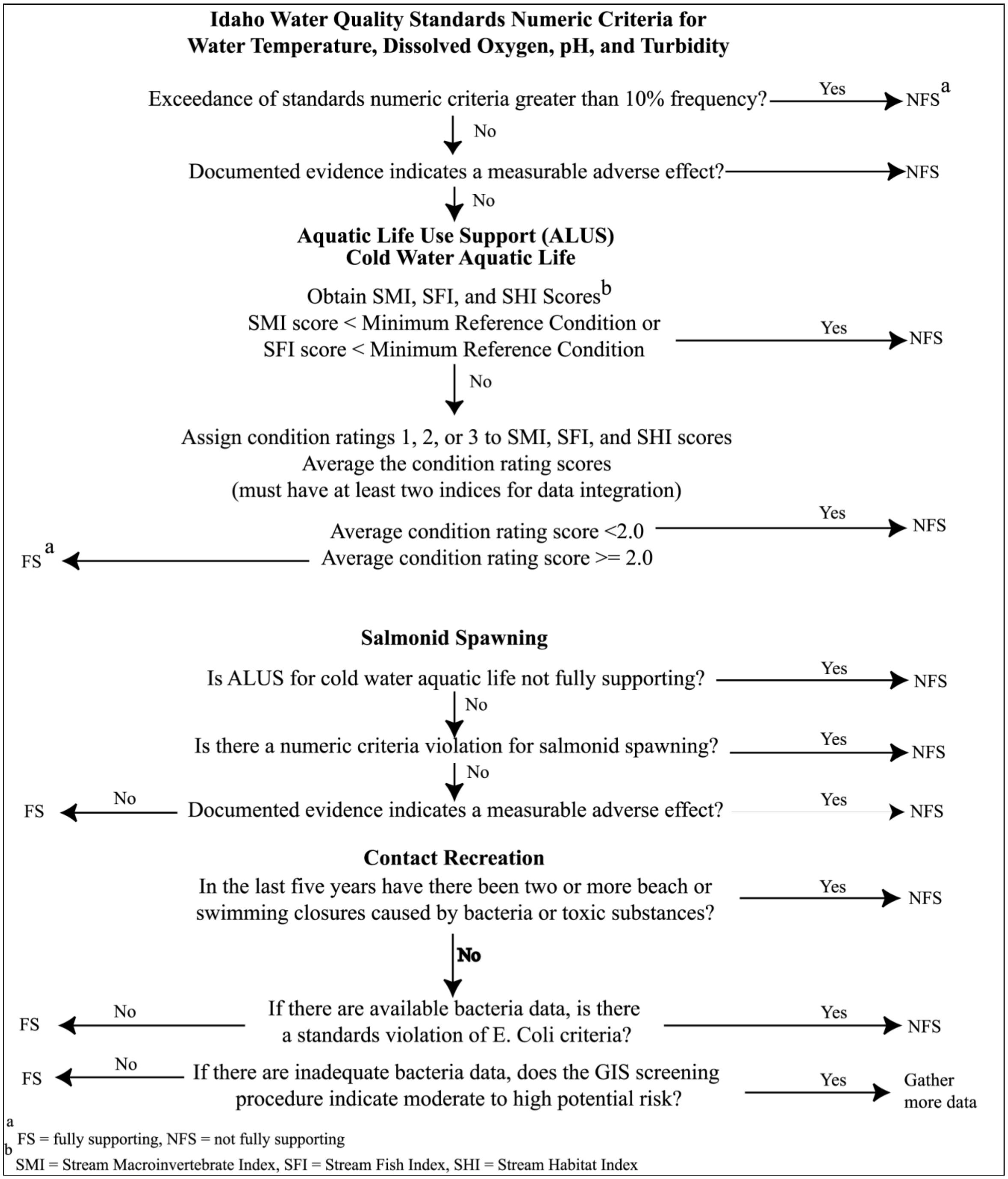



**Figure 9 Determination Steps and Criteria for Determining Support Status of Beneficial Uses in Wadeable Streams: Water Body Assessment Guidance, Second Addition (Grafe et al. 2002)**

# Pollutant/Beneficial Use Support Status Relationships

Most of the pollutants that impair beneficial uses in lakes are due to land/water disturbances caused by humans. The most common pollutants in northern Idaho lakes are dissolved oxygen, sediment, nutrients, and floating, suspended, or submerged matter (nuisance algae).

## Dissolved Oxygen

Oxygen is necessary for the survival of most aquatic organisms and essential to stream or lake purification. Dissolved oxygen (DO) is the concentration of free (not chemically combined) molecular oxygen (a gas) dissolved in water, usually expressed in milligrams per liter (mg/L), parts per million, or percent of saturation. While air contains approximately 20.9 percent oxygen gas by volume, the proportion of oxygen dissolved in water is about 35 percent, because nitrogen (the remainder) is less soluble in water. Oxygen is considered to be moderately soluble in water. A complex set of physical conditions that include atmospheric and hydrostatic pressure, turbulence, temperature, and salinity affect the solubility.

Dissolved oxygen levels of 6 mg/L and above are considered optimal for aquatic life. When DO levels fall below 6 mg/L, organisms are stressed, and if levels fall below 3 mg/L for a prolonged period, these organisms may die; oxygen levels that remain below 1-2 mg/L for a few hours can result in large fish kills. Dissolved oxygen levels below 1 mg/L are often referred to as hypoxic; anoxic conditions refer to those situations where there is no measurable DO.  Juvenile aquatic organisms are particularly susceptible to the effects of low DO due to their high metabolism and low mobility (they are unable to seek more oxygenated water).

Dissolved oxygen reflects the health or the balance of the aquatic ecosystem.  Oxygen is produced during photosynthesis and consumed during plant and animal respiration and decomposition. Oxygen enters water from photosynthesis and from the atmosphere. Where water is more turbulent (e.g., riffles, cascades), the oxygen exchange is greater due to the greater surface area of water coming into contact with air. The process of oxygen entering the water is called aeration.

Water bodies with significant aquatic plant communities can have significant DO fluctuations throughout the day. An oxygen sag will typically occur once photosynthesis stops at night and respiration/decomposition processes deplete DO concentrations in the water. Oxygen will start to increase again as photosynthesis resumes with the advent of daylight.

Temperature, flow, nutrient loading, and channel alteration all impact the amount of DO in the water. Colder waters hold more DO than warmer waters. Oxygen is necessary to help decompose organic matter in the water and bottom sediments. Nutrient enriched waters have a higher biochemical oxygen demand due to the amount of oxygen required for organic matter decomposition and other chemical reactions. This oxygen demand can result in lower lake DO levels.

## Sediment

Both suspended (floating in the water column) and lake bed sediment can have negative effects on aquatic life communities. Many fish species can tolerate elevated suspended sediment levels for short periods of time, such as during natural spring runoff, but longer durations of exposure are detrimental. Elevated suspended sediment levels can interfere with feeding behavior (difficulty finding food due to visual impairment), damage gills, reduce growth rates, and in extreme cases eventually lead to death.

Newcombe and Jensen (1996) reported the effects of suspended sediment on fish, summarizing 80 published reports on streams and estuaries. For rainbow trout, physiological stress, which includes reduced feeding rate, is evident at suspended sediment concentrations of 50 to 100 mg/L when those concentrations are maintained for 14 to 60 days. Similar effects are observed for other species, although the data sets are less reliable. Adverse effects on habitat, especially spawning and rearing habitat presumably from sediment deposition, were noted at similar concentrations of suspended sediment. Organic suspended materials can also settle to the bottom and, due to their high carbon content, diminish DO through decomposition.

## Nutrients

While nutrients are a natural component of the aquatic ecosystem, natural cycles can be disrupted by increased nutrient inputs from anthropogenic activities. Excess nutrients result in accelerated plant growth and can result in a eutrophic or enriched system.

The first step in identifying a water body's response to nutrient flux is to define which of the critical nutrients is limiting. A limiting nutrient is one that normally is in short supply relative to biological needs. The relative quantity affects the rate of production of aquatic biomass. Either phosphorus or nitrogen may be the limiting factor for algal growth, although phosphorous is most commonly the limiting nutrient in Idaho waters. Ecologically speaking, a resource is considered limiting if the addition of that resource increases growth.

Total phosphorus is the measurement of all forms of phosphorus in a water sample, including all inorganic and organic particulate and soluble forms. In freshwater systems, typically greater than 90 percent of the total phosphorus present occurs in organic forms as cellular constituents in the biota or adsorbed to particulate materials (Wetzel 1983). The remainder of phosphorus is mainly soluble orthophosphate, a more biologically available form of phosphorus than total phosphorus that consequently leads to a more rapid growth of algae. In impaired systems, a larger percentage of the total phosphorus fraction is comprised of orthophosphate. The relative amount of each form measured can provide information on the potential for algal growth within the system.

Nitrogen may be a limiting factor at certain times if there is substantial depletion of nitrogen in sediments due to uptake by rooted macrophyte beds. In systems dominated by blue-green algae, nitrogen is not a limiting nutrient due to the algal ability to fix nitrogen at the water/air interface. This ability gives them a competitive advantage over phytoplankton that cannot fix nitrogen when water nitrogen concentrations are low.

Total nitrogen to total phosphorus ratios greater than seven are indicative of a phosphorus-limited system while those ratios less than seven are indicative of a nitrogen-limited system.

Only biologically available forms of the nutrients are used in the ratios because these are the forms that are used by the immediate aquatic community.

Nutrients primarily cycle between the water column and sediment through nutrient spiraling. Aquatic plants rapidly assimilate dissolved nutrients, particularly orthophosphate. If sufficient nutrients are available in either the sediments or the water column, aquatic plants will store an abundance of such nutrients in excess of the plants' actual needs, a chemical phenomenon known as luxury consumption. When a plant dies, the tissue decays in the water column and the nutrients stored within the plant biomass are either restored to the water column or the detritus becomes incorporated into the lakebed sediment. As a result of this process, nutrients (including orthophosphate) that are initially released into the water column in a dissolved form will eventually become incorporated into the lakebed sediment. Once these nutrients are incorporated into the lakebed sediment, they are available once again for uptake by yet another life cycle of rooted aquatic macrophytes and other aquatic plants. This cycle is known as nutrient spiraling. Nutrient spiraling results in the availability of nutrients for later plant growth in higher concentrations downstream.

## Sediment – Nutrient Relationship

The linkage between sediment and sediment-bound nutrients is important when dealing with nutrient enrichment problems in aquatic systems.

It is well understood that phosphorus adsorbs to soil through precipitation as calcium carbonate in calcareous soils or through phosphorus sorption by aluminum and iron-oxide minerals. HDR (2007) prepared a good literature review of fate and transport of phosphorus in soils, soil sorption isotherms, and fate and transport of phosphorus in groundwater. Soil sorption modeling has proven soils have a finite capacity for sorption of phosphorus, with tremendous variability depending on soil type. Soils with a low percentage of calcium carbonate and/or clay particles have a lower affinity to adsorb phosphorus (HDR 2007). Regardless of the soil type, the primary form of phosphorus in soil and runoff is total phosphorus, not dissolved phosphorus because it is bound to soil.

Because phosphorus is primarily bound to particulate matter in aquatic systems, sediment can be a major source of phosphorus to rooted macrophytes and the water column. While most aquatic plants are able to absorb nutrients over the entire plant surface due to a thin cuticle (Denny 1980), bottom sediments serve as the primary nutrient source for most sub-stratum attached macrophytes. The USDA (1999) determined that other than harvesting and chemical treatment, the best and most efficient method of controlling growth is by reducing surface erosion and sedimentation.

Sediment acts as a nutrient sink under aerobic conditions. However, when conditions become anoxic, sediment releases phosphorous into the water column. Nitrogen can also be released, but the mechanism by which it happens is different. The exchange of nitrogen between sediment and the water column is for the most part a microbial process controlled by the amount of oxygen in the sediment. When conditions become anaerobic, the oxygenation of ammonia (nitrification) ceases and an abundance of ammonia is produced. This results in a loss of nitrogen oxide ($NO_x$) to the atmosphere.

Sediment can play an integral role in reducing the frequency and duration of phytoplankton blooms in lakes and rivers. In many cases there is an immediate response in phytoplankton biomass when external sources are reduced. In other cases, the response time is slower, often taking years. Nonetheless, the relationship is important and must be addressed in waters where phytoplankton is in excess.

## Floating, Suspended, or Submerged Matter (Nuisance Algae)

Algae are an important part of the aquatic food chain. However, when elevated levels of algae impact beneficial uses, the algae are considered a nuisance aquatic growth. The excess growth of phytoplankton, periphyton, and/or macrophytes can adversely affect both aquatic life and recreational water uses. Algal blooms occur where adequate nutrients (nitrogen and/or phosphorus) are available to support growth. In addition to nutrient availability, flow rates, velocities, water temperatures, and penetration of sunlight in the water column all affect algae (and macrophyte) growth. Low velocity conditions allow algal concentrations to increase because physical removal by scouring and abrasion does not readily occur. Increases in temperature and sunlight penetration also result in increased algal growth. When the aforementioned conditions are appropriate and nutrient concentrations exceed the quantities needed to support normal algal growth, excessive blooms may develop.

Water bodies with high nutrient concentrations that could potentially lead to a high level of algal growth are said to be eutrophic. The extent of the effect is dependent on both the type(s) of algae present and the size, extent, and timing of the bloom. Nuisance algae blooms appear as extensive layers or algal mats on the surface of the water; they also often create objectionable odors and coloration in water used for domestic drinking water; in extreme cases, algal blooms can also result in impairment of recreational water supplies uses due to toxicity.

Blue-green algae, or cyanobacteria, are naturally occurring in surface waters. However, because of their ability to fix nitrogen, they have a competitive advantage over phytoplankton that cannot fix nitrogen when water nitrogen concentrations are low. In eutrophic conditions, blue-green algae blooms appear in late summer and fall, and in high concentrations can be considered a nuisance. The physical appearance of blue-green algae blooms can be unsightly, often causing thick green mats along shorelines. In addition, some species can produce toxins (cyanotoxins) that may cause illness and death to animals or humans. The primary target organs for cyanotoxins are the liver and nervous system, but other health effects do occur.

In lakes, algae die, and they sink slowly through the water column, eventually collecting on the bottom sediments. The biochemical processes that occur as the algae decompose remove oxygen from the surrounding water. Because most of the decomposition occurs within the lower levels of the water column, a large algal bloom can substantially deplete DO concentrations near the bottom. Low DO in these areas can lead to decreased fish habitat as fish will not frequent areas with low DO. Both living and dead (decomposing) algae can also affect the pH of the water due to the release of various acid and base compounds during respiration and photosynthesis. Additionally, low DO levels caused by decomposing organic matter can lead to changes in water chemistry and a release of sorbed phosphorus to the water column at the water/sediment interface.

Excess nutrient loading can be a water quality problem due to the direct relationship of high total phosphorus concentrations on excess algal growth within the water column, combined with the direct effect of the algal life cycle on DO and pH within aquatic systems. Therefore, the reduction of total phosphorus inputs to the system can act as a mechanism for water quality improvements, particularly in surface-water systems dominated by blue-green algae. Phosphorus management within these systems can potentially result in improvement in nutrients (phosphorus), nuisance algae, DO, and pH.

# Summary and Analysis of Existing Water Quality Data

Data are available to support development of the total phosphorus TMDL for Fernan Lake. Data used to support this report are derived from a series of historical reports and recent targeted water quality monitoring conducted by the Citizen's Volunteer Monitoring Program on Fernan Lake.

## Inflowing Stream Hydrology

Fernan Creek is the main tributary that flows into Fernan Lake. To the north of Fernan Creek is an unnamed intermittent channel that drains into Fernan Creek near the mouth. There are no gage stations on Fernan Creek and as a result, insufficient flow data are available to display a long-term historical hydrograph of this tributary. However, from December 1999 to December 2000 DEQ conducted a water budget analysis of water flowing into and out of Fernan Lake. During those years, stream flow and stage height in Fernan Creek was monitored. Continuous stage data was regressed with flow to synthesize a stream hydrograph for the whole year (Figure 10). Typical of stream hydrographs in the Idaho Panhandle region, the highest streamflow on Fernan Creek is in the form of runoff from spring snowmelt and from rain-on-snow events occurring from November to February. Base flow on Fernan Creek is less than 1 cfs. From these data, it was estimated that 79 percent of inflowing water to Fernan Lake is from Fernan Creek, 12 percent from other un-gaged surface water, and 9 percent from precipitation (Falter 2001).

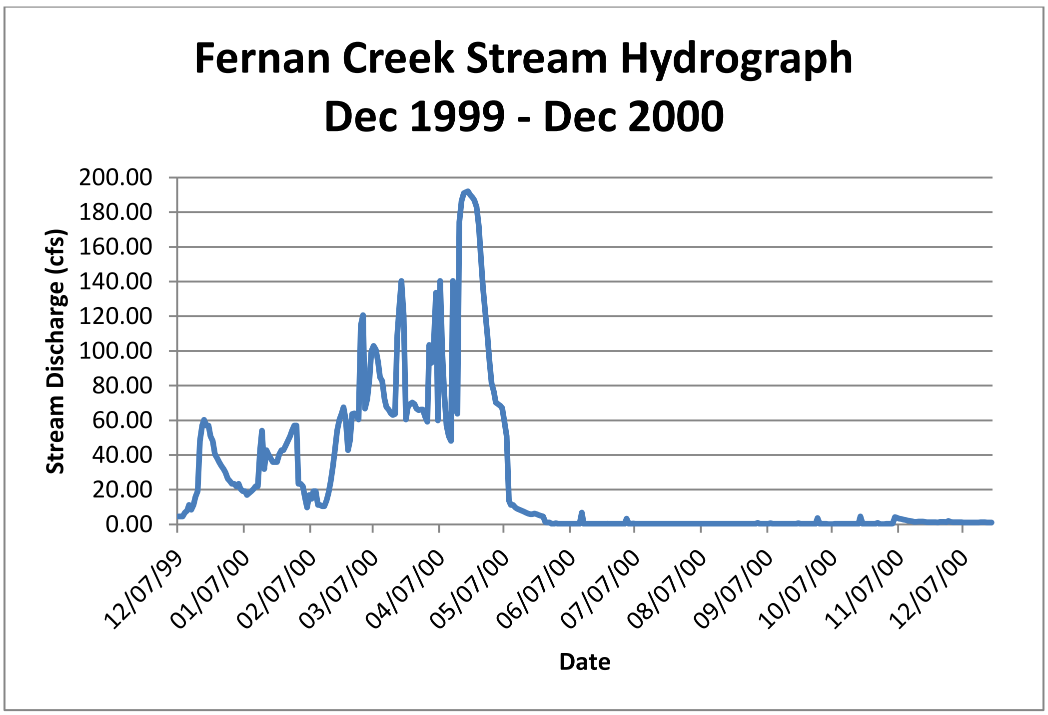



**Figure 10. Stream hydrograph of Fernan Creek, December 1999 – December 2000.**

## Water Column Data

### *Temperature*

The data for existing and available temperature measurements for Fernan Lake is summarized in Table 7. Temperature profile data, where temperatures are measured at different depths during a single monitoring event, are provided in Appendix C. The data were evaluated to better understand the frequency and duration of thermal stratification on Fernan Lake. Thermal stratification is defined as the condition where there is a rapid temperature drop (at least 3 degrees Celsius) with depth such that two layers of different temperature water exist, and mixing with overlying water is inhibited. As described in Table 8, stratification was not observed very often in Fernan Lake; therefore, it is safe to assume that when thermal stratification occurs it is short lived. This stratification scenario is typical of shallow, north Idaho lakes where wind and wave mixing lake water.

**Table 7. Temperature data for Fernan Lake (From "Deep" monitoring station)**

| Date | Data Source | Water Temperature (°C) at Depth (meters) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 5/22/1990 | [1]LWQA | | 15.5 | 15.0 | 14.0 | 13.7 | 13.4 | 13.2 | |
| 6/26/1990 | LWQA | | 22.7 | 22.6 | 21.5 | 18.0 | 15.4 | 14.8 | 14.6 |
| 8/8/1990 | LWQA | | 24.2 | 24.1 | 23.5 | 23.4 | 23.1 | 22.0 | 20.4 |
| 9/17/1990 | LWQA | | 20.3 | 19.4 | 19.0 | 18.8 | 18.8 | 18.8 | |
| 10/30/1990 | LWQA | | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | |
| 7/24/1991 | LWQA | 24.6 | 24.5 | 24.5 | 24.5 | 22.2 | | | |
| 6/24/2003 | [2]Isaacson | | 19.5 | 19.5 | 18.3 | 18.3 | 18.4 | 18.3 | |
| 7/1/2003 | Isaacson | 22.1 | 22.0 | 21.8 | 21.3 | 21.0 | 20.1 | 19.5 | 19.5 |
| 7/21/2003 | Isaacson | 25.2 | 24.9 | 24.0 | 23.4 | 23.3 | 23.1 | 23.0 | 22.7 |
| 7/29/2003 | Isaacson | 26.1 | 25.1 | 23.9 | 23.8 | 23.8 | 23.7 | 23.7 | 23.7 |
| 8/7/2003 | Isaacson | 24.4 | 24.4 | 24.3 | 23.6 | 23.6 | 23.5 | 23.4 | 23.3 |
| 8/19/2003 | Isaacson | 24.1 | 24.0 | 23.4 | 23.4 | 22.7 | 22.7 | 22.7 | 22.7 |
| 8/27/2003 | Isaacson | 22.7 | 21.5 | 23.4 | 20.8 | 20.7 | 20.7 | 20.7 | 20.7 |
| 9/4/2003 | Isaacson | 22.1 | 21.7 | 21.2 | 20.6 | 20.6 | 20.6 | 20.6 | 20.5 |
| 9/15/2003 | Isaacson | 18.2 | 28.1 | 28.1 | 17.8 | 17.3 | 17.3 | 17.3 | 17.3 |
| 5/9/2005 | [3]CVMP | 15.5 | 15.5 | 15.3 | 15.2 | 14.6 | 14.1 | 12.5 | 12.3 |
| 6/6/2005 | CVMP | 17.5 | 17.3 | 17.2 | 17.0 | 16.9 | 16.9 | 16.9 | 16.9 |
| 5/11/2006 | CVMP | 14.0 | 13.9 | 13.4 | 13.2 | 13.1 | 13.0 | 13.0 | 12.8 |
| 4/16/2007 | CVMP | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 9.3 | 9.1 | 9.0 |
| 5/14/2007 | CVMP | 17.0 | 16.3 | 16.0 | 15.0 | 14.7 | 14.6 | 14.2 | 13.2 |
| 7/16/2007 | CVMP | 25.5 | 25.3 | 24.7 | 24.5 | 24.4 | 23.8 | 22.2 | 22.0 |
| 9/18/2007 | CVMP | 18.0 | 18.0 | 18.0 | 17.8 | 17.6 | 17.6 | 17.6 | 17.6 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 5/30/2008 | CVMP | 17.1 | 16.8 | 16.6 | 16.6 | 14.7 | 11.8 | 11.8 | 11.8 |
| 6/30/2008 | CVMP | 24.4 | 23.4 | 22.4 | 21.7 | 19.2 | 16.5 | 15.2 | 14.9 |
| 8/28/2008 | CVMP | 19.2 | 19.1 | 19.0 | 18.0 | 17.8 | 17.8 | 17.8 | 17.8 |
| 9/8/2008 | CVMP | 19.3 | 18.9 | 18.3 | 18.0 | 17.9 | 17.8 | 17.7 | 17.7 |
| 9/9/2008 | CVMP | 17.7 | 17.7 | 17.7 | 17.8 | 17.8 | 17.8 | 17.8 | 17.8 |
| 9/30/2008 | CVMP | 16.9 | 16.3 | 16.2 | 15.6 | 15.5 | 15.5 | 15.3 | 15.3 |
| 10/21/2008 | CVMP | 10.3 | 10.4 | 10.4 | 10.4 | 10.4 | 10.4 | 10.4 | 10.4 |
| 1/28/2009 | CVMP | 0.6 | 2.1 | 2.3 | 2.4 | 2.6 | 3.1 | 3.7 | 4.4 |
| 6/5/2010 | CVMP | 15.9 | 15.9 | 15.8 | 15.7 | 15.5 | 15.1 | 14.8 | |
| 8/8/2011 | CVMP | 24.4 | 24.1 | 22.1 | 22.1 | 22.0 | 21.8 | 20.8 | 20.7 |
| 8/29/2011 | CVMP | 22.7 | 22.7 | 22.7 | 22.6 | 22.5 | 22.2 | 20.5 | 20.4 |
| 5/17/2011 | CVMP | 16.8 | 16.8 | 16.1 | 16.1 | 16.1 | 14.8 | 12.5 | 12.4 |
| 7/5/2012 | CVMP | 22.9 | 20.9 | 19.5 | 19.2 | 18.0 | 16.5 | 16.0 | 16.0 |
| 7/19/2012 | CVMP | 27.8 | 26.5 | 25.4 | 24.1 | 19.4 | 18.2 | 17.1 | 16.4 |
| 7/20/2012 | CVMP | 25.2 | 25.2 | 25.2 | 24.9 | 19.4 | 17.4 | 16.6 | 16.5 |
| 8/30/2012 | CVMP | 20.7 | 20.6 | 20.5 | 20.4 | 20.4 | 20.4 | 20.4 | 20.2 |

[1]LWQA = 1991 DEQ Lake Water Quality Assessment program (Mossier 1993).
[2]Isaacson = subcontracted monitoring work done by Allen Isaacson (FLCRA 2003).
[3]CVMP = Citizen Volunteer Monitoring Program.

**Table 8. Thermal condition of Fernan Lake at deep monitoring location.**

| | 1990 | 1991 | 2003 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **January** | -- | -- | -- | -- | -- | -- | -- | Strat | -- | -- | -- |
| **April** | -- | -- | -- | -- | -- | Iso | -- | -- | -- | -- | -- |
| **May** | Iso | -- | Iso | Iso | Iso | Iso | Strat | -- | | -- | Strat |
| **June** | Strat | -- | Iso | Iso | -- | -- | Strat | -- | Iso | -- | -- |
| **July** | -- | Iso | Iso | -- | -- | Iso | -- | -- | -- | -- | Strat |
| **August** | Iso | -- | Iso | -- | -- | -- | Iso | -- | -- | Iso | Iso |
| **September** | Iso | -- | Iso | -- | -- | Iso | Iso | -- | -- | Iso | -- |
| **October** | -- | -- | -- | -- | -- | -- | Iso | -- | -- | -- | -- |
| **November** | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

Iso = Isothermal, Strat = Stratified

### *Dissolved Oxygen*

The data for existing and available dissolved oxygen measurements for Fernan Lake is summarized in Table 9. Certain concentrations of dissolved oxygen are necessary for aquatic organisms and are an indicator of water quality. Idaho water quality standards protect aquatic life by establishing criteria for which Idaho waters shall meet or exceed. Idaho's water quality criteria states that dissolved oxygen should exceed 6 mg/L at all times, with the exception that the 6 mg/L does not apply for the bottom 20 percent of a lake that is less than 35 meters in depth; nor does the 6 mg/L apply to the hypolimnion of a lake if the lake is stratified. Continuous monitoring is required when evaluating dissolved oxygen for compliance with Idaho water quality standards, and since the Fernan Lake dissolved oxygen measurements are not continuous the criteria is only used as guidelines. There were several observations of dissolved oxygen concentrations below 6 mg/L, when the criteria exceptions are taken into account, none of those observations exceed Idaho water quality standards criteria.

**Table 9. Fernan Lake dissolved oxygen concentrations[1,2].**

| Date | Location | Data Source | Dissolved Oxygen (mg/L) at Depth (meters) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 5/22/1990 | Deep | LWQA | -- | 9.4 | 9.2 | 9.0 | 8.7 | 7.9 | 7.5 | |
| 6/26/1990 | Deep | LWQA | -- | 8.3 | 8.4 | 8.6 | 9.2 | 6.0 | 4.1 | 3.6 |
| 8/8/1990 | Deep | LWQA | -- | 8.2 | 8.2 | 8.2 | 8.2 | 6.3 | 5.1 | 0.8 |
| 9/17/1990 | Deep | LWQA | -- | 8.5 | 8.6 | 8.4 | 8.3 | 7.9 | 7.6 | -- |
| 10/30/1990 | Deep | LWQA | -- | 9.1 | 8.8 | 8.7 | 8.6 | 8.6 | 8.5 | -- |
| 7/24/1991 | Deep | LWQA | -- | 8.4 | 8.3 | 8.2 | 8.1 | 8.1 | -- | -- |
| 6/24/2003 | Deep | Isaacson | 6.9 | 6.4 | 6.5 | 6.4 | 6.9 | 7.0 | 6.9 | 4.8 |
| 7/1/2003 | Deep | Isaacson | 6.8 | 6.8 | 6.9 | 6.8 | 7.0 | 6.5 | 5.2 | 5.1 |
| 7/21/2003 | Deep | Isaacson | 7.1 | 6.0 | 6.1 | 7.1 | 7.4 | 6.9 | 6.4 | 5.4 |
| 7/29/2003 | Deep | Isaacson | 7.9 | 6.4 | 7.1 | 7.2 | 7.3 | 7.3 | 7.1 | 5.6 |
| 8/7/2003 | Deep | Isaacson | 7.0 | 6.5 | 6.6 | 6.5 | 6.9 | 6.4 | 6.4 | 3.8 |
| 8/19/2003 | Deep | Isaacson | 7.5 | 7.2 | 7.2 | 7.4 | 7.7 | 7.1 | 7.4 | 6.9 |
| 8/27/2003 | Deep | Isaacson | 8.1 | 7.5 | 8.1 | 7.4 | 7.7 | 7.1 | 7.4 | 3.5 |
| 9/4/2003 | Deep | Isaacson | 8.7 | 7.7 | 8.1 | 7.7 | 7.1 | 6.9 | 7.0 | 3.7 |
| 9/15/2003 | Deep | Isaacson | 7.7 | 7.7 | 7.3 | 7.1 | 6.8 | 7.0 | 6.0 | 3.8 |
| 5/9/2005 | Deep | CVMP | -- | 7.9 | 7.5 | 7.5 | 7.7 | 7.6 | 4.2 | 3.8 |
| 6/6/2005 | Deep | CVMP | 7.0 | 7.0 | 6.4 | 6.6 | 6.7 | 6.6 | 6.5 | 6.8 |
| 5/11/2006 | Deep | CVMP | 9.6 | 9.3 | 9.5 | 9.3 | 8.9 | 9.2 | 9.0 | 9.0 |
| 4/16/2007 | Deep | CVMP | 7.5 | 7.5 | 7.4 | 7.4 | 7.3 | 7.4 | 7.4 | 7.3 |
| 5/14/2007 | Deep | CVMP | 9.0 | 8.7 | 8.7 | 8.6 | 8.4 | 8.4 | 8.2 | 6.6 |
| 7/16/2007 | Deep | CVMP | 7.7 | 7.6 | 7.3 | 7.1 | 7 | 6.1 | 2.6 | 1.8 |
| 9/18/2007 | Deep | CVMP | 7.0 | 6.6 | 6.7 | 6.7 | 6.7 | 6.8 | 6.4 | 6.3 |
| 5/30/2008 | Deep | CVMP | 10.1 | 10.0 | 10.1 | 10.3 | 9.7 | 5.8 | 5.8 | 5.8 |
| 6/30/2008 | Deep | CVMP | 9.6 | 9.2 | 9.2 | 9.4 | 10.1 | 7.4 | 3.6 | 3.1 |
| 8/28/2008 | Deep | CVMP | 10.6 | 10.6 | 10.3 | 9.9 | 9.9 | 9.6 | 9.6 | 8.6 |
| 9/8/2008 | Deep | CVMP | 10.8 | 10.9 | 10.9 | 10.3 | 9.9 | 9.6 | 9.6 | 9.6 |
| 9/9/2008 | Deep | CVMP | 9.5 | 9.1 | 9.6 | 9.6 | 9.6 | 9.6 | 9.6 | 9.6 |
| 9/30/2008 | Deep | CVMP | 9.5 | 9.4 | 9.5 | 9.5 | 9.5 | 9.5 | 9.2 | 8.8 |
| 10/21/2008 | Deep | CVMP | 8.2 | 8.2 | 8.2 | 8.1 | 8.1 | 8.1 | 8.0 | 7.1 |
| 1/28/2009 | Deep | CVMP | 14.0 | 12.2 | 11.3 | 10.5 | 9.5 | 7.8 | 4.0 | 2.4 |
| 6/5/2010 | Deep | CVMP | 9.7 | 9.7 | 9.7 | 9.7 | 9.7 | 9.3 | 8.4 | -- |
| 8/8/2011 | Inlet | CVMP | 7.0 | -- | -- | -- | -- | -- | -- | -- |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 8/8/2011 | Deep | CVMP | 9.1 | 9.2 | 9.3 | 9.0 | 8.5 | 7.9 | 2.0 | 1.7 |
| 8/29/2011 | Deep | CVMP | 9.3 | 9.3 | 9.2 | 9.2 | 9.2 | 8.2 | 1.1 | 1.1 |
| 8/29/2011 | Outlet | CVMP | 8.9 | 9.1 | 8.6 | 8.0 | 2.0 | -- | -- | -- |
| 5/17/2012 | Inlet | CVMP | 9.3 | 9.3 | 9.5 | -- | -- | -- | -- | -- |
| 5/17/2012 | Deep | CVMP | 9.0 | 9.1 | 9.1 | 9.0 | 8.8 | 8.9 | 7.68 | 7.6 |
| 5/17/2012 | Outlet | CVMP | 9.1 | 9.3 | 9.2 | 9.2 | 8.2 | -- | -- | -- |
| 7/5/2012 | Inlet | CVMP | 7.7 | 7.7 | 7.7 | 7.3 | -- | -- | -- | -- |
| 7/5/2012 | Deep | CVMP | 7.9 | 8.3 | 8 | 7.8 | 6.5 | 3.3 | 2.3 | 2.2 |
| 7/5/2012 | Outlet | CVMP | 8 | 8.3 | 8.2 | 4.6 | 4.0 | 2.8 | -- | -- |
| 7/19/2012 | Deep | CVMP | 8.3 | 8.3 | 8.5 | 8.5 | 8.3 | 9.9 | 0.4 | 0.1 |
| 7/20/2012 | Deep | CVMP | 7.71 | 7.21 | 7.6 | 7.55 | 8.62 | 2.5 | 0.04 | 0.04 |
| 8/31/2012 | Deep | CVMP | 8 | 7.9 | 7.9 | 7.8 | 7.8 | 7.8 | 7.7 | 3.9 |

[1] Gray cells are dissolved oxygen concentrations below 6 mg/L, and observed in the bottom 20% of profile.
[2] Black cells are dissolved oxygen concentrations below 6 mg/L, and observed in the hypolimnion of stratified conditions in the lake.

## Water Transparency (*Secchi Depth)*

Water transparency is evaluated by measuring the maximum depth at which a standardized black and white disk can be seen from the surface. Secchi depth is related to water turbidity and algae production. Mossier (1993) found that the water transparency of Fernan Lake was primarily caused by blue-green algae blooms. He reported a range in Secchi depths from 2.2 m to 4.5 m in Fernan Lake. A historical record of Secchi depth data is represented in Table 10. The range in Secchi depth over the period of record is 1.1 m to 4.5 m at the deepest part of the lake. In a typical year, Secchi depths appear to greatest (indicating better water transparency) in the beginning of the summer (May through July) and smallest from the middle of summer until the end of summer (August through October) (Figure 11). Mean and median Secchi depths during the summer months are listed in Table 11. The data suggest a statistically insignificant negative trend in summer Secchi depths (Figure 12).

**Table 10. Secchi depths of Fernan Lake over period of record.**

| Data Source | Location | Date | Depth (m) |
|---|---|---|---|
| LWQA | Deep Station | 5/22/1990 | 7.5 |
| LWQA | Deep Station | 6/26/1990 | 3.3 |
| LWQA | Deep Station | 8/8/1990 | 2.6 |
| LWQA | Deep Station | 9/17/1990 | 2.2 |
| Isaacson | Deep Station | 6/24/2003 | 4.3 |
| Isaacson | Deep Station | 7/1/2003 | 3.7 |
| Isaacson | Deep Station | 7/11/2003 | 3.4 |
| Isaacson | Deep Station | 7/21/2003 | 3.7 |
| Isaacson | Deep Station | 7/29/2003 | 3.7 |
| Isaacson | Deep Station | 8/7/2003 | 2.3 |
| Isaacson | Deep Station | 8/19/2003 | 2.0 |
| Isaacson | Deep Station | 8/27/2003 | 1.6 |

| | | | |
|---|---|---|---|
| Isaacson | Deep Station | 9/4/2003 | 1.4 |
| Isaacson | Deep Station | 9/15/2003 | 1.1 |
| LWQA | Deep Station | 5/22/2009 | 4.5 |
| LWQA | Deep Station | 6/26/2009 | 3.3 |
| LWQA | Deep Station | 8/8/2009 | 2.6 |
| LWQA | Deep Station | 9/17/2009 | 2.2 |
| CVMP | Inlet | 5/17/2012 | 1.5 |
| CVMP | Deep Station | 5/17/2012 | 4.5 |
| CVMP | Outlet | 5/17/2012 | 4.5 |
| CVMP | Inlet | 7/5/2012 | 2.0 |
| CVMP | Deep Station | 7/5/2012 | 1.7 |
| CVMP | Outlet | 7/5/2012 | 2.0 |
| CVMP | Deep Station | 8/31/2012 | 3.0 |

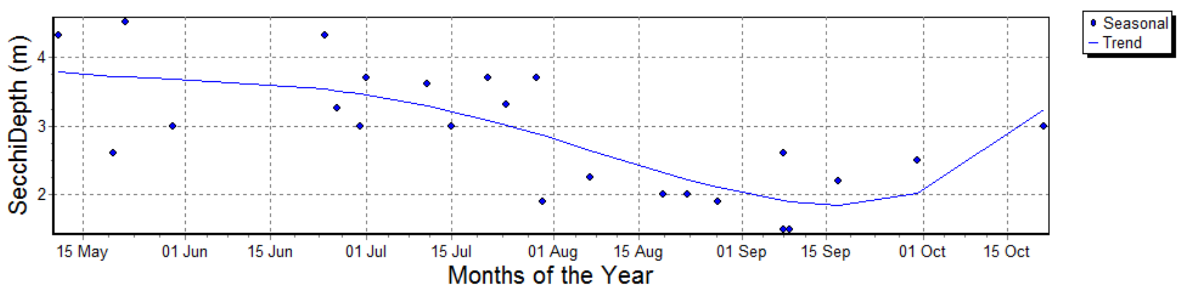



**Figure 11 Annualized Secchi depth of Fernan Lake over period of record.**

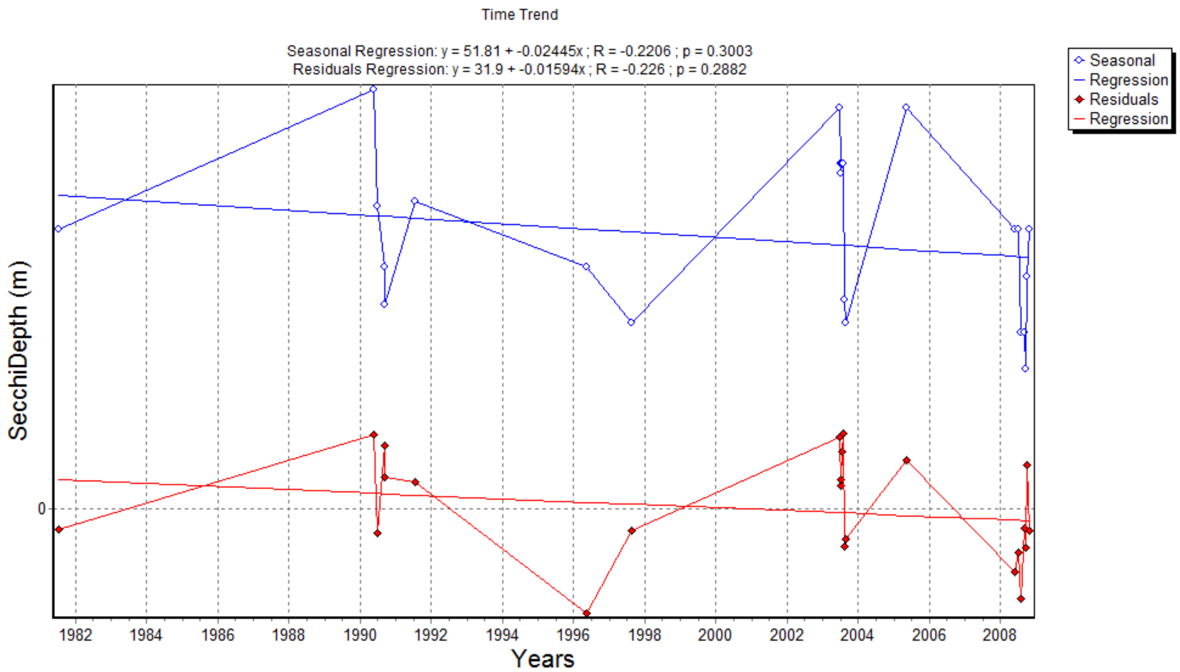



**Figure 12. Trend in Secchi Depth Over Period of Record**

**Table 11. Average Secchi depth in Fernan Lake during summer months.**

| | May | June | July | August | September |
|---|---|---|---|---|---|
| **Mean** | 5.5 | 3.6 | 3.2 | 2.4 | 1.7 |
| **Median** | 4.5 | 3.3 | 3.7 | 2.5 | 1.8 |

## *Nutrients and Chlorophyll*

Nutrients and chlorophyll are measures of the cause and response of growth, or productivity within a lake. Nutrients (in the case of Fernan Lake, phosphorus) are the food upon which cyanobacteria and algae grow. Chlorophyll is a measure of a pigment found in cyanobacteria and the chloroplasts of algae and plants. Some cyanobacteria and algae growth are healthy in a lake, but excess's in phosphorus are what lead to objectionable blooms of cyanobacteria and algae. Chlorophyll has several chemical structures. Typical for water quality science and for the purpose of this study the "chlorophyll a" molecule is the only structure measured or evaluated. Phosphorus and chlorophyll a concentrations are determined from samples taken and evaluated by a laboratory.

Nutrient and Chlorophyll a samples were collected from Fernan Lake at the deepest location in the lake. Existing and available total phosphorus and chlorophyll a results data since 1990 are shown in Table 12. Chlorophyll a samples, when taken, were typically collected at Secchi depth. Total Phosphorus samples were collected at either Secchi depth or as a composite depth integrated sample as well as at one meter from the bottom. Due to such a small data set and the data gaps between years of monitoring, the following analysis is not wholly conclusive.

To understand any seasonal patterns in total phosphorus concentrations, all existing data were annualized. It appears from the data there is time period of elevated total phosphorus concentrations between August 15 and September 15 (Figure 13), and there is no significant trend in phosphorus concentrations over the period of record (Figure 14). Further statistical analysis of total phosphorus data show that they are a normal distribution and a have upper quartile concentration of 31 µg/L (Figure 15). This value has been chosen to represent existing condition of Fernan Lake for the purposes of this TMDL. Seventy five percent of the samples collected between August 15 and September 15 are below 31 µg/L.

Chlorophyll a concentrations are graphed in Figure 16. High concentrations of chlorophyll a were observed in August and September 2003 July and August 2012.

**Table 12. Nutrient and chlorophyll a data collected on Fernan Lake**

| Fernan Lake Phosphorus and Chlorophyll a concentrations | | | | | |
|---|---|---|---|---|---|
| **Date** | **Data Source** | **Total Phosphorus (µg/L)** | | | **Chlorophyll a (µg/L)** |
| | | **@Secchi depth** | **@ Depth integrated** | **@ 1 meter off bottom** | **@ Secchi depth** |
| 5/22/1990 | LWQA[1] | 16 | -- | 18 | -- |
| 6/26/1990 | LWQA | 17 | -- | 25 | -- |
| 8/8/1990 | LWQA | 13 | -- | 26 | -- |
| 9/17/1990 | LWQA | 22 | -- | 30 | -- |
| 10/30/1990 | LWQA | 21 | -- | -- | -- |
| 6/24/2003 | Isaacson[2] | -- | 16 | -- | 3.0 |
| 7/21/2003 | Isaacson | -- | 20 | -- | 5.4 |
| 7/29/2003 | Isaacson | -- | 21 | -- | 6.1 |
| 8/7/2003 | Isaacson | -- | 16 | -- | 5.3 |
| 8/19/2003 | Isaacson | -- | 22 | -- | 7.2 |
| 8/27/2003 | Isaacson | -- | 16 | -- | 20.7 |
| 9/4/2003 | Isaacson | -- | 27 | -- | 30.3 |
| 9/15/2003 | Isaacson | -- | 30 | -- | 36.4 |
| 5/30/2008 | CVMP[3] | 19 | -- | 22 | 10.6 |
| 6/30/2008 | CVMP | 20 | -- | 32 | 7.8 |
| 7/30/2008 | CVMP | 18 | -- | 38 | 3.3 |
| 8/28/2008 | CVMP | 23 | -- | 36 | 9.6 |
| 9/30/2008 | CVMP | 20 | -- | 19 | 3.1 |
| 10/21/2008 | CVMP | 15 | -- | 22 | 4.9 |
| 1/28/2009 | CVMP | 8 | -- | -- | -- |
| 5/17/2012 | CVMP | 14.9 | -- | 43.3 | 1.7 |
| 7/5/2012 | CVMP | 26.4 | -- | 27.5 | 21.1 |
| 8/31/2012 | CVMP | 23.1 | -- | -- | 10.5 |

[1]LWQA = 1991 DEQ Lake Water Quality Assessment program (Mossier 1993).
[2]Isaacson = subcontracted monitoring work done by Allen Isaacson (FLCRA 2003).
[3]CVMP = Citizen Volunteer Monitoring Program.

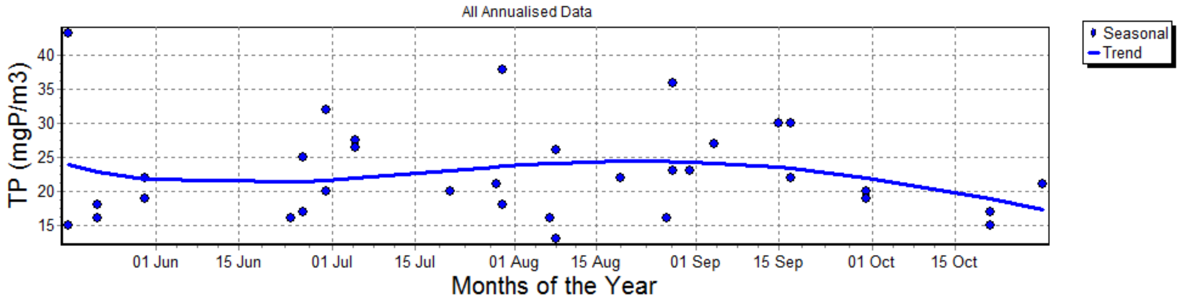



**Figure 13. Annualized Total Phosphorus Concentrations of Fernan Lake over period of record.**

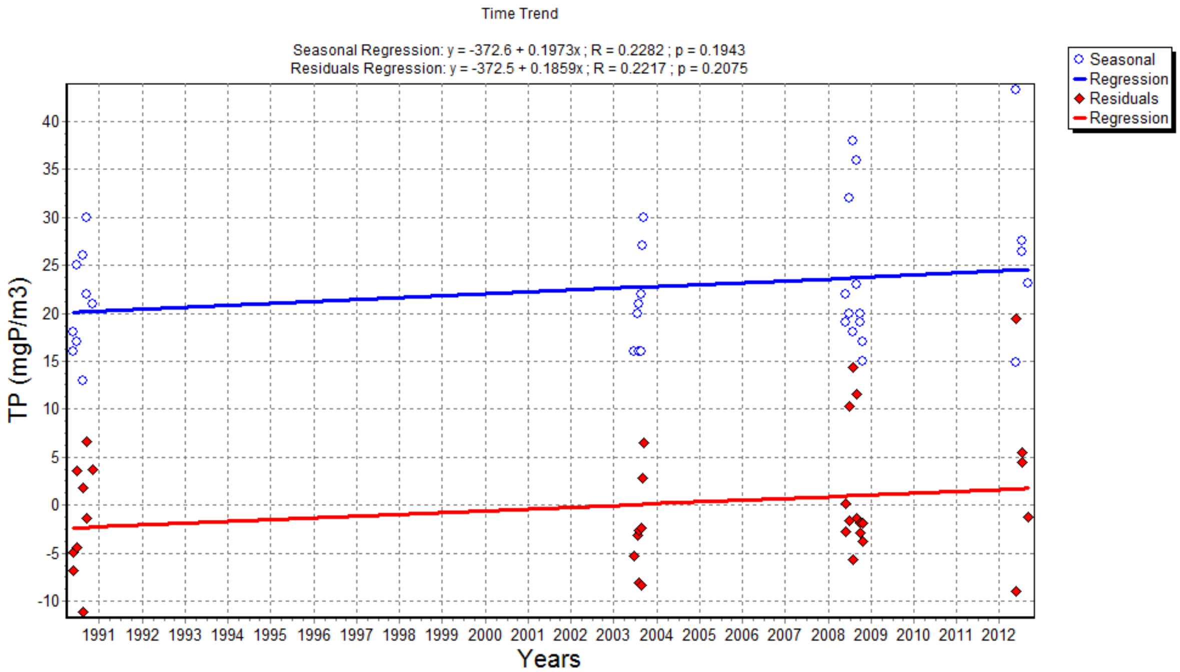



**Figure 14. Trend in Total Phosphorus Concentrations Over Period of Record**

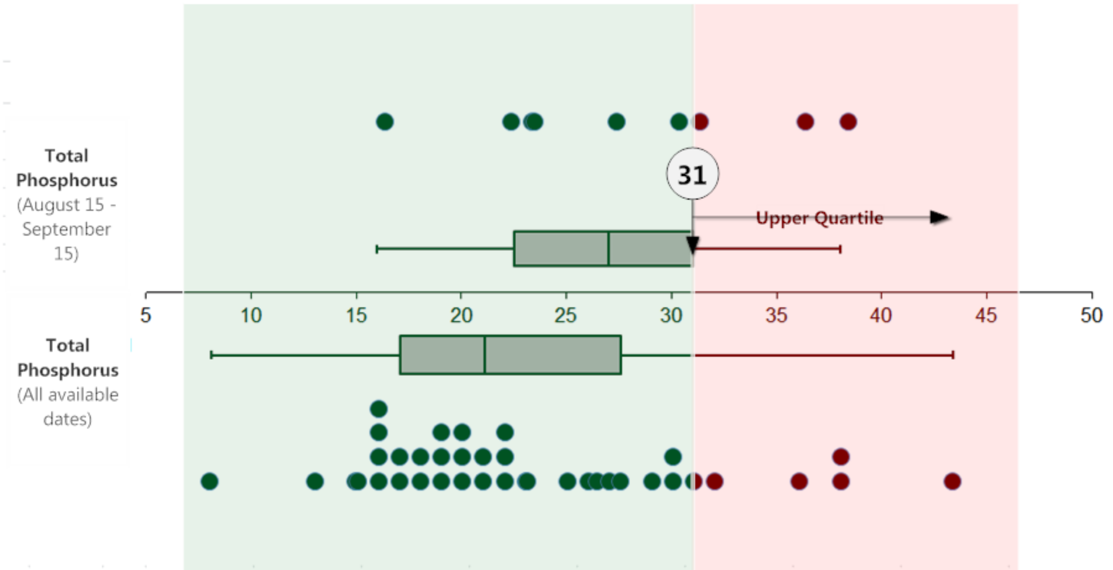



**Figure 15. Distribution of Total Phosphorus Concentrations Showing Upper Quartile of Record**

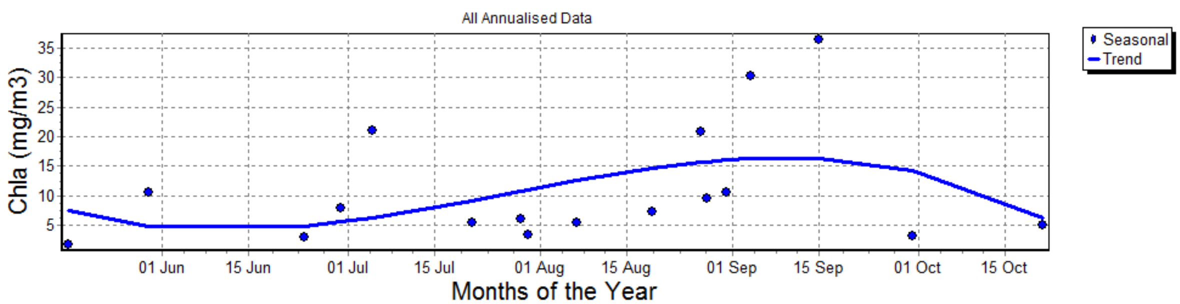



**Figure 16. Annualized Chlorophyll a Concentrations of Fernan Lake over period of record.**

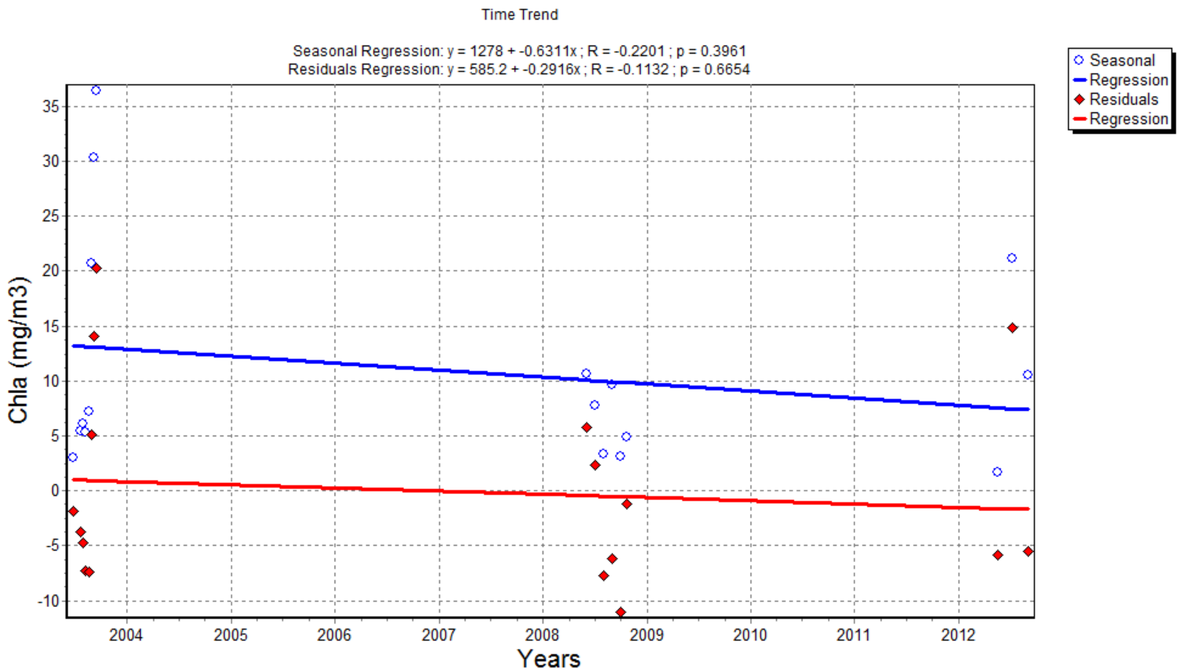



**Figure 17. Trend in Chlophyll a Concentrations over Period of Record**

## Trophic Status of Fernan Lake

Mossier (1993) described the trophic status of Fernan Lake as mesotrophic to late mesotrophic.  Falter (2001) examined historic data and conducted a series of assessments to conclude Fernan Lake is mesotrophic, but he cautioned that the shallow depth of Fernan Lake renders it susceptible to accelerated eutrophication.

Although new bathymetric data suggests a deeper mean depth than that which was reported by Mossier (1993) and Milligan (1983), the ratio of volume-to-surface area is still low, which means the lake mixes from top to bottom throughout the summer.  The absence of thermal stratification, the shallow depth of Fernan Lake, and steep shoreline favoring less-abundant plant growth would lend to a trophic status in the mesotrophic range.

## Biological and Other Data

There is no other recent data available.

# Data Gaps

While the data used to make this assessment was good, it was not a continuous long-term data set.  As such, analysis of trends in water quality, and the all analyses based on Fernan Creek stream hydrology was not robust.  It is important to maintain a continuous water quality monitoring program in Fernan Lake using CVMP or other methods with appropriate data quality control.

# Subbasin Assessment–Pollutant Source Inventory

This section includes an assessment of the known and suspected sources of phosphorus contributing to excess algae growth in Fernan Lake. Nutrient sources identified are categorized and quantified to the extent that reliable information is available. Generally, sources of phosphorus may be point or nonpoint in nature.

## Sources of Pollutants of Concern

Point sources, discrete end-of-pipe discharges, are typically those regulated through the National Pollution Discharge Elimination System (NPDES) program by the EPA. Point sources can be categorized as municipal, industrial, or storm water discharges. Nonpoint sources are diffuse sources that typically cannot be identified as entering a water body at a single location. These sources are related to land activities that contribute phosphorus to surface waters as a result of runoff producing storm events or groundwater/surface water transfer. The following discussion describes what is known regarding point and nonpoint sources of total phosphorus contributing to the eutrophication of Fernan Lake.

### Point Sources

There are no point sources or NPDES-permitted facilities within the Fernan Lake watershed that discharge to Fernan Lake. The Coeur d'Alene Municipal Separate Storm Sewer System (MS4) is under a National Pollutant Discharge Elimination System (NPDES) permit issued by Region 10 of the U.S. Environmental Protection Agency (EPA). Figure 18 is a map illustrating the City's MS4 Drainage Basins and Outfalls and their associated drainage basins (City of Coeur d'Alene, 2010). There are no outfalls under this system that discharge into Fernan Lake. One of the outfalls discharges directly into French Gulch, a tributary to lower Fernan Creek. As illustrated in the Subbasin Assessment section of this TMDL, French Gulch drains into lower Fernan Creek below the Fernan Lake outlet.

The Idaho Transportation Department District #1 Municipal Separate Storm Sewer System (MS4) is under a NPDES permit issued by Region 10 of EPA. A portion of Interstate 90 (I90) ditch drainage system is located along the French Gulch drainage. There are no I90 drainage systems that discharge directly into Fernan Lake. (ITD 2010).

The pollutant source inventory (detailed below) identifies French Gulch as a nonpoint source of pollution to Fernan Lake due to backwater effects from lower Fernan Creek into Fernan Lake during rain events in the fall. The hydraulics that create this condition are detailed below in the pollutant source inventory for French Gulch. This is not a direct discharge into Fernan Lake from a NPDES-regulated stormwater outfall or highway ditch drainage system; therefore, this source of pollution is considered nonpoint source in nature.

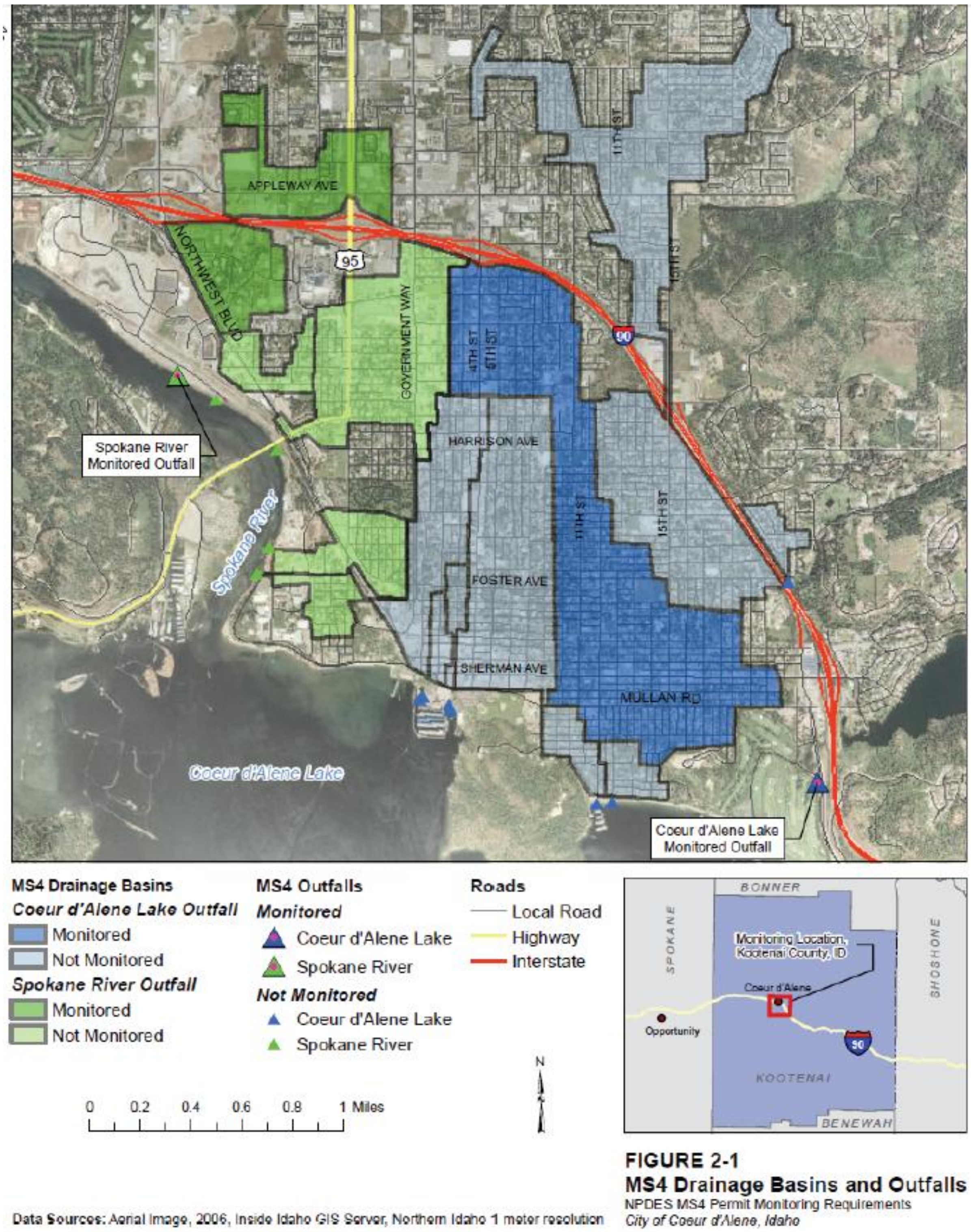



**Figure 18. City of Coeur d'Alene Drainage Basins and Outfalls under their February 2008 NPDES permit to the City of Coeur d'Alene Urbanized Area Municipal Storm Sewer Systems (MS4). Source: City of Coeur d'Alene, 2010).**

## Nonpoint Sources

The sources of nonpoint total phosphorus are summarized below. The primary non-point source of pollution into Fernan Lake is the Fernan Creek watershed. Other sources of phosphorus are Fernan Village, Fernan Lake Road, developed areas on the northern and southern hillslopes above the lake, and on an infrequent basis, backwater from French Gulch enters the lake during fall rainstorms. Sources within the lake are internal cycling and submerged macrophytes on the east and west shores of the lakes.

### *Fernan Creek Watershed*

Approximately 80 percent of inflowing water to Fernan Lake is from Fernan Creek and its tributaries that flow into the lake (Falter 2001). The Fernan Creek watershed is 3,980 ha (9,833 acres) in size of which 2,810 ha (6,943 acres) (71 percent) U.S. Forest Service property. The private land in the watershed is 1,142 ha (2,822 acres) (29 percent). Less than 1 percent of the watershed is wetlands (Figure 19).

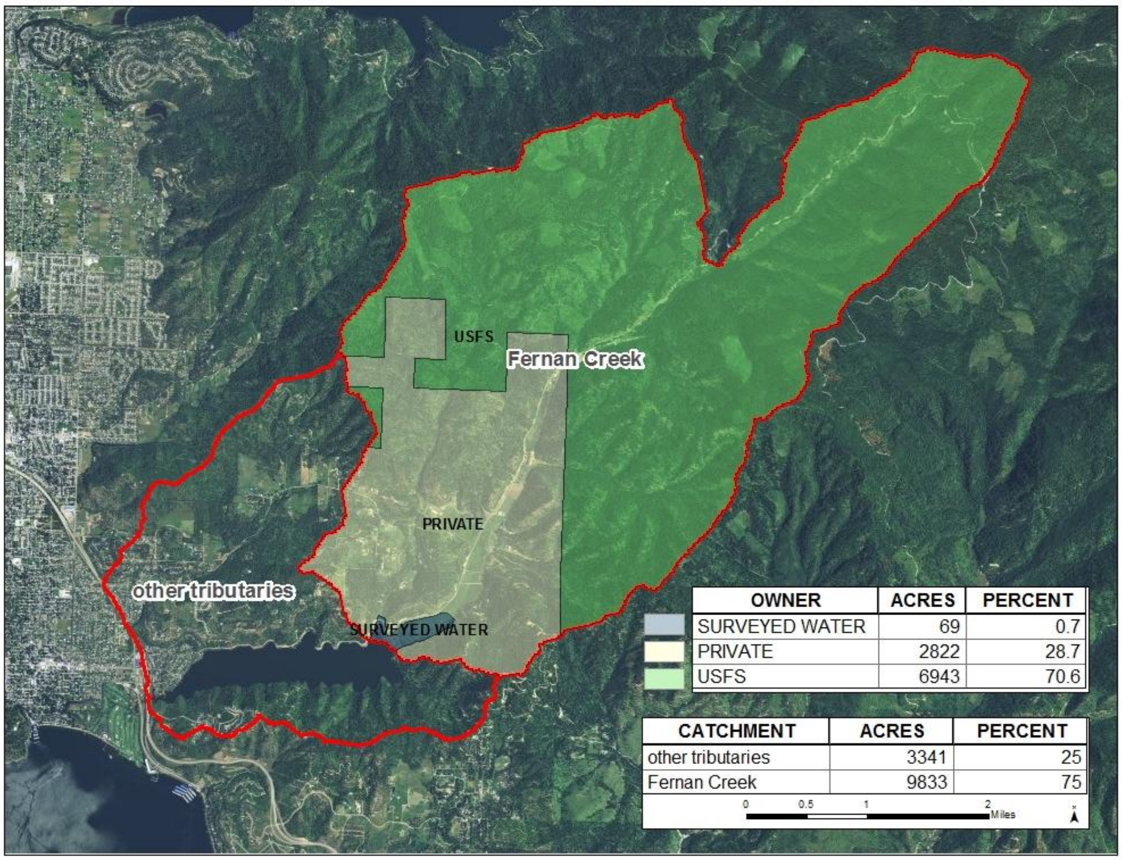



**Figure 19. A Map of the Fernan Creek watershed with landownership.**

Sources of nutrients within the Fernan Creek watershed are described below:

- US Forest Service property: This property overlies the Middle Preterozoic Prichard geologic formation, which is parent material to highly erodible fine-grained silt and clay soils. As described in the Pollutant/Beneficial Use Status Relationships section of this TMDL, phosphorus adsorbs to soil; therefore, the primary transport mechanism of phosphorus is through transport of soil from runoff. Although much of the phosphorus load from the watershed is naturally-occurring transport of phosphorus through runoff from forested areas, BMP implementation is critical on such erodible soils. Road and timber-harvest activities have the potential to increase the load of phosphorus to Fernan Creek through runoff events. Road construction, road decommissioning, and timber harvest increase water yield and sedimentation in the watershed. The increase in water yield and sediment/phosphorus transport to the creek is directly related to the location and extent of timber harvest and road construction activities. Poorly-maintained roads are also a source of sediment/nutrients in situations where runoff discharges to the Creek.

- Lower Fernan Creek. Much disturbance has occurred to lower Fernan Creek resulting in excessive erosion/sedimentation of the stream channel. In 2009, the Federal Highway Administration reconstructed Fernan Creek Road. In the process, they removed riparian vegetation and changed stream channel characteristics (Figure 20). In October 2009, the Federal Highway Administration attempted to restore the stream channel, which included a series of grade control structures made with boulders (Figure 21). The stream channel is in the process of revegetating (Figure 22). Excess material, resulting from the road reconstruction project, has been stockpiled near the Fernan Creek channel (Figure 23). There are some erosion controls in place on this stockpile. However the creek is significantly eroding the toe of the stockpile, which is contributing to sedimentation/aggradation downstream and nutrients to Fernan Lake (Figure 24).

**Figure 20. Fernan Creek before and after Federal Highway Administration road project. Pictures are from August 13, 2004 (left), and August 27, 2009 (photo courtesy of USFS) (right).**

**Figure 21. Restored stream channel with rock barbs (October 23, 2009).**

**Figure 22. Restored stream channel with new vegetation growth (May 1, 2012). Photo courtesy of USFS.**

**Figure 23. Stockpiled material from road cutslope, Fernan Creek Road Project. January 21, 2009.**

**Figure 24. Stockpiled material from road cutslope, Fernan Creek Road Project. November 14, 2012**

- Lower Fernan Creek. Just upstream of the Federal Highway Administration stream restoration project, Fernan Creek has over- widened, causing significant channel bank erosion (Figure 25). This over-widening contributes to downstream channel aggradation and nutrient loading to the lake.
- Lower Fernan Creek. Within the depositional reaches of lower Fernan Creek, channel capacity for flow has diminished; therefore, the adjacent agriculture fields are flooding more frequently – and likely transporting fertilizer and topsoil-bound nutrients from the fields to Fernan Creek (personal communication landowner) and eventually into Fernan Lake. One reach within the agriculture field is perched above the floodplain with little channel capacity (Figure 26).

**Figure 25. Over-widened eroding section of Fernan Creek. November 14, 2012.**

**Figure 26. Agriculture field perched above the floodplain with little channel capacity.**

Fernan Rod and Gun Club. Fernan Rod and Gun Club is location on US Forest Service property. To adhere to strict safety rules, several berms have been created on the property, that are immediately adjacent to Fernan Creek (Figure 27). Due to its close proximity to the berms, Fernan Creek may be eroding the toe of these berms and contributing nutrients and excess sediment deposition/erosion downstream.

**Figure 27. Perched channel above floodplain of lower Fernan Creek.**

Stacel Draw. During spring runoff, high-turbidity water has been observed from Stacel Draw into Fernan Creek. Landuse in this subwatershed is primarily agriculture and forest practices.

### *Fernan Lake Village*

Because the location of Fernan Village is adjacent to the lake, it is reasonable to assume phosphorus loading from both lawn and garden activities and stormwater from Fernan Village contributes phosphorus to the lake. Gradients of higher concentrations of water column algae have been observed in the Lake - often, the water is greener near the Fernan Village and less green away from Fernan Village. In addition, Falter (2001) observed high organic sediments in Fernan Lake just off Fernan Village, which may indicate a local nutrient source feeding a more abundant plant community.

The soils in Fernan Village have a high sand and gravel percentage, low water holding capacity, high hydraulic conductivity, and minimum calcium carbonate (USDA NRCS 2012). As such, the soils have a lower maximum phosphorus sorption capacity, and water applied in excess of the soil water holding capacity can move downward past the root zone into groundwater and connected surface water. Furthermore, the repeated application of fertilizers and organic material to soils may saturate existing phosphorus-sorption capacity, rendering them less capable of phosphorus retention.

#### Lawn and Garden

Green healthy lawns need phosphorus, which they get through fertilization. Phosphorus concentration is the "P" that the N-P-K numbers represent on fertilizer packaging. Phosphorus is an essential nutrient for plant growth, and plays an important role in photosynthesis and energy movement in plant tissues. Some of the phosphorus in a fertilizer application is used by the plant, but often there is excess which is leached downward past the root zone, into the soils, ground water and connected surface water. Knowing the minimal amount of phosphorus to add when fertilizing is difficult and requires soil testing. Most fertilizer applications over-apply phosphorus which results in excess phosphorus below the root zone where it may sorb onto soil particles or continue to be transported below the root zone. It is likely fertilizer over-application does occur in Fernan Village, and phosphorous is being transported to Fernan Lake.

#### Storm Water

Storm water is the water that comes from roadways with gutters, collection drains, and transport pipes. Stormwater can increases nutrient loadings to surface waters. Geographic, physical, and climatic factors all play a part in the extent of pollution that will make it to surface water through stormwater runoff.

Storm water from Fernan Village is collected into a series of injection wells installed in 1997. The locations of the injections wells are not known.

### Fernan Lake Road

Fernan Lake Road is a heavily-used 17.7 mile road that parallels the northern shore of Fernan Lake before following Fernan Creek up to the Fernan Saddle in the Coeur d'Alene National Forest. Falter (2001) identified its close proximity to the lake a reason why sediment and nutrient loadings to the lake from the road were substantial.

In 2010, the Federal Highway Administration widened and stabilized the road, and they installed sediment and runoff control measures. However, there are several factors that indicate the road is still a source of sediment/phosphorus to the lake: 1) due to the close proximity of the road to the shoreline of Fernan Lake, the sediment and runoff control measures may not have enough retention time to sequester all nutrients from the road, 2) riparian vegetation between the road and Fernan Lake is minimal leaving little buffer for sediment/phosphorus transport into the lake; 3) extremely large cutbanks of exposed/weathered bedrock may be a source of sediment/phosphorus during rain/runoff conditions.

### *French Gulch*

As stated in the Subbasin Assessment of this TMDL. French Gulch drains the watershed to the north of Fernan Lake. The confluence of French Gulch and Fernan Creek is just below the outlet of Fernan Lake. Following rain events in late summer/fall, flow in French Gulch backs up and through the outlet of Fernan Lake (Figure 28) (personal communication, Brian White Fernan Conservation and Recreation Association).

**Figure 28. Leading edge of French Gulch plume, summer 2011. Photo courtesy of Brian White.**

### *Septic*

In 1978, the city of Fernan Lake Village converted from septic systems to incorporation into the City of Coeur d'Alene's sewer/waste treatment system. Parcel maps from Kootenai County indicate residences that are on private septic systems within 300 feet of the lakeshore. However, Panhandle Health District estimates the load from these septic systems to Fernan Lake is probably no more than 5 percent (Fernan Lake Technical Advisory Committee 2003).

## Internal P Cycling Within the Lake

Neither detailed hydrologic studies nor specific modeling have been conducted to evaluate the internal dynamics of nutrient cycling within Fernan Lake. As with all lakes, internal sources of phosphorus include nutrient releases from lake sediments and decomposition of aquatic plants. Historical land-disturbing activities such as logging, construction, and agricultural activities in the Fernan Lake watershed, have introduced large amounts of phosphorus-containing sediments that accumulated at the bottom of the lake. Fernan Lake infrequently experiences stratification but this stratification may be periodic, being broken up by wind/wave action. This limited stratification can result in reduced DO conditions near the bottom of the lake which enhance phosphorus moving up into the water column. The steep northern and southern shorelines of Fernan Lake with the rapid drop-off to the 6 meter depth preclude the excessive growth of aquatic plants like lily pads. Much of the water flows through Fernan Lake which also suppresses excessive growth of aquatic plant species.

Additional lake study and modeling, which is beyond the scope of this TMDL, may be warranted to better define the contributions of total phosphorus from internal lake dynamics. It is reasonable to conclude internal cycling of total phosphorus is not a high percentage of loading to Fernan Lake.

## Other Nonpoint Sources

Other nonpoint sources have been grouped together, not because of lack of importance, but due to the lack of data to accurately quantify the load from these sources. This category includes the following:

- Developed property on the northern and southern end of the lakes. Stormwater runoff, particularly during spring, has been observed to cause turbidity in intermittent channels that drain to the lake.
- Undeveloped property on the northern and southern end of the lakes.
- Dispersed camp grounds on the southern end of the lake. Due to the lack of bathroom facilities at these heavily used sites, runoff from these sites likely produce a nutrient load to the lake.
- Submerged macrophytes growth in shallow areas on the eastern and western ends of the lake. Recent data collected on the southern end of Coeur d'Alene shows these area have increased total phosphorus concentrations in the water column (personal communication Glen Rothrock, DEQ).
- While the dam below Fernan Lake is not a pollutant source, the management of the dam may have implications flushing flows in Fernan Lake and to concentrations of total phosphorus in the lake.

## Pollutant Transport

The majority of phosphorus loading to Fernan Lake is the result of nonpoint transport to the lake directly from the watershed either through runoff or movement through soils to groundwater that discharges into the lake. The extent that phosphorus enters Fernan Lake from either of these pathways is dependent on soil characteristics.

The dominant soils adjacent to Fernan Lake have a high percentage of sand and gravel. They are classified as well-drained to excessively-drained, and they are rated "very limited" with regard to septic absorption field filtering capacity and seepage by the US Department of Agriculture Natural Resources Conservation Service (USDA 2012). The lack of calcium carbonate and low percentage of clay limits the soil's ability to attenuate phosphorus, which supports this rating. Land use activities generating total phosphorus may have a percentage of phosphorus that percolates though the soil into groundwater which can discharge to Fernan Lake. When it reaches the lake, however, phosphorus would be quickly bound to soil.

The primary pollutant transport pathway for phosphorus within the Fernan Lake watershed is sediment-bound phosphorus transported from rainfall/snow melt runoff from Fernan Creek. A DEQ study in 2008-2009 on 13 tributaries to Coeur d'Alene Lake during winter rain-on-snow events, spring runoff, and low-flow conditions showed the close correlation with total phosphorus concentrations and sediment. The study concluded the highest suspended sediment and nutrient concentrations were observed during early rain-on-snow events and spring runoff (DEQ 2010). Included in this study was monitoring on Fernan Creek below the Fernan Lake outlet, and results concluded total phosphorus and sediment concentrations were highest primarily during rain-on-snow events and runoff (Figure 29).

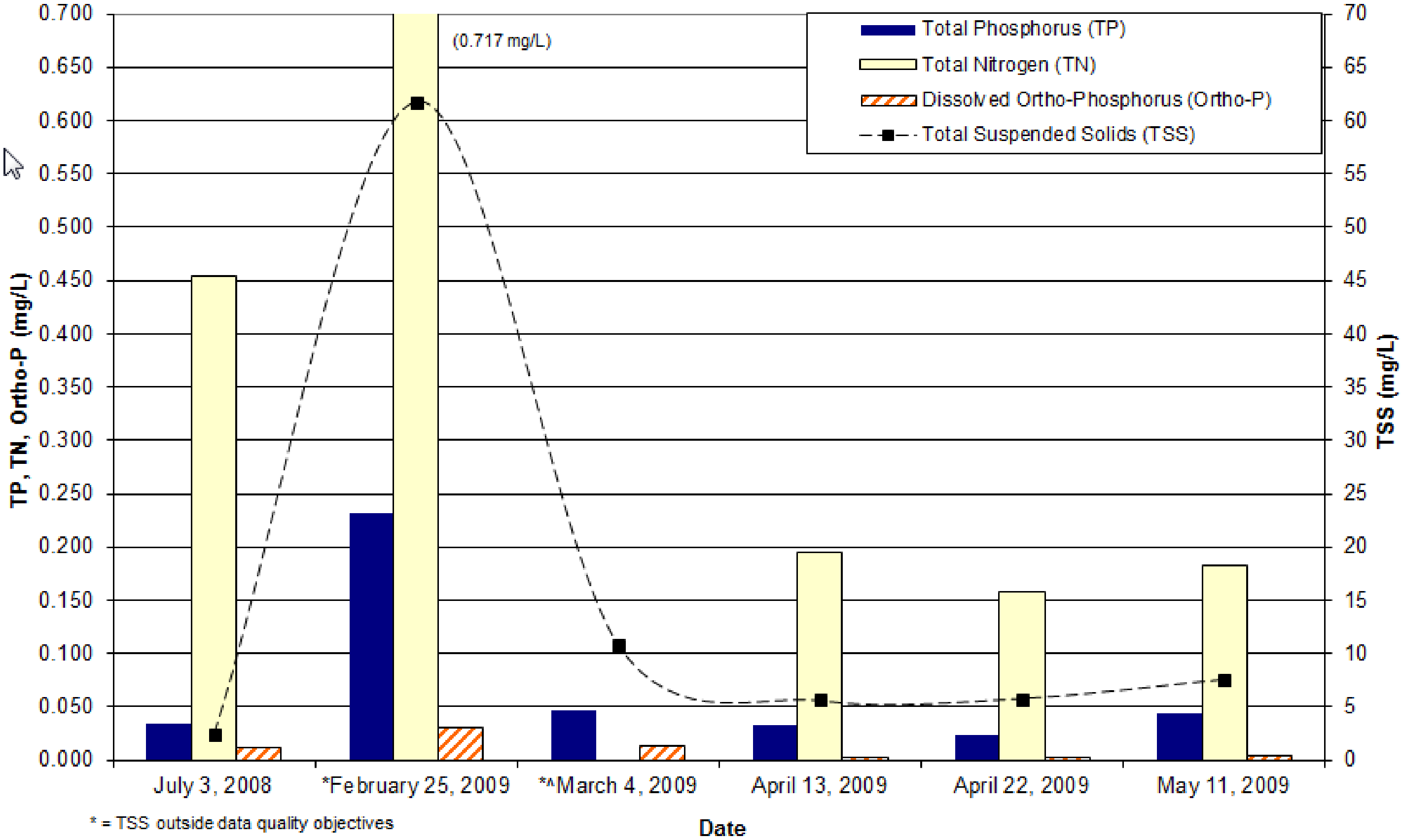



**Figure 29. Total nutrient and suspended sediment concentrations in Fernan Creek in 2008-2009. A rain-on-snow event occurred on February 25th (DEQ 2010)**

The DEQ study determined the total phosphorus loading from the tributaries to Coeur d'Alene Lake by multiplying the total phosphorus concentration by the flow of the creek at the time of sample collection. The study concluded total phosphorus loading was greatest during spring runoff. Loading from Fernan Creek showed the same results, with total phosphorus the highest during rain-on-snow events and during the months of spring runoff (Figure 30).

Although higher concentration of total phosphorus is a concern for loading to Fernan Lake, much of the higher flows pass through the lake, and colder temperature are not conducive to aquatic plant growth during the winter and early spring months. However, DEQ (2010) data concludes the dissolved ortho-phosphorus to total phosphorus ratio during base flow period in tributaries to Coeur d'Alene Lake were above that of reference streams in the region suggesting bioavailable phosphorus may be a concern for beneficial uses for the streams and for loading to the Coeur d'Alene Lake (DEQ 2010). Results of this study also suggest higher concentrations of dissolved ortho-phosphorus from Fernan Creek at base flow to Fernan Lake is likely.

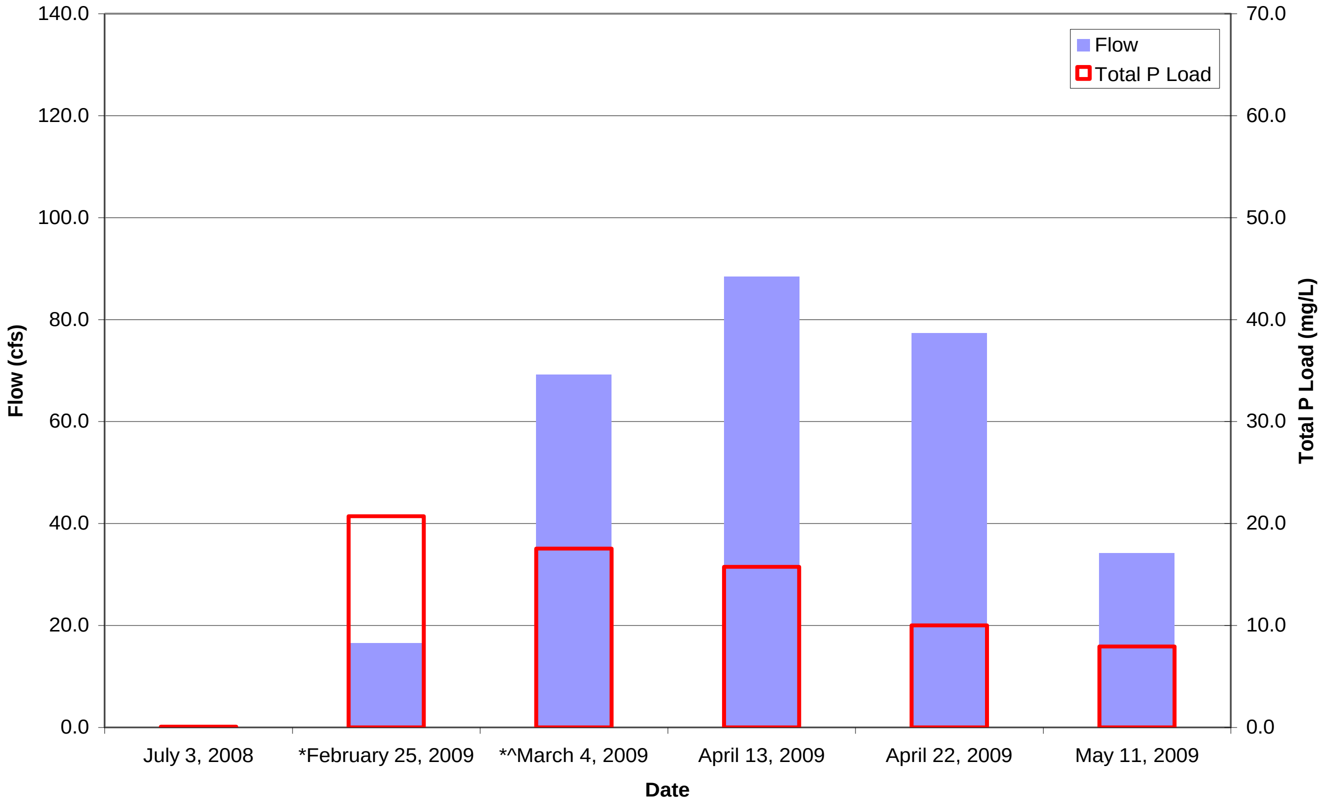



**Figure 30. Total Phosphorus loading from Fernan Creek in 2008-2009. A rain-on-snow event occurred on February 25th (DEQ 2010)**

# Data Gaps

As previously stated, there was a limited amount of data available for the development of a total phosphorus TMDL for Fernan Lake. While there are no point source discharges into Fernan Lake, the following summarizes the various data gaps that limit the accuracy of accounting for all the variables associated with the nonpoint sources of loading of phosphorus and their effect on the eutrophication of Fernan Lake**.** Where appropriate, these assumptions are identified and incorporated into the margin of safety (MOS) discussed in Section 5.

- No long-term water quality data immediately upstream of the Fernan Lake to more accurately estimate phosphorus loading from the Fernan Creek watershed. It is also important to characterize the pollutant sources in the Fernan Creek watershed to better allocate resources for TMDL implementation.
- No long-term water quality data exists for the unnamed tributary that flows into Fernan Lake's northeast inlet. It is important to understand the load from this creek into Fernan Lake.
- Additional data and modeling may improve understanding of total phosphorus contributions from internal lake dynamics.

- There may be a groundwater contribution of total phosphorus to the lake, and additional studies are necessary to understand this contribution.
- No data has been collected to accurately characterize the nutrient load from storm drains and lawn/garden fertilizers at Fernan Village.
- No data has been collected to accurately characterize the nutrient load from Fernan Lake road.
- No data has been collected to accurately characterize the nutrient load from French Gulch.
- While the dam below Fernan Lake is not a pollutant source, the management of the dam may have implications to concentrations of total phosphorus in the lake. An evaluation of dam management and its effect on total phosphorus concentrations in the lake would be very valuable.

# Subbasin Assessment – Summary of Past and Present Pollution Control Efforts

In 1978, the city of Fernan Lake Village converted from septic systems to incorporation into the City of Coeur d'Alene's sewer/waste treatment system. This project greatly reduced the amount of phosphorus delivered to Fernan Lake. Parcel maps from Kootenai County indicate a few residences that are on private septic systems within 300 feet of the lakeshore. Panhandle Health District estimates the load from these septic systems to Fernan Lake is probably less than 3 percent (Fernan Lake Technical Advisory Committee 2003).

In 1996 the Fernan Lake Conservation and Recreation Association was formed. The mission of the Fernan Lake Conservation & Recreation Association (FLCRA) is to preserve the scenic and natural resource value of the Fernan Lake Watershed and enhance its beneficial uses, both public and private, utilizing sound conservational practices." (Personal communication Susan Andrews, Fernan Lake Conservation and Recreation Association). The group has been involved in activities such as working with the City of Coeur d'Alene officials to pass city ordinances protective of the lake; participating in the DEQ-facilitated Citizen Volunteer Monitoring Program; contracting land use, geological, and water quality professionals to collect valuable data; putting together a Technical Advisory Group to utilize the data to develop a Fernan Lake Watershed Plan; and education of the community on land use practices protective of the lake.

In March 2003, The Mayor and Coeur d'Alene City Council passed a Hillside Ordinance requirements for the property annexed within the Fernan Lake watershed. The ordinance bans development of property on slopes of 35 percent or greater. It also requires the Fernan Lake Management Plan be considered in making land use decisions within the Fernan Lake Planning area (City of Coeur d'Alene 2003).

In 2010, the Federal Highway Administration widened and stabilized the road, and they installed sediment and runoff control measures. This was a big improvement from the existing road, as the road was documented to be a large source of nutrients to Fernan Lake (Mossier 1993, Falter 2001).

# Total Maximum Daily Load(s)

A TMDL prescribes an upper limit on discharge of a pollutant from all sources so as to assure water quality standards are met. It further allocates this load capacity (LC) among the various sources of the pollutant. Pollutant sources fall into two broad classes: point sources, each of which receives a wasteload allocation (WLA); and nonpoint sources, each of which receives a load allocation (LA). Natural background (NB), when present, is considered part of the LA, but is often broken out on its own because it represents a part of the load not subject to control. Because of uncertainties regarding quantification of loads and the relation of specific loads to attainment of water quality standards, the rules regarding TMDLs (Water quality planning and management, 40 CFR Part 130) require a margin of safety (MOS) be a part of the TMDL.

Practically, the margin of safety is a reduction in the load capacity that is available for allocation to pollutant sources. The natural background load is also effectively a reduction in the load capacity available for allocation to human made pollutant sources. This can be summarized symbolically as the equation: LC = MOS + NB + LA + WLA = TMDL. The equation is written in this order because it represents the logical order in which a loading analysis is conducted. First the load capacity is determined. Then the load capacity is broken down into its components: the necessary margin of safety is determined and subtracted; then natural background, if relevant, is quantified and subtracted; and then the remainder is allocated among pollutant sources. When the breakdown and allocation are completed the result is a TMDL, which must equal the load capacity.

Another step in a loading analysis is the quantification of current pollutant loads by source. This allows the specification of load reductions as percentages from current conditions, considers equities in load reduction responsibility, and is necessary in order for pollutant trading to occur. The load capacity must be based on critical conditions – the conditions when water quality standards are most likely to be violated. If protective under critical conditions, a TMDL will be more than protective under other conditions. Because both load capacity and pollutant source loads vary, and not necessarily in concert, determination of critical conditions can be more complicated than it may appear on the surface.

A load is fundamentally a quantity of a pollutant discharged over some period of time, and is the product of concentration and flow. Due to the diverse nature of various pollutants, and the difficulty of strictly dealing with loads, the federal rules allow for “other appropriate measures” to be used when necessary. These “other measures” must still be quantifiable, and relate to water quality standards, but they allow flexibility to deal with pollutant loading in more practical and tangible ways. The rules also recognize the particular difficulty of quantifying nonpoint loads and allow “gross allotment” as a load allocation where available data or appropriate predictive techniques limit more accurate estimates. For certain pollutants whose effects are long term, such as sediment and nutrients, EPA allows for seasonal or annual loads.

# In-stream Water Quality Targets

The goal of the Fernan Lake TMDL is to restore "full support of designated beneficial uses" (Idaho Code 39.3611, 3615). The designated beneficial use targeted for restoration is the long-term maintenance of the recreation use. Fernan Lake is "water quality-limited" and on the §303(d) list. Its listing is based on not meeting Idaho Water Quality Standards narrative criteria and is the presence of a number of recent potentially toxic blooms of blue-green algae where health advisories were placed on Fernan Lake. Guided by this goal, DEQ and other federal and local agencies and stakeholders are establishing and implementing a TMDL for total phosphorus for Fernan Lake.

## Target Selection

A target level of 20 µg/L has been determined that will reduce the number of blue green algae blooms to a frequency occurring in unimpacted waters similar to Fernan Lake. Blue green algae blooms happen naturally in unimpacted lakes, just not as frequently as they occur in Fernan Lake. Our goal is to reduce the frequency of Blue green algae blooms. The rule 40 CFR§130.7(c)(1) states that "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standard." Since numeric nutrient criteria (absolute numeric values for total phosphorus) do not exist in the Idaho water quality standards, a critical step in development of the TMDL determining numeric value to serve as the water quality target.

### *Rationale for Total Phosphorus Water Quality Target*

A water quality target was established through review of conditions and existing TMDLs from neighboring lakes in Idaho and Washington. Analyses include an Idaho DEQ nutrient data inventory of similar lakes in the region, and TMDLs on two other comparable lakes in the region: Black Lake and Newman Lake in eastern Washington.

### *DEQ Nutrient Data Inventory Summary*

The Idaho DEQ compiled data for Upper Priest Lake, Spirit Lake, and Upper Twin Lake to compare the different total phosphorus ranges and trophic status. While the DEQ acknowledges differences in limnology and trophic status between these three lakes and Fernan Lake, this data compilation was useful in demonstrating other practical ranges of total phosphorus concentrations that needed to be considered when setting a lake-specific water quality target. Figure 31 displays the results of the DEQ data analysis of total phosphorus concentrations for the three lakes as well as Cocolalla and Hauser Lakes in Idaho.

Table 13 provides a comparison of the EPA nutrient values for total phosphorus of 8.00 µg/L and the DEQ regional reference values for total phosphorus for the select group of lakes ranging from 6 to 18 µg/L.

### *Black Lake TMDL*

Black Lake is located in Kootenai County, and it is one of several lateral lakes along the Coeur d'Alene River, is similar to Fernan Lake. It is 346 acres in size with a maximum depth of 7.3 meters. Black Lake has a hydraulic retention time of 0.55 years. Like Fernan Lake, may stratify June through August, but like Fernan Lake, this stratification may be periodic being broken up by wind/wave action. A variety of data sources were utilized to develop a recommendation for the Black Lake TP water quality target. These data sources, which include EPA national ecoregion guidance, Idaho DEQ nutrient data analysis of regionally similar lakes, and a paleolimnology study conducted on Black Lake (DEQ 2011). A TP water quality target recommended for the Black Lake TMDL is 20 ug/L. This TMDL was approved by the EPA in 2012.

### *Newman Lake TMDL*

Newman Lake, a shallow lake located 26 miles northeast of Spokane, WA, experienced frequent blue-green algae blooms in the late summer (WADOE 2007). Newman Lake is a mesotrophic-eutrophic lake with a volume of 26,146,829 $m^3$, a mean depth of 16 feet (5.1 meters), and a maximum depth of 30 feet (9 meters). Approximately 70 percent of the watershed has forestry as the dominant landuse.

Unlike Fernan Lake, the primary source of phosphorus causing the algae blooms was from the lake sediments in late summer (WADOE 2007). To reduce this source a whole-lake alum treatment of the lake was in 1989 and a hypolimnetic oxygenator was installed in 1992. Despite these efforts, Newman Lake remained on Washington's §303(d) list of impaired waters due to phosphorus. As such a TMDL was written and approved by the EPA in 2007. The TMDL established a target total phosphorus concentration of 20 μg/L during June through August. This is based on Washington DOEs recommended total phosphorus lake criteria for the Northern Rockies eco-region.

**Figure 31. Northern Idaho Sampling Results Among Mid-size Evaluated Lakes from Baseline Studies and CVMP Monitoring Mean Total Phosphorus in Photic Zone, April-October.**

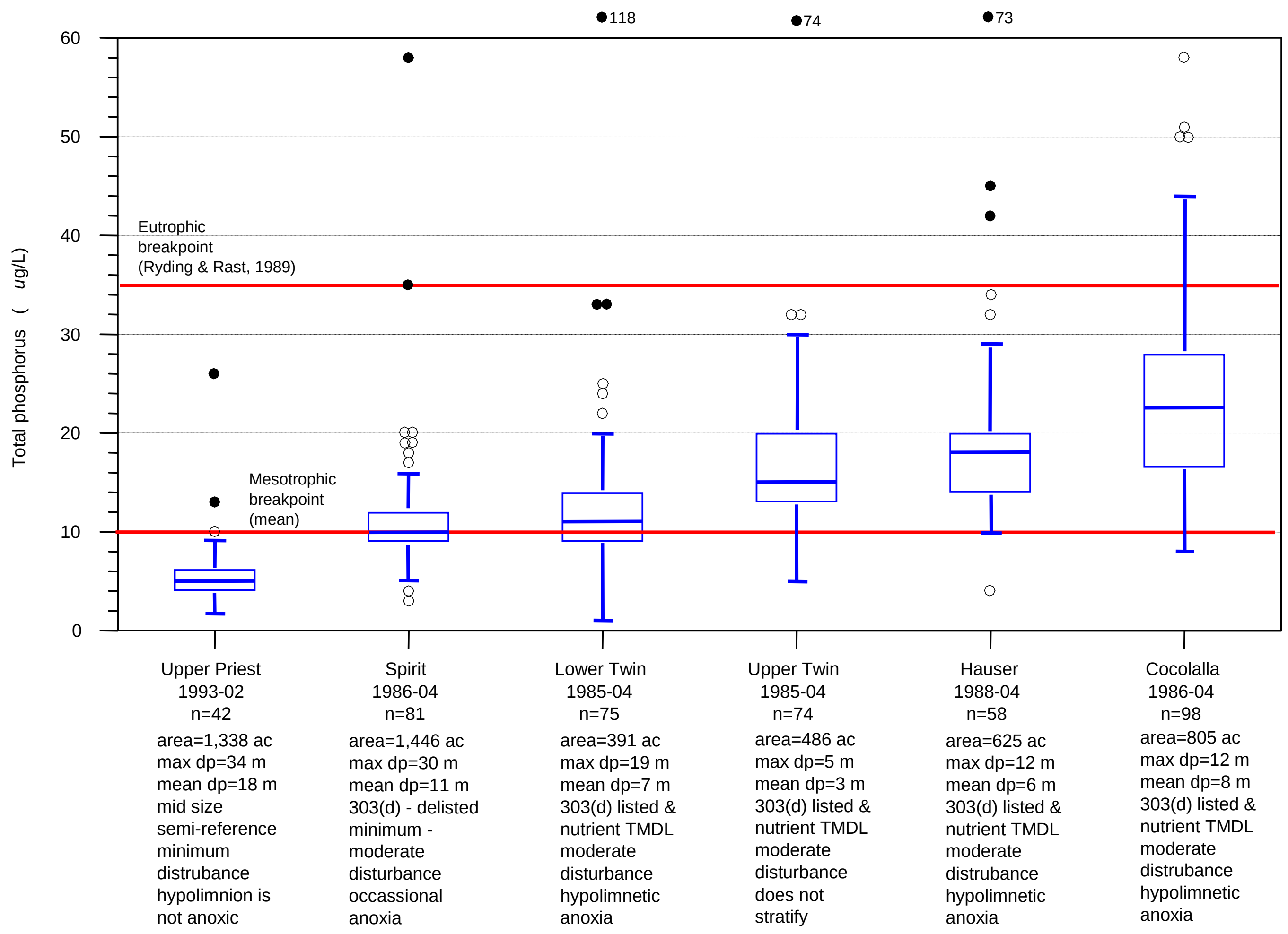


**Table 13. Comparison of Nutrient Values with Method Detection Limits**

| Constituent | State of Idaho Aquatic Uses Criteria | EPA Nutrient Ecoregion Value (µg/L) | Upper Priest Lake Mean Seasonal April –Oct. (µg/L) | Spirit Lake Mean Seasonal April – Oct. (µg/L) | Upper Twin Lake Mean Seasonal April – Oct. (µg/L) | Method Detection Limit, aka MDL (µg/L) |
|---|---|---|---|---|---|---|
| Chlorophyll a | -- | **2.1** [e] (Fluorometric method) | **2.0** [a] (1.9 median) | **3.5** [b] (2.5 median) | **6.1** [b] (5.6 median) | **5** (Spectro. method) |
| Total Phosphorus | **Narrative criteria**[1] | **8.00** [e] (summer) | **6** [a] (5 µg/L median) | **12** [b] (10 µg/L median) | **18** [b] (16 µg/L median) | **10** [2] (EPA 365.3) |
| Total Nitrogen(TKN) | **Narrative criteria**[1] | **50** [e] | **115** [a] | **380** [c] | **260** [d] | **50** |

[1]Surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses. (IDAPA 58.01.02.200.06): Nutrients or other substances from anthropogenic causes shall not be present in concentrations which will produce objectionable algal densities or nuisance aquatic vegetation, result in a dominance of nuisance species, or otherwise cause nuisance conditions.

[2]EPA Method #: 365.3 is the typical method used for TP analysis. Some laboratories have developed techniques that deliver lower MDL that reliably meet or exceed data quality objectives, but caution should be used when comparing data of unknown origins and varied laboratory techniques.

Sources : [a] Idaho DEQ baseline study from 1993 – 1995 (Rothrock 1997)
[b] Citizens Volunteer Monitoring Program (CVMP) 1988 – 2002 – oversight by Idaho DEQ
[c] Eastern Washington baseline study 1984 (Soltero and Hall 1985)
[d] University of Idaho study 1985 – 1986 (Falter 1987)
[e] EPA National Ecoregion Nutrient Guidance (EPA 2000)

### *Discussion of EPA National Ecoregion Nutrient Guidance*

Between 1998 and 2003 EPA developed and finalized nutrient criteria guidance to assist states and tribes in adopting nutrient standards. EPA's guidance values are statistically derived and disregard the nexus between causal relationships of nutrient levels and adverse water conditions. EPA developed guidance values by distinguishing natural background from anthropogenic eutrophication in ecoregions around the country. EPA utilized standardized statistical methods of establishing guidance values designed to reflect reference conditions in each water body type (rivers and streams, lakes and reservoirs, wetlands) within each ecoregion. The guidance values derived for ecoregions were developed by combining data for all lakes within each ecoregion, then applying a statistical evaluation resulting in a single number for each water quality constituent.

It was decided that the guidance value was not appropriate for Fernan Lake for several reasons. One issue affecting the acceptability of the EPA ecoregion-based nutrient criteria is the level of spatial resolution and specificity. At Level III of this classification system, the continental United States contains 104 ecoregions. There are 10 Level III ecoregions in Idaho (maps and explanations for Idaho are available at the EPA Western Ecology Division website). The Level III ecoregion containing Fernan Lake is Ecoregion #15, which encompasses the upper two thirds of Idaho plus a portion of western Montana.

The guidance value of greatest interest for Fernan Lake during the summer months is the total phosphorus concentration. There were few data (25 events) that represented total phosphorus during the summer months within Ecoregion #15. At least three of the 25, and possibly more of the events are represented by concentrations of 0.00 (zeros). Labs do not report zeros and it is unclear what these zeros represent. They could represent missing samples or below detection lab results. These zeros were included in EPA's analysis and were used to calculate an ecoregion total phosphorus guidance values. The EPA total phosphorus reference guidance value for these 25 events, and applicable to Fernan Lake, is reported as 8.00 µg/L (EPA 2000). The reported value is likely to be less certain than depicted and probably only one significant figure. As a point of comparison, lake water samples from British Columbia lakes (within the same ecoregion) suggest a natural (i.e., pre-anthropogenic) or reference level of total phosphorus between 6 and 15 µg/L (J. Stockner, pers. comm. 2004).

### Conclusions and Recommendations for Total Phosphorus Water Quality Target

Fernan Lake is a Mesotrophic lake that would naturally be found to have an intermediate level of productivity and should be commonly clear with some submerged aquatic plants and medium level of nutrients. DEQ found that an appropriate water quality target should correlate with a Mesotrophic status. DEQ used the data analysis presented in Figure 31 to define the range of 10-35 µg/L total phosphorus as representative of a Mesotrophic lake in north Idaho. We have observed that lakes neighboring Fernan Lake with most concentrations lower than 20 µg/L (Spirit, Upper Priest, Lower Twin, and Upper Twin Lakes) typically to not have blue green algae blooms. The target has been determined for Fernan Lake TMDL to be 20 µg/L.

To the extent which this has been evaluated, it is assumed that reductions in total phosphorus to meet this water quality target will reduce the rate of eutrophication and diminish the conditions that cause excess algal blooms in Fernan Lake. In addition, meeting this target may result in improvement of dissolved oxygen concentrations to levels that will support aquatic life which should decrease release of total phosphorus from the sediments in the lake bottom.

The ultimate goal is to support beneficial uses, not to solely meet target criteria. Should reductions in pollutant loading result in achievement of beneficial uses prior to meeting the recommended target, then there may be no need to reduce loads further to meet the target (except to allow for a margin of safety). Equally, if the target was to be met and beneficial uses not supported, the chosen target would be reexamined and possibly made more stringent. This assessment will be made during the 5-year review of the TMDL.

### Monitoring Points

The Fernan Lake deep monitoring station should continue to be used as the primary monitoring location to evaluate future progress toward restoring and maintaining the cold-water aquatic life use. Currently, the Citizens Volunteer Monitoring Program (CVMP) is the primary entity to collect this data. For Fernan Lake, the target should be evaluated based on an average concentration of total phosphorus of one sample per month for the months July through September, within the isothermal or epilimnion portions of the water column. This progress measurement could also be compared to an annual average total phosphorus concentration which should be used to demonstrate a statistical trend toward the 20 µg/L target. Showing progress of total phosphorus reductions over time by comparing the target to an annual average total phosphorus concentration is a practical approach for managing nonpoint sources and long-term recovery of uptake in Lake.

# Load Capacity

The load capacity of Fernan Lake is defined by the amount of phosphorus a water body can have and still support its beneficial uses. The load capacity of Fernan Lake is expressed by the following equation:

$$LC = Concentration_{Target} \times Volume_{Fernan\ Lake}$$

With a target concentration of 20 µg/L and a volume of 7.9 million $m^3$, the load capacity of Fernan Lake is 160 kg (353 lb) at any single time during the critical time period (between August 15th and September 15th).

# Estimates of Existing Pollutant Loads

Existing loads have been broken into two categories for this analysis: resulting existing load and contributing existing load. The resulting existing load is the amount of phosphorus in Fernan Lake during the critical time period. The contributing existing load is the amount that each source of phosphorus generates and delivers to Fernan Lake. Both types of existing loads are estimates made from available data. The difference between the two loads is the amount that leaves Fernan Lake through its outlet.

## Resulting Existing Load

The resulting existing load to Fernan Lake is based on the average concentration of total phosphorus during the critical time period of elevated total phosphorus concentrations between August 15 and September 15. The resulting existing load was calculated using the following equation:

$$LC = Concentration_{Avg.Existing} \times Volume_{Fernan\ Lake}$$

With an existing upper-quartile TP concentration of 31 µg/L (or 0.000031 kg/$m^3$) and a volume of 7.9 million $m^3$, the resulting existing load in Fernan Lake is 245 kg (530 lb) per year.

## Contributing Existing Load

Once the resulting existing load was determined, contributing loads were determined for the known sources of phosphorus in the watershed. As stated earlier, there are no point sources of nutrients in the Fernan Lake watershed. The primary non-point source of pollution and their estimated contributing total phosphorus loads to Fernan Lake are listed in Table 14. The method for determining the load for each source is described below.

**Table 14. Estimated contributing existing loads from sources to Fernan Lake.**

| Source | Contributing Existing Load (kg/yr) | Resulting Existing Load (lb/yr) | Proportion of Load |
|---|---|---|---|
| Fernan Creek | 3200 | 160 | 65% |
| Fernan Village Lawns | 24 | 24 | 10% |
| Fernan Village Stormwater | 4.0 | 4.0 | 2% |
| Fernan Lake Road | 14 | 14 | 6% |
| Septic | 11 | 11 | 4% |
| Internal Cycling | 24 | 24 | 10% |
| French Gulch | 1.0 | 1.0 | 0.4% |
| Other | 12 | 7.0 | 3% |

Regulations allow that loadings "...may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading," (Water quality planning and management, 40 CFR § 130.2(I)). An estimate must be made for each point source. Nonpoint sources are typically estimated based on the type of sources (land use) and area (such as a subwatershed), but may be aggregated by type of source or land area. To the extent possible, background loads should be distinguished from human-caused increases in nonpoint loads.

## Fernan Creek

Fernan Creek is the largest source of total phosphorus to Fernan Lake, with an estimated contributing existing load of 3200 kg (7055 lb). Probable sources within the Fernan Creek watershed are described in an earlier section. Due to lack of sufficient data, allocations were not assigned to the individual sources; rather, one phosphorus load allocation was assigned to the entire Fernan Creek watershed.

The phosphorus load from Fernan Creek was estimated by adding up the concentration and discharge from different flow conditions in Fernan Creek; the conditions were rain-on-snow, ascending limb, peak flow and descending limb of the hydrograph, low flow and base flow (Table 15). Discharge during each condition was taken from a hydrograph developed from the stage-flow regression using data collected by DEQ in 2000 (see Figure 10 above). No phosphorus data exists for total phosphorus concentrations for each flow condition in Fernan Creek above the lake. Using total phosphorus concentrations in Fernan Creek below the lake was not feasible due to the lag time in the lake of a sediment/phosphorus plume during rain-on-snow events. Therefore, total phosphorus concentrations were estimated using DEQ data collected in 2008-2009 from Wolf Lodge Creek. In addition to having a full data set, Wolf Lodge Creek was determined to be the best surrogate for Fernan Creek in this analysis. It was selected for the following reasons:

1. The proportions of landuse in both watersheds were comparable.
2. Wolf Lodge Creek is immediately adjacent to Fernan Creek − with the same aspect, elevation, and lithology.
3. Both watersheds have a wetland complex at the mouth.
4. Wolf Lodge Creek has a full dataset for each of the flow conditions necessary for the analysis

**Table 15. Flows in Fernan Creek at the mouth (estimated from 2000 IDEQ data).**

| | Discharge | | | Total Phosphorus Concentration | | Total Phosphorus Load | |
|---|---|---|---|---|---|---|---|
| | flow (cfs) | Days/yr | m3/yr | ug/L | kg/m3 | kg/yr | lb/yr |
| Rain-on-snow | 45 | 7 | 770,000 | 69 | 0.000069 | 53 | 120 |
| Ascending limb | 60 | 30 | 4,400,000 | 60 | 0.00006 | 260 | 570 |
| Peak flow | 300 | 30 | 22,000,000 | 110 | 0.00011 | 2,400 | 5,300 |
| Descending limb | 80 | 60 | 12,000,000 | 40 | 0.00004 | 480 | 1,100 |
| Low flow | 4 | 60 | 590,000 | 30 | 0.00003 | 18 | 40 |
| Base Flow | 1 | 178 | 440,000 | 11 | 0.000011 | 50 | 11 |
| | | 365 | | | **Total** | 3,216 | 7,141 |

Due to the strong affinity of phosphorus for sediments, approximately 50 percent of inflowing total phosphorus is permanently lost to lake sediments when sediments remain aerobic Falter (2001). It was estimated another 45 percent is passed on through the lake during to the low hydraulic retention (high discharge) time. Using this approximation, 160 kg (353 lb) of total phosphorus is introduced from Fernan Creek to Fernan Lake, which is 65 percent of the total load to the lake.

## Fernan Village

As described in detail earlier, the location of Fernan Village, the geology, and the soil physical/chemical characteristics in Fernan Village make it reasonable to assume phosphorus loading from both lawn and other landscape activities and stormwater from Fernan Village contributes to phosphorus loading to the lake.

### *Lawn and Garden*

In determining the amount of phosphorus that makes it to Fernan Lake it quickly became apparent that unknowns like application rates, cumulative contributions, fertilizer phosphorus concentration, and soil phosphorus adsorption capacity variables drove the equations used to predict amount of phosphorus load to Fernan Lake. Therefore, the following exemplifies the potential for phosphorus loading to Fernan Lake from a single home site:

This example is for a hypothetical 0.3 acre lakeside lot in Fernan Village. The house, driveway, patio take up 0.1 acres, leaving 0.2 acres to lawn and landscaping. DEQ visited a local hardware store that recommends a fertilizer that covers 4000 square feet per 20 lb. bag. The fertilizer's N-P-K numbers are 16-16-16. The fertilizer bag instructions recommend 4 applications per year. The following are assumptions from literature:

- bluegrass plant uptake rate of 0.46 lbs/10,000ft2/year (Mahler 2001) ,
- soil bulk density of 120 lbs/ft$^3$ (USDA NRCS 2012),
- phosphorus adsorption capacity of soil is 40 ppm (Mehmood 2010, MT DEQ 2005), and

- half the time grass clippings are collected and other half the time grass clippings are mulched.

In a theoretical year with 4 applications, 28 pounds of phosphorus would be added to the lawn and landscape of our hypothetical lot. Approximately 2 pounds would be taken up by plants and removed as grass clippings. Another 6.5 pounds would be adsorbed to soil below the root zone The remaining 19 pounds, hydrated by sprinklers, would be transported by ground water and potentially to Fernan Lake.

The estimated contributing phosphorus load shown in table 12 from lawns and landscaping in Fernan Village is difficult to estimate without significantly more information and understanding. However, a total estimated load of 24 kg (53 lb) or 10 percent of the total phosphorus load was assigned to Fernan Village lawns. The load was determined by evaluating the relative contribution compared to other sources (eg. Lawns are likely more than septic, similar to internal cycling), and we factored in the notion that this source exists during high hydraulic retention time (low outflow) of the lake. More importantly the load is a reminder that lawns and landscaping contribute to phosphorus loading and implementation activities can reduce this load if desired.

### *Stormwater*

To determine the amount of runoff from Fernan Village, the Modified Rational Method uses an empirical linear equation to calculate peak runoff rate and runoff volumes from a determined period with uniform rainfall intensity. The method was developed more than 100 years ago, but it is a commonly used method for drainage areas less than 20 acres (NJ Dept of Environmental Protection 2004). The Rational Method formula is:

$$Q = C \times i \times A$$

Where:

Q = peak rate of runoff ($ft^3$/sec)

C = Runoff coefficient representing relationship between rainfall and runoff: a runoff coefficient for paved surfaces of 0.7 was determined from literature (NJ Dept of Environmental Protection 2004).

i = Average intensity of rainfall for the time of concentration for a selected design storm: the average annual rainfall (inches/year) for Coeur d’Alene was determined from the National Oceanic and Atmospheric Administration, National Climatic Data Center (NCDC).

A = Drainage area in acres: the paved areas in Fernan Village were digitized using ArcGIS. The area was then calculated.

Once the peak rate of runoff of 0.03 cfs was determined, an estimated annual stormwater volume of 900,000 $ft^3$/year was calculated. To calculate a total phosphorus load, and average total phosphorus concentration data collected from French Gulch in February to April 2009 was utilized (DEQ 2010). French Gulch is a channelized ditch that drains much of the City of Coeur d’Alene stormwater. The average total phosphorus concentration from French Gulch is 106 ug/L. When calculating the load from stormwater from Fernan Village, this calculation does not include total phosphorus contributions from non-paved or roofed surfaces, nor does it assume attenuation of phosphorus in the highly porous, non-calcareous subsurface material. An estimated contributing load of 4 kg (9 lb) is estimated to be produced from stormwater from Fernan Village. This source is 1.6 percent of the total load.

## Septic

Panhandle Health District estimates the load from these septic systems to Fernan Lake is probably less than 5 percent (Fernan Lake Technical Advisory Committee 2003). In this TMDL, total phosphorus from septic tanks was assigned 4.5 percent of the load; however, it is assumed many of the homes are occupied on a seasonal basis and during high flow (low hydraulic retention time) much of the septic effluent is transported through the lake. Therefore, an 11 kg (24 lb) contributing load was assigned to septic systems.

## Internal Cycling

While additional lake study and modeling may be warranted to better define the contributions of total phosphorus from internal lake dynamics, it is reasonable to conclude internal cycling of total phosphorus is not a high percentage of loading to Fernan Lake.

To estimate internal cycling total phosphorus loading in Fernan Lake, internal cycling from Upper Twin Lake, Hauser Lake, Lower Twin Lake, and Cocolalla Lake was reviewed (Table 16). These are Mesotrophic lakes in the region with similar morphometric and limnologic characteristics

Upper Twin Lake is located in Kootenai County, and of the lakes to which we compared Fernan Lake, it is most similar to Fernan Lake. Like Fernan Lake, Upper Twin Lake a shallow, mesotrophic lake. It is 483 acres in size with a maximum depth of 5.0 meters. Like Fernan Lake, it may weakly stratify in August and September, but this stratification is quickly broken up by wind/wave action. Total phosphorus from internal cycling in Upper Fernan Lake is much lower than the other mesotrophic lakes considered in this comparison. This is due to the lack of stratification in the lake. Due to the similar lake characteristics, it is reasonable to conclude internal cycling in Fernan Lake is similar to Upper Twin Lake. Therefore, internal cycling in Fernan Lake was assigned 10 percent of the existing load or 24 kg (53 lb).

**Table 16. Internal phosphorus loading of different mesotrophic lakes in north Idaho.**

| Lake Name | Stratification? | Internal phosphorus load (kg/yr) | Percentage of total load | Source |
|---|---|---|---|---|
| Upper Twin Lake | No | 23 | 9.3 | DEQ (2011) |
| Hauser | Yes | 288 | 28.5 | DEQ (2000) |
| Lower Twin Lake | Yes | 101 | 18.2 | DEQ (2000) |
| Cocolalla | Yes | 500 | 23 | Rothrock (1995) |

## Fernan Lake Road

As stated earlier, Fernan Lake Road is a paved road which parallels the northern shore of Fernan Lake for approximately 8.5 km (5.3 miles). It is well documented that unpaved roads can be a significant source of sediment to surface water, especially in situations where the road is not well maintained or sediment control structures are not in place. However, the sediment production off paved roads is limited to that which is transported in roadside ditches and relief culverts and through direct runoff from cut and fill slopes. A literature search was conducted to better understand the sediment load from paved roads. The results are follow.

Clinton and Vose (2003) quantified total suspended solids (TSS) concentrations off four road surface types in the Southern Appalachian Mountains. They determined TSS generated from paved surfaces was slightly above background. The paved road had property sediment control measures installed. Their results reflect the combined effects of both road surface type, physical characteristics of the forest floor, soil stability and erodibility, and steepness of slope below the road surface. Reid and Dunne (1984) also indicate the road surface is the primary source of sediment from the road complex. They report sediment yield from a paved road is only 0.4 percent of that from a heavily-used gravel surface road.

Clinton and Vose (2003) indicated sediment erosion control measures on paved roads were a factor in the low TSS concentrations observed in their study. Ketcheson and Megahan (1996) observed short travel distance of sediment from sheet and rill erosion from road fill slopes. In contrast, sediment concentrated and traveled much farther from berm drains and culverts.

Due to the close proximity of the road to the shoreline of Fernan Lake, the sediment and runoff control measures may not have enough retention time to sequester all sediment and nutrients from the road. Furthermore, riparian vegetation between the road and Fernan Lake is limited, making the buffer-capacity of this area minimal. Large cutbank slopes of erodible bedrock may also be a source of sediment/phosphorus to the lake. While the paved surface of Fernan Road greatly reduces sediment transport to Fernan Lake, the cutbanks, ditches, and other features continue to contribute sediment and phosphorus to Fernan Lake. Therefore, it is estimated the road's contribution is more than septic contributions, but less than internal cycling. As such, it is reasonable to assume Fernan Lake Road is responsible for 6 percent of the contributing existing load to Fernan Lake or 14 kg (32 lb).

## French Gulch

Following rain events in late summer/fall water in French Gulch can back up and through the outlet of Fernan Lake (personal communication, Brian White, Retired Hydrogeologist and Fernan Village Resident). Flow in French Gulch during such rain events was estimated to be 0.17 $m^3$/sec (6 $ft^3$/sec) for a total of 4 days. Total phosphorus concentration during such a rain event was estimated to be 130 ug/L. Because this source is at the outlet of Fernan Lake, it is assumed some of this source is not retained in the lake, rather it is immediately transported out of the lake. Therefore, the total contributing load from French Gulch into Fernan Lake was estimated to be 1 kg (2 lb). Both flow and total phosphorus concentration were estimated using actual data collected on French Gulch by DEQ in 2009 (DEQ 2010).

## Other Nonpoint Sources

Other nonpoint sources have been grouped together, not because of lack of importance, but due to the lack of data to accurately quantify the load from these sources.

# Load Allocation

As stated earlier, a TMDL prescribes an upper limit on discharge of a pollutant from all sources so as to assure water quality standards are met. It further allocates this load capacity (LC) among the various sources of the pollutant. The specification of load reductions in this TMDL are expressed as percentages with an equitable distribution of load reduction responsibility. As previously discussed, the following equation: LC = MOS + NB + LA + WLA = TMDL is used as the method for quantifying the TMDL and allocating the loads among sources. Also previously stated, it was assumed that natural background levels are included in target concentrations chosen for total phosphorus and that the MOS for the Fernan Lake total phosphorus TMDL is implicit, which is summarized in more detail later in this section. Therefore, the Fernan Lake total phosphorus TMDL is equal to the LA which is the sum of all the nonpoint sources of total phosphorus quantified.

Existing loads and load allocations for all sources of total phosphorus to Fernan Lake are listed in Table 17. The total load reduction for all the sources is 35 percent to meet the target load capacity of 158 kg (348 lb) at any time during the critical time period (Aug 15 – Sept 15). To determine the load reduction of the sources the excess phosphorus over the target load capacity was divided among the sources according to their percentage of contribution to derive load allocations for the individual sources.

**Table 17. Load allocation and percent load reductions for total phosphorus sources to Fernan Lake**

| Existing TP concentration[1] (ug/L) | Existing load[1] (kg) | Fraction of TP reduction needed to meet target concentration | Target concentration[1] (ug/L) | TP load at target concentration[1] (kg) |
|---|---|---|---|---|
| 31 | 245 | 35% | 20 | 158 |

| Source | Existing amount of TP contributed by source (kg/yr) | Existing TP Load[1] (kg/yr) | Fraction of TP reduction needed to meet target concentration[1] (load reduction) (percent) | Amount of TP reduction needed to meet target concentration[1] (load reduction) (kg/yr) | Amount of TP contributed by source after reductions (load allocation) (kg/yr) | TP load at target concentrations [1] (kg/yr) |
|---|---|---|---|---|---|---|
| **Fernan Creek** | 3200 | 160[2] | 35% | 1120 | 2080 | 104[2] |
| **Fernan Village Lawns** | 24 | 24 | 35% | 8.4 | 16 | 16 |
| **Fernan Village Stormwater** | 4 | 4 | 35% | 1.4 | 2.6 | 2.6 |
| **Fernan Lake Road** | 14 | 14 | 35% | 4.9 | 9.1 | 9.1 |
| **Septic** | 11 | 11 | 35% | 3.9 | 7.2 | 7.2 |
| **Internal Cycling** | 24 | 24 | 35% | -- | -- | -- |
| **French Gulch** | 1 | 1 | 35% | 0.4 | 0.7 | 0.7 |
| **Other** | 12 | 7.0 | 35% | 2.5 | 7.8 | 4.6 |
| **Total** | **3290** | **245** | | **1149.9** | **2139.4** | **160.2** |

[1]Concentrations and loads are during the critical time period between August 15th and September 15th.
[2]Load remaining after Spring flows flush through Fernan Lake. At high flows, much of the TP in Fernan Creek is flushed through the outlet of Fernan Lake and it does not remain in the lake.

## Margin of Safety

To account for uncertainty associated with insufficient or unknown data, and the relationship between pollutant loads and beneficial use impairment, a margin of safety is included in development of load analyses. There are several ways to implement a margin of safety. For Fernan Lake, conservative assumptions were utilized in the watershed loading calculations. These conservative assumptions, which convey and implicit margin of safety when estimating the load allocation, are summarized below:

- The TMDL is based on an upper quartile total phosphorus concentration observed during the period between August 15 and September 15, when total phosphorus concentrations are the highest.
- The target concentration of 20 ug/L is conservative.
- Actual flow and total phosphorus data was used to calculate loads from a number of sources. Flows and total phosphorus concentrations from variable conditions (rain-on-snow, runoff, etc) were over-estimates, as they were measured at the peak of that particular condition.
- All load values were expressed in appropriate number of significant figures - conservative accounting for variability in the data. All “5”s rounded conservatively.

## Seasonal Variation

Although much of the TP loading is during spring runoff, the critical period for nutrients affecting beneficial uses in Fernan Lake generally is the warmer months of summer and early fall. Nutrients promote growth of aquatic vegetation, including algae, which usually is at its highest density in late summer - a time of high recreational use. The TMDL approach used accounted for seasonal variation by choosing the upper quartile cut off value of total phosphorus concentrations from a time period of elevated total phosphorus concentrations between August 15 and September 15. The target concentration for total phosphorus in Fernan Lake is based on the upper quartile concentration for the time period between August 15 and September 15 – the period of greatest concern for high densities of algae, blue-green algae blooms.

## Reasonable Assurance

The EPA requires that TMDLs with a combination of point and nonpoint sources and with wasteload allocations dependent on nonpoint source controls, provide reasonable assurance that the nonpoint source controls will be implemented and effective in achieving the load allocation (EPA 1991a). Nonpoint source reductions listed in the Fernan Lake TMDL will be achieved through state authority within the Idaho Nonpoint Source Management Program. Section 319 of the federal CWA requires each state to submit to EPA a management plan for controlling pollution from nonpoint sources to waters of the state.

The plan must: identify programs to achieve implementation of BMPs; furnish a schedule containing annual milestones for utilization of program implementation methods; provide certification by the attorney general of the state that adequate authorities exist to execute the plan for implementation of BMPs; and include a listing of available funding sources for these programs. The current Idaho Nonpoint Source Management Plan has been approved by EPA (December 1999) as meeting the intent of §319 of the CWA.

As described in the Idaho Nonpoint Source Management Plan, Idaho water quality standards require that if monitoring indicates water quality standards are not met due to nonpoint source impacts, even with the use of current BMPs, the practices will be evaluated and modified as necessary by the appropriate agencies in accordance with provisions of the Administrative Procedure Act (IDAPA). If necessary, injunctive or other judicial relief may be initiated against the operator of a nonpoint source activity in accordance with authority of the Director of Environmental Quality provided in Section 39-108, Idaho Code (IDAPA 58.01.02.350). Idaho water quality standards list designated agencies responsible for reviewing and revising nonpoint source BMPs based on water quality monitoring data generated through the state's water quality monitoring program. Designated agencies are: Department of Lands for timber harvest activities, oil and gas exploration and development, and mining activities; Soil Conservation Commission for grazing and agricultural activities; Transportation Department for public road construction; Department of Agriculture for aquaculture; and the Department of Environmental Quality for all other activities (Idaho Code 39-3602).

Existing authorities and programs for assuring implementation of BMPs to control nonpoint sources of pollution in Idaho are as follows:

- Nonpoint Source 319 Grant Program
- State Agricultural Water Quality Program
- Wetlands Reserve Program
- Resource Conservation and Development
- Agricultural Pollution Abatement Plan
- Conservation Reserve Program
- Idaho Forest Practices Act
- Environmental Quality Improvement Program
- Stream Channel Protection Act
- Water Quality Certification for Dredge and Fill

The Idaho water quality standards direct appointed advisory groups to recommend specific actions needed to control point and nonpoint sources affecting water quality limited water bodies. Upon approval of this TMDL by EPA Region 10, the Fernan Lake Watershed Advisory Group, with the assistance of appropriate local, state, tribal, and federal agencies, will begin formulating specific pollution control actions for achieving water quality targets listed in the Fernan Lake TMDL. The plan should be completed within 18 months of finalization and approval of the TMDL by EPA.

## Background

Background sources of total phosphorus are as follows:

- A percentage of the load from the Fernan Lake watershed is from natural runoff from undeveloped forested land.
- Loading from areas in the lake with submerged macrophytes.
- Internal cycling of phosphorus in Fernan Lake.

## Construction Storm Water and TMDL Waste Load Allocations

### *Construction Storm Water*

The Clean Water Act requires operators of construction sites to obtain permit coverage to discharge storm water to a water body or to a municipal storm sewer. In Idaho, EPA has issued a general permit for storm water discharges from construction sites. In the past storm water was treated as a non-point source of pollutants. However, because storm water can be managed on site through management practices or when discharged through a discrete conveyance such as a storm sewer, it now requires a National Pollution Discharge Elimination System (NPDES) Permit. Currently, there are no construction storm water sites in operation in the Fernan Lake watershed which required the Construction General Permit.

### *The Construction General Permit (CGP)*

If a construction project disturbs more than one acre of land (or is part of larger common development) that will disturb more than one acre), the operator is required to apply for permit coverage from EPA after developing a site-specific Storm Water Pollution Prevention Plan. Currently, there are no construction projects under the Construction General Permit in the Fernan Lake watershed.

### *Storm Water Pollution Prevention Plan (SWPPP)*

In order to obtain the Construction General Permit operators must develop a site-specific Storm Water Pollution Prevention Plan (SWPPP). The operator must document the erosion, sediment, and pollution controls they intend to use, inspect the controls periodically and maintain the best management practices (BMPs) through the life of the project

### *Construction Storm Water Requirements*

When a stream is on Idaho's § 303(d) list and has a TMDL developed DEQ may incorporate a gross WLA for anticipated construction storm water activities. TMDLs developed in the past that did not have a WLA for construction storm water activities will also be considered in compliance with provisions of the TMDL if they obtain a Construction General Permit (CGP) under the NPDES program and implement the appropriate Best Management Practices.

Typically, there are specific requirements you must follow to be consistent with any local pollutant allocations. Many communities throughout Idaho are currently developing rules for post-construction storm water management. Sediment is usually the main pollutant of concern in storm water from construction sites. The application of specific best management practices from *Idaho's Catalog of Storm Water Best Management Practices for Idaho Cities and Counties* is generally sufficient to meet the standards and requirements of the General

Construction Permit, unless local ordinances have more stringent and site specific standards that are applicable.

### Remaining Available Load/Reserve for Growth

There was no available load to assign for reserve for growth.

# Implementation Strategies

Meeting the pollutant load allocations for total phosphorus discussed in this TMDL requires implementation of various policies, programs, and projects aimed at improving water quality in Fernan Lake. Like the TMDL, the goal of the implementation plan is to reduce nutrient loading to support beneficial uses. DEQ recognizes that implementation strategies for TMDLs may need to be modified if monitoring shows that TMDL goals are not being met or if substantial progress is not being made toward achieving those goals. Conversely, should monitoring show beneficial uses are being supported prior to attainment of TMDL targets, less restrictive load allocations will be considered. Any implementation plan will concentrate on reducing nutrients. It is important that the implementation plan better characterize the nutrient sources from the Fernan Creek watershed to better allocate resources for implementation. Reduction in pollutant loadings for nonpoint sources will most likely require a mix of policy changes, program initiatives, and implementation of BMPs.

## Time Frame

Because pollutants in Fernan Lake come from nonpoint sources, implementation of pollution reduction is strictly on an opportunistic basis.  Therefore, the time frame proposed for attainment of beneficial uses in Fernan Lake is 20 years.

## Approach

The implementation plan for Fernan Lake will explore opportunities to reduce total phosphorus pollution to Fernan Lake from US Forest Service property, Fernan Village, and from private property in Fernan Creek and other parts of the Fernan Lake watershed.  It is very important to characterize the pollutant sources in the Fernan Creek watershed during the implementation phase of this TMDL.  It is also important to evaluate the dam’s effect on lake water quality during the implementation phase of this TMDL

Implementation of BMPs for other non-point sources to the lake will be addressed by Designated Management Agencies.  Grazing and agricultural aspects of the implementation plan will be written and developed by Soil Conservation Commission. Public road construction activities fall under the auspices of Transportation Department. All other activities are under the purview of the DEQ.

## Responsible Parties

The implementation of a plan to improve water quality in Black Lake will require the cooperation of many entities. These may include, but not be limited to, the following:

- Tribal Government – Coeur d’Alene Tribe
- Federal Government – Natural Resources Conservation Service, U.S. Forest Service, Bureau of Land Management, Bureau of Indian Affairs

- State Government – Departments of Environmental Quality, Lands, Transportation, Fish and Game, and Agriculture, Soil Conservation Commission
- County Government – Kootenai County
- Local Government – the City of Coeur d'Alene and Fernan Village
- Quasi-Government – Kootenai-Shoshone Soil and Water Conservation District
- Numerous private individuals

## Monitoring Strategy

Funding sources will continue to be sought that fund the CVMP program which collects valuable physical/chemical data on Fernan Lake. DEQ, the WAG, and/or Designated Management Agencies will develop and implement any other monitoring plan(s), if needed, to measure changes to water quality once management actions are taken and BMPs are installed. If monitoring shows phosphorus reduction efforts are not being achieved, DEQ will determine whether load reduction targets, load allocations, and/or the implementation strategy should be revised.

# Pollution Trading

Pollutant trading (also known as *water quality trading*) is a contractual agreement to exchange pollution reductions between two parties. Pollutant trading is a business-like way of helping to solve water quality problems by focusing on cost effective local solutions to problems caused by pollutant discharges to surface waters.

The appeal of trading emerges when pollutant sources face substantially different pollutant reduction costs. Typically, a party facing relatively high pollutant reduction costs compensates another party to achieve an equivalent, though less costly, pollutant reduction.

Pollutant trading is voluntary. Parties trade only if both are better off because of the trade, and trading allows parties to decide how to best reduce pollutant loadings within the limits of certain requirements.

Pollutant trading is recognized in Idaho's Water Quality Standards at IDAPA 58.01.02.054.06. Currently, DEQ's policy is to allow for pollutant trading as a means to meet total maximum daily loads (TMDLs), thus restoring water quality limited water bodies to compliance with water quality standards. The *Pollutant Trading Guidance* document sets forth the procedures to be followed for pollutant trading:

httotal phosphorus://www.deq.idaho.gov/water/prog_issues/waste_water/pollutant_trading/pollutant_trading_guidance_entire.pdf

## Trading Components

The major components of pollutant trading are *trading parties* (buyers and sellers) and *credits* (the commodity being bought and sold). Additionally, *ratios* are used to ensure environmental equivalency of trades on water bodies covered by a TMDL. All trading activity must be recorded in the trading database through the Idaho Clean Water Cooperative, Inc.

Both point and nonpoint sources may create marketable credits, which are a reduction of a pollutant beyond a level set by a TMDL:

- Point sources create credits by reducing pollutant discharges below NPDES effluent limits set initially by the waste load allocation.
- Nonpoint sources create credits by implementing approved best management practices (BMPs) that reduce the amount of pollutant run-off. Nonpoint sources must follow specific design, maintenance, and monitoring requirements for that BMP, apply discounts to credits generated if required, and provide a water quality contribution to ensure a net environmental benefit. The water quality contribution also ensures the reduction (the marketable credit), is surplus to the reductions the TMDL assumes the nonpoint source is achieving to meet the water quality goals of the TMDL.

### Watershed-Specific Environmental Protection

Trades must be implemented so that the overall water quality of the water bodies covered by the TMDL are protected. To do this, hydrologically-based ratios are developed to ensure trades between sources distributed throughout TMDL water bodies result in environmentally equivalent or better outcomes at the point of environmental concern. Moreover, localized adverse impacts to water quality are not allowed.

### Trading Framework

For pollutant trading to be authorized, it must be specifically mentioned within a TMDL document. After adoption of an EPA approved TMDL, DEQ, in concert with the Watershed Advisory Group (WAG), must develop a pollutant trading framework document as part of an implementation plan for the watershed that is the subject of the TMDL.

The elements of a trading document are described in DEQ's Pollutant Trading Guidance:

httotal phosphorus://www.deq.idaho.gov/water/prog_issues/waste_water/pollutant_trading/pollutant_trading_guidance_entire.pdf.

# Public Participation

House Bill 145 (HB145) has brought about changes in how WAGs are involved in TMDL development and review. The basic process for developing TMDLs and implementation plans is as follows:

1. BAG members are appointed by DEQ's director for each of Idaho's basins.
2. An "Integrated Report" is developed by DEQ every two years that highlights which water bodies in Idaho appear to be degraded.
3. DEQ prepares to begin the SBA and TMDL process for individual degraded watersheds.
4. A WAG is formed by DEQ (with help from the BAG) for a specific watershed/TMDL.
5. With the assistance of the WAG, DEQ develops an SBA and any necessary TMDLs for the watershed.
6. The WAG comments on the SBA/TMDL.

7. WAG comments are considered and incorporated, as appropriate, by DEQ into the SBA/TMDL.
8. The public comments on the SBA/TMDL.
9. Public comments are considered and incorporated, as appropriate, by DEQ into the SBA/TMDL.
10. DEQ sends the document to the U.S. Environmental Protection Agency (EPA) for approval.
11. DEQ and the WAG develop, then implement, a plan to reach the goals of the TMDL.

DEQ will provide the WAG with all available information pertinent to the SBA/TMDL, when requested, such as monitoring data, water quality assessments, and relevant reports. The WAG will also have the opportunity to actively participate in preparing the SBA/TMDL documents.

Once a draft SBA/TMDL is complete, it is reviewed first by the WAG, then by the public. If, after WAG comments have been considered and incorporated, a WAG is not in agreement with an SBA/TMDL, the WAG's position and the basis for it will be documented in the public notice of public availability of the SBA/TMDL for review. If the WAG still disagrees with the SBA/TMDL after public comments have been considered and incorporated, DEQ must incorporate the WAG's dissenting opinion.

# Conclusions

Data examined did not indicate that nutrients, sediment, or DO are impairing beneficial uses in Fernan Lake. Total phosphorus load allocations were developed from nonpoint sources in the Fernan Lake watershed. Target loading analysis predicted that if the phosphorus load is reduced as recommended, the target level of phosphorus of 20 μg/L total phosphorus in Fernan Lake shall be achieved. TMDL load allocations were assigned to the Fernan Creek watershed, Fernan Village, Fernan Creek Road, septic effluent, internal lake cycling, and other sources such as developed/undeveloped property to the north and south of the creek. Once this TMDL is approved, it is recommended Fernan Lake be moved to Section 4a of Idaho's 2014 Integrated Report (Table 18).

As time and resources allow, DEQ will continue to fund the CVMP program to collect valuable physical/chemical data on Fernan Lake. If monitoring shows phosphorus reduction efforts are not being achieved, DEQ will determine whether load reduction targets, load allocations and/or the implementation strategy should be revised.

**Table 18. Summary of assessment outcomes.**

| Water Body Name/Assessment Unit | Pollutant | TMDL(s) Completed | Recommended Changes to the 2014 Integrated Report | Justification | TMDL Loads |
|---|---|---|---|---|---|
| Fernan Lake | Total phosphorus | Yes | Move to Section 4a in 2014 Integrated Report | Nutrients impairing recreation beneficial use | 7 percent reduction |

# References Cited


American Geological Institute. 1962. Dictionary of geological terms. Doubleday and Company. Garden City, NY. 545 p.

Armantrout, N.B., compiler. 1998. Glossary of aquatic habitat inventory terminology. American Fisheries Society. Bethesda, MD. 136 p.

Batt, P.E. 1996. Governor Philip E. Batt's Idaho bull trout conservation plan. State of Idaho, Office of the Governor. Boise, ID. 20 p + appendices.

Clean Water Act (Federal water pollution control act), 33 U.S.C. § 1251-1387. 1972.

Centers for Disease Control and Prevention (CDC). 2008. Harmful Algal Blooms. United States Department of Health and Human Services. Available: httotal phosphorus://www.cdc.gov/hab/about.htm. (August 2008).

City of Coeur d'Alene. 2010. Annual Report, Municipal Separate Storm Sewer System (MS4) Federal Storm Water National Pollutant Discharge Elimination System Permit (IDS-028215). http://www.cdaid.org/mod/userpage/images/NPDESAnnualReport.pdf

City of Coeur d'Alene. 2003. Council Bill 05-1004, Ordinance Number 3207. httotal phosphorus://www.cdaid.org/mod/userpage/images/hillside.pdf.

EPA. 1996. Biological criteria: technical guidance for streams and small rivers. EPA 822-B-96-001. U.S. Environmental Protection Agency, Office of Water. Washington, DC. 162 p.

Falter, Michael. 2001. Fernan Lake (Kootenai County, Idaho) Aquatic and Fisheries Ecology with Apparent Controlling Factors. A report prepared for David Evans & Associates, Spokane, Washington.

Fernan Lake Technical Advisory Committee. 2003. Fernan Lake Watershed Management Plan, Draft. httotal phosphorus://www.cdaid.org/mod/userpage/images/fernan-watershed.pdf.

Franson, M.A.H., L.S. Clesceri, A.E. Greenberg, and A.D. Eaton, editors. 1998. Standard methods for the examination of water and wastewater, twentieth edition. American Public Health Association. Washington, DC. 1,191 p.

Grafe, C.S., C.A. Mebane, M.J. McIntyre, D.A. Essig, D.H. Brandt, and D.T. Mosier. 2002. The Idaho Department of Environmental Quality water body assessment guidance, second edition-final. Department of Environmental Quality. Boise, ID. 114 p.

HDR. 2007. Spokane County Onsite Seawge Disposal Systems Phosphorus Loading Estimate Technical Memorandum. httotal phosphorus://www.spokanecounty.org/utilities/rptdoc/2008jan/04-B%20Septic_Phosphorus_Study-FINAL.pdf

Hughes, R.M. 1995. Defining acceptable biological status by comparing with reference condition. In: Davis, W.S. and T.P. Simon, editors. Biological assessment and criteria:

tools for water resource planning and decision making. CRC Press. Boca Raton, FL. p 31-48.

Idaho Code § 39.3611. Development and implementation of total maximum daily load or equivalent processes.

Idaho Code § 39.3615. Creation of watershed advisory groups.

Idaho Department of Environmental Quality 2011. Black Lake Watershed Assessment and Total Maximum Daily Load. http://www.deq.idaho.gov/media/570794-draft_tmdl_0809.pdf

Idaho Department of Environmental Quality 2010. Coeur d'Alene Lake Tributaries 2008-2009 Nutrient and Sediment Monitoring, Final Report. httotal phosphorus://www.deq.idaho.gov/media/574860-nutrient_sediment_monitoring_report.pdf

Idaho Department of Environmental Quality. 2000. Coeur d'Alene Lake and River (17010303) Subbasin Assessment Proposed Total Maximum Daily Load. httotal phosphorus://www.deq.idaho.gov/media/453634-_water_data_reports_surface_water_tmdls_cda_lake_river_cda_lake_river_entire.pdf

Idaho Department of Environmental Quality. 2000. Sub-basin Assessment and Total Maximum Daily Loads of Lake and Streams located on or Draining to the Rathdrum Prairie. http://www.deq.idaho.gov/media/452833-upper_spokane_entire.pdf

Idaho Fish and Game. 2011. Idaho Fish and Game fishery management annual report, Panhandle Region. IDFG 11-117. httotal phosphoruss://research.idfg.idaho.gov/Fisheries%20Research%20Reports/mgt11-117Maiolie2010%20Fishery%20Management%20Annual%20Report%20Panhandle%20Region%202010%20reduced.pdf

Idaho Fish and Game. 2007. Fisheries management Plan 2007-2012. httotal phosphorus://fishandgame.idaho.gov/public/fish/planFisheries.pdf

Idaho Transportation Department. 2010. Idaho Transportation Department District One Municipal Separate Storm Sewer System (MS4) EPA NPDES Permit No: IDS-028223 Annual Report Submittal for the Reporting Period January 1, 2009-December 31, 2009. http://itd.idaho.gov/enviro/Stormwater/Overview/MS4/MS4-Annual_Reports/D1_2008-2009.pdf

IDAPA 58.01.02. Idaho water quality standards and wastewater treatment requirements.

Kann, J. and C. M. Falter 1987. Development of Toxic Blue-Green Algal Blooms in Black Lake, Kootenai County, Idaho. Idaho Water Resources Research Institute, Technical Report, Oct. 1987, 37 pp.

Karr, J.R. 1991. Biological integrity: a long-neglected aspect of water resource management. Ecological Applications 1:66-84.

Mehmood, Ayaz, Mohammad Saleem Akhtar, Rifat Hayat, and Mehruinsa Memon. 2012. Phosphorus Adsorption parameters in Relation to Soil Characteristics. Journal of Chemical Society of Pakistan. 32:2 129-139.

Milligan, J.H., Ra.A. Lyman, C.M. Flater, E.E. Krumpe, and J.E. Carlson. 1983. Classification of Idaho's freshwater lakes. Idaho Water and Energy Resources Research Institute, Moscow, Idaho. Report submitted to Idaho Divison of Environment, Boise, Idaho.

Montana Department of Environmental Quality 2005. (revised 2009). How to Perform a Nondegradation Analysis for Subsurface Watewater Treatment Systems (SWTS) Under the Subdivision Review Process. httotal phosphorus://deq.mt.gov/wqinfo/nondeg/HowToNonDeReg.mcpx

Mossier, Jere. 1993. Idaho Lake Water Quality Assessment Report. Idaho Department of Health and Welfare Division of Environmental Quality Water Quality Status Report No. 105.

New Jersey Department of Environmental Protection, Division of Watershed Management.. 2004. New Jersey Stormwater Best Management Practices Manual. http://www.njstormwater.org/bmp_manual2.htm

Rand, G.W., editor. 1995. Fundamentals of aquatic toxicology: effects, environmental fate, and risk assessment, second edition. Taylor and Francis. Washington, DC. 1,125 p.

Rothrock, Glen. 1995. Phase I Diagnostic and Feasibility Analysis Cocolalla Lake, Bonner County Idaho 1990 – 1992. Idaho Department of Health and Welfare.

Strahler, A.N. 1957. Quantitative analysis of watershed geomorphology. Transactions American Geophysical Union 38:913-920.

United States Department of Agriculture, Natural Resources Conservation Service. 2012. Web Soil Survey (WSS). http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

United States Geological Survey. 1987. Hydrologic unit maps. Water supply paper 2294. United States Geological Survey. Denver, CO. 63 pp.

Mahler, Robert. Northern Idaho Fertilizer Guide, Bluegrass Seed. University of Idaho College of Agriculture Cooperative Extension System Agricultural Experiment Station CIS 788 (rev.). http://www.ag.uidaho.edu/bluegrass/FromJohn/Kentucky%20bluegrass/Soils%20and%20Nutrition/CIS0788.pdf

Washington Department of Ecology. 2007. Newman Lake Phosphorus Total Maximum Daily Load Water Quality Improvement Report. Report number 06-10-045. https://fortress.wa.gov/ecy/publications/publications/0610045.pdf

Water Environment Federation. 1987. The Clean Water Act of 1987. Water Environment Federation. Alexandria, VA. 318 p.

Water Quality Act of 1987, Public Law 100-4. 1987.

Water quality planning and management, 40 CFR Part 130.

## GIS Coverages

Restriction of liability: Neither the state of Idaho nor the Department of Environmental Quality, nor any of their employees make any warranty, express or implied, or assume any legal liability or responsibility for the accuracy, completeness or usefulness of any information or data provided. Metadata is provided for all data sets, and no data should be used without first reading and understanding its limitations. The data could include technical inaccuracies or typographical errors. The Department of Environmental Quality may update, modify, or revise the data used at any time, without notice.

## Other Related Documents

Add any other related documents here that you didn't specifically cite in your text. Keep these to a minimum. If you don't have any, delete this section.

# Glossary

**305(b)**

Refers to section 305 subsection "b" of the Clean Water Act. The term "305(b)" generally describes a report of each state's water quality and is the principle means by which the U.S. Environmental Protection Agency, Congress, and the public evaluate whether U.S. waters meet water quality standards, the progress made in maintaining and restoring water quality, and the extent of the remaining problems.

**§303(d)**

Refers to section 303 subsection "d" of the Clean Water Act. 303(d) requires states to develop a list of water bodies that do not meet water quality standards. This section also requires total maximum daily loads (TMDLs) be prepared for listed waters. Both the list and the TMDLs are subject to U.S. Environmental Protection Agency approval.

**Acre-foot**

A volume of water that would cover an acre to a depth of one foot. Often used to quantify reservoir storage and the annual discharge of large rivers.

**Adsorption**

The adhesion of one substance to the surface of another. Clays, for example, can adsorb phosphorus and organic molecules

**Aeration**

A process by which water becomes charged with air directly from the atmosphere. Dissolved gases, such as oxygen, are then available for reactions in water.

**Aerobic**

Describes life, processes, or conditions that require the presence of oxygen.

**Adfluvial**

Describes fish whose life history involves seasonal migration from lakes to streams for spawning.

**Adjunct**

In the context of water quality, adjunct refers to areas directly adjacent to focal or refuge habitats that have been degraded by human or natural disturbances and do not presently support high diversity or abundance of native species.

**Alevin**

A newly hatched, incompletely developed fish (usually a salmonid) still in nest or inactive on the bottom of a water body, living off stored yolk.

**Algae**

Non-vascular (without water-conducting tissue) aquatic plants that occur as single cells, colonies, or filaments.

**Alluvium**

Unconsolidated recent stream deposition.

**Ambient**

General conditions in the environment (Armantrout 1998). In the context of water quality, ambient waters are those representative of general conditions,

| | |
|---|---|
| | not associated with episodic perturbations or specific disturbances such as a wastewater outfall (EPA 1996). |
| **Anadromous** | Fish, such as salmon and sea-run trout, that live part or the majority of their lives in the saltwater but return to fresh water to spawn. |
| **Anaerobic** | Describes the processes that occur in the absence of molecular oxygen and describes the condition of water that is devoid of molecular oxygen. |
| **Anoxia** | The condition of oxygen absence or deficiency. |
| **Anthropogenic** | Relating to, or resulting from, the influence of human beings on nature. |
| **Anti-Degradation** | Refers to the U.S. Environmental Protection Agency's interpretation of the Clean Water Act goal that states and tribes maintain, as well as restore, water quality. This applies to waters that meet or are of higher water quality than required by state standards. State rules provide that the quality of those high quality waters may be lowered only to allow important social or economic development and only after adequate public participation (IDAPA 58.01.02.051). In all cases, the existing beneficial uses must be maintained. State rules further define lowered water quality to be 1) a measurable change, 2) a change adverse to a use, and 3) a change in a pollutant relevant to the water's uses (IDAPA 58.01.02.003.61). |
| **Aquatic** | Occurring, growing, or living in water. |
| **Aquifer** | An underground, water-bearing layer or stratum of permeable rock, sand, or gravel capable of yielding of water to wells or springs. |
| **Assemblage (aquatic)** | An association of interacting populations of organisms in a given water body; for example, a fish assemblage or a benthic macroinvertebrate assemblage (also see Community) (EPA 1996). |
| **Assessment Database (ADB)** | The ADB is a relational database application designed for the U.S. Environmental Protection Agency for tracking water quality assessment data, such as use attainment and causes and sources of impairment. States need to track this information and many other types of assessment data for thousands of water bodies and integrate it into meaningful reports. The ADB is designed to make this process accurate, straightforward, and user-friendly for participating states, territories, tribes, and basin commissions. |
| **Assessment Unit (AU)** | A segment of a water body that is treated as a homogenous unit, meaning that any designated uses, the rating of these uses, and any associated causes and sources must be applied to the entirety of the unit. |
| **Assimilative Capacity** | The ability to process or dissipate pollutants without ill effect to beneficial uses. |

**Autotrophic**

An organism is considered autotrophic if it uses carbon dioxide as its main source of carbon. This most commonly happens through photosynthesis.

**Batholith**

A large body of intrusive igneous rock that has more than 40 square miles of surface exposure and no known floor. A batholith usually consists of coarse-grained rocks such as granite.

**Bedload**

Material (generally sand-sized or larger sediment) that is carried along the streambed by rolling or bouncing.

**Beneficial Use**

Any of the various uses of water, including, but not limited to, aquatic life, recreation, water supply, wildlife habitat, and aesthetics, which are recognized in water quality standards.

**Beneficial Use Reconnaissance Program (BURP)**

A program for conducting systematic biological and physical habitat surveys of water bodies in Idaho. BURP protocols address lakes, reservoirs, and wadeable streams and rivers

**Benthic**

Pertaining to or living on or in the bottom sediments of a water body

**Benthic Organic Matter.**

The organic matter on the bottom of a water body.

**Benthos**

Organisms living in and on the bottom sediments of lakes and streams. Originally, the term meant the lake bottom, but it is now applied almost uniformly to the animals associated with the lake and stream bottoms.

**Best Management Practices (BMPs)**

Structural, nonstructural, and managerial techniques that are effective and practical means to control nonpoint source pollutants.

**Best Professional Judgment**

A conclusion and/or interpretation derived by a trained and/or technically competent individual by applying interpretation and synthesizing information.

**Biochemical Oxygen Demand (BOD)**

The amount of dissolved oxygen used by organisms during the decomposition (respiration) of organic matter, expressed as mass of oxygen per volume of water, over some specified period of time.

**Biological Integrity**

1) The condition of an aquatic community inhabiting unimpaired water bodies of a specified habitat as measured by an evaluation of multiple attributes of the aquatic biota (EPA 1996). 2) The ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to the natural habitats of a region (Karr 1991).

**Biomass**

The weight of biological matter. Standing crop is the amount of biomass (e.g., fish or algae) in a body of water at a given time. Often expressed as grams per square meter.

**Biota**

The animal and plant life of a given region.

**Biotic**

A term applied to the living components of an area.

**Clean Water Act (CWA)**

The Federal Water Pollution Control Act (commonly known as the Clean Water Act), as last reauthorized by the Water Quality Act of 1987, establishes a process for states to use to develop information on, and control the quality of, the nation's water resources.

**Coliform Bacteria**

A group of bacteria predominantly inhabiting the intestines of humans and animals but also found in soil. Coliform bacteria are commonly used as indicators of the possible presence of pathogenic organisms (also see Fecal Coliform Bacteria, *E. Coli*, and Pathogens).

**Colluvium**

Material transported to a site by gravity.

**Community**

A group of interacting organisms living together in a given place.

**Conductivity**

The ability of an aqueous solution to carry electric current, expressed in micro (μ) mhos/centimeter at 25 °C. Conductivity is affected by dissolved solids and is used as an indirect measure of total dissolved solids in a water sample.

**Cretaceous**

The final period of the Mesozoic era (after the Jurassic and before the Tertiary period of the Cenozoic era), thought to have covered the span of time between 135 and 65 million years ago.

**Criteria**

In the context of water quality, numeric or descriptive factors taken into account in setting standards for various pollutants. These factors are used to determine limits on allowable concentration levels, and to limit the number of violations per year. The U.S. Environmental Protection Agency develops criteria guidance; states establish criteria.

**Cubic Feet per Second**

A unit of measure for the rate of flow or discharge of water. One cubic foot per second is the rate of flow of a stream with a cross-section of one square foot flowing at a mean velocity of one foot per second. At a steady rate, once cubic foot per second is equal to 448.8 gallons per minute and 10,984 acre-feet per day.

**Cultural Eutrophication**

The process of eutrophication that has been accelerated by human-caused influences. Usually seen as an increase in nutrient loading (also see Eutrophication).

| | |
|---|---|
| **Culturally Induced Erosion** | Erosion caused by increased runoff or wind action due to the work of humans in deforestation, cultivation of the land, overgrazing, and disturbance of natural drainages; the excess of erosion over the normal for an area (also see Erosion). |
| **Debris Torrent** | The sudden down slope movement of soil, rock, and vegetation on steep slopes, often caused by saturation from heavy rains. |
| **Decomposition** | The breakdown of organic molecules (e.g., sugar) to inorganic molecules (e.g., carbon dioxide and water) through biological and nonbiological processes. |
| **Depth Fines** | Percent by weight of particles of small size within a vertical core of volume of a streambed or lake bottom sediment. The upper size threshold for fine sediment for fisheries purposes varies from 0.8 to 6.5 millimeters depending on the observer and methodology used. The depth sampled varies but is typically about one foot (30 centimeters). |
| **Designated Uses** | Those water uses identified in state water quality standards that must be achieved and maintained as required under the Clean Water Act. |
| **Discharge** | The amount of water flowing in the stream channel at the time of measurement. Usually expressed as cubic feet per second (cfs). |
| **Dissolved Oxygen (DO)** | The oxygen dissolved in water. Adequate DO is vital to fish and other aquatic life. |
| **Disturbance** | Any event or series of events that disrupts ecosystem, community, or population structure and alters the physical environment. |
| ***E. coli*** | Short for *Escherichia coli*, *E. coli* are a group of bacteria that are a subspecies of coliform bacteria. Most *E. coli* are essential to the healthy life of all warm-blooded animals, including humans, but their presence in water is often indicative of fecal contamination. *E. coli* are used by the state of Idaho as the indicator for the presence of pathogenic microorganisms. |
| **Ecology** | The scientific study of relationships between organisms and their environment; also defined as the study of the structure and function of nature. |
| **Ecological Indicator** | A characteristic of an ecosystem that is related to, or derived from, a measure of a biotic or abiotic variable that can provide quantitative information on ecological structure and function. An indicator can contribute to a measure of integrity and sustainability. Ecological indicators are often used within the multimetric index framework. |
| **Ecological Integrity** | The condition of an unimpaired ecosystem as measured by combined chemical, physical (including habitat), and biological attributes (EPA 1996). |

**Ecosystem**

The interacting system of a biological community and its non-living (abiotic) environmental surroundings.

**Effluent**

A discharge of untreated, partially treated, or treated wastewater into a receiving water body.

**Endangered Species**

Animals, birds, fish, plants, or other living organisms threatened with imminent extinction. Requirements for declaring a species as endangered are contained in the Endangered Species Act.

**Environment**

The complete range of external conditions, physical and biological, that affect a particular organism or community.

**Eocene**

An epoch of the early Tertiary period, after the Paleocene and before the Oligocene.

**Eolian**

Windblown, referring to the process of erosion, transport, and deposition of material by the wind.

**Ephemeral Stream**

A stream or portion of a stream that flows only in direct response to precipitation. It receives little or no water from springs and no long continued supply from melting snow or other sources. Its channel is at all times above the water table (American Geological Institute 1962).

**Erosion**

The wearing away of areas of the earth's surface by water, wind, ice, and other forces.

**Eutrophic**

From Greek for "well nourished," this describes a highly productive body of water in which nutrients do not limit algal growth. It is typified by high algal densities and low clarity.

**Eutrophication**

1) Natural process of maturing (aging) in a body of water. 2) The natural and human-influenced process of enrichment with nutrients, especially nitrogen and phosphorus, leading to an increased production of organic matter.

**Exceedance**

A violation (according to DEQ policy) of the pollutant levels permitted by water quality criteria.

**Existing Beneficial Use or Existing Use**

A beneficial use actually attained in waters on or after November 28, 1975, whether or not the use is designated for the waters in Idaho's *Water Quality Standards and Wastewater Treatment Requirements* (IDAPA 58.01.02).

**Exotic Species**

A species that is not native (indigenous) to a region.

**Extrapolation**

Estimation of unknown values by extending or projecting from known values.

**Fauna**

Animal life, especially the animals characteristic of a region, period, or special environment.

**Fecal Coliform Bacteria**

Bacteria found in the intestinal tracts of all warm-blooded animals or mammals. Their presence in water is an indicator of pollution and possible contamination by pathogens (also see Coliform Bacteria, *E. coli*, and Pathogens).

**Fecal Streptococci**

A species of spherical bacteria including pathogenic strains found in the intestines of warm-blooded animals.

**Feedback Loop**

In the context of watershed management planning, a feedback loop is a process that provides for tracking progress toward goals and revising actions according to that progress.

**Fixed-Location Monitoring**

Sampling or measuring environmental conditions continuously or repeatedly at the same location.

**Flow**

See *Discharge*.

**Fluvial**

In fisheries, this describes fish whose life history takes place entirely in streams but migrate to smaller streams for spawning.

**Focal**

Critical areas supporting a mosaic of high quality habitats that sustain a diverse or unusually productive complement of native species.

**Fully Supporting**

In compliance with water quality standards and within the range of biological reference conditions for all designated and exiting beneficial uses as determined through the *Water Body Assessment Guidance* (Grafe et al. 2002).

**Fully Supporting Cold Water**

Reliable data indicate functioning, sustainable cold water biological assemblages (e.g., fish, macroinvertebrates, or algae), none of which have been modified significantly beyond the natural range of reference conditions.

**Fully Supporting but Threatened**

An intermediate assessment category describing water bodies that fully support beneficial uses, but have a declining trend in water quality conditions, which if not addressed, will lead to a "not fully supporting" status.

**Geographical Information Systems (GIS)**

A georeferenced database.

**Geometric Mean**

A back-transformed mean of the logarithmically transformed numbers often used to describe highly variable, right-skewed data (a few large values), such as bacterial data.

| | |
|---|---|
| **Grab Sample** | A single sample collected at a particular time and place. It may represent the composition of the water in that water column. |
| **Gradient** | The slope of the land, water, or streambed surface. |
| **Ground Water** | Water found beneath the soil surface saturating the layer in which it is located. Most ground water originates as rainfall, is free to move under the influence of gravity, and usually emerges again as stream flow. |
| **Growth Rate** | A measure of how quickly something living will develop and grow, such as the amount of new plant or animal tissue produced per a given unit of time, or number of individuals added to a population. |
| **Habitat** | The living place of an organism or community. |
| **Headwater** | The origin or beginning of a stream. |
| **Hydrologic Basin** | The area of land drained by a river system, a reach of a river and its tributaries in that reach, a closed basin, or a group of streams forming a drainage area (also see Watershed). |
| **Hydrologic Cycle** | The cycling of water from the atmosphere to the earth (precipitation) and back to the atmosphere (evaporation and plant transpiration). Atmospheric moisture, clouds, rainfall, runoff, surface water, ground water, and water infiltrated in soils are all part of the hydrologic cycle. |
| **Hydrologic Unit** | One of a nested series of numbered and named watersheds arising from a national standardization of watershed delineation. The initial 1974 effort (USGS 1987) described four levels (region, subregion, accounting unit, cataloging unit) of watersheds throughout the United States. The fourth level is uniquely identified by an eight-digit code built of two-digit fields for each level in the classification. Originally termed a cataloging unit, fourth field hydrologic units have been more commonly called subbasins. Fifth and sixth field hydrologic units have since been delineated for much of the country and are known as watershed and subwatersheds, respectively. |
| **Hydrologic Unit Code (HUC)** | The number assigned to a hydrologic unit. Often used to refer to fourth field hydrologic units. |
| **Hydrology** | The science dealing with the properties, distribution, and circulation of water. |
| **Impervious** | Describes a surface, such as pavement, that water cannot penetrate. |
| **Influent** | A tributary stream. |
| **Inorganic** | Materials not derived from biological sources. |

| | |
|---|---|
| **Instantaneous** | A condition or measurement at a moment (instant) in time. |
| **Intergravel Dissolved Oxygen** | The concentration of dissolved oxygen within spawning gravel. Consideration for determining spawning gravel includes species, water depth, velocity, and substrate. |
| **Intermittent Stream** | 1) A stream that flows only part of the year, such as when the ground water table is high or when the stream receives water from springs or from surface sources such as melting snow in mountainous areas. The stream ceases to flow above the streambed when losses from evaporation or seepage exceed the available stream flow. 2) A stream that has a period of zero flow for at least one week during most years. |
| **Interstate Waters** | Waters that flow across or form part of state or international boundaries, including boundaries with Native American nations. |
| **Irrigation Return Flow** | Surface (and subsurface) water that leaves a field following the application of irrigation water and eventually flows into streams. |
| **Key Watershed** | A watershed that has been designated in Idaho Governor Batt's *State of Idaho Bull Trout Conservation Plan* (1996) as critical to the long-term persistence of regionally important trout populations. |
| **Land Application** | A process or activity involving application of wastewater, surface water, or semi-liquid material to the land surface for the purpose of treatment, pollutant removal, or ground water recharge. |
| **Limiting Factor** | A chemical or physical condition that determines the growth potential of an organism. This can result in a complete inhibition of growth, but typically results in less than maximum growth rates. |
| **Limnology** | The scientific study of fresh water, especially the history, geology, biology, physics, and chemistry of lakes. |
| **Load Allocation (LA)** | A portion of a water body's load capacity for a given pollutant that is given to a particular nonpoint source (by class, type, or geographic area). |
| **Load(ing)** | The quantity of a substance entering a receiving stream, usually expressed in pounds or kilograms per day or tons per year. Loading is the product of flow (discharge) and concentration. |
| **Load(ing) Capacity (LC)** | A determination of how much pollutant a water body can receive over a given period without causing violations of state water quality standards. Upon allocation to various sources, and a margin of safety, it becomes a total maximum daily load. |

| | |
|---|---|
| **Loam** | Refers to a soil with a texture resulting from a relative balance of sand, silt, and clay. This balance imparts many desirable characteristics for agricultural use. |
| **Loess** | A uniform wind-blown deposit of silty material. Silty soils are among the most highly erodible. |
| **Lotic** | An aquatic system with flowing water such as a brook, stream, or river where the net flow of water is from the headwaters to the mouth. |
| **Luxury Consumption** | A phenomenon in which sufficient nutrients are available in either the sediments or the water column of a water body, such that aquatic plants take up and store an abundance in excess of the plants' current needs. |
| **Macroinvertebrate** | An invertebrate animal (without a backbone) large enough to be seen without magnification and retained by a 500µm mesh (U.S. #30) screen. |
| **Macrophytes** | Rooted and floating vascular aquatic plants, commonly referred to as water weeds. These plants usually flower and bear seeds. Some forms, such as duckweed and coontail (*Ceratophyllum sp.*), are free-floating forms not rooted in sediment. |
| **Margin of Safety (MOS)** | An implicit or explicit portion of a water body's loading capacity set aside to allow the uncertainly about the relationship between the pollutant loads and the quality of the receiving water body. This is a required component of a total maximum daily load (TMDL) and is often incorporated into conservative assumptions used to develop the TMDL (generally within the calculations and/or models). The MOS is not allocated to any sources of pollution. |
| **Mass Wasting** | A general term for the down slope movement of soil and rock material under the direct influence of gravity. |
| **Mean** | Describes the central tendency of a set of numbers. The arithmetic mean (calculated by adding all items in a list, then dividing by the number of items) is the statistic most familiar to most people. |
| **Median** | The middle number in a sequence of numbers. If there are an even number of numbers, the median is the average of the two middle numbers. For example, 4 is the median of 1, 2, 4, 14, 16; 6 is the median of 1, 2, 5, 7, 9, 11. |
| **Metric** | 1) A discrete measure of something, such as an ecological indicator (e.g., number of distinct taxon). 2) The metric system of measurement. |
| **Milligrams per Liter (mg/L)** | A unit of measure for concentration. In water, it is essentially equivalent to parts per million (ppm). |

**Million Gallons per Day (MGD)**
A unit of measure for the rate of discharge of water, often used to measure flow at wastewater treatment plants. One MGD is equal to 1.547 cubic feet per second.

**Miocene**
Of, relating to, or being an epoch of, the Tertiary between the Pliocene and the Oligocene periods, or the corresponding system of rocks.

**Monitoring**
A periodic or continuous measurement of the properties or conditions of some medium of interest, such as monitoring a water body.

**Mouth**
The location where flowing water enters into a larger water body.

**National Pollution Discharge Elimination System (NPDES)**
A national program established by the Clean Water Act for permitting point sources of pollution. Discharge of pollution from point sources is not allowed without a permit.

**Natural Condition**
The condition that exists with little or no anthropogenic influence.

**Nitrogen**
An element essential to plant growth, and thus is considered a nutrient.

**Nodal**
Areas that are separated from focal and adjunct habitats, but serve critical life history functions for individual native fish.

**Nonpoint Source**
A dispersed source of pollutants, generated from a geographical area when pollutants are dissolved or suspended in runoff and then delivered into waters of the state. Nonpoint sources are without a discernable point or origin. They include, but are not limited to, irrigated and non-irrigated lands used for grazing, crop production, and silviculture; rural roads; construction and mining sites; log storage or rafting; and recreation sites.

**Not Assessed (NA)**
A concept and an assessment category describing water bodies that have been studied, but are missing critical information needed to complete an assessment.

**Not Attainable**
A concept and an assessment category describing water bodies that demonstrate characteristics that make it unlikely that a beneficial use can be attained (e.g., a stream that is dry but designated for salmonid spawning).

**Not Fully Supporting**
Not in compliance with water quality standards or not within the range of biological reference conditions for any beneficial use as determined through the *Water Body Assessment Guidance* (Grafe et al. 2002).

**Not Fully Supporting Cold Water**
At least one biological assemblage has been significantly modified beyond the natural range of its reference condition.

**Nuisance**
Anything that is injurious to the public health or an obstruction to the free use, in the customary manner, of any waters of the state.

| | |
|---|---|
| **Nutrient** | Any substance required by living things to grow. An element or its chemical forms essential to life, such as carbon, oxygen, nitrogen, and phosphorus. Commonly refers to those elements in short supply, such as nitrogen and phosphorus, which usually limit growth. |
| **Nutrient Cycling** | The flow of nutrients from one component of an ecosystem to another, as when macrophytes die and release nutrients that become available to algae (organic to inorganic phase and return). |
| **Oligotrophic** | The Greek term for "poorly nourished." This describes a body of water in which productivity is low and nutrients are limiting to algal growth, as typified by low algal density and high clarity. |
| **Organic Matter** | Compounds manufactured by plants and animals that contain principally carbon. |
| **Orthophosphate** | A form of soluble inorganic phosphorus most readily used for algal growth. |
| **Oxygen-Demanding Materials** | Those materials, mainly organic matter, in a water body that consume oxygen during decomposition. |
| **Parameter** | A variable, measurable property whose value is a determinant of the characteristics of a system, such as temperature, dissolved oxygen, and fish populations are parameters of a stream or lake. |
| **Partitioning** | The sharing of limited resources by different races or species; use of different parts of the habitat, or the same habitat at different times. Also the separation of a chemical into two or more phases, such as partitioning of phosphorus between the water column and sediment. |
| **Pathogens** | A small subset of microorganisms (e.g., certain bacteria, viruses, and protozoa) that can cause sickness or death. Direct measurement of pathogen levels in surface water is difficult. Consequently, indicator bacteria that are often associated with pathogens are assessed. *E. coli*, a type of fecal coliform bacteria, are used by the state of Idaho as the indicator for the presence of pathogenic microorganisms. |
| **Perennial Stream** | A stream that flows year-around in most years. |
| **Periphyton** | Attached microflora (algae and diatoms) growing on the bottom of a water body or on submerged substrates, including larger plants. |
| **Pesticide** | Substances or mixtures of substances intended for preventing, destroying, repelling, or mitigating any pest. Also, any substance or mixture intended for use as a plant regulator, defoliant, or desiccant. |

**pH**

The negative $\log_{10}$ of the concentration of hydrogen ions, a measure which in water ranges from very acid (pH=1) to very alkaline (pH=14). A pH of 7 is neutral. Surface waters usually measure between pH 6 and 9.

**Phased TMDL**

A total maximum daily load (TMDL) that identifies interim load allocations and details further monitoring to gauge the success of management actions in achieving load reduction goals and the effect of actual load reductions on the water quality of a water body. Under a phased TMDL, a refinement of load allocations, wasteload allocations, and the margin of safety is planned at the outset.

**Phosphorus**

An element essential to plant growth, often in limited supply, and thus considered a nutrient.

**Physiochemical**

In the context of bioassessment, the term is commonly used to mean the physical and chemical factors of the water column that relate to aquatic biota. Examples in bioassessment usage include saturation of dissolved gases, temperature, pH, conductivity, dissolved or suspended solids, forms of nitrogen, and phosphorus. This term is used interchangeable with the term “physical/chemical.”

**Plankton**

Microscopic algae (phytoplankton) and animals (zooplankton) that float freely in open water of lakes and oceans.

**Point Source**

A source of pollutants characterized by having a discrete conveyance, such as a pipe, ditch, or other identifiable “point” of discharge into a receiving water. Common point sources of pollution are industrial and municipal wastewater.

**Pollutant**

Generally, any substance introduced into the environment that adversely affects the usefulness of a resource or the health of humans, animals, or ecosystems.

**Pollution**

A very broad concept that encompasses human-caused changes in the environment which alter the functioning of natural processes and produce undesirable environmental and health effects. This includes human-induced alteration of the physical, biological, chemical, and radiological integrity of water and other media.

**Population**

A group of interbreeding organisms occupying a particular space; the number of humans or other living creatures in a designated area.

**Pretreatment**

The reduction in the amount of pollutants, elimination of certain pollutants, or alteration of the nature of pollutant properties in wastewater prior to, or in lieu of, discharging or otherwise introducing such wastewater into a publicly owned wastewater treatment plant.

| | |
|---|---|
| **Primary Productivity** | The rate at which algae and macrophytes fix carbon dioxide using light energy. Commonly measured as milligrams of carbon per square meter per hour. |
| **Protocol** | A series of formal steps for conducting a test or survey. |
| **Qualitative** | Descriptive of kind, type, or direction. |
| **Quality Assurance (QA)** | A program organized and designed to provide accurate and precise results. Included are the selection of proper technical methods, tests, or laboratory procedures; sample collection and preservation; the selection of limits; data evaluation; quality control; and personnel qualifications and training (Rand 1995). The goal of QA is to assure the data provided are of the quality needed and claimed (EPA 1996). |
| **Quality Control (QC)** | Routine application of specific actions required to provide information for the quality assurance program. Included are standardization, calibration, and replicate samples (Rand 1995). QC is implemented at the field or bench level (EPA 1996). |
| **Quantitative** | Descriptive of size, magnitude, or degree. |
| **Reach** | A stream section with fairly homogenous physical characteristics. |
| **Reconnaissance** | An exploratory or preliminary survey of an area. |
| **Reference** | A physical or chemical quantity whose value is known and thus is used to calibrate or standardize instruments. |
| **Reference Condition** | 1) A condition that fully supports applicable beneficial uses with little affect from human activity and represents the highest level of support attainable.<br>2) A benchmark for populations of aquatic ecosystems used to describe desired conditions in a biological assessment and acceptable or unacceptable departures from them. The reference condition can be determined through examining regional reference sites, historical conditions, quantitative models, and expert judgment (Hughes 1995). |
| **Reference Site** | A specific locality on a water body that is minimally impaired and is representative of reference conditions for similar water bodies. |
| **Representative Sample** | A portion of material or water that is as similar in content and consistency as possible to that in the larger body of material or water being sampled. |
| **Resident** | A term that describes fish that do not migrate. |

**Respiration**
A process by which organic matter is oxidized by organisms, including plants, animals, and bacteria. The process converts organic matter to energy, carbon dioxide, water, and lesser constituents.

**Riffle**
A relatively shallow, gravelly area of a streambed with a locally fast current, recognized by surface choppiness. Also an area of higher streambed gradient and roughness.

**Riparian**
Associated with aquatic (stream, river, lake) habitats. Living or located on the bank of a water body.

**Riparian Habitat Conservation Area (RHCA)**
A U.S. Forest Service description of land within the following number of feet up-slope of each of the banks of streams:

300 feet from perennial fish-bearing streams
150 feet from perennial non-fish-bearing streams
100 feet from intermittent streams, wetlands, and ponds in priority watersheds.

**River**
A large, natural, or human-modified stream that flows in a defined course or channel or in a series of diverging and converging channels.

**Runoff**
The portion of rainfall, melted snow, or irrigation water that flows across the surface, through shallow underground zones (interflow), and through ground water to creates streams.

**Sediments**
Deposits of fragmented materials from weathered rocks and organic material that were suspended in, transported by, and eventually deposited by water or air.

**Settleable Solids**
The volume of material that settles out of one liter of water in one hour.

**Species**
1) A reproductively isolated aggregate of interbreeding organisms having common attributes and usually designated by a common name. 2) An organism belonging to such a category.

**Spring**
Ground water seeping out of the earth where the water table intersects the ground surface.

**Stagnation**
The absence of mixing in a water body.

**Stenothermal**
Unable to tolerate a wide temperature range.

**Stratification**
A Department of Environmental Quality classification method used to characterize comparable units (also called classes or strata).

**Stream**
A natural water course containing flowing water, at least part of the year. Together with dissolved and suspended materials, a stream normally

| | |
|---|---|
| | supports communities of plants and animals within the channel and the riparian vegetation zone. |
| **Stream Order** | Hierarchical ordering of streams based on the degree of branching. A first-order stream is an unforked or unbranched stream. Under Strahler's (1957) system, higher order streams result from the joining of two streams of the same order. |
| **Storm Water Runoff** | Rainfall that quickly runs off the land after a storm. In developed watersheds the water flows off roofs and pavement into storm drains that may feed quickly and directly into the stream. The water often carries pollutants picked up from these surfaces. |
| **Stressors** | Physical, chemical, or biological entities that can induce adverse effects on ecosystems or human health. |
| **Subbasin** | A large watershed of several hundred thousand acres. This is the name commonly given to 4th field hydrologic units (also see Hydrologic Unit). |
| **Subbasin Assessment (SBA)** | A watershed-based problem assessment that is the first step in developing a total maximum daily load in Idaho. |
| **Subwatershed** | A smaller watershed area delineated within a larger watershed, often for purposes of describing and managing localized conditions. Also proposed for adoption as the formal name for 6th field hydrologic units. |
| **Surface Fines** | Sediments of small size deposited on the surface of a streambed or lake bottom. The upper size threshold for fine sediment for fisheries purposes varies from 0.8 to 605 millimeters depending on the observer and methodology used. Results are typically expressed as a percentage of observation points with fine sediment. |
| **Surface Runoff** | Precipitation, snow melt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of nonpoint source pollutants in rivers, streams, and lakes. Surface runoff is also called overland flow. |
| **Surface Water** | All water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors that are directly influenced by surface water. |
| **Suspended Sediments** | Fine material (usually sand size or smaller) that remains suspended by turbulence in the water column until deposited in areas of weaker current. These sediments cause turbidity and, when deposited, reduce living space within streambed gravels and can cover fish eggs or alevins. |
| **Taxon** | Any formal taxonomic unit or category of organisms (e.g., species, genus, family, order). The plural of taxon is taxa (Armantrout 1998). |

**Tertiary**

An interval of geologic time lasting from 66.4 to 1.6 million years ago. It constitutes the first of two periods of the Cenozoic Era, the second being the Quaternary. The Tertiary has five subdivisions, which from oldest to youngest are the Paleocene, Eocene, Oligocene, Miocene, and Pliocene epochs.

**Thalweg**

The center of a stream's current, where most of the water flows.

**Threatened Species**

Species, determined by the U.S. Fish and Wildlife Service, which are likely to become endangered within the foreseeable future throughout all or a significant portion of their range.

**Total Maximum Daily Load (TMDL)**

A TMDL is a water body's load capacity after it has been allocated among pollutant sources. It can be expressed on a time basis other than daily if appropriate. Sediment loads, for example, are often calculated on an annual bases. A TMDL is equal to the load capacity, such that load capacity = margin of safety + natural background + load allocation + wasteload allocation = TMDL. In common usage, a TMDL also refers to the written document that contains the statement of loads and supporting analyses, often incorporating TMDLs for several water bodies and/or pollutants within a given watershed.

**Total Dissolved Solids**

Dry weight of all material in solution in a water sample as determined by evaporating and drying filtrate.

**Total Suspended Solids (TSS)**

The dry weight of material retained on a filter after filtration. Filter pore size and drying temperature can vary. American Public Health Association Standard Methods (Franson et al. 1998) call for using a filter of 2.0 microns or smaller; a 0.45 micron filter is also often used. This method calls for drying at a temperature of 103-105 °C.

**Toxic Pollutants**

Materials that cause death, disease, or birth defects in organisms that ingest or absorb them. The quantities and exposures necessary to cause these effects can vary widely.

**Tributary**

A stream feeding into a larger stream or lake.

**Trophic State**

The level of growth or productivity of a lake as measured by phosphorus content, chlorophyll *a* concentrations, amount (biomass) of aquatic vegetation, algal abundance, and water clarity.

**Total Dissolved Solids**

Dry weight of all material in solution in a water sample as determined by evaporating and drying filtrate.

**Total Suspended Solids (TSS)**

The dry weight of material retained on a filter after filtration. Filter pore size and drying temperature can vary. American Public Health Association Standard Methods (Franson et al. 1998) call for using a filter of 2.0 micron or smaller; a 0.45 micron filter is also often used. This method calls for drying at a temperature of 103-105 °C.

**Toxic Pollutants**

Materials that cause death, disease, or birth defects in organisms that ingest or absorb them. The quantities and exposures necessary to cause these effects can vary widely.

**Tributary**

A stream feeding into a larger stream or lake.

**Trophic State**

The level of growth or productivity of a lake as measured by phosphorus content, chlorophyll *a* concentrations, amount (biomass) of aquatic vegetation, algal abundance, and water clarity.

**Turbidity**

A measure of the extent to which light passing through water is scattered by fine suspended materials. The effect of turbidity depends on the size of the particles (the finer the particles, the greater the effect per unit weight) and the color of the particles.

**Vadose Zone**

The unsaturated region from the soil surface to the ground water table.

**Wasteload Allocation (WLA)**

The portion of receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. Wasteload allocations specify how much pollutant each point source may release to a water body.

**Water Body**

A stream, river, lake, estuary, coastline, or other water feature, or portion thereof.

**Water Column**

Water between the interface with the air at the surface and the interface with the sediment layer at the bottom. The idea derives from a vertical series of measurements (oxygen, temperature, phosphorus) used to characterize water.

**Water Pollution**

Any alteration of the physical, thermal, chemical, biological, or radioactive properties of any waters of the state, or the discharge of any pollutant into the waters of the state, which will or is likely to create a nuisance or to render such waters harmful, detrimental, or injurious to public health, safety, or welfare; to fish and wildlife; or to domestic, commercial, industrial, recreational, aesthetic, or other beneficial uses.

**Water Quality**

A term used to describe the biological, chemical, and physical characteristics of water with respect to its suitability for a beneficial use.

**Water Quality Criteria**

Levels of water quality expected to render a body of water suitable for its designated uses. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, or industrial processes.

**Water Quality Limited**

A label that describes water bodies for which one or more water quality criterion is not met or beneficial uses are not fully supported. Water quality limited segments may or may not be on a §303(d) list.

**Water Quality Limited Segment (WQLS)**

Any segment placed on a state's §303(d) list for failure to meet applicable water quality standards, and/or is not expected to meet applicable water quality standards in the period prior to the next list. These segments are also referred to as "§303(d) listed."

**Water Quality Management Plan**

A state or area-wide waste treatment management plan developed and updated in accordance with the provisions of the Clean Water Act.

**Water Quality Modeling**

The prediction of the response of some characteristics of lake or stream water based on mathematical relations of input variables such as climate, stream flow, and inflow water quality.

**Water Quality Standards**

State-adopted and U.S. Environmental Protection Agency-approved ambient standards for water bodies. The standards prescribe the use of the water body and establish the water quality criteria that must be met to protect designated uses.

**Water Table**

The upper surface of ground water; below this point, the soil is saturated with water.

**Watershed**

1) All the land which contributes runoff to a common point in a drainage network, or to a lake outlet. Watersheds are infinitely nested, and any large watershed is composed of smaller "subwatersheds." 2) The whole geographic region which contributes water to a point of interest in a water body.

**Water Body Identification Number (WBID)**

A number that uniquely identifies a water body in Idaho and ties in to the Idaho water quality standards and GIS information.

**Wetland**

An area that is at least some of the time saturated by surface or ground water so as to support with vegetation adapted to saturated soil conditions. Examples include swamps, bogs, fens, and marshes.

**Young of the Year**

Young fish born the year captured, evidence of spawning activity.

This page intentionally left blank for correct doubled-sided printing.

# Appendix A. Unit Conversion Chart

**Metric - English unit conversions.**

| | English Units | Metric Units | To Convert | Example |
|---|---|---|---|---|
| **Distance** | Miles (mi) | Kilometers (km) | 1 mi = 1.61 km<br>1 km = 0.62 mi | 3 mi = 4.83 km<br>3 km = 1.86 mi |
| **Length** | Inches (in)<br>Feet (ft) | Centimeters (cm)<br>Meters (m) | 1 in = 2.54 cm<br>1 cm = 0.39 in<br>1 ft = 0.30 m<br>1 m = 3.28 ft | 3 in = 7.62 cm<br>3 cm = 1.18 in<br>3 ft = 0.91 m<br>3 m = 9.84 ft |
| **Area** | Acres (ac)<br>Square Feet ($ft^2$)<br>Square Miles ($mi^2$) | Hectares (ha)<br>Square Meters ($m^2$)<br>Square Kilometers ($km^2$) | 1 ac = 0.40 ha<br>1 ha = 2.47 ac<br>1 $ft^2$ = 0.09 $m^2$<br>1 $m^2$ = 10.76 $ft^2$<br>1 $mi^2$ = 2.59 $km^2$<br>1 $km^2$ = 0.39 $mi^2$ | 3 ac = 1.20 ha<br>3 ha = 7.41 ac<br>3 $ft^2$ = 0.28 $m^2$<br>3 $m^2$ = 32.29 $ft^2$<br>3 $mi^2$ = 7.77 $km^2$<br>3 $km^2$ = 1.16 $mi^2$ |
| **Volume** | Gallons (gal)<br>Cubic Feet ($ft^3$) | Liters (L)<br>Cubic Meters ($m^3$) | 1 gal = 3.78 L<br>1 L= 0.26 gal<br>1 $ft^3$ = 0.03 $m^3$<br>1 $m^3$ = 35.32 $ft^3$ | 3 gal = 11.35 L<br>3 L = 0.79 gal<br>3 $ft^3$ = 0.09 $m^3$<br>3 $m^3$ = 105.94 $ft^3$ |
| **Flow Rate** | Cubic Feet per Second (cfs)[a] | Cubic Meters per Second ($m^3$/sec) | 1 cfs = 0.03 $m^3$/sec<br>1 $m^3$/sec = 35.31 cfs | 3 $ft^3$/sec = 0.09 $m^3$/sec<br>3 $m^3$/sec = 105.94 $ft^3$/sec |
| **Concentration** | Parts per Million (ppm) | Milligrams per Liter (mg/L) | 1 ppm = 1 mg/L[b] | 3 ppm = 3 mg/L |
| **Weight** | Pounds (lbs) | Kilograms (kg) | 1 lb = 0.45 kg<br>1 kg = 2.20 lbs | 3 lb = 1.36 kg<br>3 kg = 6.61 lb |
| **Temperature** | Fahrenheit (°F) | Celsius (°C) | °C = 0.55 (F - 32)<br>°F = (C x 1.8) + 32 | 3 °F = -15.95 °C<br>3 °C = 37.4 °F |

[a] 1 cfs = 0.65 million gallons per day; 1 million gallons per day is equal to 1.55 cfs.

[b] The ratio of 1 ppm = 1 mg/L is approximate and is only accurate for water.

This page intentionally left blank for correct doubled-sided printing.

# Appendix B. State and Site-Specific Standards and Criteria

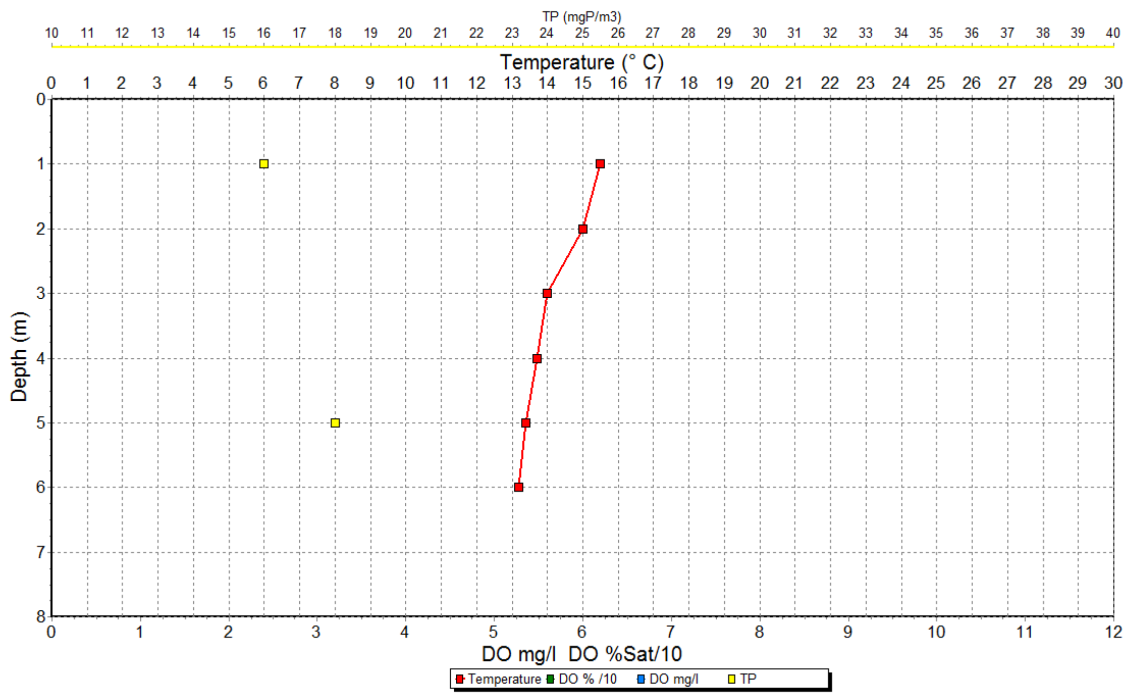
| Designated and Existing Beneficial Uses | | | | |
|---|---|---|---|---|
| **Water Quality Parameter** | **Primary Contact Recreation** | **Secondary Contact Recreation** | **Cold Water Aquatic Life** | **Salmonid Spawning (During Spawning and Incubation Periods for Inhabiting Species)** |
| **Water Quality Standards: IDAPA 58.01.02.250** | | | | |
| **Bacteria, ph, and Dissolved Oxygen** | Less than 126 *E. coli*/100 ml[a] as a geometric mean of five samples over 30 days; no sample greater than 406 *E. coli* organisms/100 ml | Less than 126 *E. coli*/100 ml as a geometric mean of five samples over 30 days; no sample greater than 576 *E. coli*/100 ml | pH between 6.5 and 9.0<br>DO[b] exceeds 6.0 mg/L[c]<br>The standard does not apply a) for the bottom 20 percent of lakes or reservoirs less than 35 meters in depth, b)the bottom 7 meters of lakes and reservoirs greater than 35 meters in depth, and c) the hypolimnion of a stratified lake or reservoir . | pH between 6.5 and 9.5<br>Water Column DO: DO exceeds 6.0 mg/L in water column or 90% saturation, whichever is greater<br>Intergravel DO: DO exceeds 5.0 mg/L for a one day minimum and exceeds 6.0 mg/L for a seven day average |
| **Temperature[d]** | | | 22 °C or less daily maximum; 19 °C or less daily average | 13 °C or less daily maximum; 9 °C or less daily average<br>Bull trout: not to exceed 13 °C maximum weekly maximum temperature over warmest 7-day period, June – August; not to exceed 9 °C daily average in September and October |
| | | | Seasonal Cold Water: Between summer solstice and autumn equinox: 26 °C or less daily maximum; 23 °C or less daily average | |
| **Turbidity** | | | Turbidity shall not exceed background by more than 50 NTU[e] instantaneously or more than 25 NTU for more than 10 consecutive days. | |
| **Ammonia** | | | Ammonia not to exceed calculated concentration based on pH and temperature. | |
| **EPA Bull Trout Temperature Criteria: Water Quality Standards for Idaho, 40 CFR Part 131** | | | | |
| **Temperature** | | | | 7 day moving average of 10 °C or less maximum daily temperature for June - September |

This page intentionally left blank for correct doubled-sided printing.

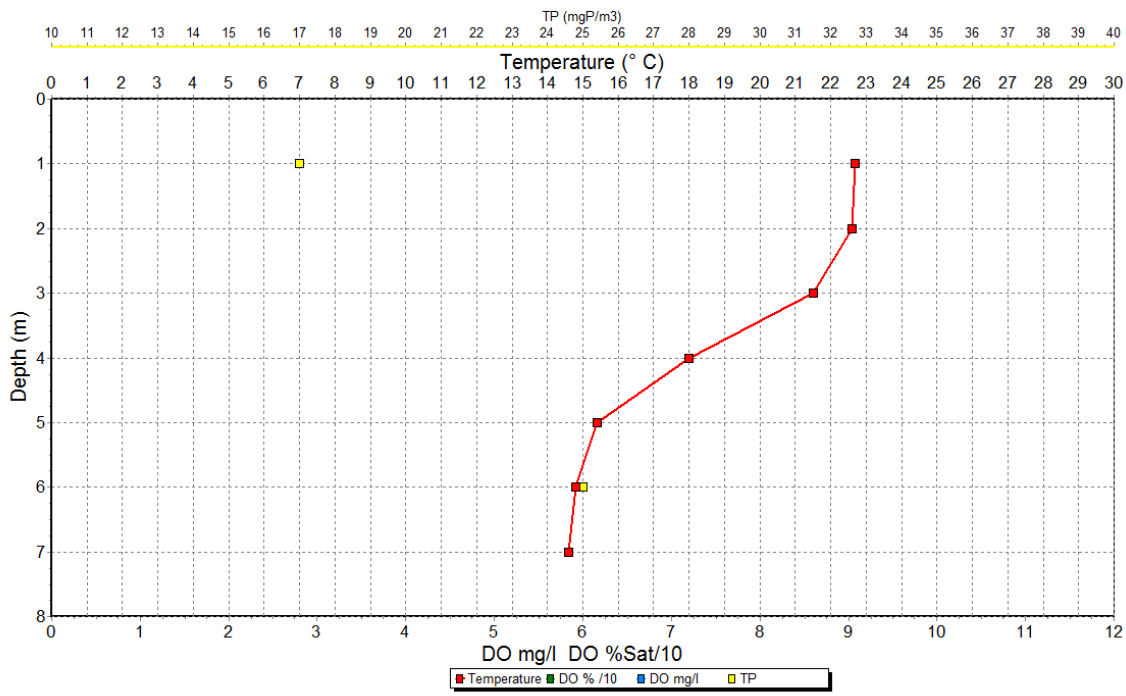
# Appendix C. Water Quality Data

## Temperature, DO, and Total Phosphorus Data

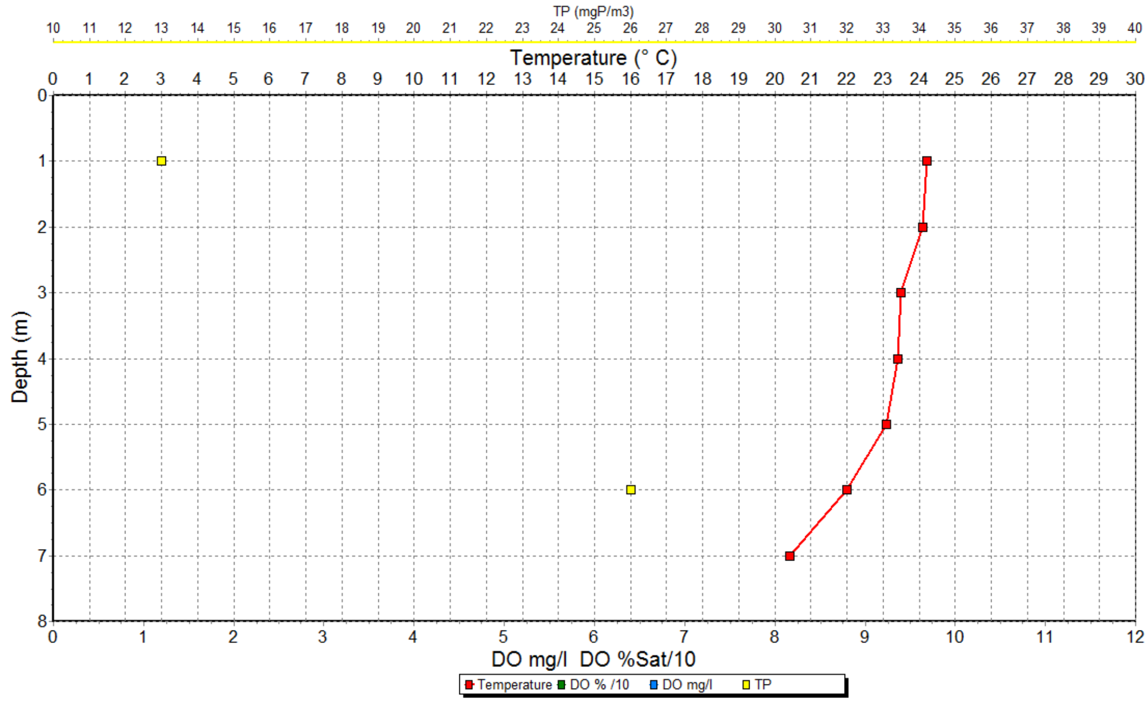
**May 22, 1990**



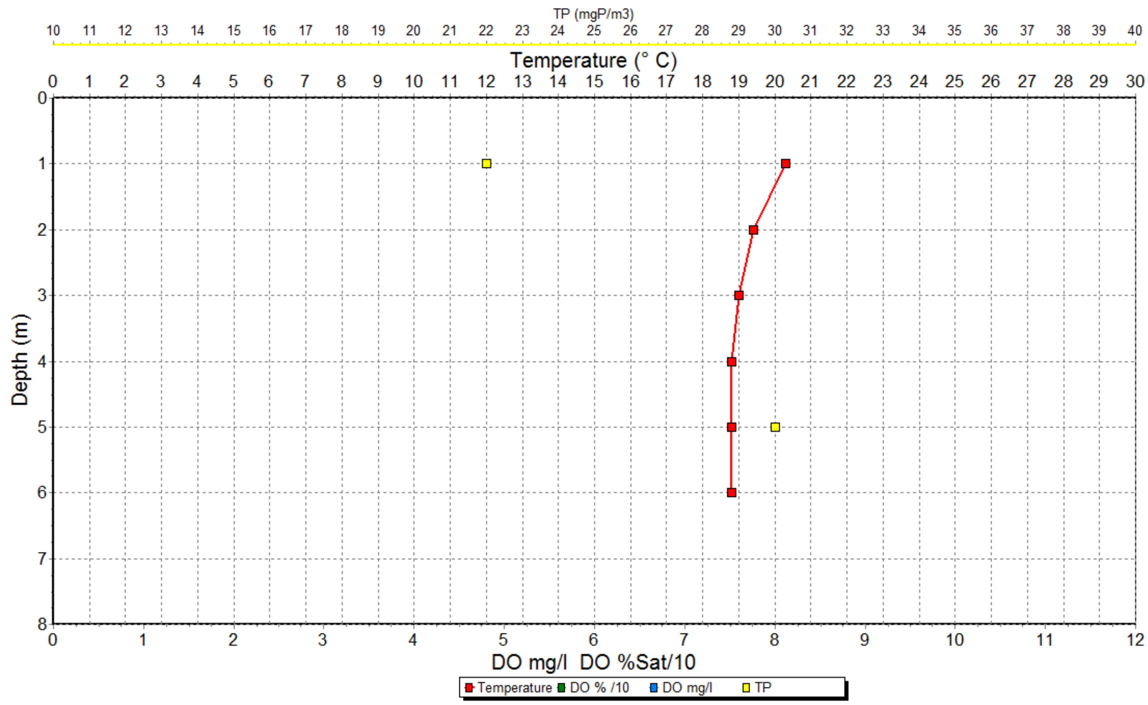

**June 26 1990**



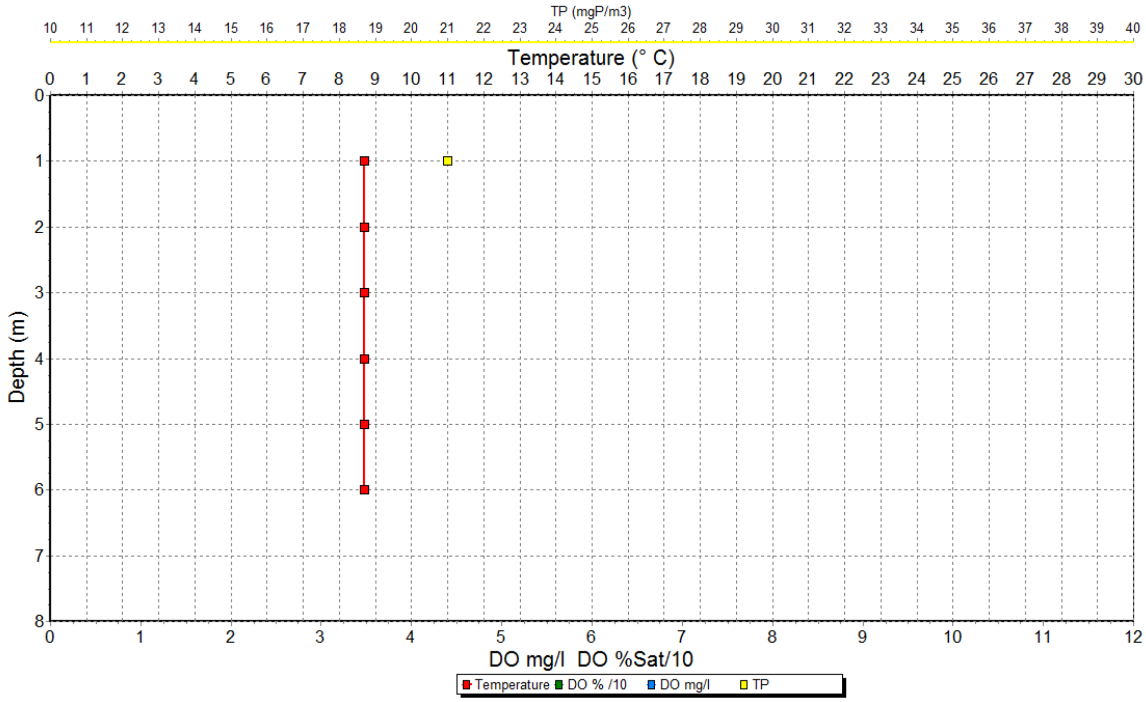
## August 8, 1990



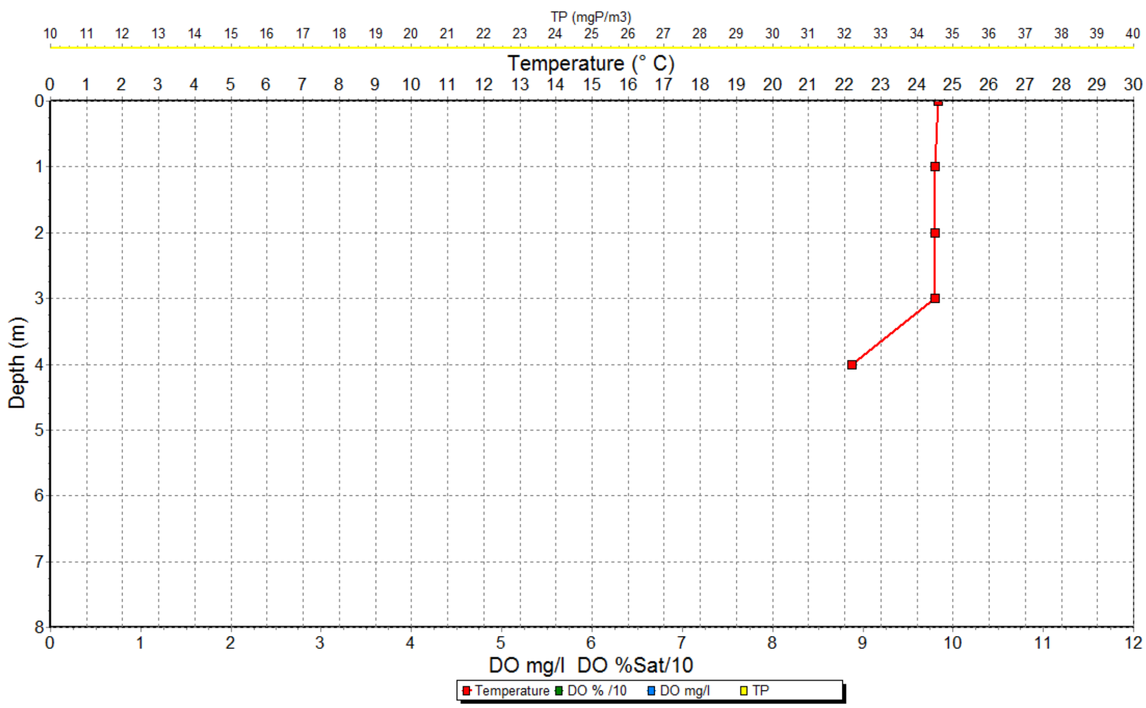

## September 17, 1990



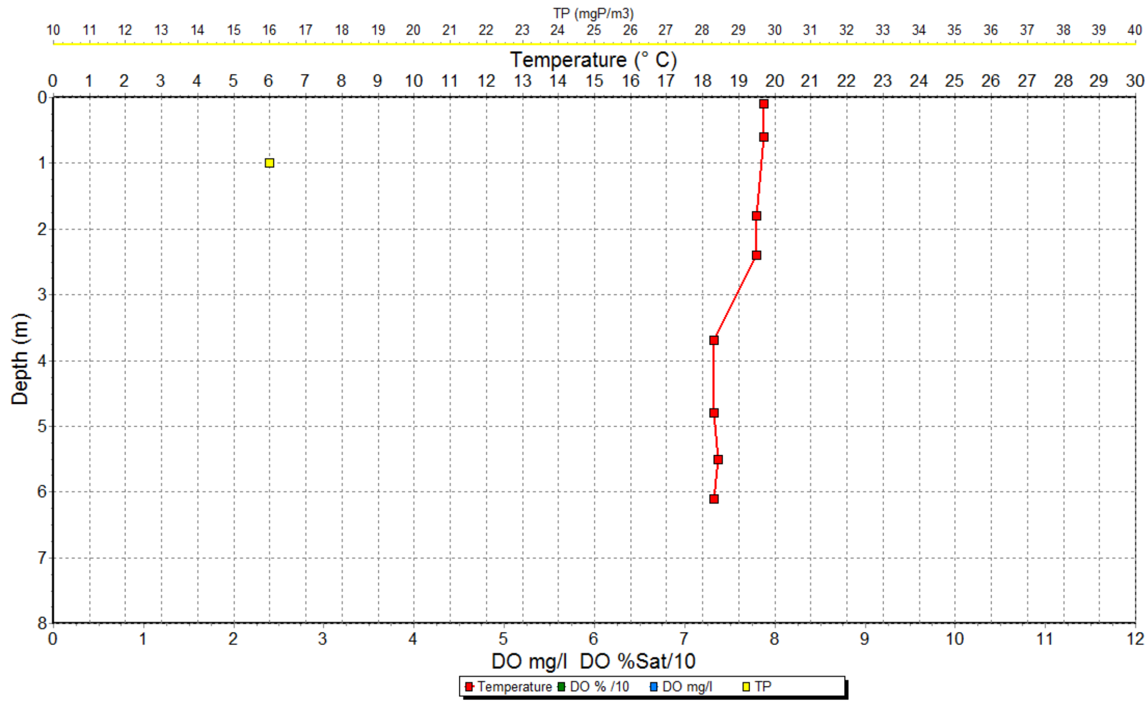
## October 30, 1990



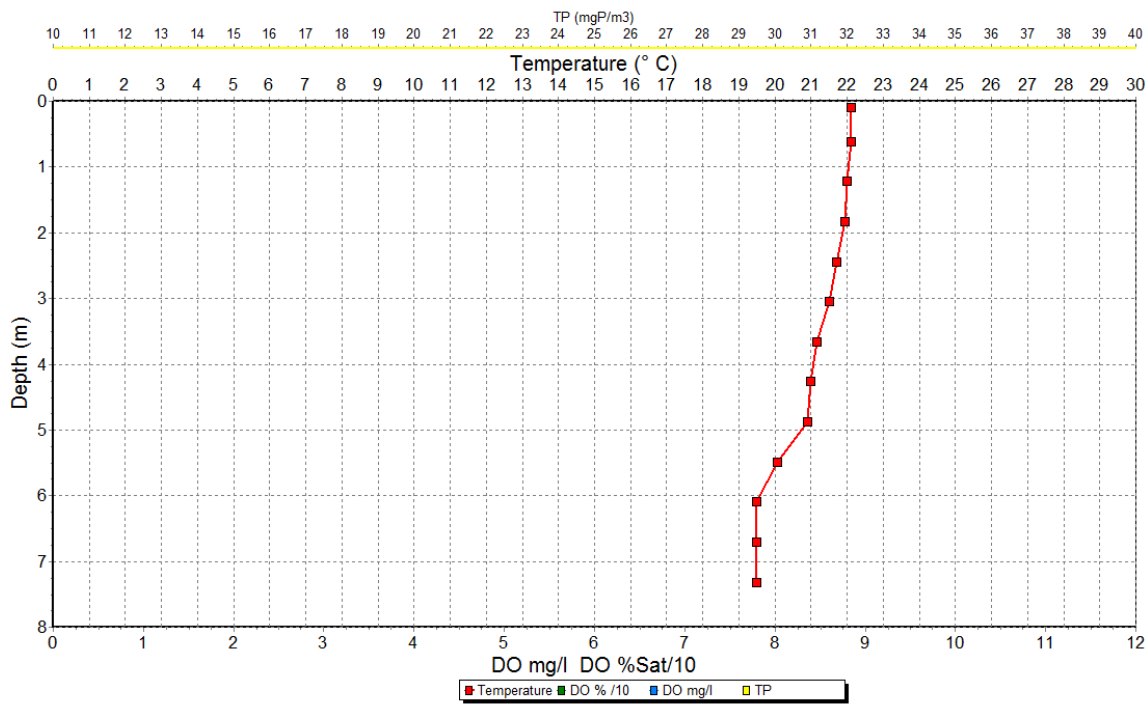

## July 24, 1991



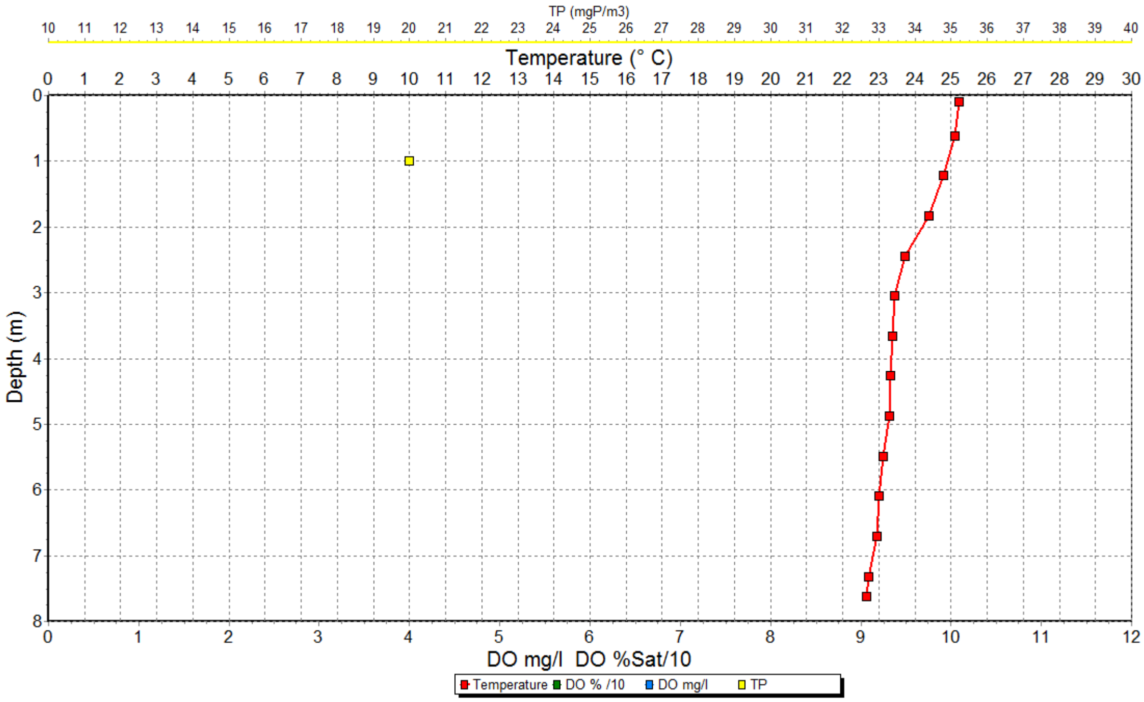
## June 24, 2003



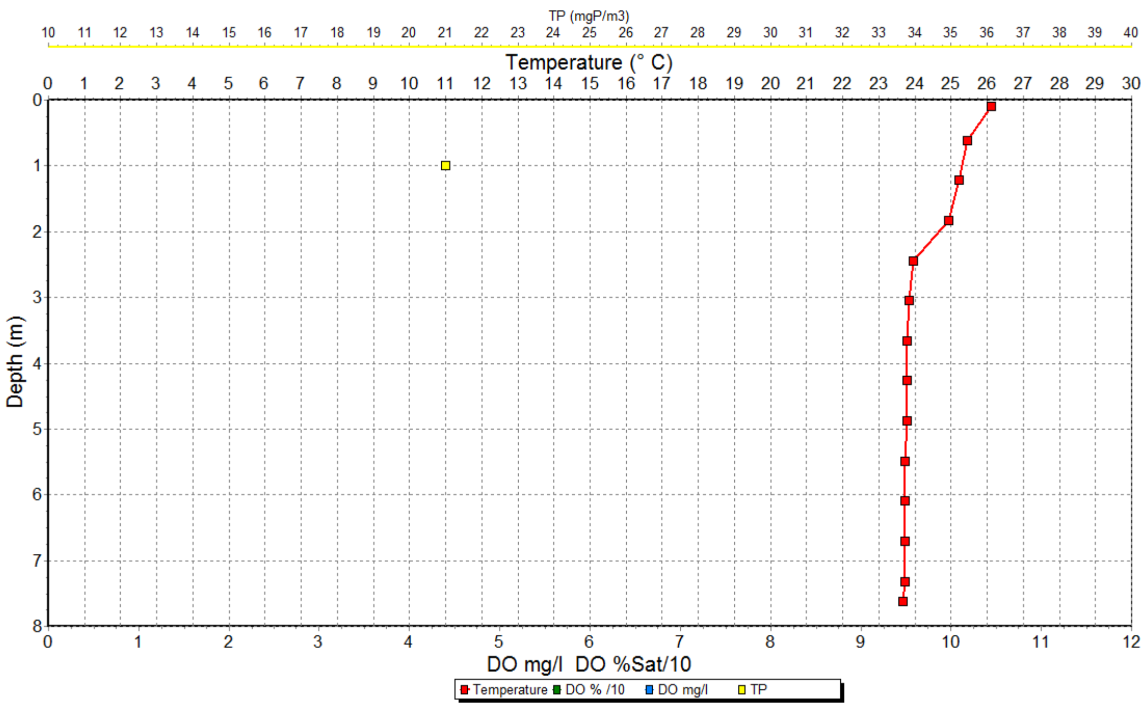

## July 1, 2003



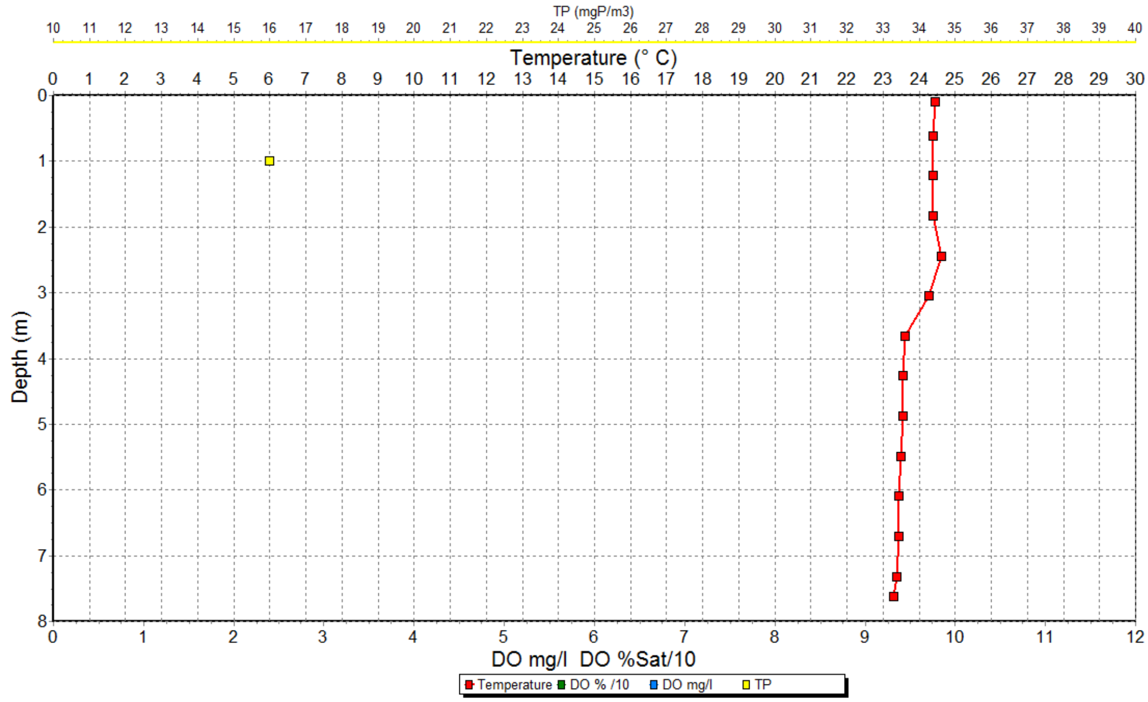
## July 21, 2003



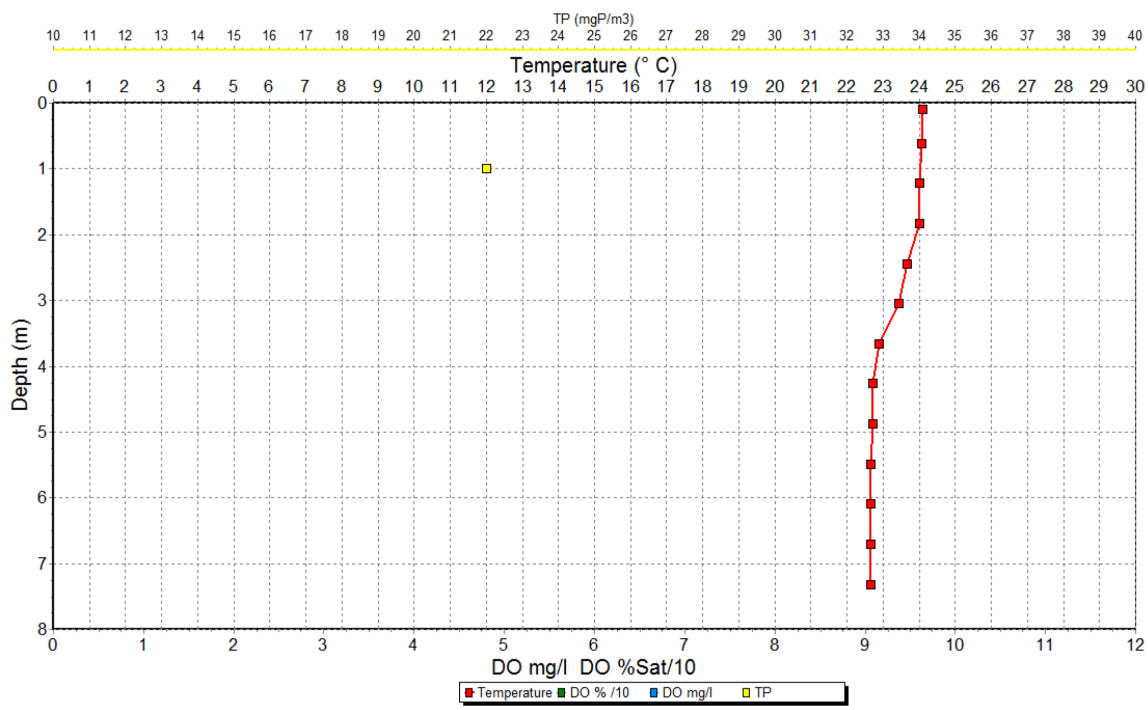

## July 29, 2003



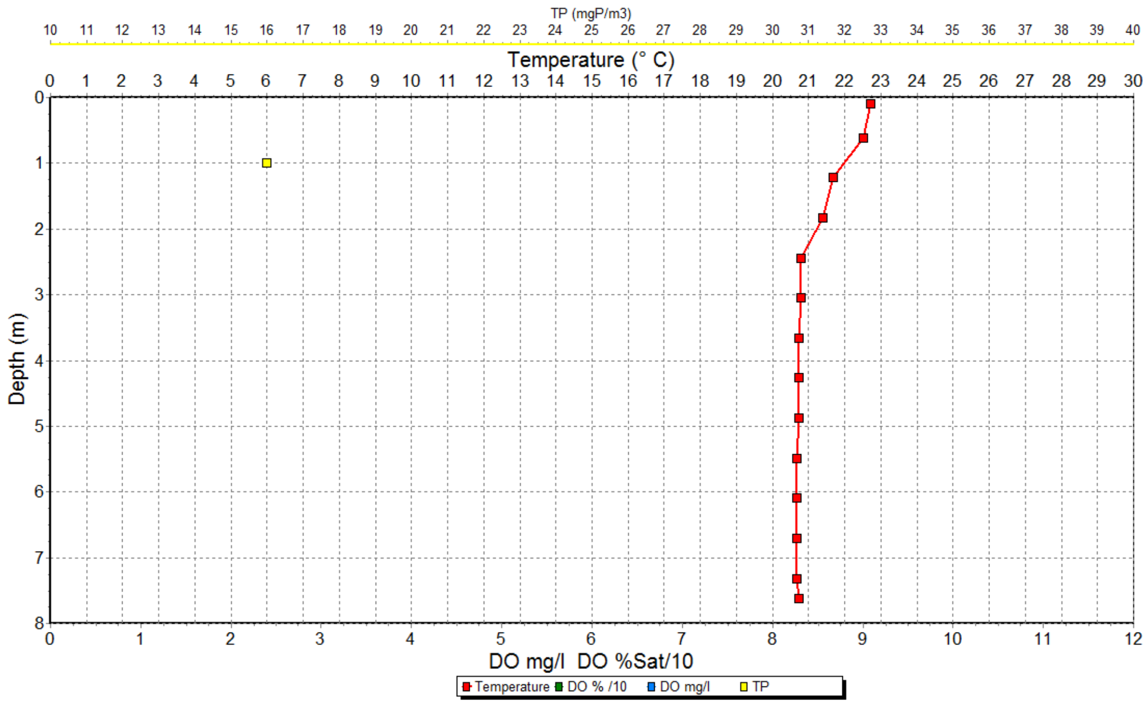
## August 7, 2003



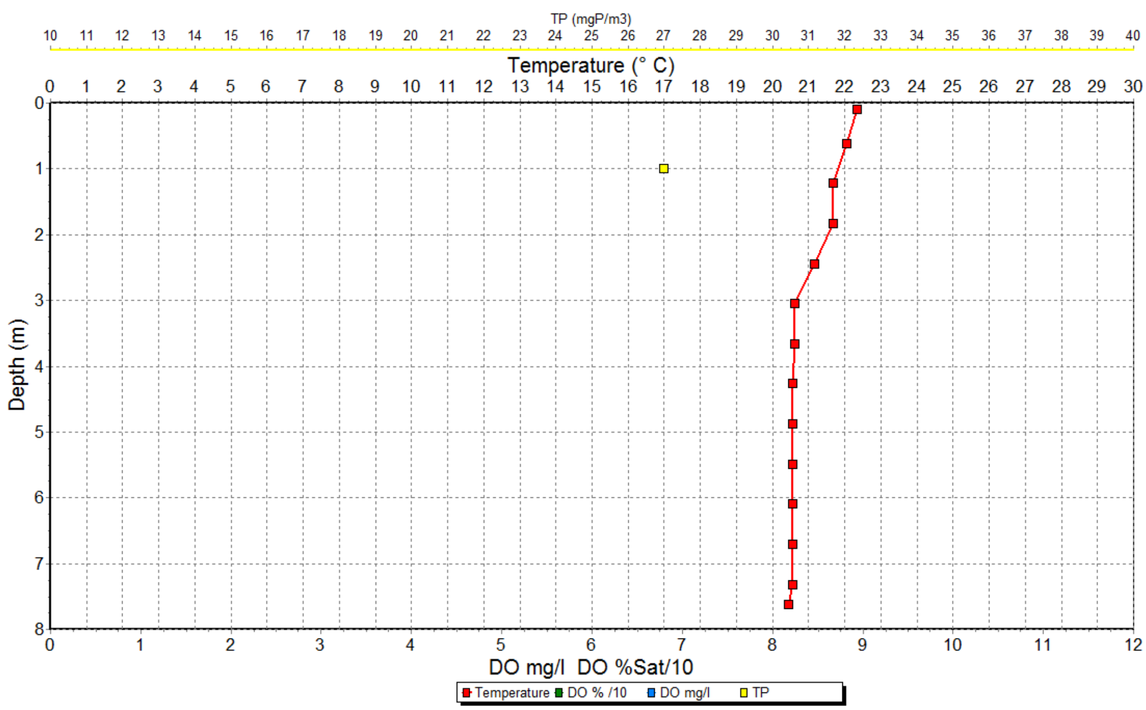

## August 19, 2003



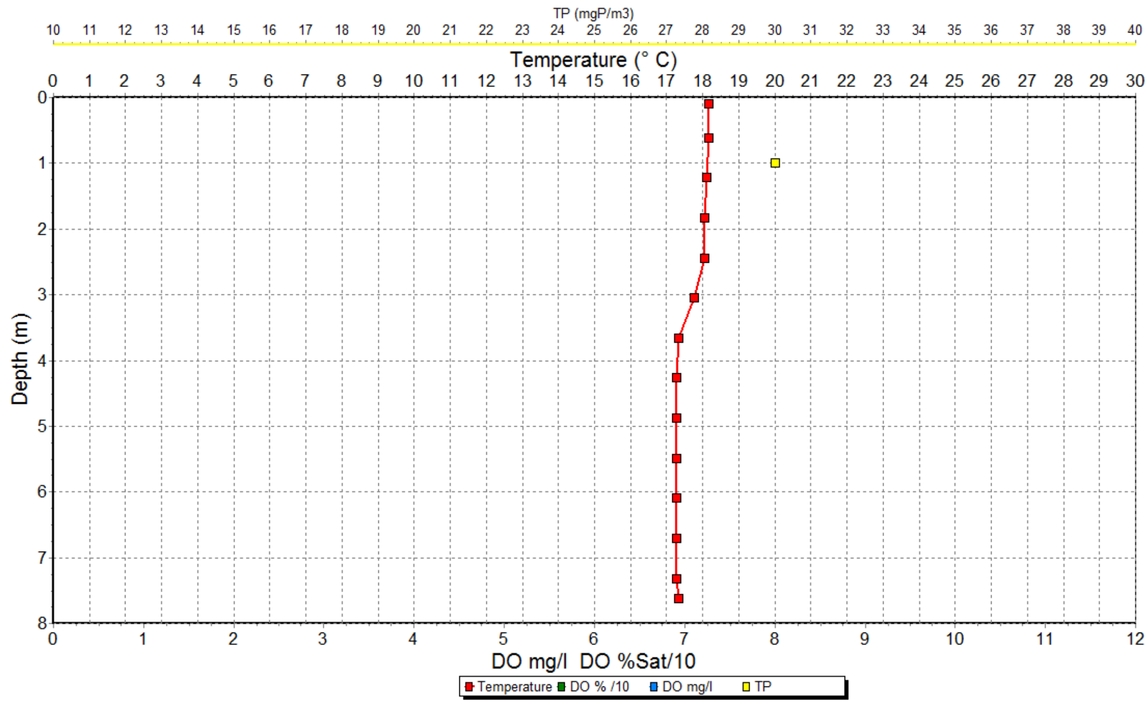
## August 27, 2003



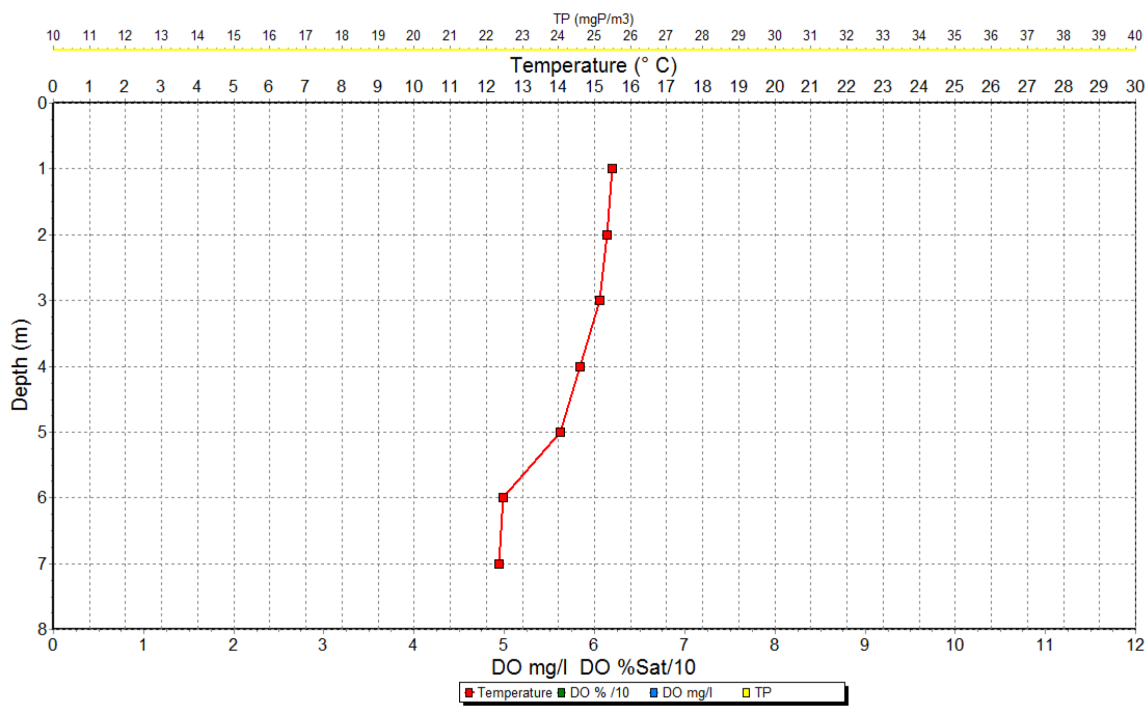

## September 4, 2003



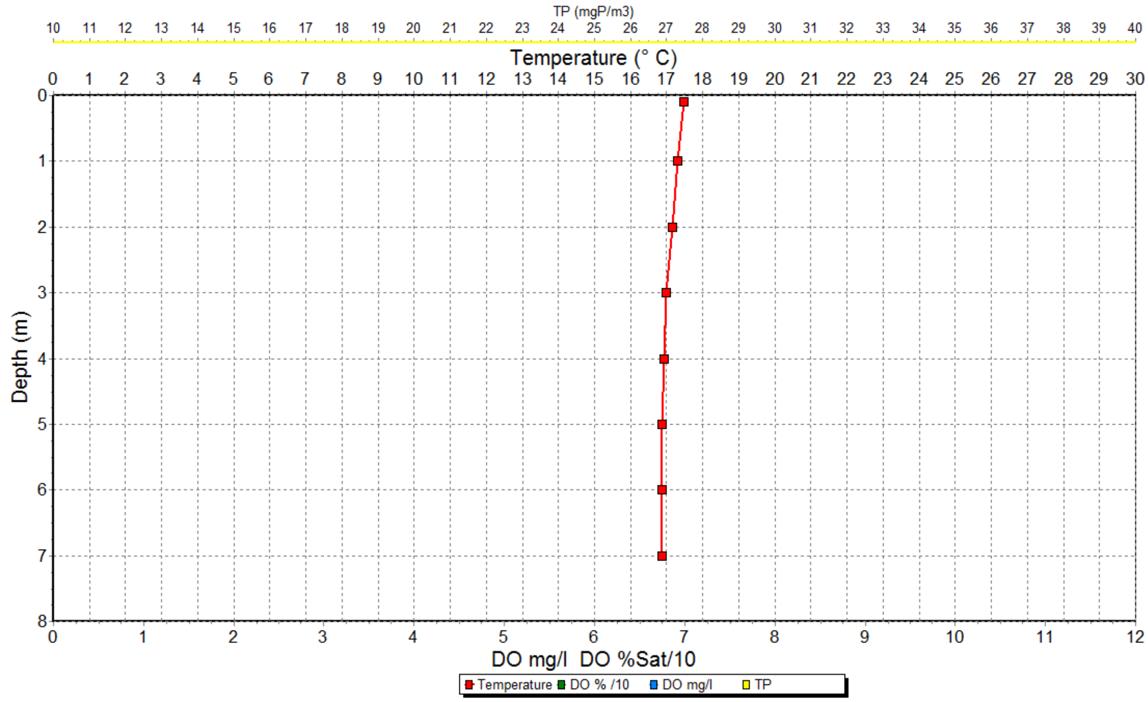
## September 15, 2003



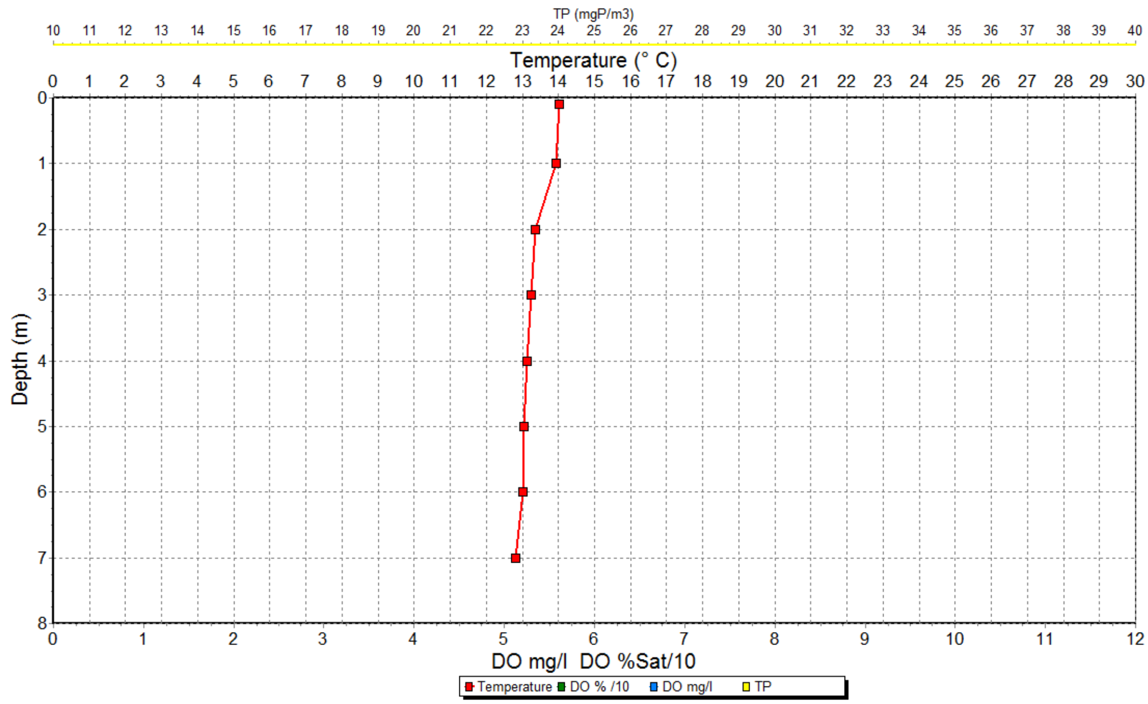

## May 9, 2005



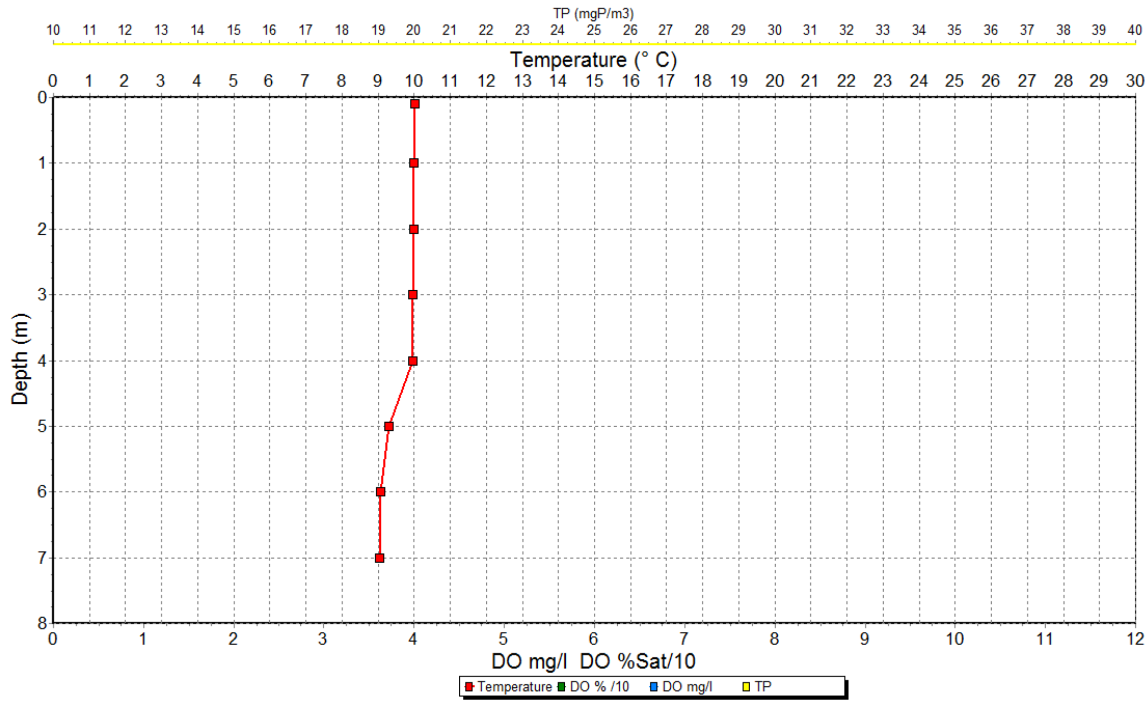
## June 6, 2005



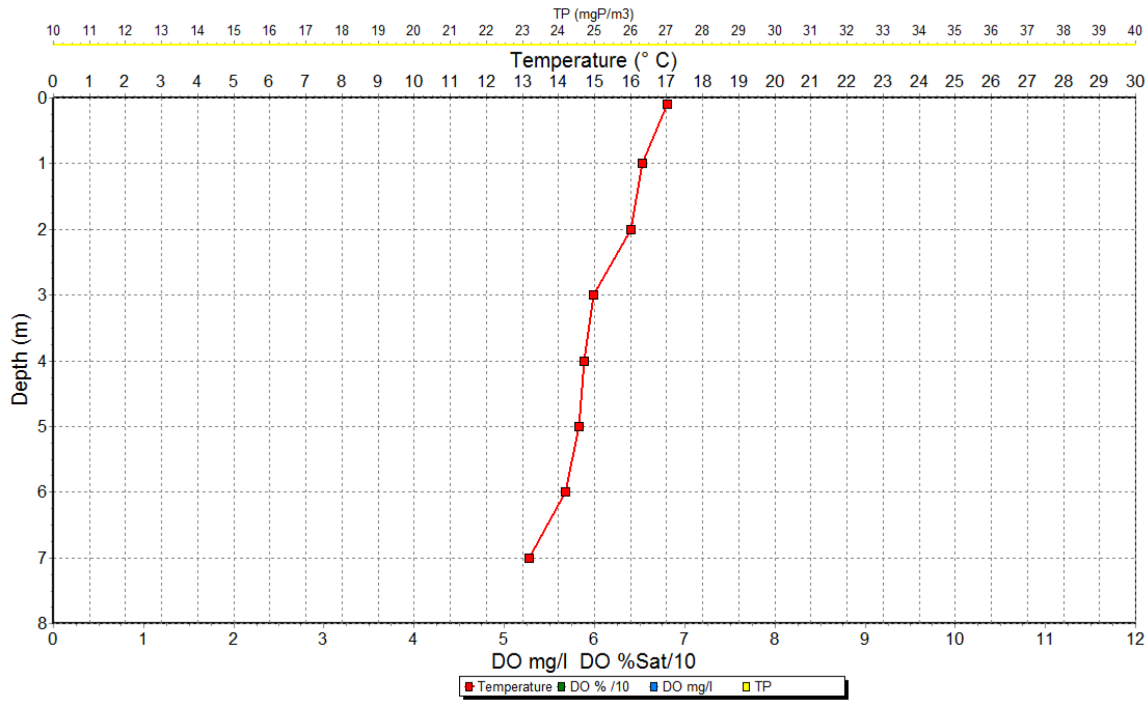

## May 11, 2006



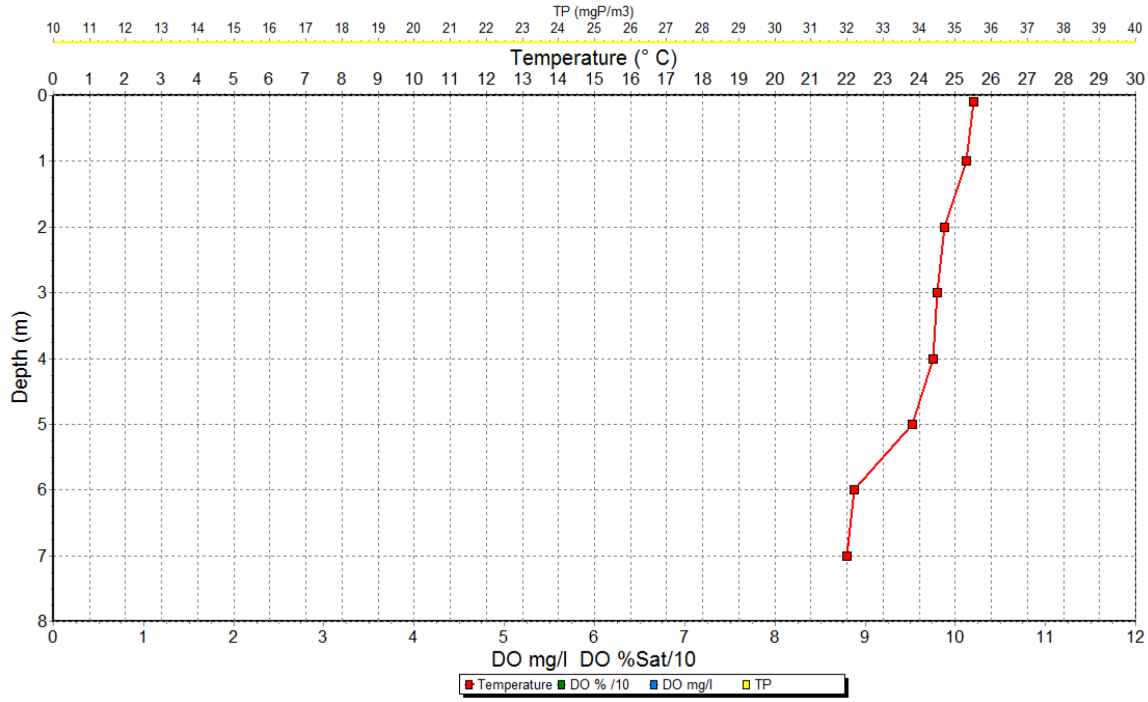
## April 16, 2007



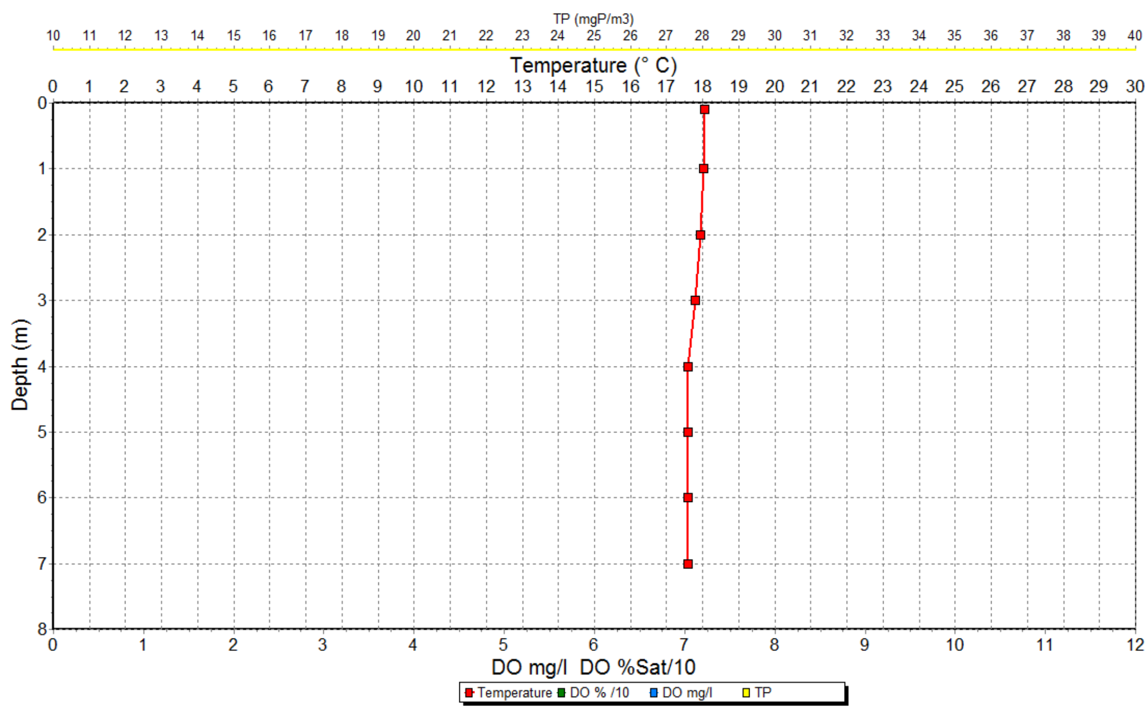

## May 14, 2007



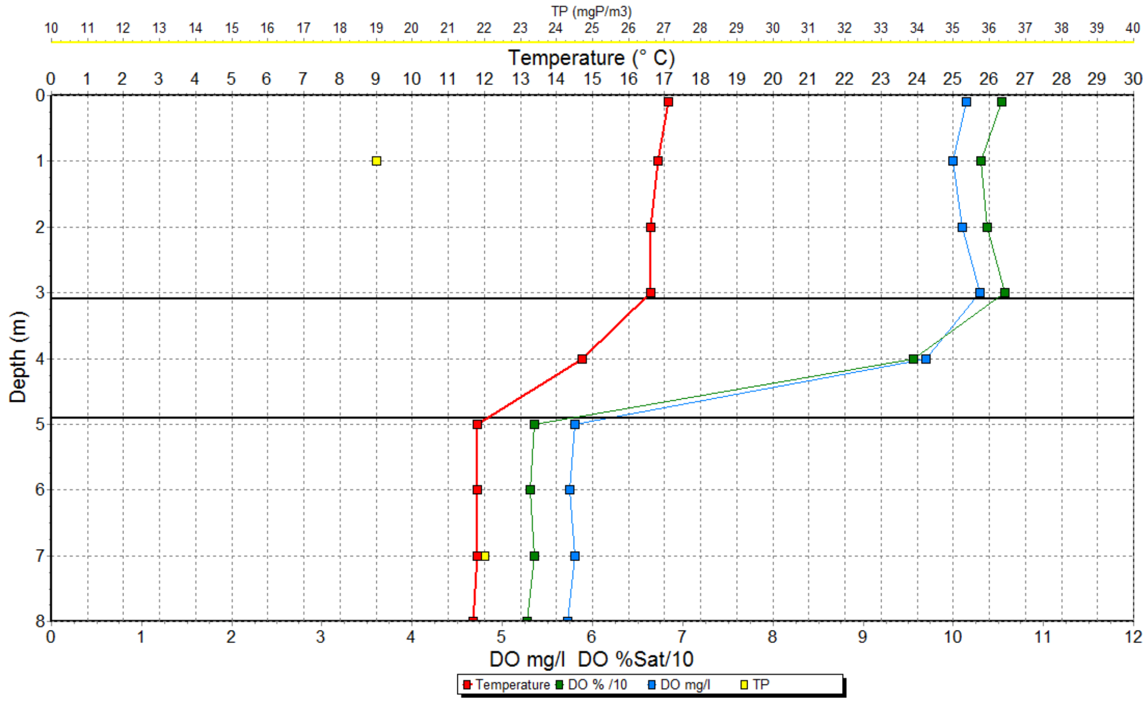
## July 16, 2007



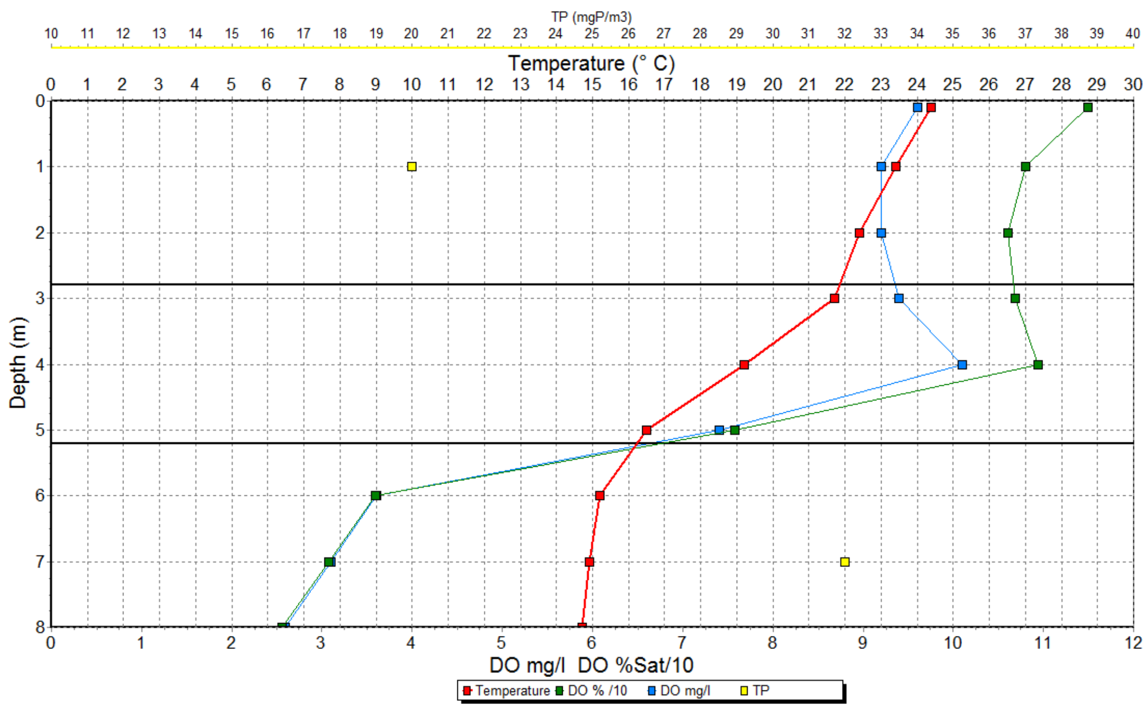

## September 18, 2007



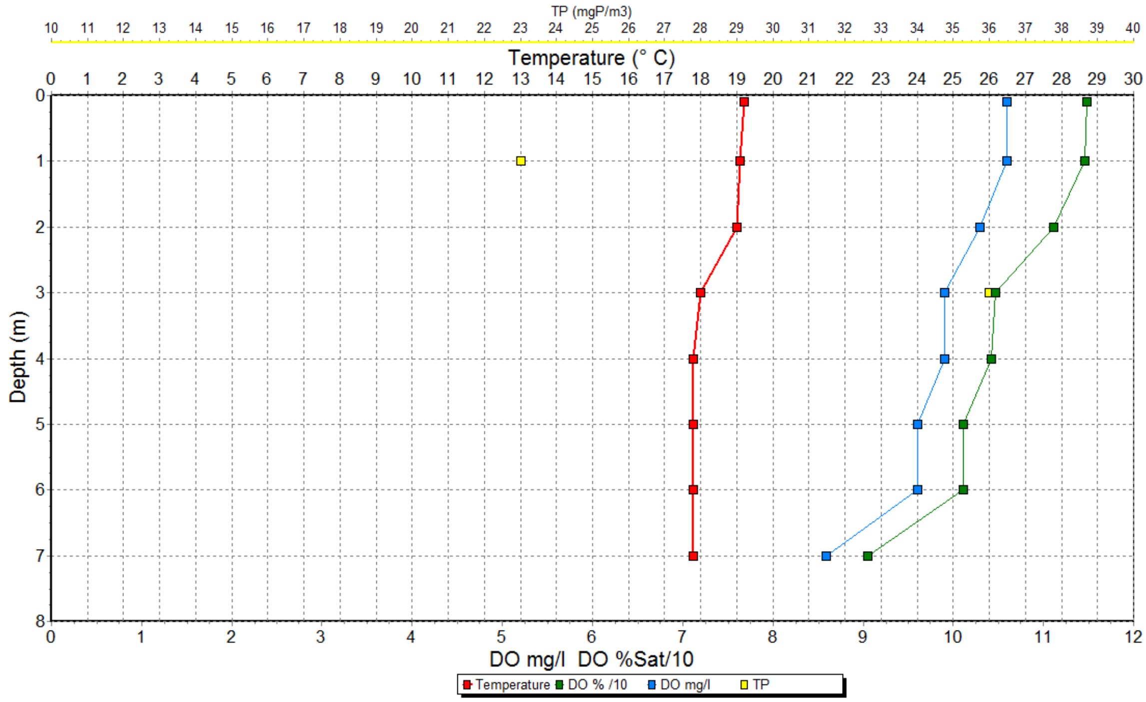
## May 30, 2008



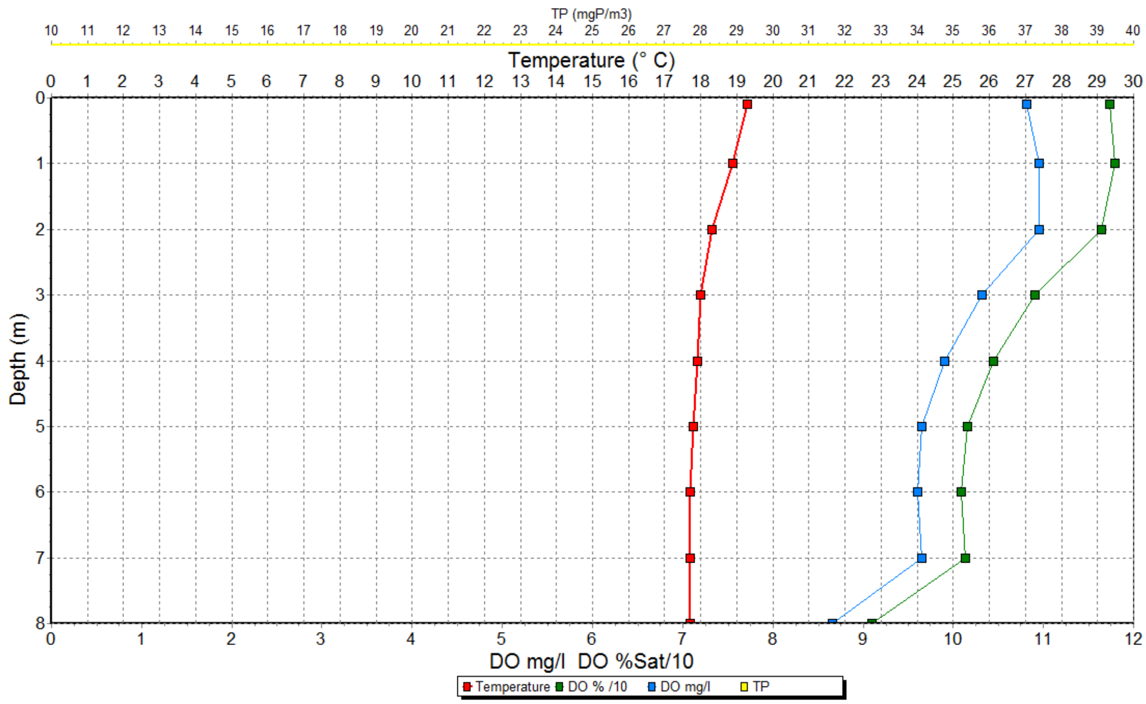

## June 30, 2008



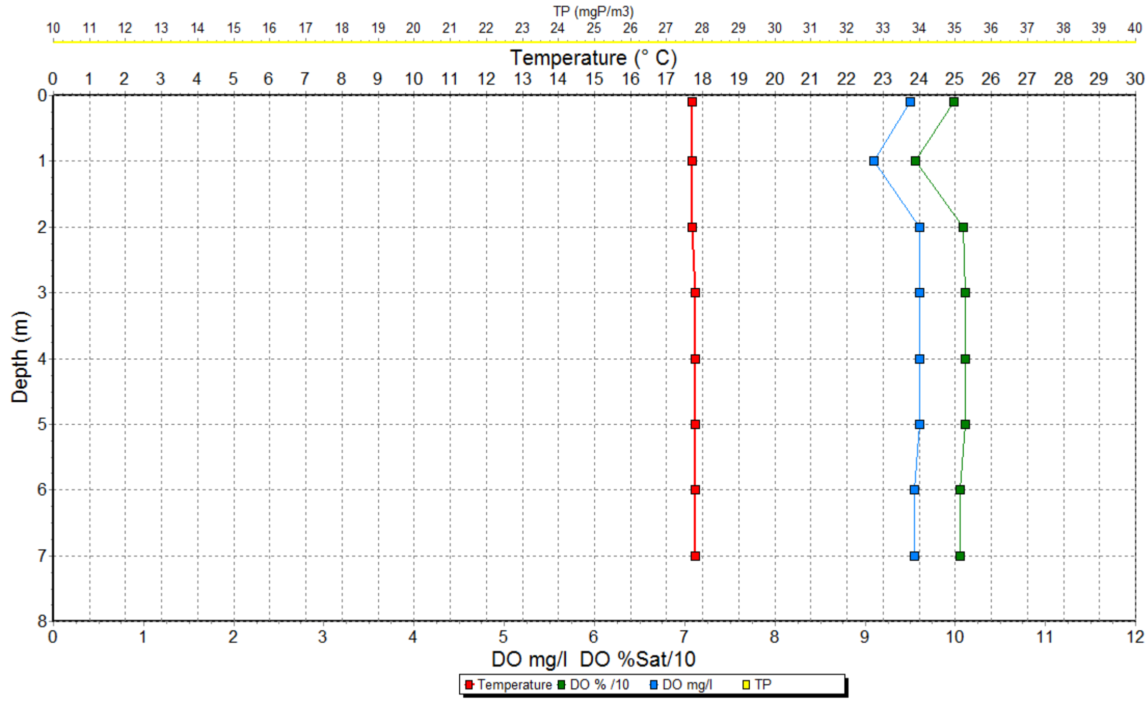
## August 28, 2008



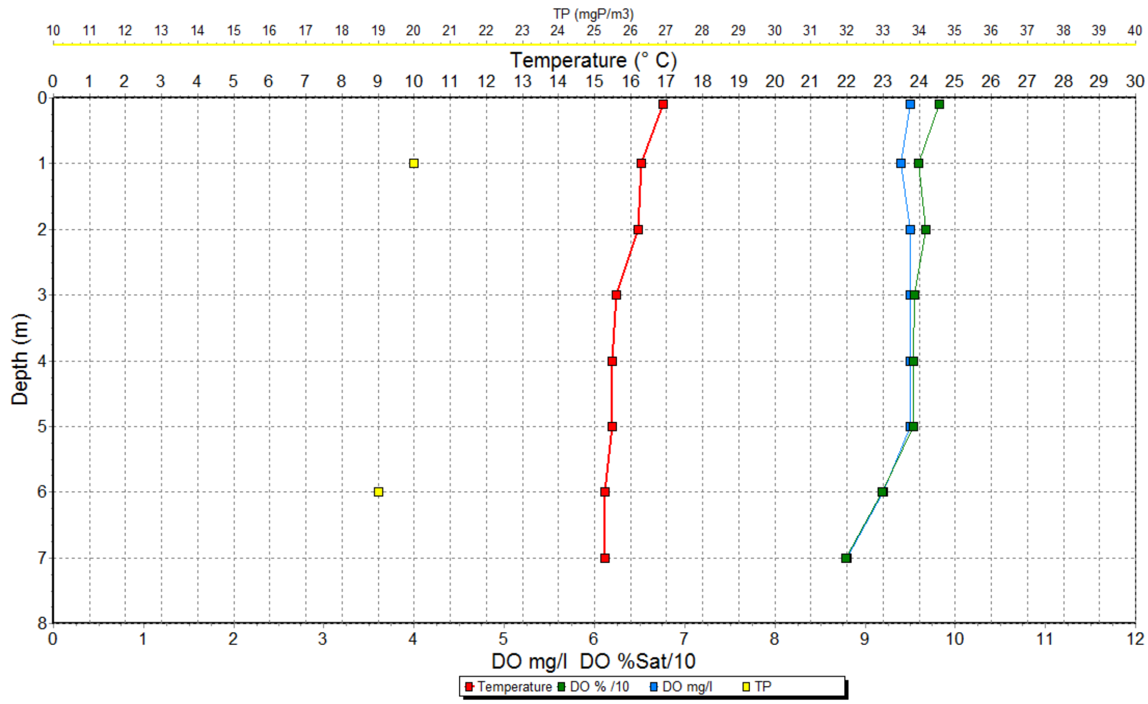

## September 8, 2008



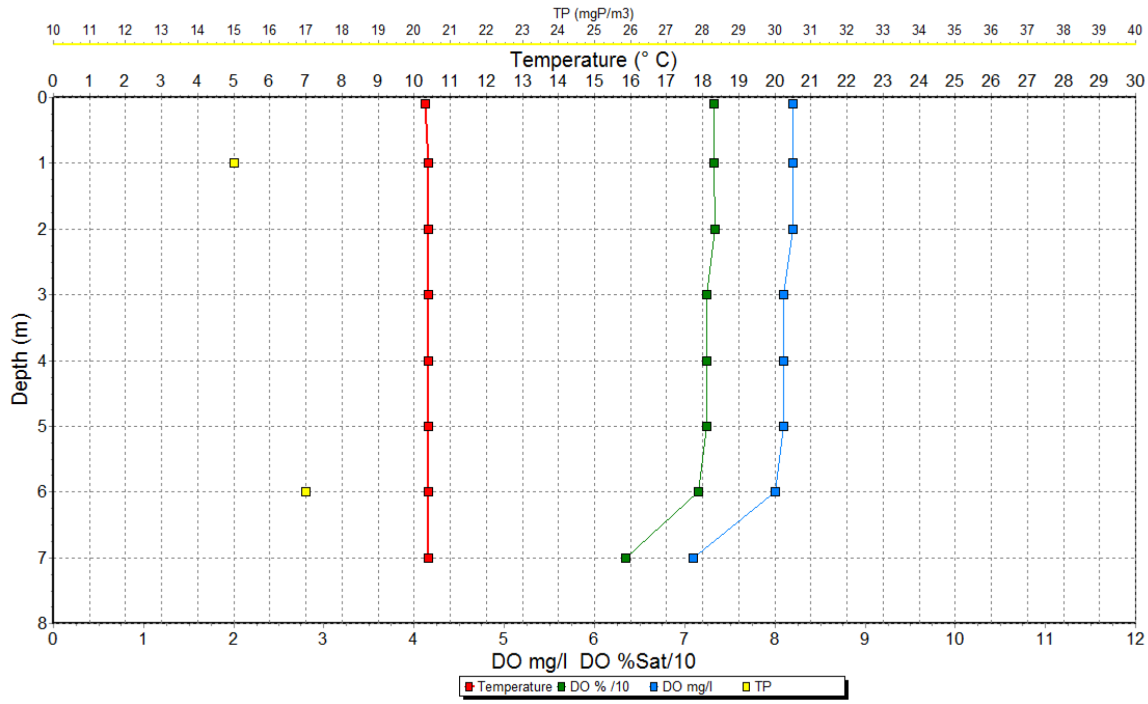
## September 9, 2008



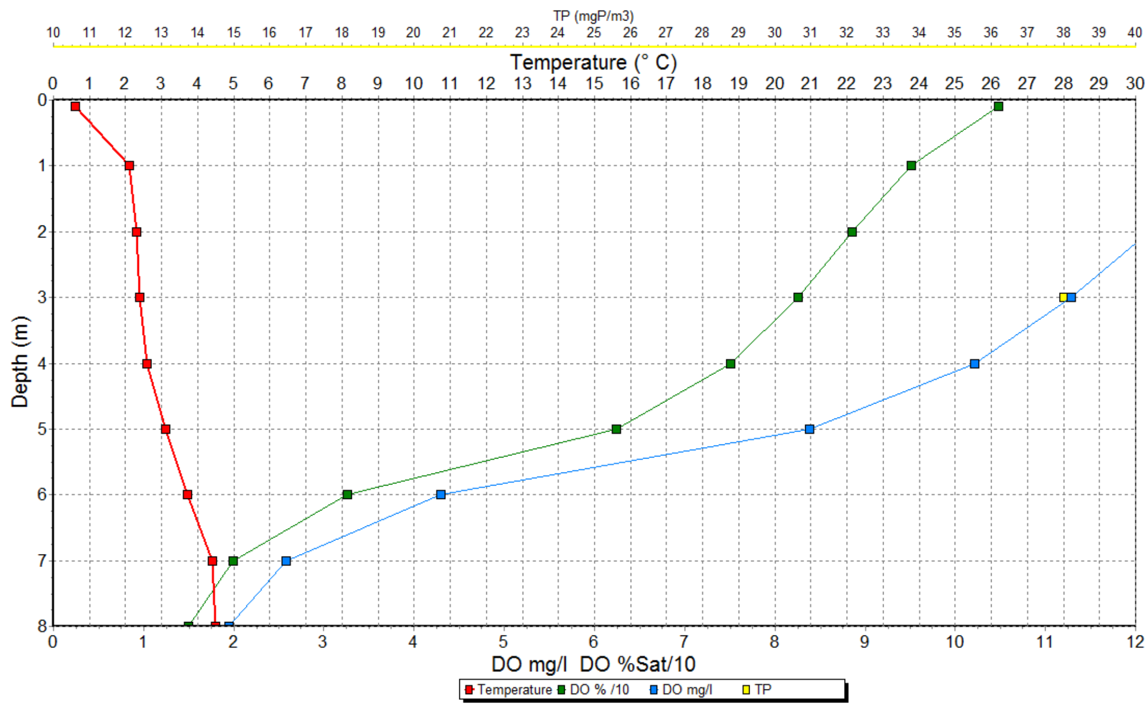

## September 30, 2008



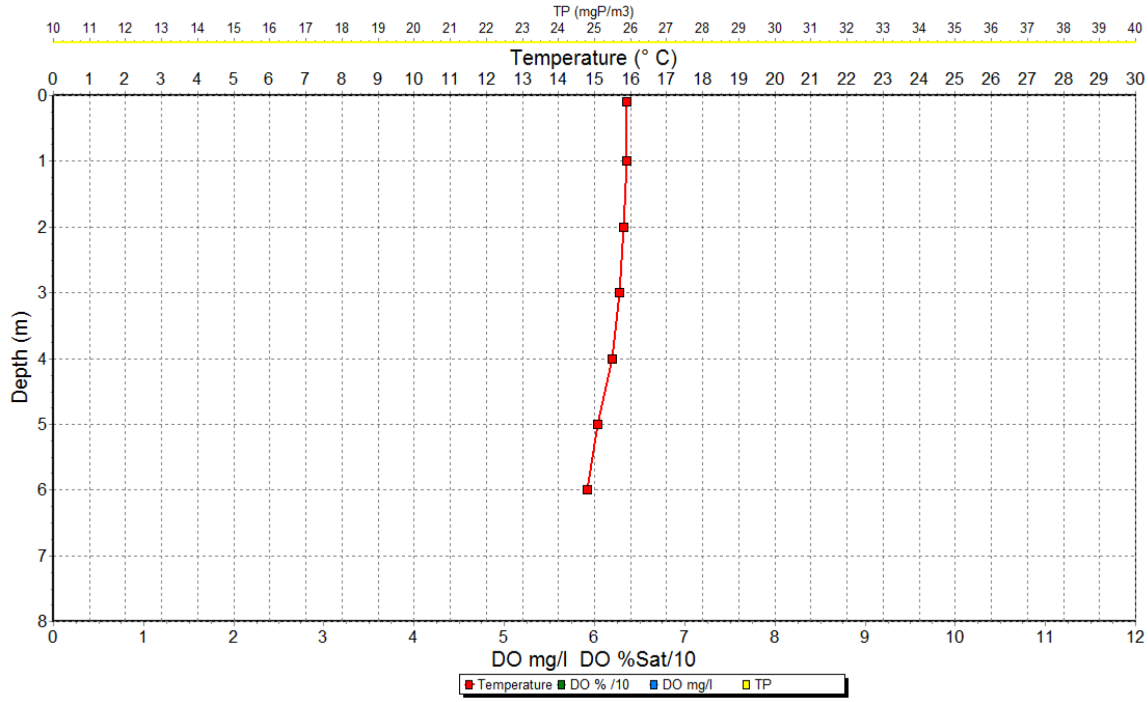
## October 21, 2008



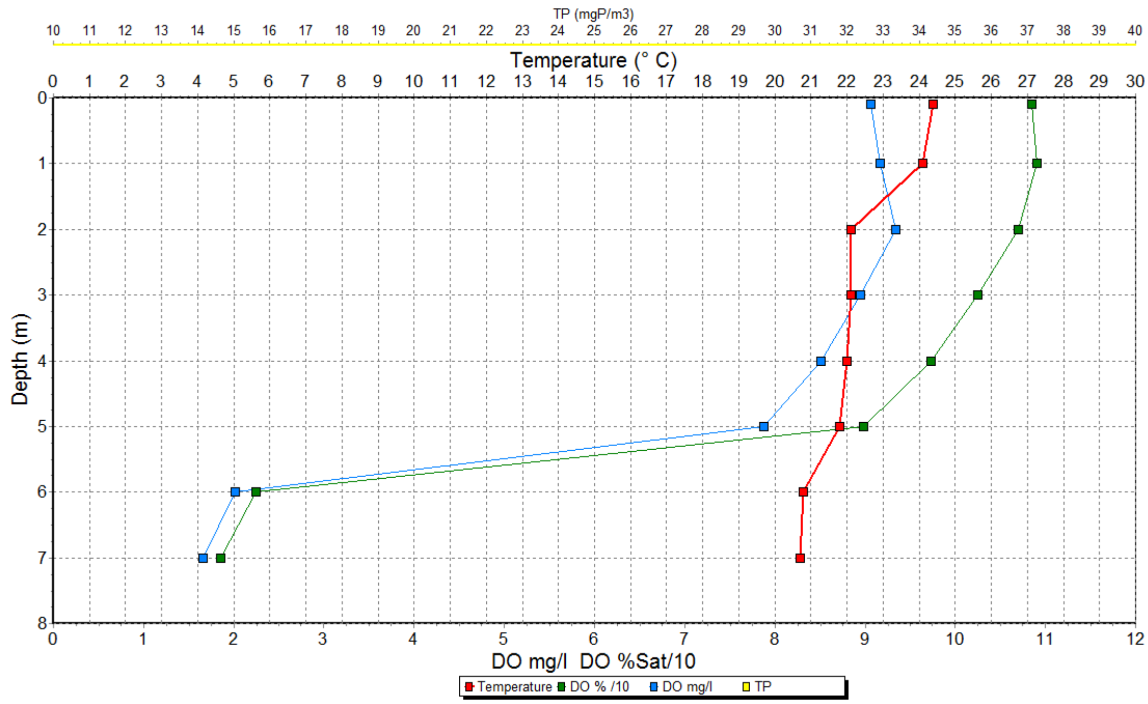

## January 28, 2009



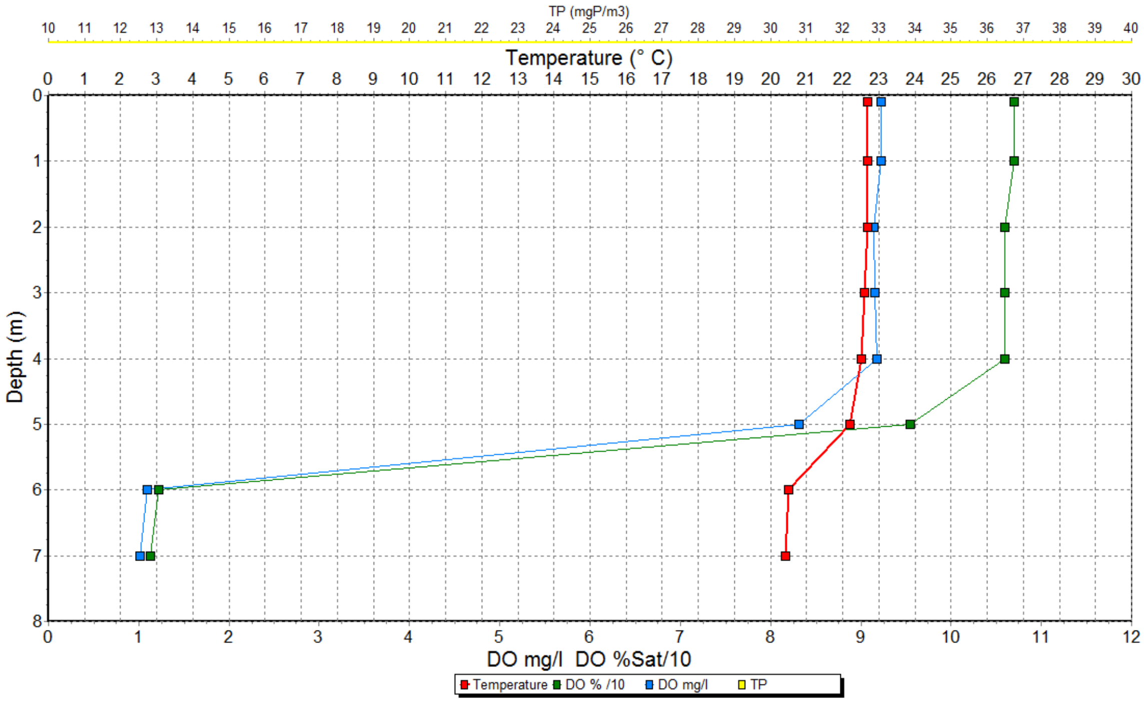
## June 5, 2010



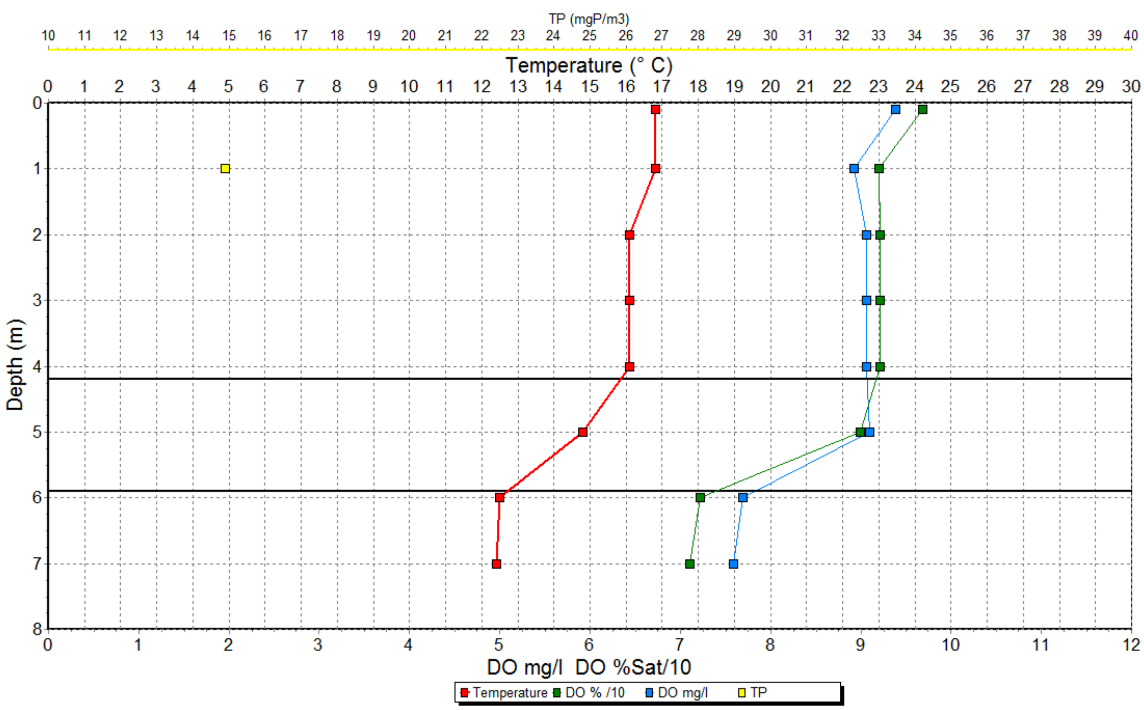

## August 8, 2011



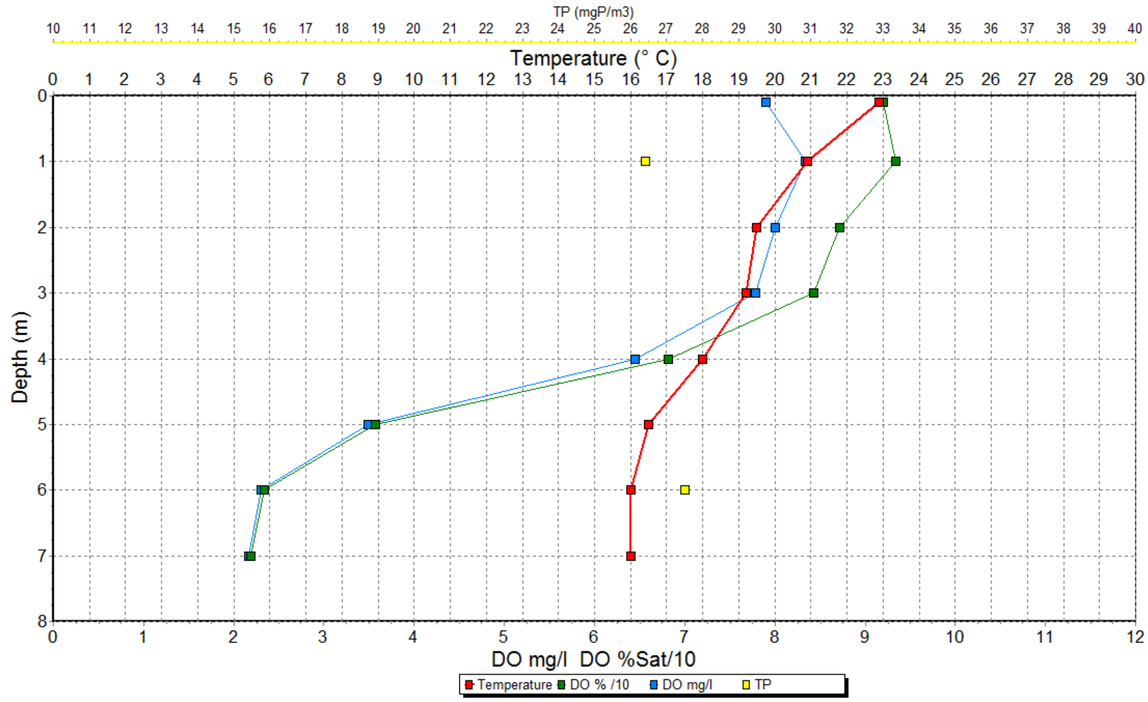
## August 29, 2011



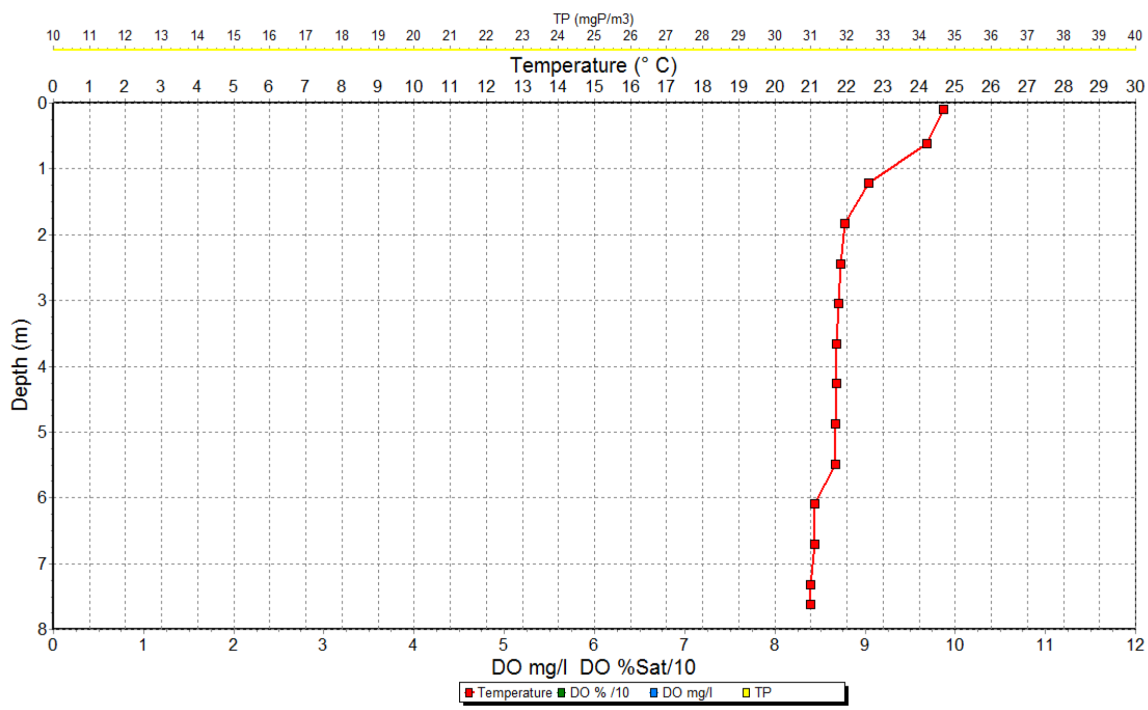

## May 17, 2012



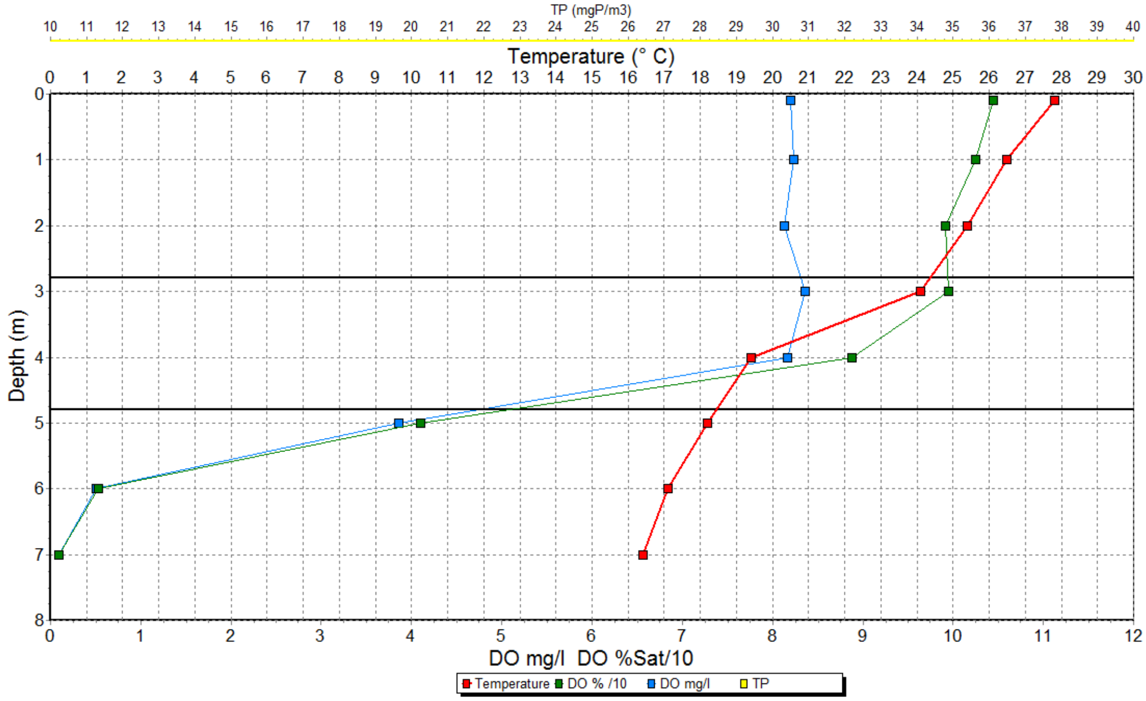
**July 5, 2012**



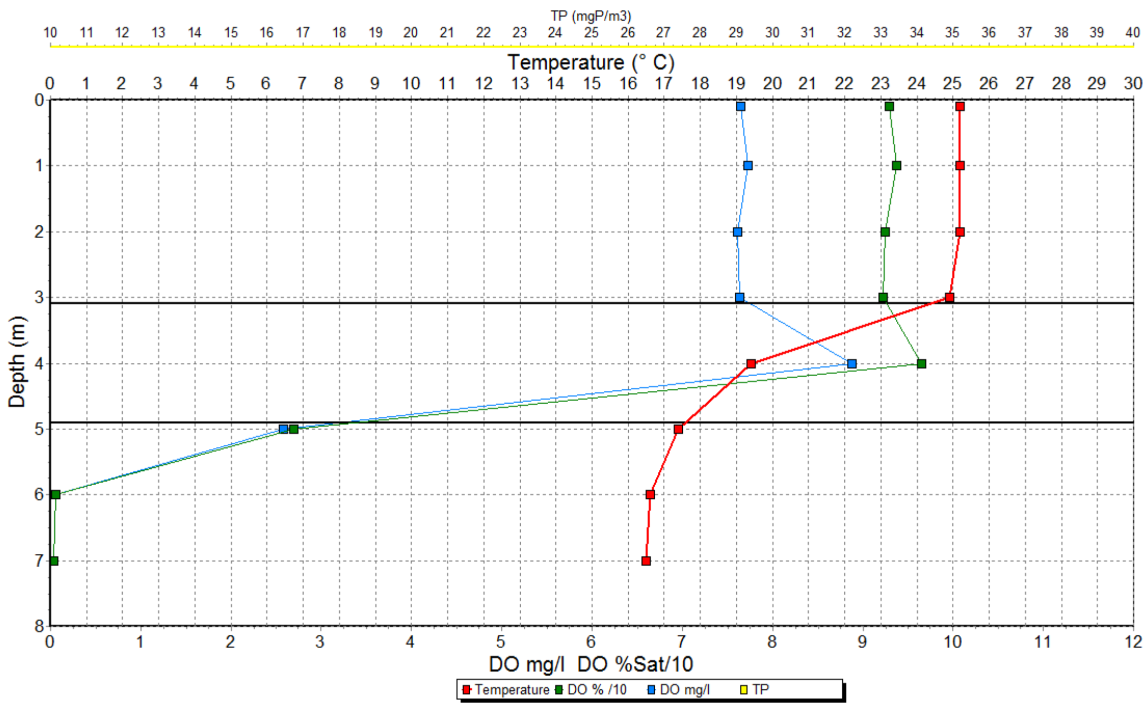

**July 11, 2012**



## July 19, 2012




## July 20, 2012



This page intentionally left blank for correct doubled-sided printing.

# Appendix D. Daily Load Table

**Daily Loads of nonpoint sources in the Fernan Lake watershed.**

| Source | Existing amount of TP contributed by source (kg/yr) | Existing TP Load[1] (kg/yr) | Fraction of TP reduction needed to meet target concentration[1] (load reduction) (percent) | Amount of TP reduction needed to meet target concentration[1] (kg/yr) | Amount of TP contributed by source after reductions (kg/yr) | TP load at target concentrations[1] (kg/yr) |
|---|---|---|---|---|---|---|
| **Fernan Creek** | 8.77 | 4.39 | 35% | 3.07 | 5.70 | 2.85 |
| **Fernan Village Lawns** | 0.07 | 0.07 | 35% | 0.02 | 0.04 | 0.04 |
| **Fernan Village Stormwater** | 0.01 | 0.01 | 35% | 0.00 | 0.01 | 0.01 |
| **Fernan Lake Road** | 0.04 | 0.04 | 35% | 0.01 | 0.02 | 0.02 |
| **Septic** | 0.03 | 0.03 | 35% | 0.01 | 0.02 | 0.02 |
| **Internal Cycling** | 0.07 | 0.07 | 35% | 0.02 | 0.04 | 0.04 |
| **French Gulch** | 0.00 | 0.00 | 35% | 0.00 | 0.00 | 0.00 |
| **Other** | 0.03 | 0.02 | 35% | 0.01 | 0.02 | 0.01 |
| **Total** | **9.01** | **4.62** | | **3.15** | **5.86** | **3.01** |

This page intentionally left blank for correct doubled-sided printing.

# Appendix E. Distribution List

This is the list of those to whom you sent (will send) the TMDL.

This page intentionally left blank for correct doubled-sided printing.

# Appendix F. Public Comments/Public Participation

Public Comments go here.