Lake Lowell TMDL: Addendum to the Lower Boise River Subbasin Assessment and Total Maximum Daily Loads

Final

Department of Environmental Quality

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Acknowledgments

Many people contributed their time and knowledge to help make this document complete. Thank you to all who contributed. Bryan Horsburgh and Julia Achabal collected and organized reference information and water quality data. Data was collected on Lake Lowell and tributary waterways by Hawk Stone, Darcy Sharp, Richard Lee, Jacob Nelson, Joe Kozfkay (IDFG), BOR and Kirk Campbell (ISDA). Susan Burch of USFWS provided reports summarizing fish tissue collection and analysis for mercury concentrations in fish and wildlife species at the refuge. The Deer Flat Wildlife Refuge provided reference articles about cyanobacteria outbreaks within the refuge and coordinated meetings regarding future reservoir sampling and visitor outreach. IDFG provided fishery information and field sampling coordination. Boise Project Board of Control provided reservoir inflow and outflow data. Darcy Sharp and Merlynn Bender worked tirelessly to calibrate the reservoir model and determine appropriate water quality targets and load capacities. This document was completed and reviewed with the help of the Lower Boise Watershed Council. Special thanks to Sherrill Doran for her assistance with stormwater and agricultural land load allocations.

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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 thousandth

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

AU assessment unit

BAG Basin Advisory Group

BLM United States Bureau of Land Management

BMP best management practice

BOD biochemical oxygen demand

BOR United States Bureau of Reclamation

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

DEQ Department of Environmental Quality

DO dissolved oxygen

DWS domestic water supply

EPA United States Environmental Protection Agency

ESA Endangered Species Act

F Fahrenheit

FWS U.S. Fish and Wildlife Service

GIS Geographical Information Systems

HUC Hydrologic Unit 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

ln natural log

m meter

m^3 cubic meter

mi mile

mi^2 square miles

MGD million gallons per day

mg/L milligrams per liter

mm millimeter

MOS margin of safety

MWMT maximum weekly maximum temperature

n.a. not applicable

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

PCR primary contact recreation

ppm part(s) per million

SBA subbasin assessment

SCR secondary contact recreation

SS salmonid spawning

SSC suspended sediment

TDS total dissolved solids

T&E threatened and/or endangered species

TIN total inorganic nitrogen

TKN total Kjeldahl nitrogen

TMDL total maximum daily load

TP total phosphorus

TS total solids

TSS total suspended solids

U.S. United States

U.S.C. United States Code

USDA United States Department of Agriculture

USFS United States Forest Service

USGS United States Geological Survey

WAG Watershed Advisory Group

WBAG *Water Body Assessment Guidance*

WLA wasteload allocation

WQS water quality standard

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 must develop a total maximum daily load (TMDL) for the pollutants, set at a level expected to achieve water quality standards.

This document addresses Lake Lowell in the Lower Boise River Subbasin (HUC ID 17050114), which is on Idaho's current §303(d) list. This subbasin assessment (SBA) and TMDL analysis have been developed to comply with Idaho's TMDL schedule. The assessment describes the physical, biological, and cultural setting; water quality status; pollutant sources; and recent pollution control actions specifically regarding Lake Lowell.

The SBA is an important first step leading to the TMDL. The starting point for this assessment was Idaho's current §303(d) list (section 5 of the integrated report) of water quality-limited water bodies. The SBA portion of this document examines the current status of Lake Lowell and defines the extent of impairment and causes of water quality limitation throughout the lake. The TMDL analysis quantifies pollutant sources and allocates responsibility for load reductions needed to return Lake Lowell to a condition of meeting water quality standards.

Lake Lowell at a Glance

Lake Lowell is located in the Lower Boise River Subbasin in southwestern Idaho (Figure A). The lake is an off-channel irrigation storage reservoir that was formed by three earth-fill dams enclosing a natural depression on a plateau between the Snake and Boise Rivers. Lake Lowell and the surrounding land is part of Deer Flat National Wildlife Refuge, which was established by executive order of President Theodore Roosevelt in 1909.

Lake Lowell is located in Canyon County, Idaho. Boise River water is supplied to the lake through direct diversion from the river to the New York Canal and through irrigation return flows from the surrounding valley. Stormwater from densely populated urban areas in Boise, Meridian, Kuna, and rural residential areas in Ada and Canyon counties; and agricultural runoff from lands in southern Ada and Canyon counties, flow into canals and drains feeding Lake Lowell. The City of Nampa is located approximately 5 miles east of the reservoir.

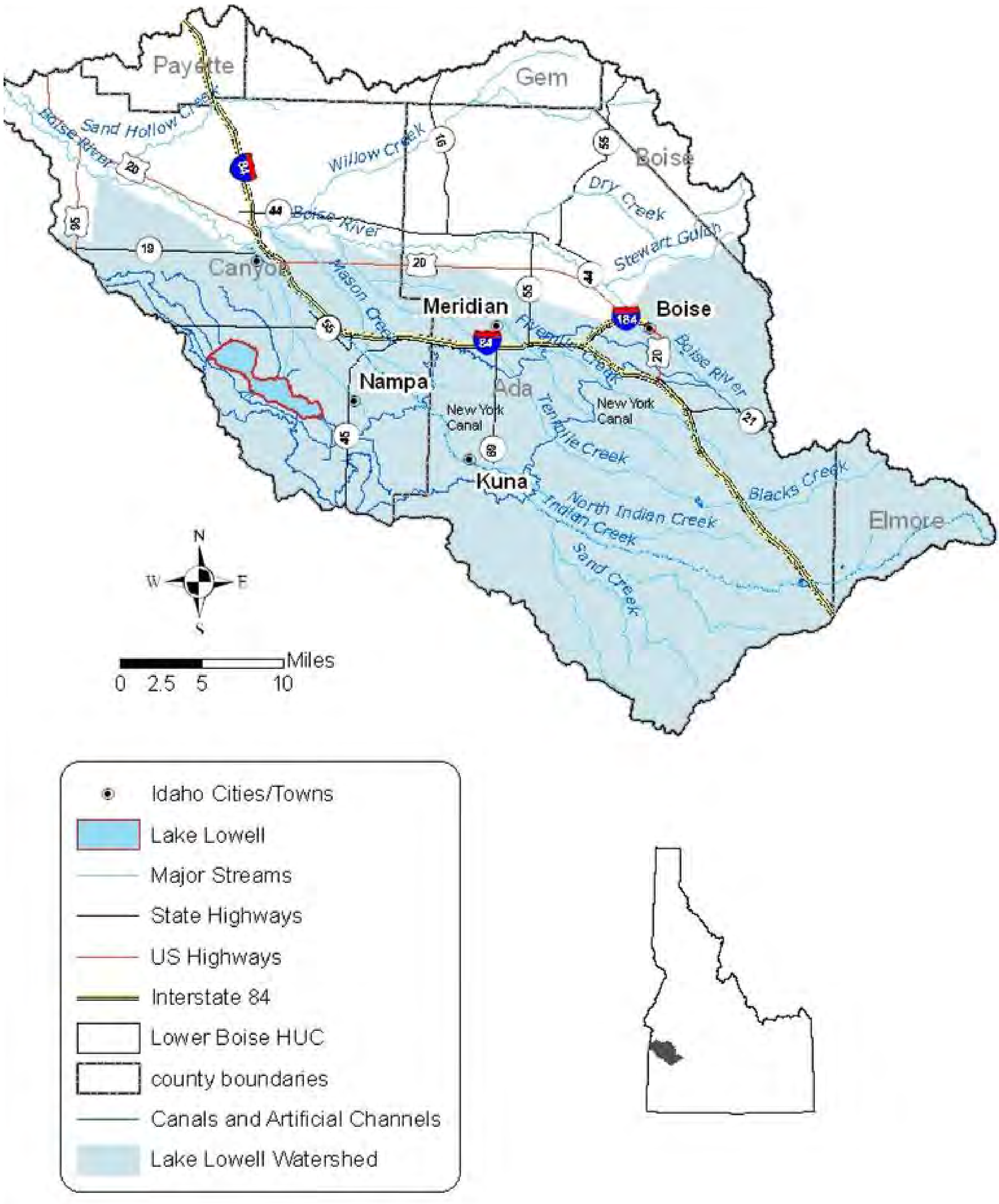


Figure A. Subbasin at a glance.

Lake Lowell was added to the 1998 §303(d) list for nutrients and low dissolved oxygen (DO) and was carried forward to subsequent lists. Excessive algae and macrophyte production result in oxygen depletion. Algal mats interfere with primary contact recreation and aesthetic values of this special resource water. Decreased levels of DO impair warm water aquatic life.

The sources of nutrient loading include phosphorus contributed by canal and drain tributaries and waterfowl. Very high concentrations of phosphorus from agricultural runoff were measured in tributary drains and wasteways. A 37% reduction of incoming loads of total phosphorus (TP) is expected to eliminate nuisance levels of aquatic vegetation and attain the water quality standard (WQS) of 5 milligrams per liter (mg/L) DO for warm water aquatic life.

Table A. Idaho 2008 Integrated Report, §303(d) listing for Lake Lowell

Water Body	Assessment Unit	Basis for Listing	Pollutant(s)	Acres of Impaired Water Bodies
Lake Lowell	17050114SW004_06	Nutrient Enrichment, Biological Indicators	Dissolved Oxygen Listed for Unknown Determined to be Total Phosphorus	9,024.8

Key Findings

A TMDL is developed for total phosphorus in Lake Lowell. Data collected indicate that beneficial uses of aesthetics, primary contact recreation, special resource water and warm water aquatic life are not met due to excessive algal and macrophyte growth. Nighttime respiration and decomposition of plant material causes oxygen depletion. Very high concentrations of TP were measured in tributary waterways to Lake Lowell ranging from 0.02 mg/L to 6.3 mg/L, with a median concentration of 0.41 mg/L. In addition, phosphorus is stored in sediment and taken up by rooted macrophytes and also released from sediment under anoxic conditions. Sediment oxygen demand from decaying organic matter results in violation of the DO standard for warm water aquatic life.

Numeric targets for Lake Lowell are set based on WQS and established targets for similar water bodies. The target for DO is greater than 5.0 mg/L, based on Idaho's numeric water quality standard for warm water aquatic life. The water quality standard for nutrients in Idaho is a narrative statement; therefore appropriate numerical targets were chosen for total phosphorus and chlorophyll-*a*. Tributaries to Brownlee Reservoir have a total phosphorus target of 0.07 mg/L, which was part of the allocation required to restore beneficial uses to Brownlee Reservoir in the EPA-approved Snake River-Hells Canyon TMDL (DEQ 2004). A commonly used chlorophyll-*a* target for reservoirs is 10 micrograms per liter (µg/L) (Raschke 1993). The Box Exchange, Transport, Temperature, and Ecology of a Reservoir (BETTER) water quality model was used to predict the effectiveness of selected targets.

A wasteload allocation for stormwater is included in the New York Canal tributary phosphorus load allocation. A margin of safety is implicit due to conservative targets, model parameters, and load allocations. The phosphorus load delivered to the reservoir and resulting changes in DO are seasonally dependent upon flow in the canal system. New York Canal, which supplies water to the system, generally flows from March 15 through September 30. Most nutrient loading to the reservoir occurs during peak irrigation season in late summer (Appendix E). This is also the time of year when water temperature is highest, and so DO levels are consequently at their lowest.

Total phosphorus loads were calculated based on averaged instantaneous concentrations and coordinating stream flow measurements. The current total watershed total phosphorus load is 241 lbs/day, and the proposed load, based on a 37% total phosphorus reduction, is 152 lbs/day, (Table B). The DO WQS is expected to be met after the 0.07 mg/L or less Lake Lowell tributary waterway phosphorus target concentration is achieved. DEQ recognizes that after the tributary waterway phosphorus input is reduced it will take time to deplete the internal stored phosphorus load. However, immediate improvements in DO are expected, with the WQS being met as the stored load decreases or is buried with sediment.

Table B. Total phosphorus load allocations for Lake Lowell subbasin.

	Load Capacity (lbs/day)	Load Allocation (lbs/day)	Load Allocation (g/acre/day)	Percent Reduction
New York Canal (+ Ridenbaugh Canal)				
Background		41.02	--	0
NPDES Permitted Discharges				
Stormwater: MS4s[a]				
Current Acres		6.78	0.52	0
Future Acres Converted from Agricultural to Urban			0.34	
Stormwater: Construction		0		
Stormwater: AFOs		0		
Non-Point Sources				
Agricultural		15.96	1.35	56
Septic Systems		?		
Ground Water		?		
MEDIAN LOAD	84.07	63.76		
Drains (Monitored and Unmonitored)				
NPDES Permitted Discharges				
Stormwater: MS4s[a]				
Current Acres		0.83	0.52	0
Future Acres Converted from Agricultural to Urban			0.34	
Stormwater: Construction		0		
Stormwater: AFOs		0		
Non-Point Sources				
Agricultural		54.23	1.35	56
Septic Systems		0		
Ground Water		?		
MEDIAN LOAD	35.22	55.06		
Lake Lowell				
Septic Systems	6.53	6.53		
Ground Water	0.84	0.84		
Waterfowl[b]	25.26	25.26		
Internal Reservoir Active Load	?	?		?
MEDIAN LOAD	32.63	32.63		
TOTAL	152	152		37

[a]Stormwater MS4 allocations: For acres contributing at the time of TMDL development no reduction is necessary and discharge needs to be the result of 30% BMP effectiveness. For all future acres converted to urban use, stormwater BMP effectiveness needs to achieve 50% effectiveness.
[b]Phosphorus load from waterfowl was estimated by BOR (BOR 2001).
? – Indicates a data gap that will need to be addressed.
lbs/day = pounds per day
g/acre/day = grams per acre per day
MS4 = municipal separate storm sewer system
NPDES = National pollutant discharge elimination system
AFO = animal feeding operation

All TMDLs required for Lake Lowell are complete, and to indicate this it will be moved to section 4a of the next integrated report (Table C). Trend monitoring will be used to document relative changes in water quality and the status of beneficial uses. At the end of each five year review period, overall progress toward attainment of WQS and beneficial uses can be assessed and targets adjusted appropriately.

Table C. Summary of assessment outcomes.

Water Body Segment/ AU	Pollutant	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
Lake Lowell 17050114SW004_06	Dissolved Oxygen	Total Phosphorus as Surrogate for Dissolved Oxygen	Move to Section 4a in the Integrated Report	Violation of numeric WQS criteria cause impairment for warm water aquatic life
Lake Lowell 17050114SW004_06	Nutrients	Total Phosphorus	Move to Section 4a in the Integrated Report	Data indicate impairment for primary contact recreation, aesthetic value and special resource water due to nuisance aquatic vegetation

Public Participation

DEQ has complied with consultation requirements of the federal Clean Water Act and state Watershed Advisory Group (WAG) in conformance with Idaho Code §39-3615. A WAG, the Lower Boise Watershed Council, is currently working to meet goals for other TMDLs in the Lower Boise River subbasin. DEQ provided the WAG with information concerning applicable WQS, water quality data, monitoring, assessments, reports, procedures, and schedules. The group met in Boise or Caldwell monthly or bi-monthly over the course of the development of the TMDL. Informal discussion of progress on Lake Lowell occurred during most meetings from 2006-2009. A formal discussion regarding pollutant targets and reservoir modeling occurred in August 2008. Progress updates were also shared with the basin advisory group in October 2006, December 2007, and October 2008. A draft document was released for WAG review in September 2009. A TAC meeting was held on October 1, 2009 to discuss WAG comments on the draft. The draft TMDL was open for a 30 day public comment period from May 3rd to June 4th 2010. The comment period was extended until July 2nd 2010, due to a formal request from ACHD.

1. 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 Clean Water Act (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 the water quality status of Lake Lowell which is in the Lower Boise River Subbasin and has been placed on Idaho's current §303(d) list. The overall purpose of the subbasin assessment (SBA) and TMDL is to characterize and document pollutant loads within the Lake Lowell basin. 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 is then used to develop a TMDL for each pollutant of concern for the Lake Lowell Subbasin (Section 5).

1.1 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 (Idaho's water quality standards must be approved by EPA). 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. An SBA and TMDL provide a summary of the water quality status and allowable TMDLs for water bodies on the §303(d) list. *Lake Lowell TMDL: Addendum to the Lower Boise Subbasin Assessment and Total Maximum Daily Loads* provides this summary for Lake Lowell.

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 Lake Lowell Subbasin 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 considers 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 pollutant to be "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. If a water body is impaired by pollution and a specific pollutant, it will only receive a TMDL for the pollutant.

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 (designate) beneficial uses for particular Idaho water bodies to support. These beneficial uses are identified in the Idaho WQS 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 and primary contact recreation are used as additional default designated uses when a water body is assessed.

An 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 support for designated beneficial use of the water body (i.e., attaining or not attaining WQS).
- Determine the degree of achievement of biological integrity.
- Compile descriptive information about the water body, particularly the identities and location of pollutant sources.
- Determine the causes and extent of the impairment when a water body is not attaining WQS.

1.2 Physical and Biological Characteristics

Lake Lowell is located in Canyon County, Idaho, about 25 miles west of Boise and about 5 miles west of Nampa. Lake Lowell is within U.S. Geological Survey (USGS) Hydrologic Unit Code (HUC) 17050114, the Lower Boise Subbasin. The full water body ID for Lake Lowell is 17050114SW004_06. The tributaries contributing to Lake Lowell include New York Canal, Ridenbaugh Canal, Highline Canal, two canal wasteways, six named agricultural drains, and numerous unnamed drains that discharge to Lake Lowell (Figure 1). The Lake Lowell drainage area is approximately 63.5 square miles in Ada and Canyon Counties. New York Canal diverts Boise river water at the Diversion Dam, approximately 2 miles downstream from Lucky Peak Dam. The canal flows in a constructed channel about 40 miles west to Lake Lowell.

The climate, geology, hydrology, and biological characteristics of the subbasin will be discussed in the following sections.

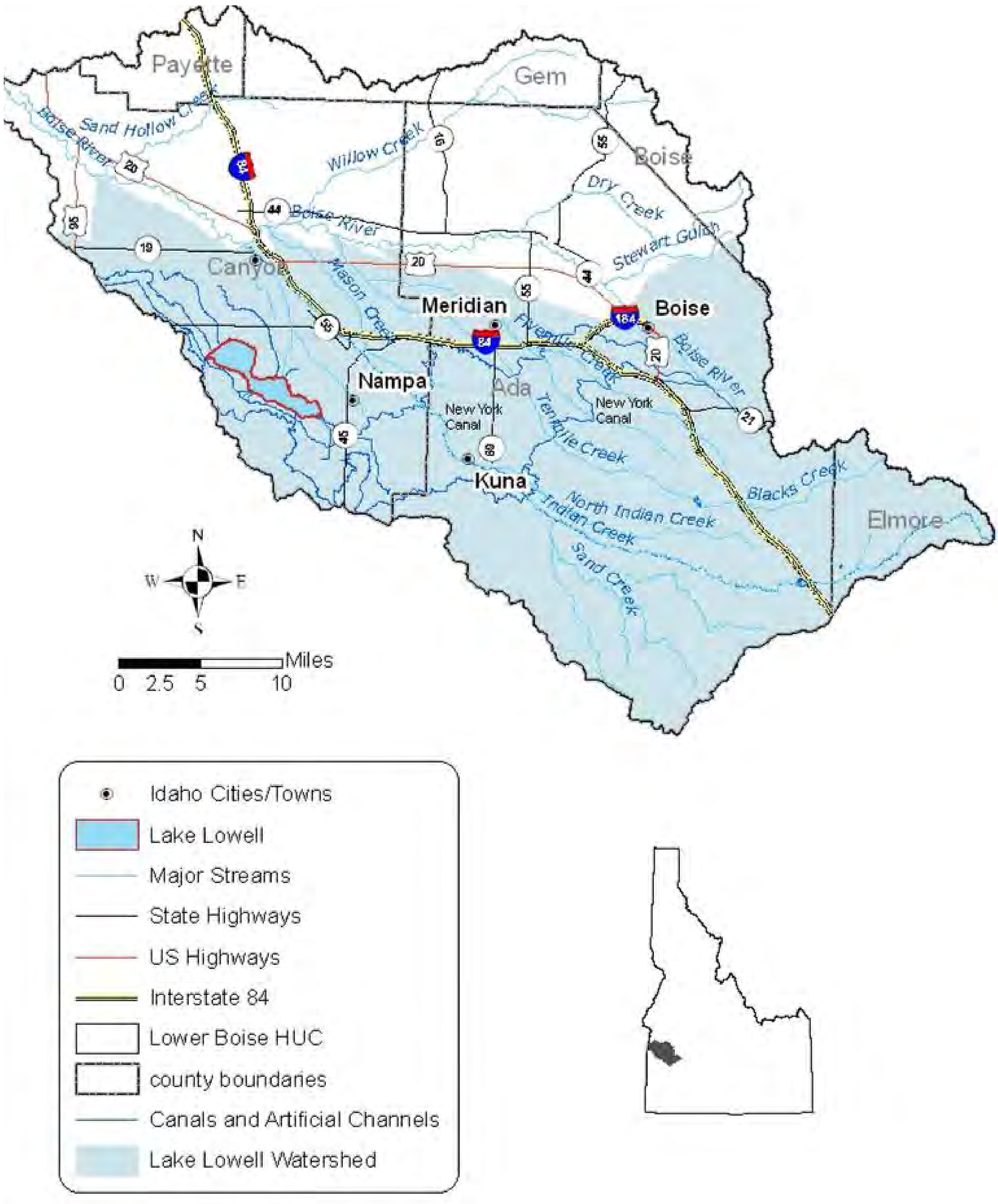


Figure 1. Subbasin at a glance.

Climate

The watershed lies within a dry climate region described generally by Trewartha (1957) as middle latitude steppe. The summer months are hot and dry with cool nights. Winters are cold and wet, though generally not severe. Lake Lowell, like most of Idaho, receives relatively little precipitation in late summer. The Deer Flat Dam weather station reports an average rainfall of 0.23 inches in July and 0.33 inches in August (Figure 2). The summer dry season in southern Idaho usually ends by October. Mean snow depth in January is 1 inch. The average relative humidity for the subbasin in winter is 67-79% and in summer 23-30%. Figure 3 illustrates that the number of sunshine days per month at the nearest weather station, in Boise, ranges from 20% in winter to about 80% in summer (National Oceanic and Atmospheric Administration [NOAA] National Climatic Data Center, http://ols.nndc.noaa.gov).

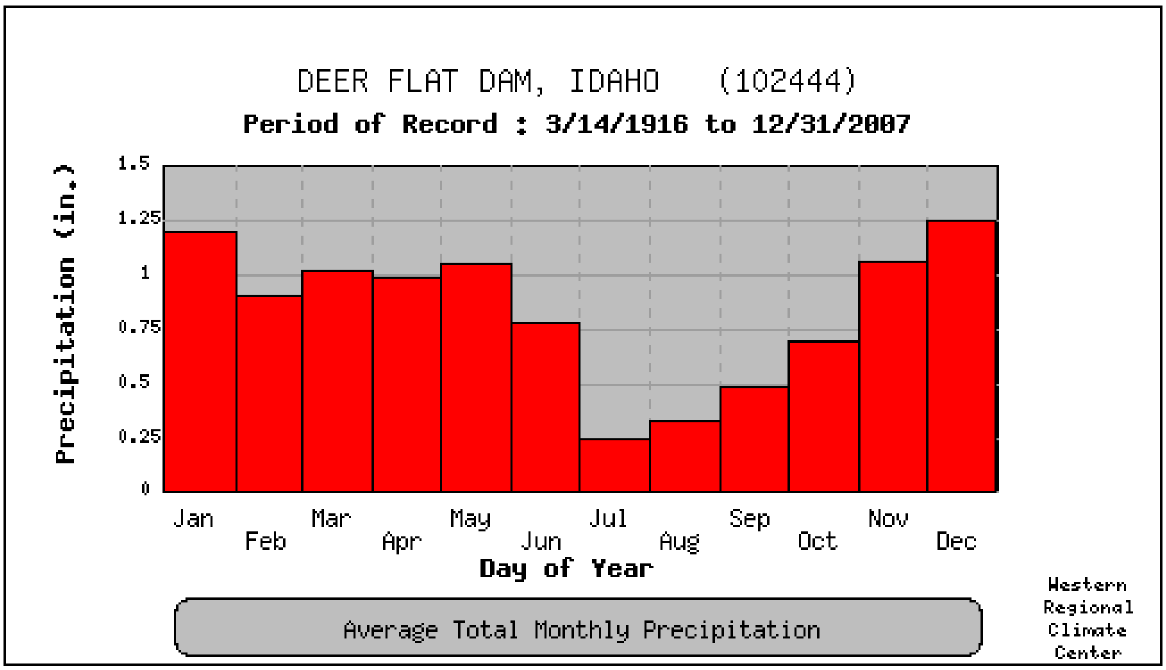


Figure 2. Average total monthly precipitation (Western Regional Climate Center, 2008).

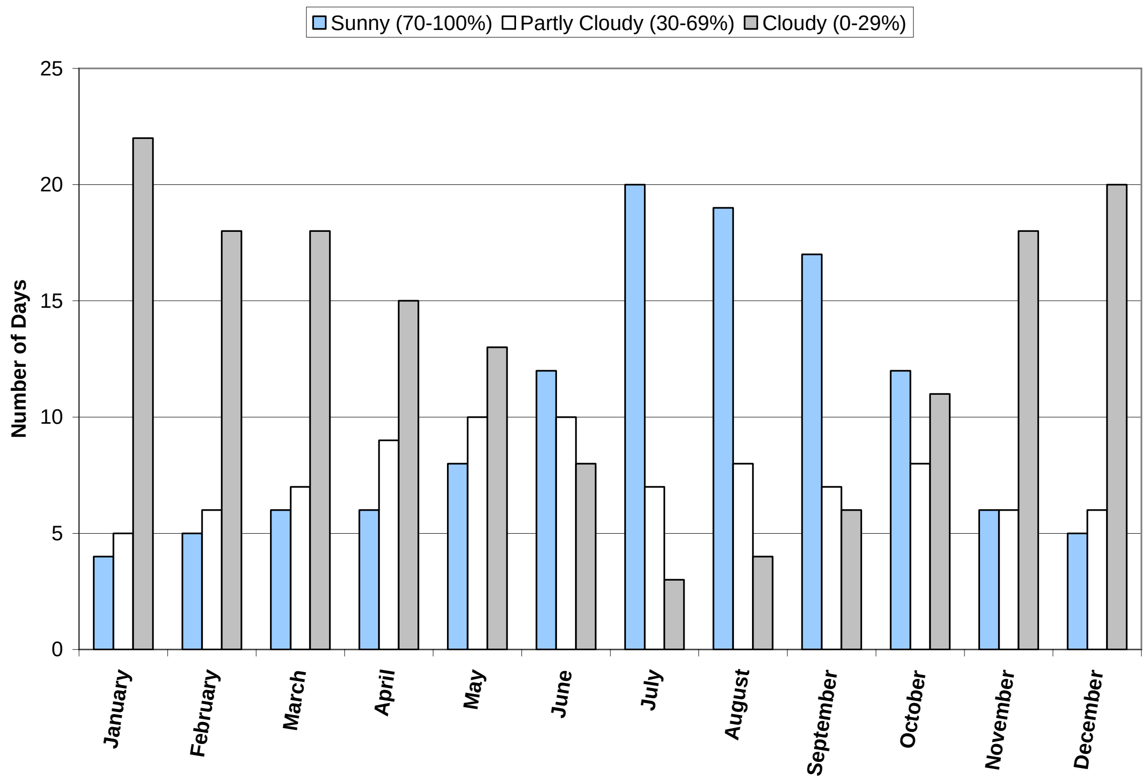


Figure 3. Number of sunny, partly cloudy and cloudy days as measured at the nearest weather station (Boise, ID), (NOAA National Data Center, 1949-2005).

The average summer (June –August) temperature during the period of 1916-2008 was 70°F at Lake Lowell (Deer Flat Dam), with an average daily maximum temperature of 85.4°F (Figure 4). Table 1 shows the annual average climatic summary within the watershed. Temperature within the subbasin can fluctuate dramatically from month to month. The Deer Flat weather station recorded extremes as low as -27 °F (January) and as high as 107 °F (July). The mean monthly temperature at Lake Lowell for January is 29.6 °F and for July is 73.3° (Western Regional Climate Center 2008, http://www.wrcc.dri.edu).

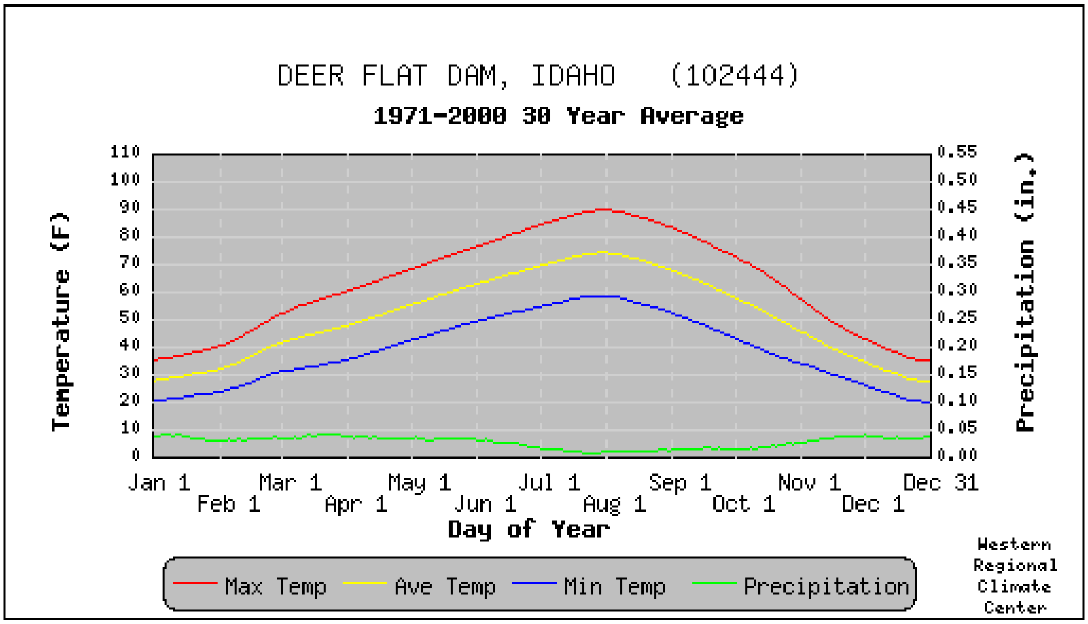


Figure 4. Average daily temperature and precipitation record (Western Regional Climate Center, 2008).

Table 1. Climatological summary data (Western Regional Climate Center, 2008)

Climate Factor	Deer Flat Dam (Station #102444)
Dates of Record	**1916-2008**
Elevation (feet)	**2510**
Average Annual Precipitation (inches)	**9.7**
Average Monthly Precipitation, March-May (inches)	**3.0**
Average Monthly Precipitation, June-August (inches)	**1.3**
Average Monthly Precipitation, September-November (inches)	**2.2**
Average Monthly Precipitation, December-February (inches)	**3.2**
Average Annual Snowfall (inches)	**9**
Maximum Average Temperature, June-August (°F)	**85.4**
Minimum Average Temperature, June-August (°F)	**55.2**
Highest Temperature (°F), (Date)	**107 (7/22/06)**
Maximum Average Temperature, December-February (°F)	**40.8**
Minimum Average Temperature, December-February (°F)	**24.0**
Lowest Temperature (°F), (Date)	**-27 (1/27/1957)**

Subbasin Characteristics

Hydrography

Lake Lowell is an off-stream storage reservoir that was created by constructing 3 dams and one dike in low areas of a natural broad remnant channel (Figure 5). These are the Upper, Middle (forest Dam), and Lower Deer Flat Embankment Dams; and the East Dike. The Upper Deer Flat Embankment Dam (crest elevation 2,539 feet) has outlets to feed the Deer Flat Caldwell Canal and the Deer Flat Nampa Canal. The Lower Deer Flat Embankment Dam (crest elevation 2,539 feet) has outlets to feed the Deer Flat North Canal and the Deer Flat Lowline Canal. The Middle Deer Flat Embankment Dam is a low dam (16 feet high) that helps close the reservoir near the Lower Deer Flat Embankment Dam. The East Dike closes off the upstream end of the reservoir where the New York Canal enters the reservoir. The water stored by Lake Lowell Reservoir irrigates 302,264 acres of land in the Snake and Boise River basins.

The New York Canal, originating at the Boise River Diversion Dam, provides most of the irrigation water to Lake Lowell (Figure 6). Numerous lateral canals branch off New York Canal and others release return water back into the main canal. Ridenbaugh Canal originates at a diversion several miles downstream in the Boise River from the Boise River Diversion Dam and joins New York Canal just before New York Canal flows into Lake Lowell. Ridenbaugh Canal flows through densely populated areas of Boise, Meridian, and small subdivisions southeast of Nampa. Smaller inputs to the lake come from agricultural return drains on the south and west shores of Lake Lowell (Figure 5).

Two stream gages maintained by the United States Geological Survey (USGS) monitor flow directed to Lake Lowell and reservoir storage. The flow diverted from the Boise River into New York Canal is estimated from the gage at the Boise River Diversion Dam. Reservoir storage in Lake Lowell is measured by the gage near the Lower Deer Flat Embankment Dam outlet structure to Deer Flat Lowline Canal. The weather station for the Western Regional Climate Center (WRCC) is also located at this dam.

Geology

The dams and reservoir are located within a large alluvial-filled basin, which is underlain by hundreds of meters of unconsolidated to slightly consolidated sediments. Most of the sediments are fluvial but some are lacustrine in origin. In some parts of the basin there are interstitial basaltic lava flows. The formation directly underlying the dam site is the Pleistocene-age Caldwell-Nampa sediments. This formation is up to 15 m (50 ft) thick and is described as unconsolidated layers and lenses of clay, silt, sand and gravel. Beneath the Caldwell-Nampa sediments, and outcropping in some places near the reservoir, is the Ten-Mile Gravel formation which is described as up to 152 m (500 ft) of poorly consolidated silt, sand, gravel and cobbles. Overlying these sediments are scattered, recent thin deposits of sand, gravel and windblown silt.

The watershed, including the canals and agricultural drainage areas, is composed of Pleistocene water-laid detritus and outwash conglomerate flood and terrace gravels. Small areas of Quaternary alluvium deposits and Middle Pleistocene canyon-filling basalt are interspersed in the canal drainages (Figure 7). The soil types dominant in the area draining to

Lake Lowell are moderately erosive with a K-factor (soil erodability index) of 0.3 or higher (Figure 8).

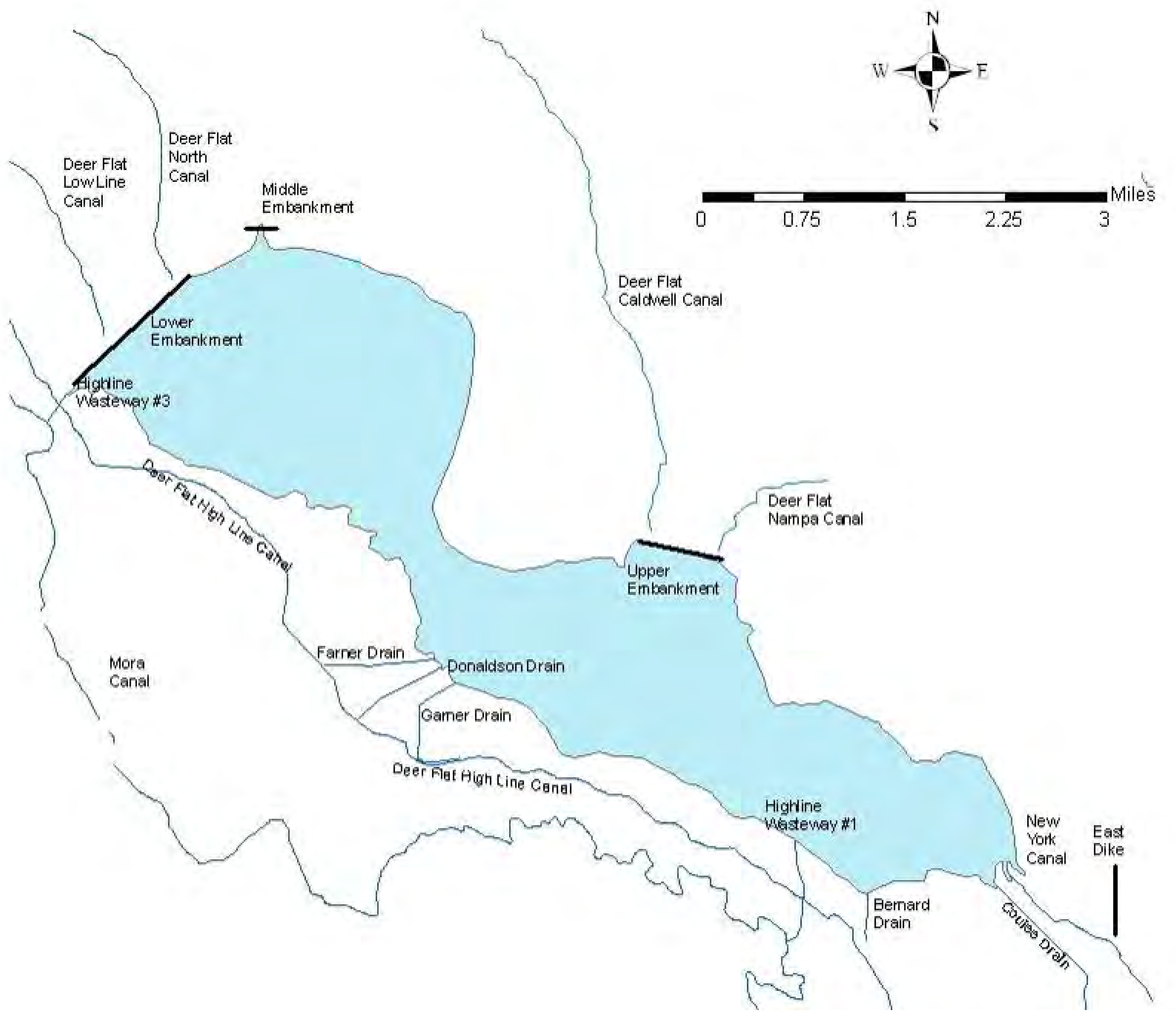


Figure 5. Lake Lowell inlets and outlets.

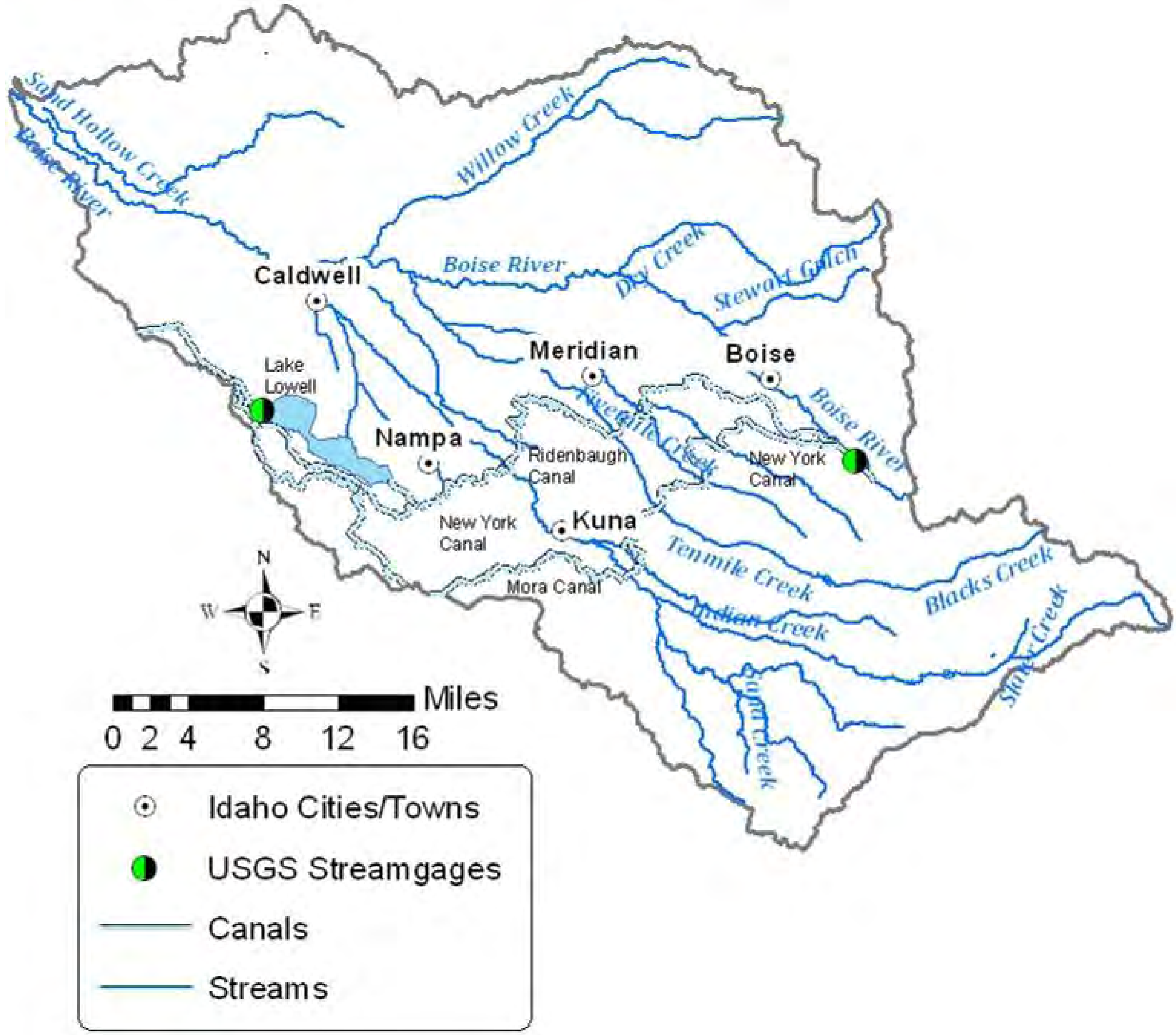


Figure 6. Lake Lowell watershed hydrography.

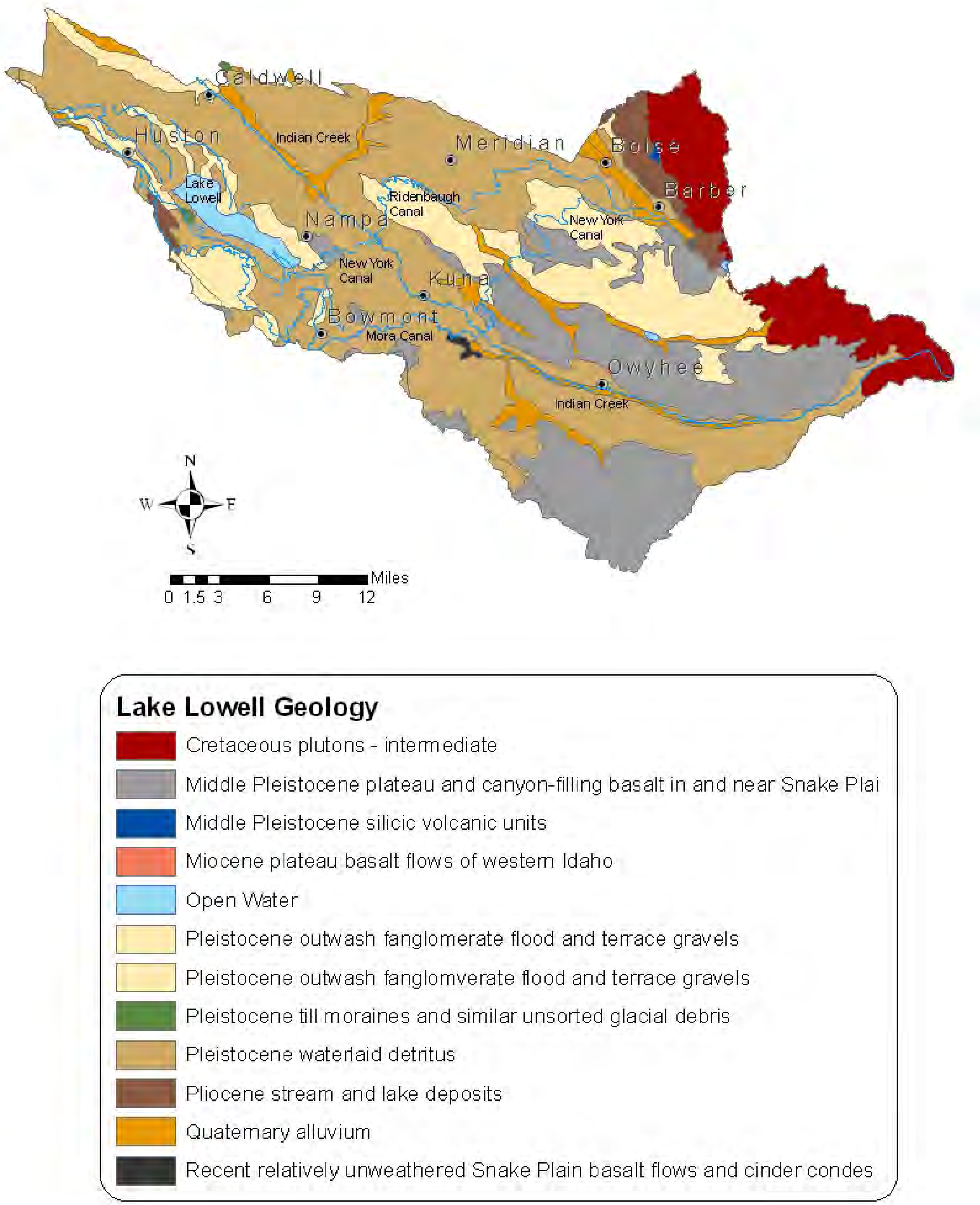


Figure 7. Lake Lowell watershed geology.

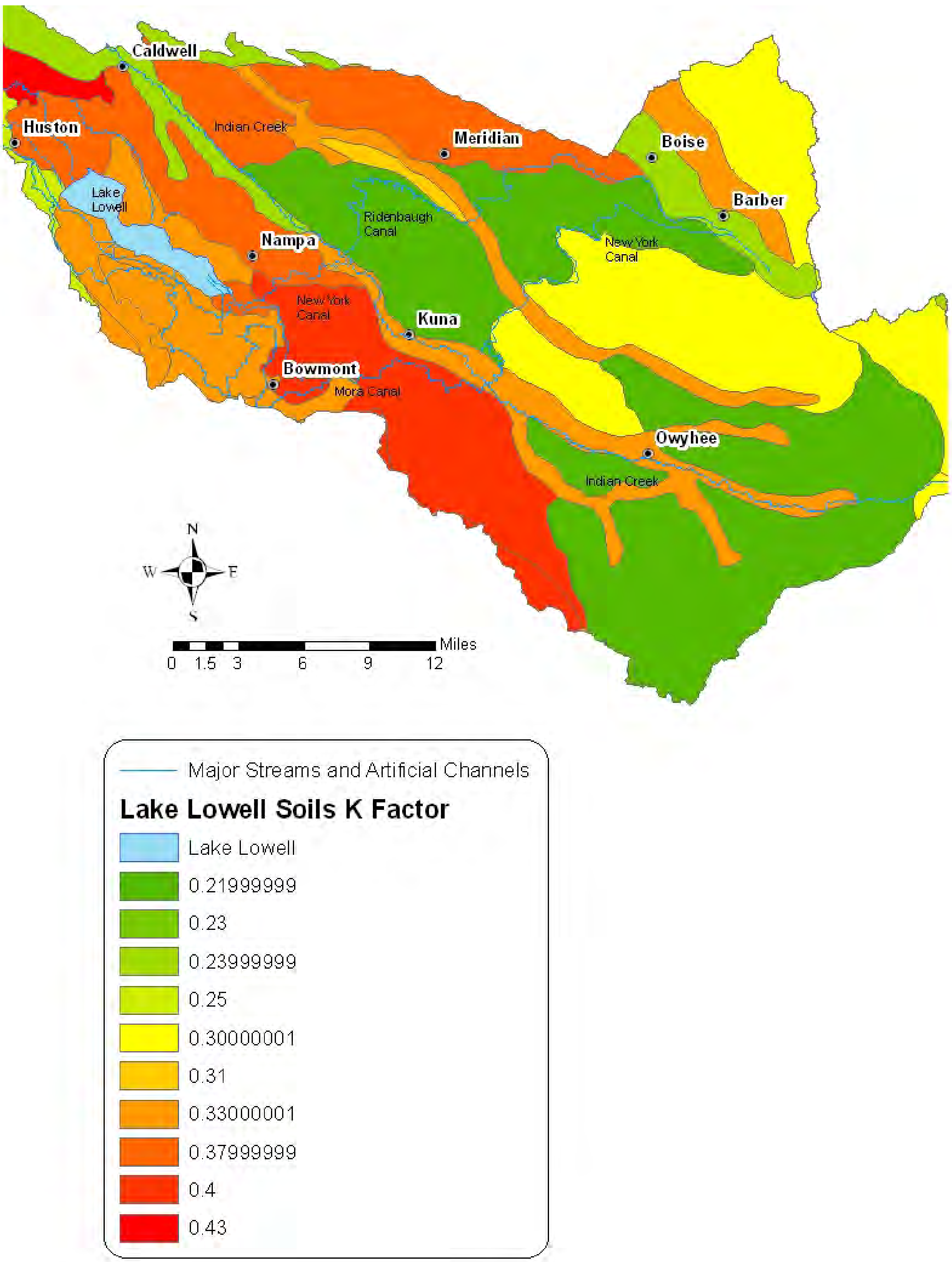


Figure 8. Lake Lowell watershed soil erodibility index (K Factor).

Topography

Lake Lowell was constructed in a natural depression in the Lower Boise River Valley southwest of the city of Nampa. There is a 300-foot decrease in elevation between the Boise River diversion to New York Canal and Lake Lowell with the lake at 2,531 feet above sea level. The watershed is bounded in the south by outwash plains underlain by igneous rock of the Snake River plain.

The Upper Deer Flat Embankment Dam is 74 feet high. The upper embankment includes two canal outlets, one at each end of the dam. Lower Deer Flat Embankment Dam is 46 feet high with a canal outlet at each end of the dam. The Middle ("Forest") Embankment is 16 feet high and 1,262 feet long. The East Dike was constructed on the eastern end of the reservoir to protect area farms from possible flooding. The crest of the Middle Embankment is about 4 feet lower than the upper and lower embankment, to serve as an emergency spillway.

Vegetation

Lake Lowell is in the Level III Snake River Plain Ecoregion of the western United States (Omernick and Gallant 1986 and Omernick 1986). This xeric intermontane basin and range area is considerably lower and more gently sloping than the surrounding mountainous subecoregions. Due to the availability of irrigation water, a large percentage of the alluvial valleys bordering the Snake River are devoted to agriculture, with vegetables such as sugar beets and potatoes being the principal crops. Cattle feedlots and dairy operations are also common in the river plain. Except for the scattered barren lava fields, the remainder of the plains and low hills in the ecoregion has potential for sagebrush steppe vegetation and is used for cattle grazing.

Fisheries

Lake Lowell provides habitat for warm water fish species. The fishery consists primarily of largemouth bass, yellow perch, black crappie, bullhead, bluegill, and channel catfish. IDFG manages the bass population with primary emphasis on a quality fishery. The bass, perch, bluegill and crappie populations are self-sustaining warm water fish communities (IDFG, 2007). Lake Lowell was historically stocked with Lahontan cutthroat trout and rainbow trout however a salmonid fishery was never established. The IDFG management goals for Lake Lowell are to focus on maintaining the warm water fishery and continue to stock channel catfish (IDFG 2007, and personal communication with SW Regional Fishery Manager). In addition to the sport fish, Lake Lowell has large self-sustaining populations of largescale sucker and common carp.

Subwatershed Characteristics

The contributing drainage area of the Lake Lowell watershed is 63.5 square miles, of which 23.3 percent is reservoir surface area (BOR 1995). Lake Lowell is 14.5 square miles in size and has 28 miles of shoreline. The lake covers approximately 9,000 surface acres at full pool and water elevation is primarily regulated by irrigation water releases. Lake Lowell was created as an irrigation storage reservoir. The reservoir has the capacity to irrigate about 300,000 acres and is drafted (water is withdrawn from it) throughout the summer to supply the demand for irrigation to downstream agricultural lands. Reservoir water levels and water quality are managed by BOR. The reservoir normally reaches the lowest elevation in late

August or early September. The reservoir elevation again rises in fall as irrigation demand decreases and New York Canal continues to flow.

Three canals are important to Lake Lowell: the New York, Mora, and Deer Flat Highline Canals. Diverted Boise River water mixed with some returned irrigation wastewater are stored in Lake Lowell for reuse on down-gradient irrigated lands. Upstream of Lake Lowell water is diverted from New York Canal to Mora Canal and Deer Flat Highline Canal to irrigate land south of Lake Lowell. The land south of the reservoir between the Mora Canal and Lake Lowell drains into the reservoir via Coulee Drain, Barnard Drain, Garner Drain, Donaldson Drain, Farner Drain, numerous small unnamed drains, and the Mora Canal/Deer Flat Highline wasteways. Lake Lowell releases are made through the Deer Flat Lowline, Deer Flat North, Deer Flat Caldwell, and Deer Flat Nampa Canals (Figure 5). Detailed hydrologic patterns are included in Section 2.4 of this SBA.

Lake Lowell is included in the Deer Flat National Wildlife Refuge, which was established by executive order in 1937. Wildlife resources are managed by the U.S. Fish and Wildlife Service (USFWS). The refuge serves as brood habitat for wood ducks and mallards and as a nesting and staging area for migratory water birds. It provides important habitat for piscivorous birds. This includes nesting habitat for Western and Clark’s grebes, as well as foraging habitat for wading birds, pelicans and cormorants. The refuge also provides habitat for other wetland and upland wildlife species and supports a warm water fishery.

The reservoir also supports water-based recreation, including fishing, boating, waterskiing, and swimming. A minimum pool, based on capability of the system and availability of the water supply, is voluntarily maintained in Lake Lowell year-round by BOR to benefit fish and wildlife populations and increase fall duck hunting opportunities (BOR 1996).

Lake Lowell hydrologic operations affect the quantity and quality of refuge habitats. Changes in reservoir water elevation affect the abundance and occurrence of shore and water birds, availability of nesting and feeding habitat, and the warm water fishery. In general, pool elevations maintained at or slightly above the established elevations provide the greatest range of benefit to the most species (USFWS 2000). High water elevations in the spring and early summer provide abundant quality brood habitat for mallard and wood duck populations, and increase the breeding success of the warm water fishery. The yearly drawdown of the reservoir in late summer and early fall exposes extensive mud flats that serve as feeding habitat for shorebird species. In addition, higher water elevations in the mid to late fall afford hunters better hunting opportunities (USFWS 2000).

1.3 Cultural Characteristics

The discovery of gold in the Boise basin on August 2, 1862 encouraged development of agriculture to feed the growing mining community. By 1864, farmers occupied all the land near the river that could be irrigated by direct diversion. By 1870, farming in the Boise Valley was well established, but most farming was limited to lands along the river and the development of new lands was hindered by lack of reliable irrigation facilities. Canals to water more desert land gradually were constructed farther out into the valley. In the early 1880s, A. D. Foote proposed construction of the New York Canal to irrigate thousands of acres south of the Boise River. Construction began, but numerous problems persisted, and after 16 years of work, only a small trickle of water flowed through the canal.

With the formation of the Reclamation Service (now the U.S. Bureau of Reclamation) in 1902, money and expertise needed to bring water to undeveloped areas would be supplied by the federal government and repaid by the water users under a low-cost, long-term loan program. Plans were developed for a large conveyance system to provide reliable irrigation water to the valley. Construction of the Boise River Diversion Dam, which supplied water to the New York Canal, was completed in 1908. Modification of the New York Canal and an extension from Indian Creek to Lake Lowell was also completed in 1908. The original canal had a capacity of about 200 cubic feet per second (cfs), which was increased to 1,500 cfs by the Reclamation Service. The modified canal had a bottom width of 40 feet with water running at a depth of about 8 feet. Construction of the Lower Embankment and Upper Embankment dams for Deer Flat Reservoir (now known as Lake Lowell) was completed in September 1908. The first water storage in the reservoir occurred in early 1909.

In addition to modifications to the existing New York Canal, the Reclamation Service modified and enlarged other canals and constructed miles of new distribution canals and laterals. Much of the excavation for these conveyances was done under a cooperative agreement between the Payette-Boise Water Users Association and the Reclamation Service. The water users association contracted with the settlers to construct the lateral system under the supervision of Reclamation, with payment for the work being made with certificates that would be accepted by Reclamation for payment of water charges in the future.

Although the landscape and culture have changed dramatically since the discovery of gold and boom of irrigated agriculture, the original irrigation infrastructure remains in use and shapes the land use, population, and economy of the Lower Boise River subbasin today.

Land Use

The lands around Lake Lowell transition from strictly rural, irrigated agriculture to a mixed agriculture and urban housing setting (Figure 9). Land use acreage estimates in this section include land that may drain to the Lower Boise River. All land in the Lower Boise HUC west of Kuna that drains to Indian Creek and then south and west to the Lower Boise River HUC boundary is included in these acreage estimates. Drainage area boundaries for overland flow are not easily distinguished and water from Indian Creek is mixed with New York Canal water when they share a channel. In addition, acreage estimates include some land that is in the reservoir outlet drainage basins. A more concise partition of acres in each land use category is used for stormwater and agricultural load allocations in the total phosphorus TMDL. Almost 75% of the land is used for agriculture or rangeland (Figure 10). Most of the remaining land (13%) is developed for residential or urban use. Ranchettes and more densely zoned housing developments occupy several large parcels overlooking the south shore of the reservoir. The north shore is undergoing a similar urbanization process as housing developments expand from Nampa toward the reservoir. This process is likely to continue in the immediate future. The Deer Flat National Wildlife Refuge boundary is becoming more sharply defined as housing tracts replace irrigated agricultural fields adjacent to the refuge boundary.

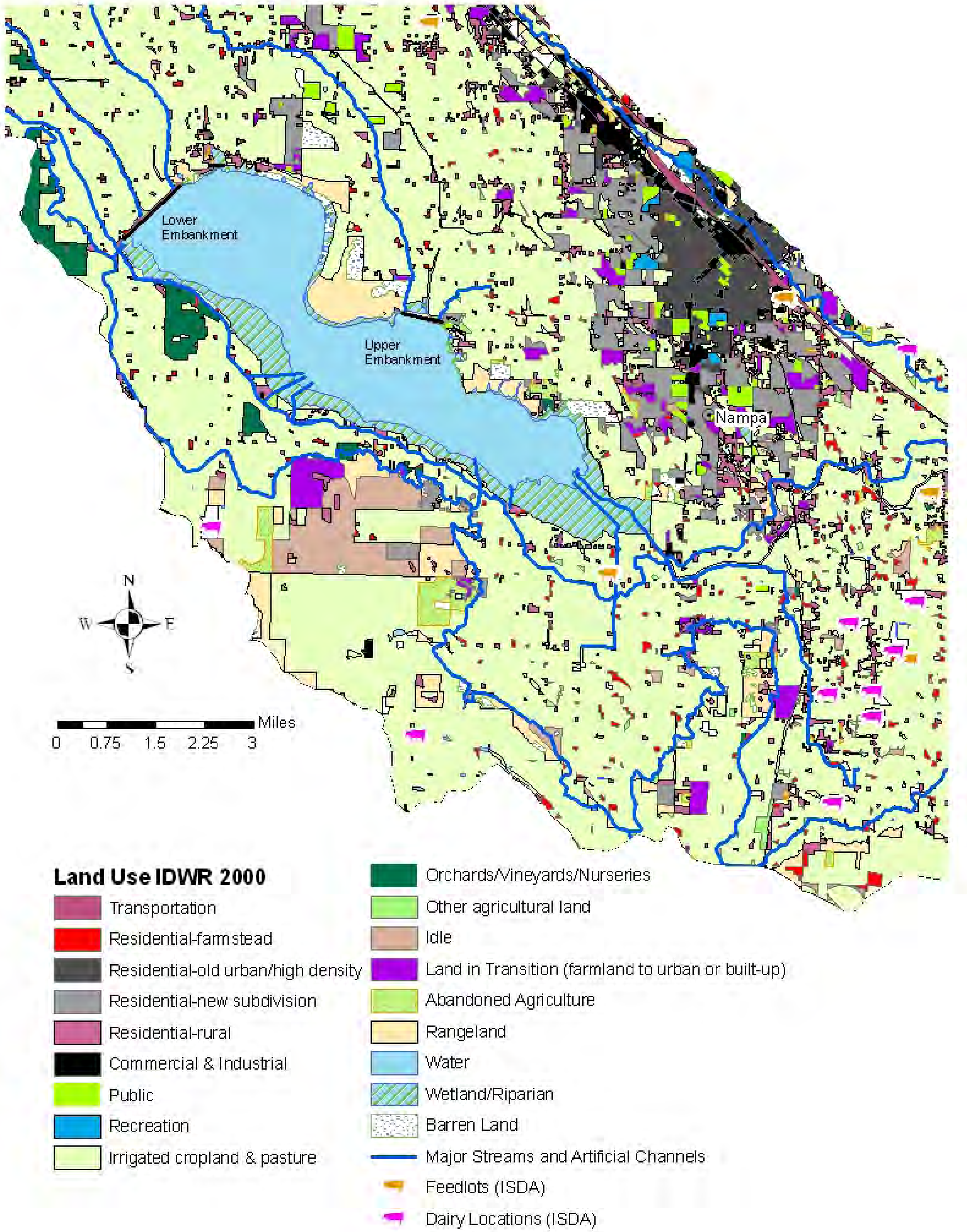


Figure 9. Lake Lowell watershed land use.

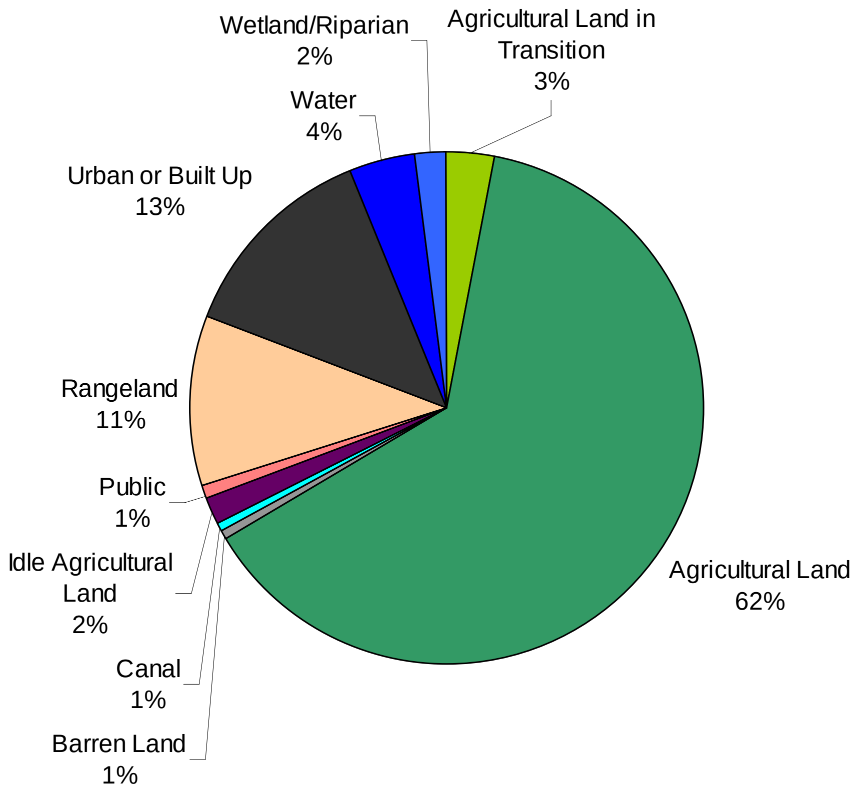


Figure 10. Percent of land in each use category.

The New York Canal carries irrigation water to all the land in the watershed. Land use along the New York Canal has changed from mainly agricultural to a mix of urban, industrial and agricultural uses. Conversion from agricultural to urban land use over the past 100 years has resulted in transfer of water used for irrigated agriculture from the east to the west end of the Treasure Valley. As a result, most of the New York Canal water destined for agricultural lands is now carried further down the conveyance system to irrigate land in western Ada and Canyon Counties. New York Canal, and Ridenbaugh Canal, and numerous laterals to these canals flow through densely populated residential and industrial areas with high potential for polluted stormwater runoff.

Land Ownership, Cultural Features, and Population

More than 80 percent of land in the watershed is privately owned (Figure 11 and Figure 12). Most of the private land is used for agriculture or residences. The remaining land is managed by federal or state agencies and most is open for public use. The largest single landowner is the Bureau of Land Management (BLM), which leases most of its land for cattle grazing. Land bordering Lake Lowell is owned by the USFWS and managed as the Deer Flat National Wildlife Refuge. The BOR and USFWS co-manage Lake Lowell. The BOR is responsible for the water quality and water level of the lake, whereas the USFWS is responsible for the management of recreational activities and wildlife resources.

The Lake Lowell watershed is within Canyon and Ada counties and is within the Boise Metropolitan Statistical Area (U.S. Census Bureau Website: http://quickfacts.census.gov).

About 90% of the Ada County population, estimated at 380,920 persons in 2008, resides within the Boise city boundary or other urban areas. The population of Ada County increased 26.6% from 2000 to 2008. Of the total population of Ada County, 206,905 live within the Lake Lowell watershed boundaries depicted in Figure 12. The boundaries include canals and drains that carry water to Lake Lowell. Although Ada county population is highly urbanized, in 2000 urban/residential land use comprised only 16% of the watershed land area. Rangeland remains the main land use (42%), followed by agricultural land use (27%) (DEQ ArcGIS database: Watershed, County, and IDWR Land Use Layers).

The population of Canyon County totaled 183,939 persons in 2008. This reflects a population increase of nearly 40% from 2000 to 2008. Of the total population of Canyon County, 105,209 live within the Lake Lowell watershed boundaries depicted in Figure 12. Only 15% of Canyon county land in the Lake Lowell watershed is considered urban/residential, many of the parcels are classified as farmstead-residential. About 69% of the land is used for agricultural purposes (2009 DEQ ArcGIS database Watershed, County and IDWR Land Use Layers). In 1999, Nampa was recognized as the second largest city in Idaho and the population continues to increase rapidly. A large percentage of the county's growth is occurring in the Lake Lowell watershed, making the lake vulnerable to negative water quality impacts related to population growth.

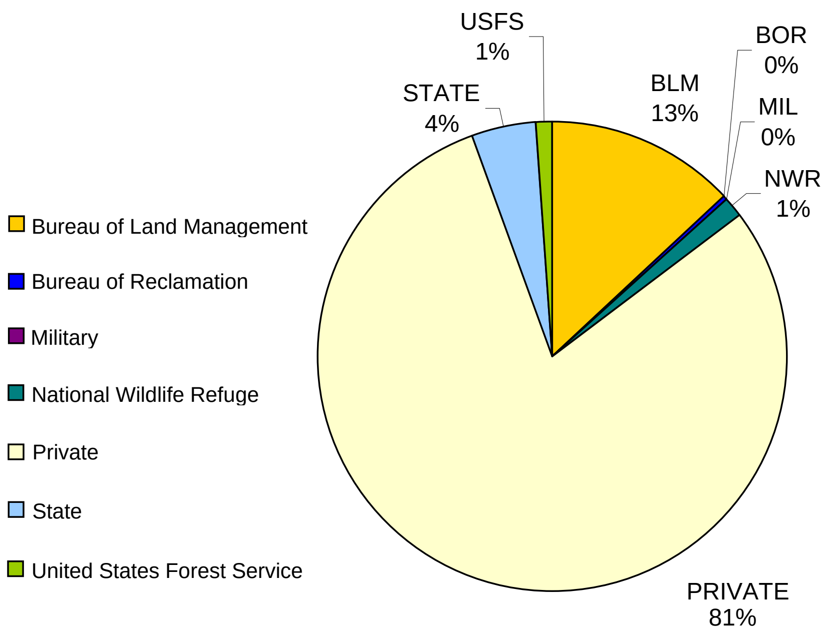


Figure 11. Land ownership percent by ownership type.

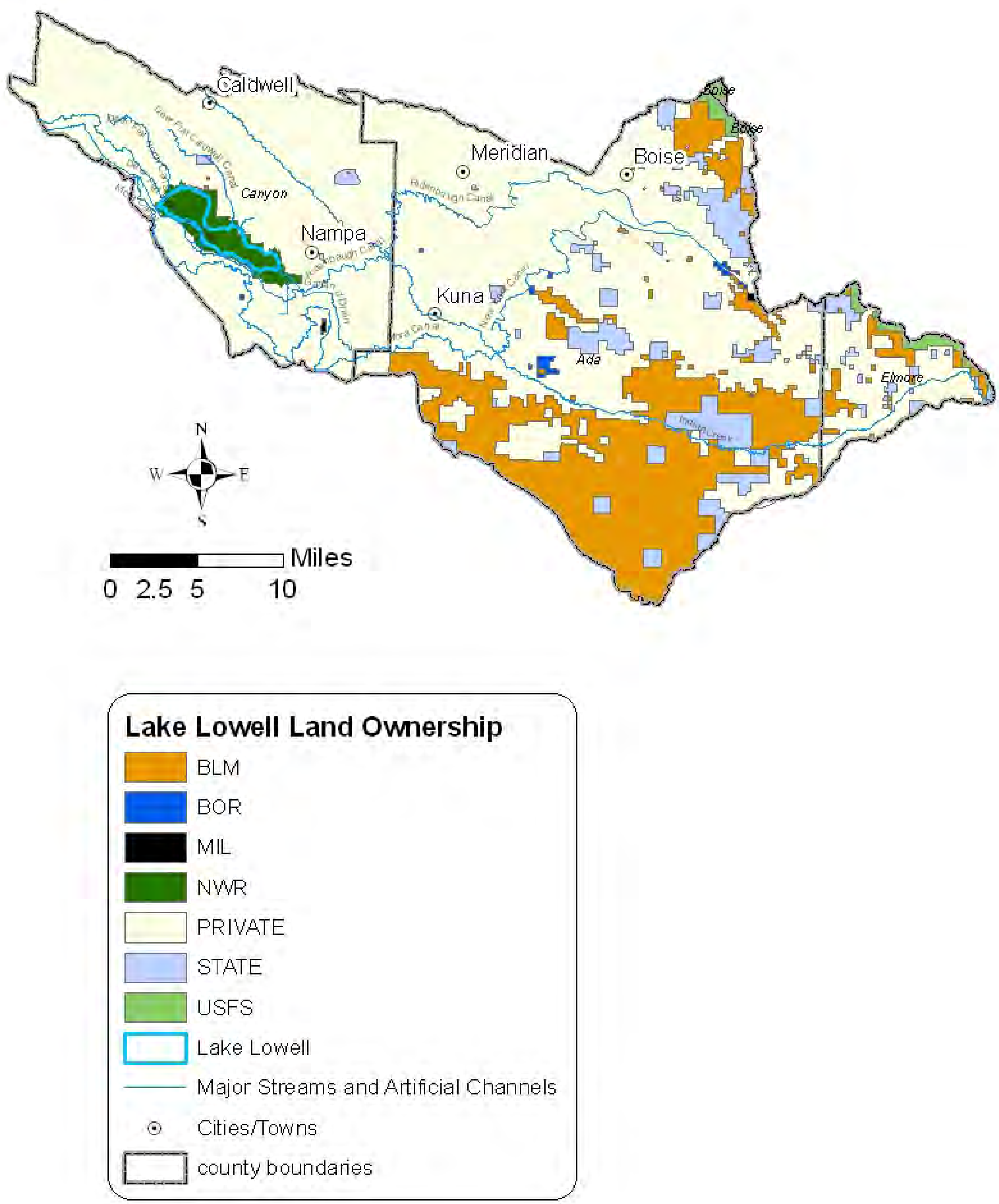


Figure 12. Lake Lowell watershed land ownership.

Current Economics

The economy of the watershed is relatively diverse. Approximately half of the employed population in Ada and Canyon counties work in four major industries: retail trade, manufacturing, health care and social assistance and construction (U.S. Census Bureau, 2008[1]). Employment categories and their distribution for Ada and Canyon counties are listed in Table 2. In 2003 the four U.S. industries with the largest shares of employment nationwide were government (14.2%), retail trade (11.0%), health care and social assistance (9.9%), and manufacturing (9.0%). Ada and Canyon counties are similar to this trend with the exception of construction replacing the government category. The industries with the largest percentage of employees were retail trade at 12.3% in Ada county and manufacturing at 16.9% in Canyon County. This employment profile is in contrast to the land use profile which is dominated by rangeland and agricultural land. This can easily be accounted for when considering that the majority of the population in Ada and Canyon counties lives within the boundaries of incorporated cities.

Table 2. Principal industries in Ada and Canyon counties.

Industry	Total Employed in Ada Cnty	Percent of all Industries	Total Employed in Canyon Cnty	Percent of all Industries
Agriculture, forestry, fishing, hunting and mining	1,546	0.8	1,781	3.8
Construction	15,740	8.6	5,495	11.8
Manufacturing	20,546	11.3	7,844	16.9
Wholesale trade	6,349	3.5	2,394	5.1
Retail trade	22,415	12.3	5,990	12.9
Transportation and warehousing	6,318	3.5	1,906	4.1
Utilities	1,736	1.0	628	1.4
Information	5,824	3.2	1,102	2.4
Finance and insurance	9,920	5.4	1,661	3.6
Real estate and rental and leasing	5,029	2.8	713	1.5
Professional, scientific, and technical services	12,638	6.9	1,873	4.0
Management of companies and enterprises	335	0.2	23	0.0
Administrative support and waste mgmt services	7,514	4.1	2,055	4.4
Educational services	12,455	6.8	2,471	5.3
Health care and social assistance	21,801	12.0	4,563	9.8
Arts, entertainment and recreation	3,352	1.8	389	0.8
Accommodation and food services	10,631	5.8	1,310	2.8
Other services	7,092	3.9	1,582	3.4
Public administration	11,133	6.1	2,721	5.9
Total	182,374		46,501	

[1]Data from U.S. Census Bureau Website: http://quickfacts.census.gov

2. Subbasin Assessment – Water Quality Concerns and Status

This section discusses water quality data and its relationship to determinations of beneficial use support in more detail for Lake Lowell. Figure 5 shows the irrigation water conveyance system and agricultural drains that feed and drain Lake Lowell. The canals and agricultural drains are not natural perennial water bodies and there is no requirement for them to meet WQS for aquatic life or contact recreation. This report presents all information that DEQ was able to gather regarding water quality in Lake Lowell, because this information allows the reader to gain a good understanding of the whole watershed.

2.1 Water Quality Limited Assessment Units Occurring in the Subbasin

The Lake Lowell reservoir is an assessment unit (AU) in the Lower Boise Subbasin. Because of the artificial nature of the canal and reservoir system and lack of available water quality data, this assessment unit was excluded from the previously completed Lower Boise SBAs and TMDLs. This section will discuss pollutants that are causing beneficial use impairment in Lake Lowell.

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

About Assessment Units

Assessment units now define all the waters of the state of Idaho. These units and the methodology used to describe them can be found in the *Water Body Assessment Guidance*, second edition (WBAGII) (Grafe et al 2002).

Assessment units (AUs) are groups of similar streams that have similar land use practices, ownership, or land management. Stream order, however, is the main basis for determining which segments of which streams belong to each AU. Because of this, even if 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 the fundamental requirement of the EPA-required 305(b) report, a report on the condition of all the waters of the state that is required under the CWA. Because AUs are a subset of water body identification numbers, there is now a direct tie to the WQS for each AU, so that beneficial uses defined in the WQS are clearly tied to streams on the landscape.

However, the new framework that uses AUs for reporting and communicating needs to be reconciled with the legacy of 303(d)-listed streams. Due to the nature of the court-ordered 1994 §303(d) listings, and the subsequent 1998 §303(d) list, all segments were identified as having boundaries from "headwater to mouth." In order to deal with these vague boundaries in the listings, and to complete TMDLs at a reasonable pace, DEQ set about writing TMDLs at the watershed scale (HUC), so that all the waters in the drainage are and have been considered for TMDL purposes since 1994.

The boundaries from the 1998 §303(d)-listed segments have been transferred to the new AU framework, using an approach quite similar to how DEQ has been writing SBAs and TMDLs. All AUs contained in any listed segment were carried forward to the 2002 §303(d) listings in Section 5 of the Integrated Report. AUs not wholly contained within a previously listed segment, but partially contained (even minimally), were also included on the §303(d) list. This was necessary to maintain the integrity of the 1998 §303(d) list and to maintain continuity with the TMDL program. This new AU-based framework will lead to better assessment of water quality listing and de-listing.

When assessing new data that indicate full support of a water body, only the AU directly represented by the monitoring data will be removed (de-listed) from the §303(d) list (Section 5 of the Integrated Report).

Listed Waters

Table 3 shows the pollutants listed and the basis of listing for each §303(d)-listed AU in the subbasin. Lake Lowell was placed on the 1998 §303(d) list and has been carried forward to the 2002 and 2008 Integrated Report §303(d) lists.

Table 3. §303(d) Segments in the Lake Lowell subbasin

Water Body Name	Assessment Unit ID Number	2008 §303(d) Boundaries	Pollutants	Listing Basis
Lake Lowell	17050114SW004_06	Lake Lowell	Low Dissolved Oxygen, Nutrient Enrichment	Nutrient Eutrophication, Biological Indicators

2.2 Applicable Water Quality Standards

Idaho adopts both narrative and numeric water quality standards to protect public health and welfare, enhance quality of water, and protect biological integrity. By designating the beneficial use or uses for water bodies, Idaho has created a mechanism for setting criteria necessary to protect those uses and prevent degradation of water quality through anti-degradation provisions. According to IDAPA 58.010.02.050 (02)a, “wherever attainable, surface waters of the state shall be protected for beneficial uses which includes all recreational use in and on the water surface and the preservation and propagation of desirable species of aquatic biota.” Beneficial use support is determined by DEQ through its water body assessment process. For water bodies with no designated beneficial uses, cold water aquatic life and recreation are presumed to be beneficial uses. The following discussion focuses on beneficial uses and water quality criteria, both narrative and numeric, applicable to each of the listed water bodies in the Lake Lowell Subbasin. A more detailed explanation of the numeric water quality targets developed as an interpretation of the narrative standards for nutrients and sediment can be found later in this section.

Beneficial Uses

Idaho WQS 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 in the following paragraphs. The WBAGII (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 a 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).

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; they are sometimes referred to as unclassified. These undesignated uses are to be designated at a later time. 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 there is an additional existing use, in addition to these presumed uses, then because of the requirement to protect levels of water quality for existing uses the additional numeric criteria for the additional existing use would also apply. As an example, if salmonid spawning were an additional existing use, then the criteria for intergravel DO and temperature would also apply. 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) could be applied in lieu of cold water criteria (IDAPA 58.01.02.101.01).

Lake Lowell has three designated beneficial uses: support of warm water aquatic life (WARM), use for primary contact recreation (PCR), and a Special Resource Water (SRW). Table 4 contains a listing of the beneficial uses of water bodies that have been assessed in the Lake Lowell Subbasin. Lake Lowell is designated as a SRW because it is within Deer Flat National Wildlife Refuge and is of prime importance to the mission of the refuge.

Table 4. Lake Lowell subbasin beneficial uses of §303(d) listed streams.

Water Body	Uses[a]	Type of Use
Lake Lowell	WARM, PCR, SRW	Designated

[a] WARM – warm water aquatic life, PCR – primary contact recreation, SRW – special resource water

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, DO, pH, ammonia, temperature, and turbidity (IDAPA 58.01.02.250) (Table 5).

Excess sediment is described by narrative criteria (IDAPA 58.01.02.200.08): "Sediment shall not exceed quantities specified in Sections 250 and 252 or, in the absence of specific sediment criteria, quantities which impair designated beneficial uses. Determinations of impairment shall be based on water quality monitoring and surveillance and the information utilized as described in Subsection 350."

Narrative criteria for excess nutrients are described in IDAPA 58.01.02.200.06, which states: "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."

Narrative criteria for floating, suspended, or submerged matter are described in IDAPA 58.01.02.200.05, which states: "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. This matter does not include suspended sediment produced as a result of nonpoint source activities."

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 WBAGII (Grafe et al. 2002). This guidance requires the use of the most complete data available to make beneficial use support status determinations.

Table 5 includes the numeric criteria most commonly used in TMDLs.

Table 5. 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**	**Warm Water Aquatic Life**
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 containing 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 containing greater than 576 *E. coli*100 ml	pH between 6.5 and 9.0 DO[b] exceeds 5.0 mg/L[c] This does not apply to the bottom 20% of water depth in lakes or reservoirs 35 meters or less and waters of the hypolimnion in stratifies lakes and reservoirs.
Temperature[d]			33 °C or less daily maximum; 29 °C or less daily average.
Mercury			Surface waters of the state shall be free from deleterious materials in concentrations that impair designated beneficial uses. For purposes of aquatic life protection it is assumed that if the weighted trophic level average of fish tissue samples meets the human health consumption standard of 0.03 mg/Kg[e] methylmercury that aquatic life will also be protected.
Turbidity			Turbidity shall not exceed background by more than 50 NTU[f] instantaneously or more than 25 NTU for more than 10 consecutive days.
Ammonia			Ammonia not to exceed calculated concentration based on pH and temperature.

[a] *Escherichia coli* per 100 milliliters
[b] DO – dissolved oxygen
[c] mg/L – 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] mg/Kg – milligrams per kilogram
[f] NTU – nephelometric turbidity units

2.3 Pollutant/Beneficial Use Support Status Relationships

Most of the pollutants that impair beneficial uses in lakes and reservoirs are naturally occurring characteristics that have been altered by humans. That is, lakes naturally have sediment, nutrients, and the like, but when human-influenced sources cause these to reach unnatural levels, they are considered “pollutants” and can impair beneficial uses. All references to pollutant affects on lakes in this section can be applied to both lakes and reservoirs.

Temperature

Temperature is a water quality factor integral to the life cycle of fish and other aquatic species. Different temperature regimes also result in different aquatic community compositions. Water temperature dictates whether a warm, cool, or cold water aquatic community is present. Many factors, natural and human-influenced, affect water temperatures. Natural factors include altitude, aspect, climate, weather, riparian vegetation (shade), and basin morphology (width and depth). Human-influenced factors include heated discharges (such as those from point sources), riparian alteration, channel alteration, and flow alteration.

Elevated reservoir temperatures can be harmful to fish at all life stages, especially if they occur in combination with other habitat limitations such as low DO or poor food supply. Acceptable temperature ranges vary for different species of fish, with cold water species being the least tolerant of high water temperatures. Temperature as a chronic stressor to adult fish can result in reduced body weight, reduced oxygen exchange, increased susceptibility to disease, and reduced reproductive capacity. High temperatures can result in death if they persist for an extended length of time. Juvenile fish are even more sensitive to temperature variations than adult fish, and can experience negative impacts at a lower threshold value than the adults, manifesting in retarded growth rates. High temperatures also affect embryonic development of fish before they even emerge from the substrate. Similar kinds of effects may occur to aquatic invertebrates, amphibians and mollusks, although less is known about them.

Thermal stratification occurs in lakes and reservoirs. Stratification results in water layers of differing temperatures. These thermal layers affect gas solubility and water chemistry. Water differs from most other compounds because it is less dense as a solid than as a liquid. Consequently ice floats, while water at temperatures just above freezing sinks. As most compounds change from liquid to solid, the molecules become more tightly packed and consequently the solid compound is denser than its liquid. Water, in contrast, is most dense at 4^oC and becomes less dense at both higher and lower temperatures. Because of this density-temperature relationship, many lakes in temperate climates tend to stratify.

During winter, if there is ice cover, the water near the lake bottom will usually be 4^oC, while the water in the upper layer is near 0^oC. As the weather warms the ice melts. The surface water heats up. When the temperature of the surface and bottom water is equal, very little wind energy is needed to mix the lake completely. This is called turnover. After spring turnover, the surface water continues to absorb heat and warm. As the temperature rises, the water becomes less dense than the cooler water below. For a while winds may still mix the lake from top to bottom, but eventually the upper water becomes too buoyant to mix completely with the denser, deeper water. Deep lakes generally become physically stratified into three identifiable layers, known as the epilimnion, metalimnion, and hypolimnion. The epilimnion is the upper, warm layer, and is typically well mixed. Below that is the metalimnion, or thermocline region; a layer of water in which temperature declines rapidly with depth. The hypolimnion is the bottom layer of colder water isolated from the epilimnion by the metalimnion. The density change at the metalimnion acts as a physical barrier, which can prevent mixing of the upper and lower layers in many lakes for several months during the summer. As weather cools in autumn, the epilimnion cools too, reducing the difference between it and the hypolimnion. As time goes on the lake gradually mixes deeper and deeper until it is eventually fully mixed; this is called fall turnover.

This pattern of mixing (spring turnover – summer stratification – fall turnover) is typical for temperate lakes. Lakes with this pattern are referred to as dimictic. However, many shallow lakes only stratify for short periods, or not at all, during the summer. Lakes that stratify and de-stratify numerous times within a summer are referred to as polymictic lakes. Lake Lowell appears to represent a polymictic lake that is wind-mixed periodically over the summer season. Polymictic water bodies are intermittently mixed and stratified, depending on the existing weather conditions (Jorgenson et al. 2005). On calm days, particularly when air temperatures are higher than surface water temperatures and no wind stirs the water surface, stratification of the water column begins and can persist until the wind starts to blow and the temperature grows cooler. When this happens, the surface water cools down, sinks because of the greater density and mixes the water body.

Dissolved Oxygen

Oxygen is necessary for the survival of most aquatic organisms and essential to reservoir 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 (ppm), or percent of saturation. While air contains approximately 20.9% oxygen gas by volume, the proportion of oxygen dissolved in water is about 35%, because nitrogen (the remainder of the air) 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 oxygen solubility.

Dissolved oxygen levels of 5 mg/L and above are considered optimal for warm water aquatic life. When DO levels fall below 5 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). In addition, oxygen is necessary to help decompose organic matter in the water and bottom sediments. 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., wind-mixing, wave action), 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 large 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, inflow, nutrient loading, and channel alteration all impact the amount of DO in the water. Colder waters hold more DO than warmer waters. As tributary inflows decrease, the amount of aeration typically decreases and the water temperature increases, resulting in decreased DO. In addition, tributary channels that have been altered to increase the effectiveness of conveying water often have fewer riffles and less aeration compared to natural stream channels. Thus, these systems may show depressed levels of DO in comparison to the DO levels before the alteration. Nutrient-enriched waters have a higher biochemical oxygen demand (BOD) due to the amount of oxygen required for organic matter decomposition and other chemical reactions. This oxygen demand results in lower DO levels.

Biological activity in lakes and reservoirs peaks during spring and summer when photosynthetic activity is driven by increased solar radiation. Furthermore, during the summer most lakes in temperate climates are stratified. The combination of thermal stratification and biological activity causes characteristic patterns in DO concentrations. In spring and fall, eutrophic (more productive) lakes tend to have uniform, well, mixed conditions throughout the water column. During summer stratification, the DO concentration in the epilimnion remains high throughout the summer because of photosynthesis and diffusion from the atmosphere. Hypolimnetic DO declines during the summer because it is cut-off from oxygen sources, while organisms continue to respire and consume oxygen. The bottom layer of the lake and even the entire hypolimnion may eventually become anoxic. Lake Lowell is polymictic and stratifies several times during the summer. Water in the lower column can become anoxic during stratification and cause a release of phosphorus and ammonium from the sediment into the water which is then suspended into the water column each time the reservoir mixes.

In winter, ice-covered eutrophic lakes may develop winter stratification of DO. If there is little or no snow cover to block sunlight, phytoplankton and some macrophytes may continue to photosynthesize resulting in a small increase in DO just below the ice. As microorganisms continue to decompose material in the lower water column and in the sediments, they consume oxygen, and the DO in lower layers is depleted. No oxygen input from the air occurs because of the ice cover, and, if snow covers the ice, it becomes too dark for photosynthesis. This condition can cause high fish mortality during winter, known as "winter kill". Low DO in the water overlying the sediments can exacerbate water quality deterioration; because when the DO level drops below 1 mg/L chemical processes at the sediment-water interface frequently cause release of phosphorus and ammonium from the sediments into the water. When the lake mixes in the spring, this released phosphorus and ammonium that has built up in the bottom water fuels algal growth.

Bacteria

Escherichia coli or *E. coli*, a species of fecal coliform bacteria, is used by the state of Idaho as the indicator for the presence of pathogenic microorganisms. Pathogens are a small subset of microorganisms (e.g., certain bacteria, viruses, and protozoa), which, if taken into the body through contaminated water or food, can cause sickness or even death. Some pathogens are also able to cause illness by entering the body through the skin or mucous membranes.

Direct measurement of pathogen levels in surface water is difficult because pathogens usually occur in very low numbers and analysis methods are unreliable and expensive. Consequently, indicator bacteria which are often associated with pathogens, but which generally occur in higher concentrations and are thus more easily measured, are assessed.

Coliform bacteria are unicellular organisms found in feces of warm-blooded animals such as humans, domestic pets, livestock, and wildlife. Coliform bacteria are commonly monitored as part of point source discharge permits (National Pollution Discharge Elimination System [NPDES] permits), but may also be monitored in nonpoint source arenas. The human health effects from pathogenic coliform bacteria range from nausea, vomiting, and diarrhea to acute respiratory illness, meningitis, ulceration of the intestines, and even death. Coliform bacteria do not have a known effect on aquatic life.

Coliform bacteria from both point and nonpoint sources impact water bodies, although point sources are typically permitted and offer some level of bacteria-reducing treatment prior to discharge. Nonpoint sources of bacteria are diffuse and difficult to characterize. Unfortunately, nonpoint sources often have the greatest impact on bacteria concentrations in water bodies. This is particularly the case in urban storm water and agricultural areas. *E. coli* is often measured in colony forming units (cfu) per 100 ml.

Nutrients

While nutrients are a natural component of the aquatic ecosystem, natural cycles can be disrupted by increased nutrient inputs from human-influenced activities. The excess nutrients result in accelerated plant growth and can result in a eutrophic or enriched system. Nutrients are transported from their sources to lakes through several chemical, physical and biological processes, which together compose the phosphorus or nitrogen cycle. These cycles are important because of the information they provide about nutrient availability and the associated impact on plant growth.

Under normal conditions phosphorus is scarce in the environment. Rocks and phosphate deposits are the main sources of natural phosphates. Release of these deposits occurs during weathering, leaching, erosion or mining. Some phosphorus is inevitably transported to aquatic ecosystems by water or wind. Total phosphorus (TP) includes all forms of phosphorus in a water sample, including all inorganic and organic particulate and soluble forms. In freshwater systems, typically greater than 90% of the TP 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 TP that consequently leads to a more rapid growth of algae. Human activities have resulted in excessive loading of phosphorus into many freshwater ecosystems. In most impaired systems, a larger percentage of the TP 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 is plentiful and continuously cycling in the environment. Nearly 80 percent of our atmosphere is nitrogen gas (N_2). Although largely available in the atmosphere, N_2 must be converted to other forms, such as nitrate (NO_3^-), before most plants and animals can use it. Conversion to usable forms occurs through four processes of the nitrogen cycle. Three processes—nitrogen fixation, ammonification, and nitrification—convert gaseous nitrogen forms that can be used by aquatic organisms. The fourth process, de-nitrification, converts nitrogen compounds back to the gaseous N_2 state. Aquatic organisms incorporate available dissolved inorganic nitrogen into their tissue. Dead organisms decompose, and nitrogen is released as ammonium ions and then converted to nitrite and nitrate, whence the process begins again.

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 phosphorus 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 nitrogen (TN) to TP ratios greater than seven are indicative of a phosphorus-limited system while those ratios less than seven are indicative of a nitrogen-limited 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. If a water body lacks biologically available nitrogen, nitrogen fixing organisms can convert nitrogen from its gaseous phase to ammonia ions. 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.

Nutrients primarily cycle between the water column and sediment. Aquatic plants rapidly assimilate dissolved nutrients, particularly orthophosphate. If sufficient nutrients are available either in the sediments or the water column, aquatic plants will store an abundance of such nutrients in excess of the plant's actual needs. This is a chemical phenomenon known as luxury consumption. When a plant dies, the tissue decays and the nutrients stored within the plant biomass are either restored to the water column or the detritus becomes incorporated into the bottom 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 bottom sediment. Once these nutrients are incorporated into the sediment, they are available once again for uptake by yet another life cycle of rooted aquatic macrophytes and other aquatic plants. Nutrients are released directly from sediment during anoxic conditions.

Aquatic organisms influence (and are influenced by) the chemistry of the surrounding environment. For example, phytoplankton extract nutrients from the water and zooplankton feed on phytoplankton. Nutrients are redistributed from the upper water to the lake bottom as the dead plankton gradually sink to lower depths and decompose. The redistribution is partially offset by the active vertical migration of the plankton.

In contrast to DO, essential nutrients such as bio-available forms of phosphorus and nitrogen typically increase in spring from snowmelt runoff and from mixing of accumulated nutrients from the bottom during spring turnover. Concentrations typically decrease in the epilimnion during summer stratification as nutrients are taken up by algae and eventually transported to the hypolimnion when the algae die and settle out. During this period, any "new" input of nutrients into the upper water may trigger a "bloom" of algae. Such inputs may be from upstream tributaries after rainstorms, die-offs of aquatic plants, pulses of urban stormwater, direct runoff from lawn fertilizer or leaky lakeshore septic systems. In the absence of rain or snowmelt, an influx of nutrients may occur when high winds mix a portion of the nutrient enriched upper waters of the hypolimnion into the epilimnion. In polymictic water bodies such as Lake Lowell, a pulse of nutrients is mixed through the water column each time weakly stratified water layers break down allowing the water to mix. Nitrogen and phosphorus in dry fallout and wet precipitation may also come from dust, fine soil particles and fertilizer from agricultural fields.

Sediment – Nutrient Relationship

The link between sediment and sediment-bound nutrients is important when dealing with nutrient enrichment problems in aquatic systems. Phosphorus is typically bound to particulate matter in aquatic systems and, thus, 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 U.S. Department of Agriculture (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. Some phosphorus will sorb to sediments in the water column or substrate and be removed from circulation. Phytoplankton, periphyton, and bacteria assimilate inorganic phosphate in the water column and change it into organic phosphorus. These organisms then may be ingested by grazers or detritivores, which in turn excrete some of the organic phosphorus. Continuing the cycle, organic phosphorus is rapidly assimilated by plants and microbes. However, when conditions become anoxic, the sediments release phosphorus 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. The result is a reduction of nitrogen oxides (NO_x) being lost to the atmosphere. De-nitrification is a process by which nitrates are reduced to gaseous nitrogen by facultative anaerobes. Facultative anaerobes, such as fungi, can flourish in anoxic conditions because they break down oxygen-containing compounds (e.g. NO_3^-) to obtain oxygen.

Sediments can play an integral role in reducing the frequency and duration of phytoplankton blooms in standing waters. In many cases, there is an immediate response in phytoplankton biomass when external sources of nutrients 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 (Ekholm *et. a*l 1997).

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, inflow rates, water temperatures, and penetration of sunlight in the water column all affect algae (and macrophyte) growth. 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.

Algal blooms also often create objectionable odors and coloration in water used for domestic drinking water and can produce intense coloration of both the water and shorelines as cells accumulate along the banks. In extreme cases, algal blooms can also result in impairment of agricultural water supplies due to toxicity. 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.

Blue-green “algae” are technically referred to as cyanobacteria since, except for their chlorophyll-based photosynthesis, they are bacteria. Blue-greens have several characteristics that often enable them to dominate and create nuisance or noxious conditions. Some blue-green species have the ability to adjust their buoyancy. They can sink or float depending on light conditions and nutrient supply. All plants, including all algae, satisfy their nitrogen requirements by absorbing nitrate or ammonium from the water. However, some blue-greens can fix molecular nitrogen from the atmosphere in a process called nitrogen fixation. This allows them to maintain high rates of growth when other forms of nitrogen are sufficiently depleted to limit growth by other types of algae. Blue-green algae typically are well-adapted to phosphorus deficiency because of their ability to absorb and store excess phosphorus when it is available, enough to last days and in some cases weeks.

Unlike green algae and diatoms, the blue-green algae are less suitable as food for primary consumers. This is partly because some blue-greens can form large colonies of cells embedded in a gelatinous matrix which may pose a handling problem for grazers. They may also produce chemicals that inhibit grazers or makes them taste bad. Consequently, blue greens have advantages over other algae at using nutrient and light resources, as well as avoiding being eaten.

Commonly, blue-green algae blooms appear as extensive layers or algal mats on the surface of the water. When present at excessive concentrations in the water column, blue-green algae often produce toxins that can result in skin irritation to swimmers and illness or even death in organisms ingesting the water. The toxic effect of blue-green algae is worse when an abundance of organisms die and accumulate in a central area.

When algae die, 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 sediment-adsorbed 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 (TP) 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 TP inputs to the system can act as a mechanism for water quality improvements, particularly in surface-water systems dominated by blue-green algae, which can acquire nitrogen directly from the atmosphere and the water column. Phosphorus management within these systems can potentially result in improvement in nutrients (phosphorus), nuisance algae, DO, and pH.

2.4 Summary and Analysis of Existing Water Quality Data

This section presents the most recent data for the Lake Lowell watershed. The information presented is used to determine whether beneficial uses (i.e., aquatic life, contact recreation) are impaired. A TMDL to restore beneficial uses is necessary if the data shows that beneficial uses are impaired by pollutants.

Flow Characteristics

The following section describes the reservoir hydrology and tributary flow characteristics.

Lake Lowell Reservoir Operations and Storage

The reservoir has an active storage capacity of 159,365 acre-feet (Table 6). The normal operation of Lake Lowell is to fill the reservoir during the non-irrigation season and release water from the reservoir as needed during the irrigation season (Figure 13). Lake Lowell is usually filled to within 2 feet of the maximum capacity by the end of March, leaving some space to fill from the beginning of April until the time of full irrigation demand. The reservoir is filled by release of storage water from Anderson Ranch Dam and Arrowrock Dam, and with water from Mores Creek that is delivered in accordance with natural-flow surface water rights. The BOR operates and maintains Anderson Ranch Dam and Arrowrock Dam facilities. The water is passed through Lucky Peak Dam and diverted at the Boise River Diversion Dam to the New York Canal (BOR 1996). Storage operations occur during the non-irrigation season and whenever the demand for irrigation water is low for lands below Lake Lowell. The irrigation season is from about March 15 to October 15. Reservoir contents decline throughout the summer because irrigation releases from the reservoir exceed inflow from the New York Canal. However, inflow from the New York Canal continues late into the irrigation season (mid-October) to ensure normal winter carryover of about 100,000 to 130,000 acre-feet of storage.

Table 6. Lake Lowell area and capacity.

Reservoir Parameter	Measurement
Maximum Water Surface Elevation	2,531.2 feet
Surface Area	9,024.8 acres
Total Capacity	173,043 acre-feet
Active Capacity	159,365 acre-feet
Length of Reservoir at Full Pool	9.2 miles
Average Width of Reservoir at Full Pool	0.65 miles

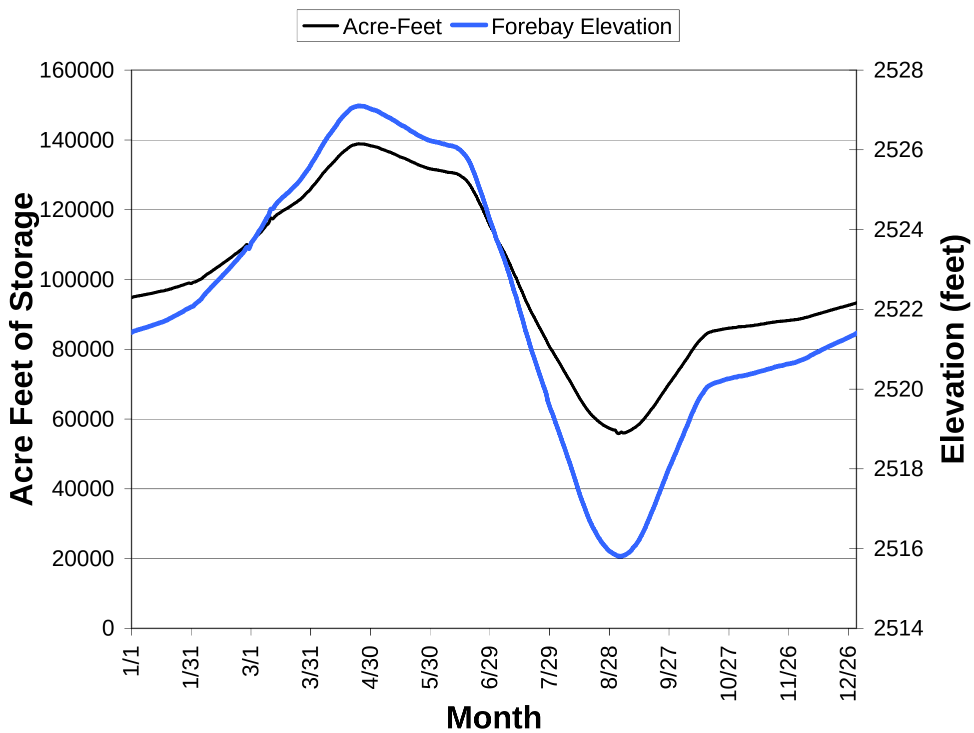


Figure 13. Lake Lowell average monthly water storage (1954-2009).

Canals and Drains

Lake Lowell is fed Boise River and irrigation return water through a complex system of irrigation conveyances (See Figure 5 and Figure 6). The Boise Project Board of Control operates and maintains the Boise River Diversion Dam, canals, laterals, and off-stream reservoirs and manages water levels in Lake Lowell. Water is distributed through the system in accordance with natural-flow rights or contracts with BOR for stored water. Inflows to the reservoir are a combination of water diverted directly from the Boise River and return flows from irrigated land. Inflows to Lake Lowell have been estimated in acre-feet and cfs based on data provided by the Boise Project Board of Control (BPBOC), data collected by DEQ and BOR in 2004-2006 and monitoring data collected by the Idaho State Department of Agriculture (ISDA) in 2002 (Table 7 and Table 8).

Lake Lowell receives the most inflow, about 180,000 acre-feet per year, from the Boise River through the New York Canal (Table 7). Inflows from the New York Canal are a combination of (background) water from the Boise River, upland irrigation drainage, stormwater runoff, septic system inputs, and return flows from privately developed lands not irrigated with surface water (BOR 2001), and ground water. Drain water originates from varied and nonspecific sources spread out along the 40-mile length of the canal. The drains are continually mixed with New York Canal waters. Irrigation season inflows from the New York Canal vary due to demands from lands farther up the conveyance system and other diversions. Flow duration analysis shows that flow through the New York Canal and associated conveyance system is relatively constant throughout the irrigation season (Figure 14).

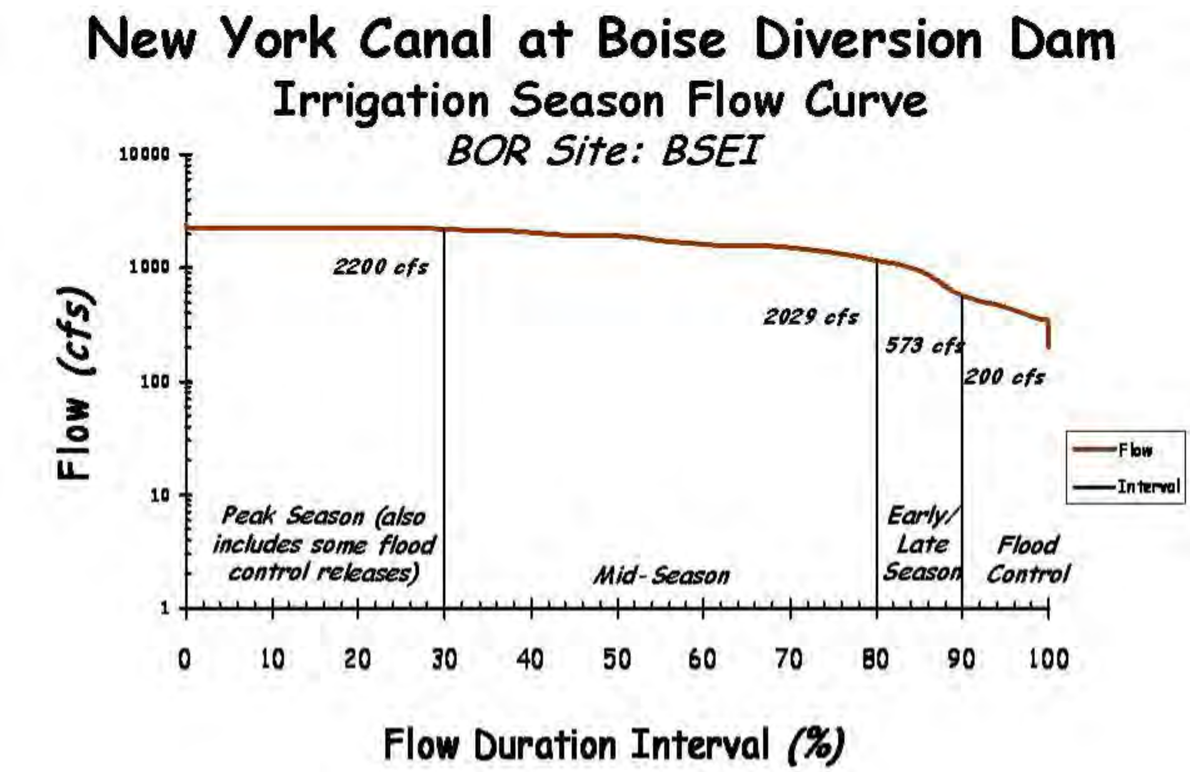


Figure 14. Flow analysis for water diversion from the Boise River to New York Canal.

The Garland Drain and Ridenbaugh Canal empty into the New York Canal downstream from Lakeshore Drive in Canyon County immediately downstream of the New York Canal's final check gates. Flows from these three points (provided by BPBOC, see Appendix F) are used to estimate inflows to Lake Lowell from the New York Canal system. The Deer Flat Highline Canal diversion is immediately upstream of the final check gates. The Garland Drain and Deer Flat Highline Canal are on the south side of the New York Canal. The drain collects wastewater from lands south and east of Lake Lowell and flows parallel to the New York Canal for a short distance before crossing under the Deer Flat Highline Canal and emptying into the New York Canal. Water for Ridenbaugh Canal is diverted from the Boise River downstream of the Boise Diversion Dam and flows through densely populated areas of

Boise and Meridian before flowing into a mix of agricultural land and recently-constructed residential areas.

An estimated 28,000 acre-feet per year of irrigation wastewater enters the reservoir from measured drains and wasteways south of the reservoir between the Mora Canal and Lake Lowell. These measured drains and wasteways are the Coulee Drain, Bernard Drain, Garner Drain, Donaldson Drain, Farner Drain, and the Mora Canal/Deer Flat Highline wasteways (Table 7 and Table 8). The drain waters consist of urban runoff, septic system inputs, and agricultural returns. The proportion of surface water and ground water are undefined at this time (BOR 1998). The Deer Flat Highline Canal bypasses water around Lake Lowell following the contour of the south shore. Two operational wasteways provide inflows to Lake Lowell by draining excess water from the Deer Flat Highline Canal to the reservoir. Wasteway No. 1, about 2-1/2 miles from the New York Canal inlet, is concrete-lined from the Deer Flat Highline Canal to the road. Wasteway No. 3, located less than one-quarter mile from the Lake Lowell Lower Embankment Dam, is not lined. These are enhanced ditches that follow natural drainage channels. An estimated 5,900 acre-feet of irrigation wastewater enter the reservoir from unmonitored drains surrounding Lake Lowell. Flow from these drains is based on aerial photography analysis.

Table 7. Average annual measured inflows into Lake Lowell[a].

Tributary	Average Annual Inflow (acre-feet)
New York Canal (including Ridenbaugh Canal and Garland Drain)	180,000
Deer Flat Highline Wasteway #1	1,800
Deer Flat Highline Wasteway #3	20,000
Coulee Drain	1,900
Bernard Drain	1200
Garner Drain	400
Donaldson Drain	900
Farner Drain	1,800
Other Minor Unmonitored Drains	5,900
Total	213,900

[a] Annual average inflow based on Boise Project Board of Control 2004, 2005 and 2009 records, DEQ and BOR 2004-2006 monitoring data, 2002 ISDA (Idaho State Department of Agriculture) monitoring data and estimations for other minor drains based on aerial photography analysis.

Table 8. Flow (cfs) statistics for Lake Lowell tributaries[a].

Statistic	New York Canal[a]	Deer Flat Wasteway #3	Farner Drain	Donaldson Drain	Garner Drain	Highline Wasteway #1	Bernard Drain	Coulee Drain
Mean	384.6	69.5	6.7	2.7	1.1	7.2	4.2	7.9
St Dev	238.9	57.5	4.9	1.2	1.3	5.7	3.4	7.1
Count	9	24	30	3	2	11	29	20
Maximum	758.0	227.0	18.5	4.0	2.0	20.0	12.6	24.0
Minimum	114.2	2.5	1.5	1.6	0.2	2.0	0.9	0.3

[a] Flow statistics based on Boise Project Board of Control 2004, 2005 and 2009 records, DEQ and BOR 2004-2006 monitoring data, 2002 ISDA (Idaho State Department of Agriculture) monitoring data and estimations for other minor drains based on aerial photography analysis.

Outflows

The reservoir is drafted (water is withdrawn from it) throughout the summer to supply irrigation water to low-elevation watershed lands. Drafts are made through the Deer Flat Lowline, Deer Flat North, Deer Flat Caldwell, and Deer Flat Nampa Canals, and the Blinkenstaff pumping station (Figure 5 and Table 9). Deer Flat Low Line and Deer Flat North Canals release water from the Lower Embankment Dam. Deer Flat Nampa and Deer Flat Caldwell canals release water from the Upper Embankment Dam. The Blinkenstaff pumps (in a small building near the Deer Flat Highline Wasteway No. 3 channel) lift reservoir water to the Mora Canal. The difference between measured inflows and outflows is water lost to evaporation and ground water. In the 1980s, water budgets in Lake Lowell showed that gains and losses to ground water were equal. In the 1990s the reservoir regularly lost between 20,000 and 50,000 acre-feet of water to the aquifer annually (BOR 2001). More recent studies suggest that ground water losses are not as large as previously thought (Schmidt 2008) and that the reservoir may be in equilibrium given its long (100-year) history. Ground water is discussed in greater detail in section 3.1.

Table 9. Average annual measured outflows from Lake Lowell.

Outlet	Average Annual Outflow (acre-feet)
Deer Flat Lowline Canal	203,000
Deer Flat Caldwell Canal	2,900
Deer Flat Nampa Canal	3,600
Blinkenstaff Pumps	1,200
Total	210,700

Water Column Data

DEQ and BOR collected water quality samples in the reservoir and the tributary canals and drains. Data are summarized in the following sections.

Reservoir Data

The Idaho DEQ collected water quality data, including DO and temperature, at one-half-meter or one-meter intervals at three sites in the reservoir: BOI 185, BOI 181 and BOI 183, which are shown in Figure 15. Site BOI 185 is 7 to 8 meters deep, Site BOI 181 is 11 meters deep, and Site BOI 183 is 4.5 meters deep. The BOR also collected data at the BOI 181 and BOI 183 sites. In addition, BOR sampled three other sites at less frequent intervals: BOI 180, BOI 182, and BOI 184. BOR recorded temperature and DO measurements at 2-meter intervals. Data for site BOI 180 and BOI 184 is included in the BOI 185 data analysis and graphs because the site conditions are similar. Data for site BOI 182 is included with site BOI 183 since site conditions are similar. All reservoir water column sample data sources are listed in Appendix C and the raw data are available from the DEQ Boise Regional Office by filing a public records request. All sampling locations are approximate since there are no permanent buoys or markers in place to mark the sample sites.

Table 10. Lake Lowell water quality sampling sites and maximum depths.

Site ID	Description	Maximum Depth (ft)	DEQ Monthly Sampling Dates	BOR Monthly Sampling Dates
BOI 180	1.5 miles east of Lower Embankment Boat Ramp	20	n.s.	July 2002 July 2005
BOI 181	Near Upper Embankment Boat Ramp	38	June – October 2003 December 2003 February – August 2004 March – November 2005 February – March 2006	July 2002 October, December 2003 February – June 2004 April, May, July, August, October, November 2005 Feb 2006
BOI 182	Southeast End	13	n.s.	July 2002 April 2004 July 2005
BOI 183	Across from Upper Embankment	11	June 2003	July 2002 July 2005
BOI 184	1 Mile SE from Lower Embankment Canal Gage Station	17	n.s.	July 2005
BOI 185	Near Lower Embankment	23	June – October 2003 December 2003 February – August 2004 March – November 2005 February – March 2006	n.s.

n.s. – not sampled

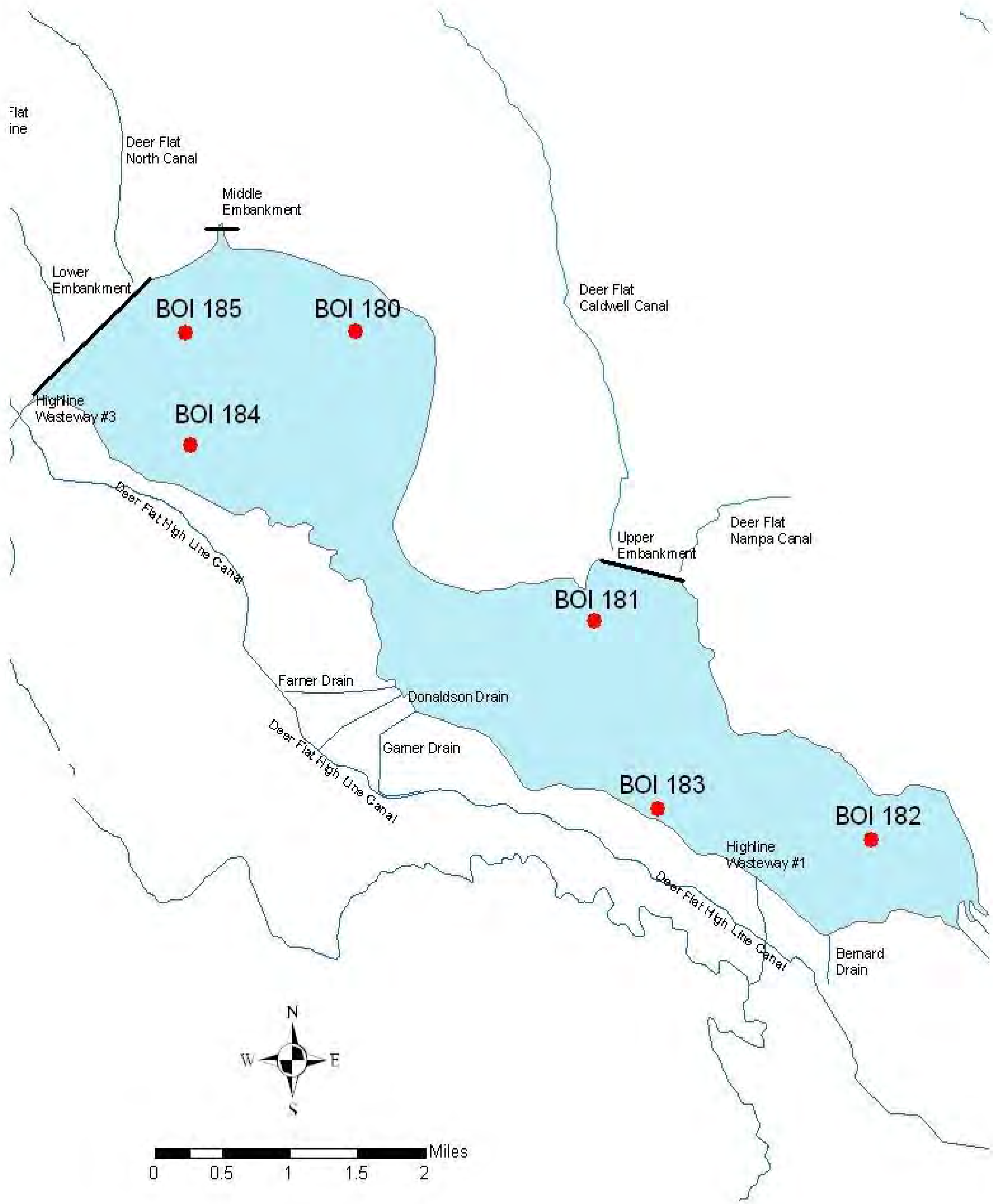


Figure 15. Locations of Lake Lowell water column sampling sites.

Temperature

Most aquatic organisms are cold-blooded, which means they are unable to internally regulate their core body temperature. Therefore, temperature exerts a major influence on their biological activity and growth. Fish, insects, zooplankton, phytoplankton, and other aquatic species all have preferred temperature ranges. When temperatures get too far above or below this preferred range, the number of organisms decreases until finally there are few or none.

The temperature criteria for waters designated as warm water fisheries is 33°C or less, with a maximum daily average not greater than 29 °C. Temperature in lakes (including any reservoir with mean detention time greater than 15 days) shall have no measureable change from natural background conditions (IDAPA 58.01.02.250.04). When the temperature exceeds criteria for more than 10% of measurements DEQ concludes beneficial uses are not supported for that water body. Figure 16, Figure 17 and Figure 18 display the temperature data for sites BOI 180, BOI 184, BOI 185, BOI 181, BOI 182, and BOI 183 in Lake Lowell. They indicate that the reservoir's temperature supports warm water aquatic life.

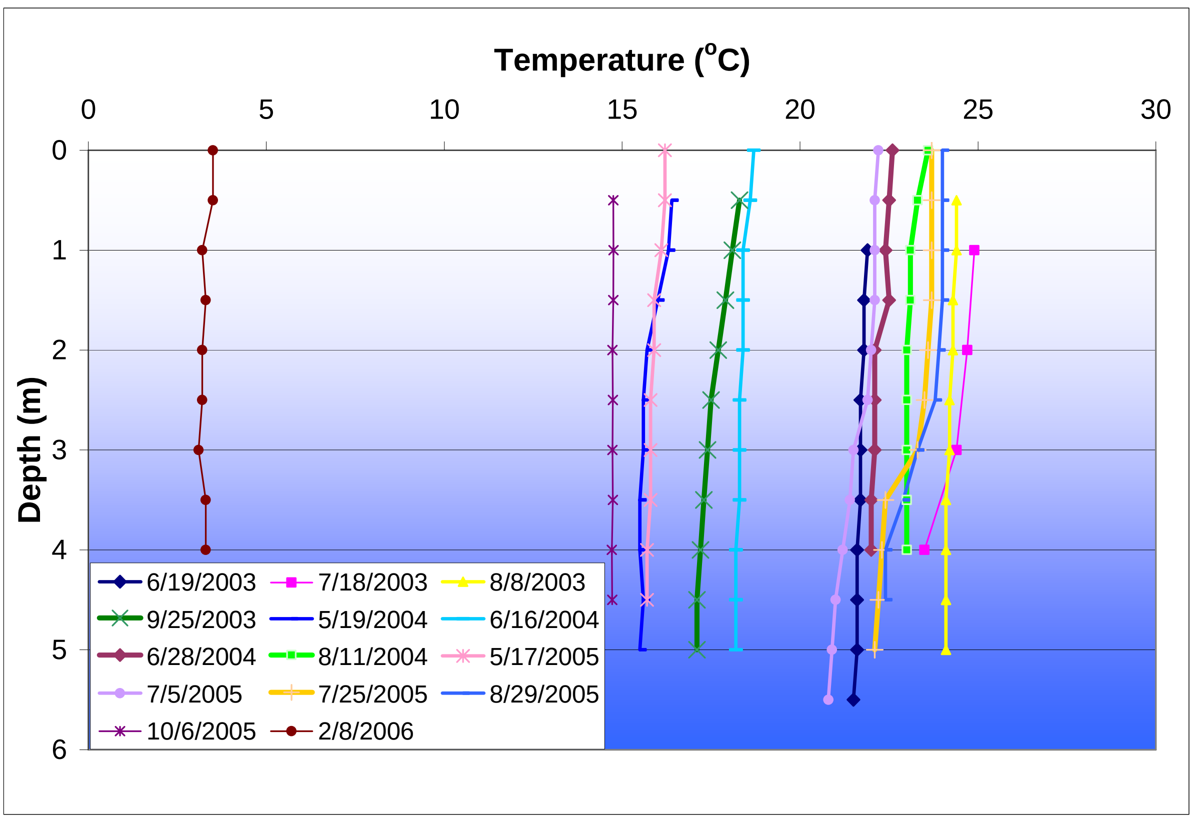


Figure 16. Lake Lowell temperature data for sites BOI 180, BOI 184, and BOI 185 from 2003-2006.

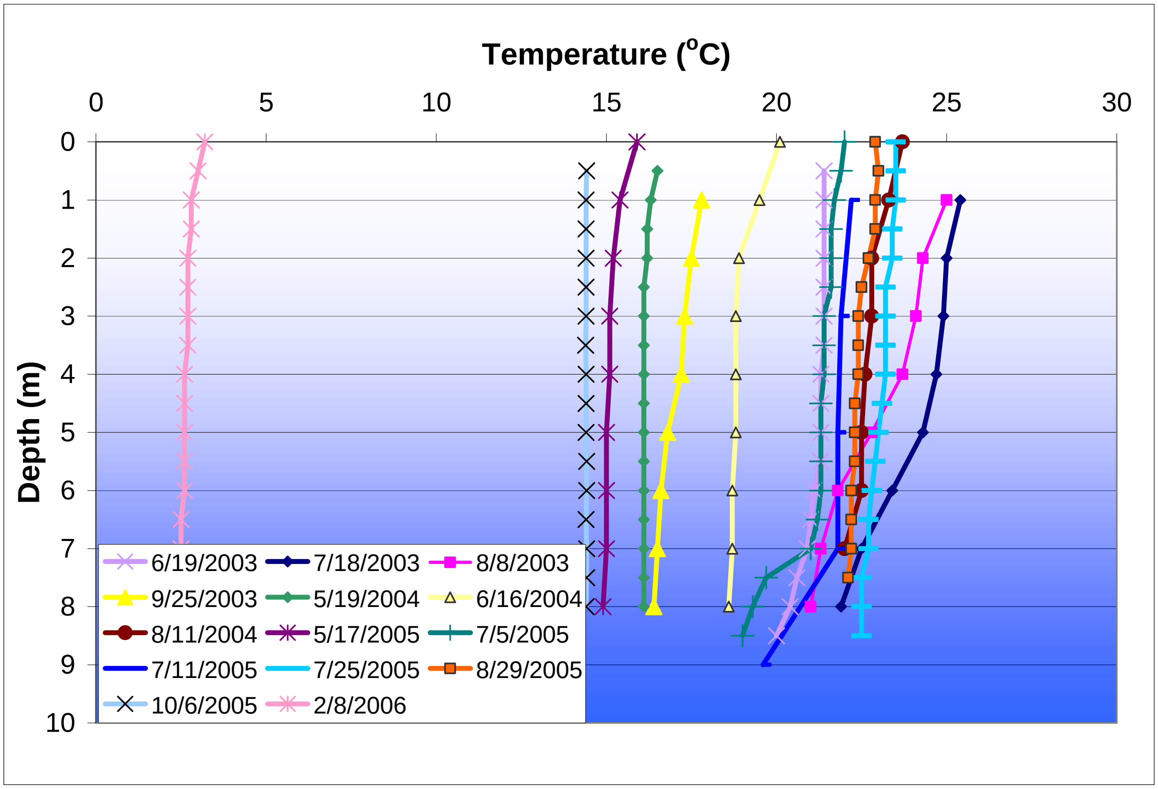


Figure 17. Lake Lowell temperature data for site BOI 181 from 2003-2006.

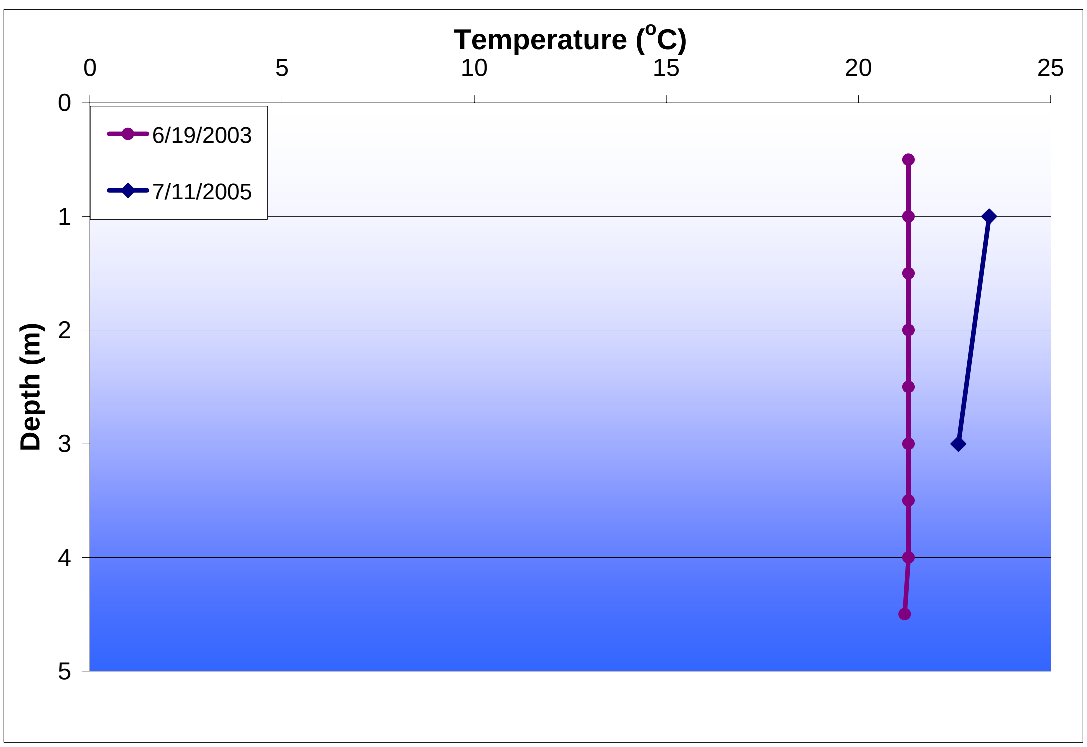


Figure 18. Lake Lowell temperature data for site BOI 182 (2003) and BOI 183 (2005).

Dissolved Oxygen

Like terrestrial animals, fish and other aquatic organisms need oxygen to live. As water moves past their gills, microscopic bubbles of DO in the water are transferred to their blood. Like any other gas diffusion process, the transfer is efficient only above certain concentrations. Lake Lowell is designated for warm water aquatic life, which requires that dissolved oxygen concentrations must exceed 5.0 mg/L at all times, except for:

- The bottom 20% of water depth
- The waters of the hypolimnion (cooler, non-circulating water below the thermocline) when the lake is stratified

Idaho DEQ sampled 3 sites in Lake Lowell from 2003-2005. The observed data applicable to the DO WQS are plotted in Figure 19, Figure 20, and Figure 21. Data from the bottom 20% of reservoir depths are not plotted since they are excluded from meeting the DO WQS. Dissolved oxygen data shown in the figures demonstrate violations of Idaho's DO WQS (Table 11). The lack of strong seasonal stratification of the entire water body classifies this reservoir as polymictic. Because Lake Lowell is a shallow water body that is often wind-mixed, isothermal DO profiles are evident in some areas of the reservoir. At times the deepest site, BOI 181, near the Upper Embankment, may stratify however to remain consistent throughout the waterbody only the bottom 20% of reservoir depth is excluded from the DO WQS analysis. Most violations of DO criteria occur at site BOI 181. When DO values from beneath the weakly stratified water layers at site BOI 181 are removed from the data set, the reservoir still does not meet the WQS.

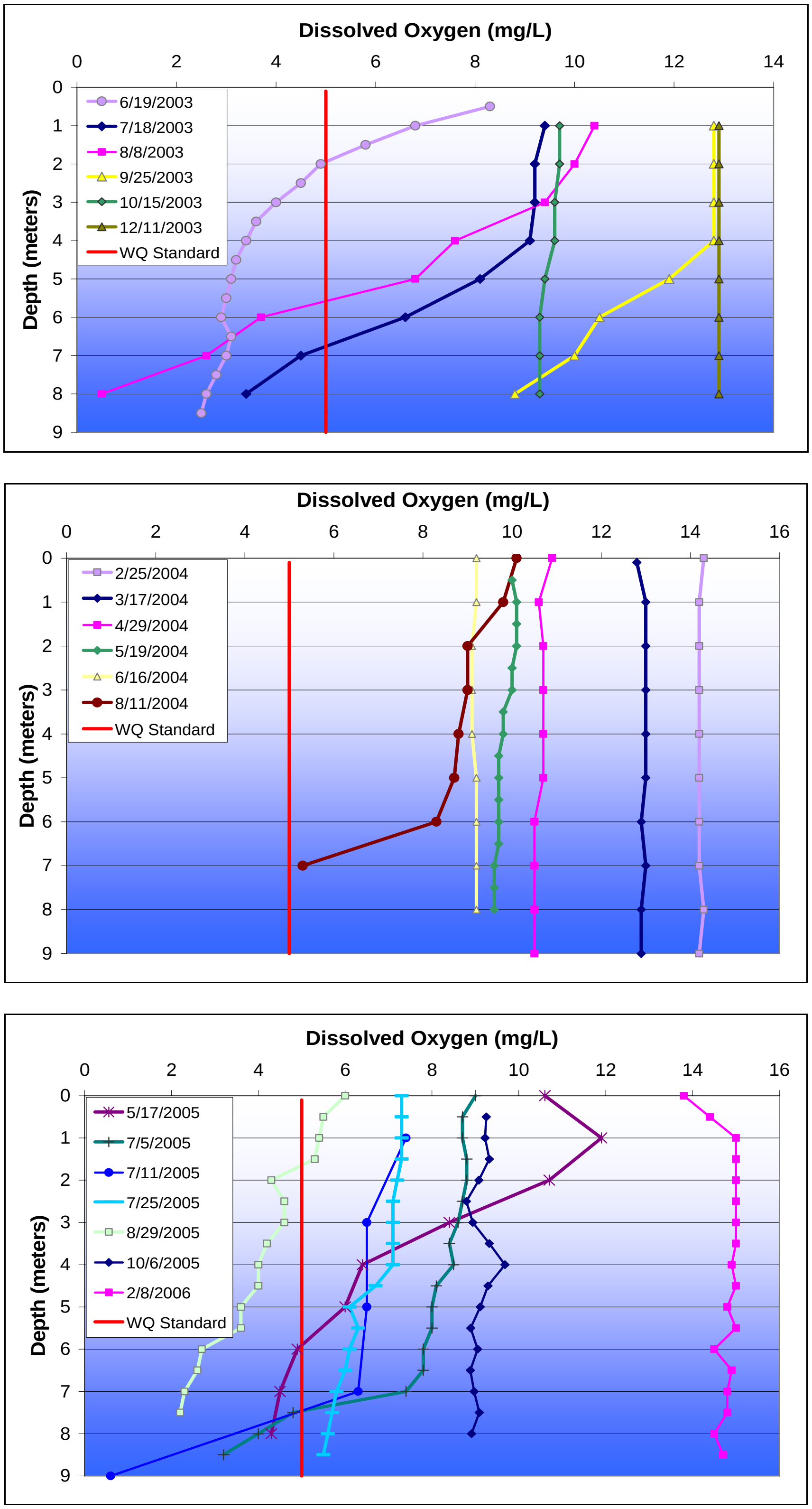


Figure 19. BOI 181 (Upper Embankment) dissolved oxygen concentrations 2003-2005.

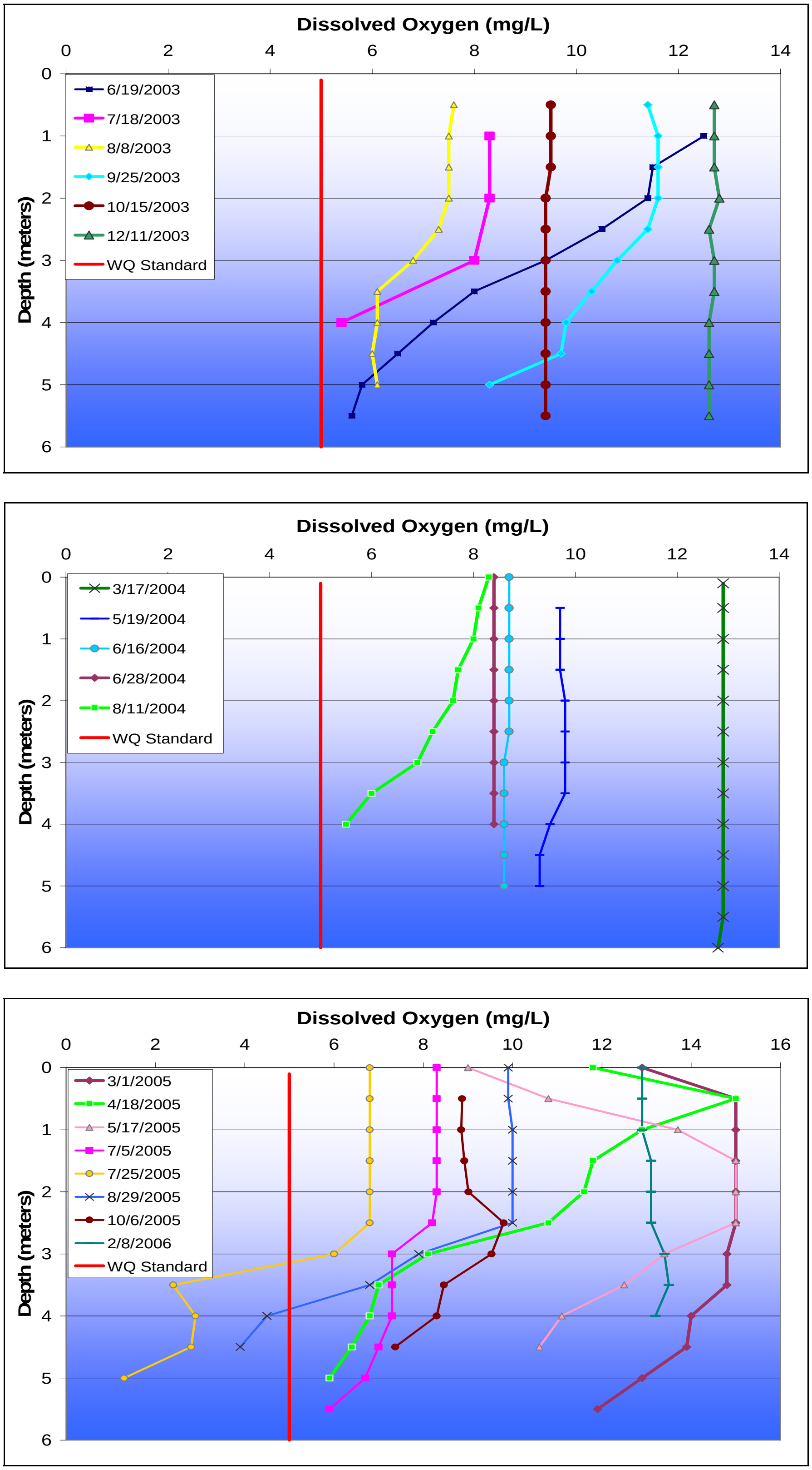


Figure 20. BOI 185 (Lower Embankment) dissolved oxygen concentrations 2003-2005.

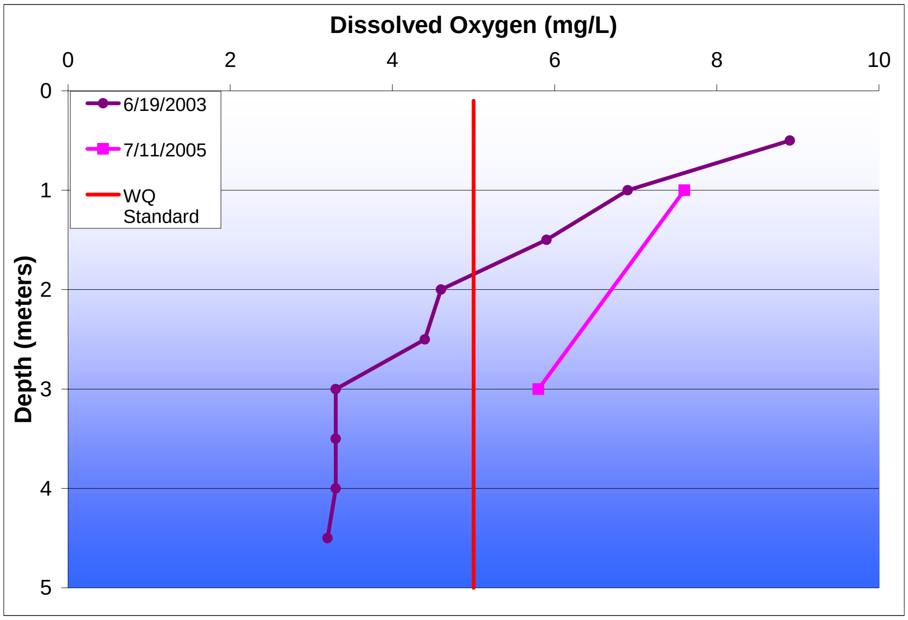


Figure 21. Site BOI 183 (South Shore) dissolved oxygen concentrations 2003.

Table 11. Observed dissolved oxygen (DO) concentrations and percent criteria exceedance for Lake Lowell 2003 to 2005.

Site	n	Number of Samples with DO below 5.0 mg/L	Percent of Samples with DO below 5.0 mg/L	Support Status
BOI 181	220	38	17.0%	Not Fully Supporting
BOI 183	11	6	55%	Not Fully Supporting
BOI 185	196	6	3%	Supporting
Total for all Sites	**425**	**50**	**12%**	**Not Fully Supporting**

Nutrients

The nutrient target for Idaho lakes and reservoirs stems from narrative criteria stating: "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." Numerous water quality reports cite excessive green and blue-green algal blooms in Lake Lowell (IFDG 1965, BOR 1977, BOR 1980, USFWS 2000). Observations from DEQ, IDFG and USFWS staff note large blooms of filamentous green algae in the water column during average water years. Also there are extensive blue-green algae blooms after there have been extended periods of lower water levels (e.g. from drought or facility maintenance) and then riparian areas are flooded (personal communication Jeff Dillon, Regional Fishery Manager, IDFG; USFWS Deer Flat National Wildlife Refuge staff). This likely causes a large pulse of nutrients to the water column. These observations support that the nutrient balance in the reservoir is out of sync and that phosphorus is in excess. When beneficial uses are impaired in a water body, a target concentration for the limiting nutrient, usually phosphorus, is set in the TMDL. From 2002 to 2006, reservoir samples were collected to determine nutrient and chlorophyll-*a* concentrations; and other parameters were measured to determine beneficial use support status of the reservoir (Table 13 and Table 14)**.**

Trophic State Index

An index frequently used to assess eutrophication in lakes and reservoirs was developed by Carlson (1977). Carlson's trophic state index (TSI) uses Secchi depth, chlorophyll-*a* concentration, and total phosphorus (TP) concentration; each producing an independent measure of trophic state (Carlson 1977; Carlson and Simpson, 1996). Index values range from approximately 0 (ultra-oligotrophic) to 100 (hypereutrophic). The index is scaled so that a TSI = 0 represents a Secchi transparency of 64 meters. Each halving of transparency represents an increase of 10 TSI units. For example, a TSI of 50 represents a transparency of 2 meters. A TSI based on chlorophyll-*a* (Chl-*a*) concentration is generally believed to be the best indication of eutrophication. The equations for calculating a TSI for each of the three parameters are shown below:

TSI (Chl-*a*) = 30.6 + 9.81 ln (Chl-*a*)
TSI (TP) = 4.15 + 14.42 ln (TP)
TSI (Secchi Depth) = 60 – 14.41 ln (Secchi Depth)

The following classification scheme is used to interpret TSI values:

TSI < 40 ultra-oligotrophic and oligotrophic lakes
40 < TSI < 50 mesotrophic lakes
50 < TSI < 70 eutrophic lakes
TSI > 70 hypereutrophic lakes

The TSI values for Lake Lowell for 2002 to 2006 are shown in Table 12. They indicate mesotrophic to eutrophic conditions. For each site, all samples collected from 2002 through 2006 were averaged to calculate a value for that site. The TSI values indicate mesotrophic to eutrophic conditions. Chl-a, which is generally considered the best indicator, indicates eutrophic conditions. The TSI values are calculated using all available data throughout the year.

Table 12. Trophic status index (TSI) values for Lake Lowell 2002 to 2006.

TSI	BOI 180	BOI 181	BOI 182	BOI 183	BOI 184	BOI 185	All-site Average
Chl-*a*	50	53	55	51	52	48	51
Total Phosphorus	40	41	40	43	46	44	42
Secchi Depth	61	57	58	60	57	60	58

Nitrogen - Phosphorus Ratio

Heavy algal blooms are often associated with increased levels of nutrients (nitrogen and phosphorus). Under normal conditions, phosphorus is scarce in the environment. However, human activities have resulted in excessive loading of phosphorus into many freshwater systems, which results in an imbalance of the natural cycling processes. Excess available phosphorus in freshwater systems can result in accelerated plant growth if other nutrients and other potentially limiting factors are available. The ratio of nitrogen to phosphorus in Lake Lowell is approximately 12:1 (see data in Table 13 and Table 14). Nitrogen to phosphorus ratios above 5-10:1 generally indicate that phosphorus rather than nitrogen limits algal growth (Chapra, 1997). The present conditions in Lake Lowell indicate excess phosphorus is driving algae blooms. If the nitrogen to phosphorus ratio in the reservoir is returned to a normal range, algal blooms and macrophytes will no longer be a nuisance.

Blue-Green Algae Blooms

In addition to algae being an unpleasant nuisance for recreation, blue-green algae (cyanobacteria) can pose a health hazard. Blooms occur in waters with high concentrations of phosphorus and nitrogen. Under certain conditions, this type of algae can release toxins into the water that are harmful to humans, pets, and livestock. These blooms are generally green or blue-green and may form thick mats or floating clumps along shorelines. The blooms typically form in late summer and dissipate in mid to late fall when water temperatures cool. Blue-green algal blooms are often observed in reports on Lake Lowell (IFDG 1965, BOR 1977, BOR 1980, USFWS 2000), with the most recent incident reported on July 17, 2009. The occurrence of blue-green algae prompted the Southwest District Health Department to issue advisories for the reservoir and outlet canals warning recreationists to avoid swimming in areas with algae blooms and restrict pet access to the water.

Some cyanobacteria species are able to fix atmospheric nitrogen and thereby gain a competitive advantage over other species, allowing blue-green algae to reach nuisance levels. Under these conditions nitrogen serves as the limiting nutrient for growth of other types of algae in a phosphorus-rich environment (Hu and Zhang 1993). Repeated blooms of blue-green algae in Lake Lowell indicate that phosphorus is in excess and that nitrogen is limiting growth of other types of algae. Reducing of water column phosphorus concentrations, which results in restoration of the nutrient balance is expected to reduce blue-green algae blooms.

Nutrient – Chlorophyll-a Relationship

From 2002 to 2006, column and bottom water samples were collected from Lake Lowell by DEQ and BOR to determine the concentrations of phosphorus, nitrogen, and chlorophyll-*a* (Table 13 and Table 14). An exhaustive microscopic enumeration of every species present in the water column is prohibitively costly, and so Lake Lowell algal biomass was not analyzed. However, measuring the concentration of chlorophyll-*a* is less technically challenging, less expensive, and provides a reasonable estimate of algal biomass. Raschke (1993) suggested that chlorophyll-*a* should not exceed 10 micrograms per liter (µg/L) to protect primary contact recreation.

The TP concentrations at each sampling site are shown in Table 13. Sample results are separated as being in the water column or within one meter of the bottom. The data show that at times phosphorus may be released from the sediment into the water column since samples collected near the sediment interface had higher concentrations than those collected nearer the surface. An additional reason that epilimnetic samples may have lower TP concentrations is that plankton and macrophytes are processing nutrients in the water column and making them unavailable.

Table 13. Reported Lake Lowell chlorophyll-a, total phosphorus (TP), and orthophosphate data descriptive statistics[1].

Year	Sample Site	Sample Location	Chlorophyll-*a* (µg/L)				TP (mg/L)				Orthophosphate (mg/L)			
			Max	Min	Mean	N	Max	Min	Mean	n	Max	Min	Mean	n
2002	BOI 180	Column			7.1	1			0.078	1			0.004	1
		Bottom							0.077	1			0.003	1
	BOI 181	Column			7.7	1			0.054	1			0.003	1
		Bottom							0.152	1			0.101	1
	BOI 182	Column			12.4	1			0.068	1			*Nd	1
		Bottom							0.058	1			*Nd	1
	BOI 183	Column			8.7	1			0.055	1			*Nd	1
		Bottom				0				0				0
2003	BOI 181	Column	19.1	3.2	10.7	5	0.061	0.027	0.037	8	0.026	0.006	0.013	5
		Bottom				0	0.284	0.045	0.149	3	0.124	0.010	0.062	3
	BOI 183	Column			5.3	1			0.035	1			0.007	1
		Bottom				0			0.048	1			0.009	1
	BOI 185	Column	15.8	2.3	7.8	4	0.041	0.024	0.033	5	0.030	0.006	0.013	4
		Bottom				1			0.046	1			0.010	1
2004	BOI 181	Column	15.0	5.2	9.6	5	0.047	0.014	0.034	9	0.019	0.003	0.011	2
		Bottom			0.0	1	0.073	0.020	0.049	3				0
	BOI 182	Column			8.1	1				0				0
		Bottom				0				0				0
	BOI 185	Column	12	6.3	9.3	4	0.044	0.02	0.034	4				0
		Bottom				0			0.090	1			0.011	1
2005	BOI 180	Column			7.3	1			0.025	1			0.003	1
		Bottom				0			0.028	1			*Nd	1
	BOI 181	Column	68.1	1.8	24.5	9	0.085	0.027	0.047	9	0.013	0.003	0.005	5
		Bottom			1.8	1	0.203	0.030	0.114	3	0.116	0.004	0.053	3
	BOI 182	Column			16.5	1			0.031	1			*Nd	1
		Bottom				0			0.041	1			*Nd	1
	BOI 183	Column			12	1			0.027	1			*Nd	1
		Bottom				0			0.280	1			*Nd	1
	BOI 184	Column			8.8	0			0.029	1			*Nd	1
		Bottom				0			0.035	1			*Nd	1
	BOI 185	Column	8.4	1.9	4.87	7	0.036	0.02	0.029	5	0.014	0	0.007	4
		Bottom			2.84	1			0.090	1			0.028	1
2006	BOI 181	Column	19.3	7.5	13.4	2	0.026	0.021	0.024	2			0.004	1
		Bottom				0				0				0

[1]Summary of all available data. Raw data are available upon request from the project file at the DEQ Boise Regional Office.

* Nd – non-detected

Table 14. Reported Lake Lowell ammonia, Kjeldahl nitrogen, and nitrate/nitrite data descriptive statistics[1].

Year	Sample Site	Sample Location	Ammonia (NH^3)(mg/L)				Kjeldahl N (mg/L)				NO_3/ NO_2 (mg/L)			
			Max	Min	Mean	n	Max	Min	Mean	n	Max	Min	Mean	n
2002	BOI 180	Column			*Nd	1			0.39	1			*Nd	1
		Bottom			*Nd	1			0.39	1			*Nd	1
	BOI 181	Column			0.02	1			0.39	1			0.01	1
		Bottom			0.39	1			0.68	1			0.01	1
	BOI 182	Column			*Nd	1			0.45	1			*Nd	1
		Bottom			*Nd	1			0.44	1			*Nd	1
	BOI 183	Column			*Nd	1			0.36	1			*Nd	1
		Bottom				0				0				0
2003	BOI 181	Column	0.21	0.00	0.07	5	0.56	0.30	0.42	8	0.05	0.01	0.03	4
		Bottom	1.00	0.38	0.69	2	2.20	0.48	1.17	3	0.01	0.01	0.01	3
	BOI 183	Column							0.37	1			0.009	1
		Bottom							0.39	1			0.02	1
	BOI 185	Column	0.02	0.00	0.01	2	0.46	0.29	0.38	5	0	0	0.01	1
		Bottom			0.01	1			0.39	1			*Nd	1
2004	BOI 181	Column			0.01	1	0.52	0.24	0.37	8	0.02	0.01	0.01	5
		Bottom			0.03	1	0.56	0.33	0.45	2				0
	BOI 182	Column				0				0				0
		Bottom				0				0				0
	BOI 185	Column	0.08	0.02	0.05	2	0.52	0.24	0.40	3	0.02	0.01	0.02	3
		Bottom			0.13	1			0.69	1			0.02	1
2005	BOI 180	Column			0.01	1			0.41	1			0.01	1
		Bottom			0.01	1			0.41	1			*Nd	1
	BOI 181	Column	0.15	0.01	0.04	9	1.06	0.33	0.60	9	0.02	0.01	0.02	6
		Bottom	0.41	0.05	0.26	3	0.74	0.39	0.58	3	0.02	0.01	0.02	3
	BOI 182	Column			*Nd	1			0.51	1			*Nd	1
		Bottom			*Nd	1			0.50	1			*Nd	1
	BOI 183	Column			*Nd	1			0.44	1			*Nd	1
		Bottom			*Nd	1			0.47	1			*Nd	1
	BOI 184	Column			*Nd	1			0.44	1			*Nd	1
		Bottom			*Nd	1			0.45	1			*Nd	1
	BOI 185	Column	0.04	0.02	0.03	5	0.5	0.34	0.44	5	0.1	0	0.02	4
		Bottom			0.12	1			0.60	1			0.02	1
2006	BOI 181	Column	0.05	0.01	0.03	2	0.50	0.45	0.48	2	0.04	0.04	0.04	2
		Bottom				0				0				0

[1]Summary statistics of all available data. Raw data are available upon request from the project file at the DEQ Boise Regional Office.

* Nd – not detected in the sample

When phosphorus and chlorophyll-*a* were collected on the same day and time, concentrations were plotted on the same graph to help visualize the relationship (Figure 22). The data show that phosphorus and chlorophyll-*a* concentrations increase during summer and fall months. June, July, and August are peak months for primary contact recreation in Lake Lowell, so nuisance algal growth that interferes with recreation is of particular concern. Previous studies have also acknowledged excess concentrations of chlorophyll-*a* in the reservoir. A 1979 BOR study documented average total phosphorus concentrations in Lake Lowell of 0.07 mg/L and average chlorophyll-*a* concentrations of 29 µg /L. A 1980 BOR study reported that the average chlorophyll-*a* concentration in Lake Lowell in July and August was 65 µg/ L (BOR 1980).

Even though Figure 22 seems to show that chlorophyll-*a* concentrations follow phosphorus concentrations in April, May, June, and August, the number of samples is too small to demonstrate a statistically significant relationship. If the data are plotted against each other, the relationship has an R^2 of only 0.11, indicating that the nutrient-chlorophyll-*a* relationship is more complex than it may first appear. For example, plants store phosphorus in their tissue, making it unavailable for measurement.

When total nitrogen is plotted against chlorophyll-*a* concentrations the relationship is statistically significant with an R^2 of 0.64 (P=0.0002) (Figure 24). This seems to support the concept that nitrogen is limiting the growth of algae, and phosphorus is in excess in this system. If this were true, then decreasing the concentration of phosphorus would eliminate the competitive advantage of blue-green algae (which fix their own nitrogen), and restore a balanced algal community. Reservoir modeling was done in order to evaluate the relationship between total phosphorus concentrations, algal growth (indicated by the chlorophyll-*a* concentration), and DO concentrations; and to help determine appropriate targets to restore beneficial uses (Appendix D).

The recurrence of filamentous and blue-green algae blooms (personal communication Jeff Dillon, Regional Fishery Manager, IDFG; USFWS Deer Flat NWR staff), mesotrophic to eutrophic TSI values, a large nitrogen to phosphorus ratio, and elevated phosphorus and chlorophyll-*a* concentrations indicate nutrient impairment in the reservoir. A total phosphorus TMDL is developed to restore beneficial uses.

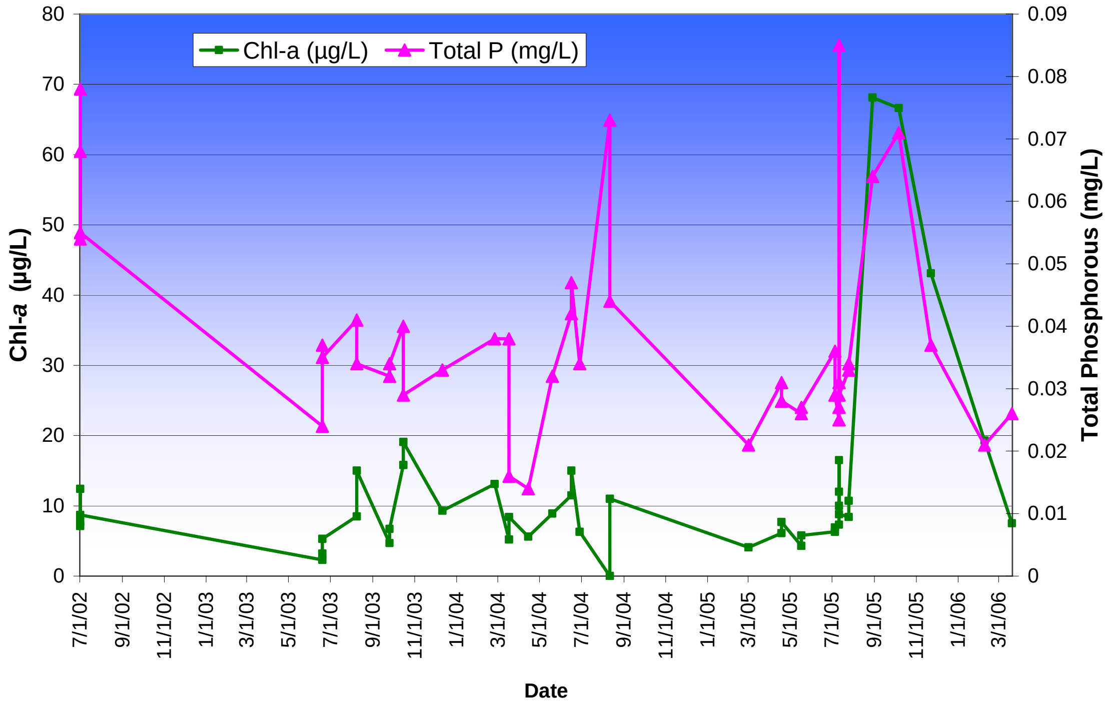


Figure 22. Phosphorus and chlorophyll-*a* data from Lake Lowell 2002-2006

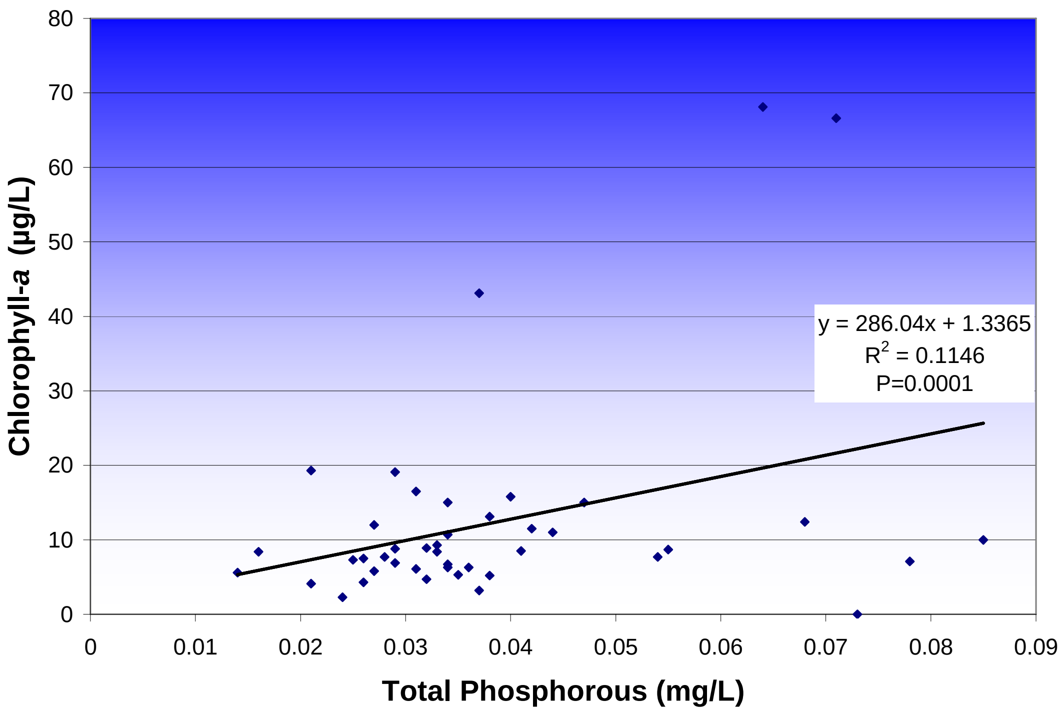


Figure 23. Total phosphorus plotted against chlorophyll-*a* data from Lake Lowell.

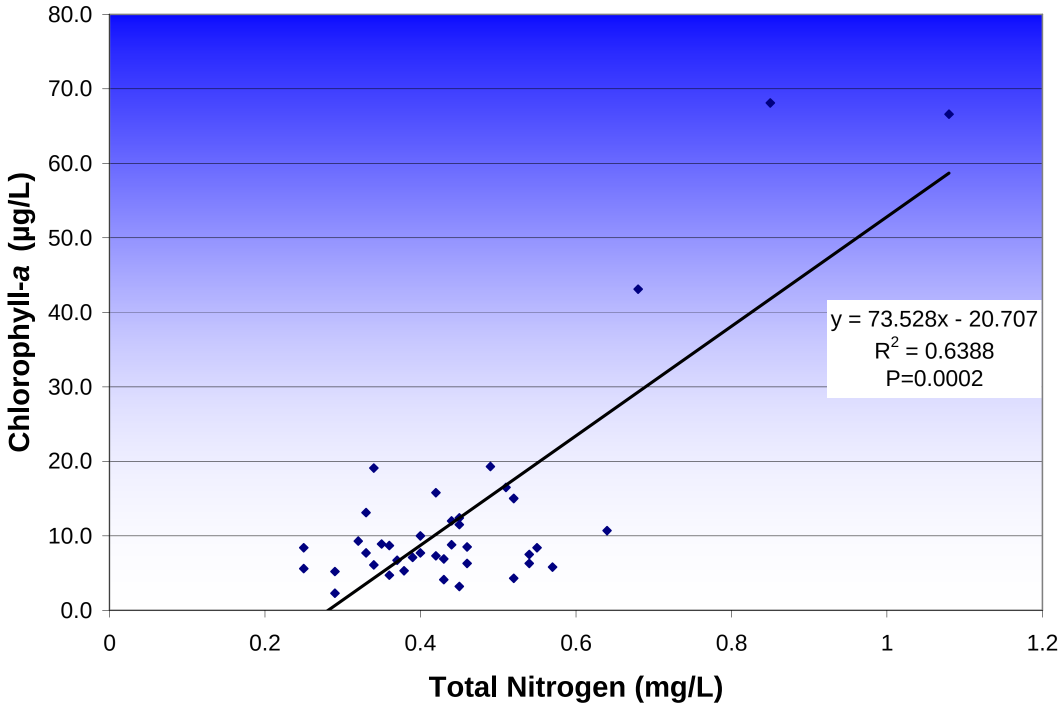


Figure 24. Total nitrogen plotted against chlorophyll-*a* data from Lake Lowell.

Other Water Column Data

In order to identify other potential sources of impairment in Lake Lowell, pH, ammonia, turbidity, and *E. coli* bacteria samples were collected, often contemporaneously with DO and temperature profiles. Samples came from surface, mid-column, and bottom strata of the reservoir.

Measurements of pH were recorded during DO profiles, and ranged from 7.5 to 9.1. With only one WQS criterion exceedance out of 57 measurements, the data indicate pH is not a problem in Lake Lowell.

Ammonia is calculated based on acute and chronic toxicity standards using pH. Many of the ammonia measurements were at or below the method detection limit (Table 15). There is no evidence of a problem with ammonia.

Table 15. Available ammonia and pH data and calculated acute and chronic ammonia maximum values for Lake Lowell.

Date	Site	pH	Temperature °C	Acute Ammonia Criterion	Chronic Ammonia Criterion	Ammonia mg/L	Support WARM[1]
7/1/02	BOI180	8.3	22.9	4.71	0.86	*Nd	Y
7/1/02	BOI180	8.3	22.2	4.71	0.89	*Nd	Y
7/1/02	BOI181	8.4	22.6	3.88	0.73	0.02	Y
7/1/02	BOI181	7.8	16.1	12.14	2.82	0.39	Y
7/1/02	BOI182	8.5	22.6	3.20	0.61	*Nd	Y
7/1/02	BOI182	8.3	21.6	4.71	0.93	*Nd	Y
7/1/02	BOI182	8.4	23.3	3.88	0.70	*Nd	Y
4/18/05	BOI181	8.2		5.73	1.71	0.03	Y
5/17/05	BOI181	8		8.41	2.36	0.02	Y
7/11/05	BOI180	8.5	22.5	3.20	0.62	0.01	Y
7/11/05	BOI180	8.3	21.4	4.71	0.94	0.01	Y
7/11/05	BOI181	8.5	22.2	3.20	0.63	0.02	Y
7/11/05	BOI181	8.2	19	5.73	1.29	0.05	Y
7/11/05	BOI182	8.6	23.4	2.65	0.49	*Nd	Y
7/11/05	BOI182	8.4	22.6	3.88	0.73	*Nd	Y
7/11/05	BOI182	8.5	23.1	3.20	0.59	*Nd	Y
7/11/05	BOI183	8.6	22.8	2.65	0.50	*Nd	Y
7/11/05	BOI184	8.6	23.4	2.65	0.49	*Nd	Y
7/11/05	BOI184	8.2	20.9	5.73	1.15	*Nd	Y
7/25/05	BOI181	7.8		12.14	3.12	0.03	Y
8/29/05	BOI181	7.8	8.7	12.14	3.12	0.03	Y
10/6/05	BOI181	9	14.4	1.32	0.38	0.03	Y
11/22/05	BOI181	9.1		1.14	0.32	0.03	Y
3/20/06	BOI181	7.5		19.89	4.32	0.05	Y

[1] WARM – Warm Water Aquatic Life Beneficial Use
* Nd – Value below method detection limit

The BOR collected 17 turbidity samples, with seven samples collected in July 2002 and 10 collected in July 2005. Turbidity is expressed in nephelometric turbidity units (NTU). The sample values range from 4-14 NTU with an average of 7 NTU. This is well within the turbidity WQS, which specifies that background turbidity shall not be exceeded by more than 50 NTU instantaneously or more than 25 NTU for more than 10 consecutive days.

The BOR also collected seven *E. coli* samples in July 2002, and ten additional samples in July 2005. Single sample results ranged from 2-34 cfu/100ml, with an average count of 13 cfu/100ml. This was far below the most stringent follow-up sampling threshold of 235 cfu/100 ml for public swimming beaches.

Tributary Waterway Data

The Idaho DEQ and BOR collected water quality data, including flow and nutrient concentrations, in 10 tributaries (Table 16). Although constructed waterways are not required to meet WQS, they are sources of pollutants to Lake Lowell. The locations of tributary sampling sites are shown on Figure 25. All sampling locations are approximate; each is at the Lake Shore Drive road crossing at the closest location where sampling was feasible and property access was granted. In addition to the previously described waterways, Garland Drain and Ridenbaugh Canal were sampled. Garland Drain enters New York Canal from the south and Ridenbaugh Canal from the north just upstream of the New York Canal BOI 023 sampling location. They were sampled to determine the load contribution they provide to New York Canal.

The sample results, reported as concentrations of ammonia, nitrate and nitrite, Kjeldahl nitrogen, TP and orthophosphate, are summarized in Table 16. All tributary water quality data sources are listed in Appendix C and raw data are available from the DEQ Boise Regional Office through a public record request. All parameters are included in reservoir modeling for the total phosphorus TMDL. Sample results show that average phosphorus concentrations in most contributing waterways exceed the total phosphorus (TP) target of 0.07 mg/L that was approved for the tributaries to Brownlee Reservoir as part of the load allocations for the Snake River-Hells Canyon TMDL (DEQ, 2004). The data indicate that the 0.07 mg/L TP target is exceeded in some drains by more than an order of magnitude. The average TP concentration in the Ridenbaugh Canal is equal to the target of 0.07 mg/L. The average TP concentration in the New York Canal just upstream from its mouth at Lake Lowell is 0.05 mg/L but exceeds the 0.07 mg/L target in 5 of 23 measurements with a maximum concentration of 0.116 mg/L.

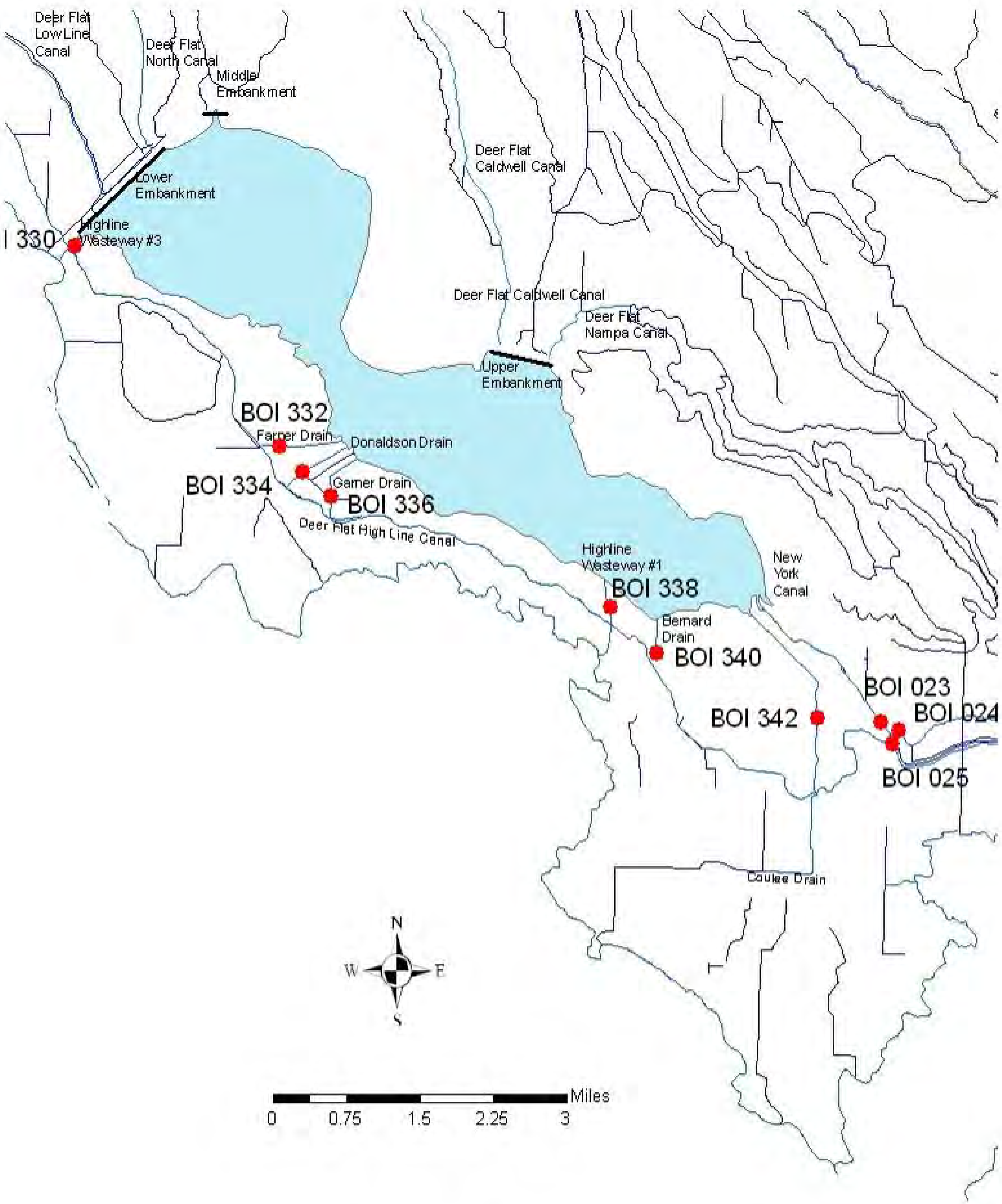


Figure 25. Locations of Lake Lowell tributary canal and drain water quality sampling sites.

Table 16. Descriptive statistics of nutrient data collected by DEQ and BOR at Lake Lowell tributary canals and drains[1].

	BOI 023 New York Canal Lakeshore Drive	BOI 024 Ridenbaugh Canal at Lakeshore Drive	BOI 025 Garland Drain at Lakeshore Drive	BOI 330 Deer Flat Wasteway #3	BOI 332 Farner Drain	BOI 334 Donaldson Drain	BOI 336 Garner Drain	BOI 338 Highline Wasteway #1	BOI 340 Bernard Drain	BOI 342 Coulee Drain
NH^3 – Mean, Std. Dev, Maximum and Minimum (mg/L)										
Mean	0.01	0.01	0.04	0.03	0.27	0.41	0.05	0.01	0.19	0.13
St Dev	0.01	0.01	0.07	0.04	0.45	0.75	0.06	0.01	0.31	0.38
Count (n)	22	8	19	22	20	5	2	17	17	21
Maximum	0.03	0.02	0.30	0.14	1.72	1.75	0.09	0.03	1.14	1.79
Minimum[2]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Kjeldahl N– Mean, Std. Dev, Maximum and Minimum (mg/L)										
Mean	0.22	0.27	0.86	0.44	2.53	2.86	0.86	0.33	2.83	1.58
St Dev	0.07	0.09	1.05	0.31	3.22	2.86	0.14	0.22	2.27	1.80
Count (n)	23	8	19	23	21	6	2	17	18	22
Maximum	0.36	0.44	4.14	1.30	14.10	8.13	0.96	1.10	9.57	8.76
Minimum[2]	0.12	0.17	0.16	0.14	0.18	0.46	0.76	0.16	0.42	0.26
$NO_2 + NO_3$– Mean, Std. Dev, Maximum and Minimum (mg/L)										
Mean	0.12	0.36	0.47	0.18	0.44	0.76	0.19	0.18	1.48	1.24
St Dev	0.05	0.23	0.31	0.18	0.78	1.13	0.21	0.12	1.69	1.20
Count (n)	22	8	19	22	20	5	2	17	17	21
Maximum	0.22	0.69	1.04	0.60	3.38	2.69	0.34	0.49	5.28	4.89
Minimum[2]	0.03	0.05	0.01	0.01	0.01	0.02	0.04	0.03	0.09	0.13

	BOI 023 New York Canal Lakeshore Drive	BOI 024 Ridenbaugh Canal at Lakeshore Drive	BOI 025 Garland Drain at Lakeshore Drive	BOI 330 Deer Flat Wasteway #3	BOI 332 Farner Drain	BOI 334 Donaldson Drain	BOI 336 Garner Drain	BOI 338 Highline Wasteway #1	BOI 340 Bernard Drain	BOI 342 Coulee Drain
TP– Mean, Std. Dev, Maximum and Minimum (mg/L)										
Mean	0.050	0.068	0.315	0.133	0.885	0.702	0.322	0.089	1.075	0.849
St Dev	0.028	0.037	0.346	0.115	0.931	0.485	0.102	0.083	0.788	1.263
Count (n)	23	8	19	23	21	6	2	17	18	22
Maximum	0.116	0.140	1.420	0.410	3.930	1.310	0.394	0.370	2.500	6.300
Minimum[2]	0.018	0.028	0.043	0.019	0.024	0.230	0.250	0.030	0.052	0.041
Orthophosphate– Mean, Std. Dev, Maximum and Minimum (mg/L)										
Mean	0.016	0.022	0.093	0.024	0.088	0.192	0.202	0.014	0.125	0.123
St Dev	0.009	0.011	0.060	0.035	0.100	0.163	0.069	0.008	0.039	0.047
Count (n)	23	8	19	23	21	6	2	17	18	22
Maximum	0.040	0.038	0.232	0.172	0.400	0.480	0.250	0.030	0.200	0.208
Minimum[2]	0.002	0.003	0.011	0.002	0.006	0.023	0.153	0.002	0.046	0.006

[1]Summary statistics of all available data. All tributary water quality data sources are listed in Appendix C and raw data are available from the DEQ Boise Regional Office through a public record request.
[2]Non-detect values were assigned a value of 50% of the minimum detection limit (per communication with BOR and EPA).

In addition to sampling by DEQ and BOR, the Idaho State Department of Agriculture (ISDA) sampled one wasteway and two drains flowing into Lake Lowell (ISDA 2003). Samples were collected twice a month and analyzed for total suspended solids (TSS), total phosphorus (TP), ortho-phosphorus (OP), and nitrate + nitrite (NO_3+NO_2-N). On-site field parameters for DO, conductivity, total dissolved solids, pH, and discharge (flow volume) were measured at the time of sample collection. The first site (DM-1) is located at Highline Wasteway #3 of the Deer Flat Highline Canal that spills irrigation water into Lake Lowell. The two other sites (LS-1 and LS-2) drain agricultural land south of Lake Lowell. All sites were accessed from Lake Shore Drive (Figure 26). The irrigation techniques were noted for the agricultural land in each drainage area.

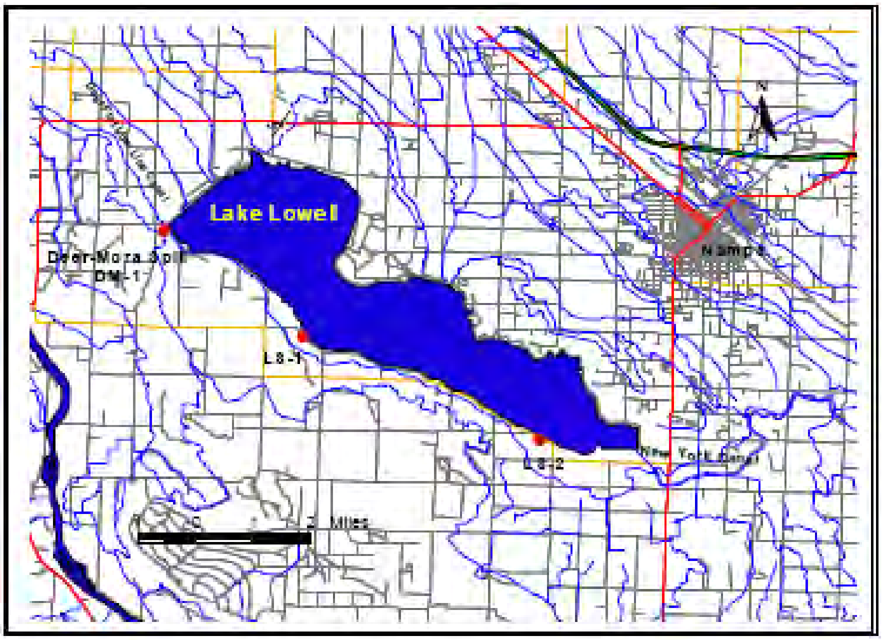


Figure 26. Idaho State Department of Agriculture (ISDA) Lake Lowell monitoring sites.

The calculated load of TP that entered Lake Lowell during the 2002 irrigation season was 10.8 tons. DM-1 (Highline Wasteway #3), LS-1 (Farner Drain) and LS-2 (Bernard Drain) contributed 5, 3.1, and 2.7 tons of TP respectively. Farner and Bernard drain monitoring sites (LS-1 and LS-2) had the highest average TP concentrations but less discharge (Table 17). Total phosphorus concentrations were highest during peak irrigation months (Figure 27).

Table 17. Mean stream flow and total phosphorus concentration at ISDA sample sites.

Parameter	Highline Wasteway #3	Farner Drain	Bernard Drain
Flow (cfs)	64.14	8.40	5.47
TSS (mg/L)	111.50	871.64	816.42
TP (mg/L)	0.18	0.89	1.07

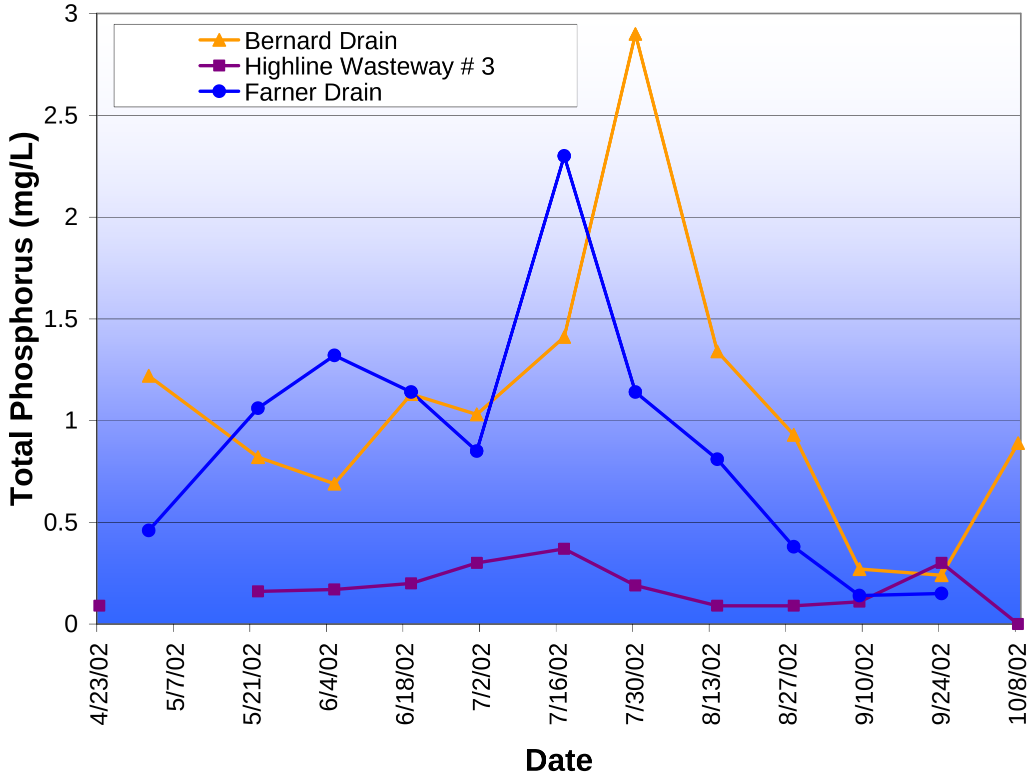


Figure 27. Total phosphorus data collected by ISDA in 2002 in Lake Lowell tributary wasteways and drains[1].

The three drains monitored during the ISDA study indicate heavy loading of sediment into Lake Lowell from agricultural lands. On average, 88% of the phosphorus entering Lake Lowell was in the particulate form, based on TSS analysis. A fourth drain that was identified but not monitored appears (based on color and discharge) to contribute loads similar to those measured at Bernard Drain (LS-2). Sediment load from the drains, entering the south side of Lake Lowell, appears to settle out in the shallow bay areas along the shoreline, where the bulk of macrophyte growth occurs. These excessive loads of sediment and nutrients may lead to eutrophication characterized by increases in phytoplankton biomass, macrophyte biomass, nuisance algae blooms, loss of water clarity, and loss of oxygen in bottom waters.

Mercury Sources and Data

Mercury occurs naturally as a mineral and is distributed throughout the environment by both natural processes and human activities. Inorganic mercury occurs naturally in rocks and soils. It is slowly released through erosion and weathering into surface waters. Mercury was commonly used in dredges and sluice boxes to recover fine gold from Mores Creek in the upper Boise River drainage, and deposited as waste in tailings piles. Industrial emissions and ore roasting associated with gold mining releases mercury into the atmosphere, resulting in mercury deposition far from the source.

Mercury from atmospheric sources reaches surface water through wet (rain) and dry (dust) deposition. Most atmospheric mercury deposition occurs as wet deposition.

Water column mercury concentrations are the result of loading to the water body from air deposition, erosion from the watershed, direct discharges, etc. Most of the mercury in surface waters maintains its natural inorganic state, but some environments (low pH, low dissolved oxygen, and high organic matter, such as those found in the bottoms of lakes and wetlands), favor the conversion of inorganic mercury to a toxic organic form, methylmercury.

Methylmercury bio-concentrates in animal tissue, and so animals at the top of the food chain, such as piscivorous (fish-eating) fish, like bass, contain the highest concentrations of methylmercury. Fish such as crappie, bluegill, and catfish also bio-accumulate mercury, but at a slower rate due to their lower trophic status.

Methylmercury bio-concentrates most strongly between water and phytoplankton—the first step in the food chain, and is preferentially accumulated in later trophic transfer (Mason *et al*, 1995). For this reason fish tissue methylmercury concentrations correlate best with water column mercury concentrations (Sveinsdottir, 2005). Despite all the steps in the bio-accumulation process, there is often a linear relation of fish tissue methylmercury to total mercury loading in a watershed as described in Kelly et al. 1995; Orihel et al. 2006; Harris et al. 2007; and Munthe et al. 2007.

Although some fish may be affected by sediment mercury concentrations, particularly bottom-feeding species that incidentally ingest sediment, fish methylmercury concentrations are generally considered to be the result of mercury concentrations in the water column. When determining attainment of beneficial uses, we make a simplifying presumption that the relation of water total mercury to fish tissue methylmercury is a fixed ratio for a given water body, resulting in a linear response, so that as mercury concentrations in water change, fish tissue methylmercury concentrations will proportionately change (Sveinsdottir, 2005). While the slope of this relation varies among water bodies (Chen 2005; Mason et al. 1995), we expect that if the water mercury concentration doubles, the fish tissue methylmercury concentration will double as well. We also presume water mercury concentrations respond proportionately to loading. This means that if the methylmercury concentration in fish tissue is greater than the criterion, there is too much mercury in the water column and mercury loads to that water body must be reduced proportionately.

Application of Water Quality Standards and Support of Beneficial Uses

Because mercury accumulates in the food chain, diet rather than water is the greater source of mercury toxicity. Until 2001, national water quality criteria developed by EPA and recommended to states under the Clean Water Act (CWA), were for water column concentrations. In 2001, EPA developed, for the first time, a fish-tissue criterion. This groundbreaking step was taken because fish tissue concentrations more directly measure human health risk from exposure to mercury. In addition, analysis of methylmercury in fish tissue overcame technical challenges for detecting and reporting low levels of mercury typical in water, and high variability in bioaccumulation. These analytical challenges had previously made it difficult to associate any given mercury concentration in water with adverse human health effects.

In April 2005, Idaho adopted EPA's recommended consumption-based fish tissue methylmercury criterion to protect the health of individuals that eat fish from Idaho surface waters (IDAPA 58.0102.210). This methylmercury criterion of 0.3 milligrams per kilogram (mg/kg) of fresh weight fish is intended to protect an adult who eats on average of 17.5 grams of fish per day—about one 8-ounce meal every other week (EPA 2001).

Prior to adopting the methylmercury criterion, Idaho relied on total mercury concentration of <12 ng/L in the water column. Accurate analysis of mercury in water column samples is problematic, due to multiple pathways for sample contamination, and so measurement of mercury in fish tissue is a good alternative to water column analysis. Fish tissue analysis also integrates variations in mercury loading over time and is more directly related to human health risk.

A statewide mercury assessment in 2007 provided evidence that even when the previous (before April 2005) WQS of 12 ng/L water column total mercury concentration criteria is met, the reported concentration in fish tissue may exceed the 0.3 mg/kg methylmercury fish tissue criteria (Essig and Kosterman 2008). In addition, in the Salmon Falls Creek Subbasin Assessment and TMDL (DEQ 2007), water column mercury concentrations did not correlate with high methylmercury concentrations in fish tissue or exceed Idaho's previous WQS. Reported water column concentrations were 1.04 to 10.6 ng/L, and the weighted average fish tissue methylmercury concentration was 0.779 mg/kg, which exceeds the present WQS criterion of 0.3 mg/kg fish tissue methylmercury. This data supports the consideration that fish tissue concentration of methylmercury is a more sensitive measure to determine beneficial use support than water column concentrations.

Lake Lowell is designated to support beneficial uses of warm water aquatic life (WARM) and is designated a special resource water (SRW) because it is a National Wildlife Refuge that provides important habitat for migratory waterfowl and other wildlife. Below are the WQS related to mercury in surface water bodies:

200. GENERAL SURFACE WATER QUALITY CRITERIA
The following general water quality criteria apply to all surface waters of the state, in addition to the water quality criteria set forth for specifically designated waters.

02. Toxic Substances. Surface waters of the state shall be free from toxic substances in concentrations that impair designated beneficial uses.

210.NUMERIC CRITERIA FOR TOXIC SUBSTANCES FOR WATERS DESIGNATED FOR AQUATIC LIFE, RECREATION, OR DOMESTIC WATER SUPPLY USE.
01. Criteria for Toxic Substances. The criteria of Section 210 apply to surface waters of the state as follows. (5-3-03)

> **a.** Columns B1, B2, and C2 of the following table apply to waters designated for aquatic life use. (5-3-03)
> **b.** Column C2 of the following table applies to waters designated for recreation use. (5-3-03)

c. Column C1 of the following table applies to waters designated for domestic water supply use.

Table 18. Excerpt from toxic substances table in IDAPA 58.01.02.

Compound	[a]CMC (µg/L) B1	[a]CCC (µg/L) B2	Water & Organisms (µg/L) C1	Organisms Only (µg/L) C2
Mercury	[b]	[b]		
Methylmercury				0.3 mg/kg [c]

a. See definitions of Acute Criteria (CMC) and Chronic Criteria (CCC), Section 010 of the WQS.
b. No aquatic life criterion is adopted for inorganic mercury. However, the narrative criteria for toxics in Section 200 of these rules applies. The Department believes application of the human health criterion for methylmercury will be protective of aquatic life in most situations.
c. This fish tissue residue criterion (TRC) for methylmercury is based on a human health reference dose (RfD) of 0.0001 mg/kg body weight-day; a relative source contribution (RSC) estimated to be 27% of the RfD; a human body weight (BW) of 70 kg (for adults); and a total fish consumption rate of 0.0175 kg/day for the general population, summed from trophic level (TL) breakdown of TL2 = 0.0038 kg fish/day + TL3 = 0.0080 kg fish/day + TL4 = 0.0057 kg fish/day. This is a criterion that is protective of the general population. A site-specific criterion or a criterion for a particular subpopulation may be calculated by using local or regional data, rather than the above default values, in the formula: TRC = [BW x {RfD – (RSC x RfD)}] / TL. In waters inhabited by species listed as threatened or endangered under the Endangered Species Act or designated as their critical habitat, the Department will apply the human health fish tissue residue criterion for methylmercury to the highest trophic level available for sampling and analysis.

Fish Tissue Analysis

In 1998, fish samples were collected by the U.S. Fish and Wildlife Service (USFWS) and the BOR for analysis to evaluate water quality conditions in Lake Lowell at Deer Flat National Wildlife Refuge. The study identified that mercury concentrations in fish tissue obtained from Lake Lowell had a trophic level average of 0.165 mg/kg. While the WQS of 0.3mg/kg is protective of public health for the general population, the Idaho Department of Health and Welfare posted a fish consumption advisory warning for the lake for bluegill, bass, carp and suckers. The advisory warning is not a determination that designated beneficial uses are not supported, but rather, is intended to help sensitive individuals (children and pregnant or nursing women) to avoid adverse effects.

Figure 28. Current Lake Lowell fish consumption advisory.

In October 2006, DEQ collected fish from Lake Lowell for fish tissue methylmercury analysis. The goal was to determine the mean methylmercury fish tissue concentration across fish trophic levels in the reservoir. The data were used to determine whether methylmercury concentrations exceed WQS in Lake Lowell. For a detailed description of the monitoring protocol and results please see the *Lake Lowell Mercury Assessment Fish Tissue Study Quality Assurance Project Plan* (Monnot 2006) or *Lake Lowell Mercury Assessment Fish Tissue Study Results and Field Summary* (Monnot 2007).

The Idaho Fish Consumption Advisory Program (IFCAP) developed a protocol to streamline sample procedures for determining fish tissue mercury concentrations for public health advisories (IFCAP 2004). This protocol included specification of fish sizes, sample processing techniques and sample analysis. An important variable for interpreting fish tissue mercury results is fish size. Larger fish are older and have had more time to accumulate mercury stores in their tissue. Therefore the most conservative approach is to target the largest size class of fish in each population. Fish sizes were not documented in the 1998 monitoring event, and the samples were from individual fish rather than multiple-fish composites. For fish collected in 2006 fish length was recorded and composite samples were analyzed (Table 19).

Idaho's WQS for mercury is a consumption-based, trophic-level-weighted average for each water body (DEQ 2005). This average is expected to reflect species that are normally consumed, and is weighted by trophic level. Since creel data were not available to determine fish consumption coefficients, Idaho uses EPA's current national default consumption rate of 17.5 g/day, broken down to 3.8 g/day from trophic level 2, 8 g/day from trophic level 3 and 5.7 g/day from trophic level 4. Appropriate target species and associated trophic levels for Lake Lowell were determined through consultation with the Idaho Department of Fish and Game (IDFG) Southwest Regional Fisheries Manager. Largemouth bass are considered trophic level 4 fishes, bluegill and catfish are considered trophic level 3 fishes, and largescale suckers and carp are considered trophic level 2 fishes.

For calculation of the trophic-level-weighted average for Lake Lowell, duplicate and original samples were averaged, averages were calculated for each trophic level and then the following equation was used to calculate the overall Lake average:

$$C_{avg} = \frac{((IR2*C2) + (IR3*C3) + (IR4*C4))}{IR2 + IR3 + IR4}$$

Where:

C_{avg} = Average Fish Tissue Concentration (mg/kg)
C2 – carp and largescale sucker
C3 – bluegill and catfish
C4 – smallmouth and largemouth bass

IR = Consumption Value for Trophic Level (mg/kg)
IR2 (carp and largescale sucker) – 3.8 g/day
IR3 (bluegill and catfish) – 8.0 g/day
IR4 (smallmouth and largemouth bass) – 5.7 g/day

All fish tissue samples were analyzed for total mercury concentration. As a conservative measure, all mercury in the sample is assumed to be methylmercury. The trophic-level-weighted average concentration of mercury for fish sampled in 2006 is 0.241 mg/kg, which is 0.059 mg/kg less than the WQS of 0.3 mg/kg (Table 20). Sucker and carp are used in Lake Lowell trophic level weighted averages as a conservative measure, because the average fish tissue mercury concentration is relatively high in comparison to bass and bluegill tissue concentrations.

In 2007, DEQ developed a monitoring plan to identify and quantify methylmercury concentrations in fish in Idaho surface waters. Lake Lowell was included in this monitoring plan and fish samples were collected for analysis (Essig and Kosterman, 2008). The calculated trophic-level-weighted average of mercury from fish collected in 2007 is 0.277 mg/kg, which is 0.023 mg/kg below the WQS. Analyses for both DEQ fish tissue sampling events were conducted by Brooks Rand LLC in Seattle, Washington. Two separate data collection events document that the WQS for mercury is not exceeded, and so a TMDL is not required.

Table 19. Mean mercury concentrations and fish lengths from Lake Lowell fish tissue samples.

	1998		2006		2007	
Species	**Total Mercury (mg/kg)**	**Standard Deviation**	**Total Mercury (mg/kg)**	**Standard Deviation**	**Total Mercury (mg/kg)**	**Standard Deviation**
Largemouth Bass	0.104	0.040	0.197	0.011	0.382	
Length (mm)	n.a.		312	39	348	29
n	7 fish fillets		Two 10-fish composite samples		One 10-fish composite sample	
Smallmouth Bass	0.242					
Length (mm)	n.a.					
n	11 fish fillets					
Bullhead			0.401			
Length (mm)			357	42		
n			3 fish – part of combined 10-fish composite sample with 7 catfish			
Catfish			0.401		0.202	
Length (mm)			714	66	475	91
n			7 fish – part of combined 10-fish composite sample with 3 bullheads		One 10-fish composite sample	
Bluegill	0.076	0.008	0.143	0.032	-	-
Length (mm)	n.a.		168	25		
n	2 fish fillets		Two 10-fish composite samples			
Carp	0.267	0.054				
Length (mm)	n.a.					
n						
Largescale Sucker	0.389	0.158	0.330	0.103		
Length (mm)	n.a.		539	22		
n	4 fish fillets		Two 10-fish composite samples			

n.a. – not available

Table 20. Lake Lowell mercury fish tissue concentrations and trophic-level-weighted averages for 1998, 2006, and 2007 samples.

Trophic Level Average		Consumption weighting Factor (g/day)	Product of Weighting Factor (8.0 g/day) and Concentration	Weighted Average Concentration (mg/kg)
	Concentration (mg/kg)			
1999				
1998				
Trophic level 2	0.316	3.8	1.2008	
Trophic level 3	0.076	8.0	0.6080	
Trophic level 4	0.188	5.7	1.0716	
		17.5	2.8804	0.165
2006				
Trophic level 2	0.330	3.8	1.2540	
Trophic level 3	0.229	8.0	1.8346	
Trophic level 4	0.197	5.7	1.1229	
		17.5	4.2115	0.241
2007				
Trophic level 3	0.202	8.0	1.6160	
Trophic level 4	0.382-	5.7	2.1774	
		13.7	3.7934	0.277

Water Column Concentration

Water samples were collected in Lake Lowell and select tributary waterways in 1998 by USFWS and in 1999, 2002, and 2005 by BOR to determine total water column mercury concentration (Figure 29, Table 21). The samples collected in 1998 were part of a contaminant study which was published by the USFWS in 1998. All samples were analyzed by the BOR water quality laboratory in Boise. Reported concentrations are between 0.22 and 0.40 µg/L on one sample date in 1998. However, unreliable collection methods were used, and samples collected in 2002 and 2005 (using a more reliable method) indicated concentrations below the detection limit of 0.2 µg/L (Table 21).

Air Data Collection

A wet deposition monitor was installed near Lake Lowell in 2008 to develop a long term record of mercury deposition from precipitation in order to evaluate spatial and seasonal trends. There are not yet enough data to draw conclusions about mercury loads, trends, or specific sources of air deposition.

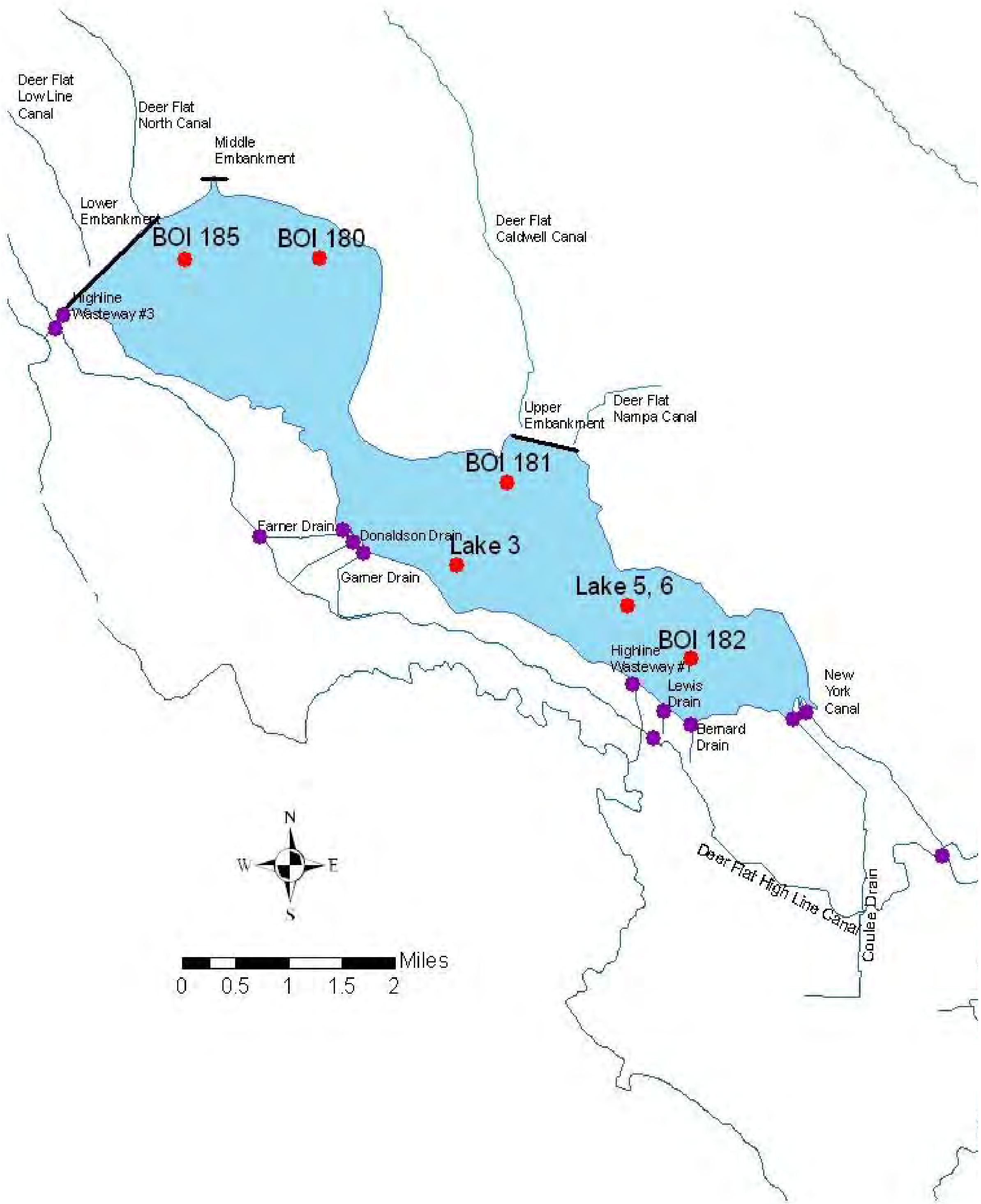


Figure 29. Lake Lowell water column total mercury concentration sample collection sites.

Table 21. Total mercury water column concentrations (µg/L) in Lake Lowell and tributary waterways.

Site	Site Description	Depth[a]	8/10/98	9/2/98	5/17/99	8/1799	7/1/02	7/11/05
BOI 180	Lake Lowell 1.5 M E Boat Ramp	Surface	ND	ND				ND
		Bottom						ND
BO I181	Lake Lowell NR Upper Embankment	Surface	0.37[b]	ND				ND
		Bottom						ND
BOI 182	Lake Lowell Southeast End	Surface	0.26 [b]					ND
		Bottom						ND
BOI 183	Lake Lowell across from Upper Embankment	Surface						ND
		Bottom						ND
BOI 184	Lake Lowell 1M SE Gage Station LL Canal	Surface						ND
		Bottom						ND
BOI 185	Lake Lowell NR Lower Embankment	Surface	0.30 [b]	ND				
Lake 3	Lake Lowell near Gott's Point	Surface	0.30 [b]	ND				
Lake 5	Lake Lowell near Garner Drain	Surface	0.40 [b]	ND				
Lake 6	Lake 5 duplicate	Surface	0.22 [b]	ND				
BOI 023	New York Canal Lake Shore Drive		0.26 [b]	ND			ND	
BOI 330	Deer Fat Wasteway #3		ND	ND				
BOI 332	Farner Drain		ND	ND				
BOI 334	Donaldson Drain		ND	ND				
BOI 336	Garner Drain		ND	ND				
BOI 338	Highline Wasteway #1		ND	ND				
BOI 340	Bernard Drain		ND	ND				
BOI 342	Coulee Drain		ND	ND				
Lewis Drain			ND	ND				
BOI 600	Highline C NR W End Lake Lowell				ND	ND		
BOI 620	Highline Canal at Diversion				ND	ND		
BOI 622	Highline Canal at Rim Road				ND	ND		
BOI 624	Highline Canal @ Farner Road				ND	ND		

[a]Sample depth is noted as either surface or bottom sample, where known.
[b] Based on the published data collection protocols, the reported results have no known range of accuracy.
ND = Not detected in sample. Method detection limit is 0.2 µg/L.

Mercury Hazards to Wildlife

Wildlife exposed to excessive mercury in their diet may experience reproductive failure, immune system impairment, behavioral modifications, motor dysfunction, or lethal toxicity.

Species in upper trophic levels that feed on fish or on other animals that feed on fish are most at risk for contamination. Since mercury is bio-concentrated, piscivorous birds like grebes, herons, and bald eagles may experience mercury poisoning, even when lower trophic levels are unaffected. Prompted by the presence of elevated mercury concentrations in fish tissue, the USFWS developed a study to determine whether there was a risk to piscivorous birds.

Reported mercury concentrations in individual whole-body fish tissue samples from Lake Lowell are below threshold concentrations recommended by Eisler (1987) for the protection of piscivorous species (USFWS 2005). Western grebe (*Aechmophorous occidentalis*) and great blue heron (*Ardea herodius*) eggs and bald eagle (*Haliaeetus leucocephalis*) feathers were collected to determine mercury concentrations. Mean mercury concentrations in grebe and heron eggs (0.12 and 0.23 µg/g fresh wet weight, respectively) are below concentrations known to affect water bird populations nesting at the refuge (USFWS 2005). The USFWS concluded that although mercury concentrations may be at concentrations that could adversely affect individual birds; mean mercury concentrations are below levels known to adversely affect nesting water bird populations. Concentrations in shed bald eagle feathers (10.2-32.7 µg/g dry weight) suggest that mercury may be bio-accumulating; however, uncertainty associated with interpreting this type of data means that the results are inconclusive (USFWS 2005, and personal Communication with the author Susan Burch, USFWS).

Based on reported fish tissue mercury concentrations that are below the WQS, the absence of detectable total mercury in the water column, and no known adverse effects on wildlife populations, 303(d)-listing for mercury is not warranted at this time.

Summary of Status of Beneficial Uses

Lake Lowell is currently on the §303(d) list for nutrient enrichment and low dissolved oxygen. Hydrologic regime and water quality data show evidence of oxygen depletion and nutrient enrichment which indicate that warm water aquatic life and primary contact recreation beneficial uses are not fully supported (Table 22). DEQ has developed a total phosphorus TMDL for Lake Lowell and so will list the water body in Section 4a of the next Integrated Report.

Table 22. Summary of beneficial use support determinations for Lake Lowell.

Beneficial Use	Support Determination	Basis for Determination
Warm Water Aquatic Life	Not Fully Supporting	DO[1] levels below WQS[2]
Aesthetics	Not Fully Supporting	Nuisance algae blooms
Primary Contact Recreation	Not Fully Supporting	Blue-green algae blooms
Special Resource Water	Not Fully Supporting	DO[1] WQS[2] violations Nuisance algae blooms

[1] DO – dissolved oxygen

[2] WQS – water quality standards

2.5 Data Gaps

This section of the report describes gaps in data for the subbasin.

- The best available data were used to determine beneficial use support status and develop the SBA and TMDL. However, DEQ acknowledges that additional data would be helpful and may increase the accuracy of the analyses. The relationship between nutrients, chlorophyll-*a*, and DO in the reservoir is extremely complex. It would be helpful to collect data for all three parameters at specified sample locations and depth intervals to enhance nutrient dynamic analysis. Little is known about the internal cycling from nutrients released from reservoir sediment. In addition, regular monitoring intervals and additional sites for tributary waterways, including discharge (flow volume) and nutrient concentration information, would help to develop more reliable load estimates. Fish tissue samples were collected by different management agencies for mercury analysis. Some of the samples were collected using unknown or disparate monitoring and processing plans. In order to compare future data, standardized plans would be helpful. DEQ, IDFG, and the IDHW have worked to develop such a plan. Routine monitoring of fish tissue methylmercury concentrations should be continued to monitor trends. It would also be beneficial to have air deposition, water column, and highest trophic level wildlife species mercury concentration data to support fish tissue analysis.
- The USFWS recommends additional sampling of reproductive success and mercury concentrations in bald eagles, and continued monitoring of other piscivorous water birds to reduce present uncertainty and monitor trends in mercury and other chemical contaminant concentrations.

3. Subbasin Assessment–Pollutant Source Inventory

This section addresses pollutant sources in the watershed, whether actually identified or potential, that may contribute to water quality impairments that prevent attainment of beneficial uses. This section provides an inventory of both point and nonpoint pollutant sources.

3.1 Sources of Pollutants of Concern

This section identifies all known pollutant sources that contribute to the impairment being addressed by the TMDL. Nutrients, both nitrogen and phosphorus, are the focus because of their impact on algal and macrophyte growths within the reservoir. As nutrient concentrations increase, algal growths are stimulated beyond levels that allow beneficial use support. Nighttime respiration and algal or macrophyte decomposition result in increased oxygen demand, which causes DO levels to drop below WQS.

Lake Lowell is a managed reservoir system that was constructed nearly 100 years ago. The sources of pollutants of concern in the reservoir are shown in Figure 30. This conceptual model represents a loading framework for nutrients into the reservoir, and also accounts for internal reservoir nutrient cycling.

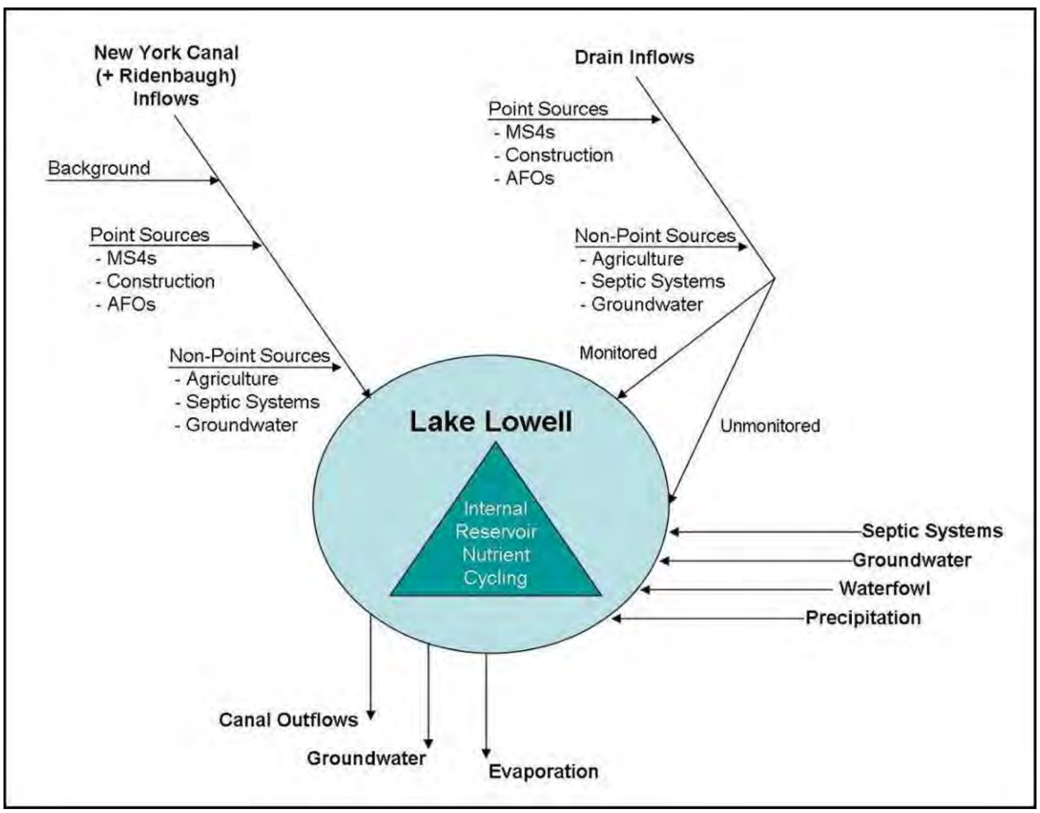


Figure 30. Lake Lowell conceptual nutrient model.

Point Sources

A point source of pollutants is characterized by having a discrete conveyance to surface water, such as a pipe, ditch, or other identified point of discharge into a receiving water body. Stormwater is a point source of phosphorus that is governed by NPDES regulation. EPA issues general NPDES permits for Municipal Separate Storm Sewer Systems (MS4s). NPDES permits have also been submitted for animal feeding operations (AFOs) and construction sites. There are currently no wastewater discharges (regulated by NPDES individual permits) that drain to the Lake Lowell watershed; this could change as urban areas expand south toward the reservoir (this issue is discussed further as it relates to septic system loads).

Stormwater Runoff

The major flow contributors to Lake Lowell (the New York Canal and Ridenbaugh Canal) flow through densely populated urban areas and irrigated agricultural land. For this reason, stormwater runoff from urban homes, streets, commercial sites, construction areas are considered sources of nutrient enrichment. Boundaries for lands that contribute stormwater flow to New York Canal and Ridenbaugh Canal are estimated using GIS by overlaying a polygon around the reservoir and drainage areas for each canal and also including a buffer along the reservoir and canals. Acres of commercial, residential, and transportation land uses inside the polygon are considered to be contributing stormwater to conveyances feeding Lake Lowell (Figure 32).

Although there are 29,792 urban acres identified within these polygons, almost all the stormwater acres (97.5%) are within the New York Canal/Ridenbaugh Canal drainage areas. Of these 29,067 acres, the Ada County Highway District (ACHD) estimates that stormwater from only 5,900 acres within Ada County actually reach either the New York Canal or the Ridenbaugh Canal (ACHD, unpublished data, 2010). Within the Lake Lowell drainage area (defined by the fifth field HUC), urban stormwater from Canyon County is accounted for within 724 acres determined through the GIS analysis.

AFOs and Construction Site NPDES Permits

Within the watershed, there are 11 applications for individual NPDES discharge permits for AFOs. However, none of these permits have current discharge limits since these facilities have less than the maximum number of livestock animals to require an individual NPDES permit. Under the general permit, these facilities are required to have nutrient management plans and no stormwater discharge offsite. Seven construction NPDES permits are on file for the watershed, but they are all expired and discharge is not anticipated. Construction sites are required to keep stormwater on site. Figure 31 shows the site locations of AFOs and construction NPDES permit sites and Table 23 lists the details of each facility.

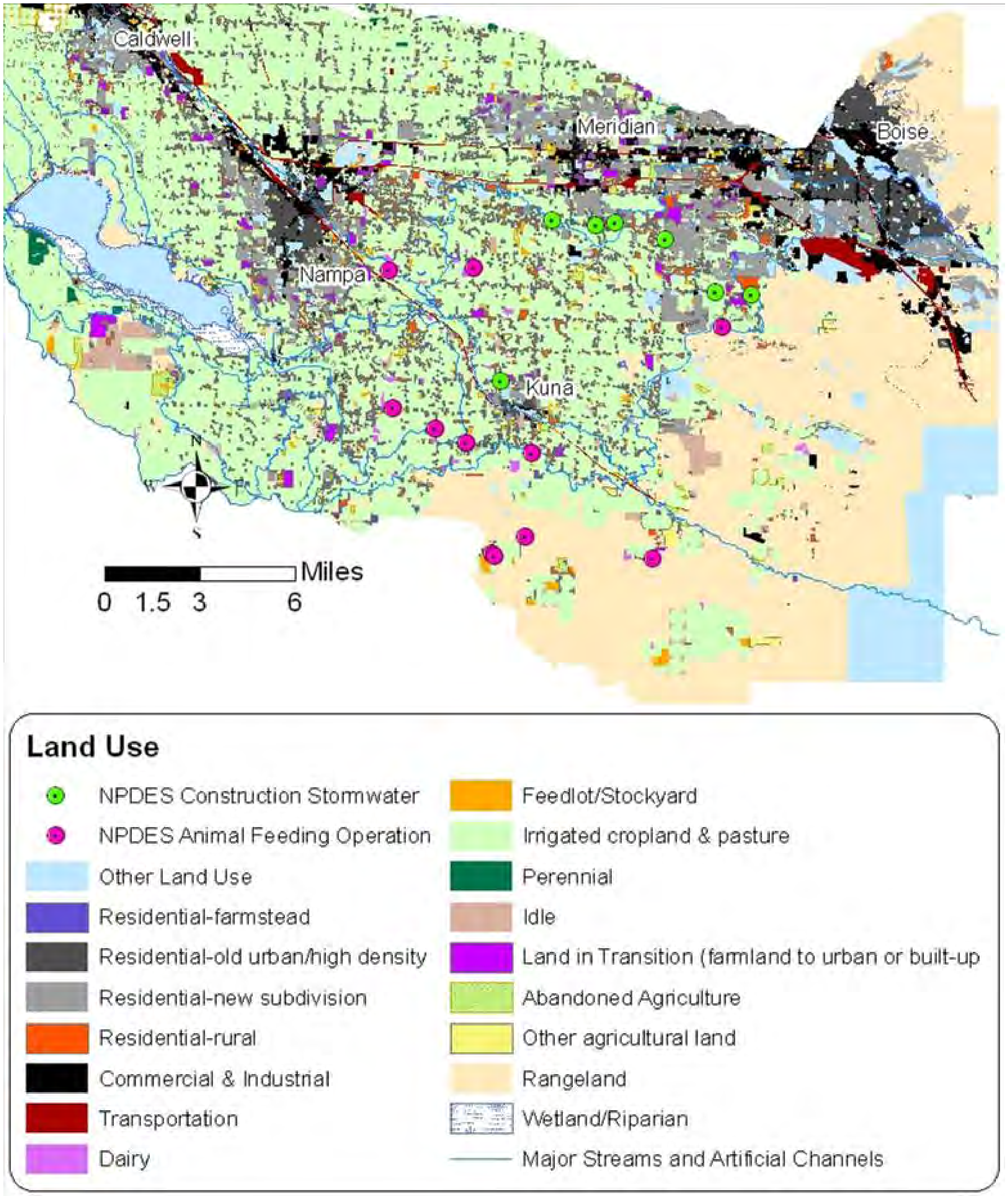


Figure 31. NPDES-permitted point sources in the Lake Lowell watershed.

Table 23. NPDES point source discharge permits in the Lake Lowell watershed.

Latitude	Longitude	Facility	Receiving Water	Permit #
Animal Feeding Operations				
Ada County				
Latitude	**Longitude**	**Facility**	**Receiving Water**	**Permit #**
43.47	-116.45	MORFORD FARMS	Undisclosed	IDU000201
43.55	-116.45	DAN VAN GROUW DAIRY	Kuna Canal	IDG010097
43.42	-116.33	ED VAN GROUW DAIRY	Undisclosed	IDG010098
43.42	-116.44	DOUBLE OO DAIRY	Undisclosed	IDG010101
43.43	-116.42	FRIESIAN VALLEY DAIRY	Undisclosed	IDG010081
43.53	-116.30	MURGOITIO DAIRY	New York Canal	IDG010138
43.47	-116.41	VANDER STELT DAIRY	Mora Canal	IDG010095
43.42	-116.43	SILVER BUTTE HOLSTEINS INC	Undisclosed	IDG010130
Canyon County				
Latitude	**Longitude**	**Facility**	**Receiving Water**	**Permit #**
43.55	-116.51	SHULERLANE FARMS INC	Indian Creek	IDG010093
43.48	-116.47	DAIRY #1 AND DAIRY #2	Undisclosed	IDG010092
43.49	-116.50	STEVE BOSCHMA DAIRY	Undisclosed	IDG010135
Construction Permits (All Facilities are in Ada County)				
Latitude	**Longitude**	**Facility**	**Receiving Water**	**Permit #**
43.55	-116.30	CHARTER POINTE LLC	Undisclosed	IDR10AG56
43.50	-116.43	CRIMSON POINT 3 (QUILCEDA)	Undisclosed	IDR10AL54
43.57	-116.33	FOREST GLEN SUBDIVISON #1	Undisclosed	IDR10AA02
43.58	-116.40	BEAR CREEK DEVELOPMENT	Ridenbaugh Canal	IDU000117
43.58	-116.38	TUSCANY VILLAGE DEVELOPMENT	Tenmile Creek	IDU000126
43.58	-116.36	SODA SPRINGS SUBDIVISION	Undisclosed	IDR10AD14
43.58	-116.38	TUSCANY VILLAGE DEVELOPMENT	Tenmile Creek	IDU000153

Nonpoint Sources

Pollution from nonpoint sources is generated from a geographical area where pollutants are dissolved or suspended in overland flow and then delivered to surface water. Various potential sources of nonpoint pollution exist within the Lake Lowell watershed. These include nutrient loadings from animal wastes and chemical fertilizers applied to agricultural land, septic systems, ground water inflows and nutrient loading from waterfowl. Cycling of phosphorus within the reservoir is also a potential source of phosphorus.

The canal and drain phosphorus loads are related to land use activities that occur in the watershed and include agricultural and residential activities. See Figure 32 and Figure 12 for associated land use types and land ownership. The land use is assumed to contribute to the conveyance system waterways because all runoff over the landscape goes to this system.

Agricultural Discharges

Land use in the watershed is dominated by irrigated crops and pasture. While the locations of agricultural diversions and drains can be identified as specific points on the landscape, the CWA designates these as nonpoint sources due to the impact that widespread land use activities have on the water channeled through these systems. The data from a 2003 ISDA study indicate that agricultural acres currently under furrow or flood irrigation practices, rather than sprinkler, contribute the largest concentration of sediment, phosphorus, and nitrogen.

Nutrients from agricultural lands are transported primarily during the irrigation season while agricultural canals and drains are flowing. The majority of the precipitation in the basin is received during the non-irrigation season. Precipitation events can transport nutrient-laden sediment to the dry ditches or canals. The nutrients will be mobilized in spring when water is returned to the irrigation system, causing a large pulse of available nutrients.

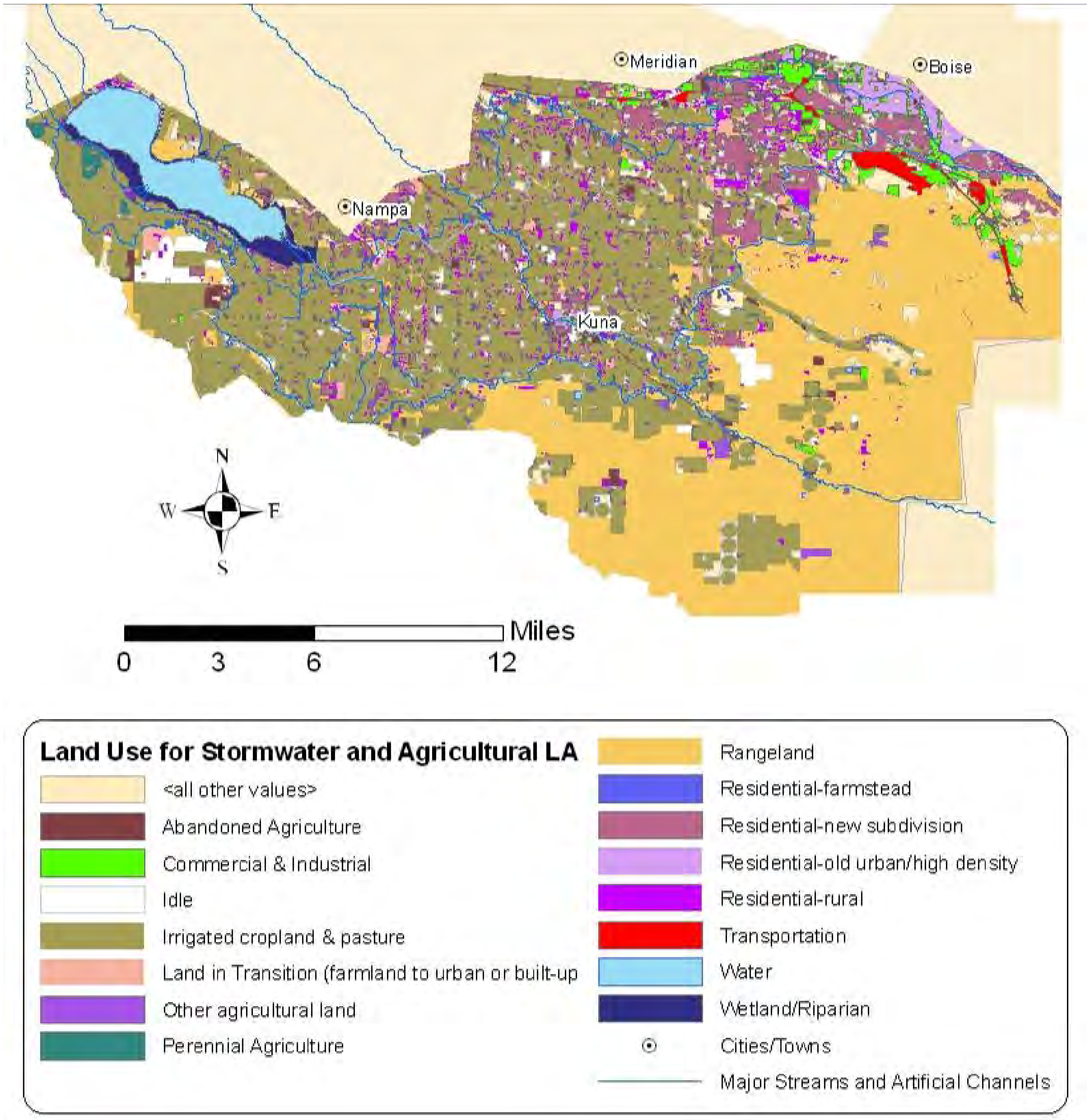


Figure 32. Land uses that contribute stormwater and nonpoint source phosphorus loads to Lake Lowell.

Boundaries for land acres that contribute agricultural runoff flow directly to Lake Lowell and New York and Ridenbaugh canals are estimated using GIS by overlaying a polygon around the reservoir and each canal and also including a buffer along the reservoir and canals (Figure 32). Approximately 87,500 of the acres that drain to Lake Lowell are irrigated cropland. These acres are located along the water conveyance system and contribute nonpoint loading of phosphorus. Within the watershed, TP is delivered from irrigated cropland and animal-related phosphorus sources. Water is delivered to the agricultural land (18,099 acres) directly surrounding and to the south of Lake Lowell primarily through Mora and Highline Canals and return water is transported to lake Lowell by drains and wasteways. Total phosphorus concentrations have been collected from six drains and two wasteways that drain along the south shore of Lake Lowell. Phosphorus data for these sites can be found in Appendix E. Numerous additional drains were observed along the shores of Lake Lowell. To locate all additional drains that may contribute phosphorus to Lake Lowell, satellite images were reviewed and all constructed and maintained channels that appeared to contribute flow to the reservoir were marked (Figure 33). Twenty-four channels that appear to be human-created are observed based on visual drainage patterns. Although some of these sites may represent a combination of runoff that is captured and routed to monitored drains via Lakeshore Drive road ditches, 24 unmonitored drains were included in the analysis to be conservative. Currently monitored sites are marked on the figure with blue points and unmonitored sites are marked with alphabetically labeled red markers. Because flow measurements from any individual drain, including the smaller drains, are limited, aerial photography was used to estimate the number of acres that contributes loads to these unmonitored drains. This information is provided in Appendix F. The loading rate from the monitored drains (on a per-acre basis) is used to assess the load from unmonitored drainage areas.

Figure 33. Satellite image of unmeasured drainage channels (red markers) contributing flow to Lake Lowell.

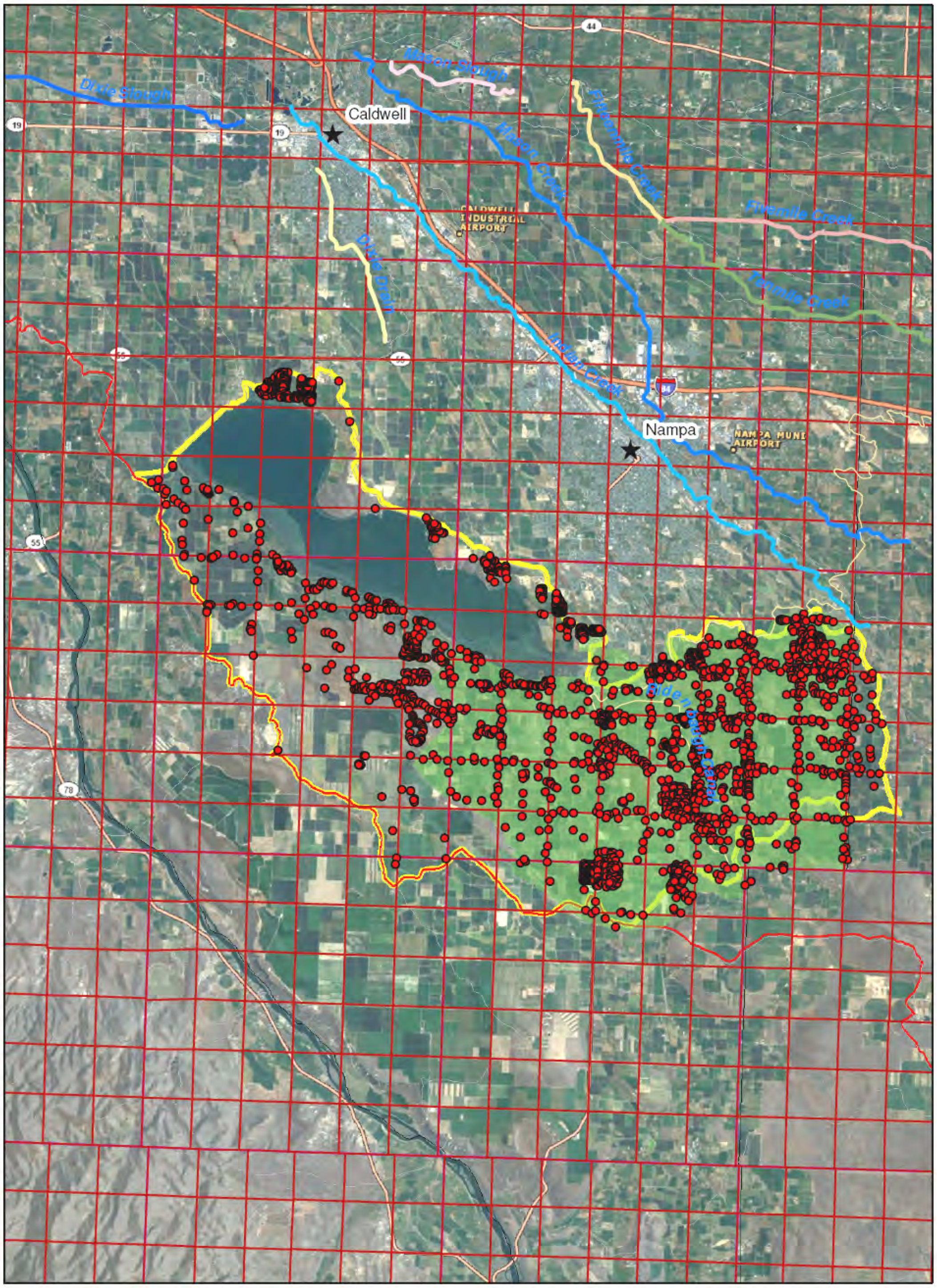
Direct measurement of total phosphorus loading data from agricultural lands (69,401 acres) that contribute agricultural runoff to New York and Ridenbaugh canals does not exist. Current TP loading from agricultural lands was therefore estimated using flow rate and TP concentration data from six drains and two wasteways that drain along the south shore of

Lake Lowell. TP and flow data for the measured drains is provided in Appendix E. Areas designated as irrigated agriculture within the polygon surrounding Lake Lowell (18,099 acres total) were assumed to contribute agricultural phosphorus runoff. Load estimates and allocations for agricultural runoff from monitored drains are used to estimate the agricultural component of the load for New York Canal (which includes Ridenbaugh Canal) based on the number of agricultural acres that drain directly back to these canals.

New York Canal and Ridenbaugh Canal traverse from the Boise River across several subwatersheds (Fivemile Creek, Eightmile Creek, Tenmile Creek, Mason Creek and Indian Creek) before reaching Lake Lowell. These creeks are routed underneath New York Canal and Ridenbaugh Canal, except Indian Creek, which shares a channel with New York Canal for several miles. In addition, at time the banks of New York canal have levees making it higher than the surrounding landscape. The complex hydrology makes determining the acres that contribute overland flow to New York and Ridenbaugh Canal challenging. Therefore, the number of acres contributing phosphorus load to these canals was back-calculated by subtracting the background and stormwater load from the known existing TP load for New York Canal then dividing by the per acre loading rate determined from the monitored drains and wasteways on the south shore of Lake Lowell. Using this method it was determined that 5,485 agricultural acres drain to New York and Ridenbaugh canals.

Septic Systems

Public outreach efforts by Southwest District Health Department target septic owners and encourage regular septic system maintenance, which may minimize nutrient loading to shallow ground water. Nutrients from septic systems are believed to enter the Lake Lowell drainage and loading from these systems was estimated using the methodology consistent with the Cascade Reservoir TMDL (DEQ 1998). Within the Lake Lowell drainage, a review of aerial topography suggests there are a total of 2,336 septic systems (Figure 34; see also Appendix F).



NOTE: Data provided by City of Nampa based on aerial topography. Green shaded area represents Nampa's Planning Service Area.

Figure 34. Summary of septic systems in the Lake Lowell drainage area.

Ground Water

In terms of ground water inflows and outflows, a 2008 USBOR/IDWR study (Schmidt 2008) on the water budget of the Lake Lowell watershed (including inputs and outputs) estimated an annual balance as shown in Figure 35.

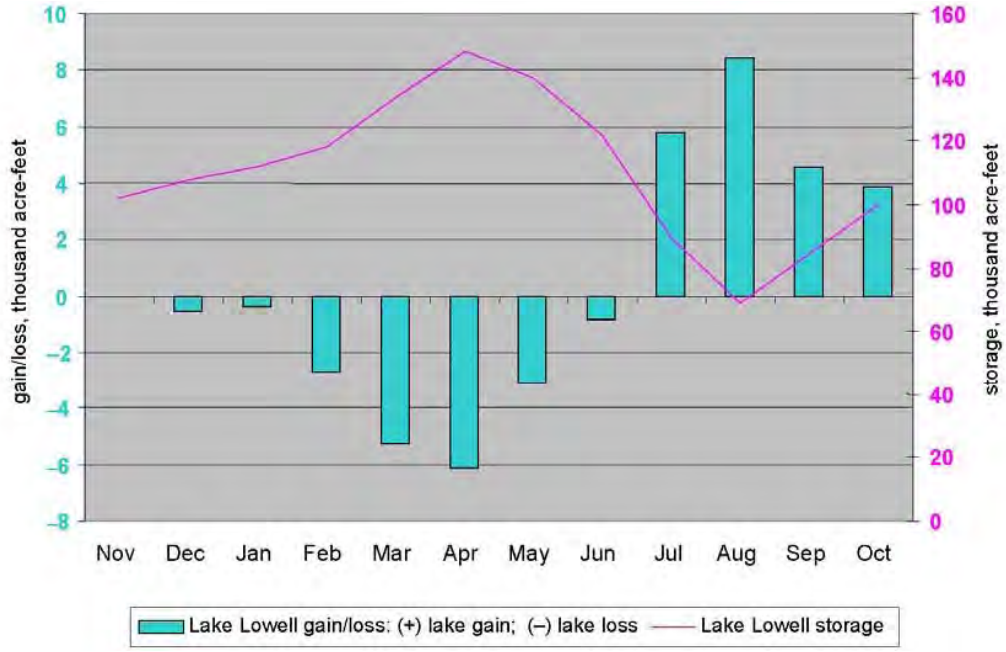


Figure 35. Average monthly reservoir level and gain-or-loss from Lake Lowell (from Schmidt 2008, p. 66).

The report caveats these data, which indicate a net annual gain of 4,000 AF, with the following statement: "… given how long the reservoir has been in place, Lake Lowell is likely to be in near equilibrium (on an average annual basis) with the underlying aquifer. Although there are significant seasonal fluctuations in lake gains and losses, these tend to balance out over the course of a year" (p. 53). Nonetheless, small annual ground water inflow (and resulting load) in this assessment was estimated based on months of inflow presented in the 2008 report. To estimate a corresponding phosphorus concentration to establish the existing load, data from the IDWR monitoring well database will be used.

Other Nonpoint Sources

Waterfowl and wildlife are potential sources of nutrient loads to the reservoir. The area is a National Wildlife Refuge and is designated in the WQS as a Special Resource Water. Lake Lowell is heavily used by waterfowl during spring and fall migration seasons. The irrigation water hydrologic regime is perfectly suited to accommodate spring and fall migratory patterns. The slow draw-down of the lake for irrigation in late spring and summer exposes mud flats that provide abundant habitat for nesting and rearing shorebirds. The lake also produces large amounts of aquatic vegetation for birds to feed on, particularly smartweed which is an important food for migratory fuel in the fall. Phosphorus load estimates suggest that about 4,174 kg/yr (25.26 lbs/day) of the total reservoir phosphorus load is associated with waterfowl use (BOR 2001). BOR believes that much of the waterfowl loading occurs from September through January and that early spring reservoir operations flush out much of the waterfowl load before algal growth accelerates.

Recent IDFG surveys indicate that common carp are abundant in Lake Lowell. Weight per unit effort indices indicate that carp composed 49% of the fish biomass in 2006 (Kozfkay et al. 2009). In other systems, highly abundant rough fish populations, especially carp, have degraded water quality, altered food webs, and negatively impacted native or recreationally important fish populations (Zambrano et al. 2001; Jackson et al. 2010). Carp are benthic omnivores and feed primarily on aquatic invertebrates by rooting in sediments (Panek 1987). This feeding behavior increases turbidity by re-suspending sediments leading to lower light penetration. Additionally, nitrogen and phosphorus are re-distributed in the water column which may facilitate nuisance algae blooms further reducing light penetration (Moss et al. 2002). Little is known about internal nutrient cycling in Lake Lowell and the effects associated with carp feeding behavior on phosphorus cycling in Lake Lowell have not been quantified.

3.2 Data Gaps

This section of the report describes gaps in data about pollutant sources and transport mechanisms.

- The best available data are used to determine pollutant sources. However, additional data would be helpful to increase accuracy of load estimates.
- Establishing regular monitoring sites and sampling intervals would help to develop more precise load estimates. Because return flow is not constant, additional flow information for agricultural drains would also be helpful.
- In addition, drainage basins for the individual drains, canals, and canal returns have not been delineated, making phosphorus load estimates in the basin challenging.
- The influence of ground water and septic systems throughout the New York Canal system is unclear.
- The influence of ground water and septic system inputs to drains in the Lake Lowell drainage area is unclear.
- The influence of precipitation and evaporation on phosphorus loading to Lake Lowell is unclear.
- Little is known about internal nutrient cycling and specific water-sediment interface dynamics in Lake Lowell. Internal loading from nutrients released from reservoir sediment is a significant data gap. This information is important to determine how long after TP targets are met it will be before algal blooms and DO depletion of the metalimnion diminish to concentrations that support beneficial uses.

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4. Subbasin Assessment – Summary of Past and Present Pollution Control Efforts

Past and present pollution control activities in the Lake Lowell Subbasin have involved both public and private entities. Some conversion from furrow or flood irrigation to sprinkler irrigation, nutrient management, and construction of sediment ponds and filter strips has occurred.

ISDA collected water quality data from 11 tributaries and drains in the Lower Boise River subbasin from 1997 through 2003 and published a report on each subwatershed. Lake Lowell irrigation drains were included in this study. An implementation plan for agricultural best management practices (BMPs) and a guidance document for evaluating their effectiveness were developed in 2003. The TMDL implementation plan for agricultural lands identifies critical acres and prioritizes land for BMPs by identifying acres that have the greatest effect on pollutant delivery to the Boise River as Tier I lands. For sediment pollutant reduction, priority acres are surface-irrigated croplands with the steepest slopes or closest to the Boise River, and riparian acres grazed by livestock. Ada and Canyon County Soil Conservation Districts work with private landowners to implement pollution prevention BMPs on their properties. These activities include water conservation, erosion prevention, and nutrient management.

The USFWS and the BOR, who own and manage Lake Lowell, are committed to improving water quality in Lake Lowell. BOR develops water conservation plans for all projects and updates these plans every five years. Deer Flat National Wildlife Refuge is interested in active partnerships that work toward improving water quality as it impacts wildlife resources and providing outreach to visitors and the community . USFWS outreach staff visits schools throughout the watershed with programs designed to improve knowledge about the refuge and the importance of habitat conservation and environmental protection. They have an annual weekend field clinic with fun educational activities as well as hands-on habitat improvement and pollution prevention field trips. The refuge is in the process of completing a comprehensive conservation plan (CCP). The CCP provides management direction for a refuge for 15 years by documenting desired future conditions and management actions needed to achieve them, serving as a guide to improve refuge habitat and infrastructure for wildlife conservation and refuge visitors. The process includes coordination with other management and regulatory agencies to develop a refuge management plan.

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5. Total Maximum Daily Load

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.

Based on results of the subbasin assessment (SBA), total phosphorus and low dissolved oxygen are the pollutants of concern for Lake Lowell. The selected water quality targets focus on total phosphorus and chlorophyll-*a* concentrations that are expected to reduce algal and macrophyte growth to levels that to support all beneficial uses. When this is achieved, dissolved oxygen concentrations will meet the water quality standards (WQS) for the warm water aquatic life beneficial use.

5.1 In-stream Water Quality Targets

The goal is to restore "full support of designated beneficial uses" (Idaho Code 39.3611, 3615). The objective of this TMDL is to reduce nutrient loading so that loads are in conformance with the LC for the reservoir. Monitoring of the pollutant load and beneficial use support will occur throughout the implementation phase of the TMDL. Pollutant reduction can be achieved by decreasing TP inputs to the reservoir by using appropriate BMPs on urban and agricultural land, including but not limited to use of fertilizer in amounts that are optimal and not excessive, use of sprinkler irrigation instead of flood or furrow irrigation, and use of sediment-filtering strips and sediment-settling ponds.

For nutrients, Idaho has adopted a narrative criterion. In the absence of numeric criteria for nutrients, DEQ uses the response of algae to selected concentrations of nutrients to determine the level of pollution reduction necessary to achieve support of all beneficial uses. The concentration that produces desired algal conditions is selected as the nutrient concentration target.

Design Conditions

Land use and hydrology must be considered when quantifying seasonal and annual variability and critical timing of sediment loading. Nutrient delivery to the canal and reservoir system usually occurs when tributary canals and drains are flowing during the irrigation season. The canal systems generally have water in them from March through October with flows varying in response to irrigation demand. The canal system is also occasionally used during the non-irrigation season for flood control. Flood control water is diverted from the Boise River and through the canal system eventually returning to the Boise River. Nutrients can be stored in dry or non-flowing channels during the non-irrigation season and then mobilized during precipitation events, periods of excessive irrigation, or when water is again diverted through the channel. DEQ used the best available data to calculate actual loads delivered to Lake Lowell based on flow at the time nutrient concentrations were measured. Because flows and concentrations vary throughout the year, loads from individual sampling dates were calculated and then averaged to produce an average daily load for each tributary canal or drain. The average daily TP target concentration of 0.07 mg/L or less for this TMDL is applicable throughout the year even at times when the system would generally be dry.

Target Selection

The interrelationship of phosphorus concentration, algae, and DO both in the reservoir and in the tributary waterways is complex. Addition of excess phosphorus to a system causes greater than normal productivity of algae. Excess algae deplete DO in the water column through nighttime respiration and decomposition of algae and other plant material. DEQ and BOR modeled reservoir conditions to determine realistic TP and chlorophyll-*a* loads for land use in the subbasin that would also meet the DO numeric criteria and allow all beneficial uses to be restored.

Dissolved Oxygen

In Lake Lowell, which is designated for warm water aquatic life, the WQS for DO is numeric (IDAPA 58.01.02.250.04). The WQS states that dissolved oxygen concentrations must exceed 5 mg/L at all times (except for the bottom 20% of the water depth and waters of the hypolimnion).

Nutrients

In Idaho, the WQS for nutrients is narrative (IDAPA 58.01.02.200.06):

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.

Quantification of aquatic primary production can be challenging. It is uncommon to collect data on algae, since the laboratory tests are expensive and sometimes inaccurate or inconclusive. Chlorophyll-*a* is an indicator of the primary productivity of algae, and therefore its quantity. Most nutrient studies use chlorophyll-*a* analyses, since those tests are more cost effective. Relevant literature was searched in order to determine appropriate target values for chlorophyll-*a* and TP. A target chlorophyll-*a* concentration of 10 µg/L or less supports primary contact recreation uses in reservoirs (Raschke 1993). A total phosphorus target of 0.07 mg/L or less was established in the Snake River–Hells Canyon (SR-HC) TMDL (DEQ 2004) for Brownlee Reservoir tributaries. All impaired and non-impaired tributaries to the Snake River-Hell’s Canyon watershed (Snake River RM 409-272.5) were assigned this target concentration at each river mouth included in the SR-HC TMDL, so that the Snake River and Brownlee Reservoir, which are impaired for nutrients, could meet beneficial uses. In addition to the TP load allocations upstream Snake River segment and the tributaries, a DO load allocation was established for Brownlee Reservoir to offset the calculated reduction in assimilative capacity due to the Hells Canyon Complex reservoirs. Modeling analysis confirms that these TP and chlorophyll-*a* targets are appropriate for meeting beneficial uses in Lake Lowell (Appendix D), without an additional increase of DO.

Water Quality Model Verification of Appropriate Target Conditions

It is assumed all beneficial uses are supported when proposed targets are reached. To determine that appropriate targets were selected, DEQ used a water quality model that was developed by BOR specifically for Lake Lowell. The purpose of using the model is to illustrate the relationship between TP, chlorophyll-*a*, and DO in the Lake Lowell reservoir.

Model Overview

The Box Exchange, Transport, Temperature, and Ecology of a Reservoir (BETTER) model is a branched two-dimensional box reservoir water quality model. This model was applied to Lake Lowell by the BOR Technical Services Division in Denver, Colorado (Bender 2000). The model uses a two-dimensional array of longitudinal and vertical elements to calculate flow exchange, heat budget and DO concentrations. The model simulates thermal stratification and effects of weather and flow on the water layers. DO components include sediment oxygen demand, biochemical oxygen demand, ammonia, surface aeration, algal photosynthesis, respiration, and nutrient cycling. Functionalities of the BETTER model include basic eutrophication processes such as those among observed seasonal patterns of temperature, nutrients, algae, DO, organic matter, and pH relationships. The model's general capabilities and limitations are shown in Table 24. A significant limitation to this model is that output is only available for the time period from typical reservoir ice-out (day ~84) to ice-in (day ~ 365), which coincidentally coincides closely with the irrigation season for Lake Lowell. Because it does not model reservoir conditions over an entire year period, sequential runs cannot be used to predict changes in water quality over an extended time period. An example of this limitation is evidenced from modeling of Cascade Reservoir (DEQ 1998). Model results for Cascade reservoir for a 50% reduction in nutrient and organic inflow loading showed only minimal effect on water quality within the reservoir over the single season modeled. This is not surprising as load reductions would be expected to require more than a single season to show significant water quality improvements due to internal cycling of nutrients within the reservoir. Another limitation of the BETTER model is that data inputs and outputs are defined in a 12-hour time step. Thus the effects of events lasting less than 12 hours (i.e. a 3 hour windstorm) are not within the models predictive capability.

Table 24. Capabilities and limitations of the BETTER model.

Capabilities	Comments
Physical Processes	Matched density placement, turbulent mixing, stratification, heating, cooling, and convective mixing, light extinction, evaporation, aeration, wind mixing and outflow advection.
Water quality processes	Algal photosynthesis, respiration, decay and settling, organic decay, sediment processes, and nutrient uptake by algae.
Inputs/Outputs	Multiple stream inflows; point and nonpoint inflows; precipitation; multiple withdrawals.
Geometry	Multiple water bodies consisting of multiple branches. Longitudinal and vertical segmentation scheme in a reservoir.
Site Specific Parameter Values	Ability to adjust parameters specifically for monitoring locations or areas of water body with differing environmental conditions
Limitations	**Comments**
Hydrodynamics	Laterally averaged
Water quality	No zooplankton or macrophytes
Long term water quality parameter prediction	Model single year time frame, does not model ice cover conditions.

Model Calibration

Calibration is a process whereby measured data and modeled values are compared. The compared values are assessed to determine if the modeled values provide an adequate reflection of measured data—in other words, do modeled values match reality? If the comparison is not adequate, coefficients or assumptions in the model are adjusted until the model gives useful results. If a model is a theory about the real world, then calibration tests the theory with all observed data available (Cole and Wells 2003).

The BETTER model was calibrated using all available data and coefficients were adjusted for the Lake Lowell system in the modeling effort recorded in Bender 2000. These were not readjusted for the modeling of year 2004 since the water quality dynamics were already calibrated in the earlier model and the coefficients remained the same.

The most complete one-year flow and water quality data set was used for modeling and to check calibration of the model for this TMDL. This was year 2004 data for the reservoir and drains; a summary of all data is in Section 2.4. To test the calibration, current conditions were modeled and compared with actual data for DO profiles in the reservoir during 2004 sampling. When measured data were plotted against calculated (modeled) data, BOI 185 had an average coefficient of $R^2 = 0.76$ (consisting of four sample dates for which $R^2 = 0.82$, 0.58, 0.70, and 0.93). The average for BOI 181 was $R^2 = 0.645$ (consisting of four sample dates for which $R^2 = 0.61$, 0.86, 0.14, and 0.97). See Appendix D for comparisons of the measured and calculated data. Comparison R^2 values for 2004 chlorophyll-*a* and TP were not calculated because there is not enough 2004 TP and chlorophyll-*a* data. Based on the apparent good fit for the other calibrated constituents the expectation is that the model predicts TP and Chlorophyll-*a* with precision similar to the DO calibration.

Water Quality Constituents in Model

The BOR collected data that resides in the STORET database. DEQ downloaded this data and formatted it for entry into the BETTER model. For each day, the input files include inflow to reservoir, outflows from the dam, and weather parameters including dry bulb temperature, dew point temperature, wind speed, and solar radiation. Inflow and outflows were interpolated from a monthly water balance estimate provided by BPBOC, which included daily flow recorded for New York Canal at Lakeshore Drive. For each branch coming into the reservoir, parameters include temperature, turbidity, DO, pH, alkalinity, algae, detritus, dissolved organics, ammonia, nitrate + nitrate, bio-available phosphorus, and dye (an inert substance to evaluate travel time). When the BETTER model was previously calibrated by the BOR for tributary waterways, organic inputs were set at 0.5 µg /L for algae, 1.5 mg/L for detritus, and 1.5 mg/L for dissolved organics. The BOR recommended these settings be retained for current conditions. The other water quality parameters were derived from 10 BOR water quality sampling events, entered stepwise rather than interpolated. Tributary waterway input files were created for three levels of nutrient input: current conditions, 0.025 mg/L total phosphorus, and 0.07 mg/L total phosphorus. For target conditions, the organic inputs were reduced proportionally to the corresponding reduction in total phosphorus.

Please consult Appendix D for the Lake Lowell TMDL model development report. All model parameters used and data sources are fully explained in this document and the original model development report *Two-Dimensional Water Quality Modeling of Lake Lowell* (Bender 2000).

Model Execution

These three input files were executed separately and output was produced for segments one and four, which correspond to DEQ sampling sites BOI 185 and BOI 181, where most data had been collected in the reservoir. Output was formatted to display DO at 5-foot depth intervals starting at 2.5 feet and algae at the surface of the reservoir. The model calibration and results demonstrate that the target DO, TP, and chlorophyll-*a* concentrations for this TMDL would result in meeting all beneficial uses (See also Appendix D and Estimates of Existing Pollutant Load and Load Allocation Section).

Model Results - Chlorophyll-*a*

Both target and current concentrations of chlorophyll-*a* in Lake Lowell were calculated by the BETTER model using chlorophyll-*a* data collected in 2004 (Figure 36). Data used in the model to calculate predicted concentrations for target conditions are based on the predicted chlorophyll-*a* concentration when TP concentrations are at the 0.07 mg/L target in the tributaries. For the model input files, all organic components were reduced by the same proportional amount that total phosphorus was reduced. For current conditions model input files for organic components were unchanged and tributary TP concentrations were entered using average concentrations from sampling in 2004. Under current conditions, modeled chlorophyll-*a* concentrations exceed the reduced concentration expected for target conditions by approximately 3 times (Figure 36). The calculated chlorophyll-*a* concentrations for target conditions would be well below the 10 µg/L target.

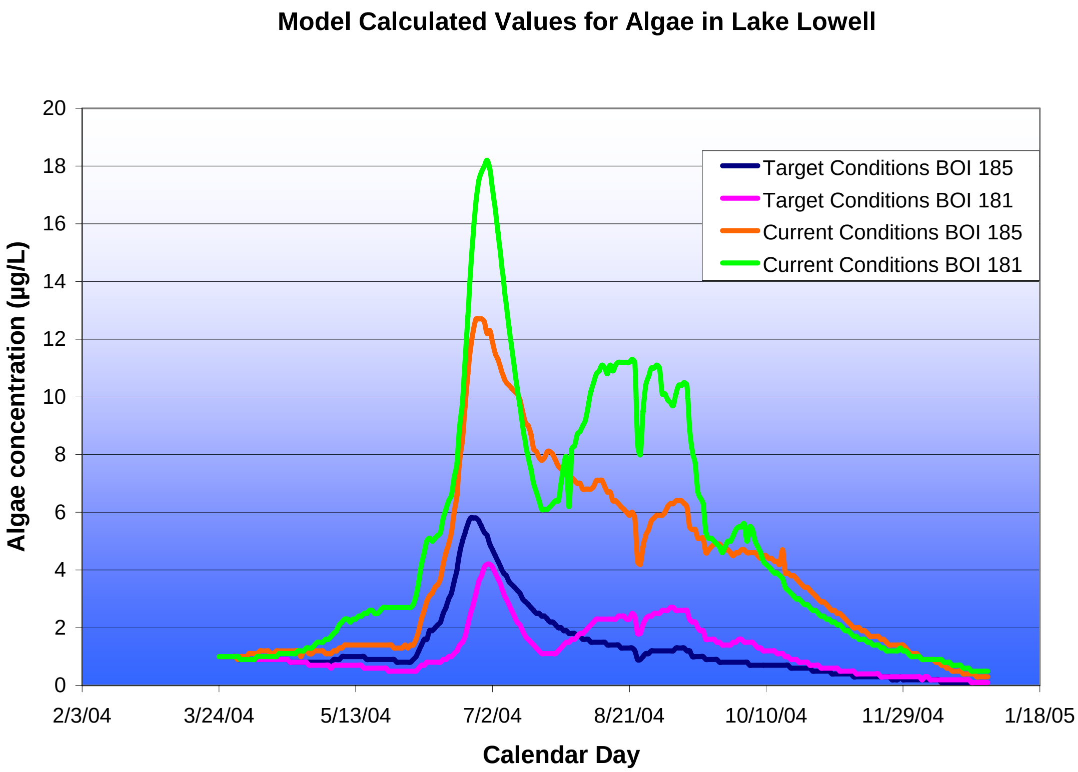

Figure 36. Lake Lowell chlorophyll-*a* concentrations from BETTER model for sites BOI 181 and BOI 185.

Model Results - Dissolved Oxygen

The target concentration for DO is 5 mg/L at all times, excluding the bottom 20% of the reservoir depth. In order to calculate the predicted change in DO resulting from meeting the 0.07 mg/L target for TP in tributary waterways, TP inflows from all tributaries were changed from 2004 levels to the 0.07 mg/L target. The BETTER model showed that there will be few or no exceedances of the DO WQS at monitoring sites when phosphorus inputs are reduced to the target concentrations (Figure 37 and Figure 38). In the figures lines are dashed and colors changed to make exceedances more easily distinguishable. Although dissolved oxygen has been measured at less than the 5.0 mg/L criterion, these measurements have been at depths that are excluded from WQS because they are in the bottom 20% of depth. The WQS allow exclusion of the hypolimnion; however, since Lake Lowell is polymictic and does not remain stratified throughout the summer in all locations DEQ made the conservative assumption that this site was not stratified. Evidence from DO profiles presented in section 2.4 of the SBA show this may not be the case, however it is impractical to differentiate between stratified and non-stratified profiles when graphing model output.

The model predicts no exceedances at site BOI 185. At site BOI 181, 98% of the time the DO target concentration is met. On very rare occasions (12 days) DO in the deepest water layer applicable to the WQS may temporarily dip lower than 5.0 mg/L. The model may overestimate DO exceedances since all tributary TP inputs are set to 0.07 mg/L, yet the current mean TP concentration in New York Canal is 0.05 mg/L. Additionally, the load allocation in this TMDL for New York Canal is more stringent due to Idaho's antidegradation policy (IDAPA 58.01.02.051). Agricultural runoff entering New York Canal is allocated a percent load reduction equivalent to other tributary waterways in the subbasin.

In the original model development for Lake Lowell in 2000, a reduction in nutrients and organic loading had a significant, immediate effect on Lake Lowell water quality by increasing DO concentrations of the lower layers near the upper embankment dam. From this observation BOR concluded that significant loading reductions over several years may improve Lake Lowell water quality cumulatively because, over time, sediments that are rich in nutrients would be naturally covered (BOR, Bender 2000).

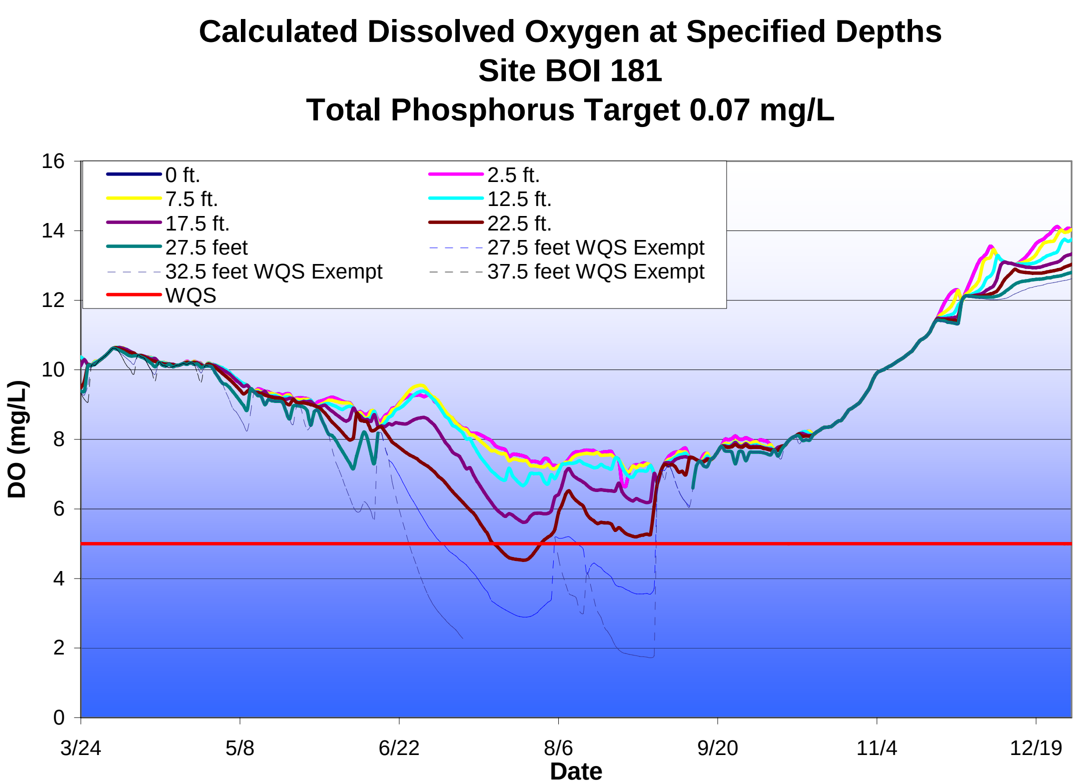

Figure 37. Lake Lowell modeled dissolved oxygen concentrations from BETTER model for site BOI 181 at 0.07 mg/L TP target in tributary waterways.

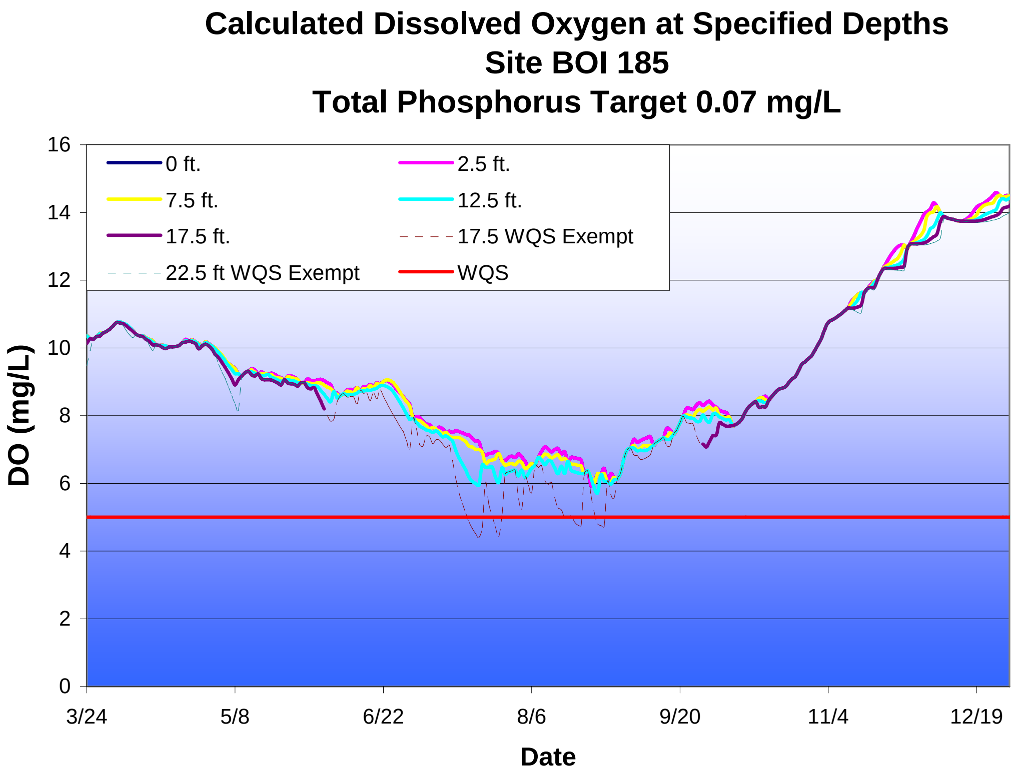

Figure 38. Lake Lowell modeled dissolved oxygen concentrations from BETTER model for site BOI 185 at 0.07 mg/L TP target in tributary waterways.

Monitoring Points

BOR and DEQ have collected water samples at several established monitoring stations in Lake Lowell. Regular monitoring to track progress toward the attainment of DO, TP, and chlorophyll-*a* targets should occur at monitoring site BOI 181, the deepest point in the reservoir. An additional monitoring site near the Lower Embankment, at either BOI 185 or BOI 184, would also be beneficial to determine whether target conditions are being met throughout the reservoir. Although these sites are shallower and do not regularly become anoxic, algae blooms are subject to wind direction and not evenly distributed throughout the reservoir on any given day. Monitoring at more than one location would give a clearer picture of chlorophyll-*a* concentrations and corresponding effects on reservoir beneficial uses. The DO compliance analysis would include concentrations in water depths that are applicable to the WQS; i.e. the bottom 20% of the reservoir depth would be excluded.

Routine monitoring of incoming TP concentrations at all tributaries to Lake Lowell is also necessary. Eight established monitoring sites exist on these tributaries, as earlier described. The implementation plan may also designate additional monitoring of Ridenbaugh Canal and Garland Drain to determine the loads they each deliver to New York Canal. Ridenbaugh Canal flows through densely populated urban areas in Boise and then through rural residential areas and agricultural areas. Garland Drain is a major drain for agricultural lands south and east of Lake Lowell. The implementation plan may also designate additional monitoring sites on drains that have not previously been sampled.

Monitoring sites have also been established on the outlet canals from Lake Lowell. These sites are important to determine net reduction in TP accumulation in the reservoir. Phosphorus cycling in the reservoir is challenging to predict and accurately measure. If loads entering and leaving the reservoir are known, trend monitoring of chlorophyll-*a* and DO concentrations in the reservoir should indicate when the internal phosphorus load has been depleted to levels that support beneficial uses.

5.2 Load Capacity

The load capacity (LC) is "the greatest load a water body can receive without violating water quality standards" (40 CFR § 130.2). Seasonal variations and a margin of safety (MOS) to account for uncertainty are considered to be part of the LC. Sources of uncertainty include lack of knowledge about how much assimilative capacity the water body has, uncertain relation of selected targets to beneficial uses, and variability in measurement of concentrations of TP, chlorophyll-*a* and DO. .

Load Capacity Estimates

All TP load capacity estimates are conservatively estimated recognizing an inflow target that is the lower of either the existing inflow concentration (that is, inflow concentrations cannot increase up to 0.07 mg/L) or the target of 0.07 mg/L. For example, the New York Canal load capacity is equal to the current load because the TP concentration is currently less than 0.07 mg/L. Since New York Canal discharges to an impaired water body, the concentration of TP cannot increase from its current level (IDAPA 58.01.02.051, Antidegradation Policy). The total load capacity for the system is estimated at 152 lbs/day as shown in Table 25 (the corresponding existing load data for each source are described in more detail in Section 5.3).

Flow measurements for each sample day are in Appendix E. Phosphorus load estimates from drains that have not been monitored were extrapolated based on current monitoring data as described in Section 3.1 and discussed in more detail in Section 5.3. The modeled changes in chlorophyll-*a* and DO concentrations that are expected when the current load is reduced to equal the overall load capacity discussed in the *Target Selection* and *Estimate of Existing Pollutant Loads* sections of this TMDL.

Table 25. Summary of load capacity.

			Load Capacity (lbs/day)
New York Canal (Includes Ridenbaugh Canal)[a]			
	Background		
	NPDES Permitted Discharges		
		Stormwater: MS4s	
		Stormwater: Construction	
		Stormwater: AFOs	
	Non-Point Sources		
		Agricultural	
		Septic Systems	
		Ground Water	
		MEDIAN LOAD	84.07
Drains (Monitored and Unmonitored)[b]			
	NPDES Permitted Discharges		
		Stormwater: MS4s	
		Stormwater: Construction	
		Stormwater: AFOs	
	Non-Point Sources		
		Agricultural	
		Septic Systems	
		Ground Water	
		MEDIAN LOAD	35.33
Lake Lowell			
	Septic Systems		6.53
	Ground Water		0.84
	Waterfowl [c]		25.26
	Internal Reservoir Nutrients (Active Load)		?
TOTAL			152

[a]New York Canal load capacity derived by multiplying the 0.05mg/L target concentration by the median flow.
[b]Drains load capacity derived by multiplying the 0.07mg/L target concentration by the median flow for each drain and taking the sum.
[c]Phosphorus load from waterfowl was estimated by BOR (BOR 2001).
? – Indicates a data gap that will need to be addressed.
lbs/day = pounds per day
MS4 = municipal separate storm sewer system
NPDES = National pollutant discharge elimination system
AFO = animal feeding operation

5.3 Estimates of Existing Pollutant Loads

Federal regulations allow that loads "...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)). The only permitted point source affecting nutrient loads in Lake Lowell is stormwater from urbanized areas in Ada and Canyon counties. The existing stormwater load and all estimated nonpoint loads that could be quantified as part of this TMDL are outlined below.

Background Loads

The New York Canal brings nutrients to Lake Lowell under two different flow regimes: 1) an irrigation period when the canal brings water from the Boise River, as well as small volumes of return flows from irrigated runoff and urban stormwater, and 2) a shorter wintertime period when the BPBOC tries to fill Lake Lowell. The BPBOC monitors inflow to Lake Lowell via four input points: New York Canal (@ Lakeshore Drive upgradient from where the Ridenbaugh Canal and Garland Drain enter the canal), Ridenbaugh Canal (@ Lakeshore Drive), Garland Drain (@ Lakeshore Drive), and Deer Flat Wasteway #3 (near the Lower Embankment of Lake Lowell). Inflow data were requested for 2004, 2005, and 2009 to calculate flow contribution to Lake Lowell from the New York Canal. Flow records obtained from the BPBOC in June 2010 (see Appendix F) indicate the volume contributed to Lake Lowell by New York Canal during 2004, 2005, and 2009 (Table 26). Inflow data from Deer Flat Wasteway #3 was not used to establish inflow rates for the New York Canal system because they are included in the drain inflow dataset.

Table 26. Boise Project Board of Control records of monthly inflows to Lake Lowell via the New York Canal and outflows from the reservoir in acre feet.

	2004		2005		2009			
Month	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow		
Jan	20,429							
Feb	20,481							
March					15,135			
Apr					35,749			
May	23,848	28,788	32,498	17,903	29,007	32,512		
June	14,004	38,076	32,656	27,575	35,860	32,983		
July	35,649	39,186	17,718	34,598	18,134	44,604		
Aug.	38,518	32,178	15,009	35,804	22,803	46,823		
Sept	41,903	19,309	27,071	21,407	39,231	37,710		
Oct.	16,520	6,151	8,056	3,280	707	11,705		
Nov.								
Dec.								
TOTAL	211,352	163,688	133,009	140,567	196,626	206,337		
							Acre Feet Average Inflow	Cfs/Day Average Inflow
IRR	162,182	160,613	128,981	138,926	163,263	200,485	151,476	418
NON-IRR	49,170	3,076	4,028	1,640	33,363	5,852	28,854	80

Information was also requested from BPBOC for those dates in which New York Canal inflow TP concentration data was collected by DEQ or BRO (Table 27). Inflow data and TP concentrations were used to calculate TP load to Lake Lowell via the New York Canal (Table 28). A summary of loads entering the reservoir from the New York Canal based on the dataset provided by BPBOC (summarized in Table 26, Table 27, and Table 28) is provided in Table 29. Loads may require revision if data collected in the future yield different median values.

Table 27. Boise Project Board of Control records of 2004-2006 monitoring collection day inflows to Lake Lowell via the New York Canal.

	New York Canal	Ridenbaugh Canal	Garland Drain	New York Canal	Ridenbaugh Canal	Garland Drain	Sum
Date	Miners Inch (Raw)			cfs			
6/24/2004	5,050	0	660	101	0	13.2	114
7/19/2004	33,300	500	950	666	10	19	695
8/9/2004	22,500	500	700	450	10	14	474
9/9/2004	25,150	540	600	503	10.8	12	525
10/5/2004	37,300	190	410	746	3.8	8.2	758
4/25/2005	4,500	900	530	90	18	10.6	118
7/24/2005	10,700	530	800	214	10.6	16	240
8/3/2006	11,200	470	700	224	9.4	14	247
8/24/2006	12,900	500	1,000	258	10	20	288

Table 28. Boise Project Board of Control records of 2004-2006 monitoring collection day total inflows to Lake Lowell TP concentration and associated TP load.

Date	Diversion Dam (cfs)	Nek York Canal Inflow to Lake Lowell_ (cfs)	TP (mg/l)	TP load (lbs/day)	Median Load (lbs/day)
6/24/2004	2316.38	114	0.053	32.6	74.1
7/19/2004	2322.52	695	0.060	224.8	
8/9/2004	2247.71	474	0.029	74.1	
9/9/2004	1882.25	526	0.025	70.9	
10/5/2004	1555.84	758	0.022	89.9	
4/25/2005	695.47	119	0.052	33.2	
7/24/2005	2284	241	0.076	98.6	
8/3/2006	2266.51	247	0.049	65.3	
8/24/2006	2222.65	288	0.115	178.5	
MEDIAN	2248	288	0.052		

NOTE: Nutrient runoff data are typically log-normally distributed, which means that a median value is a more appropriate representation of typical conditions than an average (Driscoll 1986). In order to derive a representative load, median flow values were also used.

Table 29. Summary of median loads to Lake Lowell in 2004, 2005, and 2009 via the New York Canal.

Flow Regime Period	Flow (cfs)	TP Concentration (mg/L)	TP Load (lbs/day)
Irrigation	288[a]	0.052[a]	74.09
Non-Irrigation	93[b]	0.020[c]	9.98
TOTAL			84.07

[a]Refer to Table 28.
[b] Median value for non-irrigation season flow (Table 26)
[c]TP concentration for non-irrigation season is from USGS monitoring data at Diversion Dam (NWIS) see Appendix G.
NOTE: Nutrient runoff data are typically log-normally distributed, which means that a median value is a more appropriate representation of typical conditions than an average (Driscoll 1986). In order to derive a representative load, median flow values were also used.

Building on this information, estimated background loads (originating from the Boise River) are summarized in Table 30.

Table 30. Summary of median background loads to Lake Lowell in 2004, 2005, and 2009 via the New York Canal.

Flow Regime Period	Flow (cfs)	TP Concentration (mg/L)	TP Load (lbs/day)
Irrigation	288[a]	0.020[b]	31.04
Non-Irrigation	93[c]	0.020[b]	9.98
TOTAL			41.02

[a]Refer to Table 28.
[b]TP concentration for non-irrigation season is from USGS monitoring data at Diversion Dam (NWIS) see Appendix G.
[c]Median value for non-irrigation season flow (Table 26).

Point Source

Stormwater Runoff

Current stormwater load estimates and waste load allocations in this TMDL are based on ACHD monitoring data from which the loading analysis from the *Lower Boise River Implementation Plan Total Phosphorus* (DEQ 2008) was developed. To remain consistent throughout the subbasin the loading rates calculated for the implementation plan are used and text for the stormwater section of this TMDL is taken directly from the referenced document.

In the desert climate of the lower Boise River, stormwater runoff from urban-suburban areas can be divided into wet and dry weather discharges. Wet weather runoff can occur during rainfall events. On average there are 50 rainfall events during the year that exceed 0.05-inches (HDR 1998) and 39 events that exceed 0.1-inches (From Western regional Climate Center 2007). During the period of May through September (period of record 1940-2006), there are, on average, 11 events per year that exceed 0.1-inches. Dry weather discharges measured in the Boise Area municipal separate storm sewer system (MS4) area appear to be more continuous in nature, and are potentially influenced by many different sources such as ground water and surface water from irrigation and overflows. Other more intermittent urban-suburban dry weather sources could include car washing, side walk cleaning, and construction related activities.

ACHD stormwater data used to calculate daily loads are found in the Attachment 3 and 4 of the *Lower Boise River Implementation Plan Total Phosphorus* (DEQ 2008). Using these data, stormwater TP loads for the Boise Area MS4 have been estimated and reported annually to EPA. Annual wet weather loads are based on total rainfall inches per year (recorded at the National Weather Service station at the Boise Airport), location specific runoff coefficients, and location specific storm event mean concentrations. The wet weather loads are for rainfall events of various sizes and assume the runoff volume occurred over 24 hours. The NPDES reported wet weather loads are used to estimate existing average annual "per acre" loads based on existing land uses and include some level of stormwater treatment.

Average annual loads are based on event mean concentrations and annual runoff volumes estimated for each year. This represents the average load that would be generated during each storm event and distributed over a one-year period. The estimated wet weather TP load is 0.15 g/ac/day.

Dry weather loads are based on samples collected twice per week for the period July 20, 2006 through September 27, 2006. While the dry weather loads are generally smaller, they flow continuously and therefore produce a higher annual load compared to the wet weather discharges. Available dry weather data are averaged and used as a "placeholder" estimate for the stormwater dry weather WLAs. Further investigations of dry weather flows are needed to delineate the proportion of flow attributed to ground water and the specific surface water sources, and better define areas that contribute to flow and loads. The estimated dry weather TP load is 0.37g/ac/day.

The wet and dry weather loads are added together to get a total TP load of 0.52 g/ac/day. As discussed in Section 3.1, although there are 29,792 urban acres identified within these polygons, almost all the stormwater acres (97.5%) are within the New York Canal/Ridenbaugh Canal drainage areas. Of these 29,067 acres, the Ada County Highway District estimates that only 5,900 acres within Ada County actually reach either the New York Canal or the Ridenbaugh Canal (ACHD, unpublished data, 2010). Within the Lake Lowell drainage area (defined by the fifth field HUC), urban stormwater from Canyon County is accounted for within 724 acres determined through the GIS analysis.

Thus, the current load from stormwater to the New York Canal system is 6.78 lbs/day and the current load from stormwater within the Lake Lowell drainage area is 0.83 lbs/day.

One component of dry weather flows not fully accounted for are loads associated with surface water irrigation and overflows from upgradient (above MS4 boundaries) agricultural runoff. Loads associated with these discharges would tend to increase in areas where irrigation water has been reused; as the TP concentration of surface water and ground water increases.

This pollutant load estimate is a placeholder until more accurate data can be collected. The stormwater load is allocated for the entire Lake Lowell subbasin and has not been partitioned by MS4 permit areas. Estimated TP concentrations are derived from analysis and data, as summarized in the *Lower Boise River Implementation Plan Total Phosphorus* (DEQ 2008).

AFOs and Construction Sites

The eleven AFOs in the watershed are required by the NPDES permit to have nutrient management plans and no stormwater discharge offsite. The seven construction NPDES permits on file for the watershed are required to manage stormwater onsite.

Nonpoint Sources

The current load estimates for TP were made using all available data collected from tributaries from 2002-2006.

Agricultural Loads

Agricultural runoff was estimated using the BOR and DEQ monitoring data collected from some of the drains that reach Lake Lowell. These data are summarized in Table 31.

Table 31. Summary of median TP loads to Lake Lowell via monitored drains.

Tributary Waterway	Number Days Sampled	TP Load (lbs/day)
Deer Flat Wasteway #3	24	38.76
Farner Drain	30	12.82
Donaldson Drain	3	11.04
Garner Drain	2	1.56
Highline Wasteway #1	11	2.03
Bernard Drain	29	15.91
Coulee Drain	20	20.59
TOTAL LOAD		102.72

1) Raw data are provided in Appendix E.
2) These values represent median values as discussed previously, due to the lognormal nature of nutrient runoff data sets (Driscoll 1986).

Because these drain data were collected at the mouth of each drain, these values represent loads that originate from agricultural lands, as well as approximately 724 acres of urban stormwater runoff. To avoid double-counting the stormwater load (previously estimated at 0.83 lbs/day), the total mouth load coming from non-stormwater sources was reduced from 102.72 to 101.89 lbs/day.

These monitored drains represent 14,961 acres of agricultural land (see Section 3.1 and Appendix F). On a per acre basis, this equates to 3.09 g/agricultural acre/day. For reference, other data in the watershed suggest that 4.9 g/agricultural acre/day of TP is being discharged into the mainstem Boise River watershed (*Lower Boise River Implementation Plan Total Phosphorus* [DEQ 2008]). So, the Lake Lowell information is consistent with other watershed data, and the lower loading rates make sense because the agricultural landowners adjacent to the New York Canal (and Ridenbaugh) and those within the Lake Lowell drainage area likely do not reuse the available irrigation water as much as those agricultural landowners along mainstem tributaries such as Mason Creek and Dixie Drain (where each reuse cycle may contribute to higher TP loading rates).

There are also a number of unmonitored drains that contribute loads to the reservoir (see Section 3.1 and Figure 33). In order to use available monitoring data to estimate the loads from the unmonitored drains, this loading rate was applied to the acreages represented by the unmonitored drains (3,138 agricultural acres). The acres associated with the unmonitored drains were estimated using aerial photography as detailed in Appendix F. If there are conservatively 24 unmonitored drains, this equates to an estimated additional load of 21.37 lbs/day, for a total agricultural non-point source load of 123.26 lbs/day (101.89 lbs/day from monitored drains and 21.37 lbs/day from unmonitored drains) within the Lake Lowell drainage area.

An estimated 5,325 agricultural acres drain directly back to the New York Canal system. The number of acres was back-calculated by subtracting the background and stormwater load from the known existing TP load for New York Canal (see Section 3.1). Using the same loading value (3.09 g/agricultural acre/day), these acres are estimated to contribute 36.26 lbs/day to the overall New York Canal load of 84.07 lbs/day (Table 29).

Septic Systems

Within the Lake Lowell drainage, there are a total of 2,336 septic systems (Figure 34). Based on an estimated population occupancy assumption of 2.77/house and an assumption of 10% of the phosphorus being trapped in the soil (see Appendix F), this equates to a medium-range loading estimate of 6.53 lbs/day as shown in Table 32.

Table 32. Summary of existing loads to Lake Lowell via septic systems.

		# Septic Tanks	Population Est. Occupancy (2.77/house)	High 1.8 kg/yr	Med 0.9 kg/yr	Low 0.3 kg/yr	If 10% of P trapped in soil High 1.8 kg/yr	Med 0.9 kg/yr	Low 0.3 kg/yr
	Nampa Planning Service Area	1572	4354.44	7838	3919	1306	7054	3527	1176
	Remaining Area	764	2116	3809	1905	635	3428	1714	571
Sum	LLowell WTRSHD	2336	6471	11647	5824	1941	10483	5241	1747
				(lb/d)	(lb/d)	(lb/d)	(lb/d)	(lb/d)	(lb/d)
	Nampa Planning Service Area			9.76	4.88	1.63	8.78	4.39	1.46
	Remaining Area			4.74	2.37	0.79	4.27	2.13	0.71
Sum	LLowell WTRSHD		Sum	14.50	7.25	2.42	13.05	6.53	2.18

The Nampa Planning Service Area is shaded in green in Figure 34 (p 81).

Ground Water

Loading from ground water to Lake Lowell can be estimated using two sources: flow data from a 2008 BOR/IDWR study (Schmidt 2008) on the water budget of the watershed (including Lake Lowell inputs and outputs) and concentration data collected by IDWR/USGS from local shallow (completed to depths less than 50-ft) ground water wells in the Lake Lowell vicinity.

Lake Lowell has a yearly-average gain of 3,750 acre-feet from ground water (Schmidt 2008, see Figure 35 and Appendix F). This equates to an inflow of 5.2 cfs.

Although most of the local potable wells are deep (completed to depths below 50-ft), there were a limited number of shallow wells with phosphorus monitoring data. Shallow wells were used for this analysis because they reflect the shallow ground water system that is discharging to, and recharging from, Lake Lowell. These are shown in Figure 39.

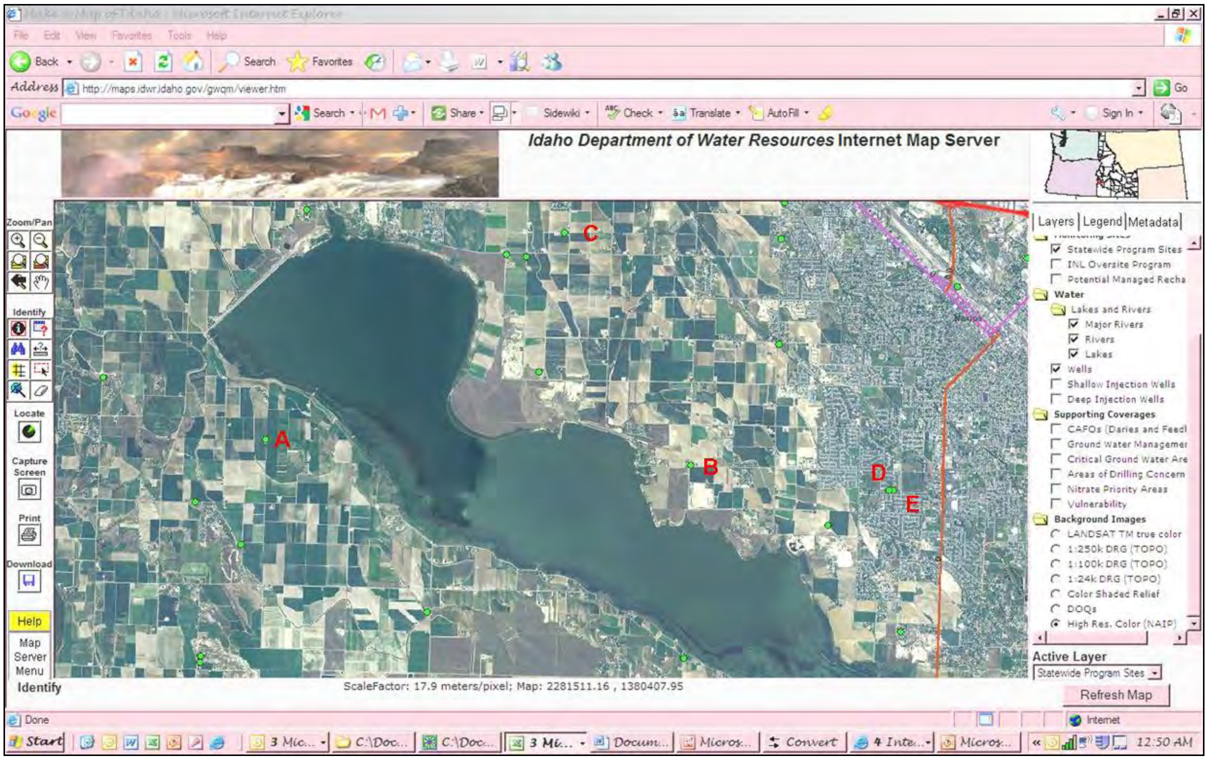

Figure 39. Local shallow ground water wells in the vicinity of Lake Lowell (from IDWR).

The letters in Table 39 refer to shallow wells that were included in this assessment (see Appendix F). The median orthophosphorus concentration from these wells from data collected over the last 15 years was 0.030 mg/L. In the absence of TP data, this value was used as a surrogate to derive an annual ground water loading estimate of 0.84 lbs/day.

Internal Reservoir Nutrient Cycling

Within Lake Lowell, phosphorus has been added to the reservoir over its 100-year history. Some, but not all of that phosphorus leaves the reservoir via the outlet canals and ground water losses. The remaining phosphorus either suspends within the water column or deposits within the sediments (see discussion in Section 2.3). Actual cycling of phosphorus within the reservoir is not well understood, and remains a data gap. Based on the available inflow, outflow, and storage data, an estimated annual mass balance is shown in Figure 40.

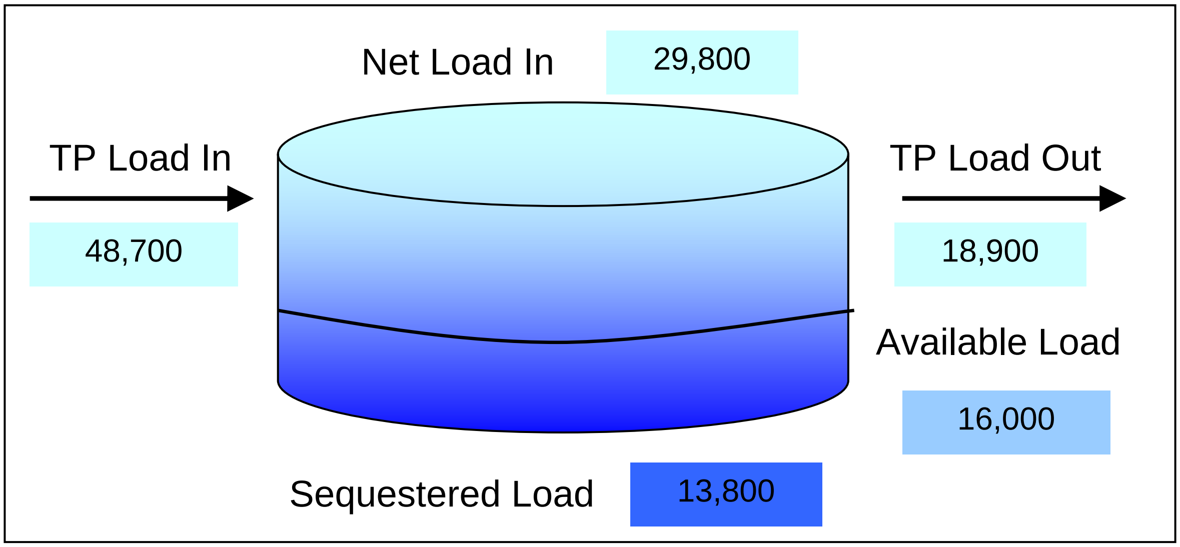

Figure 40. Conceptual annual mass balance of nutrients within Lake Lowell (lbs/year).

This means that of the phosphorus that enters the reservoir, but does not leave (29,800 lbs/year), about 54% could be active within the water column, and 46% could be inactive within the anoxic bottom sediments. As the TMDL is implemented, controlling the input of nutrients might need to be coupled with internal control of active phosphorus as part of reservoir nutrient cycling processes.

Summary of Existing Loads

Given all of the above data analysis, the estimated existing loads to Lake Lowell are summarized in Table 33. The existing loading into the reservoir is estimated at 241 lbs/day.

Table 33. Current TP loads to Lake Lowell (lbs/day).

			Load (lbs/day)
New York Canal (Includes Ridenbaugh Canal)			
	Background		41.02
	NPDES Permitted Discharges		
		Stormwater: MS4s	6.78
		Stormwater: Construction	
		Stormwater: AFOs	
	Non-Point Sources		
		Agricultural	36.26
		Septic Systems	
		Ground Water	
		MEDIAN LOAD	84.07
Drains (Monitored and Unmonitored)			
	NPDES Permitted Discharges		
		Stormwater: MS4s	0.83
		Stormwater: Construction	
		Stormwater: AFOs	
	Non-Point Sources		
		Agricultural	123.26
		Septic Systems	
		Ground Water	
		MEDIAN LOAD	124.09
Lake Lowell			
	Septic Systems		6.53
	Ground Water		0.84
	Waterfowl[a]		25.26
	Internal Reservoir Active Load		?
TOTAL			241

NOTE: ? indicates a data gap that will need to be addressed as part of Adaptive Management.
[a]Phosphorus load from waterfowl was estimated by BOR (BOR 2001).
? – Indicates a data gap that will need to be addressed.
lbs/day = pounds per day
MS4 = municipal separate storm sewer system
NPDES = National pollutant discharge elimination system
AFO = animal feeding operation

On an annualized basis, this equates to 48,743 lbs/year (Table 34). The conversion of lbs/day to lbs/year is not a straight 365-day conversion because not all sources contribute phosphorus on a daily basis. Loads are initially developed using available daily flow data on a lbs/day basis.

Table 34. Summary of current loads to Lake Lowell (annualized).

TP Load Source	TP lbs/day	TP lbs/year
New York Canal	84.07	15,335
Drains	124.09	22,646
Septic Systems	6.53	1,384
Ground Water Gain	0.84	178
Waterfowl	25.26	9,201
TOTAL	241	48,743

Three outlets drain water from Lake Lowell for use as irrigation by the city of Nampa, city of Caldwell and agricultural lands to the west (see Figure 25). Flow for a fourth canal, Deer Flat North Canal, is pumped from the Deer Flat Lowline Canal. Flow and nutrient data from these outlets are used to estimate the TP load leaving Lake Lowell (data in Appendix E). This information is helpful when used to estimate the reduction in internal TP load of the reservoir. Median flow in Deer Flat Nampa and Deer Flat Caldwell canals is 10 and 8 cfs, respectively. Median flow in Deer Flat Lowline canal is the highest at 560 cfs. The median TP concentration for all outlet canals is similar at 0.036 mg/L for Deer Flat Nampa and Caldwell canals and 0.035 mg/L for Deer Flat Lowline Canal. As expected, these measured outflow concentrations are consistent with internal reservoir TP concentrations (see Figure D-1 in Appendix D).

Based on monitoring conducted by DEQ in 2004-2006, the total load exiting the reservoir through the canals is 109 lbs/day (Table 35). This monitoring suggests that about 42% of the phosphorus load delivered to Lake Lowell on an annual basis is exported (see Figure 40), which indicates a very large load is available for internal cycling. Internal cycling of nutrients is complex and dependent upon the amount of plant and animal detritus in sediment, biological activity, frequency of turnover of water layers, flow (or wind agitation) that may stir up sediment, and sediment interface oxygen concentrations.

Table 35. Summary of Current TP loads from outlet canals draining Lake Lowell.

Outlet Waterway	n	Median TP Load (lbs/day)
Deer Flat Caldwell Canal	14	2.01
Deer Flat Nampa Canal	13	2.08
Deer Flat Lowline Canal	7	95.29
Total Current Load Leaving Lake Lowell through Canals		99.38

lbs/day = pounds per day
n = number of samples
TP = Total Phosphorus

Chlorophyll-*a*

Current concentrations of chlorophyll-*a* in Lake Lowell are calculated by the BETTER model for site BOI 181 and Site BOI 185 (Figure 41). Tributary TP concentrations were estimated using water quality sampling data collected in 2004. This was then used to predict chlorophyll-*a* concentrations in the model. Model input files for all other organic components were unchanged. Under current conditions, chlorophyll-*a* concentrations exceed the 10 µg/L target chlorophyll-*a* concentration at both sampling locations in late June and early July, and at Site BOI 181 in August and early September.

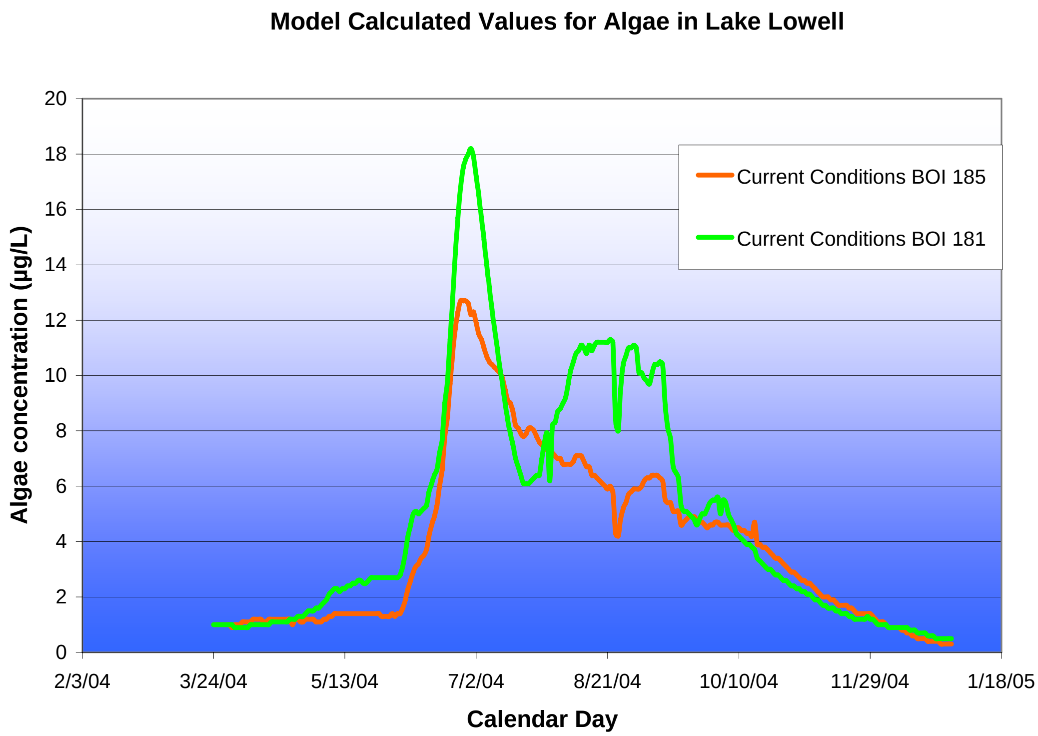

Figure 41. Calculated chlorophyll-*a* concentrations from BETTER model for Lake Lowell sites BOI 181 and BOI 185.

Dissolved Oxygen

Currently, DO concentrations in Lake Lowell fall below the minimum WQS concentration (5.0 mg/L) in 12% of all measurements (See Section 2.4). The DO concentrations are calculated as output from the BETTER model when 2004 TP tributary concentrations are entered into the model with no additional changes to coefficients or parameters. The DO output from the model for each 5 foot depth interval starting at a depth of 2.5 feet is included in Figure 42 and Figure 43 for the reservoir segments represented by sites BOI 185 and BOI 181. Water from the bottom 20% percent of the water column is excluded from meeting the 5.0 mg/L WQS (target concentration). In Figure 38 and Figure 39, plotted lines for times when the DO WQS does not apply are dashed and colored differently than coordinating depth interval lines for times that the WQS applies. As expected from DO data presented in the SBA, exceedances of the WQS do not occur at the shallowest site (BOI 185), but do occur for 18 days from mid-July to early August and again for 14 days from mid- August to the beginning of September at Site BOI 181.

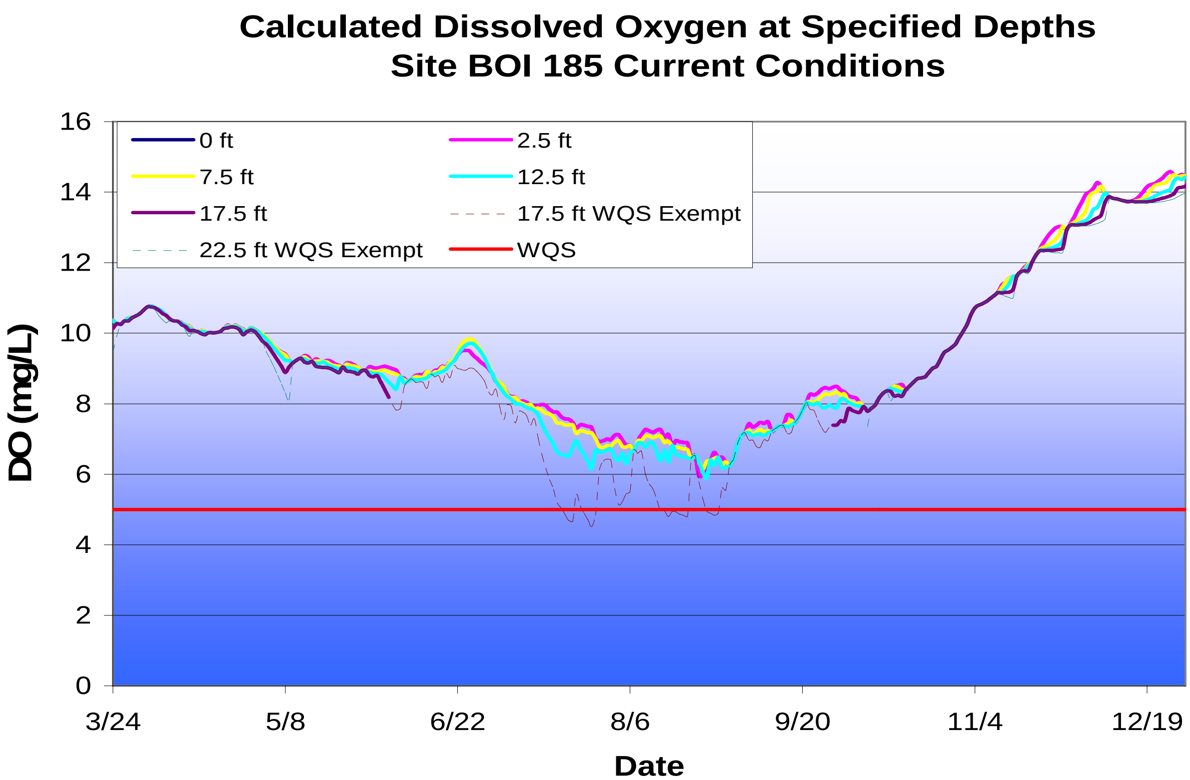

Figure 42. Dissolved oxygen concentrations from BETTER model for current conditions at Lake Lowell, site BOI 185.

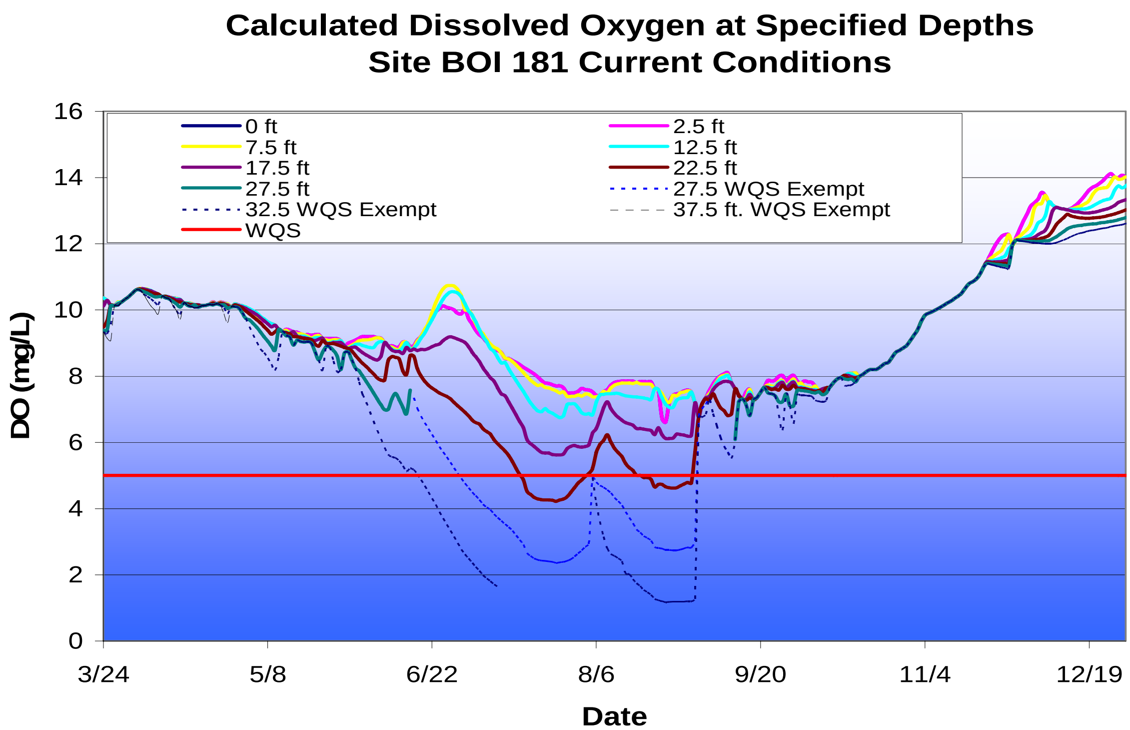

Figure 43. Dissolved oxygen concentrations from BETTER model for current conditions at Lake Lowell, site BOI 181.

5.4 Load Allocations

This section describes the DO and nutrient wasteload allocations (WLAs) and load allocations (LAs) for the Lake Lowell subbasin. Stormwater from urbanized areas in Ada and Canyon counties is an NPDES-permitted point source of phosphorus loads to Lake Lowell. The available TP load is allocated among the tributary waterways. Nutrient allocations are made based on the average daily flow for each tributary. All allocations are based on achieving the system load capacity of 152 lbs day and an average TP target concentration of 0.07 mg/L or less.

Point Source – Stormwater

Current stormwater load estimates and waste load allocations (WLAs) in this TMDL are based on loading analysis from the *Lower Boise River Implementation Plan Total Phosphorus* (DEQ 2008). To remain consistent throughout the subbasin the loading rates and allocation basis calculated for the implementation plan are used and text for the stormwater section of this TMDL is taken from the referenced document.

The stormwater WLA is based on existing loads, recognizing that retrofitting the existing systems is not feasible. Runoff from new urban development will need to be managed carefully, using appropriate BMPs and consistent with the overall TP reduction goal of 50% applied to new development and substantial redevelopment as in the *Lower Boise River*

Implementation Plan Total Phosphorus (2008) (Table 36). The 50% TP reduction from stormwater would be accomplished through establishing BMPs that target phosphorus reduction, and increased attention to on-site stormwater inspection, maintenance, and public education.

The WLAs and LAs provided for stormwater and agricultural sources are expressed as lbs/day and g/acre/day. Allocations in terms of g/acre/day loads are established to ensure nutrient sources will be controlled for these two land uses independently of any revised total number of acres for the two land uses in the future. Underlying this approach is an understanding that (1) the allocations are made to the land use acres and (2) the allocations for each land use established by the TMDL attains the load capacity for Lake Lowell. Please note, if agricultural acres are converted to urban stormwater acres, the net reduction in g/acre/day and in the total annual load to Lake Lowell would be an approximate annualized reduction of 1.01 g/acre/day. It is anticipated that these additional reductions to the annual nutrient load to Lake Lowell, if they occur, will be accounted for during the Five-Year Review of the Lake Lowell TMDL.

Table 36. Stormwater total phosphorus loads per acre for untreated, current, and future conditions.

Load Type	Treatment Level (%)	Load (g/ac/day)
Untreated	**0%**	**0.68**
Current Acres[1]	**30%**	**0.52**
Load Capacity for Future Acres[2]	**50%**	**0.34**

[1]Current Acres – acres included in Estimates of Existing Pollutant Loads section of this TMDL
[2]Future Acres –acres that substantially redeveloped or are converted from another land use designation to developed acres contributing to the stormwater load after this TMDL is submitted to EPA for approval.

Not all members of the stormwater workgroup for the *Lower Boise River Implementation Plan Total Phosphorus* (DEQ 2008) agree on the methodology used to estimate stormwater loads during both dry-weather and wet-weather conditions, particularly given the relative lack of stormwater monitoring data and a better understanding of what that monitoring data may represent. As part of the implementation process, the stormwater WLAs established in this TMDL may be reevaluated as additional data are collected and assessed.

Margin of Safety

A margin of safety (MOS) for this TMDL is based on conservative nutrient targets and load allocations. The MOS for this TMDL is partially implicit because the 0.07 mg/L TP target is conservative. This target relies on EPA's approved SR-HC TMDL (DEQ 2004) which utilized an implicit MOS of 13% that applied to tributaries of the Snake River and Brownlee Reservoir.

Conservative measures are also used in applying the BETTER model output to load allocations. The BETTER model input for all tributaries is 0.07 mg/L TP for the target condition simulation. Existing TP concentration in New York Canal, the largest TP load contributor, are less than 0.07 mg/L. Additional reductions from the current average concentration are incorporated in the New York Canal load allocation. These reductions are based on achievement of stormwater and agricultural TP reductions.

Model results indicate that meeting the TP target will result in a nearly two-thirds reduction in algal biomass from current conditions. This is expected to result in chlorophyll-*a* concentrations between 4 and 6 µg/L (Figure 41). This is below the proposed target of 10 µg/L commonly suggested for reservoirs to achieve desired levels of primary production. The TP target will allow the reservoir to meet Idaho's narrative criteria for nutrients and also result in DO concentrations that support WARM beneficial uses.

Seasonal Variation

Nutrient delivery to Lake Lowell is dependent on seasonal hydrology because the reservoir is supplied with water from irrigation canals and agricultural drains. These waterways have minimal or no flow during the non-irrigation season and peak pollutant delivery is in July and August, the months of highest irrigation water use. Total phosphorus targets of 0.07 mg/L or less for tributary waterways and the 5.0 mg/L DO WQS need to be met throughout the year.

Reasonable Assurance

The reasonable assurance that the Lake Lowell TMDL, will meet its goal of attaining WQS is based on three components: 1) point sources will meet the terms of their NPDES permits, which typically must be achieved within 2 permit cycles, 2) the assumption that voluntary implementation of BMPs is rigorous enough to meet the agricultural nonpoint source load ; and 3) assessment of overall progress towards attainment of WQS and related beneficial uses based on trend monitoring that documents relative changes in various aquatic organism populations and in physical and chemical water quality parameters over a 5-year period in conjunction with data from various agencies, organizations, and water user industries.

DEQ recognizes that implementation strategies for TMDLs may need to be modified if monitoring shows that the TMDL goals are not being met or significant progress is not being made toward achieving the goals. Current load estimates are based on water quality monitoring sites in the reservoir and tributary waterways. Future monitoring should continue and a monitoring plan should be considered as part of the implementation plan.

Background

Background concentrations of TP have been measured at or below 0.02 mg/L for the Lower Boise River at the diversion for New York Canal (the Boise River Diversion Dam) (1990-2008 data downloaded from http://waterdata.usgs.gov/nwis). For calculation of this concentration, non-detect measurements are assigned one-half method detection value. This method of non-detect value substitution is consistent with Chapter 3.5 of the DEQ Statistical Guidance for Determining Background Ground Water Quality and Degradation (DEQ 2009). Background load is estimated for New York Canal because it is the source of all water in the conveyance system. The annual background load of TP for New York Canal is 41.02 lbs/day (see Table 30.

Ground water loads on an annual basis have been estimated at 0.84 lbs/day (see Section 5.3).

Lake Lowell is heavily used by waterfowl during spring and fall migration seasons. Total phosphorus load estimates suggest that about 25 lbs/day (4,174 kg/yr) of the total reservoir phosphorus load is associated with waterfowl use (BOR 2001). BOR believes that much of the waterfowl loading occurs from September through January and that early spring reservoir operations flush out much of the waterfowl load before algal growth accelerates. Phosphorus sources from wildlife, especially since this is a designated wildlife refuge, are considered as natural background condition.

Reserve

A reserve for growth has not been specifically allocated for this TMDL. The watershed is becoming increasingly urban. Much of the nutrient loading resulting in impairment of beneficial uses is the result of runoff from agricultural land. As the land use shifts to urban, the pollutant load may decrease by 1.01 g/acre/day. . Thus, allocations are expected to decrease. Existing stormwater and agricultural sources, as well as any new point sources, are expected to meet the 0.07 mg/L or lower TP target in accordance with the land use acres and the allocations for each land use established by the TMDL attain the load capacity for Lake Lowell. And, it is anticipated that these additional reductions to the annual nutrient load to Lake Lowell, if they occur, will be accounted for during the Five-Year assessment of the Lake Lowell TMDL.

It should be noted that the City of Nampa is planning for additional wastewater treatment to accommodate population growth in the Lake Lowell drainage (see Appendix F). Current planning projections indicate that if the new plant discharges TP at an effluent concentration of 0.070 mg/L, it would generate 1,250 lbs/year. This load could be accommodated by the corresponding reduction in septic loading (currently estimated at 1,384 lbs/year, as shown in Table 34).

It should also be noted that a number of septic systems shown on the northwest corner of Lake Lowell may be taken offline when the City of Caldwell extends its sewer collection area as outlined in their master planning documents; these loads would be treated via Caldwell’s existing WWTF that discharges to the Boise River and represent a potential reduction in phosphorus loading to Lake Lowell.

Construction Storm Water and TMDL Wasteload Allocations

Construction Storm Water

The Clean Water Act (CWA) 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 nonpoint source of pollutants. However, because storm water can be managed on site or when discharged through a discrete conveyance such as a storm sewer, it now requires a National Pollution Discharge Elimination System (NPDES) 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.

Storm Water Pollution Prevention Plan (SWPPP)

In order to obtain the Construction General Permit (CGP) operators must develop a site-specific Storm Water Pollution Prevention Plan. The operator must document the erosion, sediment, and pollution controls they intend to use, inspect the controls periodically, and maintain the 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 did not have a WLA for construction storm water activities. DEQ considers construction operators in compliance with provisions of the TMDL if they obtain a CGP under the NPDES program and implement the appropriate BMPs.

Typically there are specific requirements that must be followed 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 BMPs 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 GCP, unless local ordinances have more stringent and site–specific standards that are applicable.

Remaining Available Load

The following should be considered the tabular summarization of the SBA and TMDL processes. They also the meet the legal definition of a TMDL such that:

$$TMDL = LC = NB + MOS + LA + WLA$$

Where
LC = Load Capacity
NB = Natural Background
MOS = Margin of Safety
LA = Load Allocation (nonpoint sources)
WLA = Waste Load Allocation (point sources)

Rearranging the equation and solving for Load Allocation yields:

$$LA = LC - MOS - NB - WLA$$

Individual components of the TMDL equation, LC, MOS, and NB, were presented in previous discussions. A background load is partitioned from New York Canal LA based on a 0.02 mg/L concentration and the mean flow. Background concentration for other tributary waterways is included in the LA for the tributary.

The current load estimate for New York Canal is less than the load associated with a 0.07 mg/L target concentration; therefore the LA is proportionally smaller so that the TP load does not increase from current conditions. Information was available to partition the New York

Canal load between background, stormwater and agricultural runoff sources. Natural background and stormwater LAs for Lake Lowell were discussed above. Load allocations for nonpoint sources are consistent with LAs and reductions for the same land use type in other tributary waterways.

To achieve the system load capacity, recognizing that background, ground water, and waterfowl loads cannot be reduced, control of point and non-point sources will be required. In the future, loading from septic systems can be reduced by expanding municipal wastewater treatment to include areas that currently use septic systems. In the interim, the septic load allocation is equal to the current TP load for this source. Consistent with other TMDLs in the Boise River watershed, sources have “shared the pain” and opted for consistent reductions. For example, in the sediment TMDL for the Boise River, each tributary was assigned a load reduction of 37% to meet the overall TMDL targets, even though some tributaries were contributing larger loads than others. Similarly, stormwater and agricultural sources are treated the same whether they drain to the New York Canal, or whether they drain to Lake Lowell directly. Loads from the New York Canal should decrease, which provides more flexibility for those landowners that drain directly to Lake Lowell.

The current total watershed load is 241 lbs/day, and the proposed load based on phosphorus reduction is 152 lbs/day, which is a 37% reduction in the total incoming TP load from tributary canals and drains (Table 37).

Table 37. Total phosphorus load allocations for Lake Lowell subbasin.

	Load Capacity (lbs/day)	Load Allocation (lbs/day)	Load Allocation (g/acre/day)	Percent Reduction
New York Canal (+ Ridenbaugh Canal)				
Background		41.02	--	0
NPDES Permitted Discharges				
Stormwater: MS4s[a]				
Current Acres		6.78	0.52	0
Future Acres Converted from Agricultural to Urban			0.34	
Stormwater: Construction		0		
Stormwater: AFOs		0		
Non-Point Sources				
Agricultural		15.96	1.35	56
Septic Systems		?		
Ground Water		?		
MEDIAN LOAD	84.07	63.76		
Drains (Monitored and Unmonitored)				
NPDES Permitted Discharges				
Stormwater: MS4s[a]				
Current Acres		0.83	0.52	0
Future Acres Converted from Agricultural to Urban			0.34	
Stormwater: Construction		0		
Stormwater: AFOs		0		
Non-Point Sources				
Agricultural		54.23	1.35	56
Septic Systems		0		
Ground Water		?		
MEDIAN LOAD	35.22	55.06		
Lake Lowell				
Septic Systems	6.53	6.53		
Ground Water	0.84	0.84		
Waterfowl[b]	25.26	25.26		
Internal Reservoir Active Load	?	?		?
MEDIAN LOAD	32.63	32.63		
TOTAL	152	152		37

[a]Stormwater MS4 allocations: For acres contributing at the time of TMDL development no reduction is necessary and discharge needs to be the result of 30% BMP effectiveness. For all future acres converted to urban use, stormwater BMP effectiveness needs to achieve 50% effectiveness.
[b]Phosphorus load from waterfowl was estimated by BOR (BOR 2001).
? – Indicates a data gap that will need to be addressed.
lbs/day = pounds per day
g/acre/day = grams per acre per day
MS4 = municipal separate storm sewer system
NPDES = National pollutant discharge elimination system
AFO = animal feeding operation

The WLAs and LAs provided for stormwater and agricultural sources are expressed as lbs/day and g/acre/day. Allocations in terms of g/acre/day loads are established to ensure nutrient sources will be controlled for these two land uses independently of any revised total number of acres for the two land uses in the future. Underlying this approach is an understanding that (1) the allocations are made to the land use acres and (2) the allocations for each land use established by the TMDL attains the load capacity for Lake Lowell. Please note, if agricultural acres are converted to urban stormwater acres, the net reduction in g/acre/day and in the total annual load to Lake Lowell would be an approximate annualized reduction of 1.01 g/acre/day. It is anticipated that these additional reductions to the annual nutrient load to Lake Lowell, if they occur, will be accounted for during the Five-Year Review of the Lake Lowell TMDL.

The target for TP for each tributary is a concentration of less than or equal to 0.07 mg/L or less TP as measured at the mouth of the tributary and applies throughout the year. Because the TP target is concentration-based, actual allowable tributary LAs under the TMDL are dependant on actual tributary flow and will fluctuate year to year. The TP LAs listed in this table are based on median tributary canal and drain flows measured in 2002, 2004, 2005 and 2006, which are not necessarily average irrigation years. Therefore they do not necessarily represent the calculated LAs for any specific year or different series of years.

The DO WQS of 5.0 mg/L at all times is expected to be met after the 0.07 mg/L or less load allocations met and the internal load of phosphorus in the reservoir is buried under reservoir sediment.

It is the responsibility of the land management agencies and private individuals to determine appropriate BMPs to meet the nonpoint source LAs during the implementation plan development. A finer allocation based on land ownership or other mechanism is not needed at this time and likely won't be necessary if water quality targets can be met by the aggregate reductions of those sources that are prescribed a reduction in load through the implementation plan. Cost effectiveness of both reservoir and tributary waterway BMP implementation should be considered in all implementation projects. A total reduction of 89 lbs/day of phosphorus needs to be achieved to restore beneficial uses. Most of the phosphorus load comes from privately-owned agricultural land. Prioritization for BMP implementation to reduce phosphorus loads should be assessed as cooperative agreements are made and not limited to reducing TP contribution on all tributary waterways at the same rate. The goal of this TMDL is to restore beneficial uses to Lake Lowell by reducing the overall TP load to the reservoir by 89 lbs/day; therefore phosphorus reductions from any source will help meet this goal.

5.5 Implementation Strategies

The purpose of this implementation strategy is to outline the pathway by which a more specific implementation plan will be developed within 18 months of TMDL approval. The more specific implementation plan will provide details of the actions needed to achieve load reductions (set forth in this TMDL), set a schedule for those actions, and specify monitoring needed to document actions and progress toward meeting state water quality standards. In the meantime, a cursory implementation strategy is developed to identify the general issues such as responsible parties, a time line, and a monitoring strategy for determining progress toward meeting the TMDL goals outlined in this document.

The objective of the Lake Lowell Subbasin TMDL is to allocate total phosphorus loads among different pollutant sources, so that the appropriate control actions can be taken and WQS can be achieved. The total pollutant load on these water bodies is derived from nonpoint sources. The TMDL has attempted to consider the effect of all activities or processes that cause or contribute to the water quality-limited conditions.

Control measures to implement this TMDL do not contain NPDES authorities, with the exception of stormwater, but are based on the reasonable assurance that state and local authorities will act to reduce nonpoint source pollution. An outline of basic responsible parties is provided below. The Lake Lowell TMDL has LAs calculated with margins of safety to meet water quality standards. The allocations, however, are based on estimates that have used available data and information. Monitoring to collect new data is necessary to assess progress toward the target phosphorus load reduction.

Time Frame

The expected time frame for attaining WQS and restoring beneficial uses is a function of management intensity, climate, ecological potential, and natural variability of environmental conditions. It is recognized that improvement in water quality will not be instantaneous as there is already a substantial store of organic material in the reservoir. Even with aggressive BMP implementation, depletion of nutrient loads currently stored in the reservoir sediment may not occur for many years. The effects of historic land management activities have accrued over many decades and recovery of natural beneficial uses may take longer than anticipated.

Total phosphorus target concentrations and estimated load reductions of phosphorus in lbs/day have been identified as part of this LA process. A preliminary goal set in this TMDL to encourage identification of implementation priorities is to reduce TP concentration in tributary waterways by at least 0.1 mg/L every 5 years until the target concentration or LAs are met. It is expected that these preliminary goals will be refined as site-specific implementation plans are developed and information on nutrient reduction efficiency is collected. Assuming active BMP implementation and available financial resources we expect beneficial use support to be achieved in 20-30 years.

Responsible Parties

Development of the final implementation plan for the Lake Lowell TMDL will proceed under the existing practice established for the state of Idaho. The plan will be cooperatively developed by the Lower Boise WAG, the affected private landowners, and “designated agencies,” with DEQ cooperation and input. Of the four entities, the WAG will act as an integral part of the implementation planning process to identify appropriate implementation measures. Other individuals may also be identified to assist in the development of the site-specific implementation plans if their areas of expertise are identified as being beneficial to the process.

Designated state agencies are responsible for assisting with preparation of specific implementation plans, particularly for those sources for which they have regulatory authority or programmatic responsibilities. Idaho’s designated state management agencies are:

- Idaho Department of Lands (IDL): timber harvest, oil and gas exploration and development mining.
- Idaho Soil and Water Commission (SWC) and County Soil Conservation Districts: grazing and agriculture.
- Idaho Transportation Department (ITD): public roads.
- Idaho State Department of Agriculture (ISDA): aquaculture, animal feeding operations (AFOs), confined animal feeding operations (CAFOs).
- Idaho Department of Environmental Quality: all other activities.

To the maximum extent possible, the implementation plan will be developed with the participation of federal partners and land management agencies (i.e., Natural Resource Conservation Service, U.S. Fish and Wildlife Service, Bureau of Reclamation, and Environmental Protection Agency). In Idaho, these agencies, and their federal and state partners, are charged by the CWA to lend available technical assistance and other appropriate support to local efforts/projects for water quality improvements.

All stakeholders in the Lake Lowell watershed have responsibility for implementing the TMDL. DEQ and "designated agencies" in Idaho have primary responsibility for overseeing implementation in cooperation with landowners and managers. Their general responsibilities are outlined below:

- **DEQ** will oversee and track overall progress on the specific implementation plan and monitor the watershed response. DEQ will also work with local governments on urban/suburban issues.
- **SWC**, working in cooperation with local Soil and Water Conservation Districts and NRCS, will provide technical assistance to agricultural landowners. These agencies will help landowners design BMP systems appropriate for their property, and identify and seek appropriate cost-share funds. They also will provide periodic project reviews to ensure BMPs are working effectively. Implementation of BMPs for non-point source pollution is done on a voluntary basis by private landowners.
- **ITD** will be responsible for ensuring appropriate BMPs are used for construction and maintenance of public roads.
- **ISDA** will be responsible for working with agriculture and aquaculture operators to install appropriate pollutant control measures. Under a memorandum of understanding with EPA and DEQ, ISDA also inspects AFOs, CAFOs and dairies to ensure compliance with NPDES requirements.
- **BOR** will be responsible for appropriate maintenance and operation of water conveyance, storage, and hydroelectric facilities and assessing the effects of pollutants on their facilities.

The designated agencies, the WAG, and other appropriate public process participants are expected to:

- Develop and implement BMPs to achieve LAs.

- Give reasonable assurance that management measures will meet LAs through both quantitative and qualitative analysis of management measures.
- Adhere to measurable milestones for progress.
- Develop a reasonable timeline for implementation in order to achieve WQS and beneficial uses as identified in the time frame to achieve beneficial use support, with reference to costs and funding.
- Develop and implement a monitoring plan to determine if BMPs are being implemented, BMP effectiveness, LA and WLA attainment, and WQS attainment.

In addition to the designated agencies, the public, through the WAG's process and other equivalent processes, will be provided with opportunities to be involved in developing the implementation plan to the maximum extent practical. Public participation significantly affects public acceptance of the document and the proposed control actions. Stakeholders (landowners, local governing authorities, taxpayers, industries, and land managers) are the most educated regarding the pollutant sources and will be called upon to help identify the most appropriate control actions for each area. Experience has shown that the best and most effective implementation plans are those that are developed with substantial public cooperation and involvement.

Monitoring Strategy

The objectives of a monitoring effort are to demonstrate any long-term recovery, provide better understanding of natural variability, track implementation of projects and BMPs and track effectiveness of TMDL implementation. This monitoring and feedback mechanism is a major component of the "reasonable assurance of implementation" for the TMDL implementation plan.

The implementation plan will be tracked by accounting for the numbers, types, and locations of projects, BMPs, educational activities, or other actions taken to improve or protect water quality. The mechanism for tracking specific implementation efforts will be reports submitted to DEQ.

The "monitoring and evaluation" component has two basic categories:

- Tracking the implementation progress of specific implementation plans; and
- Tracking the progress of improving water quality through monitoring physical, chemical, and biological parameters.

Monitoring plans will provide information on progress being made toward achieving TMDL allocations and achieving water quality standards and will help in the interim evaluation of progress as described under the adaptive management approach.

Implementation plan monitoring has two major components:

- watershed monitoring, and
- BMP monitoring.

While DEQ has the primary responsibility for watershed monitoring, other agencies and entities have shown an interest in such monitoring. In these instances, data sharing is encouraged. The designated agencies have primary responsibility for BMP monitoring.

Watershed Monitoring

Watershed monitoring measures the success of the implementation measures in accomplishing the overall TMDL goals and includes both reservoir and tributary waterway monitoring. Monitoring of BMPs measures the success of individual pollutant reduction projects. Implementation plan monitoring will also supplement the watershed information available during the development of associated TMDLs and will fill data gaps.

In the Lake Lowell Subbasin TMDL, watershed monitoring has the following objectives:

- Evaluate watershed pollutant sources,
- Refine baseline conditions and pollutant loading,
- Evaluate trends in water quality data,
- Evaluate the effectiveness of implementation actions in reducing pollutant loadings, and
- Gather information and fill data gaps to more accurately determine pollutant loading.

BMP/Project Effectiveness Monitoring

Site or BMP-specific monitoring may be included as part of specific implementation projects if determined appropriate and justified. Such projects will be the responsibility of the designated project manager or grant recipient. The objective of an individual project monitoring plan is to verify that BMPs are properly used and maintained and are working as designed. Monitoring for pollutant reductions at individual projects typically consists of spot checks, annual reviews, and evaluation of advancement toward reduction goals. The results of these reviews can be used to recommend or discourage similar projects in the future and to identify specific watersheds or reaches that are particularly ripe for improvement.

Evaluation of Efforts over Time

Reports on progress toward TMDL implementation will be prepared to provide the basis for the assessment and evaluation of progress. Documentation of TMDL implementation activities, actual pollutant reduction effectiveness, and projected load reductions for planned actions will be included. If water quality goals are being met, or if trend analyses show that implementation activities are resulting in benefits that indicate that water quality objectives will be met in a reasonable period of time, then implementation of the plan will continue. If monitoring or analyses show that water quality goals are not being met, the strategy for implementation activities will be revised.

5.6 Conclusions

Lake Lowell was placed on the 1998 §303(d) list and carried forward to the 2008 §303(d) list for nutrient and dissolved oxygen impairment. The reservoir was examined for all sources of impairment and the suspected pollutant sources were confirmed; the outcomes are listed in Table 38. Reservoir modeling efforts show that a decrease in phosphorus loading to 0.07 mg/L or less for all tributary waterways would result in meeting dissolved oxygen and nutrient WQS and restoration of beneficial uses.

The Lake Lowell TMDL for total phosphorus is specified and discussed in this document. Related implementation activities should focus on reducing total incoming phosphorus loads by 37%. A 56% reduction in current TP loads for agricultural acres is required. As a result of decreasing phosphorus loads, it is anticipated that algae concentration will decrease and dissolved oxygen concentrations will increase, resulting in restoration of all beneficial uses.

Table 38. Summary of assessment outcomes.

Water Body Segment/ AU	Pollutant	TMDL(s) Completed	Recommended Changes to §303(d) List	Justification
Lake Lowell 17050114SW004_06	Dissolved Oxygen	Total Phosphorus as Surrogate for Dissolved Oxygen	Move to Section 4a in the Integrated Report	Violation of numeric dissolved oxygen WQ criteria
Lake Lowell 17050114SW004_06	Nutrients	Total Phosphorus	Move to Section 4a in the Integrated Report	Data indicate impairment for primary contact recreation, aesthetic value and special resource water due to nuisance aquatic vegetation

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GIS Coverages

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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.

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).

Ammonification

When a plant dies, an animal dies, or an animal expels waste, the initial form of nitrogen is organic. Bacteria, or in some cases, fungi, convert the organic nitrogen within the remains back into ammonium (NH_4^+), a process called ammonification

Anaerobic

Describes the processes that occur in the absence of molecular oxygen and describes the condition of water that is devoid of molecular oxygen.

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.

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.

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.

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.

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).

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.

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.

Decomposition

The breakdown of organic molecules (e.g., sugar) to inorganic molecules (e.g., carbon dioxide and water) through biological and nonbiological processes.

Denitrification

The process of decomposition of nitrites and nitrates (by bacteria) that results in the eventual release of nitrogen gas into the atmosphere

Designated Uses	Those water uses identified in state water quality standards that must be achieved and maintained as required under the Clean Water Act.
Detritivore	Heterotrophs that obtain nutrients by consuming detritus (decomposing organic matter)
Dimictic	Describes lakes and reservoirs that freeze over and normally go through two stratification mixing cycles within a year
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.
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.

Epilimnion

The top-most layer in a thermally stratified lake, occurring above the deeper hypolimnion. It is warmer and typically has a higher pH and dissolved oxygen concentration than the hypolimnion. Being exposed at the surface, it typically becomes turbulently mixed as a result of surface wind-mixing. It is also free to exchange dissolved gases (i.e. O_2 and CO_2) with the atmosphere.

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).

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

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).

Flow
See *Discharge*.

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

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.

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.

Hypolimnion

The dense, bottom layer of water in a thermally-stratified lake. It is the layer that lies below the thermocline. Typically the hypolimnion is the coldest layer of a lake in summer, and the warmest layer during winter. Being at depth, it is isolated from surface wind-mixing during summer, and usually receives insufficient irradiance (light) for photosynthesis to occur.

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.

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.

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.

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.

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.

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.

Metalimnion

The middle layer of a thermally stratified lake or reservoir. In this layer there is a rapid decrease in temperature with depth. Also called thermocline.

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).

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.

Nitrogen Fixation

The biological process by which nitrogen (N_2) is converted into ammonia.

Nitrification

The biological oxidation of ammonia with oxygen into nitrite followed by the oxidation of these nitrites into nitrates.

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 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.

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.

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.
Polymictic	lakes that do not develop strong thermal stratification; thus, their waters can mix from top to bottom throughout the ice-free period
Population	A group of interbreeding organisms occupying a particular space; the number of humans or other living creatures in a designated area.
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.
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. 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.
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.

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.

Subbasin

A large watershed of several hundred thousand acres. This is the name commonly given to 4^{th} 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 6^{th} field hydrologic units.

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.

Thermocline

A thin but distinct layer in a lake or reservoir, in which temperature changes more rapidly with depth than it does in the layers above or below. The thermocline may be thought of as an invisible blanket which separates the upper mixed layer from the calm deep water below. Also known as the metalimnion.

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 Dissolved Solids

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

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 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.

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.

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 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.

Appendix A. Unit Conversion Chart

Table A-1. Metric - English unit conversions.

	English Units	Metric Units	To Convert	Example
Distance	Miles (mi)	Kilometers (km)	1 mi = 1.61 km 1 km = 0.62 mi	3 mi = 4.83 km 3 km = 1.86 mi
Length	Inches (in) Feet (ft)	Centimeters (cm) Meters (m)	1 in = 2.54 cm 1 cm = 0.39 in 1 ft = 0.30 m 1 m = 3.28 ft	3 in = 7.62 cm 3 cm = 1.18 in 3 ft = 0.91 m 3 m = 9.84 ft
Area	Acres (ac) Square Feet (ft^2) Square Miles (mi^2)	Hectares (ha) Square Meters (m^2) Square Kilometers (km^2)	1 ac = 0.40 ha 1 ha = 2.47 ac 1 ft^2 = 0.09 m^2 1 m^2 = 10.76 ft^2 1 mi^2 = 2.59 km^2 1 km^2 = 0.39 mi^2	3 ac = 1.20 ha 3 ha = 7.41 ac 3 ft^2 = 0.28 m^2 3 m^2 = 32.29 ft^2 3 mi^2 = 7.77 km^2 3 km^2 = 1.16 mi^2
Volume	Gallons (gal) Cubic Feet (ft^3)	Liters (L) Cubic Meters (m^3)	1 gal = 3.78 L 1 L= 0.26 gal 1 ft^3 = 0.03 m^3 1 m^3 = 35.32 ft^3	3 gal = 11.35 L 3 L = 0.79 gal 3 ft^3 = 0.09 m^3 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 1 m^3/sec = 35.31cfs	3 ft^3/sec = 0.09 m^3/sec 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 1 kg = 2.20 lbs	3 lb = 1.36 kg 3 kg = 6.61 lb
Temperature	Fahrenheit (°F)	Celsius (°C)	°C = 0.55 (F - 32) °F = (C x 1.8) + 32	3 °F = -15.95 °C 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.

Appendix B. State and Site-Specific Standards and Criteria

IDAPA 58 TITLE 01 CHAPTER 02
58.01.02 - WATER QUALITY STANDARDS

056. SPECIAL RESOURCE WATERS.
01. Designations. Waters of the state may be designated as special resource waters. Designation as a special resource water recognizes at least one (1) of the following characteristics: (7-1-93)

a. The water is of outstanding high quality, exceeding both criteria for primary contact recreation and cold water aquatic life; (4-5-00)
b. The water is of unique ecological significance; (7-1-93)
c. The water possesses outstanding recreational or aesthetic qualities; (7-1-93)
d. Intensive protection of the quality of the water is in paramount interest of the people of Idaho; (7-1-93)
e. The water is a part of the National Wild and Scenic River System, is within a State or National Park or wildlife refuge and is of prime or major importance to that park or refuge; or (4-5-00)
f. Intensive protection of the quality of the water is necessary to maintain an existing, but jeopardized beneficial use. (4-5-00)

02. Designated Waters. Those waters of the state determined to be special resource waters are listed in Sections 110 through 160. (4-5-00)

03. Restrictions of Point Source Discharges to Special Resource Waters and Their Tributaries. Point source discharges to special resource waters and their tributaries shall be restricted as specified in Subsection 400.01.b.

100. SURFACE WATER USE DESIGNATIONS.
Waterbodies are designated in Idaho to protect water quality for existing or designated uses. The designated use of a waterbody does not imply any rights to access or ability to conduct any activity related to the use designation, nor does it imply that an activity is safe. For example, a designation of primary or secondary contact recreation may occur in areas where it is unsafe to enter the water due to water flows, depth or other hazardous conditions. Another example is that aquatic life uses may be designated in areas that are closed to fishing or access is not allowed by property owners. Wherever attainable, the designated beneficial uses for which the surface waters of the state are to be protected include: (3-15-02)

01. Aquatic Life. (7-1-93)

a. Cold water (COLD): water quality appropriate for the protection and maintenance of a viable aquatic life community for cold water species. (4-5-00)
b. Salmonid spawning (SS): waters which provide or could provide a habitat for active self-propagating populations of salmonid fishes. (3-30-07)
c. Seasonal cold water (SC): water quality appropriate for the protection and maintenance of a viable aquatic life community of cool and cold water species, where cold water aquatic life may be absent during, or tolerant of, seasonally warm temperatures. (4-5-00)
d. Warm water (WARM): water quality appropriate for the protection and maintenance of a viable aquatic life community for warm water species. (4-5-00)
e. Modified (MOD): water quality appropriate for an aquatic life community that is limited due to one (1) or more conditions set forth in 40 CFR 131.10(g) which preclude attainment of reference streams or conditions. (4-5-00)

02. Recreation. (7-1-93)

a. Primary contact recreation (PCR): water quality appropriate for prolonged and intimate contact by humans or for recreational activities when the ingestion of small quantities of water is likely to occur. Such activities include, but are not restricted to, those used for swimming, water skiing, or skin diving. (4-5-00)
b. Secondary contact recreation (SCR): water quality appropriate for recreational uses on or about the water and which are not included in the primary contact category. These activities may include fishing, boating, wading, infrequent swimming, and other activities where ingestion of raw water is not likely to occur. (4-5-00)

03. Water Supply. (7-1-93)

a. Domestic: water quality appropriate for drinking water supplies. (4-5-00)
b. Agricultural: water quality appropriate for the irrigation of crops or as drinking water for livestock. This use applies to all surface waters of the state. (4-5-00)
c. Industrial: water quality appropriate for industrial water supplies. This use applies to all surface waters of the state.

101. NONDESIGNATED SURFACE WATERS.
01. Undesignated Surface Waters. Surface waters not designated in Sections 110 through 160 shall be designated according to Section 39-3604, Idaho Code, taking into consideration the use of the surface water and such physical, geological, chemical, and biological measures as may affect the surface water. Prior to designation, undesignated waters shall be protected for beneficial uses, which includes all recreational use in and on the water and the protection and propagation of fish, shellfish, and wildlife, wherever attainable. (3-23-98)

a. Because the Department presumes most waters in the state will support cold water aquatic life and primary or secondary contact recreation beneficial uses, the Department will apply cold water aquatic life and primary or secondary contact recreation criteria to undesignated waters unless Sections 101.01.b and 101.01c. are followed. (4-5-00)
b. During the review of any new or existing activity on an undesignated water, the Department may examine all relevant data or may require the gathering of relevant data on beneficial uses; pending determination in Section 101.01.c. existing activities will be allowed to continue. (3-23-98)
c. If, after review and public notice of relevant data, it is determined that beneficial uses in addition to or other than cold water aquatic life and primary or secondary contact recreation are appropriate, then the Department will: (4-5-00) i. Complete the review and compliance determination of the activity in context with the new information on beneficial uses, and (3-23-98) ii. Initiate rulemaking necessary to designate the undesignated water, including providing all necessary data and information to support the proposed designation.

109.HUC INDEX AND ABBREVIATIONS FOR SECTIONS 110, 120, 130, 140, 150, AND 160.
03. Abbreviations. (4-5-00)

a. COLD -- Cold Water Communities. (4-5-00)
b. SS -- Salmonid Spawning. (4-5-00)
c. SC -- Seasonal Cold Water Communities. (4-5-00)
d. WARM -- Warm Water Communities. (4-5-00)
e. MOD -- Modified Communities. (4-5-00)
f. PCR -- Primary Contact Recreation. (4-5-00)
g. SCR -- Secondary Contact Recreation. (4-5-00)
h. DWS -- Domestic Water Supply. (4-5-00)
i. SRW -- Special Resource Water. (4-5-00)
j. NONE -- Use Unattainable. (4-5-00)
k. No entry in the Aquatic Life or Recreation columns -- nondesignated waters for those uses. (3-15-02)

200.GENERAL SURFACE WATER QUALITY CRITERIA.
The following general water quality criteria apply to all surface waters of the state, in addition to the water quality criteria set forth for specifically designated waters. (4-5-00)
01. Hazardous Materials. Surface waters of the state shall be free from hazardous materials in concentrations found to be of public health significance or to impair designated beneficial uses. These materials do not include suspended sediment produced as a result of nonpoint source activities. (8-24-94)
02. Toxic Substances. Surface waters of the state shall be free from toxic substances in concentrations that impair designated beneficial uses. These substances do not include suspended sediment produced as a result of nonpoint source activities. (8-24-94)

03. Deleterious Materials. Surface waters of the state shall be free from deleterious materials in concentrations that impair designated beneficial uses. These materials do not include suspended sediment produced as a result of nonpoint source activities. (8-24-94)

04. Radioactive Materials. (7-1-93)

a. Radioactive materials or radioactivity shall not exceed the values listed in the Code of Federal Regulations, Title 10, Chapter 1, Part 20, Appendix B, Table 2, Effluent Concentrations, Column 2. (8-24-94)

b. Radioactive materials or radioactivity shall not exceed concentrations required to meet the standards set forth in Title 10, Chapter 1, Part 20, of the Code of Federal Regulations for maximum exposure of critical human organs in the case of foodstuffs harvested from these waters for human consumption. (7-1-93)

05. 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. This matter does not include suspended sediment produced as a result of nonpoint source activities. (8-24-94)

06. 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. (8-24-94)

07. Oxygen-Demanding Materials. Surface waters of the state shall be free from oxygen-demanding materials in concentrations that would result in an anaerobic water condition. (7-1-93)

08. Sediment. Sediment shall not exceed quantities specified in Sections 250 and 252, or, in the absence of specific sediment criteria, quantities which impair designated beneficial uses. Determinations of impairment shall be based on water quality monitoring and surveillance and the information utilized as described in Section 350. (4-5-00)

09. Natural Background Conditions as Criteria. When natural background conditions exceed any applicable water quality criteria set forth in Sections 210, 250, 251, 252, or 253, the applicable water quality criteria shall not apply; instead, there shall be no lowering of water quality from natural background conditions. Provided, however, that temperature may be increased above natural background conditions when allowed under Section 401. (3-30-07)

210.NUMERIC CRITERIA FOR TOXIC SUBSTANCES FOR WATERS DESIGNATED FOR AQUATIC LIFE, RECREATION, OR DOMESTIC WATER SUPPLY USE.

01. Criteria for Toxic Substances. The criteria of Section 210 apply to surface waters of the state as follows. (5-3-03)

a. Columns B1, B2, and C2 of the following table apply to waters designated for aquatic life use. (5-3-03)

b. Column C2 of the following table applies to waters designated for recreation use. (5-3-03)

c. Column C1 of the following table applies to waters designated for domestic water supply use.

Table B-1. Excerpt from toxic substances table in IDAPA 58.01.02.

Compound	[a]CMC (µg/L) B1	[a]CCC (µg/L) B2	Water & Organisms (µg/L) C1	Organisms Only (µg/L) C2
Mercury	[b]	[b]		
Methylmercury				0.3 mg/kg [c]

a. See definitions of Acute Criteria (CMC) and Chronic Criteria (CCC), Section 010 of the WQS.
b. No aquatic life criterion is adopted for inorganic mercury. However, the narrative criteria for toxics in Section 200 of these rules applies. The Department believes application of the human health criterion for methylmercury will be protective of aquatic life in most situations.
c. This fish tissue residue criterion (TRC) for methylmercury is based on a human health reference dose (RfD) of 0.0001 mg/kg body weight-day; a relative source contribution (RSC) estimated to be 27% of the RfD; a human body weight (BW) of 70 kg (for adults); and a total fish consumption rate of 0.0175 kg/day for the general population, summed from trophic level (TL) breakdown of TL2 = 0.0038 kg fish/day + TL3 = 0.0080 kg fish/day + TL4 = 0.0057 kg fish/day. This is a criterion that is protective of the general population. A site-specific criterion or a criterion for a particular subpopulation may be calculated by using local or regional data, rather than the above default values, in the formula: TRC = [BW x {RfD – (RSC x RfD)}] / TL. In waters inhabited by species listed as threatened or endangered under the Endangered Species Act or designated as their critical habitat, the Department will apply the human health fish tissue residue criterion for methylmercury to the highest trophic level available for sampling and analysis.

iv. **Implementation Guidance for the Idaho Mercury Water Quality Criteria.** (4-6-05) (1) The "Implementation Guidance for the Idaho Mercury Water Quality Criteria" describes in detail suggested methods for discharge related monitoring requirements, calculation of reasonable potential to exceed (RPTE) water quality criteria in determining need for mercury effluent limits, and use of fish tissue mercury data in calculating mercury load reductions. This guidance, or its updates, will provide assistance to the Department and the public when implementing the methylmercury criterion. The "Implementation Guidance for the Idaho Mercury Water Quality Criteria" also provides basic background information on mercury in the environment, the novelty of a fish tissue criterion for water quality, the connection between human health and aquatic life protection, and the relation of environmental programs outside of Clean Water Act programs to reducing mercury contamination of the IDAHO ADMINISTRATIVE CODE IDAPA 58.01.02 Department of Environmental Quality Water Quality Standards Page 145 IAC 2007 environment. The "Implementation Guidance for the Idaho Mercury Water Quality Criteria" is available at the Department of Environmental Quality, 1410 N. Hilton, Boise, Idaho 83706, and www.deq.idaho.gov. (4-6-05) (2) The implementation of a fish tissue criterion in NPDES permits and TMDLs requires a non-traditional approach, as the basic criterion is not a concentration in water. In applying the methylmercury fish tissue criterion in the context of NPDES effluent limits and TMDL load reductions, the Department will assume change in fish tissue concentrations of methylmercury are proportional to change in water body loading of total mercury. Reasonable potential to exceed (RPTE) the fish tissue criterion for existing NPDES sources will be based on measured fish tissue concentrations potentially affected by the discharge exceeding a specified threshold value, based on uncertainty due to measurement variability. This threshold value is also used for TMDL decisions. Because measured fish tissue concentrations do not reflect the effect of proposed new or increased discharge of mercury, RPTE in these cases will be based upon an estimated fish tissue methylmercury concentration, using projected changes in waterbody loading of total mercury and a proportional response in fish tissue mercury. For the above purposes, mercury will be measured in the skinless filets of sport fish using techniques capable of detecting tissue concentrations down to point zero five (0.05) mg/kg. Total mercury analysis may be used, but will be assumed to be all methylmercury for purposes of implementing the criterion.

250.SURFACE WATER QUALITY CRITERIA FOR AQUATIC LIFE USE DESIGNATIONS.

01. General Criteria. The following criteria apply to all aquatic life use designations. Surface waters are not to vary from the following characteristics due to human activities: (3-15-02)

a. Hydrogen Ion Concentration (pH) values within the range of six point five (6.5) to nine point zero (9.0); (3-30-01)

b. The total concentration of dissolved gas not exceeding one hundred and ten percent (110%) of saturation at atmospheric pressure at the point of sample collection; (7-1-93)

02. Cold Water. Waters designated for cold water aquatic life are not to vary from the following characteristics due to human activities: (3-15-02)

a. Dissolved Oxygen Concentrations exceeding six (6) mg/l at all times. In lakes and reservoirs this standard does not apply to: (7-1-93) i. The bottom twenty percent (20%) of water depth in natural lakes and reservoirs where depths are thirty-five (35) meters or less. (7-1-93) ii. The bottom seven (7) meters of water depth in natural lakes and reservoirs where depths are greater than thirty-five (35) meters. (7-1-93) iii. Those waters of the hypolimnion in stratified lakes and reservoirs. (7-1-93)

b. Water temperatures of twenty-two (22) degrees C or less with a maximum daily average of no greater than nineteen (19) degrees C. (8-24-94)

c. Temperature in lakes shall have no measurable change from natural background conditions. Reservoirs with mean detention times of greater than fifteen (15) days are considered lakes for this purpose.(3-15-02)

d. Ammonia. The following criteria are not to be exceeded dependent upon the temperature, T (degrees C), and pH of the water body: (3-15-02)

i. Acute Criterion (Criterion Maximum Concentration (CMC)). The one (1) hour average concentration of total ammonia nitrogen (in mg N/L) is not to exceed, more than once every three (3) years, the value calculated using the following equation: (3-15-02)

$$CMC = \frac{0.275}{1 + 10^{7.204 - pH}} + \frac{39.0}{1 + 10^{pH - 7.204}}$$

ii. Chronic Criterion (Criterion Continuous Concentration (CCC)). (3-15-02) (1) The thirty (30) day average concentration of total ammonia nitrogen (in mg N/L) is not to exceed, more than once every three (3) years, the value calculated using the following equations: (3-15-02)

(a) When fish early life stages are likely present:

$$CCC = \left(\frac{0.0577}{1+10^{7.688-pH}} + \frac{2.487}{1+10^{pH-7.688}}\right) \bullet MIN(2.85, 1.45 \cdot 10^{0.028(25-T)})$$

(b) When fish early life stages are likely absent:

$$CCC = \left(\frac{0.0577}{1+10^{7.688-pH}} + \frac{2.487}{1+10^{pH-7.688}}\right) \bullet 1.45 \cdot 10^{0.028(25-T)})$$

(2) The highest four-day (4) average within the thirty-day (30) period should not exceed two point five (2.5) times the CCC. (3-15-02)

(3) Because the Department presumes that many waters in the state may have both spring-spawning and fall-spawning species of fish present, early life stages of fish may be present throughout much of the year. Accordingly, the Department will apply the CCC for when fish early life stages are present at all times of the year unless: (3-15-02)

(a) Time frames during the year are identified when early life stages are unlikely to be present, and (3-15-02)
(b) The Department is provided all readily available information supporting this finding such as the fish species distributions, spawning periods, nursery periods, and the duration of early life stages found in the water body; and (3-15-02)
(c) The Department determines early life stages are likely absent. (3-15-02)

e. Turbidity, below any applicable mixing zone set by the Department, shall not exceed background turbidity by more than fifty (50) NTU instantaneously or more than twenty-five (25) NTU for more than ten (10) consecutive days. (8-24-94)
f. Salmonid Spawning. The Department shall determine spawning periods on a waterbody specific basis taking into account knowledge of local fisheries biologists, published literature, records of the Idaho Department of Fish and Game, and other appropriate records of spawning and incubation, as further described in the current version of the "Water Body Assessment Guidance" published by the Idaho Department of Environmental Quality. Waters designated for salmonid spawning, in areas used for spawning and during the time spawning and incubation occurs, are not to vary from the following characteristics due to human activities: (3-30-07)

i. Dissolved Oxygen. (8-24-94) (1) Intergravel Dissolved Oxygen. (8-24-94) (a) One (1) day minimum of not less than five point zero (5.0) mg/l. (8-24-94)

(b) Seven (7) day average mean of not less than six point zero (6.0) mg/l. (8-24-94)

(2) Water-Column Dissolved Oxygen. (8-24-94)

(a) One (1) day minimum of not less than six point zero (6.0) mg/l or ninety percent (90%) of saturation, whichever is greater. (8-24-94)

ii. Water temperatures of thirteen (13) degrees C or less with a maximum daily average no greater than nine (9) degrees C. (8-24-94)

g. Bull Trout Temperature Criteria. Water temperatures for the waters identified under Subsection 250.02.g.i. shall not exceed thirteen degrees Celsius (13C) maximum weekly maximum temperature (MWMT) during June, July and August for juvenile bull trout rearing, and nine degrees Celsius (9C) daily average during September and October for bull trout spawning. For the purposes of measuring these criteria, the values shall be generated from a recording device with a minimum of six (6) evenly spaced measurements in a twenty-four (24) hour period. The MWMT is the mean of daily maximum water temperatures measured over the annual warmest consecutive seven (7) day period occurring during a given year. (3-30-01)

i The bull trout temperature criteria shall apply to all tributary waters, not including fifth order main stem rivers, located within areas above fourteen hundred (1400) meters elevation south of the Salmon River basin- Clearwater River basin divide, and above six hundred (600) meters elevation north of the Salmon River basin- Clearwater River basin divide, in the fifty-nine (59) Key Watersheds listed in Table 6, Appendix F of Governor Batt's State of Idaho Bull Trout Conservation Plan, 1996, or as designated under Sections 110 through 160 of this rule. (3-23-98)

ii. No thermal discharges will be permitted to the waters described under Subsection 250.02.g.i. unless socially and economically justified as determined by the Department, and then only if the resultant increase in stream temperature is less than five-tenths degrees Celsius (0.5C).

03. Seasonal Cold Water. Between the summer solstice and autumn equinox, waters designated for seasonal cold water aquatic life are not to vary from the following characteristics due to human activities. For the period from autumn equinox to summer solstice the cold water criteria will apply: (3-15-02)

a. Dissolved Oxygen Concentrations exceeding six (6) mg/l at all times. In lakes and reservoirs this standard does not apply to: (4-5-00)

i. The bottom twenty percent (20%) of water depth in natural lakes and reservoirs where depths are thirty-five (35) meters or less. (4-5-00)
ii. The bottom seven (7) meters of water depth in natural lakes and reservoirs where depths are greater than thirty-five (35) meters. (4-5-00)
iii. Those waters of the hypolimnion in stratified lakes and reservoirs. (4-5-00)

b. Water temperatures of twenty-six (26) degrees C or less as a daily maximum with a daily average of no greater than twenty-three (23) degrees C. (3-30-01)
c. Temperature in lakes shall have no measurable change from natural background conditions. Reservoirs with mean detention times of greater than fifteen (15) days are considered lakes for this purpose.(3-15-02)
d. Ammonia. Concentration of ammonia are not to exceed the criteria defined at Subsection 250.02.d. (3-15-02)

04. Warm Water. Waters designated for warm water aquatic life are not to vary from the following characteristics due to human activities: (3-30-07)

a. Dissolved oxygen concentrations exceeding five (5) mg/l at all times. In lakes and reservoirs this standard does not apply to: (7-1-93)

i. The bottom twenty percent (20%) of the water depth in natural lakes and reservoirs where depths are thirty-five (35) meters or less. (7-1-93)
ii. The bottom seven (7) meters of water depth in natural lakes and reservoirs where depths are greater than thirty-five (35) meters. (7-1-93)
iii. Those waters of the hypolimnion in stratified lakes and reservoirs. (7-1-93)

b. Water temperatures of thirty-three (33) degrees C or less with a maximum daily average not greater than twenty-nine (29) degrees C. (8-24-94)
c. Temperature in lakes shall have no measurable change from natural background conditions. Reservoirs with mean detention times of greater than fifteen (15) days are considered lakes for this purpose.(3-15-02)
d. Ammonia. The following criteria are to be met dependent upon the temperature, T (degrees C), and pH of the water body: (3-15-02)

i. Acute Criterion (Criterion Maximum Concentration (CMC)). The one (1) hour average concentration of total ammonia nitrogen (in mg N/L) is not to exceed, more than once every three (3) years, the value calculated using the following equation:

$$CMC = \frac{0.411}{1 + 10^{7.204 - pH}} + \frac{58.4}{1 + 10^{pH - 7.204}}$$

ii. Chronic Criterion (Criterion Continuous Concentration (CCC)). Concentrations of ammonia are not to exceed the criteria defined at Subsection 250.02.d.ii. (3-15-02)

251.SURFACE WATER QUALITY CRITERIA FOR RECREATION USE DESIGNATIONS.

01. E. Coli Bacteria. Waters designated for recreation are not to contain E. coli bacteria, used as indicators of human pathogens, in concentrations exceeding: (4-11-06)

a. Geometric Mean Criterion. Waters designated for primary or secondary contact recreation are not to contain E. coli bacteria in concentrations exceeding a geometric mean of one hundred twenty-six (126) E. coli organisms per one hundred (100) ml based on a minimum of five (5) samples taken every three (3) to seven (7) days over a thirty (30) day period. (4-11-06)

b. Use of Single Sample Values. A water sample exceeding the E. coli single sample maximums below indicates likely exceedance of the geometric mean criterion, but is not alone a violation of water quality standards. If a single sample exceeds the maximums set forth in Subsections 251.01.b.i., 251.01.b.ii., and 251.01.b.iii., then additional samples must be taken as specified in Subsection 251.01.c.: (4-11-06)

i. For waters designated as secondary contact recreation, a single sample maximum of five hundred seventy-six (576) E. coli organisms per one hundred (100) ml; or (4-11-06)

ii. For waters designated as primary contact recreation, a single sample maximum of four hundred six (406) E. coli organisms per one hundred (100) ml; or (4-11-06)

iii. For areas within waters designated for primary contact recreation that are additionally specified as public swimming beaches, a single sample maximum of two hundred thirty-five (235) E. coli organisms per one hundred (100) ml. Single sample counts above this value should be used in considering beach closures. (4-11-06)

c. Additional Sampling. When a single sample maximum, as set forth in Subsections 251.01.b.i., 251.01.b.ii., and 251.01.b.iii., is exceeded, additional samples should be taken to assess compliance with the geometric mean E. coli criteria in Subsection 251.01.a. Sufficient additional samples should be taken by the Department to calculate a geometric mean in accordance with Subsection 251.01.a. This provision does not require additional ambient monitoring responsibilities for dischargers. (4-11-06)

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Appendix C. Data Sources

Table C-1. Data sources for Lake Lowell Subbasin Assessment[1].

Water Body	Data Source	Type of Data	When Collected
Lake Lowell and tributary canals and drains	DEQ Boise Regional Office	Flow data, water chemistry grab samples, mercury fish tissue data	2002-2006
Lake Lowell and tributary canals and drains	BOR Storet Database	Flow data, water chemistry grab samples, mercury water column samples	2004-2006
Lake Lowell and tributary canals and drains	BPBOC	Flow data	2004, 2005, 2009
Lake Lowell tributary canals and drains	ISDA	Flow data, water chemistry grab samples,	2002
Lake Lowell	USFWS	Mercury fish tissue data	1998
New York Canal	USGS	Background TP concentration	1990-2008
New York Canal	ACHD and Lower Boise River Implementation Plan Total Phosphorus	Stormwater TP concentration and acres contributing to the stormwater load	2003-2006, 2010

[1]Summary of all available data. All water quality data sources are listed in Appendix C and data are available from the DEQ Boise Regional Office through a public record request

Appendix D. BETTER Model

Water Quality Modeling for Lake Lowell Nutrient TMDL

Darcy D. Sharp

Department of Environmental Quality

November 2008

Appendix D Table of Contents

Model Purpose

The purpose of the model is to illustrate the relationship between total phosphorus, chlorophyll-*a* and dissolved oxygen in the Lake Lowell Reservoir in the Lower Boise watershed (HUC 17050114). This modeling addresses the question: if tributary total phosphorus concentrations were reduced to average target values of 0.025 mg/L and of 0.070 mg/L TP, what are the trends in dissolved oxygen and chlorophyll-*a* concentrations in Lake Lowell? The target total phosphorus concentration of 0.025 mg/L was recommended by the Environmental Protection Agency (EPA) as a level that should not be exceeded in a reservoir in order to prevent nuisance algal growth (EPA 1986). The target total phosphorus concentration of 0.07 mg/L was established by Idaho DEQ in the Snake River-Hell's Canyon TMDL as the load allocated to the lower Boise River subbasin in order to support cold water aquatic life beneficial uses in the Hell's Canyon reach of the Snake River (DEQ 2004). A target chlorophyll-*a* concentration of 10 µg/L supports primary contact recreation uses in reservoirs (Raschke 1993).

Modeled dissolved oxygen results show that dissolved oxygen displays very little response to a change in total phosphorus values. At a depth where violations of the dissolved oxygen water quality standard occur, meeting target tributary total phosphorus concentrations of either 0.025 or 0.07 mg/L will increase the level of dissolved oxygen, and results in minimal or no violations of the water quality standard. Most of what appears to be violations of the water quality standard in the model output are actually in the bottom 20% of reservoir depths or the hypolimnion layer which, which are excluded from meeting the 5.0 mg/L dissolved oxygen standard. Algal concentrations are responsive to changes in total phosphorus values. Meeting a 0.07 mg/L total phosphorus target results in an average 43 to 47% reduction in algal concentration, which will in turn meet the target of 10 µg/L chlorophyll-*a* concentration.

Model Overview

The Box Exchange Transport Temperature Ecology Reservoir (BETTER) model is a branched two-dimensional box reservoir water quality model. This model was applied to Lake Lowell by the Bureau of Reclamation (BOR), Denver, CO (Bender 2000). One modeling scenario indicated that reducing inflow nutrients and organics by 50% would improve dissolved oxygen of the lower layers of the reservoir.

Functionalities of the BETTER model include basic eutrophication processes such as those between observed seasonal patterns of temperature, nutrients, algae, dissolved oxygen, organic matter and pH relationships. General model capabilities and limitations are shown in Table D-1.

Table 1. BETTER model capabilities and limitations.

Capabilities	Comments
Physical Processes	Matched density placement, turbulent mixing, stratification, heating, cooling, and convective mixing, light extinction, evaporation, aeration, wind mixing and outflow advection.
Water quality processes	Algal photosynthesis, respiration, decay and settling, organic decay, sediment processes, and nutrient uptake by algae.
Inputs/Outputs	Multiple stream inflows; point and nonpoint inflows; precipitation; multiple withdrawals.
Geometry	Multiple water bodies consisting of multiple branches. Longitudinal and vertical segmentation scheme in a reservoir.
Limitations	**Comments**
Hydrodynamics	Laterally averaged
Water Quality	No zooplankton or macrophytes

Target Discussion and Data Analysis

The interrelationship of phosphorus concentration, algae, and dissolved oxygen both in the reservoir and in the tributary waterways is a complex one. Addition of excess phosphorus to a system causes greater than normal productivity of algae. Excess algae deplete dissolved oxygen in the water column by nighttime respiration and because of decomposition of algae and other plant material. However, how much excess phosphorus is needed to cause excess algal growth and dissolved oxygen water quality criteria violations of the Idaho water quality standards remains to be discovered in this modeling study. In Lake Lowell, which is designated for warm water aquatic life, the water quality standard for dissolved oxygen is numeric:

> **IDAPA 58.01.02.250 SURFACE WATER QUALITY CRITERIA FOR AQUATIC LIFE USE DESIGNATIONS.**
> **04. Warm Water.** Waters designated for warm water aquatic life are to exhibit the following characteristics: (4-5-00)
> **a.** Dissolved oxygen concentrations exceeding five (5) mg/L at all times. In lakes and reservoirs this standard does not apply to: (7-1-93)
> **i.** The bottom twenty percent (20%) of the water depth in natural lakes and reservoirs where depths are thirty-five (35) meters or less. (7-1-93)
> **ii.** The bottom seven (7) meters of water depth in natural lakes and reservoirs where depths are greater than thirty-five (35) meters. (7-1-93)
> **iii.** Those waters of the hypolimnion in stratified lakes and reservoirs. (7-1-93)

Lake Lowell is about 11 meters deep at the deepest site near the upper embankment.

The water quality standard for nutrients is narrative:

> **IDAPA 58.01.02.200 GENERAL SURFACE WATER QUALITY CRITERIA.**
> **06. 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. (8-24-94)

The target total phosphorus (TP) concentration of 0.025 mg/L TP was recommended by the Environmental Protection Agency (EPA) as a level that should not be exceeded in a reservoir in order to prevent nuisance algal growth (Gold Book, EPA 1986). The target concentration of 0.07 mg/L TP was established by Idaho DEQ in the Snake River-Hell's Canyon TMDL as the concentration for establishing the load allocated to the lower Boise River and its tributaries in order to support cold water aquatic life beneficial uses in the Hell's Canyon reach of the Snake River (DEQ 2004). A target chlorophyll-*a* concentration of 10 µg/L supports primary contact recreation uses in reservoirs (Raschke 1993). This modeling analysis will show the effect on dissolved oxygen and algal productivity in the reservoir if incoming TP is reduced to the suggested target concentrations of 0.025 mg/L TP and 0.07 mg/L TP in the tributary waterways.

Reservoir data

Figure 1 shows phosphorus and chlorophyll-*a* data collected by the Idaho Department of Environmental Quality (DEQ) and the Bureau of Reclamation (BOR) in Lake Lowell for the year 2004. Chlorophyll-*a* data is a simpler and cheaper analysis in the laboratory than that of algae, and is therefore commonly collected as an indicator of the quantity of algae, or its primary productivity.

For reference, target concentrations of phosphorus and chlorophyll-*a* are as follows. Phosphorus concentrations in a reservoir should not exceed 0.025 mg/L to prevent nuisance algae according to the Gold Book (EPA 1986). Chlorophyll-*a* should not exceed 10 µg/L to protect primary contact recreation (Raschke 1993).

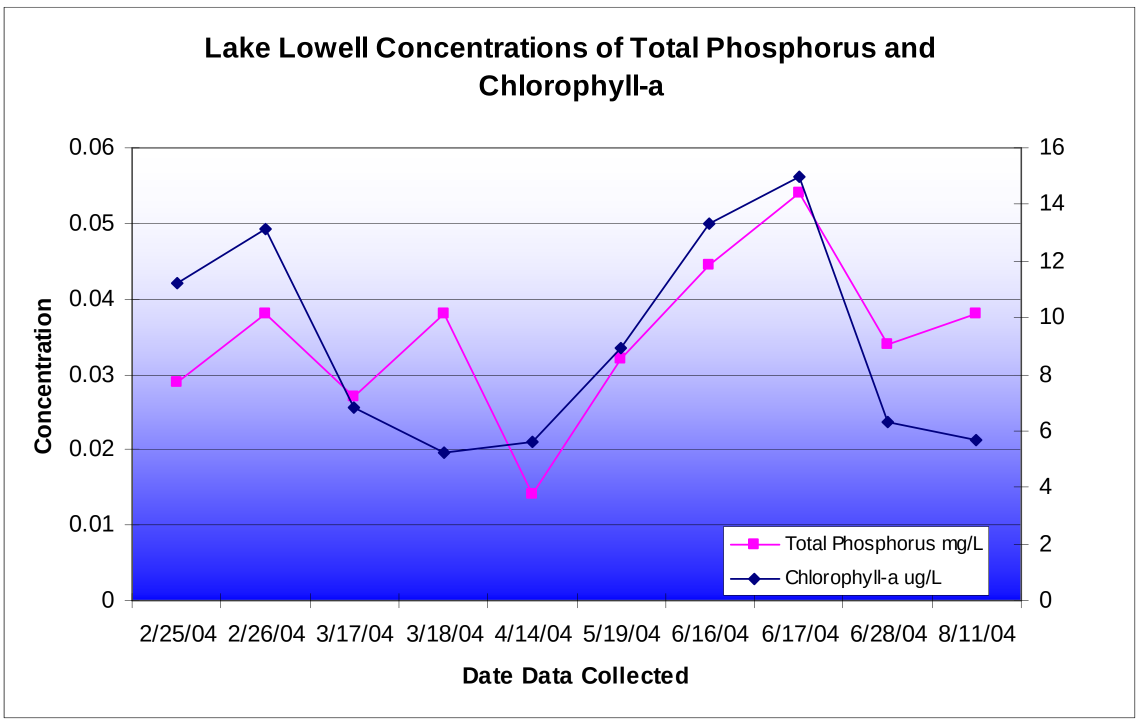


Figure 1. Phosphorus and chlorophyll-*a* data in Lake Lowell, 2004.

Other evidence suggests that nuisance algal growth is a greater concern than is suggested by the eight samples depicted in Figure 1. Observations from DEQ, IDFG and USFWS staff note large blooms of filamentous green algae in the water column during average water years. Also there are extensive blue-green algae blooms when water levels return to normal after reservoir drawdowns or drought (personal Communication Jeff Dillon, Regional Fishery Manager, IDFG; USFWS Deer Flat Wildlife Refuge staff). Previous studies have found excess concentrations of chlorophyll-*a* in the reservoir. Monitoring by BOR in 1979 BOR study documented total phosphorus in the reservoir at an average of 0.07 mg/L with an average of 29 µg/L of chlorophyll-*a* (BOR 1979). Monitoring by BOR in 1980 showed that the average chlorophyll-*a* concentration in July and August was 65 µg/L (Zimmer and Glover 1980).

The Idaho DEQ collected further water quality data including dissolved oxygen and temperature at one-meter intervals at two sites in the reservoir. Site 1 is shallower, 7 to 8 meters deep. Site 2 is the deeper one at about 11 meters. Sample locations are shown in Figure 2. Locations are approximate since there are no permanent buoys or markers in place to mark the sample sites.

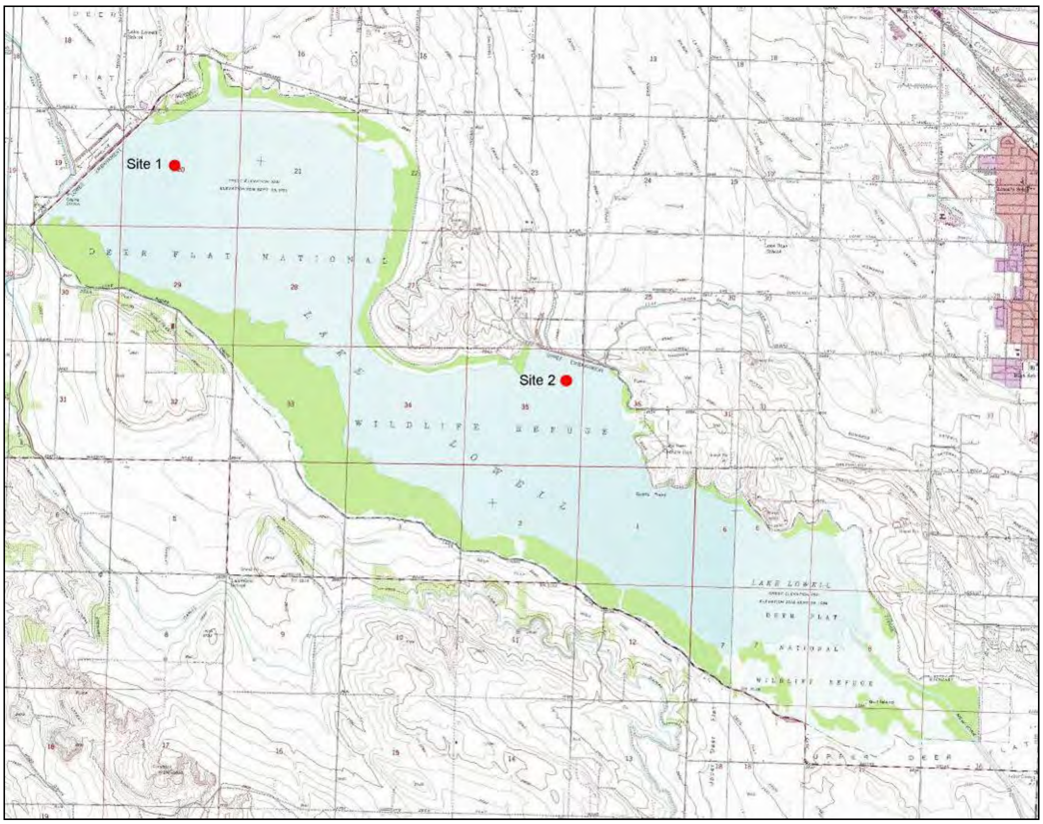
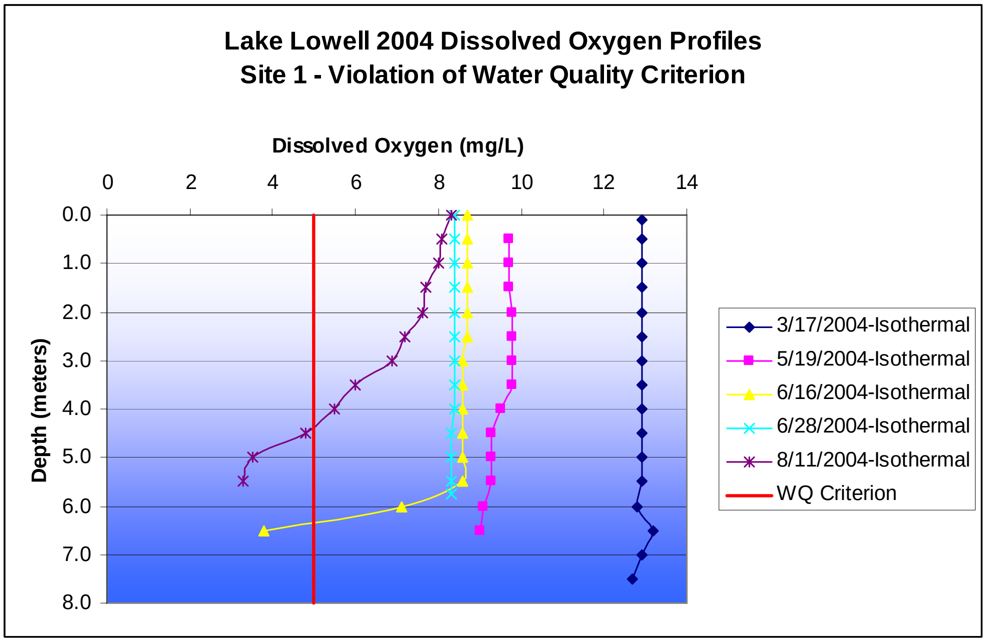


Figure 2. Idaho Department of Environmental Quality dissolved oxygen sample locations in Lake Lowell.

Dissolved oxygen data from the reservoir shown in Figure 3 demonstrate when there are violations of Idaho's water quality standards. Lake Lowell is designated for warm water aquatic life. For this beneficial use, dissolved oxygen concentrations must exceed 5.0 mg/L at all times. In reservoirs, this does not apply to:

- The bottom 20% of water depth where the reservoir is 35 meters or less
- The waters of the hypolimnion in stratified lakes and reservoirs



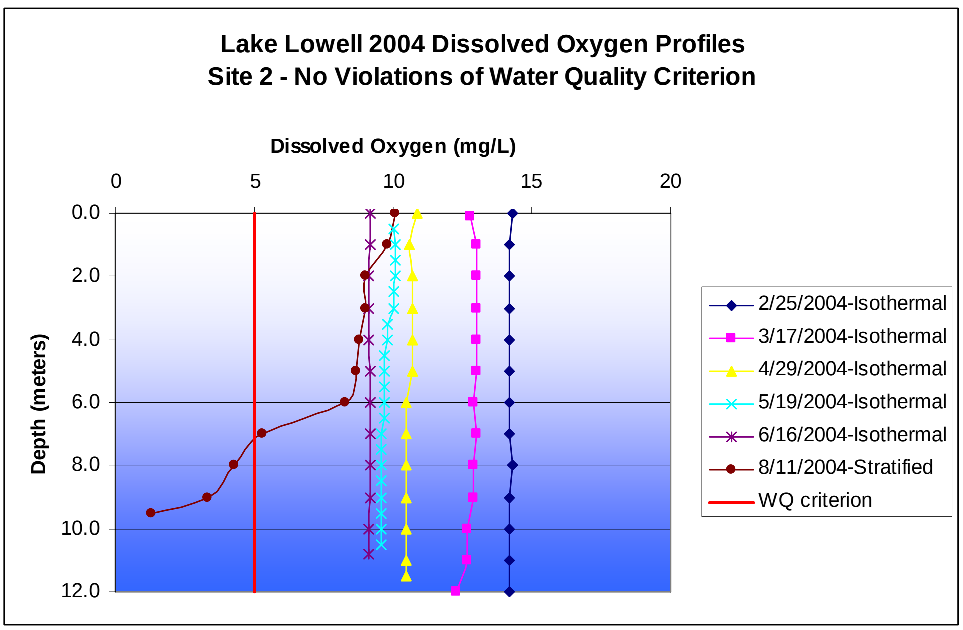


Figure 3. Dissolved oxygen data in Lake Lowell compared with Idaho water quality standard.

From these graphs, the violations of Idaho water quality standards for warm water aquatic life were mid-June and August at site 1 (BIO 185). It is unfortunate that there were no data collected in July or after August that year, since it may have demonstrated a trend. The dissolved oxygen values below 5 mg/L at site 2 (BIO 181) are not violations since the reservoir was thermally stratified at that time, and the DO values below 5.0 mg/L are in the hypolimnion..

Tributary Waterway Data

Lake Lowell is created by damming the output of 8 tributary waterways: the New York Canal, Coulee, Bernard, Garner, Donaldson, and Farner Drains, Highline Wasteway #1 and Highline Wasteway #3 (Deer Flat wasteway #3 below). Data from the BOR is available for five of the waterways, shown in Table D-2 below.

Table 2. Total phosphorus tributary waterway data from Bureau of Reclamation and calculated load.

Location	Date	Total Phosphorus (mg/L)	Stream Flow (cfs)	TP Load (lbs/day)	Average Load (lbs/day)
Bernard Drain	5/3/04	0.045	4	1.0	
	6/28/04	0.075	2.5	1.0	
	8/9/04	0.096	5	2.6	
	9/9/04	0.034	7	1.3	
	10/5/04	0.034	7.5	1.4	1.7
Coulee Drain	4/19/04	0.26	2	2.8	14.7
	5/3/04	0.57	2	6.1	
	6/28/04	0.84	5	22.6	
	7/19/04	0.052	1.8	0.5	
	8/9/04	2.24	4	48.3	
	9/9/04	1.89	2	20.4	
	10/5/04	0.41	1	2.2	
Deer Fat Wasteway #3	4/19/04	0.097	51.4	26.9	48.3
	5/3/04	0.28	67.5	101.9	
	6/28/04	0.2	95.7	103.2	
	7/19/04	0.25	34.9	47.0	
	8/9/04	0.16	39.8	34.3	
	9/9/04	0.026	85.7	12.0	
	10/5/04	0.02	120.5	13.0	
Farner Drain	4/19/04	0.56	5	15.1	6.3
	5/3/04	0.35	1.5	2.8	
	6/28/04	0.73	1.5	5.9	
	8/9/04	0.86	1.5	7.0	
	9/9/04	0.2	4	4.3	
	10/5/04	0.18	2.5	2.4	
New York Canal Lakeshore Drive	4/19/04	0.08			157.7
	5/3/04	0.041			
	6/28/04	0.053	238	68.0	
	7/19/04	0.06	666	215.4	
	8/9/04	0.029	450	70.3	
	9/9/04	0.025	1880	253.3	
	10/5/04	0.022	1532	181.7	

mg/L – milligrams per liter
cfs – cubic feet per second
TP – total phosphorus
lbs/day – pounds per day

The average total phosphorus concentration for all the tributaries equals 0.34 mg/L. When load is calculated, New York Canal brings the highest load into Lake Lowell, averaging almost 158 pounds per day. The total phosphorus daily loads are plotted in Figure 4.

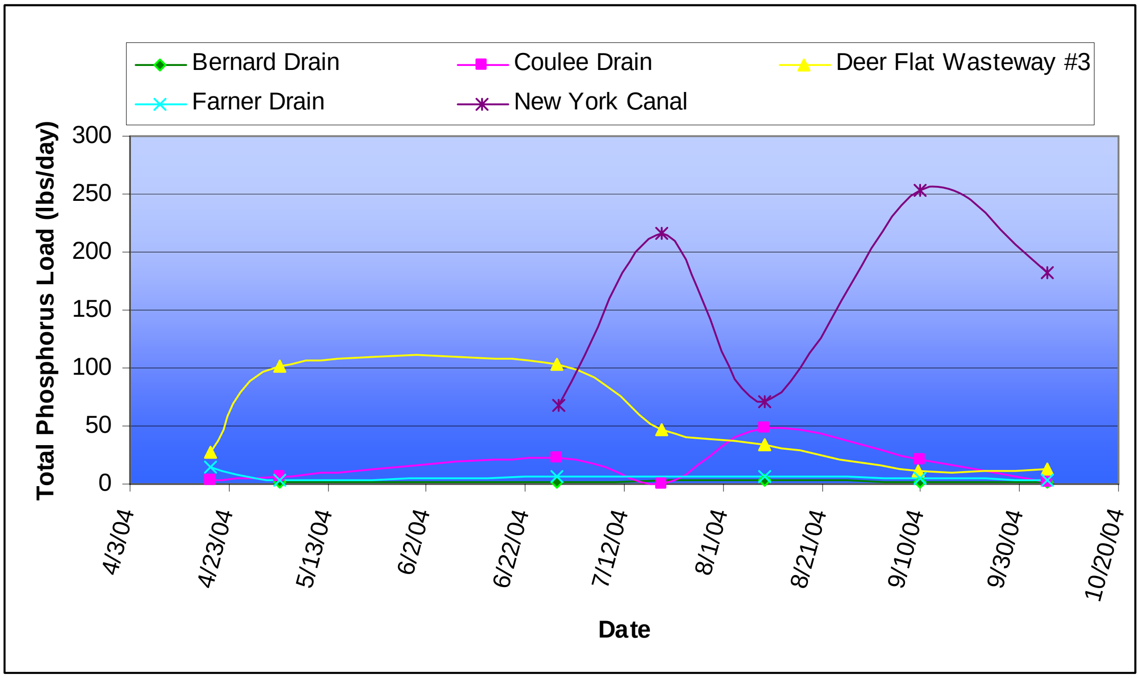


Figure 4. Total phosphorus loads in tributary waterways to Lake Lowell.

Barnard and Farner Drains have the lowest loads, Coulee Drain and Deer Flat Wasteway #3 have the next highest loads, and New York Canal has the highest load.

Four canals drain Lake Lowell: Deer Flat Lowline, Deer Flat North, Deer Flat Caldwell, and Deer Flat Nampa Canals. There are BOR data for all but Deer Flat North Canal, which has the smallest streamflow. Available data is shown in Table 3 below. Figure 5 shows the total phosphorus loads of samples collected by BOR during the same time frame as the inlet samples.

Table 3. Total phosphorus outlet waterway data from BOR and calculated load.

Location	Date	Total Phosphorus (mg/L)	Stream Flow (cfs)	TP Load (lbs/day)	Average Load (lbs/day)
Deer Flat Caldwell Canal	4/19/04	0.024	15	1.9	1.7
	5/3/04	0.0001	18	0.0	
	6/28/04	0.036	12	2.3	
	7/26/04	0.04			
	8/9/04	0.032	12	2.1	
	9/9/04	0.051	12	3.3	
	10/5/04	0.025	5	0.7	
Deer Flat LL Below Lake Lowell	4/19/04	0.031	570	95.2	97.7
	5/3/04	0.01	590	31.8	
	6/28/04	0.035	597	112.6	
	7/19/04	0.03	677	109.5	
	8/9/04	0.054	560	163.0	
	9/9/04	0.05	414.8	111.8	
	10/5/04	0.041	270.2	59.7	
Deer Flat Nampa Canal	4/19/04	0.021	20	2.3	2.4
	5/3/04	0.012	25	1.6	
	6/28/04	0.042	18	4.1	
	7/19/04	0.044			
	8/9/04	0.036	10	1.9	
	9/9/04	0.042	10	2.3	

mg/L – milligrams per liter
cfs – cubic feet per second
TP – total phosphorus
lbs/day – pounds per day

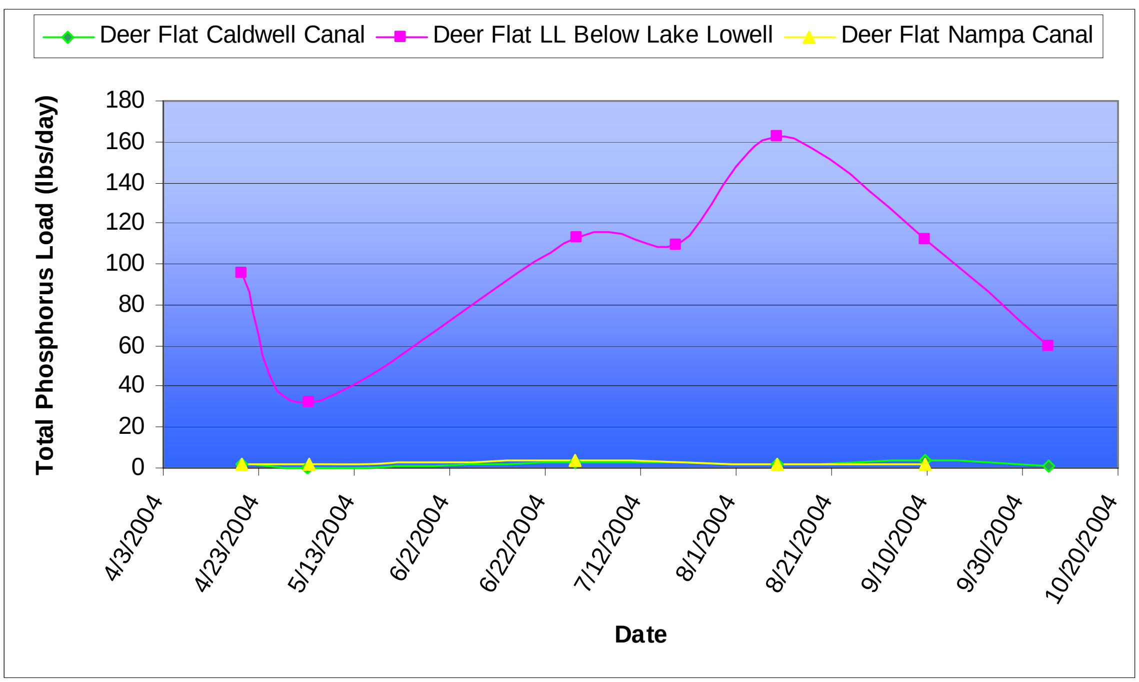


Figure 5. Total phosphorus loads in outlets flowing from Lake Lowell.

The average total phosphorus concentration of all of the outlets equals 0.033 mg/L, more than ten times less than the average inlet concentration. For the load, the average incoming load is 45.7 pounds per day and the average outgoing load is 33.9 pounds per day. This indicates that the reservoir retains whatever excess phosphorus not utilized by algal growth in its sediments.

The BETTER model actually computes bioavailable orthophosphate, so these total phosphorus concentration data had to be converted for input into the model. Since the fraction of bioavailable orthophosphate in total phosphorus may vary from system to system, the fraction in this system was calculated by dividing average tributary waterway orthophosphate values into average total phosphorus values. Orthophosphate is 20% of the total phosphorus, so all of the data was reduced by 20% for the input file.

Model Data Sources

This section identifies the sources of all data used in the model, and describes the steps taken to ensure data quality. The input files described below were prepared for the purpose of constructing a hydrodynamic and water quality model in the Lake Lowell reservoir with inputs including New York Canal and other drains. The purpose of the model is to illustrate the relationship between total phosphorus, chlorophyll *a* and dissolved oxygen among the tributaries and within the reservoir.

Modeled Reservoir Schematic

The Bureau of Reclamation (BOR) surveyed Lake Lowell in 1994 (Ferrari 1995) in order to establish the reservoir’s topography, area-capacity relationships, and elevation datum. While meeting these objectives, the survey resulted in area and capacity curves, and a map of the topography. These data were used to develop the bathymetry of Lake Lowell for the BETTER model. Originally, the Department of Environmental Quality (DEQ) asked BOR for these data to use in developing another model, but it was determined that since all of the bathymetry and coefficients were already built into the BETTER model, the model would be shared with DEQ to expedite model development.

The model geometry divides the reservoir into 7 segments. All incoming flow is accounted for in:

- Branch 1, which is New York Canal
- Branch 2, which is local inflow
- Diffuser 1 consists of Coulee Drain, Bernard Drain, and Highline Wastewater #1
- Diffuser 2 consists of Farner, Donaldson, and Garner Drains
- Diffuser 3 consists of Highline Wasteway #3

Branch 2 consists of all of the minor drains and ground water seeps, and it also accounts for evapotranspiration. In the water balance of the model, if evapotranspiration exceeds the drains and seeps, this is a negative number.

Output consists of two discharge pumps (Deer Flat Nampa Canal and Deer Flat Caldwell Canal) from the upper embankment dam and two bottom discharges (Deer Flat Lowline Canal and Deer Flat North Canal) from the lower embankment dam.

See Figure 6 for a plan view of the modeled area, which is duplicated from the BOR model report (Bender 2000).

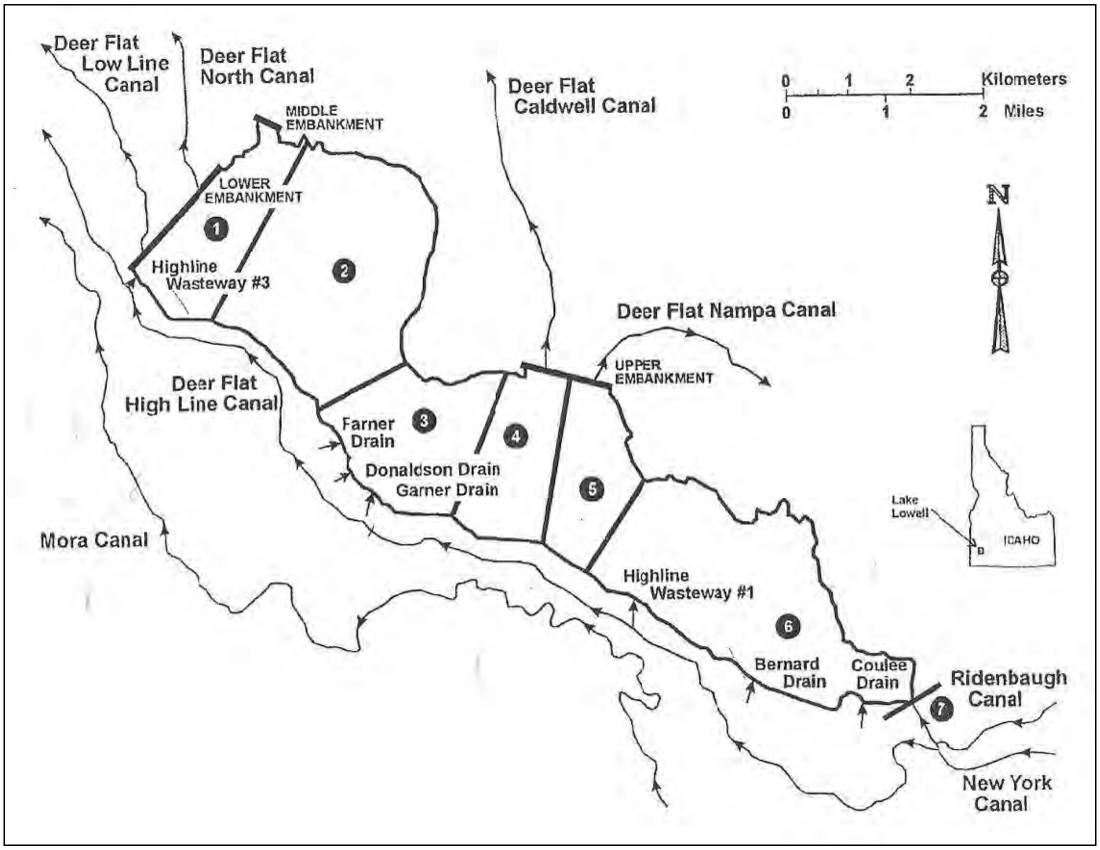


Figure 6. Plan view of modeled segmentation for Lake Lowell.

Mainstem inflow and temperature

Streamflow data for the modeled year 2004 is from Idaho Power Company's daily real-time stream gauge directly below the Diversion Dam for New York Canal near Boise. The gauge, USGS 13203000, was monitored by the United States Geological Service (USGS) from 1989 through 1995 and by Idaho Power Company from 1997-2007. Temperature data is provided by BOR for all modeled drains except for Garner and Donaldson Drain and Highline Wasteway #1. Temperature was recorded once a month throughout the water year (May to October), so temperature was entered stepwise between actual data for entry into the model. Daily average streamflow and temperature are upstream boundary conditions for the model.

Meteorology

Data for weather is from the Agrimet weather station operated at Nampa, Idaho. Daily parameters for the year 2004 are available online from the Bureau of Reclamation Agrimet website (http://www.usbr.gov/pn/agrimet/). The following parameters are input to the model as daily data:

- Mean daily air temperature
- Mean daily dewpoint temperature
- Wind speed
- Daily solar radiation

The BETTER model is set up for day/night data, and since there were only daily data from Agrimet, the night data was the same except that solar radiation was set to zero.

Bathymetry and Geometry

The BOR executed an extensive reservoir survey of Lake Lowell in 1994 (Ferrari 1995). The project resulted in bathymetry maps and in establishing area-capacity relationships. The bathymetry was measured with depth sounding equipment aboard a survey vessel which navigated a grid by a positioning system. These data points were used in a computer graphics program to generate area-capacity relationships. In addition, aerial photography examined below a surface elevation of 2515 feet led to developing an above-reservoir area.

These data were used in Bender 2000 for the water quality modeling of Lake Lowell to develop a geometry input file. This file contains bottom elevation and five-foot layers up to the surface elevation for each of 7 segments in the reservoir.

Withdrawals

There are four irrigation withdrawals from Lake Lowell, including Deer Flat Lowline, North, Caldwell, and Nampa Canals. Streamflow was measured by BOR from all but Deer Flat North Canal. In addition, the Boise Project Board of Control provided monthly outflow data for all of the four canals. Using these two datasets, the streamflow for the outflow was interpolated for all of the missing dates to make a complete daily file.

Water Quality Constituents

The BOR collected data that resides in the STORET database. The DEQ downloaded this data and formatted it for entry into the BETTER model. For each day, the input files include inflow to reservoir, outflows from the dam, and weather parameters including drybulb temperature, dewpoint temperature, windspeed, and solar radiation. Inflow and outflows were interpolated from a monthly water balance estimate by the local irrigation district and a daily streamflow recorded for New York Canal. For each branch coming into the reservoir, parameters include temperature, turbidity, dissolved oxygen, pH, alkalinity, algae, detritus, dissolved organics, ammonia, nitrate + nitrite, bioavailable orthophosphate, and dye (an inert substance to evaluate travel time). When the BETTER model was previously calibrated by the BOR for tributary waterways, organic inputs were set at 0.5 mg/L for algae, 1.5 mg/L for detritus, and 1.5 mg/L for dissolved organics. The BOR recommended these settings be retained for current conditions. The other water quality parameters were derived from 10 BOR water quality sampling events, entered stepwise rather than interpolated.

Model Calibration

Calibration is a process whereby measured data and modeled values are compared. The compared values are assessed to determine if modeled values provide an adequate reflection of measured data. If the comparison is not adequate, coefficients or assumptions in the model are adjusted until the model gives useful results. If a model is a theory about the real world, then calibration tests the theory with all observed data available (Cole and Wells 2003).

The BETTER model coefficients were adjusted for the Lake Lowell system in the modeling effort recorded in Bender 2000. These were not readjusted for the modeling of year 2004 since the water quality dynamics were already calibrated in the earlier model and the coefficients remained the same.

To test the calibration, current conditions were modeled and compared with actual data for dissolved oxygen profiles in the reservoir. When measured data was plotted against calculated data, Site 1 (BOI 185) had an average coefficient of R^2=0.76 (consisting of four sample dates with R^2=0.82, 0.58, 0.70 and 0.93). The average for Site 2 (BOI 181) was R^2=0.645 (consisting of four sample dates with R^2=0.61, 0.86, 0.14 and 0.97). See Appendix A for comparisons of the measured and calculated data.

2004 R^2 values for chlorophyll-*a* and TP were not calculated because there is not enough 2004 TP and chlorophyll-*a* data. Based on the apparent good fit for the other calibrated constituents the expectation is that the model predicts TP and Chlorophyll-*a* with precision similar to the DO calibration.

Model Execution and Results

To determine the effect of phosphorus reductions on the algae and dissolved oxygen levels in the reservoir, modeled simulations of a reduction in phosphorus were executed. The simulations showed an increase in dissolved oxygen in the reservoir. There were areas where dissolved oxygen was less than 5.0 mg/L; however, they were almost always in the bottom 20% of reservoir depth or in the hypolimnion layer. Algal production in the reservoir shows a marked reduction with each reduction of total phosphorus input.

Model Execution

Tributary waterway input files for current conditions, 0.025 mg/L total phosphorus, and 0.07 mg/L total phosphorus were created. When the BETTER model was previously calibrated by the BOR for tributary waterways, organic inputs were set at 0.5 mg/L for algae, 1.5 mg/L for detritus, and 1.5 mg/L for dissolved organics. The BOR recommended these settings be retained for current conditions. For target conditions, the organic inputs were reduced proportionally to the corresponding reduction in total phosphorus.

These three input files executed separately and output was produced for segments one and four, which correspond to BURP sites one and two where data had been collected in the reservoir. Output was formatted to display dissolved oxygen at 2.5-foot depths and algae at the surface of the reservoir.

Results

Modeled data presented in the Appendix of this report demonstrate that decreasing incoming total phosphorus results in increased levels of dissolved oxygen, especially in the lower layers where violations of the warm water aquatic life standard can occur. The scenario where tributary waterways contribute only 0.025 mg/L of total phosphorus apparently result in a sterile system where so little algal growth occurs that not enough dissolved oxygen is being produced. With 0.07 mg/L of total phosphorus, dissolved oxygen production is more realistic.

The 0.07 total phosphorus target increases levels of dissolved oxygen in the lower layers of the reservoir. However, when the lower layers dip below 5.0 mg/L dissolved oxygen, these occurrences must be analyzed for conditions where the water quality standard does not apply, which is the bottom 20% of water depth and waters of the hypolimnion when the reservoir is stratified. When calculated dissolved oxygen dips below 5.0 mg/L, it is found that violations of the warm water criterion occur from 26 to 31 days of the year, whether the incoming total phosphorus is set at current levels averaging 0.34 mg/L or target values of 0.025 and 0.07 mg/L (Figure 7).

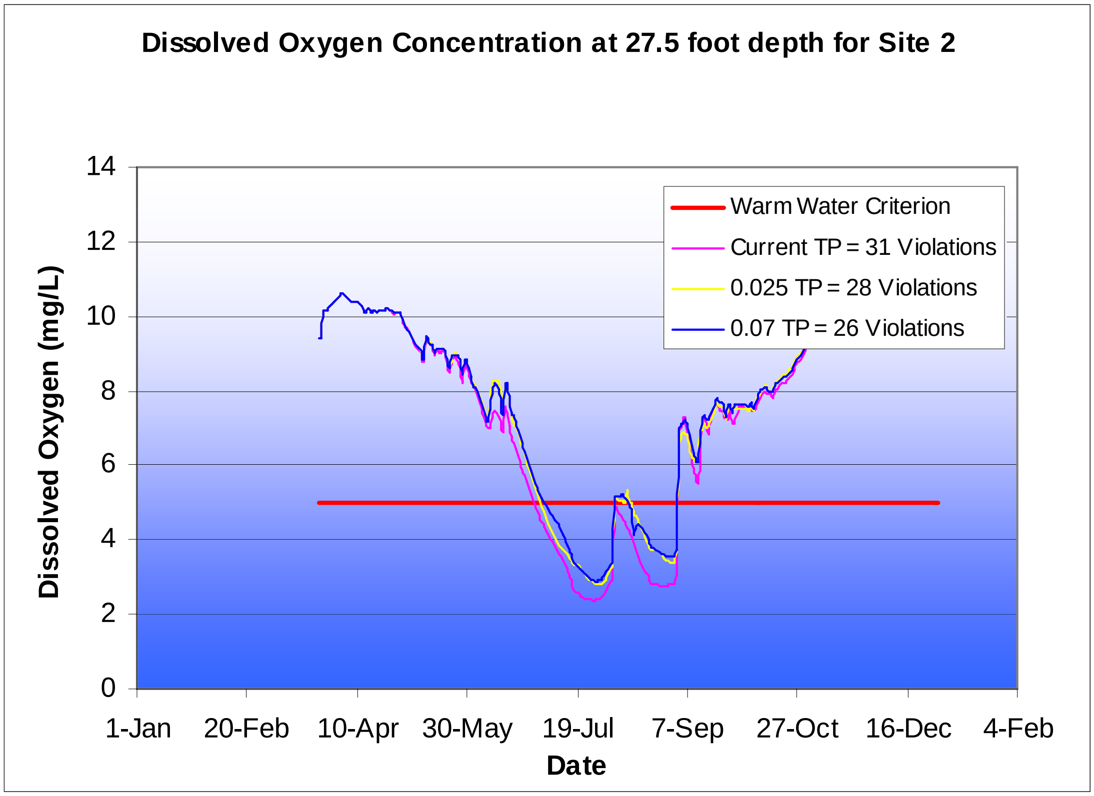
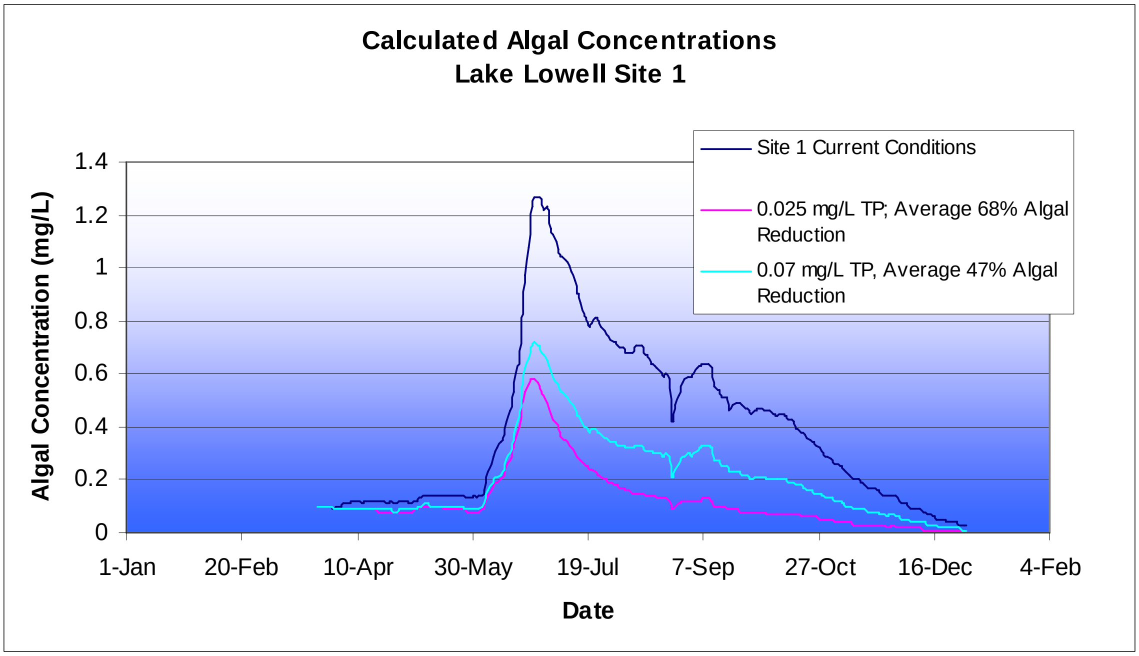


Figure 7. Calculated dissolved oxygen values produced by three varying total phosphorus concentrations at site 2 near the upper embankment.

At the deepest level of Lake Lowell, dissolved oxygen dips below 5.0 mg/L approximately the same number of times whatever the incoming total phosphorus concentration. Although dissolved oxygen does not dip as low, it still drops below 5.0 mg/L nearly as often as under current conditions. When analyzed by exclusion of the bottom 20% of water depth and predicted hypolimnion layers, violations of the water quality standard occur only on rare occasions. A limitation of this model is that it cannot predict changes that occur over a longer period than the typical ice-free season. Therefore the model does not account for reductions in the internal phosphorus load as nutrient inputs are reduced. It is expected that after the internal load is exported through outlet canals or buried by sediment dissolved oxygen concentrations will no longer violate WQS.

The model shows that algal concentrations are very responsive to changes in incoming total phosphorus. Figure 8 shows the reductions calculated for algal growth when total phosphorus is reduced in the tributary waterways. For the input files, organic components were reduced proportionally to the amount that total phosphorus was reduced.



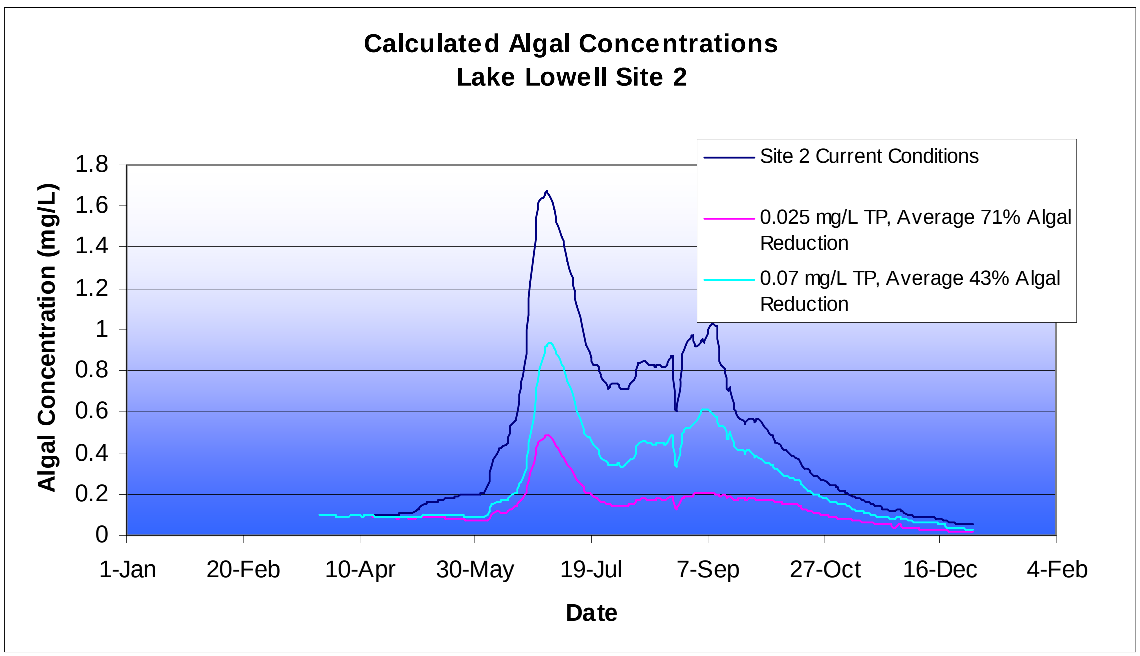


Figure 8. Calculated algal concentration values produced by three varying total phosphorus concentrations at Lake Lowell site 1 and site 2.

The model only calculates algae, not chlorophyll-*a*, but the BOR and DEQ have only collected chlorophyll-*a* data in the area. It is uncommon to collect data on algae, since the laboratory tests are elaborate and expensive. Chlorophyll-*a* is an indicator of the primary productivity of algae, and therefore its quantity. It is common to have laboratory analyses done on chlorophyll-*a* since those tests are more cost effective. The proportion of chlorophyll-*a* in the algal body is variable depending on the site and the species of algae present. Since no algal data have been collected in the Lake Lowell system, there is no direct measure of the ratio of chlorophyll-*a* to algae.

However, the percent reduction in algal concentration from calculating target TP values can be applied to existing chlorophyll-*a* data (Table 4).

Table 4. Percent reductions applied to DEQ measured chlorophyll-*a* data.

Date	Lake Lowell Site 1			Lake Lowell Site 2		
	Measured Chl-*a* (µg/L)	68% Reduction (µg/L)	47% Reduction (µg/L)	Measured Chl-*a* (µg/L)	71% Reduction (µg/L)	43% Reduction (µg/L)
6/19/2003	2.3	0.736	1.219	3.2	0.928	1.824
8/8/2003	8.5	2.72	4.505	15	4.35	8.55
9/25/2003	4.7	1.504	2.491	6.7	1.943	3.819
10/15/2003	15.8	5.056	8.374	19.1	5.539	10.887
2/25/2004	ns			11.2	3.248	6.384
3/17/2004	8.4	2.688	4.452	5.2	1.508	2.964
6/16/2004	11.5	3.68	6.095	15	4.35	8.55
6/28/2004	6.3	2.016	3.339	ns		
8/11/2004	11	3.52	5.83	0.3	0.087	0.171
3/1/2005	4.1	1.312	2.173	ns		
4/18/2005	6.1	1.952	3.233	7.7	2.233	4.389
5/17/2005	4.3	1.376	2.279	5.8	1.682	3.306
7/5/2005	6.3	2.016	3.339	6.9	2.001	3.933
7/25/2005	8.4	2.688	4.452	10.7	3.103	6.099

ns- not sampled

From these percent reductions in algal concentration, it is apparent that the target chlorophyll-*a* concentration of 10 µg/L would have been met in any of the samples collected throughout the water years 2004 and 2005 with the 43 to 47% reduction in algal concentration supplied by 0.07 mg/L of total phosphorus coming into the system.

Model Conclusions and Peer Review

Executing the BETTER model for Lake Lowell reservoir and its tributary waterways indicates that meeting a total phosphorus target of 0.07 mg/L will result in reduced algal growth and will also result in increasing the dissolved oxygen concentrations at the bottom of the reservoir. Although the dissolved oxygen levels will increase, it may not be enough to meet the warm water criterion of 5.0 mg/L at the deepest levels of the reservoir during all times of the year. When further analysis was done, most modeled events where dissolved oxygen dipped below 5.0 mg/L were in the bottom twenty percent of reservoir depth or what is predicted as the hypolimnion. Therefore these exceedances are excluded from meeting the DO water quality standard for lakes and reservoirs. When calculated dissolved oxygen in water layers subject to WQS dips below 5.0 mg/L, it is found that violations of the warm water criterion occur from 26 to 31 days of the year, whether the incoming total phosphorus is set at current levels averaging 0.34 mg/L or target values of 0.025 and 0.07 mg/L (Figure 7). The total phosphorus target of 0.07 mg/L from tributary waterways will reduce algal growth enough to meet the in-reservoir chlorophyll-*a* target of 10 µg/L. This will support the beneficial uses of primary and secondary contact recreation by reducing nuisance aquatic growth and algal mass.

The model was peer-reviewed during its development by Merlynn Bender at the Technical Service Center, Denver, Colorado for the BOR. Mr. Bender’s comments about the model results follow in full:

> “The previously calibrated Lake Lowell BETTER model was used for this study and is discussed in the report, “Two-dimensional water quality modeling of Lake Lowell” prepared by Merlynn Bender of the Bureau of Reclamation, September 2000. This model was previously calibrated to dry (1977), average (1975), and wet (1997) conditions to cover a range of hydrologic conditions. Recently additional 2004 data was incorporated into this study to verify the previous calibration. Input data sets for 2004 were assembled by the Idaho Department of Environmental Quality (DEQ) for use in the calibrated Lake Lowell BETTER model. The 2004 model simulation outputs were plotted and analyzed and then compared to a reduced phosphorus target test scenario proposed by DEQ. Modeled water quality output was checked for the seasonal period from early spring through winter of calendar year 2004. Nutrient and organic loadings were calculated in the same format as the model calibration for use in comparing to dry, average, and wet year loadings. Auxiliary computer programs were used to calculate the modeled daily algal biomass and modeled daily volumes of water with low dissolved oxygen (DO) concentration in Lake Lowell throughout the season.”
>
> “The year 2004 loadings produced expected amounts of modeled algal biomass and modeled dissolved oxygen concentrations. In the modeling test scenario, cutting phosphorus concentrations to target levels defined by DEQ reduced modeled total bioavailable phosphorus loadings by as much as two thirds resulting in about half the modeled algal biomass in Lake Lowell. However, it appears that wind-mixing of oxygen-rich surface waters into the lower layers of this relatively shallow lake results in minimal difference in modeled water volume with low DO between the current and target conditions. This suggests that cutting phosphorus loading may reduce algal biomass while minimally changing the low DO volume of Lake Lowell (Bender 2008).”

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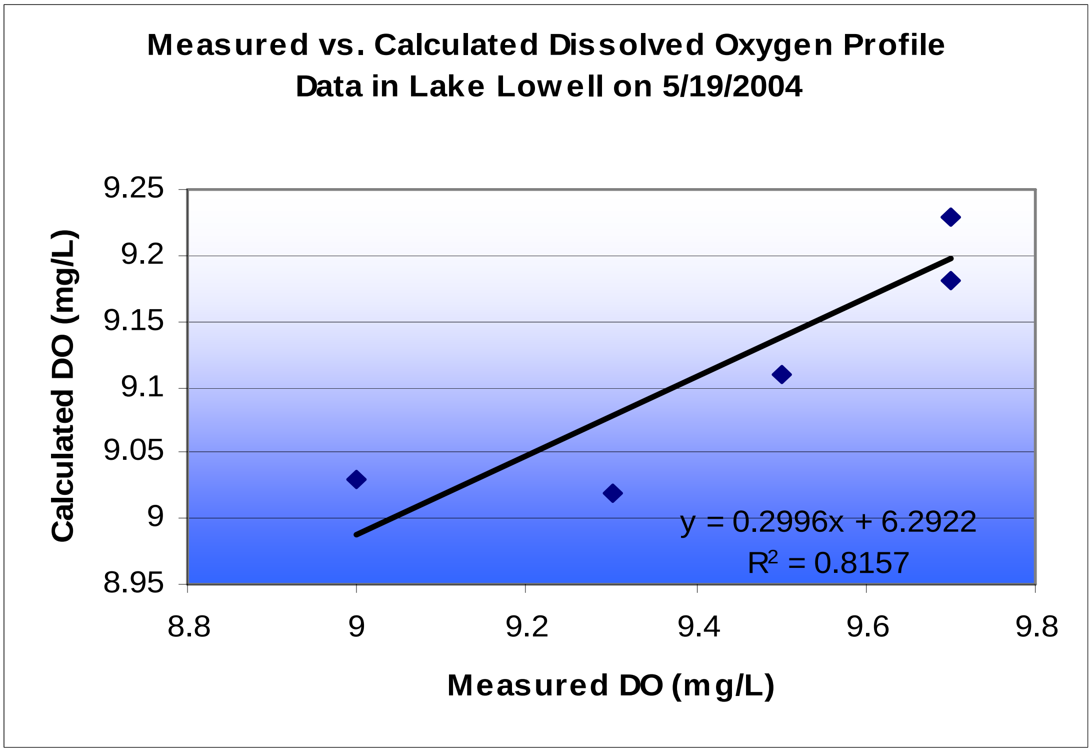
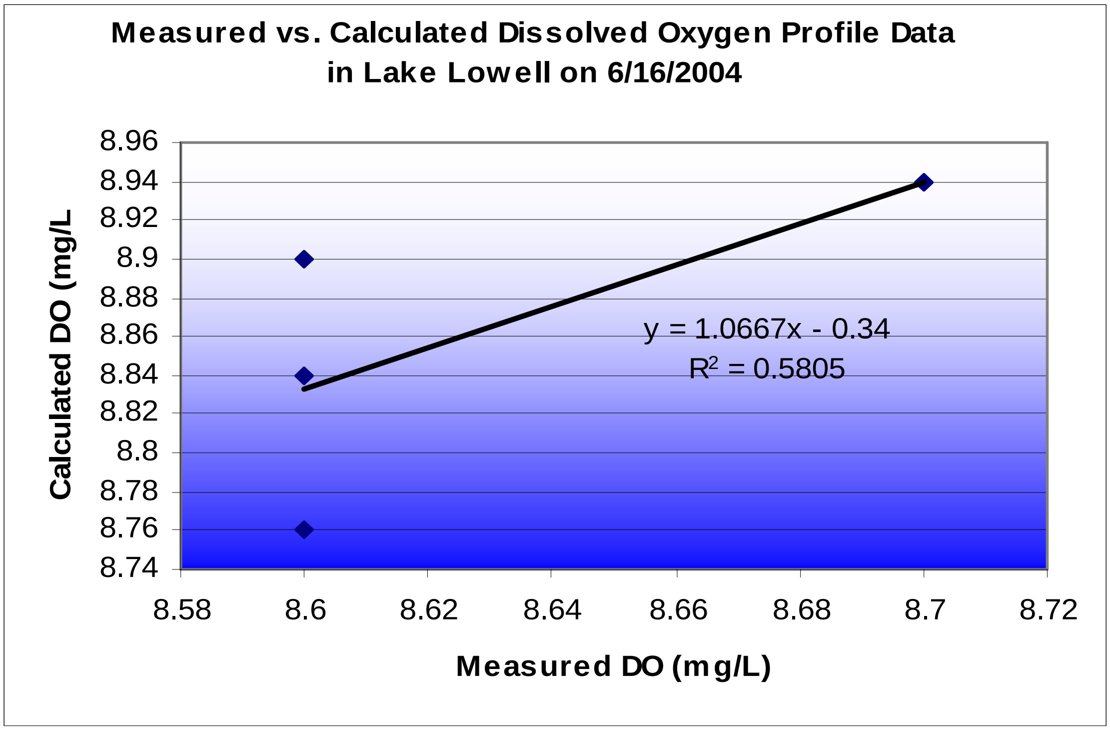
Appendix

Appendix Table 1. Model calculated and actual measured dissolved oxygen profile data for Site 1 (BOI 185).

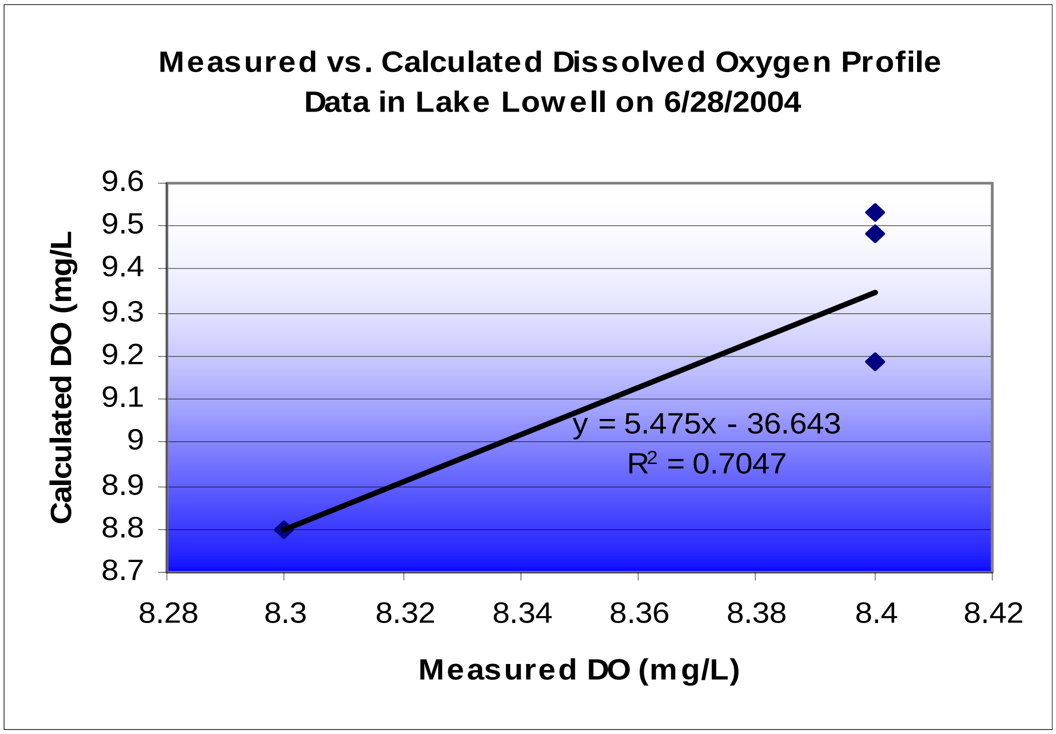
Site 1	Calculated			Site 1	Measured	
Date	DO (mg/L)	Depth (ft)	Meters	Date	DO (mg/L)	Depth (m)
3/17	Not modeled					
4/29	10.16	0	0			
	10.16	2.5	0.762			
	10.16	7.5	2.286			
	10.15	12.5	3.81			
	10.09	17.5	5.334			
	10.06	22.5	6.858			
		25				
5/19	9.23	0		5/19/2004	9.7	0
	9.23	2.5			9.7	0.5
	9.18	7.5			9.7	1.0
	9.11	12.5			9.5	4.0
	9.02	17.5			9.3	5.0
	9.03	22.5			9	6.5
6/16	8.94	0		6/16/2004	8.7	0.0
	8.94	2.5	0.762		8.7	1.0
	8.9	7.5	2.286		8.6	3.0
	8.84	12.5	3.81		8.6	4.0
	8.76	17.5	5.334		8.6	5.0
6/28	9.19	0	0	6/28/2004	8.4	0.0
	9.19	2.5	0.762		8.4	1.0
	9.53	7.5	2.286		8.4	3.0
	9.48	12.5	3.81		8.4	4.0
	8.8	17.5	5.334		8.3	5.5
8/11	7.23	0		8/11/2004	8.3	0.0
	7.23	2.5	0.762		8	1.0
	7.08	7.5	2.286		6.9	3.0
	6.9	12.5	3.81		6	3.5
	5.73	17.5	5.334		3.3	5.5



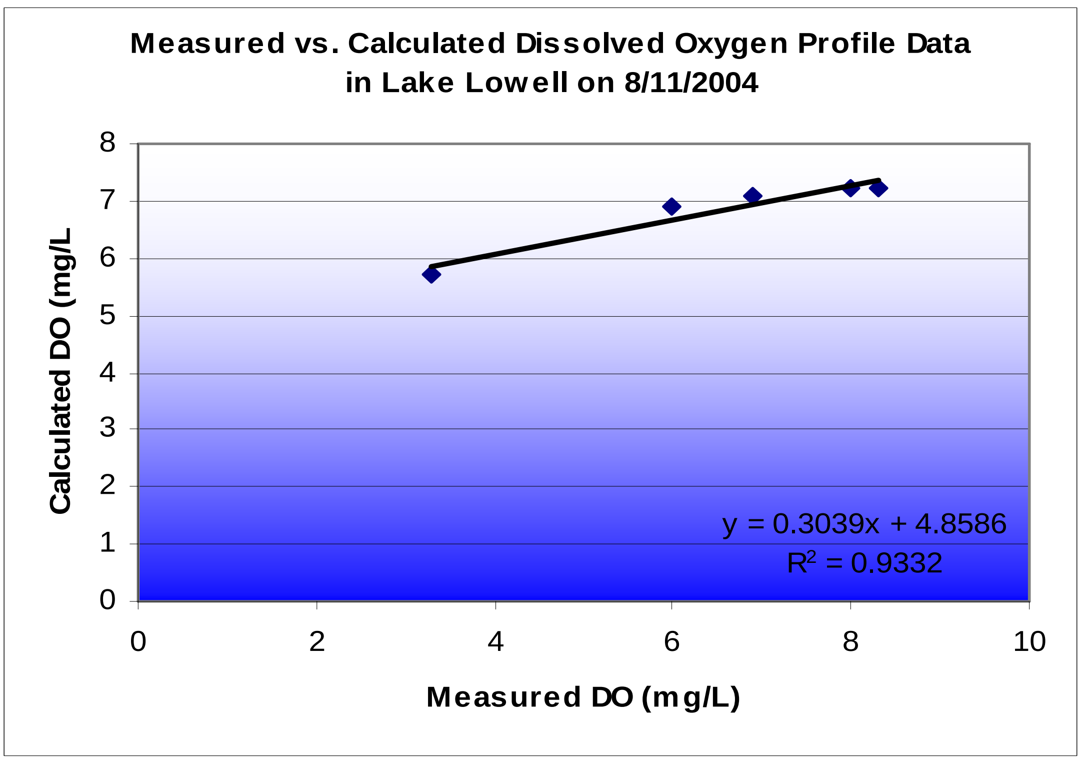
Appendix Figure 1. Comparison of measured dissolved oxygen profile data and model calculated values for 5/19/04 at Site 1 (BOI 185).



Appendix Figure 2. Comparison of measured dissolved oxygen profile data and model calculated values for 6/16/2004 at Site 1 (BOI 185).



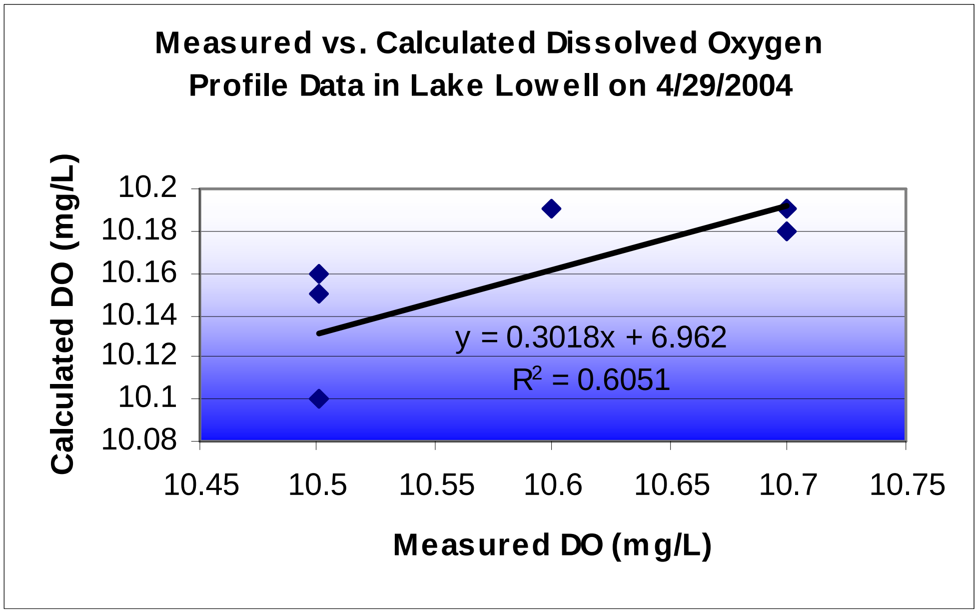
Appendix Figure 3. Comparison of measured dissolved oxygen profile data and model calculated values for 6/28/2004 at Site 1 (BOI 185).



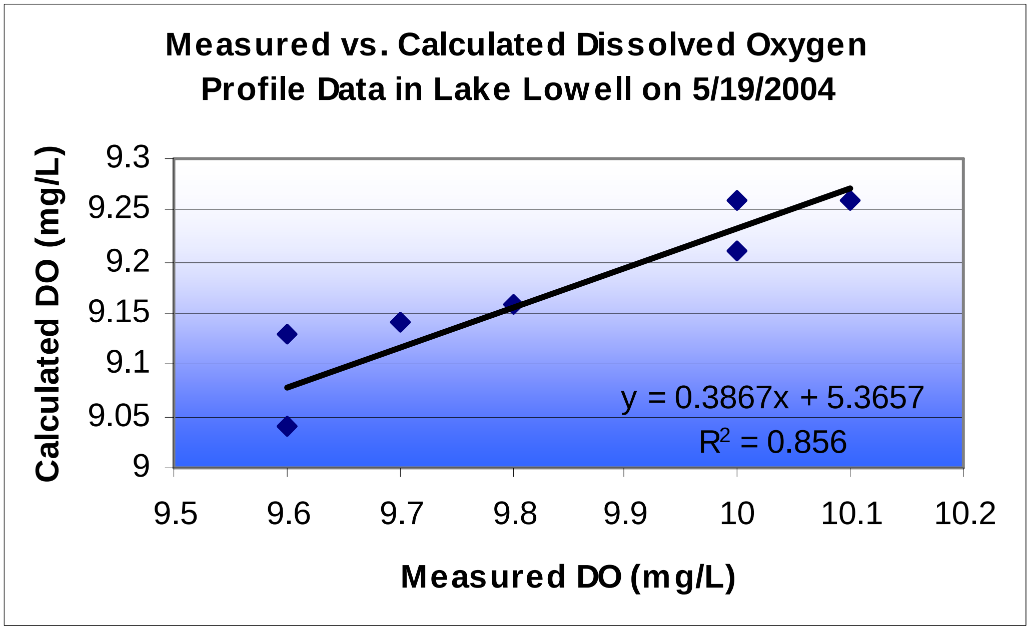
Appendix Figure 4. Comparison of measured dissolved oxygen profile data and model calculated values for 8/11/2004 at Site 1 (BOI 185).

Appendix Table 2. Model calculated and actual measured dissolved oxygen profile data for Site 2 (BOI 181).

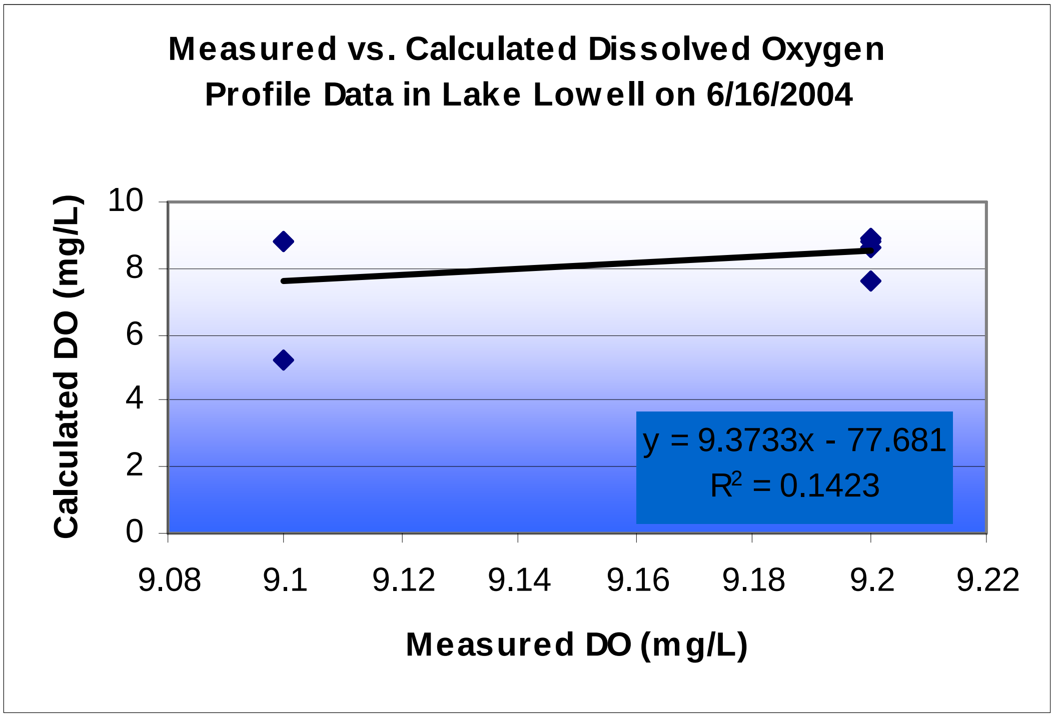
Site 2	Calculated			Site 2	Measured	
Date	DO (mg/L)	Depth (ft)	Depth (m)	Date	DO (mg/L)	Depth (m)
4/29	10.19	0		4/29/2004		
	10.19	2.5	0.762		10.6	1
	10.19	7.5	2.286		10.7	3
	10.18	12.5	3.81		10.7	4
	10.16	17.5	5.334		10.7	5
	10.15	22.5	6.858		10.5	7
	10.1	27.5	8.382		10.5	8
	10.1	32.5	9.906		10.5	10
	10.1	35	10.668		10.5	11.5
5/19	9.26	0	0	5/19/2004	10	0
	9.26	2.5	0.762		10.1	1
	9.21	7.5	2.286		10	3
	9.16	12.5	3.81		9.8	4
	9.14	17.5	5.334		9.7	5
	9.13	22.5	6.858		9.6	7
	9.04	27.5	8.382		9.6	8
	9.04	32.5	9.906		9.6	10
			0			
6/16	8.9	0	0	6/16/2004	9.2	0
	8.9	2.5	0.762		9.2	1
	8.84	7.5	2.286		9.1	3
	8.8	12.5	3.81		9.1	4
	8.77	17.5	5.334		9.2	5
	8.62	22.5	6.858		9.2	7
	7.58	27.5	8.382		9.2	8
	5.21	32.5	9.906		9.1	10
			0			
6/28	10	0	0			
	10	2.5	0.762			
	10.72	7.5	2.286			
	10.55	12.5	3.81			
	9.16	17.5	5.334			
	7.21	22.5	6.858			
	5.23	27.5	8.382			
	3.15	32.5	9.906			
			0			
8/11	7.81	0	0	8/11/2004	10.1	0
	7.81	2.5	0.762		9.8	1
	7.73	7.5	2.286		9	3
	7.48	12.5	3.81		8.8	4
	6.87	17.5	5.334		8.7	5
	5.82	22.5	6.858		5.3	7
	4.33	27.5	8.382		4.3	8
	2.57	32.5	9.906		1.3	10



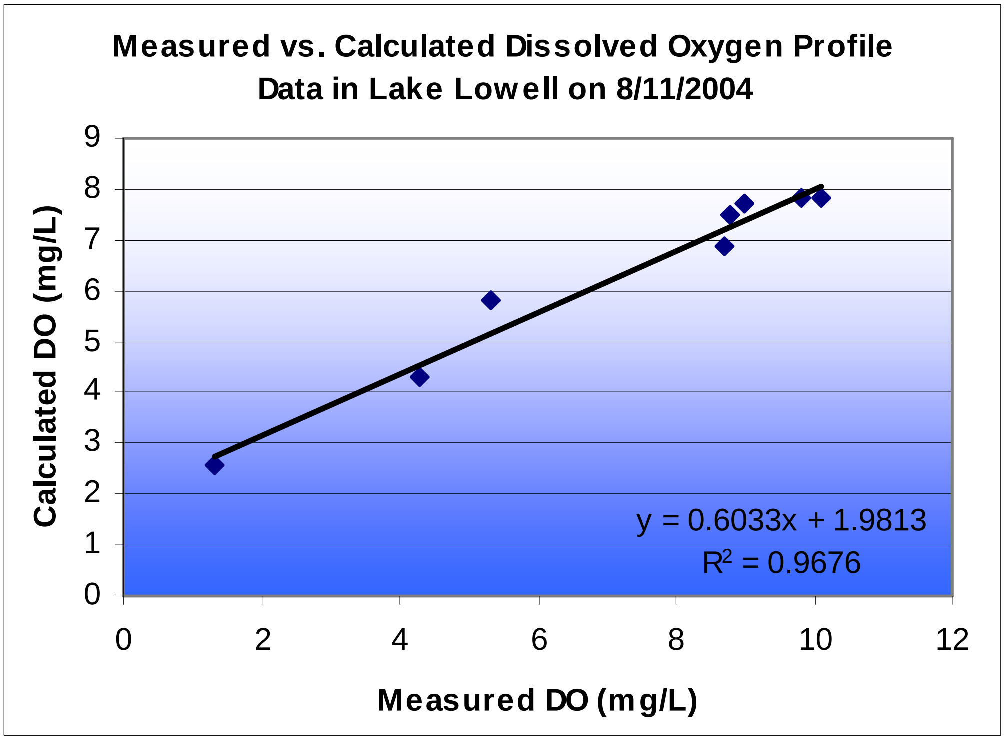
Appendix Figure 5. Comparison of measured dissolved oxygen profile data and model calculated values for 4/29/2004 at Site 2 (BOI 181).



Appendix Figure 6. Comparison of measured dissolved oxygen profile data and model calculated values for 5/19/2004 at Site 2 (BOI 181).



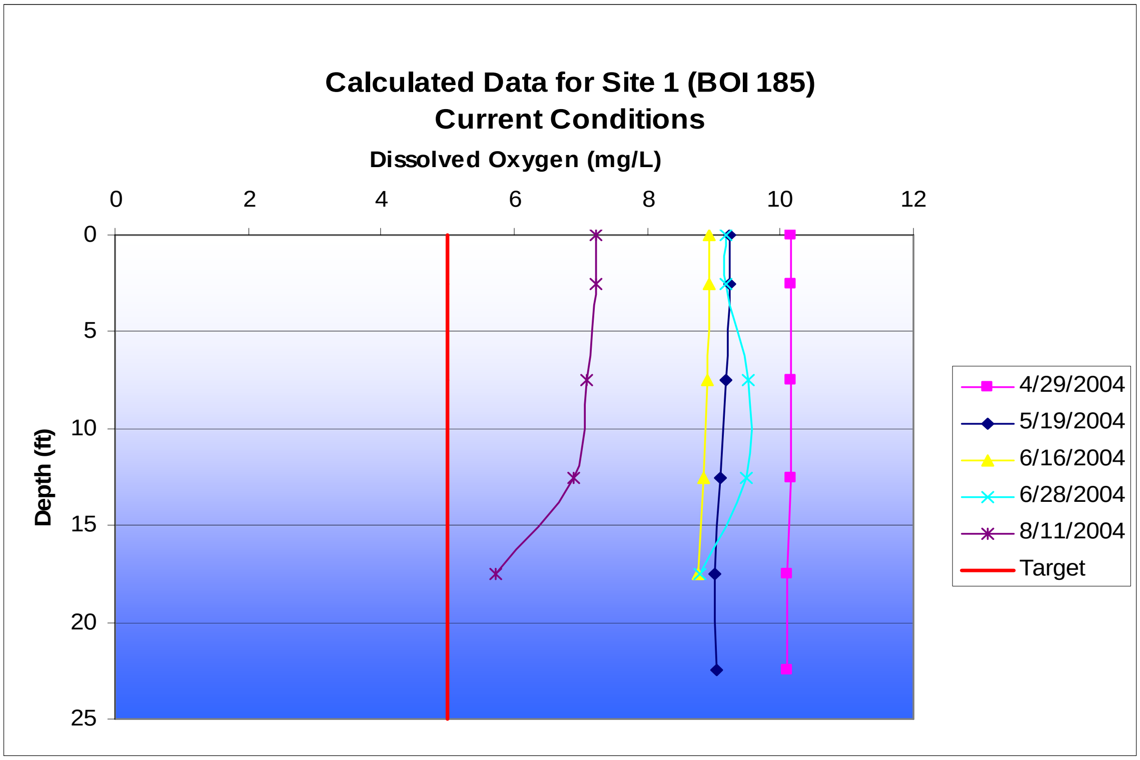
Appendix Figure 7. Comparison of measured dissolved oxygen profile data and model calculated values for 6/16/2004 at Site 2 (BOI 181).



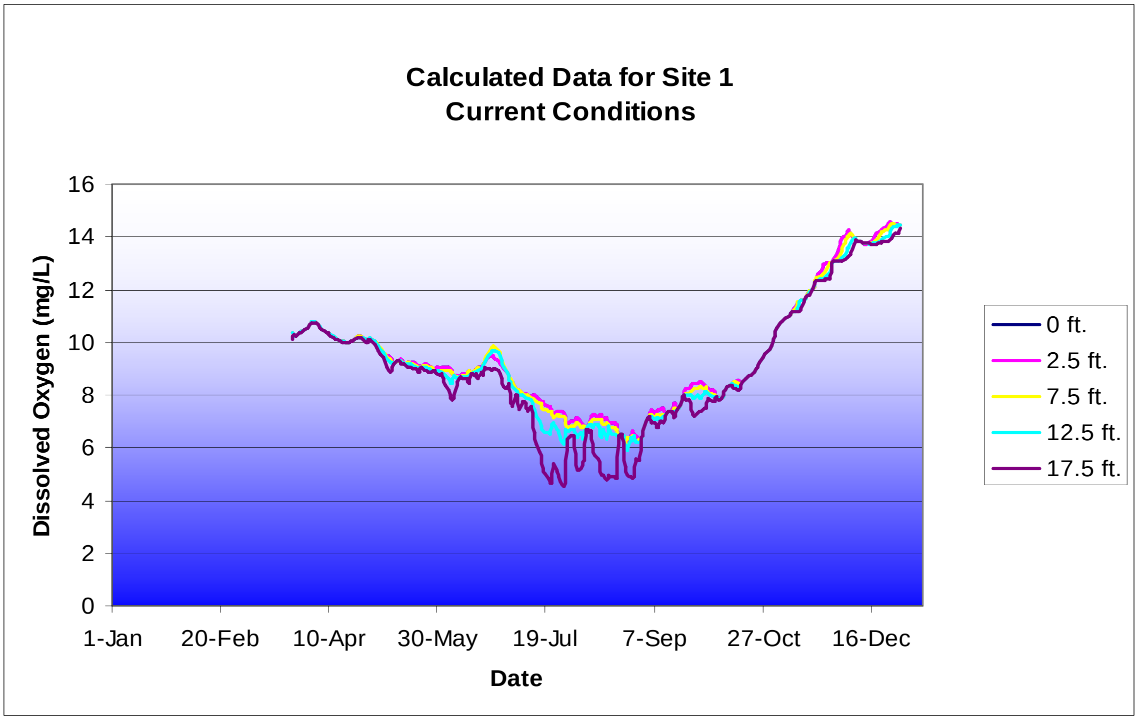
Appendix Figure 8. Comparison of measured dissolved oxygen profile data and model calculated values for 8/11/2004 at Site 2 (BOI 181).

Appendix Table 3. Model calculated dissolved oxygen profile data for Site 1 (BOI 185) under current conditions, a 0.025 mg/L TP target and a 0.07 mg/L TP target.

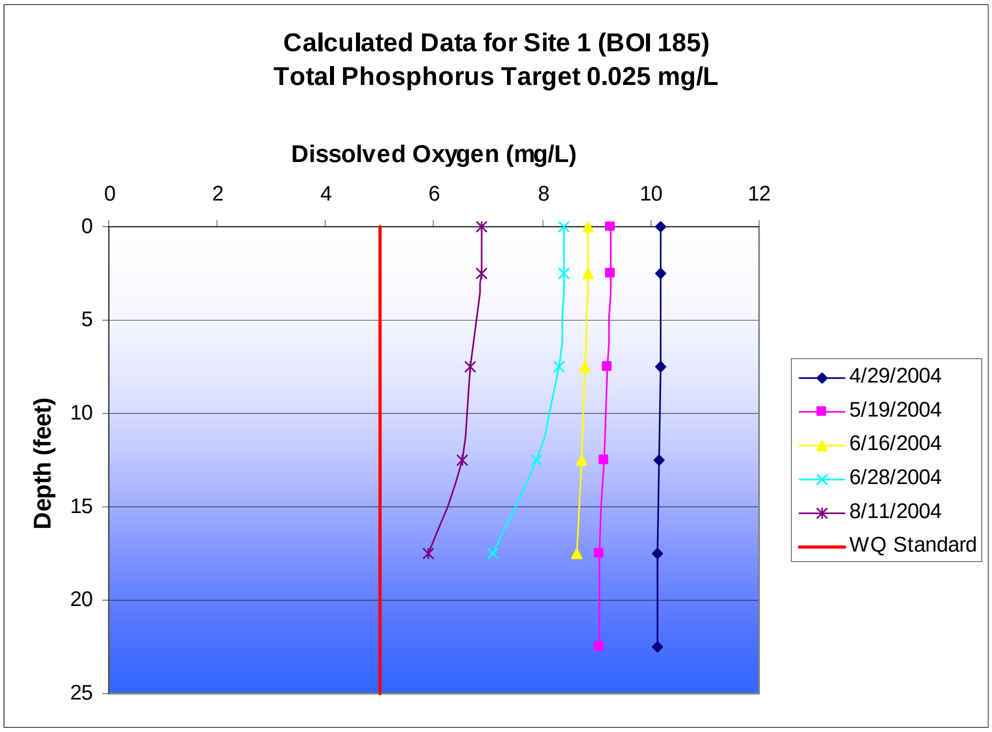
Date	Depth (ft)	Current Conditions	0.025 mg/L TP Target Conditions	0.07 mg/L TP Target Conditions
		DO (mg/L)	DO (mg/L)	DO (mg/L)
4/29	0	10.16	10.18	10.18
	2.5	10.16	10.18	10.18
	7.5	10.16	10.18	10.18
	12.5	10.15	10.16	10.16
	17.5	10.09	10.11	10.11
	22.5	10.09	10.11	10.11
5/19	0	9.23	9.26	9.25
	2.5	9.23	9.26	9.26
	7.5	9.18	9.21	9.21
	12.5	9.11	9.15	9.15
	17.5	9.02	9.06	9.05
	22.5	9.03	9.06	9.05
6/16	0	8.94	8.83	8.85
	2.5	8.94	8.83	8.85
	7.5	8.9	8.78	8.8
	12.5	8.84	8.71	8.73
	17.5	8.76	8.64	8.66
6/28	0	9.19	8.4	8.56
	2.5	9.19	8.4	8.56
	7.5	9.53	8.31	8.55
	12.5	9.48	7.88	8.23
	17.5	8.8	7.09	7.53
8/11	0	7.23	6.88	7.02
	2.5	7.23	6.88	7.02
	7.5	7.08	6.67	6.84
	12.5	6.9	6.52	6.67
	17.5	5.73	5.9	5.69



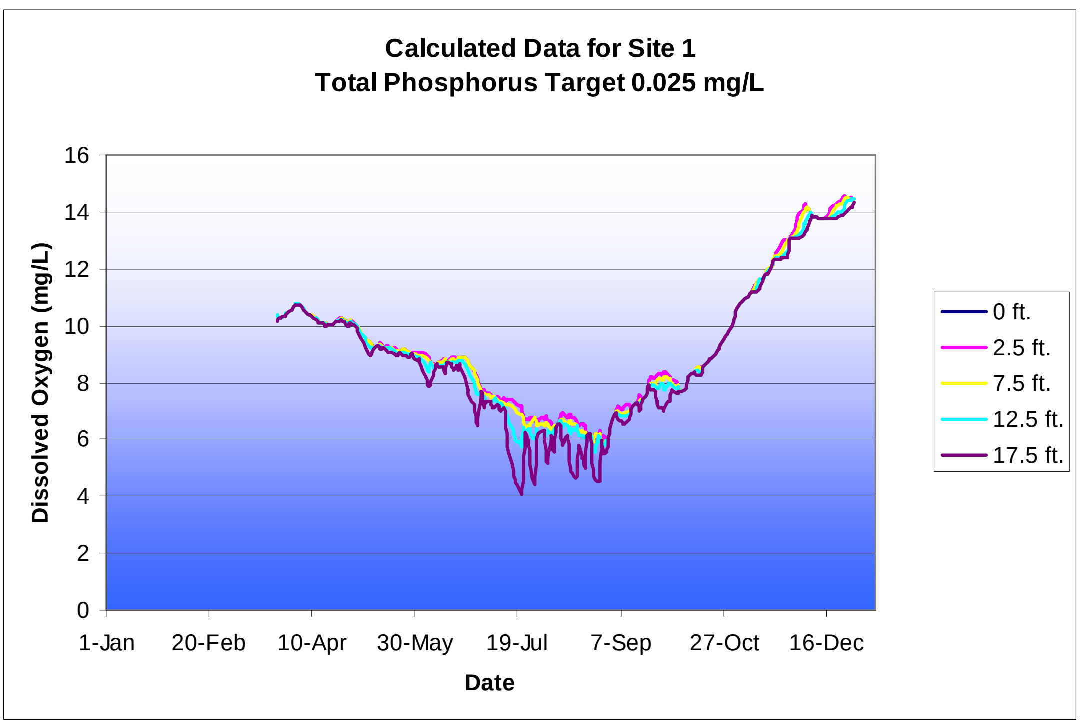
Appendix Figure 9. Model calculated dissolved oxygen profile data for current conditions at Site 1 (BOI 185).



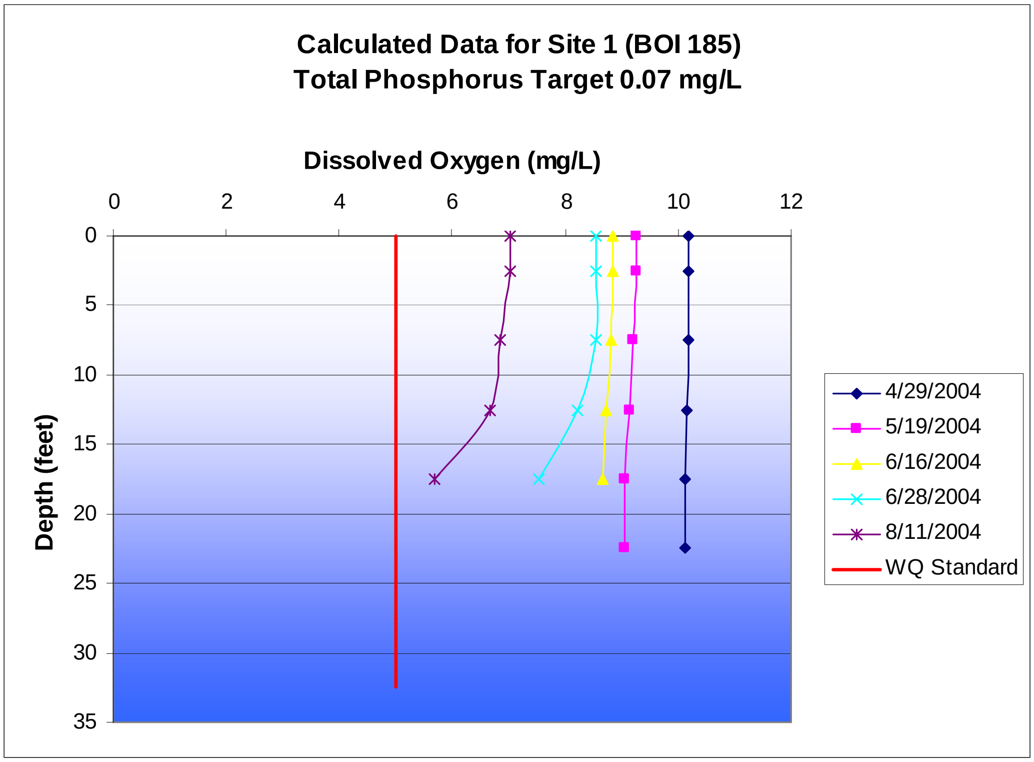
Appendix Figure 10. Model calculated dissolved oxygen data for current conditions at Site 1 (BOI 185).



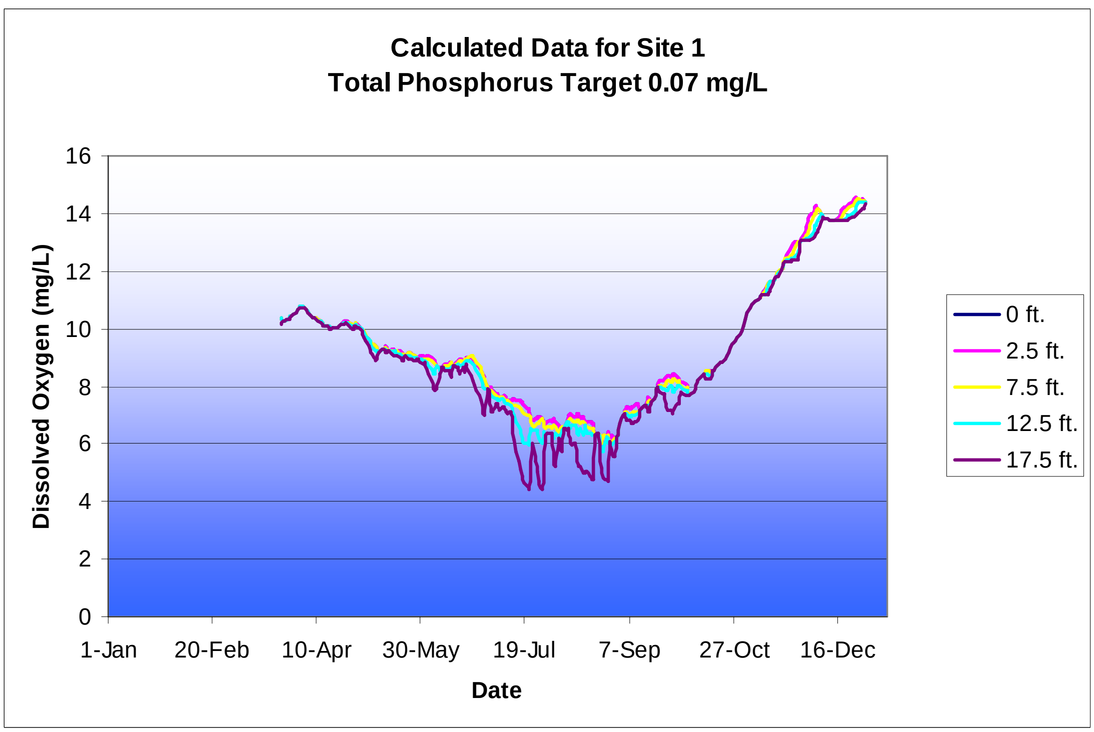
Appendix Figure 11. Model calculated dissolved oxygen profile data for Site 1 (BOI 185) with a reservoir tributary total phosphorus target of 0.025 mg/L.



Appendix Figure 12. Model calculated dissolved oxygen data for Site 1 (BOI 185) with a reservoir tributary total phosphorus target of 0.025 mg/L.



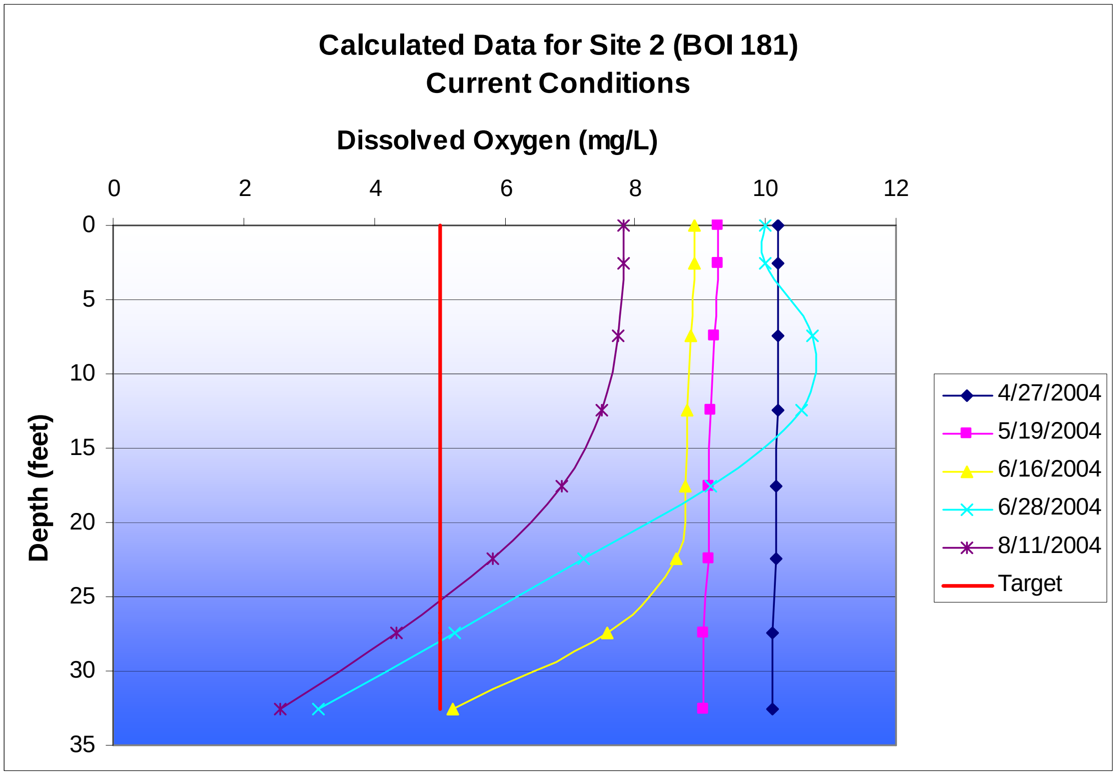
Appendix Figure 13. Model calculated dissolved oxygen data for Site 1 (BOI 185) with a reservoir tributary total phosphorus target of 0.07 mg/L.



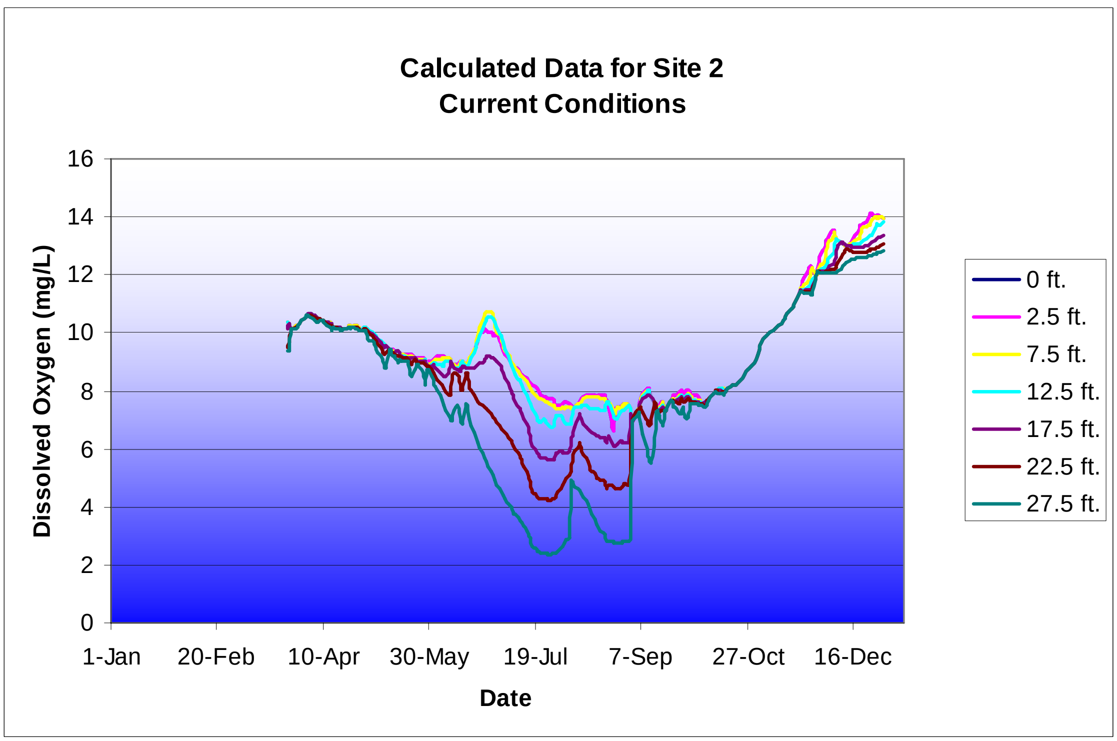
Appendix Figure 14. Model calculated dissolved oxygen data for Site 1 (BOI 185) with a reservoir tributary total phosphorus target of 0.07 mg/L.

Appendix Table 4. Model calculated dissolved oxygen profile data for Site 2 (BOI 181) under current conditions, a 0.025 mg/L TP target and a 0.07 mg/L TP target.

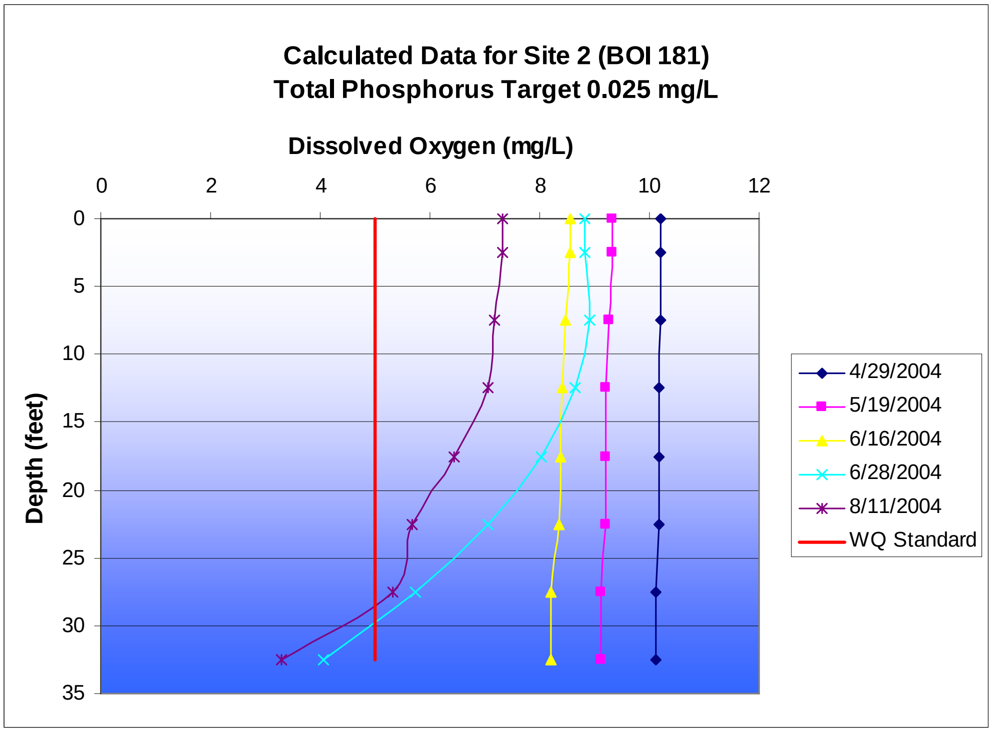
Date	Depth (ft)	Current Conditions	0.025 mg/L TP Target Conditions	0.07 mg/L TP Target Conditions
		DO (mg/L)	DO (mg/L)	DO (mg/L)
4/29	0	10.19	10.2	10.2
	2.5	10.19	10.2	10.2
	7.5	10.19	10.2	10.2
	12.5	10.18	10.19	10.19
	17.5	10.16	10.18	10.17
	22.5	10.15	10.17	10.17
	27.5	10.1	10.12	10.11
	32.5	10.1	10.12	10.11
5/19	0	9.26	9.32	9.31
	2.5	9.26	9.32	9.31
	7.5	9.21	9.27	9.26
	12.5	9.16	9.22	9.21
	17.5	9.14	9.21	9.2
	22.5	9.13	9.2	9.18
	27.5	9.04	9.11	9.1
	32.5	9.04	9.11	9.1
6/16	0	8.9	8.57	8.56
	2.5	8.9	8.57	8.56
	7.5	8.84	8.47	8.47
	12.5	8.8	8.4	8.4
	17.5	8.77	8.38	8.37
	22.5	8.62	8.35	8.34
	27.5	7.58	8.2	8.18
	32.5	5.21	8.2	8.18
6/28	0	10	8.82	9.27
	2.5	10	8.82	9.27
	7.5	10.72	8.9	9.56
	12.5	10.55	8.65	9.38
	17.5	9.16	8.02	8.62
	22.5	7.21	7.06	7.36
	27.5	5.23	5.74	5.86
	32.5	3.15	4.05	4.05
8/11	0	7.81	7.33	7.64
	2.5	7.81	7.33	7.64
	7.5	7.73	7.19	7.54
	12.5	7.48	7.07	7.34
	17.5	6.87	6.45	6.9
	22.5	5.82	5.67	6.24
	27.5	4.33	5.31	5.04
	32.5	2.57	3.3	3.44



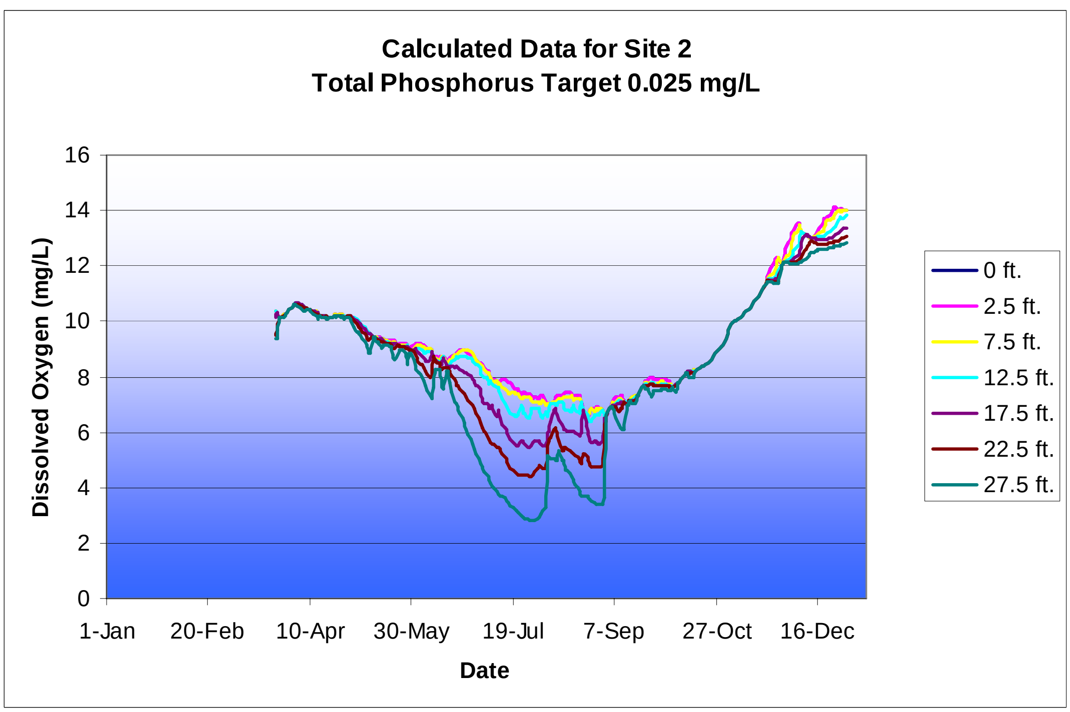
Appendix Figure 15. Model calculated dissolved oxygen profile data for current conditions at Site 2 (BOI 181).



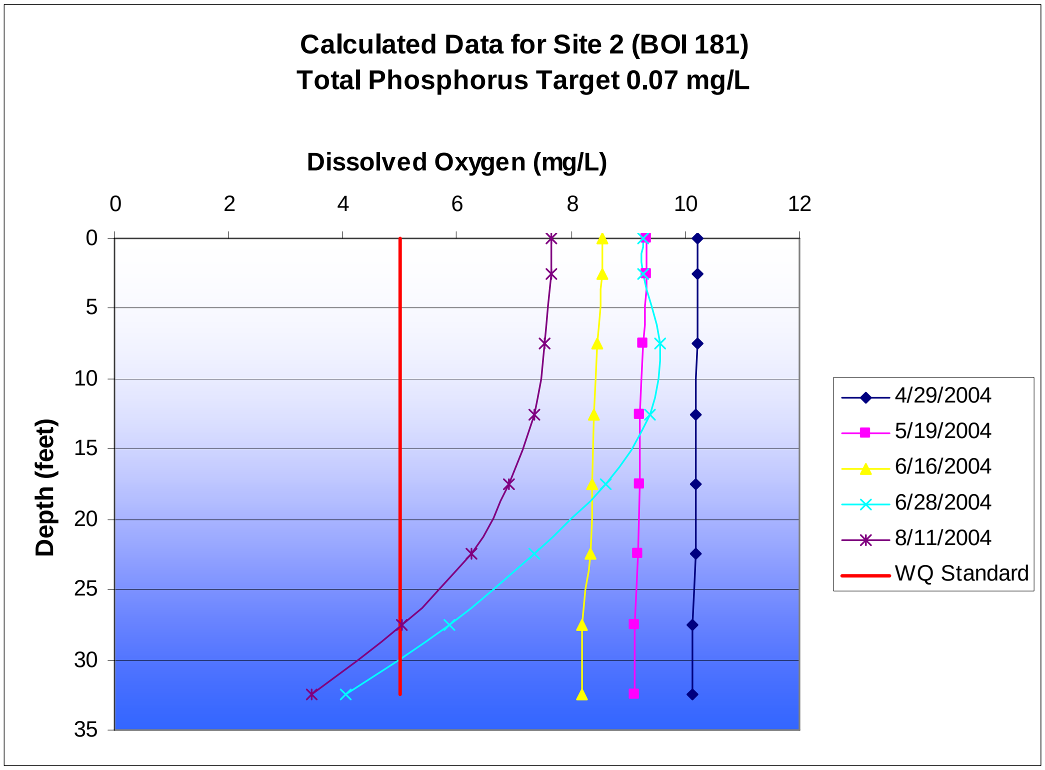
Appendix Figure 16. Model calculated dissolved oxygen data for current conditions at Site 2 (BOI 181).



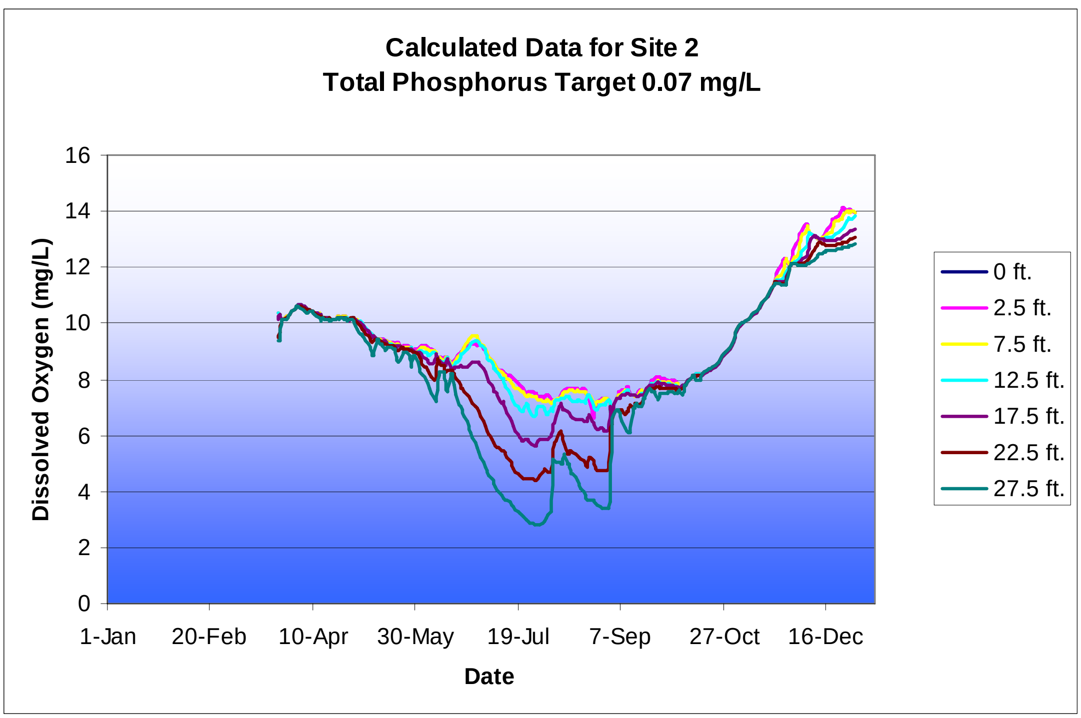
Appendix Figure 17. Model calculated dissolved oxygen profile data for Site 2 (BOI 181) with a reservoir tributary total phosphorus target of 0.025 mg/L.



Appendix Figure 18. Model calculated dissolved oxygen data for Site 2 (BOI 181) with a reservoir tributary total phosphorus target of 0.025 mg/L.



Appendix Figure 19. Model calculated dissolved oxygen data for Site 2 (BOI 181) with a reservoir tributary total phosphorus target of 0.07 mg/L.



Appendix Figure 20. Model calculated dissolved oxygen data for Site 2 (BOI 181) with a reservoir tributary total phosphorus target of 0.07 mg/L.

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Appendix E. Data Used to Develop Total Phosphorus Load

Table E-1. Lake Lowell tributary total phosphorus (TP) loads[1].

Site ID	Location Description	Date	Flow (cfs)	TP mg/L	TP Load lbs/day	Site Median Load
BOI023	**New York Canal @ Lake Shore Drive**	06/24/04	114.2	0.053	32.6	74.09
		07/19/04	695.0	0.060	224.8	
		08/09/04	474.0	0.029	74.1	
		09/09/04	525.8	0.025	70.9	
		10/05/04	758.0	0.022	89.9	
		04/25/05	118.6	0.052	33.2	
		07/24/06	240.6	0.076	98.6	
		08/03/06	247.4	0.049	65.3	
		08/24/06	288.0	0.115	178.5	
BOI025	**Garland Drain**	04/19/04	8.500	0.360	16.5026	13.78
		05/03/04	13.200	0.280	19.9325	
		06/28/04	14.500	0.480	37.5353	
		07/19/04	19.000	0.530	54.3075	
		08/09/04	14.000	0.600	45.3012	
		09/09/04	12.000	0.171	11.0664	
		10/05/04	8.200	0.079	3.4936	
		04/25/05	15.000	0.124	10.0310	
		07/11/05	4.000	1.420	30.6322	
		05/15/06	0.800	0.151	0.6515	
		09/12/06	13.000	0.060	4.2065	
		10/10/06	7.000	0.085	3.2088	
BOI330	**Deer Fat Wasteway #3**	04/19/04	51.400	0.097	26.8884	38.76
	DEQ/BRO Monitoring	05/03/04	67.500	0.280	101.9277	
		06/28/04	95.700	0.200	103.2220	
		07/19/04	34.900	0.250	47.0539	
		08/09/04	39.800	0.160	34.3426	
		09/09/04	85.700	0.026	12.0167	
		10/05/04	120.500	0.020	12.9971	
		04/25/05	94.600	0.037	18.8766	
		07/11/05	2.500	0.033	0.4449	
		04/24/06	205.000	0.137	151.4624	
		08/03/06	40.990	0.203	44.8750	
		08/24/06	59.500	0.340	109.1004	
	ISDA Monitoring	04/23/02	78.600	0.090	38.1501	
		05/22/02	58.900	0.160	50.8236	
		06/05/02	43.000	0.170	39.4228	
		06/19/02	14.100	0.200	15.2083	
		07/01/02	36.700	0.300	59.3769	
		07/17/02	35.300	0.370	70.4380	
		07/30/02	18.600	0.190	19.0589	
		08/14/02	24.700	0.090	11.9886	
		08/28/02	60.300	0.090	29.2678	
		09/09/02	227.000	0.110	134.6632	
		09/24/02	155.000	0.300	250.7745	
		10/08/02	17.500	0.050	4.7189	

Site ID	Location Description	Date	Flow (cfs)	TP mg/L	TP Load lbs/day	Site Median Load
BOI332	**Farner Drain**	04/19/04	5.0	0.560	15.1004	12.82
	DEQ/BOR Monitoring	05/03/04	1.5	0.350	2.8313	
		06/28/04	1.5	0.730	5.9053	
		08/09/04	1.5	0.860	6.9570	
		09/09/04	4.0	0.200	4.3144	
		10/05/04	2.5	0.180	2.4269	
		04/25/05	3.0	0.810	13.1050	
		05/23/05	4.0	0.430	9.2760	
		07/11/05	3.80	3.930	80.5391	
		08/15/05	13.20	1.680	119.5952	
		05/15/06	7.50	1.380	55.8176	
		06/12/06	12.0	1.810	117.1360	
		07/10/06	15.0	2.180	176.3511	
		07/24/06	2.4	0.970	12.5549	
		08/03/06	10.1	0.297	16.1774	
		08/07/06	10.0	1.300	70.1090	
		08/24/06	7.9	0.265	11.2902	
		09/12/06	2.5	0.106	1.4291	
		10/10/06	2.5	0.380	5.1234	
	ISDA Monitoring	05/02/02	3.1	0.46	7.6904	
		05/22/02	4.9	1.06	27.8397	
		06/05/02	10.4	1.32	74.0351	
		06/19/02	14.4	1.14	88.5315	
		07/01/02	9.570	0.85	43.8694	
		07/17/02	14.90	2.3	184.8181	
		07/30/02	18.5	1.14	113.7384	
		08/14/02	2.77	0.81	12.1003	
		08/28/02	2.61	0.38	5.3488	
		09/09/02	5.36	0.14	4.0469	
		09/24/02	5.97	0.15	4.8294	
BOI334	**Donaldson Drain**	07/19/04	2.4	0.270	3.4947	11.04
		07/11/05	1.6	1.280	11.0449	
		08/15/05	4.00	1.310	28.2593	
BOI336	**Garner Drain**	06/12/06	2.0	0.250	2.6965	1.56
		07/24/06	0.2	0.394	0.4250	
BOI338	**Highline Wasteway #1**	05/03/04	4.0	0.045	0.9707	2.03
		06/28/04	2.5	0.075	1.0112	
		08/09/04	5.0	0.096	2.5886	
		09/09/04	7.0	0.034	1.2835	
		10/05/04	7.5	0.034	1.3752	
		04/25/05	4.0	0.094	2.0278	
		07/10/06	2.0	0.163	1.7581	
		08/07/06	9.0	0.146	7.0864	
		08/24/06	2.85	0.370	5.6869	
		09/12/06	15.0	0.044	3.5594	
		10/10/06	20.0	0.044	4.7458	

Site ID	Location Description	Date	Flow (cfs)	TP mg/L	TP Load lbs/day	Site Median Load
BOI340	**Bernard Drain**	04/19/04	2.0	0.260	2.8044	15.91
	DEQ/BOR Monitoring	05/03/04	2.0	0.570	6.1480	
		06/28/04	5.0	0.840	22.6506	
		07/19/04	1.8	0.052	0.5048	
		08/09/04	4.0	2.240	48.3213	
		09/09/04	2.0	1.890	20.3855	
		10/05/04	1.0	0.410	2.2111	
		07/11/05	1.4	0.840	6.3422	
		08/15/05	12.0	1.980	128.1377	
		05/15/06	1.8	0.800	7.7659	
		06/12/06	5.0	0.900	24.2685	
		07/10/06	4.0	0.780	16.8262	
		07/24/06	1.0	2.300	12.4039	
		08/03/06	0.9	1.500	7.2806	
		08/07/06	6.0	2.500	80.8950	
		08/24/06	5.0	0.920	24.8078	
		10/10/06	1.0	0.360	1.9415	
	ISDA Monitoring	05/02/02	2.42	1.22	15.9223	
		05/22/02	3.27	0.82	14.4608	
		06/05/02	3.69	0.69	13.7311	
		06/19/02	5.23	1.13	31.8721	
		07/01/02	10.1	1.03	56.1034	
		07/17/02	12.6	1.41	95.8120	
		07/30/02	10.0	2.9	156.3970	
		08/14/02	8.17	1.34	59.0415	
		08/28/02	4.91	0.93	24.6261	
		09/09/02	2.16	0.27	3.1452	
		09/24/02	1.12	0.24	1.4496	
		10/08/02	1.98	0.89	9.5035	
BOI342	**Coulee Drain**	04/19/04	4.0	1.060	22.8663	20.59
		05/03/04	5.0	0.680	18.3362	
		06/28/04	2.0	0.390	4.2065	
		07/19/04	8.0	1.250	53.9300	
		08/09/04	5.0	1.420	38.2903	
		09/09/04	3.0	0.220	3.5594	
		10/05/04	2.0	0.117	1.2620	
		04/25/05	1.5	0.820	6.6334	
		05/23/05	0.8	0.041	0.1769	
		07/11/05	5.6	0.380	11.4763	
		08/15/05	21.0	0.420	47.5663	
		05/15/06	9.0	0.580	28.1515	
		06/12/06	24.0	0.860	111.3115	
		07/10/06	20.0	0.600	64.7160	
		07/24/06	0.3	0.601	0.9724	
		08/03/06	15.21	6.300	516.7734	
		08/07/06	12.0	0.660	42.7126	
		08/24/06	10.35	0.530	29.5833	
		09/12/06	3.50	0.600	11.3253	
		10/10/06	6.0	0.360	11.6489	

Table E-2. Lake Lowell outlet canal total phosphorus (TP) loads[1].

Site ID	Location Description	Date	Flow (cfs)	TP mg/L	TP Load lbs/day	Site Median Load
BOI610	**Deer Flat Caldwell Canal**	04/19/04	15	0.024	1.9	2.01
		06/28/04	12	0.036	2.3	
		08/09/04	12	0.032	2.1	
		09/09/04	12	0.051	3.3	
		10/05/04	5	0.025	0.7	
		04/25/05	3	0.028	0.5	
		05/23/05	4	0.037	0.8	
		07/11/05	2	0.044	0.5	
		04/24/06	6	0.036	1.2	
		05/15/06	8.4	0.036	1.6	
		07/10/06	13	0.032	2.2	
		08/07/06	15	0.060	4.9	
		09/12/06	7.5	0.100	4.0	
		10/10/06	6	0.117	3.8	
BOI612	**Deer Flat Nampa Canal**	04/19/04	20	0.021	2.3	2.08
		05/03/04	25	0.012	1.6	
		06/28/04	18	0.042	4.1	
		08/09/04	10	0.036	1.9	
		09/09/04	10	0.042	2.3	
		04/25/05	5	0.028	0.8	
		05/23/05	6	0.028	0.9	
		07/11/05	13.8	0.028	2.1	
		04/24/06	10	0.040	2.2	
		05/15/06	10	0.037	2.0	
		07/10/06	10	0.034	1.8	
		08/07/06	12	0.051	3.3	
		09/12/06	12	0.065	4.2	
BOI008	**Deer Flat LL Below Lake Lowell**	04/19/04	570	0.031	95.3	95.29
		05/03/04	590	0.010	31.8	
		06/28/04	597	0.035	112.7	
		08/09/04	560	0.054	163.1	
		09/09/04	414.8	0.050	111.9	
		10/05/04	270.2	0.041	59.7	
		04/25/05	398	0.032	68.7	

cfs = cubic feet per second; mg/L – milligrams per liter; lbs/day = pounds per day

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Appendix F. Data Submitted by LBWC During the Public Comment Period.

Lower Boise Watershed Council

322 East Front Street, Suite 200, Boise, Idaho 83702 . Tom Dupuis facilitator 208-383-6312 . www.lowerboisewatershedcouncil.org

July 1, 2010

Lauri Monnot
DEQ Regional Office
1445 N. Orchard
Boise, ID 83706

RE: Comments on the April 2010 Draft Lake Lowell TMDL: Addendum to the Lower Boise River Subbasin Assessment and Total Maximum Daily Loads

Dear Ms. Monnot,

Thank you for the opportunity to provide comments on the April 2010 Draft Lake Lowell TMDL: Addendum to the Lower Boise River Subbasin Assessment and Total Maximum Daily Loads. We appreciate all of the efforts to date that DEQ has put into this important document.

As key stakeholders that live and work in the Treasure Valley, we represent government, agriculture, business, and conservation interests concerned with the water quality of the Lower Boise River watershed. By coordinating and integrating everyone's actions, the Lower Boise Watershed Council (LBWC) strives to implement protective and fair plans to protect this precious resource.

The LBWC understands how our water quality is linked to the quality of life - and economy - in the Treasure Valley. We have three key goals – all of which require broad cooperation and collaboration:

- Maintain local control of water quality improvement activities through balanced water quality plans, high-quality monitoring, and prioritized actions that provide the best benefit - for the least cost.
- Ensure everyone is aware of the steps being taken by all stakeholders to meet our water quality goals for the Treasure Valley.
- Secure grant money and maximize the benefits of leveraging local funds for additional local, state, and federal resources.

Our comments on the draft Lake Lowell TMDL relate primarily to two issues: 1) viewing the TMDL in the context of a reservoir system; and 2) bringing additional defensible data to DEQ's attention. To streamline this comment letter, these issues are discussed in more detail in the following attachment, which includes potential text changes to the draft TMDL for DEQ consideration.

Thank you for consideration of these suggestions and incorporation of the additional data.

Sincerely,

Lee J. Van De Bogart *(for)*

Johanna Bell, City of Boise
Chairperson

Cc:
Lower Boise Watershed Council Board:

Erica Anderson-Maguire, Ada County Highway District
Bob Braun, Amalgamated Sugar
Paul Calverly, Ada Soil and Water Conservation District
Robbin Finch, City of Boise
Henry Hamanishi, Simplot Company
Helen Larson-Hickman, Flood District #10
Alan Newbill, Pioneer Irrigation District
Liz Paul, Idaho Rivers United
Dan Steenson, Ringert Law
Lee Van De Bogart, City of Caldwell

Attached Data Appendix

This information contains the backup analysis and data used to develop the comments from the Lower Boise Watershed Council. Similar to our main Attachment, if DEQ accepts our comments, this information can be directly rolled into a revised TMDL document. This appendix provides information specific to five main areas:

- New Inflow Data from the Boise Project Board of Control
- ACHD Stormwater Acres
- Septic System Loading Analysis from City of Nampa
- Ground Water Flows and Concentration Data
- Unmonitored Drain Analysis

Data provided herein are also being submitted to DEQ via a compiled spreadsheet for ease of use.

New Inflow Data from the Boise Project Board of Control

The BPBOC monitors inflow to Lake Lowell via four input points: New York Canal (MC-10 @ Lakeshore Drive upgradient from where the Ridenbaugh Canal and Garland Drain enter the canal), Ridenbaugh Canal (@ Lakeshore Drive), Garland Drain (@ Lakeshore Drive), and Deer Flat Wasteway #3 (near the Lower Embankment of Lake Lowell). Inflow data from Deer Flat Wasteway #3 was not used to establish inflow rates for the New York Canal system because they are included the Drain Inflow dataset provided by DEQ. Information was requested for those dates in which inflow concentration data had been collected by the U.S. Bureau of Reclamation. Inflow data were also requested for 2004, 2005, and 2009 to confirm whether the Deer Flat Wasteway #3 flows were already removed from the New York Canal inflow calculations.

Doran, Sherrill/SEA

From: JERRI FLOYD [JFLOYD@BOISEPROJECT.ORG]
Sent: Monday, June 07, 2010 2:05 PM
To: Doran, Sherrill/SEA
Subject: Lake Lowell Inflows
Attachments: MEASUREMENTS.xlsx

Sherrill,
Paul ask me to get this info for you so have attached an excel worksheet with the numbers. He also wanted you to have the outflow information.

Jerri

Please send her the three inflows, but, also send her the outflows for the same dates...

Thanks a Bunch
Paul

From: Sherrill.Doran@CH2M.com [mailto:Sherrill.Doran@CH2M.com]
Sent: Thursday, June 03, 2010 1:47 PM
To: pdeveau@boiseproject.org
Subject: Lake Lowell Inflows

Thanks tons, Paul!

The data that were received are summarized below (and contained in the spreadsheet).

BPBOC provided raw data on 6/7/2010.

	MC#10	RIDEN.	GARLAND	MC#10	RIDEN.	GARLAND	SUM
DATE	Miners Inch (Raw)			cfs			
6/24/2004	5,050	0	660	101	0	13.2	114.2
7/19/2004	33,300	500	950	666	10	19	695
8/9/2004	22,500	500	700	450	10	14	474
9/9/2004	25,150	540	600	503	10.8	12	525.8
10/5/2004	37,300	190	410	746	3.8	8.2	758
4/25/2005	4,500	900	530	90	18	10.6	118.6
7/24/2006	10,700	530	800	214	10.6	16	240.6
8/3/2006	11,200	470	700	224	9.4	14	247.4
8/24/2006	12,900	500	1,000	258	10	20	288

BPBOC provided raw data on 6/7/2010.

	2004		2005		2009	
	INFLOW	OUTFLOW	INFLOW	OUTFLOW	INFLOW	OUTFLOW
Jan.	20,429	-	-	-	-	-
Feb.	20,481	-	-	-	-	-
Mar.	-	-	-	-	15,135	-
Apr.	-	-	-	-	35,749	-
May	23,848	28,788	32,498	17,903	29,007	32,512
June	14,004	38,076	32,656	27,575	35,860	32,983
July	35,649	39,186	17,718	34,598	18,134	44,604
Aug.	38,518	32,178	15,009	35,804	22,803	46,823
Sept.	41,903	19,309	27,071	21,407	39,231	37,710
Oct.	16,520	6,151	8,056	3,280	707	11,705
Nov.	-	-	-	-	-	-
Dec.	-	-	-	-	-	-

In addition to these data, outflow data were also provided by BPBOC. Outflow loads in our comments were calculated based on the DEQ-reported measured flow taken the day of sampling to be consistent with the inflow loading methodology.

BPBOC Data

	DEERFLAT LOWLINE	DEERFLAT NORTH	DEERFLAT CALDWELL	DEERFLAT NAMPA	DEERFLAT LOWLINE	DEERFLAT NORTH	DEERFLAT CALDWELL	DEERFLAT NAMPA
	Miners Inch (Raw)				cfs			
6/24/2004	14,950	2,100	2,064	1,462	299	42	41	29
7/19/2004	43,250	2,241	1,368	1,291	865	45	27	26
8/9/2004	38,150	1,861	1,485	1,166	763	37	30	23
9/9/2004	32,350	591	634	1,166	647	12	13	23
10/5/2004	30,400	753	300	-	608	15	6	-
4/25/2005	21,700	329	300	415	434	7	6	8
7/24/2006	50,250	2,607	1,484	1,826	1,005	52	30	37
8/3/2006	43,750	2,384	1,976	1,874	875	48	40	37
8/24/2006	35,950	1,093	1,484	1,642	719	22	30	33

In terms of the water balance, the revised inflow data from New York Canal were combined with data already provided by DEQ for the drains and outflow canals. These calculations are provided in the enclosed spreadsheet within the "ConceptualModel_AnnualMass" worksheet.

ACHD Stormwater Acres

ACHD continues to survey its stormwater system to comply with NPDES requirements. They provided an estimate of urban/suburban acreage that connects to the New York Canal (including the co-located portion of Indian Creek) and the Ridenbaugh Canal for Ada County.

Doran, Sherrill/SEA

To: Erica Anderson-Maguire
Subject: RE: Ada County acres

From: Erica Anderson-Maguire [mailto:emaguire@achdidaho.org]
Sent: Wednesday, June 09, 2010 10:57 AM
To: Doran, Sherrill/SEA
Subject: Ada County acres

Sherrill –
Here are the Ada County acres we have mapped that contribute to Lake Lowell. These numbers are based on outfall delineation and mapping of the watershed that discharges from the outfall. Erica

Ridenbaugh Canal	3755 Acres
Indian Creek	268 Acres
New York Canal	1881 Acres
Total	5904

Erica Anderson Maguire
Stormwater Quality Coordinator
3775 Adams Street
Garden City, Idaho 83714
p 208-387-6254
f 208-387-6391

ACHD
Committed to Service

Septic System Loading Analysis from City of Nampa

The City of Nampa submitted the following letter and spreadsheet for inclusion in the analysis. Their spreadsheet information has also been rolled into the enclosed spreadsheet for transparency.

Michael J. Fuss, P.E., MBA
Public Works Director

Sheri L. Murray
Executive Assistant

City of Nampa
Public Works Department

July 1, 2010

Ms. Johanna Bell
Chair, Lower Boise Watershed Council
c/o Tom Dupuis, CH2M HILL
322 East Front Street
Boise, ID 83702

Subject April 2010 Draft Lake Lowell Total Maximum Daily Load (TMDL)

Dear Johanna:

We appreciate the efforts the Lower Boise Watershed Council (LBWC) has taken to consolidate and submit comments to the Idaho Department of Environmental Quality (IDEQ) from the various Lake Lowell watershed stakeholders. Based on our review of the LBWC's consolidated comments to date, we agree with them and feel they address the City of Nampa's specific comments and concerns.

The City of Nampa is submitting this letter to formally document our comments on the April 2010 Draft Lake Lowell TMDL, as summarized below. A copy of this letter and enclosures is also being provided to IDEQ.

Septic Tank Loadings

In the June 14, 2010, Technical Advisory Committee meeting on the draft TMDL, there was discussion regarding the absence of existing septic tank phosphorus loads. Nampa has existing plans (MWH 2009 and JUB 2009) for a new wastewater treatment plant (WWTP) in the watershed that could offset the septic system loads as the City grows in the future. As such, Nampa completed an analysis to help quantify the septic system loads for inclusion in the TMDL. The following is a bulleted summary of the methodology used to estimate the septic tank loads to Lake Lowell:

- Aerial topography was reviewed to determine the number of dwelling units in the areas of interest
- Each residence was assumed to have occupancy of 2.77 people (US Census Bureau Nampa, Idaho "QuickFacts")

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- The septic system phosphorus loading assumptions used in the Cascade Lake TMDL were duplicated for Lake Lowell. This equates to a medium contribution rate of 0.9 kg/yr per person that is subsequently derated 10% to account for phosphorus that is captured in the soil. Using this methodology, the total existing septic load contribution to Lake Lowell was estimated at 6.53 lbs/day
- Lastly, the septic tanks were not considered to contribute to the lake on a year round basis. To estimate the seasonal variability of septic tank phosphorus contributions, monthly groundwater flow estimates in and out of Lake Lowell (RD Schmidt 2008) were used. The septic tanks are assumed to only contribute phosphorus to the lake when it is being recharged by groundwater. No septic tank contribution is assumed during periods without groundwater recharge. The result is an estimated total annual existing septic tank contribution of 1,384 lbs/yr

Enclosed with this letter is an electronic graphical representation of the Lake Lowell areas of interest and existing housing units as well as a copy of the spreadsheet used to calculate the phosphorus loads.

Future Point Source Load Offsets

Since the above referenced new WWTP is not presently permitted and the exact timing of its construction is uncertain, Nampa is not asking for a specific load allocation for it at this time. However, we request that the TMDL include a discussion of how existing non-point sources (septic tanks specifically) can be offset by future point sources. By doing this, we feel that future loads from our planned WWTP will have a clearer mechanism to be considered in future updates to this TMDL.

To aid in this discussion we have developed an estimate of the phosphorus load from the satellite WWTP Nampa is planning. The following is a summary of the assumptions made in this load estimate. The spreadsheet provided with this letter also includes the WWTP phosphorus load calculations.

- Existing planning documents (MWH 2009 and JUB 2009) project that Nampa's population will increase by approximately 100,000 people by the year 2030. To help document the potential for the proposed future WWTP to allow growth and also offset existing non-point septic system loads, it was conservatively assumed that 50- to 60- percent of this growth would occur south of Lewis Lane in the Lake Lowell drainage area. This assumption results in a 6 mgd capacity satellite WWTP by the year 2030
- It is assumed that this growth and the service area for the WWTP will occur in the portion of the Lake Lowell watershed detailed in our planning documents (shown in green in the enclosed figure). The remainder of the watershed would remain as is, with septic systems

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- To account for reuse of treated effluent from the WWTP during the growing season, 2009 Lawn Evapotranspiration (ET) Data from the Nampa AgriMet station was utilized. It was assumed that 100% of the effluent is reused when ET is at its highest. At lower ET rates, it is assumed that excess treated wastewater is discharged directly or indirectly to Lake Lowell
- When discharging to surface waters, the WWTP is assumed to have an effluent concentration of 0.07 mg/l

Based on these assumptions and associated calculations, the addition of a satellite WWTP in the Lake Lowell watershed would allow growth and not increase loads to Lake Lowell. Even with the addition of 50,000 to 60,000 residents and a WWTP to the watershed, it is estimated that annual phosphorus loads to Lake Lowell would decrease from 1,364 lb/yr to 1,246 lbs/yr.

Stormwater Loadings

Nampa appreciates the discussions we have had with members of the LBWC regarding stormwater load allocations and how they are addressed in the draft TMDL. We support the stormwater point source load allocation calculations and methodology being proposed by the LBWC and its adoption into the draft TMDL.

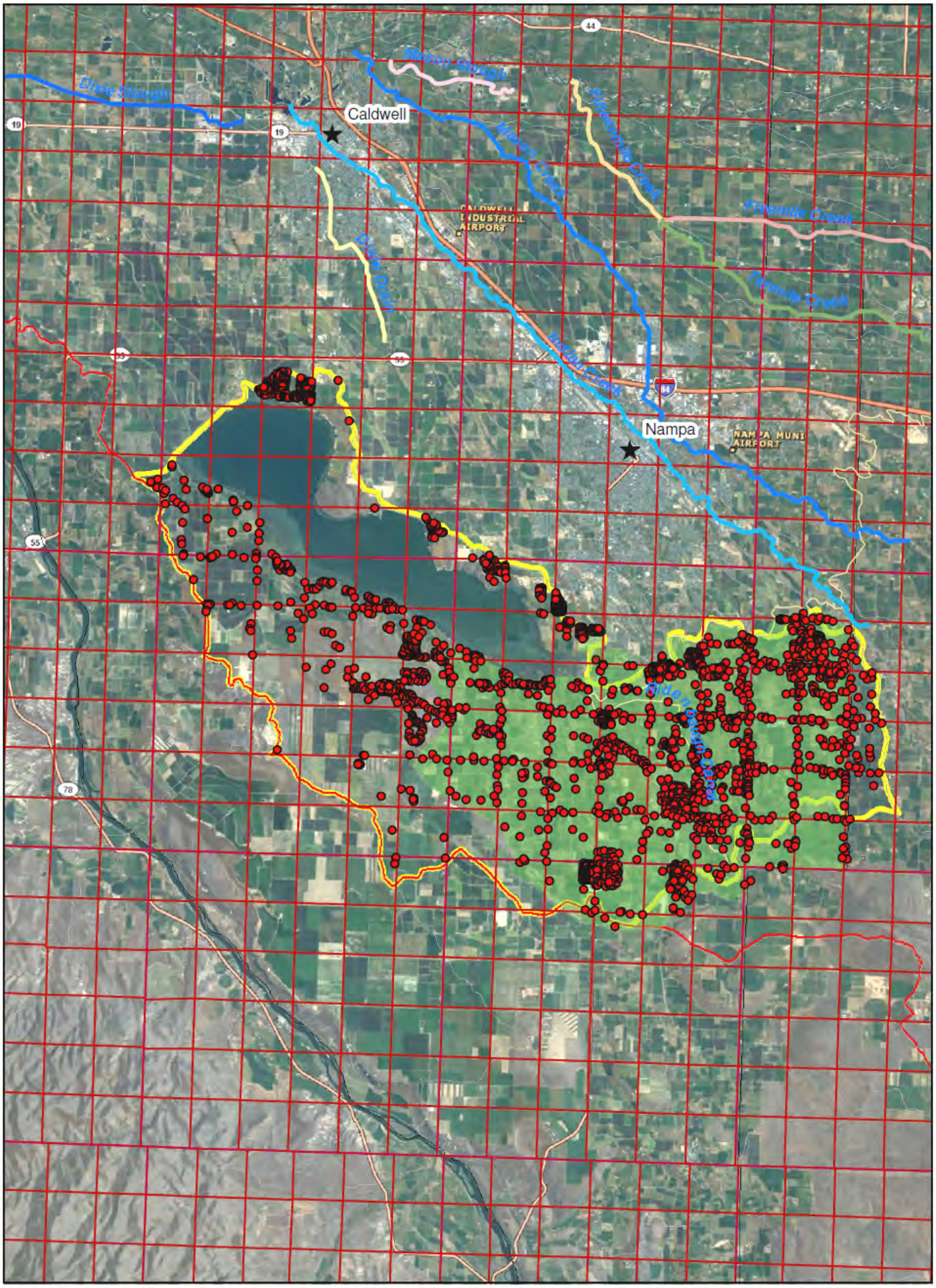
Your assistance is much appreciated. Feel free to contact me if you have any questions.

Sincerely,

Michael J. Fuss, P.E.
Public Works Director

cc: Craig Shepard/IDEQ
Lauri Monnot/IDEQ
Sherrill Doran/CH2M HILL
Craig Anderson/MSA
Cheryl Jenkins/City of Nampa
file

enclosures: Graphic of Lake Lowell Septics
Spreadsheet Phosphorus Load to Lake Lowell


Dixie Slough
Mason Slough
Caldwell
Mason Creek
Fifteenmile Creek
Fivemile Creek
Tenmile Creek
Dixie Drain
CALDWELL INDUSTRIAL AIRPORT
Indian Creek
Nampa
NAMPA MUNI AIRPORT
44
19
55
84
78

Ground Water Flows and Concentration Data

Ground water loads were estimated using RD Schmidt's water balance (Schmidt 2008) and UDGD/IDWR well database data.

Ground water inflows from Schmidt (2008) are summarized below, and shown in the following figure from the report.

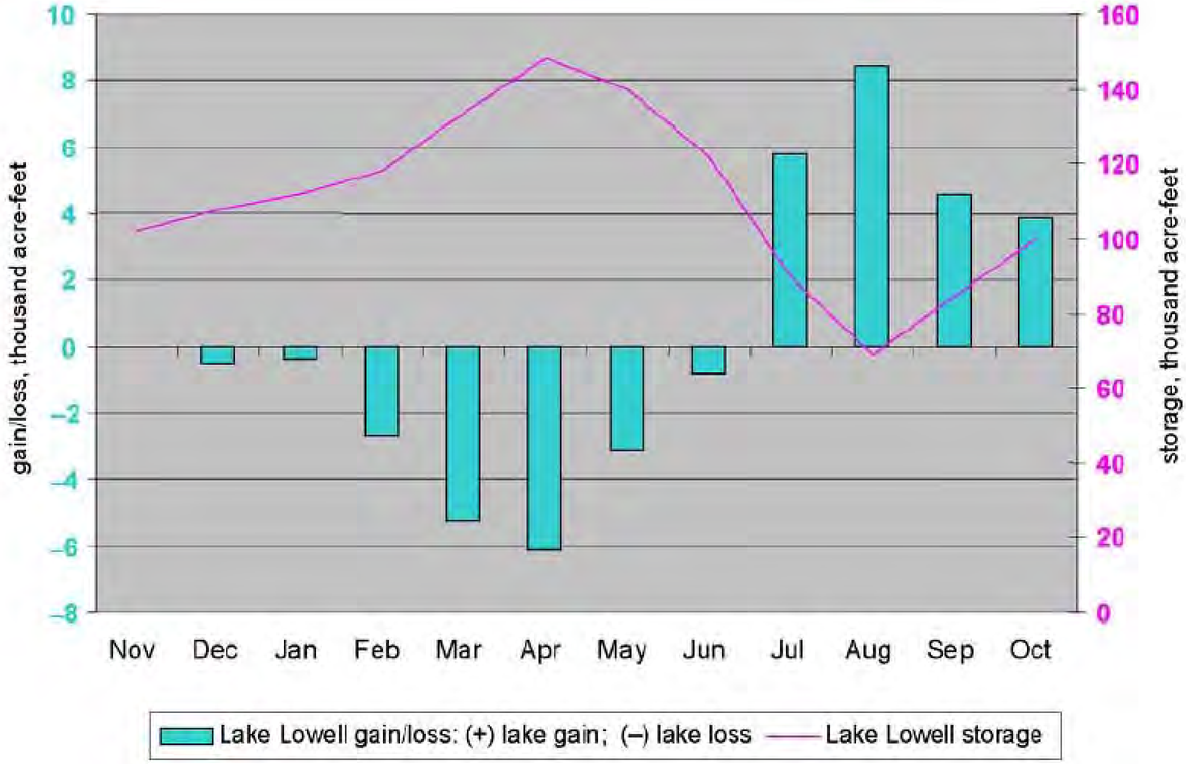
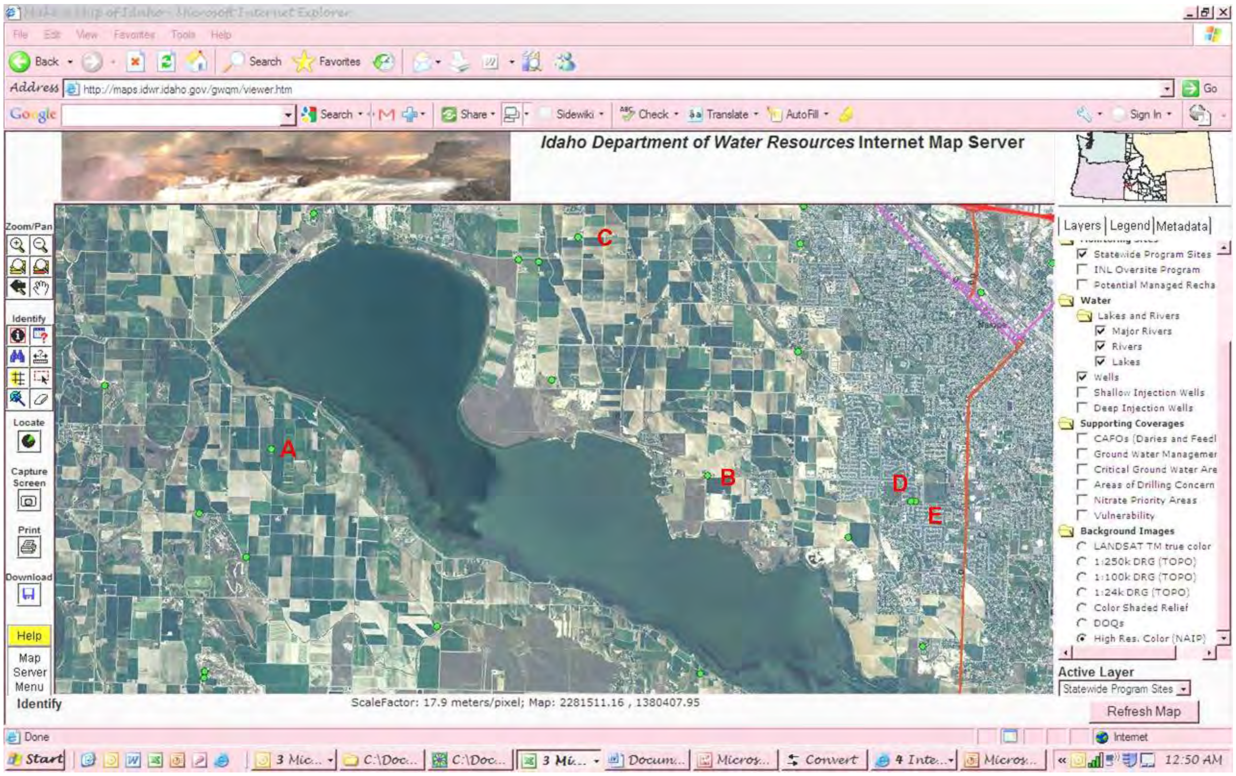


Figure 3–5. Average monthly reservoir level and gain-or-loss from Lake Lowell.

These values are provided in a companion spreadsheet to the Schmidt report, and included in the enclosed spreadsheet to our comments.

Lake Lowell gain/loss, (+) lake gain (-) lake loss													
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	annual
	4	-522	-366	-2,727	-5,244	-6,120	-3,107	-815	5,785	8,402	4,556	3,906	3,752
/1000	0.00	-0.52	-0.37	-2.73	-5.24	-6.12	-3.11	-0.81	5.78	8.40	4.56	3.91	3.75
Lake Lowell storage													average
/1000	101.78	107.63	111.81	118.07	133.80	147.99	139.64	121.74	89.63	68.65	84.63	99.78	110.43

For concentration data, five shallow (completed to a depth of below 50-ft) were found within the IDWR/USGS database (http://maps.idwr.idaho.gov/gwqm/viewer.htm), shown below.



Data downloaded for these five wells are shown below and included in the enclosed spreadsheet.

MEDIAN 0.030

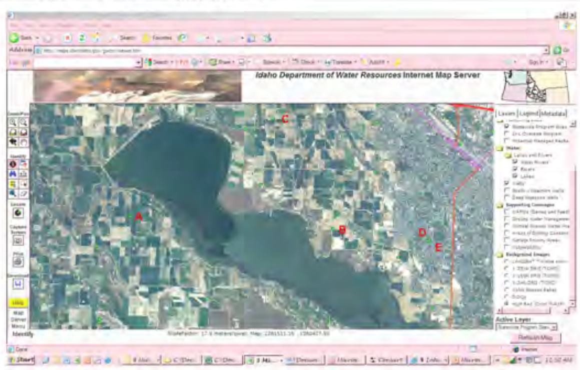
IDWR/USGS	WELL A			
09/22/1994	Inorg & Field	Phosphate, ortho	0.02	mg/l
08/07/1996	Inorg & Field	Phosphate, ortho	0.03	mg/l
08/18/1997	Inorg & Field	Phosphate, ortho	0.011	mg/l
08/03/1998	Inorg & Field	Phosphate, ortho	0.032	mg/l
06/15/1999	Inorg & Field	Phosphate, ortho	0.028	mg/l
06/28/2000	Inorg & Field	Phosphate, ortho	0.022	mg/l
07/09/2001	Inorg & Field	Phosphate, ortho	0.018	mg/l
06/10/2002	Inorg & Field	Phosphate, ortho	0.36	mg/l
07/01/2003	Inorg & Field	Phosphate, ortho	0.02	mg/l
06/03/2004	Inorg & Field	Phosphate, ortho	0.03	mg/l
07/05/2005	Inorg & Field	Phosphate, ortho	0.02	mg/l
07/27/2006	USGS Results	Phosphate, ortho	0.033	mg/l
06/27/2007	Mixed	Phosphate, ortho	0.097	mg/l
06/27/2007	Mixed	Phosphate, ortho	0.032	mg/l
08/13/2008	Mixed	Phosphate, ortho	0.045	mg/l
08/13/2008	Mixed	Phosphate, ortho	0.139	mg/l

WELL B				
08/03/1994	Inorg & Field	Phosphate, ortho	0.02	mg/l
07/08/1998	Inorg & Field	Phosphate, ortho	0.029	mg/l

WELL C				
06/01/2004	Inorg & Field	Phosphate, ortho	0.04	mg/l

WELL D	
sample_dt	p00671
10d	12s
9/5/1996	0.08
7/2/2001	0.07
7/2/2001	
7/14/2006	0.094

WELL E		
sample_dt	p00671	
10d	12s	
8/6/1992	0.03	
8/9/1996	0.04	
8/9/1996		
8/9/1996		
6/22/2000	0.03	
6/22/2000		
7/11/2005	0.01	< 0.02



Unmonitored Drain Analysis

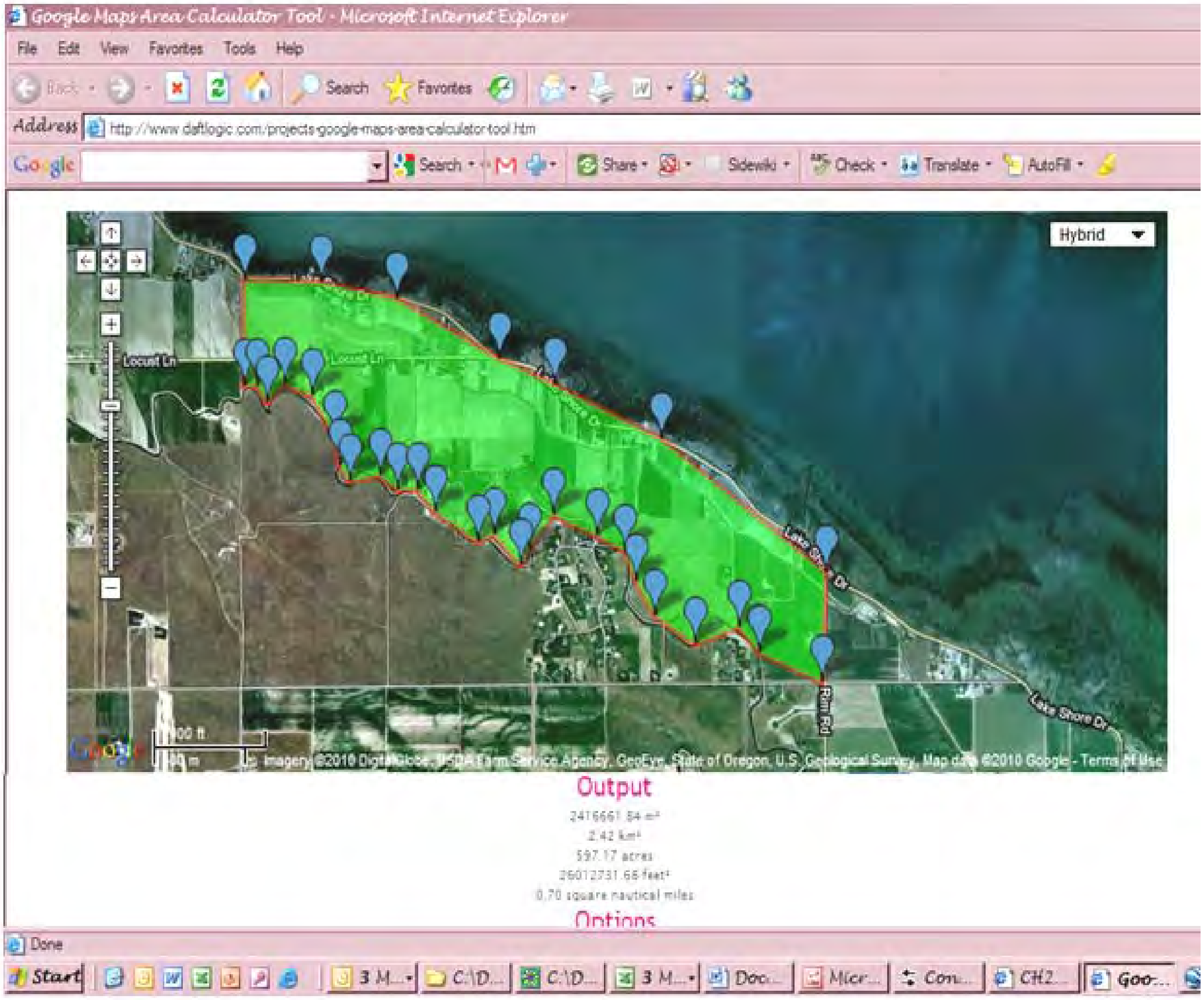
To develop an estimate of loading for those drains that were not monitored by BOR/DEQ, which may number up to 24 drainages, an estimate of loading area per drain was developed.

Of the 24 drains, there were groupings of drains that were used to develop an average drainage area per drain as follows:

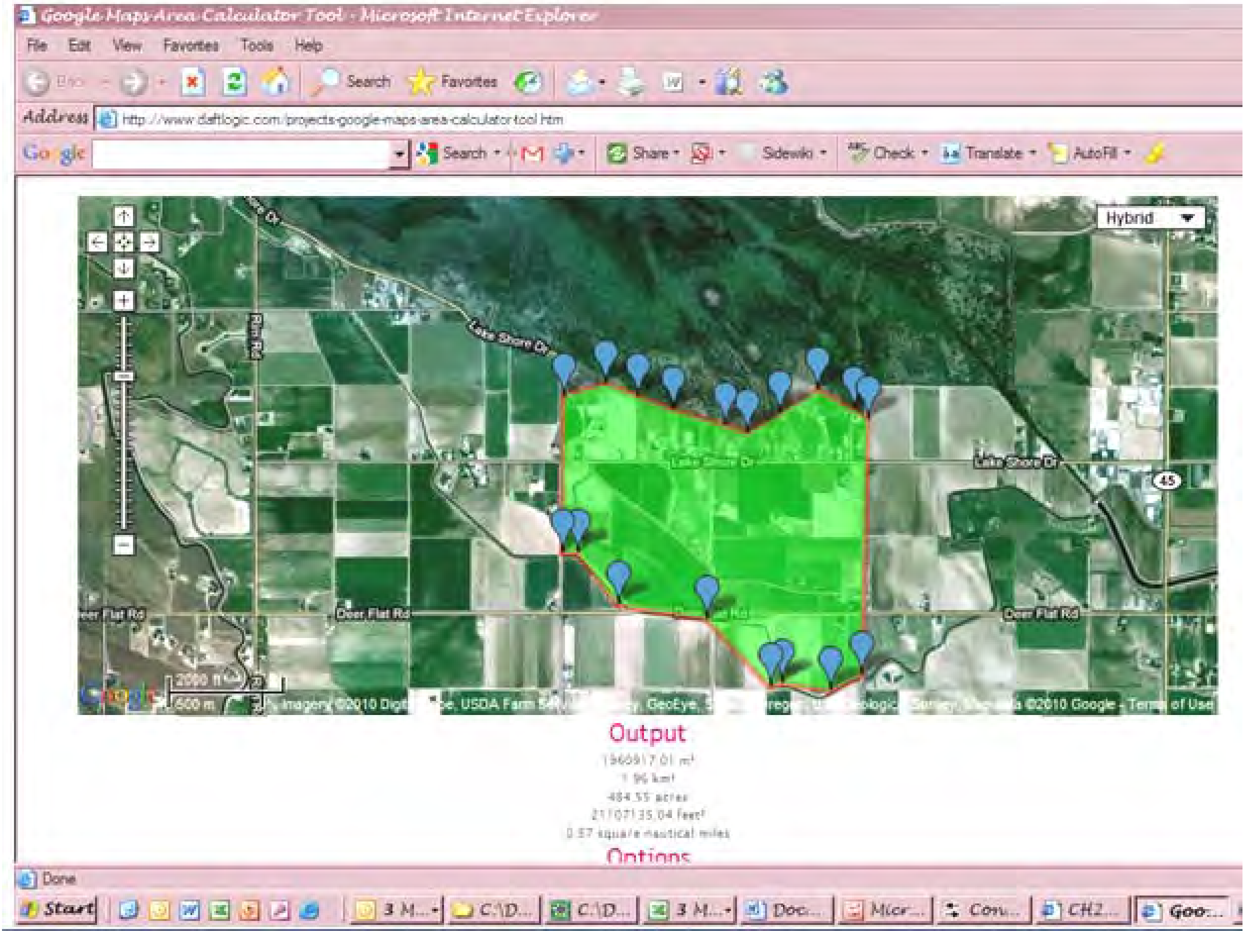
Figure 32. Satellite image of unmeasured drainage channels (red markers) contributing flow to Lake Lowell.

Contributing acreages for each area were estimated by visual observation based on upgradient canals/ditches and intersecting roads.

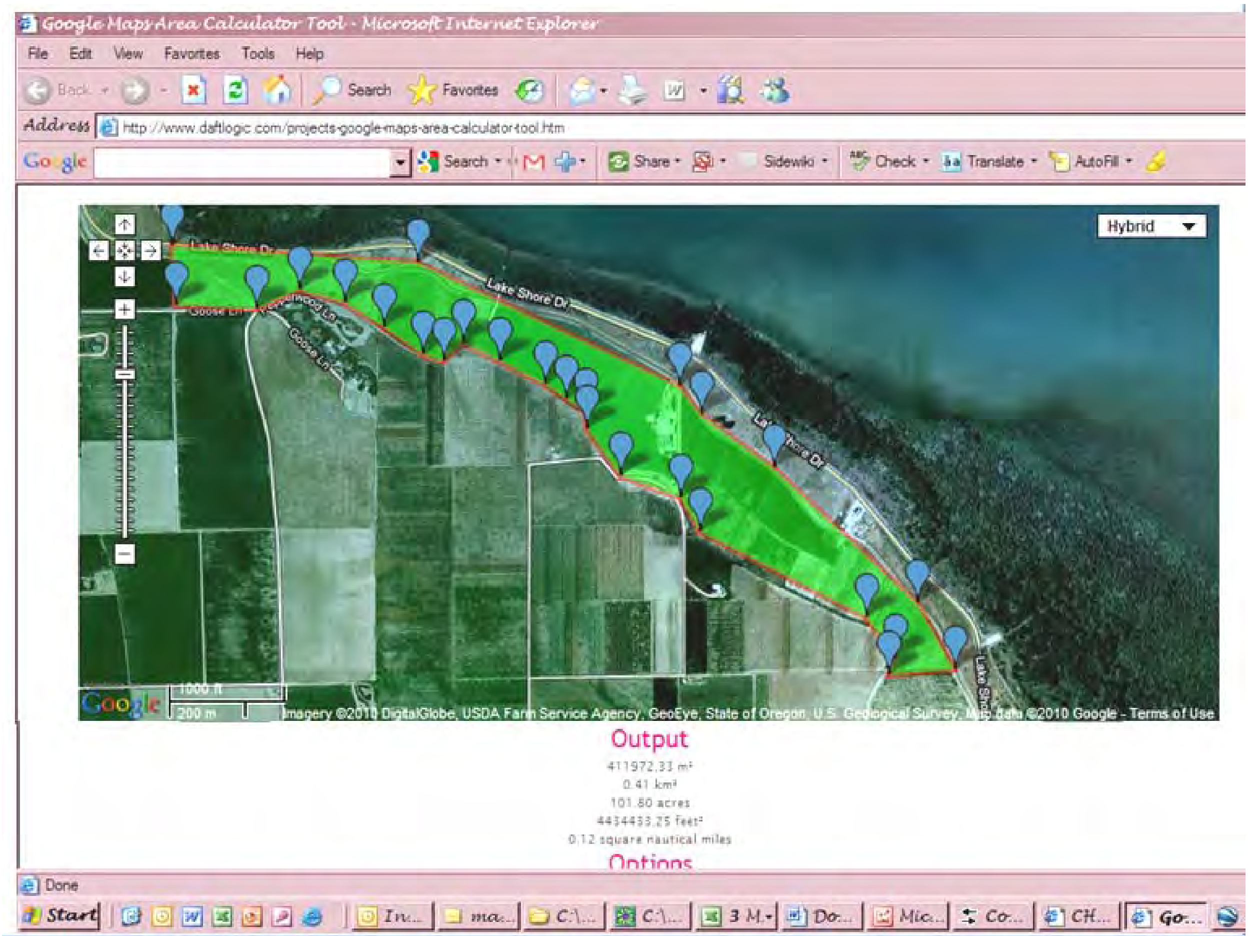
#1


Google Maps Area Calculator Tool - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address http://www.daftlogic.com/projects-google-maps-area-calculator-tool.htm
Hybrid
Locust Ln
Lake Shore Dr
Rim Rd
Output
2416661.84 m²
2.42 km²
597.17 acres
26012731.66 feet²
0.70 square nautical miles
Options
Done
Start

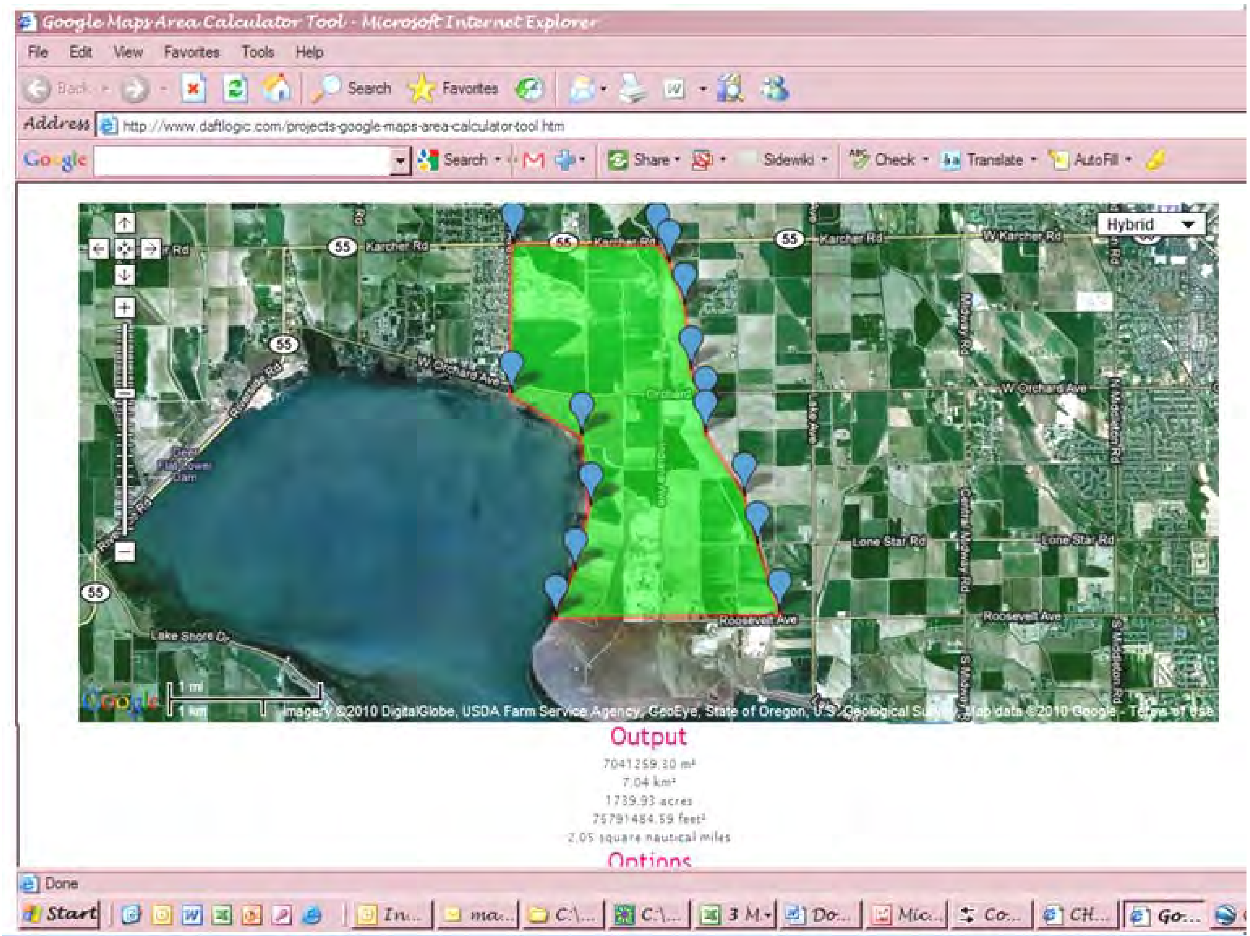
#2


Google Maps Area Calculator Tool - Microsoft Internet Explorer
File Edit View Favorites Tools Help
http://www.daftlogic.com/projects-google-maps-area-calculator-tool.htm
Hybrid
Lake Shore Dr
Deer Flat Rd
Output
1960917.01 m²
1.96 km²
484.55 acres
21107135.04 feet²
0.57 square nautical miles
Options

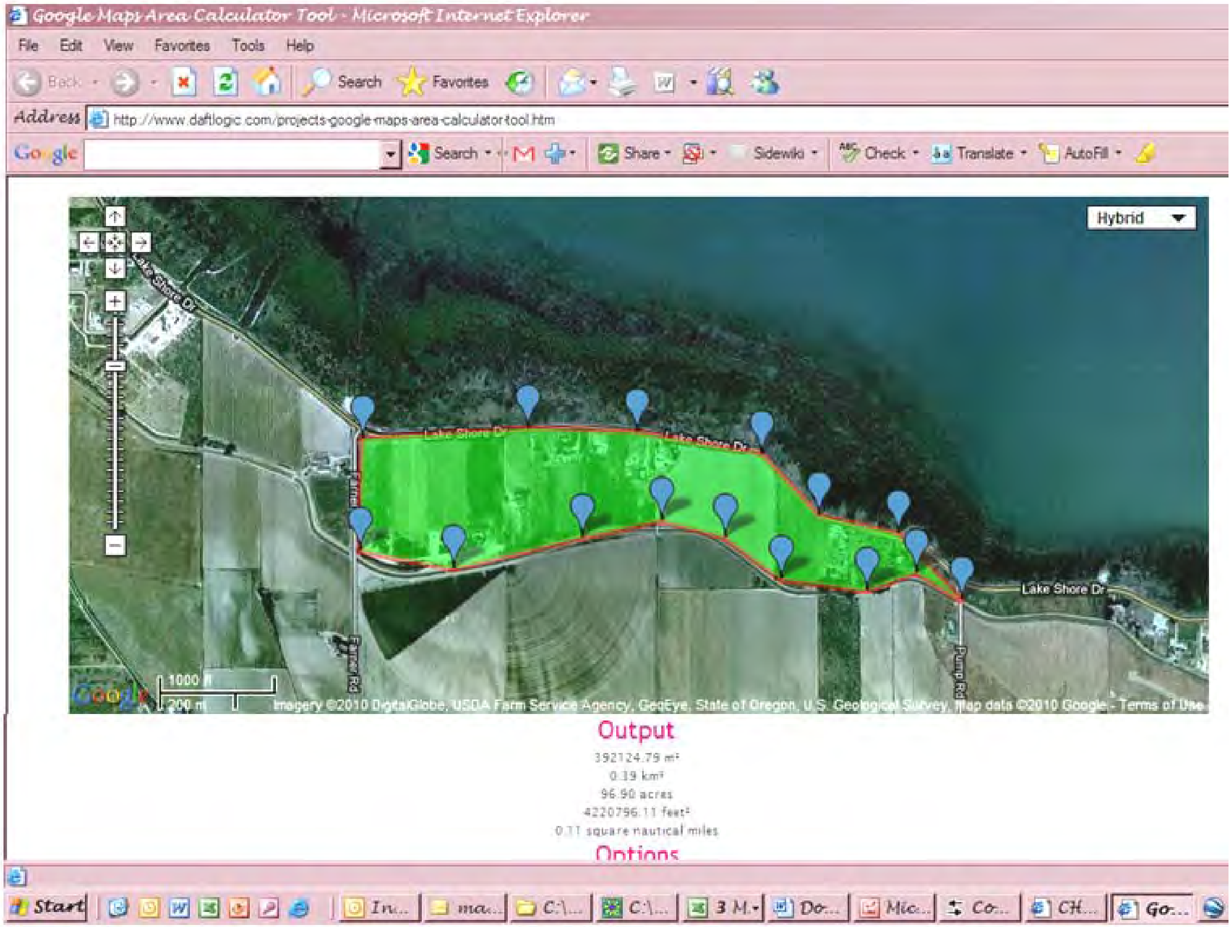
#3


Google Maps Area Calculator Tool - Microsoft Internet Explorer
http://www.daftlogic.com/projects-google-maps-area-calculator-tool.htm
Hybrid
Lake Shore Dr
Output
411972.33 m²
0.41 km²
101.80 acres
4434433.25 feet²
0.12 square nautical miles
Options

#4


Google Maps Area Calculator Tool - Microsoft Internet Explorer
http://www.daftlogic.com/projects-google-maps-area-calculator-tool.htm
Karcher Rd
W Karcher Rd
W Orchard Ave
Lone Star Rd
Roosevelt Ave
Lake Shore Dr
Hybrid
Imagery ©2010 DigitalGlobe, USDA Farm Service Agency, GeoEye, State of Oregon, U.S. Geological Survey, Map data ©2010 Google
Output
7041259.30 m²
7.04 km²
1739.93 acres
75791484.59 feet²
2.05 square nautical miles
Options

#5



These outputs were then used to estimate an average contributing acreage per unmonitored drain of 131 acres/drain. Applying this to the total 24-unmonitored drain dataset, this equates to 3,138 acres that contributes to the unmonitored drains.

Unmonitored

Area	# Drains	´DA	DA/drain	(From mapping.)
#1	7	597	85	
#2	4	485	121	
#3	2	102	51	
#4	5	1740	348	
#5	2	97	48	
			131	AVE

n	Unmonitored DA	
24	3138	ag acres that drain directly to Lake Lowell that are not monitored
	20.7	lbs/day ag drain load

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Appendix G. Distribution List

Bill Stewart, EPA

Boise Project Board of Control

BOR Pacific Northwest Region and Snake River Office

Deer Flat National Wildlife Refuge

Friends of Lake Lowell Watershed Group

Helen Rueda, EPA

Jeff Dillon, Idaho Department of Fish and Game

Lower Boise Watershed Council Members

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Appendix H. Public Comments

Person/Agency Commenting	Comment	Response
Executive Summary		
USFWS, Deer Flat NWR	Table A, pg xix The acres of impaired water bodies for Lake Lowell are reported as 6,056.53. This number appears too low and changes dependent on lake water level. The acreage should be reported in correlation with a lake level and/or as an average. The acreage reported in Table A is not consistent with the acres reported on page 13 and in Table 6. Surface water acreage says 9,000 at full pool which differs than acreage reported in Table A	Thank you for pointing out the inconsistency resulting from a GIS coverage error. It has been corrected and all acreages are reported as 9,024.8 acres at full pool.
BOR	Page xix, 2nd paragraph: The sources of nutrient loading presented throughout the document indicate that high levels of nutrients are found only in drains and storm water returns. The New York Canal and waterfowl were shown to be either below acceptable target concentrations or minor sources respectively.	Text revised to clarify that TP concentrations are high in drains and at acceptable levels in New York Canal and that although water fowl contribute a large phosphorus load this is considered part of background conditions.
Subbasin Assessment - Watershed Characterization		
SWC	Please address grammatical and format errors on pages 8, and 9 and Figure 8 and Figure 12.	Reviewed and appropriate corrections were made.
USFWS, Deer Flat NWR	pg 14. Please include fish eating birds in this discussion. The refuge is important nesting habitat for Western and Clark's grebes, as well as foraging habitat for wading birds, pelicans and cormorants. Mercury and contaminants that are present and/or bioaccumulate in fish will have a detrimental effect on most wildlife, but particularly on fish eating birds.	Suggested additions were made.
USFWS, Deer Flat NWR	The map on page 19 is not correct. The Bureau of Reclamation (BR) and USFWS co-manage Lake Lowell. BR is responsible for the water quality and water level of the lake, whereas the USFWS is responsible for the management of the Lake including recreational activities and wildlife management. The current map shows the lake as owned by the State (light blue color) which is inaccurate.	Figures were updated, lake color was removed and map reflects ownership only. Joint management details were clarified in the document text.
Subbasin Assessment - Water Quality Concerns and Status		
SWC	Grammatical/format errors in page 21, 25 and 27	Reviewed and appropriate corrections made.

SWC	Lake Lowell is not a natural lake. It is an irrigation reservoir that shouldn't be treated as natural lake with respect to beneficial use reconnaissance protocols. The BU should be agricultural water supply. There are no natural streams that feed the lake only canals and irrigation return drains. Therefore, it should be recommended to EPA for removal from the 303d list of impaired water bodies.	The highly managed nature of this reservoir system is emphasized throughout the document. Agricultural water supply is a beneficial use that applies to all water bodies of the state (see Appendix B. According to IDAPA 58.010.02.050 (02)a "wherever attainable, surface waters of the state shall be protected for beneficial uses which includes all recreational use in and on the water surface and the preservation and propagation of desirable species of aquatic biota." This includes assessment of beneficial use support and development of necessary TMDLs for all water bodies with impaired designated, presumed or existing uses.
Idaho Power	The Lake Lowell TMDL states on page 23, "Idaho WQS 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 designated uses, existing uses, and presumed uses. Lake Lowell is designated for warm water aquatic life (IDAPA 58.01.02.140.12). IDAPA 58.01.02.010.32 defines existing uses as "[t]hose beneficial uses actually attained in waters on or after November 28, 1975, whether or not they are designated for those waters…" The Lake Lowell TMDL states on page 13 that Lahontan cutthroat trout are stocked into the waters. Idaho Department of Fish and Game stocking records indicate a long history of stocking Lahontan cutthroat trout into Lake Lowell (http://fishandgame.idaho.gov/apps/stocking/fish_data.cfm). Therefore, by definition Lahontan cutthroat trout are an existing use. The Lake Lowell TMDL goal as stated on page 80 is to restore "full support of designated uses." Table 5 indentifies that warm water aquatic life criteria have been selected to protect designated and existing uses. The existing use of Lahontan cutthroat trout would likely not be protected by the warm water aquatic life criteria. It seems appropriate to assume, therefore, that the Lake Lowell TMDL and associated wasteload and load allocations would not be protective of the existing uses as required by IDAPA 58.01.02.050.02.b that states, "[i]n all cases, existing beneficial uses of the waters of the state will be protected." Perhaps the	DEQ does not believe "put and take" or a stocked fishery that is not sustainable without continued management constitutes an existing use. IDFG is no longer stocking Lahontan cutthroat or rainbow trout. In many years of stocking, a salmonid population was never established. Communication with the IDFG regional fishery manager confirmed that IDFG plans to only support a warm water fishery.

	seasonal cold water aquatic life numeric criteria are more appropriate targets for the Lake Lowell TMDL so as to protect both designated and existing beneficial uses. Additionally, the practical application of existing uses as presented on page 23 seems to conflict with the definition. The Lake Lowell TMDL presented a practical application as "…to apply the existing use of salmonid spawning to a water that could support salmonid spawning, but salmonid spawning is not occurring due to other factors, such as dams blocking migration." In the example, you state "…salmonid spawning is not occurring…" If the use had not occurred since November 28, 1975, by definition, salmonid spawning cannot be an existing use. It seems your practical application could better describe designated uses (IDAPA 58.01.02.010.20); "…[t]hose beneficial uses assigned to identified waters… whether or not the uses are being attained."	
USFWS, Deer Flat NWR	Pg24- Excess sediment is described by narrative criteria and quantities should not impair designated uses. The designated uses for Lake Lowell are support of warm water aquatic life, primary recreation and a Special Resource Water. Lake Lowell is designated a Special Resource Water because is the Deer Flat NWR. The refuge has jurisdiction along with the Bureau of Reclamation for managing the lake. The Service is concerned that sediment is not listed as a pollutant of concern for any of the conditions described for the beneficial use designations of Lake Lowell. Total suspended solids measured at sites that drain to the lake from agricultural lands described in the report from Idaho State Department of Agriculture seem excessive (ISDA Technical Report Summary W-6,March 2003). Results from this study report total suspended solids (TSS) concentrations released from agricultural drains reaching 2000 – 3000 mg/L and average between 100 and 800 mg/L for the growing season. Excessive TSS can promote deleterious effects that are 3-fold. One effect being a reduction in invertebrate and fish habitat or inhibit growth of submerged macrophytes and other aquatic flora. In addition, suspended solids will transport absorbed nutrients and other harmful toxins like pesticides and heavy metals from irrigated agricultural lands to the lake. Evidence suggests that because toxic substances were found present in the sediments in the lake (USFWS, 2000) their original source was likely from runoff of nearby lands in which they were applied.	Data do not reflect an impairment of beneficial uses caused by excess sediment or turbidity in Lake Lowell. This TMDL is intended to remedy low dissolved oxygen levels. It is expected that effective BMP implementation to reduce total phosphorus loads delivered to Lake Lowell will also result in reduced sediment load. A suggestion for further investigation of toxic substance sources is included in the data gaps section.
BOR	Page 25, Table 5: There are several typographical errors within this table.	Reviewed and appropriate corrections made.

USFWS, Deer Flat NWR	Pg29-30: Algal mats were not considered a pollutant of concern in this TMDL analysis because they are described as directly correlated pollutant to TP. If the external source of TP is reduced then the assumption is that algal blooms/chlorophyll a concentrations will also be reduced. External loading of TP may not be the only factor required for reducing algae/chlorophyll a concentrations. Internal loading from sediments may be a large enough component of the loading to the lake that would continue to promote algal blooms even after external sources are reduced. Algal blooms have been documented to impair the recreational use of the lake and should be considered its own pollutant. In addition, information on the cyanotoxins released by toxin-producing algae is non-existent for the lake. In other study areas, these toxins have been found present in the tissue of fish and muscles and should be identified as a potential threat to the public that rely on this as a food source.	Algal mats are the result of excess TP (the pollutant of concern). The TMDL is developed to address TP loading in the system as well as improve reservoir dissolved oxygen levels. TMDL implementation will result in decreases in nuisance algae and increases in dissolved oxygen. Information regarding internal loading is included in the pollutant source inventory). For further explanation of the relationship between nutrients and nuisance algae please refer to p. 29-33. Water body assessment and TMDL development is directed by Idaho Administrative code 58.01.02, including pollutants addressed in the WQS. Cyanotoxins are not included in the WQS.
BOR	Page 27 paragraph 2: Please explain more fully the consequences of a reservoir being polymictic on temperature. The consequences of polymixis are also missing from your discussion on dissolved oxygen and nutrients. For example, Polymictic reservoirs get a pulse of nutrients from the sediments throughout the summer as weak stratified layers break down. This may also continue to occur in spite of nutrient reductions to tributaries if there is considerable internal load.	Clarifying text was added to these sections.
BOR	Page 30, paragraph 3: Your discussion of limiting nutrients lacks some clarity on reservoir systems, and in some cases contains contradictions. Systems dominated by blue-green algae are nitrogen limited for most other beneficial or palatable algae. It is the ability of the cyanobacteria to fix nitrogen from the atmosphere that allows them to reach nuisance levels (see page 32 2nd full paragraph). Consequently, most lakes with blue-green blooms show signs of nitrogen limitation. In effect the balance of nutrients is what is off when lakes and reservoirs experience cyanobacteria blooms.	Clarifying text was added to these sections.
SWC	-Page 30, second paragraph states the TN:TP	Sections reviewed and

	greater than 7 are indicative of a P-limited system, then sentence 6 of the Phosphorus-Nitrogen Ratio paragraph on page 45 states that P to N ratios above 5-10:1 indicate P limits algal growth. Please clarify.	corrections and clarifications were made.
LBWC	More complete inflow and outflow information for Lake Lowell has been acquired from Boise Project Board of Control. Please consider adjusting the Flow Characteristics section and load capacity and allocations accordingly.	Submitted data was reviewed and appropriate adjustments were made to the Flow Characteristics and Load Capacity and Allocations sections.
BOR	Page 41 paragraph 2: You indicate that Figure 17 depicts stratification, this is not apparent in this figure.	Clarified text discussion to reflect that weak stratification periodically develops in the water column.
Idaho Power	Lake Lowell is designated for warm water aquatic life (IDAPA 58.01.02.140.12). As such, applicable numeric criteria are 33 °C or less with a maximum daily average not greater than 29 °C (IDAPA 58.01.02.250.04.b). The Lake Lowell TMDL concluded on page 39 that data indicated "…temperature supports warm water aquatic life" and, on page 79, that "total phosphorus and low dissolved oxygen are the pollutants of concern for Lake Lowell." IDAPA 58.01.02.250.04.c requires that temperatures in lakes designated for warm water aquatic life "shall have no measurable change from natural background conditions." Reservoirs with mean detention times of greater than 15 days are considered lakes for this purpose. Table 6 identifies the volume of Lake Lowell to be 173,043 acre-feet. Table 7 identifies the total average annual inflow into Lake Lowell to be 254,400 acre-feet; very similar to the annual average outflow of 231,300 acre-feet (Table 9). These data calculate a hydraulic retention time much greater than 15 days. Therefore, Lake Lowell shall have no measureable change from natural background conditions regardless of meeting numeric criteria. The Lake Lowell TMDL did not 1) define natural background conditions for temperature nor 2) evaluate whether there is a measurable change from these conditions. The Boise River, which receives Lake Lowell TMDL waters, is listed as impaired by temperature and will require a TMDL. Other downstream waters also have temperature load allocations on which upstream waters contribute to the impairment. IPC understands the onerous task to define natural background conditions in a watershed with a long history of anthropogenic influences. However, failure to assess the level of their impact in comparison to other thermal impacts inequitably	DEQ supports determination of natural background temperature in Lake Lowell when resources allow. In the interim, the warm water aquatic life designation and associated WQS is appropriate for shallow, low elevation lakes and man-made reservoirs in xeric climates. Lake Lowell does not discharge directly to water bodies that are subject to WQS appropriate for cold water aquatic life. Water discharged from Lake Lowell to the canal system is re-used prior to entering any water body of the state.

	increases the load allocations to some sources and none to others. Only after considering all temperature effects from all sources can equitable temperature allocations be made. Dismissing temperature as a pollutant of concern based solely on warm water aquatic life numeric criteria may unduly saddle other parties with additional responsibility. If there is a measureable change from natural background conditions, it is appropriate that either Lake Lowell be considered for listing as impaired by temperature or a TMDL for temperature developed. Such considerations are important as downstream waters are temperature limited.	
BOR	Page 44-45 Trophic State Index discussion: The values presented in table 12 indicate that the reservoir is oligotrophic in regards to total phosphorus. This contradicts the discussion in previous sections where TP is considered excess. Also chlorophyll a TSI values presented in Table 12 range from oligotrophic to mesotrophic. TSI values of 50 have been used in other TMDLs to strike a balance between water clarity and fish production. In general the TSI discussion does not support the case that nuisance conditions exist within the reservoir.	Calculations and data in the table were reviewed. TSI values indicate mesotrophic to eutrophic conditions as indicated in the beneficial use assessment. During review a mistake was found in the Chl-a TSI calculation equation. This resulted in higher eutrophic TSI values.
SWC	-Page 44, Table 11, 'BOI 183' column, 'n' row: n should be changed from 9 to 11, which reflects the number of data points depicted in Figure 21 for site BOI 183, and which also produces the 55% in the Percent of Samples with DO below 5.0 mg/L column.	Table was reviewed and appropriate changes were made.
BOR	Page 45 Phosphorus-Nitrogen Ratio: The discussion and ratios presented in this section are nitrogen to phosphorus ratios. The text appears to have been inverted. Please clarify the statement that ratios above 10 indicate phosphorus limitation which is then followed by a statement that indicates that Lake Lowell's ratio is 14 and is nitrogen limited. This discussion may also benefit from an analysis of the organic and inorganic fractions of both nitrogen and phosphorus.	This section was reviewed and appropriate changes to the text were made. The data set did not include fractionation of organic and inorganic nitrogen and phosphorus.
SWC	Pg. 47 and 48, Tables 13 and 14 How do you generate a mean from 1 sample (n=1)? If there is actually only 1 sample per site per year, then is this data adequate enough to draw conclusions?	When there was only one sample per site, per year the data value was placed in the mean column to simplify the table view. Beneficial use support conclusions are based upon the entire data set.
SWC	-Pg. 47 and 48, Tables 13 and 14 Why wasn't every	DEQ recognizes it is

	site sampled every year?	optimal to have a more complete data set. This data set represents data that was collected by DEQ and submitted by land management agencies during the call for data. Site 181 and 185, where most data are collected, are the best representative sites for the reservoir.
BOR	Page 49 paragraph 1: You indicate that the total phosphorus to chlorophyll a relationship is not statistically significant, yet in Figure 23 you present the relationship with a p value that would indicate that the relationship was highly significant.	The TP-Chl-a relationship is not statistically significant. While the p-value is statistically significant, that represents the likelihood that conditions exist by chance. The R-square value, which indicates how direct the relationship is between the behavior of the dependent and independent variable, is not statistically significant.
BOR	Page 49 paragraph 3: Your conclusions in this paragraph are not supported by your tables and figures. TSI values presented range from oligotrophic to mesotrophic, TN:TP ratios in and of themselves do not indicate nuisance aquatic vegetation is occurring, and some nutrients were only elevated sporadically at a few bottom locations. In addition chlorophyll a values presented were also only sporadically elevated. Also, no information about the frequency duration of extent of the blue green algae was presented in the document to this point.	The paragraph was reviewed and further clarifying text was added. The TSI values (Table 12) range form mesotrophic to eutrophic. The most dependable TSI values, the Chl-a values, indicate eutrophic conditions. Nutrient levels (Table 13and 14 and Figure 23) are elevated. The SR-HC and Cascade TMDLs and literature references indicate nutrient enrichment in the reservoir column when TP concentrations are > 0.025 mg/l and Chl-a concentrations are greater than 10 µg/l.
SWC	Pg. 50, Figure 24 There appears to be outliers (>40ug/L) in the regression analysis for chl-a vs nitrogen. If these points are removed, then is there a statistically significant relationship?	Removal of the outliers does not result in a more or less statistically significant relationship. Additionally, there is no justification to remove the outliers, they are a valid part of the data set.
USFWS, Deer Flat NWR	Turbidity, which has been used as a surrogate for TSS, was found not to exceed the water quality standard. Because the relationship between turbidity and TSS are not always well correlated, TSS should	Based on turbidity and Secchi disc measurements, beneficial uses in the reservoir are not impaired

	be evaluated as a potential pollutant as it appears excessive and likely is causing deleterious conditions as discussed on pages 56 and 67. There are no criteria for TSS by either the DEQ or the EPA and therefore a TMDL would require further investigation to assess the potential for pollutant status, which DEQ should consider.	by sediment. TSS is high in drains and wasteways discharging to Lake Lowell The sediment does not remain suspended once it reaches the reservoir. . Implementation activities to reduce phosphorus will also result in reduced sediment delivery.
EPA	In Table 16 on pages 54 and 55 of the TMDL shows the average total phosphorus concentrations in the tributaries. For Highline Wasteway # 1, the total phosphorus concentration is shown as 0.089 mg/l. The percent reduction needed to bring that to the target concentration of 0.07 mg/l is 21%. In Table 29 on page 99 the reduction specified for this waterbody is 7%. Why is there such a difference?	The information presented in Table 16 are descriptive statistics of the flow and nutrient concentration data set. The load estimates and allocations in Table 29 are calculated by calculating the load for each monitoring day and then taking a site average load in order to develop the load allocation (see Appendix E).
SWC	-Pg.62, The SBA-TMDL states that "The trophic-level-weighted average concentration of mercury for fish sampled in 2006 is 0.241 mg/kg, which is 0.59 mg/kg less than the WQS of 0.3 mg/kg (Table 20)." There appears to be a subtraction error in this statement.	Reviewed the calculation and corrected the decimal error.
USFWS, Deer Flat NWR	Pg 67 – The TMDL report states that concentrations of mercury in bald eagle feathers suggest mercury may be bio-accumulating, but also states there is uncertainty associated with interpreting the data. In addition, data reported in Table 19 and 20 shows mean mercury concentrations are generally increasing over time. With the variability in the data, the limited availability of mercury wildlife impact studies, and bioaccumulation concerns it is preemptive to conclude that there are no known adverse effects from mercury on wildlife populations. Please refer to Burch and King (2000) for a brief overview of mercury impacts to wildlife.	Conclusions from a follow up study to the study referenced were also not conclusive. The author, Susan Burch (USFWS), was contacted regarding her professional opinion about the effect on the water bird population. Her conclusion is that while individual birds may be detrimentally affected, it is not clear that the population is adversely effected. The recommendation was for further research. The data reported in Table 19 and 20 should be considered with the caveat that mercury is bioaccumulated as fish grow. Therefore fish size is very important to consider.

		The Data Gaps section (p 67) recommends continued monitoring to assess trends.
USFWS, Deer Flat NWR	Inflows to Lake Lowell are a combination of water diverted from the Boise River and irrigation return flows from the upper Boise Valley. Due to the nature of the drainage in the valley, there are many potential contaminant pathways (drains, ditches, and canals) into the reservoir. Because previous studies have investigated traditional water quality parameters, OCs, and trace elements, future studies should focus on chemicals likely to be used on agricultural fields or in CAFOs, or those likely to be found in storm water for this sector. Based on the USFWS report released in 2000 (Burch) on water quality in Lake Lowell, findings show that toxic chemicals are present in the sediments. These same chemicals were minimal in the water column. The contaminated sediments are a potential source of toxins to the food chain, starting with benthic organisms up through to fish and waterfowl.	Recommendations regarding future investigations of chemical contaminants are included in the data gaps section.
Subbasin Assessment – Pollutant Source Inventory		
LBWC	It may be helpful to view the pollutant source inventory and TMDL in the context of a reservoir system and include a conceptual diagram of pollutant sources	Thank you for your comment . Suggested changes were made.
LBWC	Editorial changes to Point and Nonpoint source Assessment.	Text was reviewed and appropriate changes were made.
LBWC	ACHD has provided more accurate acreage estimates for stormwater runoff to New York Canal. Please update the Pollutant Source Inventory, Load Capacity, and Load Allocation sections as appropriate.	Submitted urban stormwater acreage estimates were reviewed and appropriate changes were made to the Pollutant Source Inventory, Load Capacity, Current Load and Load Allocation sections
SWC	Pg. 71-Does DEQ need to identify the latitude and longitude of AFOs?	Geographical coordinates are public information and included in the NPDES permit.
SWC	Pg. 72-TP concentrations from 6 drains and 2 wasteways show that there is more TP loading on the south side of the lake. Deer Flat Caldwell, Lowline, and Nampa Canals have zero to few exceedances of the phosphorus target of 0.07 mg/L. On Pg. 91, The TMDL states that “Currently, only 14% of the phosphorus load delivered to Lake Lowell is exported, which indicates a very large load is available for internal cycling.” Couldn’t this also indicate that less phosphorus is being delivered to the lake than calculated?	Inflow and outflow loads are based on concentration and flow from tributary canals and drains.
ACHD	Pg. 72, Stormwater Runoff - ACHD has mapped the	Thank you for your

	watershed areas within Ada County that drain to the New York Canal and the Ridenbaugh Canal (tributary to the New York Canal). Results of the mapping indicate that approximately 5,900 acres of urbanized land drain to the New York and Ridenbaugh Canals via the storm drain system or overland flow. ACHD recommends updating the estimated area delineated as contributing stormwater loads to the New York Canal.	comment and submission of more precise acreage estimates. Current loads and load allocations were revised based on this information.
ACHD	Pg. 73, Figure 31 - IDEQ estimated agricultural and urban land use acreage estimates for the Lake Lowell watershed appear to consist of areas that overlap with the lower Boise watershed TP Implementation Plan. The land contributing to Lake Lowell needs to be clearly delineated to avoid confusion relative to implementation of TMDLs. Or, DEQ needs to clearly state where and when these allocations are applicable.	Agricultural acreage estimates were refined and further clarifying statements regarding applicable allocations were added to section 5.4.
LBWC	In the current draft some of the acreage estimates appear high and may include land that drains to ground water or tributaries of the Boise River. Please consider adjusting acres contributing agricultural runoff to include only lands that contribute directly to the canals and drains.	Agricultural acreage estimates were reviewed and refined.
SWC	-Pg. 74 The SBA-TMDL states that "Areas designated as irrigated agriculture were assumed to contribute agricultural phosphorus runoff." This rationale does not consider that treated agricultural lands may contribute no phosphorus and some agricultural lands may contribute more or less than others.	The per-acre allocation was based on available flow and TP concentration data. This data was collected on drains that contain land with differing treatment levels. BMP implementation should prioritize areas with the most need for improvement
SWC	Pg. 74-Can flow and phosphorus concentration from the unmeasured drains be measured to provide a more accurate representation of loading? The SBA-TMDL states that "Flow from these drains is assumed to be the lowest average flow from all the measured drains (Garner Drain, 1.1 cfs) because they are easily identified at the same scale from the satellite image. To simplify load estimates these drains are assigned the average TP concentration from all measured drains to Lake Lowell (0.67 mg/L)." Also why was the average TP concentration for all measured drains used rather than the TP concentration for the Garner Drain?	The method used to assess TP loading was revised. This includes estimation of acres contributing to unmonitored drains and application of a TP loading rate on a per-acre basis based on all monitored drains.
ACHD	Pg. 75, Other Nonpoint Sources - Septic systems are "considered a small contributor", yet there was no effort to estimate the load or provide an allocation. This "zero allocation" could be interpreted to prohibit new septic systems.	The revised document includes estimated septic load and load allocation based on data collected by the City of Nampa for a

		proposed wastewater treatment plant.
City of Nampa	In the June 14,2010, Technical Advisory Committee meeting on the draft TMDL, there was discussion regarding the absence of existing septic tank phosphorus loads. Nampa has existing plans (MWH 2009 and JUB 2009) for a new wastewater treatment plant (WWTP) in the watershed that could offset the septic system loads as the City grows in the future. As such, Nampa completed an analysis to help quantify the septic system loads for inclusion in the TMDL. The following is a bulleted summary and load calculation spreadsheet were submitted to include in an appendix	Thank you for your comment and for addressing this data gap. The submitted load estimate was included in the current load estimate section and the submitted summary was included in Appendix F.
LBWC	Pollutant source inventory and TMDL load allocations should include estimates of ground water and septic loading to Lake Lowell.	Estimates for ground water and septic loading were included. These estimates were based on LBWC submitted data and comments
IDFG	Recent Department surveys indicate that common carp are abundant in Lake Lowell. Weight per unit effort indices indicate that carp composed 49% of the fish biomass in 2006 (Kozfkay et al. 2009). In other systems, highly abundant rough fish populations, especially carp, have degraded water quality, altered food webs, and negatively impacted native or recreationally important fish populations (Zambrano et al. 2001; Jackson et al. 2010). Carp are benthic omnivores and feed primarily on aquatic invertebrates by rooting in sediments (Panek 1987). This feeding behavior increases turbidity by re-suspending sediments leading to lower light penetration. Additionally, nitrogen and phosphorus are re-distributed in the water column which may facilitate nuisance algae blooms further reducing light penetration (Moss et al. 2002). Successful carp control efforts have led to reduced turbidity, lower nitrogen and phosphorus levels, as well as recovery of native aquatic plant communities leading to better fish and waterfowl habitats (Moss et al. 2002). Based on an extensive literature review and our recent fish community assessments, the Department believes it likely that carp are adversely impacting water quality in Lake Lowell. Therefore, we request that the IDEQ consider adding to the Lake Lowell TMDL the potential to the Lake Lowell TMDL the potential that high densities of carp are a contributing factor to water quality impairment. In addition, the Department believes that physical removal of carp by various methods may be a cost effective means of reducing carp abundance and biomass and subsequently improving water quality.	High densities of carp have been added to the Pollutant Source Inventory section as a contributing factor to nutrient enrichment in Lake Lowell.

ACHD	Pg. 75 Data Gaps - No estimate of internal cycling is provided. IDEQ states “Little is known about internal nutrient cycling”. However, only 14% of the TP load is estimated as being exported from Lake Lowell (pg. 91). This indicates that every year over 86% of inflow load is accumulated every year. This rapidly increasing internal source is available for cycling and is an important factor related to time frame for recovery. Some estimate of internal cycling should be provided and could be based on model calibration.	Lack of knowledge of nutrient cycling is acknowledged as a data gap. A mass balance conceptual model was added to the document. Data is not available to estimate internal cycling.
LBWC	The data gap discussion should include ground water, septic and precipitation influences on pollutant loading	Suggested text additions were reviewed and included in the data gap discussion
Subbasin Assessment – Summary of Past and Present Pollution Control Efforts		
USFWS, Deer Flat NWR	The USFWS does not have any jurisdiction for water quality. Therefore, we do not currently have plans to develop a water quality monitoring and management plan for Lake Lowell. However, we are very interested in active partnerships that work towards improving the Lake’s water quality as it directly impacts our trust resources and this will be discussed in the upcoming CCP process.	Jurisdictional authority and management goals for USFWS and BOR have been clarified throughout the document.
Total Maximum Daily Load		
Idaho Power	The Lake Lowell TMDL incorrectly cites the development of the Snake River-Hells Canyon total phosphorus target of 0.07 mg/L. Specifically, the Lake Lowell TMDL states on page 81 that the nutrient target was established “…so that Brownlee Reservoir, which is impaired for nutrients, could meet beneficial uses.” The Snake River-Hells Canyon Total Maximum Daily Load (SR-HC TMDL)1 explicitly states the target was “…based on the requirements of the Upstream Snake River segment (RM 409 to 335) of the SR-HC TMDL reach.” “The additional needs of the reservoir segments are addressed in the allocation of dissolved oxygen…” IPC suggests the Lake Lowell TMDL correctly acknowledge that the SR-HC TMDL nutrient target was developed based on the needs of the Snake River and not Brownlee Reservoir. As stated, the SR-HC TMDL developed a total phosphorus target based on the requirements of the Snake River. This analysis predicted a total phosphorus concentration of 0.07 mg/L would result in a 14 μg/L chlorophyll-*a* concentration. Table 13 reports total phosphorus data for Lake Lowell. The 2002-2006 average total phosphorus concentration is 0.05 mg/L. Assuming the SR-HC TMDL analysis is applicable to Lake Lowell, these data indicate the	As stated in the document, tributary concentrations of phosphorus drive enrichment in Lake Lowell. The SR-HC TMDL discusses on pp. 31, 32, 65, 77, 82, 88, 95, 96, 109, 116, 120, 137, 138, 139, 141, 142, 145, 148, 149, 150, 151, 152, 153, 156, 157, 158, 481, 555, and 566 the relationship between nutrient enrichment from the Snake River and its tributaries and impairment of beneficial uses in Brownlee reservoir. For this reason, TMDL targets for tributaries to Lake Lowell at a concentration of 0.07 mg/l TP is deemed appropriate. DEQ recognizes that the 0.07 mg/l tributary target for the Snake River is supplemented by an additional necessary

	Lake Lowell average total phosphorus concentration is already less than the threshold target of 0.07 mg/L established to protect beneficial uses in the Snake River. This suggests the SR-HC TMDL target analysis may not be applicable to protect beneficial uses in Lake Lowell.	increase dissolved oxygen for Brownlee Reservoir. Water Quality modeling for Lake Lowell indicates that nuisance algae and dissolved oxygen beneficial uses can be met through tributary load reductions without addition of dissolved oxygen to the reservoir, unlike the situation with Brownlee Reservoir.
BOR	Page 84 Model Results: The BETTER Model predicts that the DO issues will be averted if all tributary waterways including the New York Canal (NYC) are held at 0.070 mg/L TP. Yet throughout the document the NYC is held to a lower standard. In effect this reduces the predicted load into the reservoir and should achieve the needed DO changes more rapidly. However, it also deprives the users of the NYC from an allocation that could be used for nutrient trading in the future or as a reserve allocation for future growth. A better rational for this inconsistency is needed within the document. In addition the model should be run to incorporate this change to determine if the change in outcomes results in a significant improvement in the timelines for achieving the needed DO improvements.	IDAPA 58.01.02.051 (Antidegradation Policy) applies to New York Canal as a tributary affecting water quality in Lake Lowell, which is impaired because of nutrient enrichment. Allocations cannot be provided for New York Canal that would further degrade water quality in Lake Lowell. Output from the model incorporates the range of capabilities within the model developed by BOR to evaluate water quality and management options. The model is not capable of reliably predicting water quality improvement beyond one irrigation season at a time.
BOR	Page 84 first paragraph: The basis for the NYC allocation being more stringent because "…loads from agricultural and stormwater runoff that could be improved with appropriate BMPs..." could be applied to all sources of TP in the basin and does not form the basis of a rational reason that the NYC load should be more stringent.	Federal regulations under the Clean Water Act require states to adopt an antidegradation policy. As such IDAPA 58.01.02.051 (Antidegradation Policy) applies to New York Canal as a tributary of Lake Lowell.
LBWC	Nutrient data are typically log-normally distributed, which means that a median value is a more appropriate representation of typical conditions than an average (Driscoll 1986). In order to derive a representative load, median flow values should also be used. Please revise load capacity estimates and load allocations as appropriate..	Load estimates and allocation were revised using median values.
BOR	Sources of TP entering the NYC are still given a 0.070 mg/L allocation as shown in this paragraph.	Load allocations have been revised. All allocations for

	Please explain how sources to a system can be given a higher allocation than the tributary water in which they discharge.	New York Canal add up to less than the current estimated load. Load allocations for non-point agricultural sources contributing to New York Canal and Lake Lowell are required to reduce an equal percentage.
BOR and LBWC	Page 87 fourth paragraph: The method used for determining unmonitored drain discharge minimizes the predicted load from these sources. It may be more appropriate to use a different method to estimate the flow from the unmonitored drains, such as average or median discharge from the monitored drains. This would be consistent with the approach used to estimate TP concentration.	The method used to assess TP loading was revised. This includes estimation of acres contributing to unmonitored drains and application of a TP loading rate on a per-acre basis based on all monitored drains.
City of Nampa and LBWC	Since the above referenced new WWTP is not presently permitted and the exact timing of its construction is uncertain, Nampa is not asking for a specific load allocation for it at this time. However, we request that the TMDL include a discussion of how existing nonpoint sources (septic tanks specifically) can be offset by future point sources. By doing this, we feel that future loads from our planned WWTP will have a clearer mechanism to be considered in future updates to this TMDL. To aid in this discussion we have developed an estimate of the phosphorus load from the satellite WWTP Nampa is planning. The following is a summary of the assumptions made in this load estimate. The spreadsheet provided with this letter also includes the WWTP phosphorus load calculations.	Thank you for your comment and submitted data. A discussion of septic loading was added. The letter and map submitted with your comment was added to Appendix F.
ACHD and LBWC	Pg. 89, Stormwater Runoff – IDEQ states that TP allocations for Stormwater would be based on the TP Implementation Plan (IDEQ 2008). ACHD supports the use of these allocations for consistent application throughout the lower Boise Watershed and adjoining areas.	Thank you for your comment. Allocations have been revised in accordance with the allocation in the TP Implementation Plan.
ACHD and LBWC	While the allocations in the TP Implementation Plan are accurately referenced, the allocations in this draft appear to be inappropriately applied. A few important examples of the differences are provided below. a) Pg. 89, Stormwater Runoff – The TP Implementation Plan wet weather stormwater loading estimates were based on an average of 50 events in a year that exceed measured rainfall of 0.05 inches. The runoff loads were annualized to 0.15 g/ac/day (pg 82). As stated in the TP Implementation Plan, these storms produce "event	The suggested discussion regarding daily/annual stormwater allocations and future conversion of acres was added to the TMDL.

	based" runoff averaging over 6 g/ac/day. Also stated in the TP Implementation Plan (pg. 81): "EPA, the stormwater permitting agency, has acknowledged this concern and indicated the need to state this assumption in the stormwater allocation." ACHD recommends IDEQ explicitly state that measured daily loads can exceed "average daily allocations" as long as annual allocations are met through implementation of management actions required in NPDES permits. b) Over time some of the agricultural land draining to Lake Lowell, estimated to be 87,500 acres (pg. 73), will be converted to urban land. The anticipated increase in urban area was included in the stormwater allocation in the TP Implementation Plan, but is not included in the Lake Lowell draft TMDL. At a minimum, the TMDL needs to acknowledge this transition to urban land. If not, this could be interpreted as zero allocation as land is converted from agricultural land uses. An alternative to specifying a wasteload allocation in pounds per day (kg/d) would be to establish the load allocation on a per acre basis (g/ac/day). As agricultural lands convert to urban land use, this total loading would decrease below the agricultural load after the required percentage reduction.	
City of Nampa	Nampa appreciates the discussions we have had with members of the LB WC regarding stormwater load allocations and how they are addressed in the draft TMDL. We support the stormwater point source load allocation calculations and methodology being proposed by the LBWC and its adoption into the draft TMDL.	Thank you for your comment.
SWC	Pg. 96 The SBA-TMDL states that, "Background loads are not estimated for other tributaries to Lake Lowell since nonpoint sources of phosphorus in these waterways have not been partitioned." Please explain.	This statement has been removed. A background load is calculated for New York Canal because it is the source for all water in the conveyance system.
SWC	Pg. 96 As the designated agency for grazing and agriculture we are not expected to give reasonable assurance to implement BMPs to achieve LAs. Additionally, the term "reasonable assurance" is not in the TMDL rule and the term should not be applied to designated agencies such as the SWC, formerly the ISCC.	Revisions were made to the text to clarify that BMP implementation for non-point source pollutants is voluntary for private landowners. Please review the following federal and state references for clarification on this issue: United States Code Title 33, Chapter 26, Subchapter III Section 1313(e) (F), Section 1329(b), and Section 1329(c); "Appendix To The

		Memorandum of Understanding Implementing the Nonpoint Source Water Quality Program in the State of Idaho Specifying Implementation of the Agricultural Pollution Abatement Plan, 1991"; and the Idaho Agricultural Pollution Abatement Plan, 2003. SWC is the designated management agency to recommend and oversee implementation of BMPs on private agricultural and grazing lands in Idaho.
ACHD	Pg. 97, Reserve – Allocations for growth in this draft TMDL are based on allowing an inflow with a concentration of 0.07 mg/L. However, this is not a "load allocation", but would be considered an additional or new load. Because this is not an allocation, the TMDL could be interpreted as providing zero capacity (or no net increase) for growth. Additionally, this could be interpreted as requiring stormwater to meet 0.07 mg/L at the end of pipe discharge, which is not practical or the intent of the TMDL as stated by IDEQ. ACHD requests deleting the following text (pg 97) to eliminate the potential for this interpretation: "A reserve for growth has not been specifically allocated for this TMDL. The watershed is becoming increasingly urban. Much of the nutrient loading resulting in impairment of beneficial uses is the result of runoff from agricultural land. As the land use shifts to urban, the pollutant load is expected to decrease. Existing stormwater and agricultural sources, as well as any new point sources, are expected to meeting the 0.07 mg/L TP target."	There is no reserve for growth in this TMDL. A land use acre allocation has been incorporated into the load allocation table. This allows the potential for a future reserve for growth as allocations are met.
BOR	Page 97 Reserve: Future agricultural uses and storm water sources are expected to meet 0.07 mg/L. This is the basis of the reserve for growth. This statement implies that all sources to the NYC will reach this level as well. The result will be the nonattainment of the more stringent allocation for the NYC in the future.	The phrase 'or lower' was added to account for the lower allocation that New York Canal, and anything discharging to it, has in this TMDL.
ACHD	Pg. 97, Construction Stormwater – a) "The Clean Water Act (CWA) requires operators of construction sites to obtain permit coverage to discharge storm water to a water body or to a municipal storm remove sewer and insert drain	DEQ Attorney General Office and Region 10 EPA have reviewed this template language for the Construction Stormwater

	system." b) "However, because stormwater can be managed on site or when discharged through a discrete conveyance such as a storm remove sewer and insert drain system, it now requires a National Pollution Discharge Elimination System (NPDES) Permit."	section of all TMDLs. No changes or additions were made to this section.
SWC	Pg. 98 According to Pg.99 (see below), the load allocation will not be revised if WQ goals can be met. If 69,403 agricultural acres is not accurate, then will this load be revised? -Pg. 99 The SBA-TMDL states, "A finer allocation based on land ownership or other mechanism is not needed at this time and won't be needed if water quality targets can be met by the aggregate reductions of those sources that are prescribed a reduction in load through the implementation plan."	Acreage estimates have been refined and the associated load allocation has also been revised. In the future, progress toward achieving targets and the appropriateness of loads will be assessed during each TMDL five year review.
ACHD	Pg. 99, Table 29 – A recommended approach for addressing this conversion is to establish load allocations only on a per acre load basis in the load allocation table and for clarification, insert the following text under the allocation table: Please delete: "The load and waste load allocations provided for agricultural and stormwater sources are expressed as annualized g/acre/day. Allocations in terms of g/acre/day loads are established to ensure nutrient sources will be controlled for these two land uses independently of any revised total number of acres for the two land uses in the future. Underlying this approach is an understanding that (1) the allocations are made to the land use acres and (2) the allocations for each land use established by the TMDL attains the load capacity for Lake Lowell. Please note, if agricultural acres are converted to urban stormwater acres, the net reduction in g/acre/day and in the total annual load to Lake Lowell would be an approximate annualized reduction of 0.83 g/acre/day. And, it is anticipated that these additional reductions to the annual nutrient load to Lake Lowell, if they occur, will be accounted for during the Five-Year assessment of the Lake Lowell TMDL."	The suggested change was incorporate, with one exception. The 0.83 g/acre/day reduction for future acres converted form agricultural to urban stormwater use was changed to a potential reduction of 1.01 g/acre/day. This is consistent with 50% BMP effectiveness for future stormwater acres based on the Lower Boise TP Implementation Plan and also with comments/revisions submitted by ACHD and LBWC during this comment period.
BOR	Page 99 second full paragraph: The allocations presented in this TMDL result in a net gain of TP to the reservoir. There is no estimated depletion of TP from the internal load. The TMDL should indicate only sediment burial.	Suggested change was made.
ACHD	Pg 100, Time Frame – The time frame for decreasing inflow concentration is projected as 0.01 mg/L every five years. The average concentration of	The decimal error for projected concentration decreases was corrected.

	the drains discharging to Lake Lowell is 0.67 mg/L (pg 90). The time needed to meet the 0.07 mg/L inflow concentration target would be 300 years (i.e., ((0.67-0.07)/0.01)*5).	With Active BMP implementation, DEQ expects to achieve the TP target within 30 years. This statement is followed with a discussion of this and that refining preliminary goals as implementation plans are developed and nutrient reduction efficiency information is collected.
Idaho Power	The Lake Lowell TMDL states on page 100 a preliminary goal is to reduce total phosphorus concentration in tributaries by at least 0.01 mg/L every five years until the target of 0.07 mg/L or load allocations are met. The average total phosphorus concentration from all measured drains is 0.67 mg/L (page 90). While some sources will undoubtedly meet the target or load allocations in a reasonable timeframe, time to implementation, based on average drain concentrations, would be 300 years [i.e., ((0.67-0.07)/0.01)*5)]. This may be further confounded by the storage of inflowing nutrient loads and internal cycling. The Lake Lowell TMDL estimated on page 91 that only 14% of the phosphorus load delivered to Lake Lowell is exported. This may extend the implementation timeframe many fold until stored nutrients are no longer available for cycling.	The decimal error for projected concentration decreases was corrected. With Active BMP implementation, DEQ expects to achieve the TP target within 30 years. This statement is followed with a discussion of this and that refining preliminary goals as implementation plans are developed and nutrient reduction efficiency information is collected.
SWC	Pg. 101 SBA-TMDL states that “ISCC, working in cooperation with local Soil and Water Conservation Districts and ISDA…”-please remove ISDA and replace with NRCS. We work with NRCS and the Districts. ISDA is a regulatory agency that is designated for point sources on CAFOs and aquaculture. Also please include that implementation of BMPs for non-point source pollution is voluntary.	Suggested changes were made.
SWC	Pg. 102 The paragraph beginning with… The designated agencies… states the following under bullets 1 and 2: 1) Develop and implement BMPs to achieve LAs, 2) Give reasonable assurance the management measures will meet LAs. These statements are misleading because according to Idaho Code 39-3611 (10) "Nothing in this section shall be interpreted as requiring best management practices for agricultural nonpoint source activities which are not adopted on a voluntary basis..."	Language was inserted above that implementation is done on a voluntary basis.
BOR	Page 102 third bullet item: BOR responsibilities are over stated. It appears that you have included Idaho Department of Agriculture and Ada/Canyon Highway Districts’ responsibilities into this bulleted item. As clearly demonstrated throughout the	Text regarding responsibility for mitigating effects of pollutants was removed.

	TMDL the sources of pollutants to the NYC and Lake Lowell are agricultural and storm water sources. The agencies responsible for assessing and mitigating these pollutant sources are also clearly defined in past TMDLS and water quality standards. Suggest changing to BOR responsible to maintain and operate the water conveyance, storage, and hydroelectric facilities.	
General Comments		
Erica Anderson Maguire, ACHD	ACHD supports the comments submitted by the Lower Boise Watershed Council.	Thank you for your comment.
Erica Anderson Maguire, ACHD	Given the substantive loading changes proposed by the Lower Boise Watershed Council, as well as the comments received by ACHD and others, ACHD would appreciate if IDEQ issued a revised draft for a final round of public comment.	Even though some data was submitted more than a year after data requests were made, which may change load allocations the fundamental concepts methods and processes have remained constant. The purpose of a Public Comment period is to inform of any relevant data or changes needed. Therefore, an additional round of public comment is not warranted.
City of Nampa	We support the stormwater point source load allocation calculations and methodology being proposed by the LBWC and its adoption into the draft TMDL.	Thank you for your comment.
SWC	The ISCC is now called Idaho Soil and Water Conservation Commission (SWC).	Appropriate changes were made.
SWC	Please remove any reference within the document that portrays the ISWC, formerly the ISCC, in partnership with ISDA.	Appropriate changes were made.
USFWS, Deer Flat NWR	Deer Flat NWR is not responsible for water quality at Lake Lowell. Bureau of Reclamation has jurisdiction for water levels and water quality. This needs to be made very clear in the document. Although the USFWS is concerned with the current water quality of the lake as it affects our trust resources, we do not have jurisdiction over the water quality.	Appropriate changes were made.
Trent Cadogan	I really appreciate looking into a water study for Lake Lowell. It is our primary spot for fishing, boating and water sports because of the proximity to our house. I knew something was up when our family doctor cautioned us from using Lake Lowell ... we have a child with an impaired immune system. Thanks.	Thank you for your comment.
Frank R. Kenny	I really don't know the details here other than it was too dangerous for me or my labrador to swim in the lake after August last year. You folks at DEQ know	Thank you for your comment.

	what to do and we need to have clean water to enjoy and recreate in during our hot summers. No one wants to live near a dead lake. That's the kind of thing you hear about in Russia. There is surely a measured balance between recreation and irrigation and it lies in the trained hands of those we trust. Please let me know if there is anything that I, a concerned citizen and kayaker can do.	
Jeremy/Kimmi Onthank	I think that it is great that Everyone is working so hard on Lake Lowell it does need to maintain its warm water aquatic life but I do think that it can do this while maintaining boat traffic on the lake they do it all around the states.	I contacted the concerned citizens directly and explained the purpose of the SBA and TMDL and that there is no link between these and restricting boat access.
Larry Raganit	I have lived in Caldwell, Idaho since 1952. Our family has had a long history of fishing and boating at Lake Lowell. It is very important to us and our grandchildren. I do not recall from the 1960's to 2003 of any problems related to fishing and boating at the lake. Both wildlife and local citizens lived to together without government intervention. We are all stewards of our environment. Not only at the lake but at home here in Idaho. When you shut out taxpayers who contribute money to Fish & Wildlife funds, its makes no sense. There is no reason why the lake can be used for wildlife and also area residents who spend money at local businesses to go to Lake Lowell and enjoy what the lake offers. I went to a meeting at Lake Lowell when Senator Crapo came for comments about shutting Lake Lowell down for motorized boats. Boaters from all groups protested the thought of it. Also at the meeting it came up that Fish & Wildlife had put a ban on a certain group at Lake Lowell without input. That came as a surprise to Senator Crapo, and he turned it over to Fish & Wildlife area director. Have not heard anything about that ban lately. When you are responsible for wildlife and fish. Then try to make stronger regulations that restrict fishing also makes no sense. Aren't you looking out for the general public's use of the lake for fishing which has motorized boats? If you have fished the lake you know the best fishing sometimes is away from the bank. A boat can get you to those fishing spots that could not normally get to. There has to be a balance with wildlife and public use of Lake Lowell. I have not seen any publicized records of adverse effects of use of Lake Lowell, only proposed changes. By the way what are the proposed changes the Fish & Wildlife planning? I would like a copy so that I can forward your plans for Lake Lowell. Have you put posted in the local papers about comments about proposed changes to Lake Lowell?	I contacted the concerned citizen directly and explained the purpose of the SBA and TMDL and that there is no link between these and restricting boat access.

Chris Horton	I am a local angler who has been fishing lake Lowell for several years. I am writing you to voice my opinion. Lake Lowell is a great lake with lots of opportunity. It allows for people to enjoy the outdoors without having to travel great distances. It also allows people the opportunity to spend quality time with there families in the outdoors. I understand Lake Lowell is an important breeding ground for many species of birds. That too is important to me as an avid duck hunter. I fish many local tournaments on that body of water too. Much of the funding that goes towards places like Lake Lowell comes from outdoorsmen and woman like me and my wife. Please be sure to keep all the anglers and hunters like my wife and I when considering any changes. There are many rumors of motor restrictions on Lake Lowell. I believe that, if implemented could have a large effect on many local businesses. The biggest concern to me is the water level. The constant dropping of the pools must have an effect on both the fishery and the wildlife. I believe for Lake Lowell to truly flourish that the water level must remain higher then it has the last few years in the mid summer months. I believe that DEQ, USFWS and local sportsmen groups can make Lake Lowell a place that people want to visit from all over the west. Thank you for your time.	I contacted the concerned citizen directly addressing his concern about fluctuating lake levels and the designated management agency for reservoir operations. I also explained the purpose of the SBA and TMDL and that there is no link between these and restricting boat access or recreational opportunities.
Douglas R Danser	As a Bass Fisherman and a government dam control center operator for over 30 years it would be a shame to lose Lake Lowell as a premier fishing lake. I think Idaho has a lot to be proud of right now because most of the tournaments we are involved in are right in Idaho. We have at times not been able to fish our own states lakes due to shut downs etc. and have had to neighboring Oregon to fish. The government needs to also realize that bass fishermen as a whole help the environment as well as the fisheries habitat. On TV there is a fishing show that one of the BASS elite series fishermen fishes in a lake inside or near a town. Lake Lowell would be the only lake we can still get a normal equipped boat in and fish close to Nampa. It is a special thing to boaters and anglers alike to be able to not travel far from home to a quality lake to enjoy what nature has provided. Please help us keep Lake Lowell a true "City" fishing paradise.	I contacted the concerned citizen directly and explained the purpose of the SBA and TMDL and that there is no link between these and restricting boat access.
Gary Wiese	I would like to comment during the open period for Lake Lowell. My family has spent time on Lake Lowell and we would like to continue this with no further restrictions on fishing, water skiing and swimming. Thank you for your consideration.	I contacted the concerned citizen directly and explained the purpose of the SBA and TMDL and that there is no link between these and restricting boat access or recreational opportunities.

Jeff Kocina	Does the use of older 2 stroke outboards by the public have an excessively adverse effect on water quality and wildlife? Would a restriction of only allowing far cleaner 4 stroke or cleaner 2 stroke engines during peak periods of use help in achieving a sustainable solution for all concerned parties?	I contacted the concerned citizen directly and explained the purpose of the SBA and TMDL and that there is no link between these and restricting boat access.
Neil Russell	I would like to comment about any changes being considered. I have lived in Nampa the past 46 years, and grew up fishing at Lake Lowell, and hope that all users are being considered in any possible changes. I am now a bass fisherman, and have fished numerous times over the years at Lowell. Any and all of my friends practice catch and release, not only at Lowell but with any bass fisheries, as we enjoy the catch, and look forward to the possibility of future catches. Lowell is very unique to the SW Idaho fisheries for bass in that it offers us the use of techniques involved in catching bass in the heavy brush of Lowell.	I contacted the concerned citizen directly and explained the purpose of the SBA and TMDL and that there is no link between these and restricting boat or recreational access.
Rick and Carlene Badillo	Just wanted to throw my two cents in on lake Lowell. I have been fishing and duck hunting out there religiously for about 15 years. During the summer I'm out there at least once a week attempting to catch largemouth bass. Usually the bass are too smart! The only notable declines in fish population I've seen has been when the hole in the dam wasn't fixed correctly and caused the lake levels to remain low for 2+ years. As far as the wintering waterfowl populations, they seem to be consistent with our flyways numbers. Concerning the many other birds that live, nest and rest there. The wife and I are always amazed at the variety of birds and animals we get to enjoy on our fishing expeditions. I have yet to see any valid biological studies stating there is a decline and that is directly related to recreational use. Maybe a study could be done on all the chemicals being dumped into the lake via pesticides, trash etc. I realize the lake's original intent was irrigation, but........ The east end is "no wake" and you have the Osprey nesting area closed which are great tools. Maybe more education and enforcement would be an alternative, I can't tell you how many times I've personally witnessed anglers keeping numerous bass out of season and have phoned Fish and Game or spoke to the angler, a lot of them are not aware of the restrictions and unfortunately some don't care. It just seems to me there are so many OTHER different tools and options that can be utilized then some bureaucrat in D.C. saying "close it down". I.E. Skiing/wakeboarding only on certain days of the week. No motorized boats on Wednesdays. Charge	I contacted the concerned citizen directly and explained the purpose of the SBA and TMDL and that there is no link between these and restricting boat access or recreational opportunities.

	usage fees with the option to purchase annual passes to offset your dept. operation costs. Etc, etc, etc. I strongly feel Lake Lowell can be a viable resource for EVERYONE to enjoy people and animals alike without restricting use completely. Thank you for your time,	