Teton River Subbasin Assessment
And
Total Maximum Daily Load

Photo courtesy of Timothy Randle, Bureau of Reclamation

Department of Environmental Quality

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The cooperation of the landowners along the North Fork Teton River made it possible to conduct an inventory of the entirety of that river.

Many individuals at the Department of Environmental Quality assisted in preparing this report. Sheryl Hill gathered and complied data and drafted much of the document; Mark Shumar, Marti Bridges, and Amy Luft revised and completed the final version of the report; Dinah Reaney, Darcy Sharp, Mark Shumar, and Don Zaroban provided technical assistance; and Troy Saffle, Derek Young, Jim Szpara, Kimberly Ball, and Tammy Gallion provided additional assistance in the preparation of this document.

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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 waterbodies required by this section

ì micro, one-one millionth

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

BLM United States Bureau of Land Management

BOD biological 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

EPA United States Environmental Protection Agency

EPT insects of the orders Ephemeroptera, Plecoptera, and Trichoptera

F Fahrenheit

FERC Federal Energy Regulatory Commission

FMID Freemont Madison Irrigation District

FRREC Fall River Rural Electric Cooperative

FTU formazin turbidity unit

GIS Geographical Information Systems

HI habitat index

HUC Hydrologic Unit Code

IDAPA Refers to citations of Idaho administrative rules

IDFG Idaho Department of Fish and Game

IDWR Idaho Department of Water Resources

INEEL Idaho National Engineering and Environmenal Laboratory

IWRB Idaho Water Resources Board

JTU Jackson turbidity unit

km kilometer

m meter

MBI macroinvertebrate index

MGD million gallons per day

mg/L milligrams per liter

mm millimeter

MSWCD Madison Soil and Water Conservation District

NPDES National Pollutant Discharge Elimination System

NRCS Natural Resources Conservation Service

NTU nephelometric turbidity unit

NWS National Weather Service

RMP resource management plan

SAWQP State Agriculture Water Quality Project

SCC Idaho Soil Conservation Commission

SNOTEL Snow telemetry

STATSGO State Soil Geographic Database

TKN Total Kjeldahl nitrogen

TN total nitrogen

TMDL total maximum daily load

TSCD Teton Soil Conservation District

TSS total suspended solids

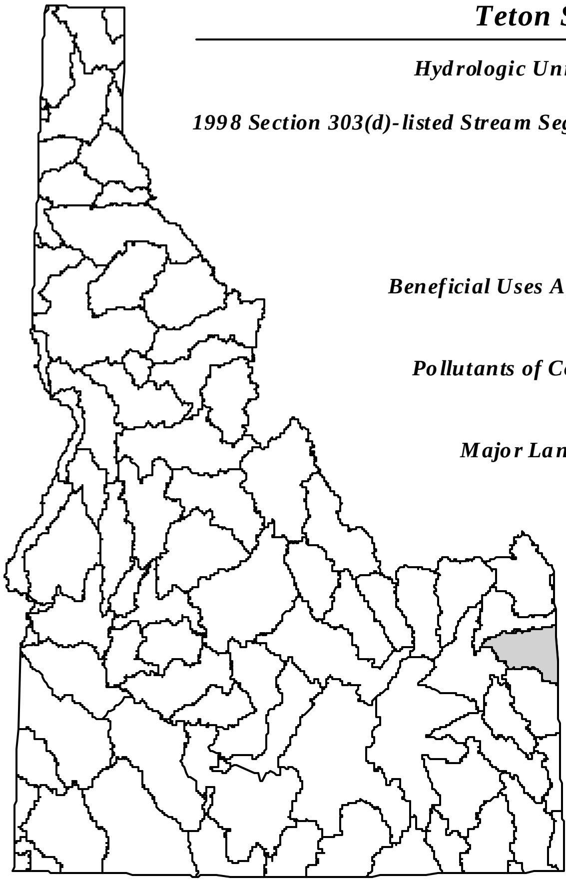
USDA United States Department of Agriculture

USFWS United States Fish and Wildlife Service

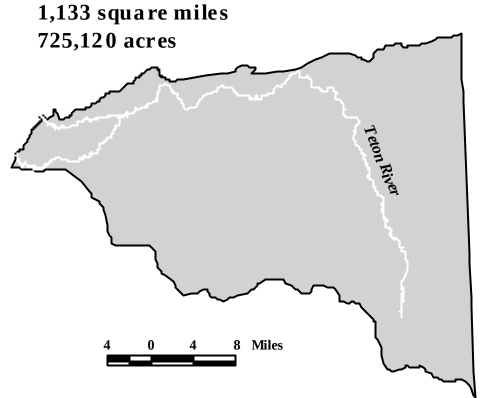
USGS United States Geological Survey

WQLS water quality limited segment

Teton Subbasin at a Glance



Hydrologic Unit Code	**17040204**
1998 Section 303(d)-listed Stream Segments	**Badger, Darby, Fox, Horseshoe, Moody, North Leigh, Packsaddle, South Leigh, and Spring Creeks; Teton River from headwaters to Bitch Creek; North Fork Teton River**
Beneficial Uses Affected	**Cold Water Aquatic Life Salmonid Spawning**
Pollutants of Concern	**Sediment, Nutrients, Temperature Flow Alteration, Habitat Modification**
Major Land Uses	**Agriculture, Recreation**
Area	**1,133 square miles 725,120 acres**



EXECUTIVE SUMMARY

The Teton Subbasin is one of three watersheds that comprise the Henry's Fork Basin. The Teton River drains an area of 806 square miles in Idaho and 327 square miles in Wyoming. The river originates from headwater streams in the Teton, Big Hole, and Snake River mountain ranges and flows more than 64 miles to the point at which it discharges to the Henry's Fork River. Twenty river miles southwest of this point, the Henry's Fork joins the South Fork Snake River to form the mainstem of the Snake River.

The Teton Subbasin is physically and biologically diverse. Elevations range from almost 11,000 feet along the eastern edge of the subbasin to approximately 4,800 feet in the Henry's Fork floodplain of the western subbasin. The eastern portion of the subbasin lies within the Middle Rocky Mountain physiographic province, the western portion lies within the Snake River Plain physiographic subprovince, and the south central portion lies within the Basin and Range physiographic province. Natural vegetation includes Douglas fir, western spruce-fir, lodgepole pine, and alpine meadow plant communities at higher elevations, and sagebrush steppe and saltbrush/greasewood communities at lower elevations. A defining feature of the Teton Subbasin is the extensive wetland complex associated with the upper Teton River. Climate varies within the subbasin according to elevation, but is generally characterized by cold winters, with average minimum daily temperatures of less than 10 ^{o}F in January, and mild summers, with average maximum daily temperatures of less than 85 ^{o}F in July. The annual precipitation averages less than 16 inches and the growing season is short, with less than 82 days exceeding a temperature of 32 ^{o}F in nine years out of ten. The average total precipitation is greatest in May and June, and average total snowfall is greatest in December and January. The average annual snowfall at Driggs, in the upper subbasin, is 65 inches.

Three distinct reaches of the Teton River have been defined by the geologic and topographic features of the subbasin. The river takes form at the southern end of the first reach, which is a structural basin referred to as Teton Valley or Teton Basin. This basin is approximately five miles wide and 20 miles long, and was at one time blocked at its northern end by volcanic deposits. The lake-type depositional area filled with fine-sized debris washed from the alluvial fans that formed at the base of the Teton Range. This produced soils that are poorly drained organic-rich silty clay loams and gravelly loams underlain by a relatively impervious layer of clay. Now, as streams flow out of the Teton Range, water subsides into the coarse-sized, well-drained alluvium along the eastern edge of the basin. The water percolates through the soil until it reaches the impervious layer, then apparently flows along this surface until it re-emerges as springs and seeps approximately two-to-three miles west of the point at which it subsided. These conditions create the wetlands of the Teton Valley. The second reach of the Teton River includes the canyon that it carved through the felsic and basaltic volcanic deposits of the subbasin. At its confluence with Bitch Creek, a major tributary, the river makes an almost 90^{o} turn to the west. Teton Canyon, with steep walls rising as high as 500 feet, contains the river for approximately 17 miles. In 1975, Teton Dam was completed at the lower end of the canyon to create a reservoir for irrigation water. In June 1976, when the reservoir behind the dam had almost filled, the earthen dam collapsed. More than 250,000 acre-feet of water and four million cubic yards of embankment material flowed through the breach in less than six hours. Reconstruction of the dam was not attempted, and the United States Bureau of Reclamation recently studied the effects of the dam collapse on the river channel and canyon in an effort to determine future management of the area. The third reach of the river extends from the Teton dam site to the Henry's Fork, and includes the floodplains of the North and South Forks of the Teton River and the Henry's Fork River. This reach was extensively altered by the flood that followed the collapse of the Teton Dam, and by the mitigation and restoration work that followed the flood.

Stream discharges in the Teton Subbasin are generally a function of snowmelt runoff. Peak discharges occur in May or June when average total precipitation reaches a maximum and warmer average daily temperatures accelerate the rate of snowmelt. In the upper subbasin, two periods of peak flow are associated with two distinct snowmelt periods. The first occurs when snow at lower elevations melts in March and April; the second occurs when snow at higher elevations melts in late May and June, and is accompanied by rainfall. Many of the streams that originate in the Teton and Big Hole mountain ranges do not connect to the Teton River except during periods of peak flow.

Approximately 75% of land in the Teton Subbasin west of the Idaho-Wyoming border is privately owned, and the principal land use is cultivated agriculture. The eastern portion of Teton Subbasin is located in Teton County, Wyoming, and Teton County, Idaho; the western half of the subbasin is located primarily in Madison County. According to the 1997 National Census of Agriculture, approximately 78,000 cropland acres were harvested in Teton County, Idaho, and 149,000 cropland acres were harvested in Madison County. Almost 74% of the harvested acres in Teton County and 86% of the harvested acres in Madison County were irrigated. Major crops were barley, wheat, hay, and potatoes. In terms of livestock production, the inventory of beef and dairy cattle was at least ten times the inventory of hogs, sheep, and poultry, with each county reporting approximately 8,600 animals. The total market value of crops produced in both counties was more than $95 million; the total market value of livestock produced in both counties was more than $13 million.

Approximately 25% of the Teton Subbasin is federally or state-owned, and the majority of this land is managed by the Caribou-Targhee National Forest. Land use on the forest in the eastern portion of the subbasin, most of which is located in Wyoming, is determined primarily by its status as wilderness and grizzly bear habitat. The Jedediah Smith Wilderness Area, which borders Teton National Park, has experienced limited timber harvest but receives heavy recreational use with more than 60,000 visitors each year. Grand Targhee Ski and Summer Resort is adjacent to the wilderness area, and is a major destination of tourists. Management of forest lands in the Big Hole Mountains is directed toward opportunities for motorized and nonmotorized recreation, improvement of big game habitat, and improvement of ecosystem health. The Big Hole Mountains have been extensively logged and livestock grazing is a common land use.

Agriculture has historically been the principal land use influencing water quality in the Teton Subbasin. Of the thirteen segments on Idaho's 1998 §303(d) list of water quality impaired waterbodies in the subbasin, sediment is cited as the pollutant responsible for impairment of nine. The principal processes that generate sediment are 1) sheet and rill erosion due to rain and snow runoff from cultivated fields and 2) streambank erosion due to grazing, channel alteration, and flood irrigation. Significant sources of sediment also include the collapse of Teton Dam; natural mass wasting events, particularly on Teton and Trail Creeks; and poorly maintained roads and culverts, particularly in areas where roads were constructed for timber harvest.

The other pollutants shown on Idaho's 1998 §303(d) list are also associated primarily with agricultural land uses. Flow alteration occurs because flow is diverted from streams for use as irrigation water. Habitat alteration, particularly fish spawning habitat, is directly related to the accumulation of sediment in stream substrates. Thermal modification (i.e., temperature) has been attributed to removal of riparian vegetation and loss of shade, apparently due to grazing. Nutrients, particularly nitrogen, have been attributed to cattle manure, fertilizer, and crops such as alfalfa hay.

The effects of agricultural practices on water quality in the Teton Subbasin have not gone unnoticed by the agricultural community, and for more than fifty years, the Madison Soil and Water Conservation District and Teton Soil Conservation District have actively promoted resource conservation practices within the subbasin. Both districts have worked closely with the United States Department of Agriculture (USDA) Natural Resources Conservation Service to educate farmers about conservation practices and to obtain funding to assist farmers in implementing those practices. In fact, many of the streams that appear on Idaho's 1998 §303(d) list were originally listed because the Teton Soil Conservation District (TSCD) requested assistance from the Idaho Department of Health and Welfare in identifying water quality problems. Because of the activities of the conservation districts, the most erodible croplands have been removed from cultivation through the Conservation Reserve Program. Within the last fifteen years in the Teton Valley, the widespread practice of leaving fields fallow in summer has been completely replaced by practices that incorporate residue management and conservation tillage. These practices have significantly reduced the amount of soil transported to surface waters in the valley. Currently, the conservation districts are working through the USDA Environmental Quality Incentives Program to expand implementation of conservation practices.

Because of rapidly changing land uses, activities other than agriculture will have an increasingly important influence on water quality in the Teton Subbasin in the future. Since 1990, population growth in the Teton Subbasin has surged, particularly in the Teton Valley area. In 1990, the population of the Teton Subbasin was less than 30,000, with more than 87% of the population residing in Madison County. From 1990 to 1998, the population of Teton County, Idaho, increased by almost 60% and the population of Teton County, Wyoming, increased by almost 27%. By comparison, the population of the entire United States grew less than 9% during the same period. Population growth in the lower subbasin had been relatively stable until 2001 when Rick's College, a two-year college located at Rexburg, was converted to the Idaho campus of Brigham Young University. This prompted an immediate boom in construction of single-family and multiple-unit dwellings in anticipation of growing faculty, staff, and student populations.

Rural sprawl is the name given to the pattern of housing development currently occurring in the Teton Subbasin, particularly in the Teton Valley. Because of the aesthetic and recreational values offered by the area, and a lower cost of living relative to Jackson, Wyoming, land is becoming much more valuable for development than for farming. New residents do not settle in established communities, but on lots surrounded by several acres that simulate a rural lifestyle. During a six-year period from 1991 to 1997, approximately 4,000 acres of farmland in the Teton Valley were subdivided for construction of single-family homes, and approximately 150 subdivisions had been platted by 1997. Several additional subdivisions have been approved since 1997, and at least two planned communities are currently being developed. One community offers 85 single-family residences and at least 70 multiple housing units; the other features a golf course and 540 housing units. Factors related to rural development that may affect ground and water quality include, but are not limited to, the following: a reduction in total wetland acreage, subdivision of wetlands into smaller and less functional wetland parcels, alteration of subsurface water tables due to loss of wetlands, alterations of spring and surface water flows, increased numbers of septic systems, increased numbers of drinking water wells, and increased road construction and maintenance.

Only two point-source discharges that require permits under the National Pollutant Discharge Elimination System are located in the Teton Subbasin. The municipal wastewater treatment system at Driggs was recently upgraded to allow for regionalization of wastewater treatment, and a collection system extending from Driggs to the community of Victor at the southern end of Teton Valley was completed in 1999. Based on available information, the Driggs facility does not appear to contribute increased concentrations of nutrients to the Teton River, where it discharges after flowing through approximately five miles of wet meadow. The second municipal wastewater treatment system in the subbasin is at Rexburg, and discharges directly to the South Fork Teton River when weather conditions permit. The Rexburg facility influences water quality to the extent that at certain times of the year treated wastewater is a major source of water in the South Fork Teton River, its receiving water. However, the South Fork is downstream of any §303(d) listed segments in this subbasin.

Generally, the quality of water in the Teton Subbasin is good, as indicated by the continued presence of the native Yellowstone cutthroat trout (*Onchorhynchus clarki bouvieri*). This subspecies of cutthroat trout is an Idaho "species of special concern" because it is low in numbers, limited in distribution, and has suffered significant habitat losses. The U.S. Fish and Wildlife Service was petitioned to list the Yellowstone cutthroat trout as threatened under the Endangered Species Act, but in February 2001, the U.S. Fish and Wildlife Service concluded that the petition did not provide substantial biological information to indicate that listing was warranted. The decline of Yellowstone cutthroat trout throughout its range has been attributed primarily to hybridization with rainbow trout (*Onchorhynchus mykiss sp.*). In the Teton Subbasin, reproductive isolation between cutthroat and rainbow trout has apparently prevented hybridization in most areas, providing a genetic refuge. Although the abundance of cutthroat trout in the Teton Subbasin has been reduced due to habitat degradation, the subbasin is one of seven in the Greater Yellowstone Ecosystem that has been identified as offering a significant opportunity for restoration.

The objectives of the Teton Subbasin assessment are to identify waterbodies that 1) require development of a total maximum daily load (TMDL), 2) may be removed from the §303(d) list because they are not impaired, 3) must be deferred for TMDL development until a later date because of insufficient data on which to develop a load allocation, 4) are not subject to TMDL development because the pollutant responsible for impairment is habitat modification or flow alteration, or 5) are candidates for future §303(d) listing. The goal of a TMDL is to restore an impaired waterbody to a condition that meets state water quality standards and supports designated beneficial uses. A TMDL is the sum of the individual wasteload allocations for point sources of a pollutant, load allocations for nonpoint sources and natural background levels, and a margin of safety. Because of the variety of ways in which nonpoint source pollutants may enter a waterbody, a TMDL must also address seasonal variations in pollutant loading and critical conditions that contribute to pollutant loading.

The approach used to develop a TMDL incorporates several assumptions regarding our knowledge of natural systems and human-caused changes in natural systems. These assumptions include 1) that the amount of a pollutant that can be assimilated by a waterbody without violating water quality standards and impairing beneficial uses is known and can be quantified, 2) that natural background levels of a pollutant are known or can be determined, 3) that violations of water quality standards or impairments of beneficial uses can be directly linked to a single pollutant, and 4) that the data required to develop a load for a particular waterbody is available or can be readily obtained. None of these assumptions were valid for waterbodies in the Teton Subbasin. The Region 10 Office of the U.S. Environmental Protection Agency acknowledges the uncertainty associated with these assumptions, and has proposed an adaptive management strategy for addressing this uncertainty.

An adaptive management TMDL emphasizes near-term actions to improve water quality and can be employed when data only weakly quantify links between sources, allocations, and in-stream targets. Limited water quality data were available for the §303(d)-listed stream segments in the Teton Subbasin. Although load allocations have been developed for most of these segments, these allocations are based on information gathered more than ten years ago. Due to improved farming practices (e.g., elimination of summer fallow in the Teton Valley) and changes in land use, pollutant sources and resource concerns have changed since this information was collected. An adaptive management strategy makes provisions for addressing these changes during the implementation phase of the TMDL.

The adaptive management strategy will be incorporated into the TMDL Implementation Plan developed by designated management agencies. The designated roles of numerous government agencies in implementing Idaho's nonpoint source management program and TMDLs are described in the *Idaho Nonpoint Source Management Plan* (DEQ 1999b). An implementation plan for privately owned agricultural lands will be developed by the Soil Conservation Commission and Idaho Association of Soil Conservation Districts in cooperation with the Madison Soil and Water Conservation District, TSCD, and Yellowstone Soil Conservation District, with technical support from the affiliated field offices of the Natural Resources Conservation Service. Implementation plans for publicly owned lands in the Teton Subbasin will be the responsibility of the Idaho Department of Lands, U.S. Forest Service, Bureau of Land Management, and Bureau of Reclamation. Within 18 months of approval of the *Teton Subbasin Assessment and Total Maximum Daily Load (TMDL)* by the U.S. Environmental Protection Agency, the Idaho Falls Regional Office of DEQ will review each implementation plan and facilitate coordination among designated agencies to integrate the plans into a single, comprehensive implementation plan.

Conclusions based on the subbasin assessment are shown in the following table

Table A. Allocations of total maximum daily loads (TMDLs) and deferrals of TMDLs for §303(d) listed streams in the Teton Subbasin.

Waterbody	WQLS[1] Number	Boundaries	Pollutant(s)	Stream Miles	Load Allocations and Other Actions
Badger Creek	2125	Highway 32 to Teton River	Sediment	8.51	16,367 tons/year sediment (38% reduction).
Darby Creek	2134	Highway 33 to Teton River	Sediment Flow alteration	3.48	694 tons/year sediment (73% reduction). No TMDL for flow alteration.
Fox Creek	2136	Wyoming Line to Teton River	Sediment Temperature Flow alteration	9.18	949 tons/year sediment (72% reduction). Temperature TMDL rescheduled for end of 2002. No TMDL for flow alteration.
Horseshoe Creek	2130	Confluence of North and South Forks to Teton River	Flow alteration	7.03	No TMDL for flow alteration.
Moody Creek	2119	Forest boundary to Teton River	Nutrients	25.38	Nutrient TMDL rescheduled for the end of 2002.
North Leigh Creek	5230	Wyoming line to Spring Creek	Unknown[2]	4.90	Included in the Spring Creek watershed and TMDL.
Packsaddle Creek	2129	Headwaters to Teton River	Sediment Flow alteration	9.88	1,924 tons/year sediment (46% reduction). No TMDL for flow alteration.
South Leigh Creek	2128	Wyoming line to Teton River	Sediment	11.30	8,269 tons/year sediment (46% reduction).
Spring Creek	2127	Wyoming line to Teton River	Sediment Temperature Flow alteration	12.60	12,027 tons/year sediment (42% reduction). Temperature TMDL rescheduled for end of 2002. No TMDL for flow alteration.
Teton River	2118	Headwaters to Trail Creek	Habitat alteration	2.65	No TMDL for habitat alteration.
Teton River	2117	Trail Creek to Highway 33	Sediment Habitat alteration	20.00	105,141 tons/year sediment (41% reduction). No TMDL for habitat alteration.
Teton River	2116	Highway 33 to Bitch Creek	Sediment Habitat alteration Nutrients	10.10	121,508 tons/year sediment (41% reduction). 101,882 lbs/year total phosphorus (78% reduction). No TMDL for habitat alteration.
North Fork Teton River	2113	Forks to Henry's Fork, Snake River	Sediment Nutrients	14.64	52,818 tons/year sediment (41% reduction). 66,149 lbs/year total phosphorus (67% reduction). 198,448 lbs/year nitrate (8% total reduction).

[1]WQLS: Water quality limited segment shown in the 1998 §303(d) list.
[2]North Leigh Creek was added to the 1998 §303(d) list because beneficial use reconnaissance program data collected by DEQ indicated that beneficial uses were not supported. The pollutant responsible for impairment of beneficial uses cannot be determined using BURP data alone, so a pollutant was not listed. Because a U.S. Department of Agriculture 1992 sediment yield study included North Leigh Creek in the Spring Creek watershed and in Spring Creek's yield calculation, we consider it part of the Spring Creek TMDL.

TETON SUBBASIN ASSESSMENT

INTRODUCTION

This subbasin assessment was prepared pursuant to the Idaho total maximum daily load (TMDL) development schedule (Idaho Sportsmen's Coalition v. Browner, No. C93-943WD, Stipulation and Proposed Order on Schedule Required by Court, April 7, 1997), §303(d) of the Clean Water Act (Public Law 92-500 as amended, 33 U.S.C. §1251 *et seq.*), and the United States Environmental Protection Agency (EPA) Water Quality Planning and Management Regulations (40 CFR Part 130.7).

The objective of the Clean Water Act (CWA) is to “restore and maintain the chemical, physical and biological integrity of the Nation's waters” (33 U.S.C. §1251 *et seq.*). To achieve this objective, the CWA specifies several national goals and policies, including the following:

1) It is the national goal that the discharge of pollutants into the navigable waters be eliminated by 1985
2) It is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water be achieved by July 1, 1983

...and

7) It is the national policy that programs for the control of nonpoint sources of pollution be developed and implemented in an expeditious manner so as to enable the goals of this Act to be met through the control of both point and nonpoint sources of pollution.

Despite implementation of numerous provisions of the CWA, many of the nation's waters still have not been restored to a “fishable and swimmable” condition. Section 303(d) of the CWA (refer to Appendix A for entire text) addresses these remaining waters by requiring that states submit biennially a list of water quality impaired waterbodies (i.e., a §303(d) list) to the EPA. With oversight from the EPA, the states are then responsible for developing a TMDL for the pollutant or pollutants responsible for impairment of each waterbody (EPA 1996).

The goal of the TMDL is to restore the impaired waterbody to a condition that meets state water quality standards. According to the EPA (1996),

> A TMDL is a written, quantitative assessment of water quality problems and contributing pollutant sources. It specifies the amount of a pollutant or other stressor that needs to be reduced to meet water quality standards, allocates pollution control responsibilities among pollution sources in a watershed, and provides a basis for taking actions needed to restore a waterbody. More specifically, a TMDL is the sum of the individual wasteload allocations (WLAs) for point sources [of pollution], load allocations (LAs) for nonpoint sources [of pollution] and natural background, and a margin of safety (MOS).

In 1997, the Idaho Department of Health and Welfare, Division of Environmental Quality (now Department of Environmental Quality [DEQ]), and Region 10 EPA finalized an eight-year schedule for developing TMDLs in Idaho. Background information regarding development of this schedule is contained in Appendix B. The EPA Region 10 approved the portion of the 1998 §303(d) list that pertains to the Teton Subbasin on May 1, 2000.

The subbasin assessment and TMDL is a three-step process that includes 1) preparing a subbasin assessment, 2) developing a TMDL or watershed management plan, and 3) developing an implementation plan.

The purpose of the subbasin assessment is to:

1) describe the physical, biological, and cultural attributes of the subbasin, particularly in relation to surface water resources;
2) summarize existing water quality information available for the drainage;
3) describe applicable water quality standards;
4) identify and evaluate pollution sources and disturbance activities that contribute to impairment of water quality;
5) summarize past and present pollution control efforts; and
6) outline water quality management needs including identifying those waterbodies that a) require development of a TMDL, b) may be removed from the §303(d) list because they are not impaired, c) are not subject to TMDL development because the pollutant responsible for impairment is habitat modification or flow alteration, or d) are candidates for §303(d) listing.

If the subbasin assessment demonstrates a 303(d) listed waterbody is not impaired and is meeting its designated beneficial uses and the water quality standards, DEQ will not develop a TMDL and will recommend de-listing of the waterbody in the next 303(d) listing cycle. If the EPA approves the revised list, a TMDL will not be developed for the excluded waterbody.

Conversely, if the subbasin assessment demonstrates that a waterbody not on the current §303(d) list is water quality impaired, the waterbody will be included on the next §303(d) list prepared for submission to EPA. TMDLs or management and control plans will not be developed for newly listed waterbodies until at least 2006, following completion of the current TMDL schedule. During this time, it is possible that the waterbody will be restored to a condition that meets water quality standards, making development of a TMDL unnecessary.

PHYSICAL CHARACTERISTICS OF THE TETON SUBBASIN

Topography

One of the most distinctive topographic features of the Teton Subbasin is the western slope of the Teton Mountain Range. The eastern slope of the Teton Range is among the most recognizable views in the world because its face rises abruptly from the Snake River valley below it. The unique peaks of the three Tetons remain recognizable from the west, although the peaks grade more gently into rolling farmland. Although total elevational changes within the subbasin are almost 6,000 feet from the eastern boundary of the subbasin in the Teton Mountains of Wyoming to the western boundary near the Henry's Fork River, this change occurs over a horizontal distance of up to 50 miles (Figure 1). Other unique features of the Teton Subbasin are the deep, steep-walled canyons of the Teton River, Badger Creek, Bitch Creek, Milk Creek, Canyon Creek, and Moody Creek. These canyons appear abruptly in a landscape of level or gently rolling farmland, and access to the canyons in most places is extremely difficult.

Three mountain ranges define the eastern, southeastern, and south central boundaries of the subbasin: the Teton, Snake River, and Big Hole mountain ranges. The Teton Valley, a north-south trending valley approximately five miles wide and 20 miles long, is defined by the convergence of these three mountain ranges. Elevations exceeding 10,000 feet occur along the entire length of the eastern boundary of the subbasin in the Teton Range. Streams originating from the Teton Range may drop as much as 4,000 feet in elevation as they flow a horizontal distance of less than 15 miles toward the Teton Valley.

Darby Creek originates near Fossil Mountain at an elevation of 10,912 feet (3,327 meters [m]), and Teton Creek originates near Battleship Mountain at an elevation of 10,676 feet (3,255 m). North of the valley in the northeast corner of the subbasin, Bitch Creek originates near Rammel Mountain at an elevation of 10,138 feet (3,091 m). Streams flowing toward the Teton Valley from the Snake River Range and Big Hole Mountains originate at elevations ranging from approximately 7,000 to 9,000 feet (2,130 -2,700 m). Trail Creek originates near Oliver Peak at an elevation of 9,003 feet (2,744 m), and Canyon Creek originates near Garns Mountain at an elevation of 9,013 feet (2,748 m). Streams originating in the Big Hole Mountains flow east into the Teton Valley, north into the Teton River Canyon, and west into the South Fork Teton River.

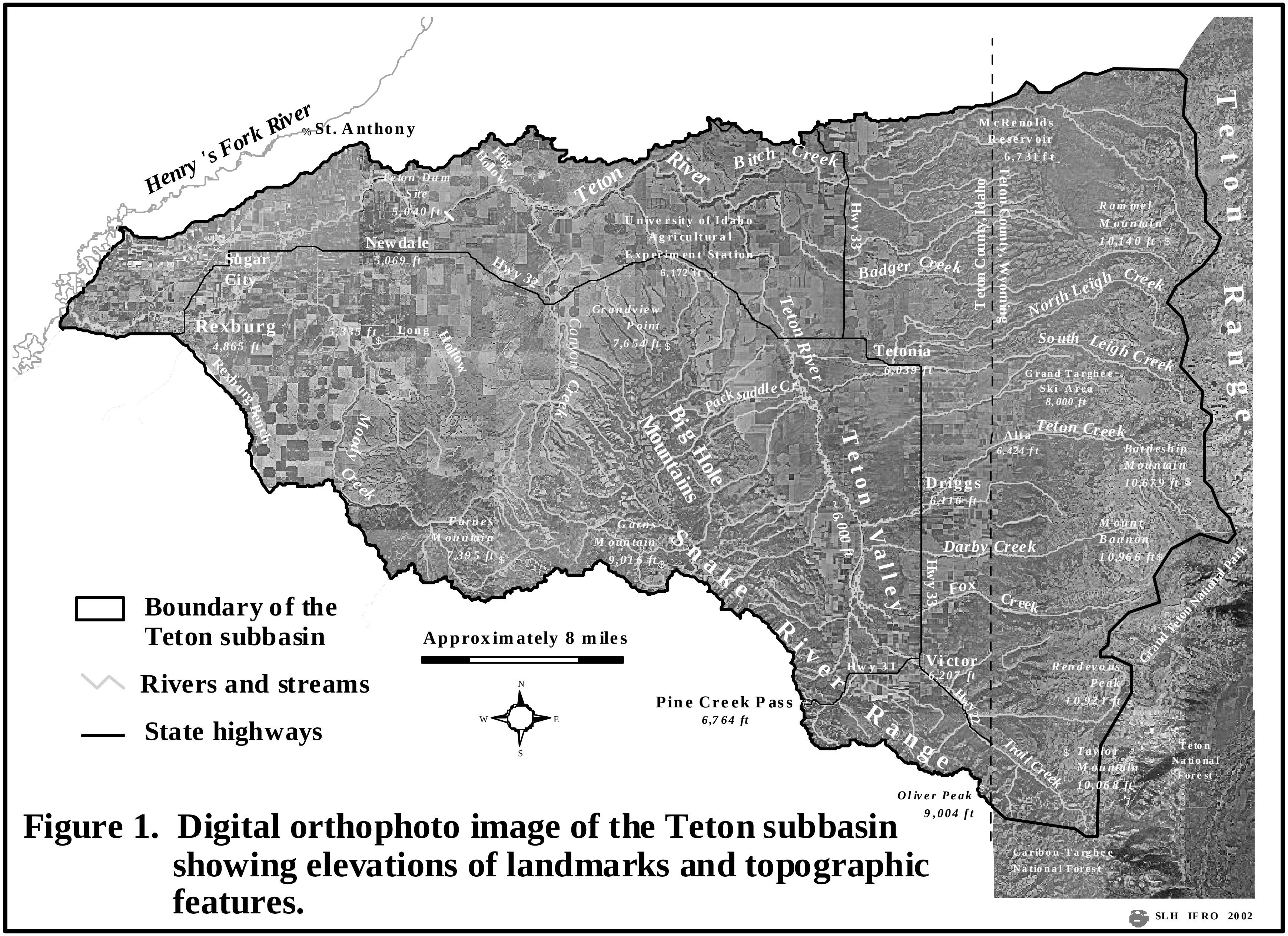


Figure 1. Digital orthophoto image of the Teton subbasin showing elevations of landmarks and topographic features.

Climate

Long-term, continuous climate data have been collected by the National Weather Service (NWS) at several locations in the Teton Subbasin. In the western portion of the subbasin, temperature and precipitation data were collected at Sugar City from 1948 until 1977, when the station was moved to Rick's College in Rexburg. In the eastern portion of the subbasin, an NWS climate station originally located at Felt in 1919 was moved to Tetonia in 1932 and then to the Tetonia Experiment Station in 1952 (USDA 1969). These three locations are within a six-mile radius of each other, and vary less than 100 feet in elevation. The only climate station in the subbasin that has remained in its original location is at Driggs. This station has been operational since 1907 (USDA 1969). The official names and numbers of the NWS Cooperative Stations currently operating in the Teton Subbasin are Rexburg Rick's College, number 107644; Tetonia Experiment Station, number 109065; and Driggs, number 102676 (Abramovich *et al.* 1998).

Temperatures within the Teton Subbasin generally decrease from west to east as elevations increase. These temperature changes correspond to elevational differences of 1,250 feet between Rexburg and the Tetonia Experiment Station, and 1,200 feet between Rexburg and Driggs (Table 1).

Higher temperatures in the western portion of the subbasin contribute to a longer growing season. The probable length of the growing season nine in every ten years is 82 days at Rexburg, 44 days at Driggs, and 34 days at the Tetonia Experiment Station (Table 2).

A comparison of the growing season at the Tetonia Experiment Station, which is 25 miles east of Rexburg, and the growing season at Driggs, which is 33 miles east of Rexburg, indicates that within the eastern portion of the subbasin, a relatively minor change in average temperature results in a noticeable change in growing season (Tables 2 and 3).

In the Teton Subbasin, average total precipitation is greatest in May and June, and average total snowfall is greatest in December and January (Table 4). Based on data from the three NWS climate stations in the subbasin, average total precipitation is approximately 12% less at Rexburg than at the Tetonia Experiment Station or Driggs. Average monthly precipitation at Rexburg exceeds the average at the Tetonia Experiment Station and Driggs only in May and November. But despite lower total precipitation, Rexburg receives approximately 17 inches more snow than the Tetonia Experiment Station and only eight inches less snow than Driggs (Table 4). Furthermore, the difference in total snowfall between the Tetonia Experiment Station and Driggs, a distance of less than ten miles, is almost 26 inches (Table 4). This pattern of snowfall over a relatively small distance seems to demonstrate the enormous influence of the Big Hole Mountains and the Teton Range on local climatic conditions.

Table 1. Average daily maximum and minimum temperatures measured at Sugar City and Rexburg[1], Tetonia Experiment Station[2], and Driggs[3].

Period	Average Daily Maximum Temperature (°F)			Average Daily Minimum Temperature (°F)		
	Sugar City-Rexburg	Tetonia Exp. Sta.	Driggs	Sugar City-Rexburg	Tetonia Exp. Sta.	Driggs
January	28.9	28.1	29.6	9.0	5.4	5.9
February	34.7	33.2	34.5	13.5	8.9	9.5
March	44.4	39.3	40.5	20.9	15.0	16.3
April	56.7	49.8	51.9	29.1	25.1	25.6
May	67.3	61.7	62.8	37.5	32.9	33.5
June	75.2	70.7	71.1	43.7	39.4	40.1
July	84.1	80.5	81.1	47.9	44.8	46.1
August	83.7	79.1	80.0	45.8	42.9	43.9
September	73.9	69.4	70.5	37.6	35.3	36.3
October	60.6	56.7	58.6	29.1	26.9	27.7
November	42.7	39.8	41.0	21.0	16.3	17.1
December	31.0	30.1	32.2	11.1	7.6	8.9
Annual	56.9	53.2	54.5	28.9	25.0	25.9

[1]The values reported are time-weighted averages of data collected at Sugar City from 8/1/1948 to 5/1/1976 and at Rexburg from 7/1/1977 to 12/31/1998. Source: Western Regional Climate Center, *http://www.wrcc.dri.edu/cgi-bin/cliRECtM.pl?idsuga* and *http://www.wrcc.dri.edu/cgi-bin/cliRECtM.pl?idrexb*.
[2]Source: Western Regional Climate Center, *http://www.wrcc.dri.edu/cgi-bin/cliRECtM.pl?idteto*. Period of record: 5/18/1952 to 12/31/1998.
[3]Source: Western Regional Climate Center, *http://www.wrcc.dri.edu/cgi-bin/cliRECtM.pl?iddrig*. Period of record: 1/3/1930 to 12/21/1998.

Table 2. Length of growing season: probabilities of the number of days at Rexburg, Driggs, and Tetonia that will exceed minimum temperatures of 24 °F, 28 °F, and 32 °F.[1]

Probability[2]	Number of days greater than 24 °F			Number of days greater than 28 °F			Number of days greater than 32 °F		
	Rexburg	Driggs	Tetonia	Rexburg	Driggs	Tetonia	Rexburg	Driggs	Tetonia
9 years in 10	146	113	95	118	80	68	82	44	34
5 years in 10	165	136	122	136	107	91	104	73	63
1 year in 10	183	158	148	154	133	113	126	102	93

[1]Source: Abramovich *et al.* (1998)
[2]Based on data collected from 1961 to 1990

Table 3. Length of growing season: probabilities that the last freezing temperature in spring and first freezing temperature in fall will occur later or earlier than a particular date in Rexburg, Driggs, and Tetonia.[1]

Probability that the last date will be later than the date shown and that the first date will be earlier than the date shown[2]	Last date in spring and first date in fall that the daily minimum temperature is:								
	equal to or less than 24 °F			equal to or less than 28 °F			equal to or less than 32 °F		
	Rexburg	Driggs	Tetonia	Rexburg	Driggs	Tetonia	Rexburg	Driggs	Tetonia
5 years in 10	April 21 Oct 4	May 10 Sept 24	May 16 Sept 20	May 11 Sept 25	May 27 Sept 13	June 3 Sept 8	May 30 Sept 12	June 19 Sept 2	June 23 Aug 28
2 years in 10	May 2 Sept 24	May 19 Sept 15	May 28 Sept 10	May 22 Sept 16	June 9 Sept 3	June 15 Aug 28	June 11 Sept 3	July 3 Aug 22	July 5 Aug 16
1 year in 10	May 8 Sept 19	May 25 Sept 9	June 4 Sept 5	May 29 Sept 11	June 15 Aug 29	June 22 Aug 23	June 17 Aug 28	July 11 Aug 15	July 11 Aug 10

[1]Source: Abramovich *et al.* (1998)
[2]Based on data collected from 1961 to 1990

Table 4. Summary of precipitation and snowfall data collected within the Teton Subbasin at Sugar City and Rexburg[1], Tetonia Experiment Station[2], and Driggs[3].

Period	Average Total Precipitation (Inches)			Average Total Snowfall (Inches)			Average Snow Depth (Inches)		
	Sugar City-Rexburg	Tetonia Exp. Sta.	Driggs	Sugar City-Rexburg	Tetonia Exp. Sta.	Driggs	Sugar City-Rexburg	Tetonia Exp. Sta.	Driggs
January	1.1	1.5	1.4	13.1	16.1	14.9	9	2	13
February	1.0	1.0	1.1	10.3	2.9	8.6	7	1	13
March	1.1	1.0	1.2	4.8	2.1	9.1	3	0	6
April	1.2	1.3	1.2	2.5	1.4	4.8	0	0	1
May	2.1	2.1	1.8	0.5	0.5	1.6	0	0	0
June	1.5	1.8	1.9	0.0	0.0	0.2	0	0	0
July	1.0	1.1	1.1	0.0	0.0	0.0	0	0	0
August	0.7	1.1	1.2	0.0	0.0	0.0	0	0	0
September	0.9	1.3	1.2	0.1	0.3	0.4	0	0	0
October	1.0	1.2	1.2	1.3	0.7	2.0	0	0	0
November	1.3	1.0	1.1	7.0	5.5	8.6	1	1	1
December	1.1	1.4	1.4	16.2	9.2	14.2	5	6	6
Annual	14.0	15.9	15.7	55.7	38.7	64.5	2	3	3

[1]The values reported are time-weighted averages of data collected at Sugar City from 8/1/1948 to 5/1/1976 and at Rexburg from 7/1/1977 to 12/31/1998. Source: Western Regional Climate Center, http://www.wrcc.dri.edu/cgi-bin/cliRECtM.pl?idsuga and http://www.wrcc.dri.edu/cgi-bin/cliRECtM.pl?idrexb.
[2]Source: Western Regional Climate Center, http://www.wrcc.dri.edu/cgi-bin/cliRECtM.pl?idteto. Period of record: 5/18/1952 to 12/31/1998.
[3]Source: Western Regional Climate Center, http://www.wrcc.dri.edu/cgi-bin/cliRECtM.pl?iddrig. Period of record: 1/3/1930 to 12/21/1998.

Snow pack at higher elevations within the subbasin are monitored at the Pine Creek Pass snow telemetry (SNOTEL) station and three snow course stations operated by the Natural Resources Conservation Service (NRCS). The Pine Creek SNOTEL station is located along the southeastern divide between the Teton and Palisades Subbasins at an elevation of 6,720 feet. The data collected at this station since October 1988 can be accessed through the Western Regional Climate Center Internet site at http://www.wrcc.dri.edu/cgi-bin, and a summary of average monthly snow water equivalent data is shown in Table 5. Snow water equivalent values are highest on April 1, and rapidly decline between May 1 and June 1 (Table 5).

Peak flows in streams and rivers throughout the subbasin are generally caused by a combination of spring rains and snowmelt. Average total precipitation reaches a maximum throughout the subbasin in May and June, which coincides with warmer average daily temperatures (Table 1) and rapidly decreasing snow depth (Table 4). According to England (1998), snowmelt is the predominant cause of runoff in the Teton Subbasin, and snowmelt high runoff, as measured in the Teton River near St. Anthony gage station, occurs in June.

Table 5. Average values for snow depths and snow water equivalents (SWE) measured at Natural Resources Conservation Service SNOTEL and snow course stations in the Teton Subbasin from 1961 to 1990[1].

	Station Name and Type							
	McRenolds Reservoir Snow Course		Packsaddle Spring Snow Course		Pine Creek Pass SNOTEL		State Line Snow Course	
Date	Depth (inches)	SWE (inches)	Depth (inches)	SWE (inches)	Depth (inches)	SWE (inches)	Depth (inches)	SWE (inches)
January 1	-[2]	7.6	-	12.2	31	6.9	28	6.1
February 1	-	12.5	-	18.2	43	11.3	38	9.8
March 1	-	16.6	-	24.3	49	15.1	43	12.7
April 1	-	19.2	-	27.5	49	17.2	45	14.8
May 1	-	14.2	-	25.1	27	11.3	20	8.2
June 1	--[3]	--	--	--	-	0.7	-	0.5

[1]Source: Abramovich *et al.* (1998)
[2]Not reported
[3]No measurable snow

Geology

At least two, and possibly three, physiographic provinces converge in the Teton Subbasin. According to Short (1999), the western and central portions of the subbasin are within the Snake River Plain physiographic subprovince of the Colorado Plateau, and the eastern portion of the subbasin is within the Middle Rocky Mountains province. Stevenson (1990a, 1990b) adds a third province by placing the Big Hole Mountains of the south central portion of the subbasin within the Basin and Range physiographic province. The distinctions between these provinces are apparent in the varied geomorphology, topography, and soils of the subbasin.

The *Geologic Map of Idaho* (IDL 1978) shows nineteen distinct geologic units within the Teton Subbasin. For simplicity, these units have been combined into the four categories shown in Figure 2. The sedimentary deposits of the Big Hole, Snake River, and Teton Mountain Ranges formed 65 to 245 million years ago when ancient oceans and lakes existed in this region. The limestones, sandstones, siltstones, and shales that comprise these deposits were folded and faulted, displacing the Teton Mountain Range upward 20,000 feet and forming the Big Hole Mountains and Snake River Range. A structural basin, underlain by Mesozoic-age bedrock, was also formed by this process, and is referred to as the Teton Basin or Teton Valley.

The Teton Valley is bounded by the Big Hole Mountains on the west, the Snake River Range on the south, and the Teton Range on the east. The valley is approximately five miles wide and 20 miles long. The north end of the valley was originally blocked by volcanic deposits, which created a lake-type depositional area (Stevenson 1990a). During the Quarternary Period, 1.6 to 0.01 million years ago, the area filled with detritus formed from the weathering of the surrounding mountains. According to Wood (1996),

> as the surrounding mountains were uplifted, alluvial-fan deposits began to accumulate rapidly on their flanks. The higher elevations were subject to erosion...while the lower elevations were subject to deposition of alluvial sediments, silts, sands and gravels. ... In the alluvial fans the coarsest debris [pebbles and boulders] is nearest the mouths of the tributary canyons. The size then decreases toward the base of the fans where the debris consists largely of clay, silt, sand, and small gravel. Such deposits are the result of erratic conditions of streamflow where the fan may at one time have received coarse material carried by a flood and soon after received only the finer sediments carried by the stream. ... From time to time, volcanic rocks of silicic composition, probably closely allied with those in the Yellowstone Park area, flowed out across the valley, covering or interlayering with the alluvial sand and gravels.

During the Pleistocene Epoch of the Quarternary Period, the Teton Mountains, and possibly the Big Hole Mountains, were glaciated in three recognized stages. "Glacial drift, consisting of poorly sorted sand, gravel, and boulders, was deposited in nearly all the tributary canyons in the Teton Range" (Wood 1996). These deposits were overlain by wind-blown silt, covering much of the valley floor west of the Teton River and in the northern and northeastern parts of the valley; the depth of loess in these areas ranges from 0 to 100 feet (Wood 1996).

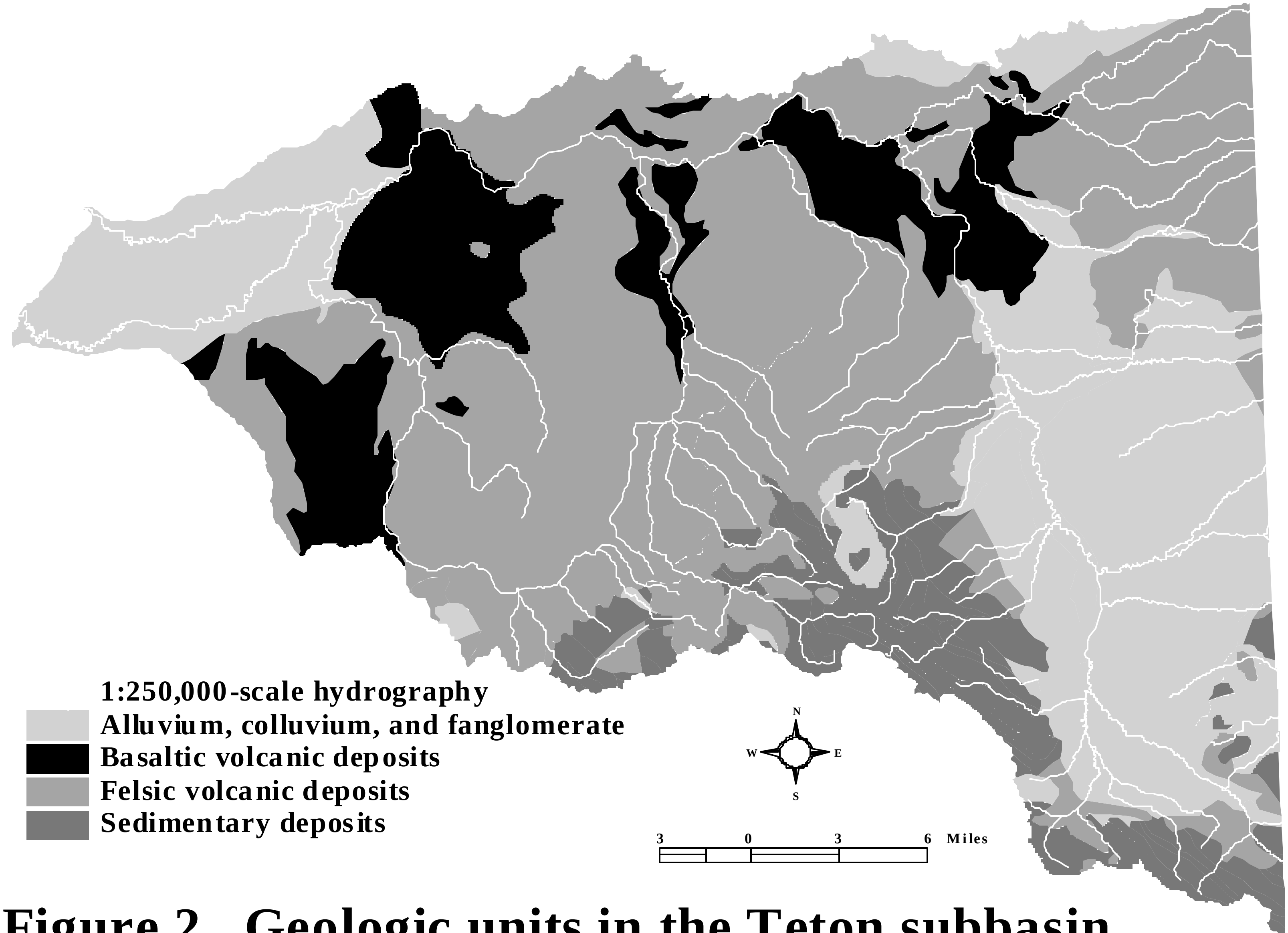


Figure 2. Geologic units in the Teton subbasin.

The felsic volcanic deposits found at the northern end of the Teton Basin are similar to those of the central portion of the subbasin. Rhyolite rock is found at the surface at numerous locations, and extends to a depth of 860 feet in the Bitch Creek subwatershed (Wood 1996). The basalts that occur at the very northern extent of the valley were deposited between periods of felsic deposition. Eventually, the Teton River eroded a steep-walled canyon through the basalt at the northern end of the valley. As the river flows through volcanic deposits, its course appears to be determined by the locations of large deposits of basalt. At the confluence of Bitch Creek, the river makes an almost 90^o turn to the west as it flows along the northern extent of a large basalt formation (Figure 2).

The channels of several large tributary streams of the Teton River were also apparently determined by the locations of basalt formations (Figure 2). Badger Creek, Bitch Creek, Milk Creek, Canyon Creek, and Moody Creek have each carved steep-walled canyons that appear abruptly in a landscape otherwise characterized by rolling loess-covered hills. Randle *et al.* (2000) describes the geologic formation of the Teton River canyon as follows.

> During the late Pliocene and early Pleistocene age (2.1 million years ago), the Huckleberry Ridge tuff, a 200- to 600- foot-thick flow of rhyolite from Yellowstone Caldera, was deposited over a pre-existing uneven landscape (Pierce and Morgan, 1992). The Teton River started downcutting through the rhyolite, likely due to uplifting of the Rexburg Bench in relation to the subsidence of the adjacent Snake River Plain to the west. Following incision of the Teton River into the Huckleberry Ridge tuff, a single younger basalt flow entered the Teton River canyon just downstream from the present dam site and flowed upstream, covering river gravel and filling the lower part of the canyon to a depth of about 125 feet (Magleby, 1968). The Teton River continued its active erosion cycle and extensively eroded the intracanyon basalt flow. The lower river near the dam site then changed from degradation to aggradation, resulting in the deposition of over 100 feet of sand and gravel, completely burying the remnants of the intracanyon basalt flow (Magleby, 1968). ...Today, steep canyon walls typically rise 300 to 500 feet above the river in the nearly 17-mile-long reach upstream from Teton Dam that was inundated by Teton Reservoir.

After the Teton River exits the canyon, it flows through a geologic area described as “Pleistocene outwash fanglomerate flood and terrace gravels” (IDL 1978). In this area, materials washed out of Pleistocene glaciers and deposited in the alluvial fan of the river have cemented into solid rock (i.e., fanglomerate). This geologic formation, like the formations described for the Teton Valley, overlays and is probably interlayed with materials of volcanic origin. In fact, all of the western Teton Subbasin lies within the Kilgore caldera, formed by the same events that created the eastern Snake River Plain.

Formation of the eastern Snake River Plain began 10 to 17 million years ago when a volcanic system located in what is now southwestern Idaho began migrating in a northeasterly direction at an estimated rate of 4.5 millimeters (mm) per year (Link and Phoenix 1996) to 2 to 4 centimeters (cm) per year (Christiansen and Embree 1987, Maley 1987). This system is produced by movement of the North American tectonic plate southwestward over a stationary plume of heat in the earth's mantle (the Snake River Plain-Yellowstone Hot Spot) (Link and Phoenix 1996). As the continental crust passes above the hot spot, it melts,

> ...producing explosive eruptions of light-colored lava or ash, with the composition of rhyolite. These eruptions coincide with collapse of calderas (topographic depressions formed after the rhyolitic volcanic eruptions) which form above what had been magma chambers. ... After the rhyolite eruptions have ceased, dark lava known as basalt is erupted, and covers over the subsided rhyolite topography. ...after rhyolite eruptions cease, thermal doming of the land surface is reduced and the area subsides back to near its prior elevation (Link and Phoenix 1996).

This process is considered responsible for a series of caldera-forming eruptions that have propagated in a northeasterly direction to form the eastern Snake River Plain. The leading edge of the volcanic system, the Yellowstone resurgent caldera (Alt and Hyndman 1989) or Yellowstone Plateau volcanic field (Christiansen and Embree 1987), is located at the eastern edge of the Upper Henry's Fork Subbasin. Resurgent calderas erupt enormous volumes of rhyolite lava at intervals of several hundreds of thousands of years. The Yellowstone resurgent caldera has erupted three times at intervals of approximately 600,000 years, creating the Henry's Fork, Huckleberry Ridge, and Yellowstone calderas. Three million years earlier, the resurgent caldera erupted in what is now the western half of the Teton Subbasin, creating the Kilgore caldera.

The Kilgore caldera extends south of present-day Rexburg to Heise and north to the Centennial Mountains (Hackett *et al.* 1986). The surface features of the Kilgore caldera are no longer discernable. Because the Kilgore caldera covers an area approximately the size of the Henry's Fork, Huckleberry Ridge, and Yellowstone calderas combined, the volume of eruptive material produced by Kilgore must have exceeded 3,500 cubic kilometers (km^3). By comparison, eruption of Mount St. Helens produced less than 2 km^3 of material (Wood 1996).

Hydrography and Hydrology

The Henry's Fork basin is comprised of the Upper Henry's Fork Subbasin, the Lower Henry's Fork Subbasin, and the Teton Subbasin. Immediately south of the Teton Subbasin, the Henry's Fork River joins the South Fork Snake River to form the mainstem of the Snake River (Figure 3).

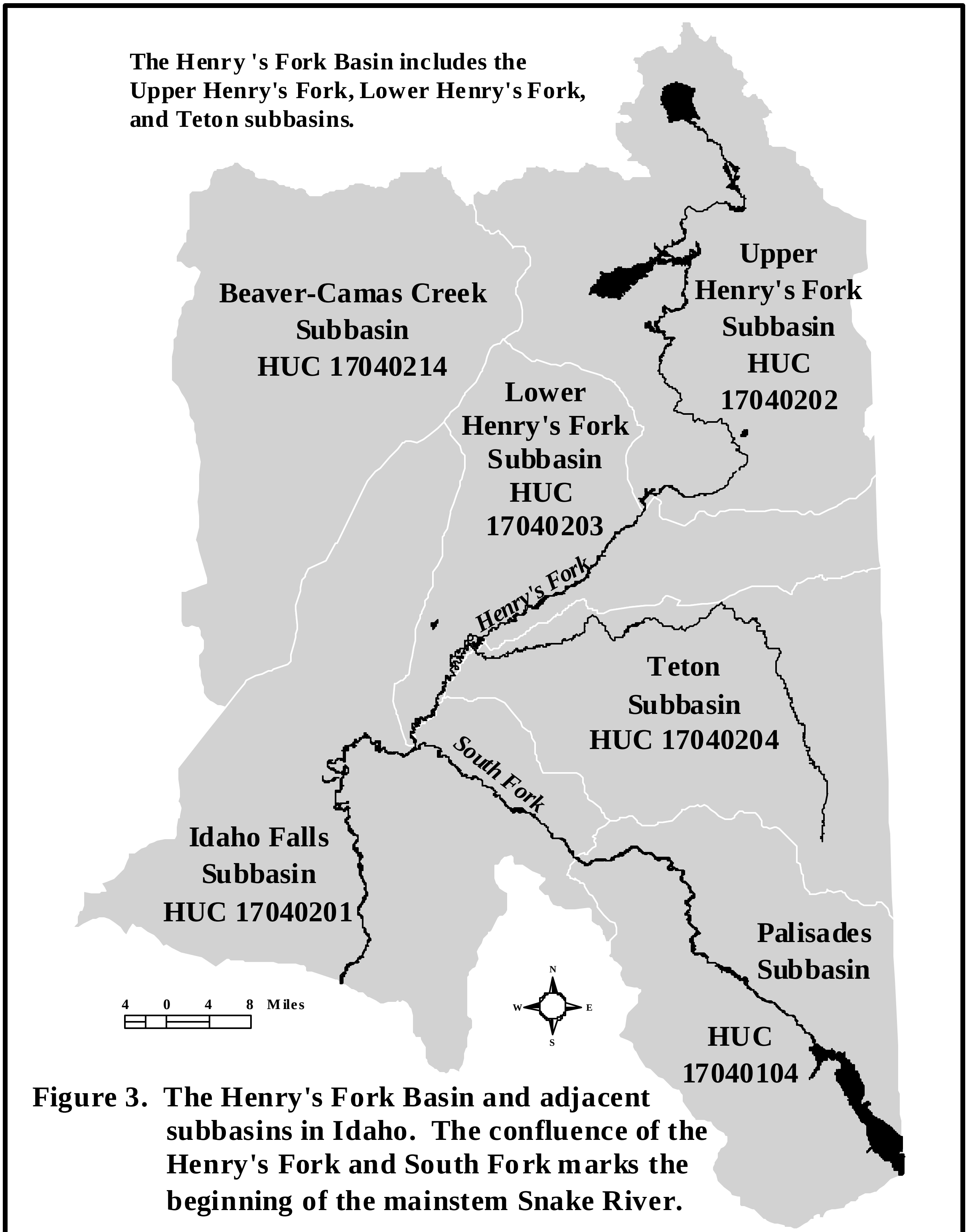


Figure 3. The Henry's Fork Basin and adjacent subbasins in Idaho. The confluence of the Henry's Fork and South Fork marks the beginning of the mainstem Snake River.

The Teton River drains an area of 806 square miles in Idaho and 327 square miles in Wyoming. The river originates from headwater streams in the Teton, Snake River and Big Hole Mountain Ranges and flows more than 64 miles to the point at which it discharges to the Henry's Fork of the Snake River. Approximately 16 river miles upstream from its discharge point, the Teton River divides into two channels. On U.S. Geological Survey (USGS) topographic maps, the northernmost channel is named *Teton River* and the southernmost channel is named *South Teton River*. But these channels are more commonly known as the North Fork and South Fork Teton River, and are referred to as such throughout this document.

The USGS has operated gage stations at 24 locations within the Teton Subbasin, though only four stations are currently in operation (Figure 4 and Appendix C). Several of the discontinued stations were located on tributary streams in the upper subbasin, and most of these were operational only from 1946 through the early 1950s. One station, *Teton River near St. Anthony*, has been operating discontinuously since 1890. Water quality data have also been collected at this station for the following intervals: water years 1977-1981, October 1989 to September 1990, November 1992 to September 1996, and water year 1999.

Discharge data for the four active gage stations in the Teton Subbasin are presented in graphical form in Figure 5. These graphs were taken directly from the USGS web site for water years 1981-1999, the period during which all stations were operating.

England (1998) analyzed flood frequency and flow duration for the Teton River as part of the Bureau of Reclamation's (BOR's) Teton Canyon restoration study. His conclusions include 1) flooding in the Teton Subbasin is caused by three mechanisms: warm rains from winter storm systems, spring rain-on-snow, and snowmelt; 2) the largest peak discharges are caused by winter storms, although flow volumes for rainfall-dominated floods are substantially less than snowmelt-dominated floods; 3) snowmelt is the predominant cause of runoff in the Teton Subbasin; and 4) the snowmelt high runoff at the *Teton River near St. Anthony* gage occurs in June. But the maximum discharge recorded at the *Teton River near St. Anthony* gage, excluding the peak estimated on June 5, 1976 following the Teton Dam collapse, occurred in February 1962 (Appendix C). The peak flow of 11,000 cubic feet per second (cfs) was caused by a combination of factors that included prolonged rainfall and unusually warm temperatures, and produced damaging floods in Rexburg, Sugar City, and Teton. Philbin (2001) reviewed the unit discharge data shown in Appendix C and concluded that peak flows in the upper subbasin are driven by snowmelt whereas peak flows in the lower subbasin are driven by spring rains on saturated soils.

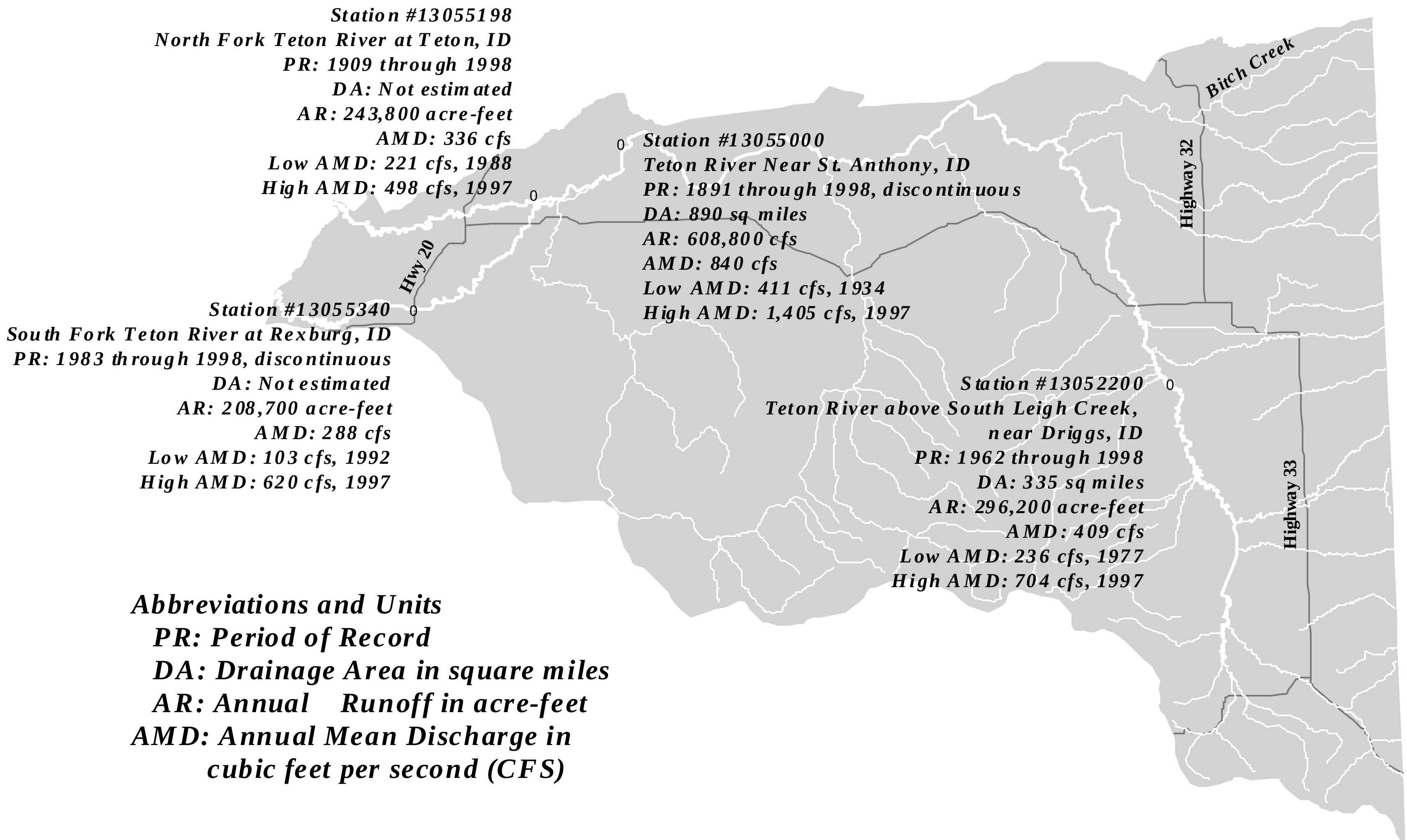


Figure 4. Locations of U.S. Geological Survey surface-water stations currently operating in the Teton subbasin, and summaries of discharge data for the period of record through 1998. Source: U.S. Geological Survey Water-Data Report ID-98-1.

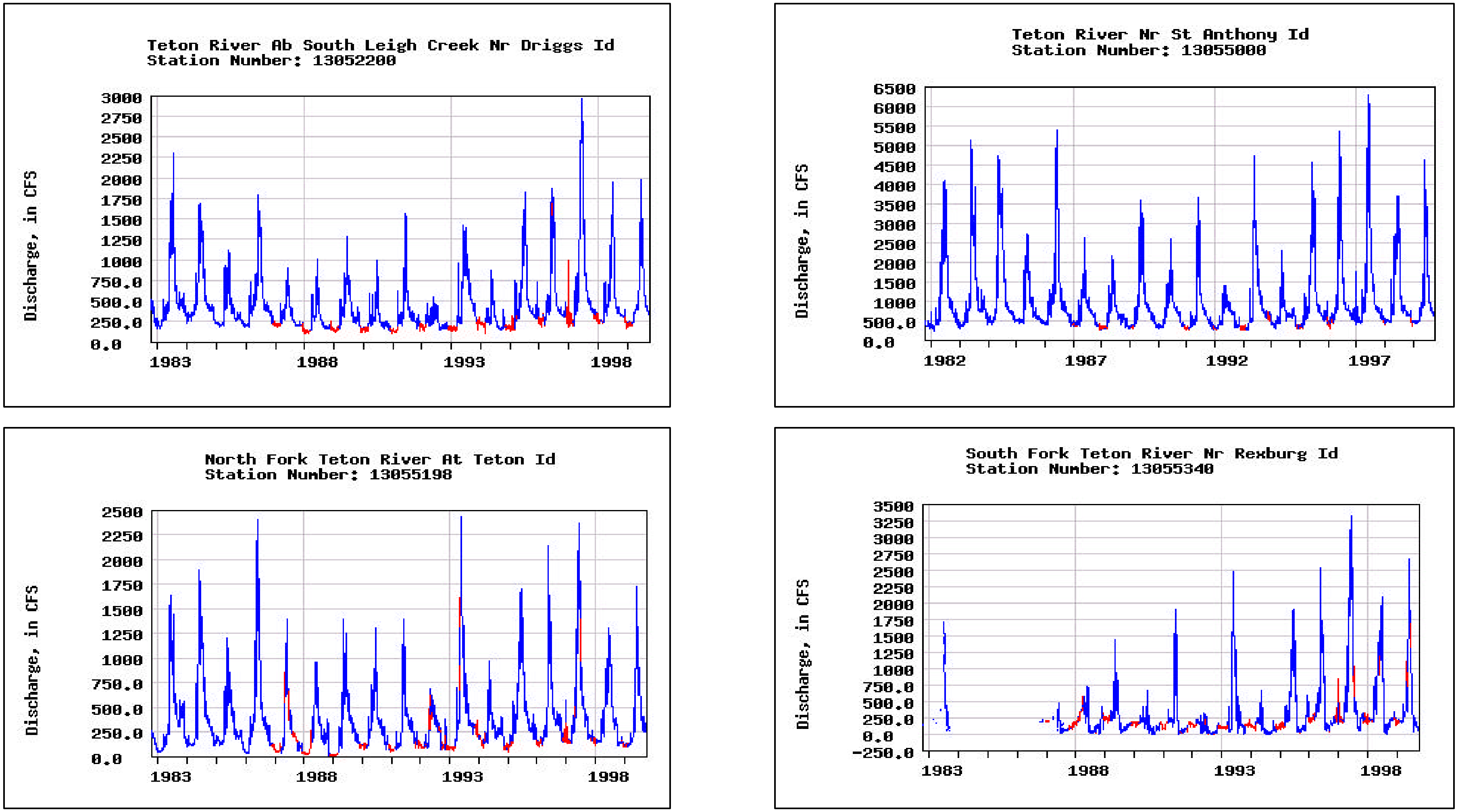


Figure 5. Discharge data recorded or estimated since 1982 at active USGS gage stations in the Teton subbasin. Graphs were taken directly from the USGS data retrieval site at http://waterdata.usgs.gov/nwis-w/ID.

Comparisons of the maximum unit discharges shown in Appendix C are indicative of the relative importance of the Bitch Creek subwatershed to the entire Teton Subbasin. The maximum unit discharge recorded for Bitch Creek (23.2 cfs/mile^2) was almost twice the maximum unit discharge recorded for the entire subbasin upstream of the *Teton River near St. Anthony* gage (12.4 cfs/mile^2). It was more than four times the maximum unit discharge recorded for the entire subbasin upstream of Bitch Creek, as measured at the *Teton River below Badger Creek* gage (4.9 cfs/mile^2). The contribution of Bitch Creek to surface flow is so significant that when the first survey map of the upper Teton Subbasin was produced, the Teton River was named *Pierre's River*, and Bitch Creek was labeled *North Fork of Pierre's River* (Thompson and Thompson 1981). Bitch Creek is still often referred to as the North Fork by residents of the Teton Valley.

The waters of the Teton Subbasin have been used intensively for irrigation since the late 1800s, and natural flow regimes have been significantly altered throughout the subbasin (Carter and Steele 1955, USDA 1981). Water users in the Teton Subbasin are served by the Fremont-Madison Irrigation District (FMID), which is defined geographically by the Henry's Fork Basin (FMID 1992). The district was organized in 1935, and has acted as a forum for, and representative of, water-related issues in Fremont, Madison, and Teton counties. The BOR provides a total of 150,204 acre-feet of storage space in Island Park and Grassy Lake Reservoirs to FMID. The FMID does not own any water supply and distribution facilities outright, but it manages and maintains the Crosscut Canal and the BOR's five exchange wells. The Crosscut Canal provides water from Island Park Reservoir to water users who divert from the Teton River by transferring storage water from the Henry's Fork River near Chester to the Teton River upstream of the forks. The exchange wells were constructed by the BOR in the 1970s as appurtenances of the Teton Basin Project to provide additional irrigation water in dry years. Although the Teton Basin Project was not completed because of the failure of the Teton Dam, water in the exchange wells replaces waters diverted to district entities during low water years. A list of diversions from, and returns to, the lower Teton River, is shown in Table 6.

Despite the return flows indicated in Table 6, not all water removed from the river for irrigation returns to the river via surface flow. According to Gégo and Johnson (1996), in some cases "canals divide into laterals that further divide into numerous ditches that apparently do not return to the river." Furthermore, irrigation return flows which benefit the lower Teton River "mostly originate from canals diverting water from the Falls River and the Henry's Fork." The Crosscut Canal, constructed in the 1930s, diverts water from the Henry's Fork and delivers it to Falls River Canal and the Teton River a few miles downstream of the Teton Dam site, increasing the amount of water available in the lower Teton Basin (Gégo and Johnson 1996, IWRB 1992). The average volume of water diverted from the lower Teton River for water years 1983 through 1986 was 292,022 acre-feet (IWRB 1992).

A water budget for the diversions and return flows in the Teton Subbasin upstream of the Teton Dam site has apparently not been prepared. A more thorough and precise survey of the Teton Valley diversions is expected to be made by Idaho Department of Water Resources (IDWR) adjudication staff when they review the water right claims in the area, which is currently scheduled for the year 2003 (Olenichak 2000).

Table 6. Irrigation diversions, return flows, and supplemental flows in the lower Teton Subbasin (after Gégo and Johnson 1996 and Olenichak 2000).

Segment of River	Diversions	Return or Supplemental Flows
Central Teton River	Wilford Irrigation and Manufacturing Company Canal	Cross Cut Canal delivers water to the Teton River from the Henry's Fork
	Teton Irrigation, Teton Generation Station, and Siddoway Ditch	Exchange wells
	Pioneer Ditch	
	Steward Ditch	
North Fork Teton River	Pincock-Byington Ditch	Farmer's Friend Canal
	Teton Island Feeder, Salem Irrigation, and Teton Island Canal	Exchange wells
	North Salem Agriculture and Milling Canal	Salem Union Company
	Roxana Canal	
	Island Ward Canal	Island Ward Canal, which diverts from the North Fork, receives return flows from the Consolidated Farmers Canal
	Saurey-Sommers Canal	
South Fork Teton River	Pincock-Garner Canal Company	Exchange wells and Teton Generation Station
	McCormick Ditch (abandoned 1999)	Moody Creek, which discharges to the South Fork via a constructed channel, receives return flows from the Teton Canal, East Teton Canal, and Enterprise Canal, though Moody Creek is diverted to the Woodmansee-Johnson Canal
	Bigler Slough Ditch	Teton Island Canal, which diverts water from the North Fork, also discharges to the South Fork
	Woodmansee-Johnson Canal	
	City of Rexburg Canal	
	Rexburg Irrigation Canal	

In the late 1960s and early 1970s, the U.S. Department of Agriculture (USDA) provided funding and NRCS technical support to replace some surface irrigation ditches in the Teton Valley with pipelines. Pipelines were installed near or below the Caribou-Targhee National Forest boundary on Trail, Game, Fox, Packsaddle, and Patterson Creeks to reduce losses of irrigation water due to infiltration. As much as 30% of the water diverted through irrigation ditches was estimated to have filtered through the subsoil prior to installation of the pipelines (Ray 1999). Although diversion of water through pipelines altered surface and subsurface flow, the practice also eliminated miles of ditches that had previously served as sources of sediment. The Packsaddle pipeline is in need of maintenance and repair, and failure of the pipeline will require a return to the use of irrigation ditches (Lerwill 2000). The current condition of all pipelines in the subbasin needs to be evaluated, and possible sources of funding for repair and maintenance identified. Preferably, this evaluation would also include an analysis of the effects of pipeline diversions on the hydrology and wetlands of the Teton Valley, and consider alternatives that would address values other than delivery of irrigation water and sediment reduction.

Three dams exist on the Teton River, though only one is currently maintained. The Felt Dam Hydroelectric Project is located approximately one-half mile above the mouth of Badger Creek. The dam was constructed in 1921, and is now owned by the Fall River Rural Electric Cooperative (FRREC). By the 1980s, the reservoir behind Felt Dam had filled with sediment, according to the Federal Energy Regulatory Commission (FRREC 1982).

In the early 1980s, Bonneville Pacific Corporation of Salt Lake City entered into a 35-year lease with FRREC to upgrade and operate the Felt Dam Hydrolectric Project. The powerhouse was relocated to maximize hydraulic head, transmission lines were relocated, and the access road was widened. Because of violations of the CWA during construction, Bonneville Pacific was required to complete on- and off-site environmental mitigation projects.

Because of the influence of Felt Dam on flow within the Teton River, the Henry's Fork Water Quality Subcommittee recommended that the segment of the Teton River identified in Idaho's Water Quality Standards as "US-20, Teton River - Spring Creek to Badger Creek" be revised. A new segment of the river bounded by the normal elevation of Felt Dam pool (5530 feet) and the Felt Dam outlet was added, and the boundaries of upstream and downstream segments were modified correspondingly (Appendix D).

Other dam sites in the subbasin include Fox Creek near the forest boundary, Webster Dam on Moody Creek, the Linderman Dam in Teton Canyon near the confluence of Milk Creek, and the Teton Dam site. Fox Creek Dam has been in place at least 20 years and was apparently built to create a settling pond for a quarry operation. The concrete dam is approximately eight feet high, but the area behind it has filled to a depth of approximately 6 feet. Webster Dam was built around 1900 and its reservoir has since filled with sediment. It now resembles a wet meadow and the dam is a barrier to upstream fish passage. The Linderman Dam was built in the 1950s for irrigation purposes but is no longer functional. Remnants of the dam remain in the Teton River channel, but the dam is not a barrier to fish movement. The Teton Dam was completed in 1975 and collapsed in 1976. On the day the dam collapsed, a discharge of 1.7 million cfs was estimated for the Teton River at the St. Anthony gage. Although a major portion of the earth-filled dam remains, it is not a barrier to fish migration.

The USGS identifies the Teton Subbasin as hydrologic unit code (HUC) 17040204. This eight-digit code indicates the location of the subbasin within successively smaller hydrologic units (USGS 1998). The Teton River cataloging unit is located in the Pacific Northwest region (HUC 17), Upper Columbia subregion (HUC 1704), and Upper Snake accounting unit (HUC 170402). It is bounded in Idaho on the north by the Lower Henry's Fork cataloging unit (HUC 17040203), on the southwest by the Idaho Falls cataloging unit (17040201) and on the southeast by the Palisades cataloging unit (HUC 17040104) (Figures 3, 6, and 7).

As shown in Table 7, the Teton Subbasin contains 44 waterbody units, designated US-1 through US-44 to signify that the units are located in the Upper Snake River Basin. Although multiple stream segments may exist within a unit, the designated beneficial uses for each segment within a unit are identical. As previously mentioned, when the proposed waterbody units were published, the Water Quality Subcommittee of the Henry's Fork Watershed Council reviewed the lists and associated waterbody identification maps for the entire Henry's Fork basin, and made extensive recommendations to DEQ regarding revision of the boundaries. As explained in the *Administrator's Response to Oral and Written Comments on Docket #16-0102-9704* (DEQ 1999a), the only recommendations that were incorporated in the final version of the proposed rule were changes in boundary nomenclature and use designations. The recommendations of the council incorporate knowledge of streamflow that cannot be determined from a 1:100,000-scale hydrography and are therefore included in this assessment (Appendix D) as a reference for designation of beneficial uses and TMDL implementation planning.

Soils

Soils in the Teton Subbasin have been well characterized. Soils occurring on the Caribou-Targhee National Forest are described in the ecological unit inventory prepared by Bowerman *et al.* (1999), and soils occurring on privately owned land are described in surveys published by the USDA Soil Conservation Service (now NRCS). A survey of the Teton County area was issued in 1969 (USDA 1969), a survey of the Madison County area was issued in 1981 (USDA 1981), and a survey of the western part of Fremont County was issued in 1993 (USDA 1993). The Teton County area soil survey is currently being digitized to enable development of geographical information system (GIS) coverages. Digitization is being completed by the Idaho National Engineering and Environmental Laboratory (INEEL) and the Idaho State University GIS Center with support from Teton County, Teton Soil Conservation District (TSCD), Bureau of Land Management (BLM), and the NRCS. Completion of this project will facilitate detailed land use planning and management.

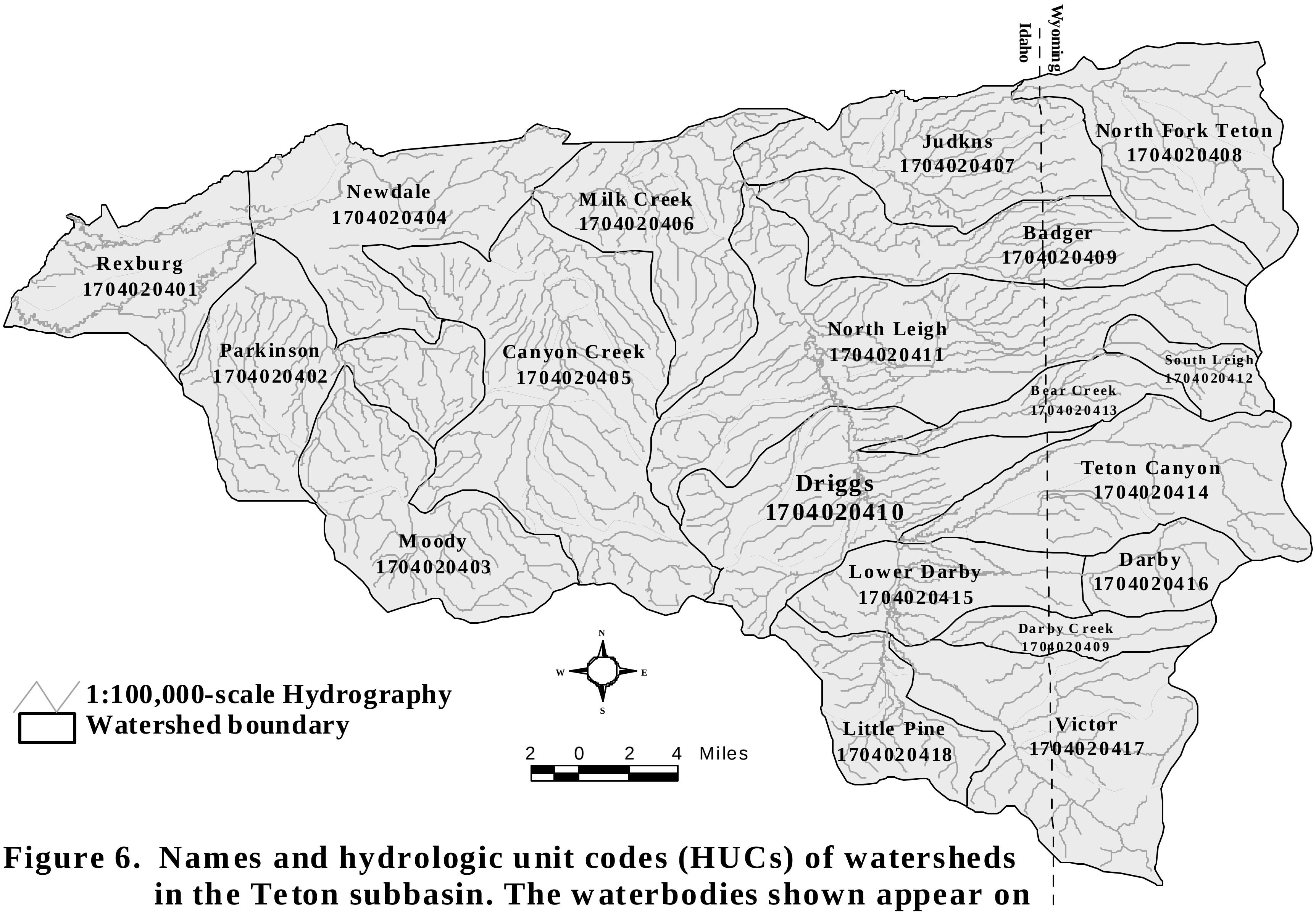


Figure 6. Names and hydrologic unit codes (HUCs) of watersheds in the Teton subbasin. The waterbodies shown appear on maps scaled 1:100,000, and include intermittent streams.

Label	Subwatershed	Acres
A	Badger Creek	
B	Badger Creek	40,474
C	Teton River	
1	Rammel Hollow	7,487
2	Spring Creek	27,962
3	South Leigh Creek	20,551
4	Packsaddle Creek	7,008
5	Dry Hollow	2,587
6	Horseshoe Creek	13,899
7	No Name	4,085
8	Dry Creek	29,158
9	Teton Creek	33,260
10	Spring Creek II	14,608
11	Twin Creeks	5,080
12	Mahogany Creek	7,023
13	Teton River	6,487
14	Foster Slough	3,548
15	Darby Creek	19,780
16	Bouquet Creek	3 ,301
17	Patterson Creek	4,903
18	Trail Creek	28,397
19	Fox Creek	15,429
20	Game Creek	8,604
21	Moose Creek	14,272
22	Drake Creek	2,661
23	Little Pine Creek	7,739
24	Warm Creek	7,739

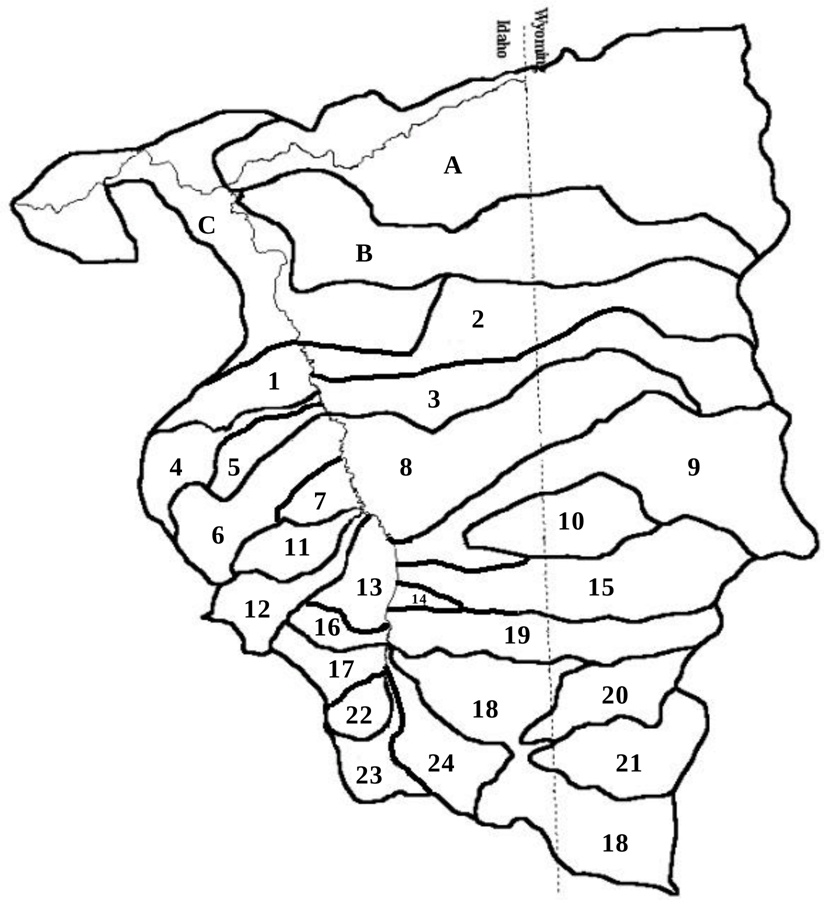


Figure 7. Subwatershed boundaries in the upper Teton River subbasin (after TSCD 1990 and USDA 1992).

Table 7. Excerpt of *IDAPA 58.01.02 - Water Quality Standards and Wastewater Treatment Requirements*, showing the boundaries of waterbody units listed for the Teton Subbasin. The prefix "US" indicates that the unit is located in the Upper Snake River Basin.

Unit	Waters
US-1	South Fork Teton River - Teton River Forks to Henry's Fork
US-2	North Fork Teton River - Teton River Forks to Henry's Fork
US-3	Teton River - Teton Dam to Teton River Forks
US-4	Teton River - Canyon Creek to Teton Dam
US-5	Moody Creek - Long Hollow Creek to mouth
US-6	Moody Creek - confluence of North and South Fork Moody Creeks to Long Hollow Creek
US-7	South Fork Moody Creek - source to mouth
US-8	North Fork Moody Creek - source to mouth
US-9	Long Hollow Creek - source to mouth
US-10	Tributaries to Canyon Creek Canal - source to mouth
US-11	Canyon Creek - Crooked Creek to mouth
US-12	Canyon Creek - Warm Creek to Crooked Creek
US-13	Canyon Creek - source to Warm Creek
US-14	Calamity Creek - source to mouth
US-15	Warm Creek - source to mouth
US-16	Crooked Creek - source to mouth
US-17	Teton River - Milk Creek to Canyon Creek
US-18	Milk Creek - source to mouth
US-19	Teton River - Badger Creek to Milk Creek
US-20	Teton River - Spring Creek to Badger Creek
US-21	Teton River - Mahogany Creek to Spring Creek
US-22	Packsaddle Creek - source to mouth
US-23	Horseshoe Creek - source to mouth
US-24	Mahogany Creek - source to mouth
US-25	Teton River - Patterson Creek to Mahogany Creek
US-26	Patterson Creek - source to mouth
US-27	Teton River - source to Patterson Creek
US-28	Trail Creek - Moose Creek to mouth
US-29	Trail Creek - Idaho/Wyoming border to and including Moose Creek
US-30	Fox Creek - Idaho/Wyoming border to mouth
US-31	Darby Creek - Idaho/Wyoming border to mouth
US-32	Teton Creek - Idaho/Wyoming border to mouth
US-33	Dry Creek - source to mouth
US-34	South Leigh Creek - Idaho/Wyoming border to mouth
US-35	Spring Creek - North Leigh Creek to mouth
US-36	North Leigh Creek - Idaho/Wyoming border to mouth
US-37	Spring Creek - source to North Leigh Creek
US-38	Badger Creek - confluence of North and South Fork Badger Creeks to mouth
US-39	South Fork Badger Creek - source to mouth
US-40	North Fork Badger Creek - source to mouth
US-41	Bitch Creek - Swanner Creek to mouth
US-42	Swanner Creek - source to mouth
US-43	Horse Creek - source to mouth
US-44	Bitch Creek - source to Horse Creek

Soil surveys consist of general soil map units or soil associations that are subdivided into detailed map units. General map units are usually thousands of acres in size and delineate unique natural landscapes consisting of distinctive patterns of soils, relief, and drainage (USDA 1993). A detailed map unit may be as small as an acre in size and delineates a specific soil, soil series, or soil complex.   General map units indicate the suitability of large areas for general land use; detailed map units indicate the suitability of more localized areas for specific uses such as crop production and placement of septic systems, roads, and building sites.

Soils in the Teton Subbasin are categorized into ten general map units in Madison County, eight units in Teton County, and three units in Fremont County. But because these map units were identified over a 25-year period using techniques and terminology unique to each county, they cannot be linked to create a map of the entire subbasin. The NRCS has circumvented this problem by compiling soil survey data and generalizing it statistically to a scale of 1:250,000 (USDA 1995). The resulting State Soil Geographic (STATSGO) database is one of three maintained by the NRCS, and is designed as a tool for resource planning, management, and monitoring at the multi-county, state, and regional levels.

Soils in the Teton Subbasin in Idaho are categorized into 15 STATSGO map units (Figure 8 and Table 8). More than half the soils in the subbasin are classified as silty loams or loams containing more than 45% silt-sized particles. According to the USDA soil particle classification system, silt-sized particles are greater than 0.002 mm and less than 0.05 mm in diameter (Brady and Weil 1996). Relative to very clayey or very sandy soils, silty loams are well-suited to cultivation but are easily eroded by wind and water. In the Teton Valley, upland soils (ID129 and ID130) are a combination of silt loams, gravelly loams, and cobbly loams, whereas lowland soils bordering the river (ID131) are a combination of silty clay loams and gravelly loams. Silty clay loams and gravelly loams also occur along the northwestern border of the subbasin in the floodplains of the North and South Fork Teton and Henry's Fork Rivers (ID122 and ID123). The increased proportion of clay in the lowland soils increases water-holding capacity, reduces aeration and drainage, and reduces the potential for erosion.

The susceptibility of soil to accelerated erosion is a function of the following six factors:

R = climatic erosivity (rainfall and runoff)
K = soil erodibility
L = slope length
S = slope gradient or steepness
C = cover and management
P = erosion-control practice

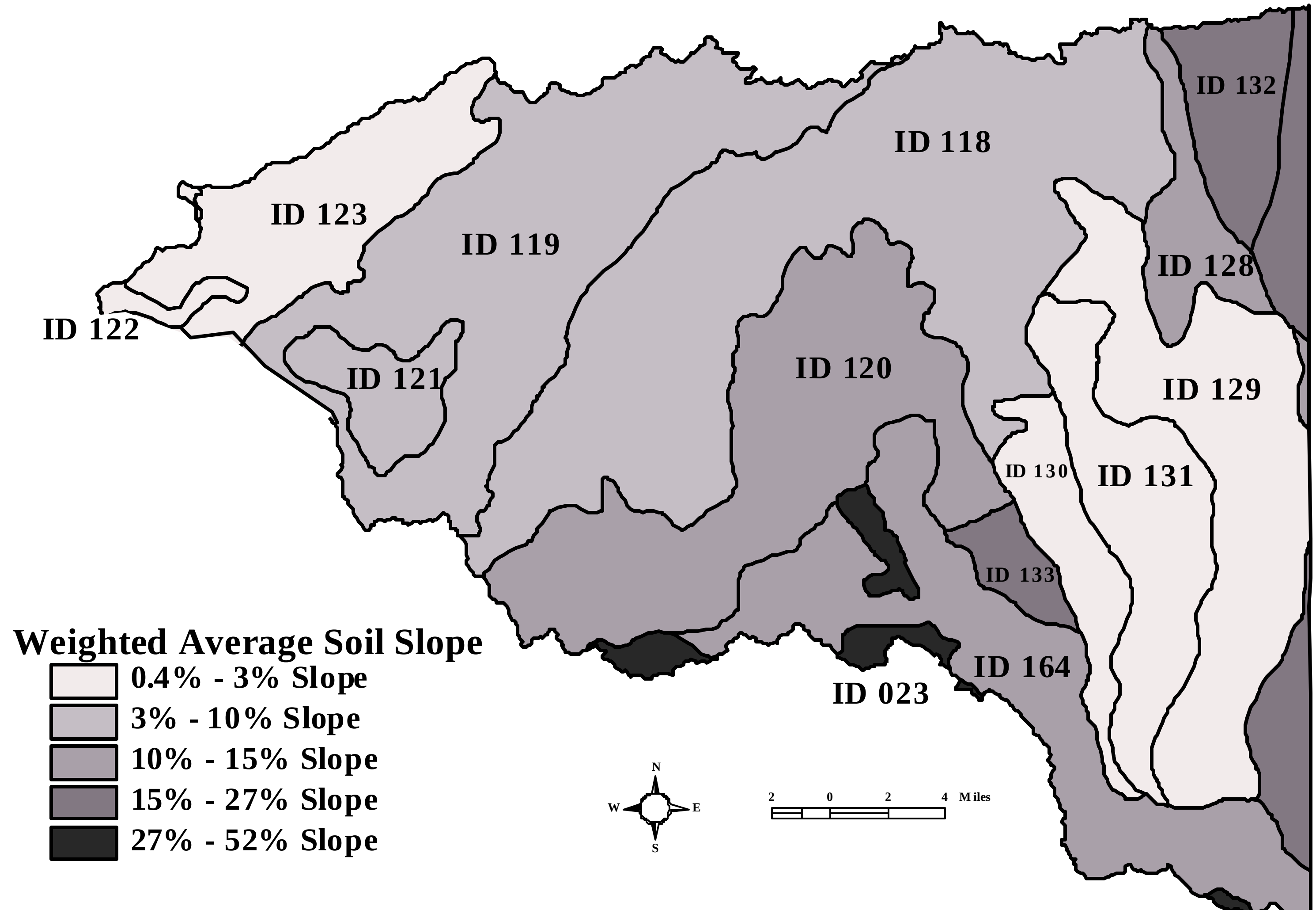


Figure 8. State Soils Geographic (STATSGO) map units and weighted average soil slopes.

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Table 8. Summary of STATSGO soil information for the Teton Subbasin[1].

Map Unit	Soil Association Name and Description[2]	Area (acres)	Area (mi^2)	Average Values For: Slope (%)	Depth (inch)	K Factor[3]
ID118	*Ririe-Lantonia-Tetonia*: Deep to very deep, well-drained silt loam soils on dissected plateaus; formed in wind laid materials; native vegetation includes bluebunch wheatgrass, Sandberg bluegrass, Idaho fescue, and sagebrush	117,394	183	6-20	12	0.39
ID119	*Rexburg-Ririe-Tetonia*: Deep, well-drained silt loam soils on dissected plateaus; formed in wind laid materials; native vegetation includes bluebunch wheatgrass, Sandberg bluegrass, Idaho fescue, and sagebrush	77,366	121	5-10	10	0.43
ID120	*Karlan-Greys-Turnerville*: Well-drained silt loam soils underlain by rhyolite or rhyolite tuff bedrock; formed in loess with residuum from bedrock (*Karlan*) or very deep loess (*Greys* and *Turnerville*); native vegetation includes grass (*Karlan*), aspen, chokecherry, wild rose and pinegrass (*Greys*), or lodgepole pine, Douglas-fir, and pinegrass (*Turnerville*)	65,493	102	10-23	12	0.40
ID129	*Driggs-Tetonia-Badgerton:* Level to gently sloping, well-drained soils that formed in alluvium and loess over gravel and sand; native vegetation includes bluebunch wheatgrass, Sandberg bluegrass, Idaho fescue, and sagebrush	52,576	82	2-5	8	0.34
ID164	*Judkins-Stringam-Targhee*: Well-drained, extremely stony loam soils formed in rhyolite bedrock and small amount of loess; native vegetation includes lodgepole pine, Douglas-fir, and pinegrass (*Judkins*)	50,773	79	4-22	8	0.31
ID123	*Withers-Annis-Blackfoot*: Deep, somewhat poorly drained silty clay loams and silt loams formed in alluvium on river terraces and floodplains	32,042	50	0-1	8	0.33
ID131	*Zohner-Furniss-Foxcreek*: Poorly drained silty clay loams and gravelly loams formed in alluvium derived from limestone, granite, quartzite, gneiss, and sandstone; native vegetation includes sedges, ruches, shrubby cinquefoil, willows, and other water-tolerant plants	30,602	48	0.2-2	11	0.23

According to the universal soil-loss equation and revised universal soil-loss equation, the product of these factors is equivalent to soil loss. Soil erodibility, or K factor, is a relative index of the susceptibility of bare, cultivated soil to particle detachment and transport by rainfall. It is an inherent property of soil that is related to its infiltration capacity and structural stability. Soils with high infiltration capacities and good structural stability are not easily eroded and have low K factors less than 0.2. Soils with intermediate infiltration capacities and moderate structural stability are moderately erodible and have K factors from 0.2 to 0.3. Soils with low infiltration capacities and poor structural stability are highly erodible and have K factors ranging from more than 0.3 to approximately 0.6 (Brady and Weil 1996). The average K factors shown in Figure 9 indicate that most soils in the Teton Subbasin are moderately to highly erodible.

Slope gradient, along with slope length, are topographic features that also influence erosion potential. Soils with steeper slopes are generally more susceptible to erosion though the complexity of the slope and a soil's susceptibility to rill and interrill erosion can significantly alter erosion potential. The map units with the highest average slope values are ID132, which corresponds to the upper Bitch Creek and upper Badger Creek watersheds, and ID133, which corresponds to the upper Horseshoe Creek and upper Mahogany Creek watersheds (Table 8 and Figure 9).

Soil depth, which is also shown in Table 8, is one of several factors that determine the tolerable soil loss, or T-value, of a soil. T-values have been developed by the NRCS for all cultivated soils in the United States, and range from approximately 2 tons/acre to 5 tons/acre. The T-value is an informed estimate of the maximum amount of soil that can be lost annually from cultivated land by wind and water erosion without degrading the long-term productivity of the soil. Erosion-control management plans prepared by farmers with assistance from the NRCS generally incorporate T-values as the planning level for erosion rates. In the Teton Subbasin, T-values range from 2 tons/acre for shallow soils to 5 tons/acre for deep soils. This latter value is equivalent to the amount of soil covering a one-acre cultivated field to a depth of 1/32 inch.

BIOLOGICAL CHARACTERISTICS OF THE TETON SUBBASIN

Vegetation

The Teton Subbasin is located within the Snake River Basin/High Desert ecoregion and Middle Rockies ecoregion of the Pacific Northwest (Omernik and Gallant 1986). The boundary between these ecoregions corresponds approximately to the boundaries between privately owned agricultural lands and lands managed by the U.S. Forest Service. The natural plant communities of the Snake River Plain/High Desert ecoregion are sagebrush steppe (i.e., sagebrush and wheatgrass) and saltbush/greasewood. In the Teton Subbasin, native plants on uplands that have largely been converted to crop production include bluebunch wheatgrass, Sandberg bluegrass, Idaho fescue, and sagebrush (USDA 1969 and 1981).

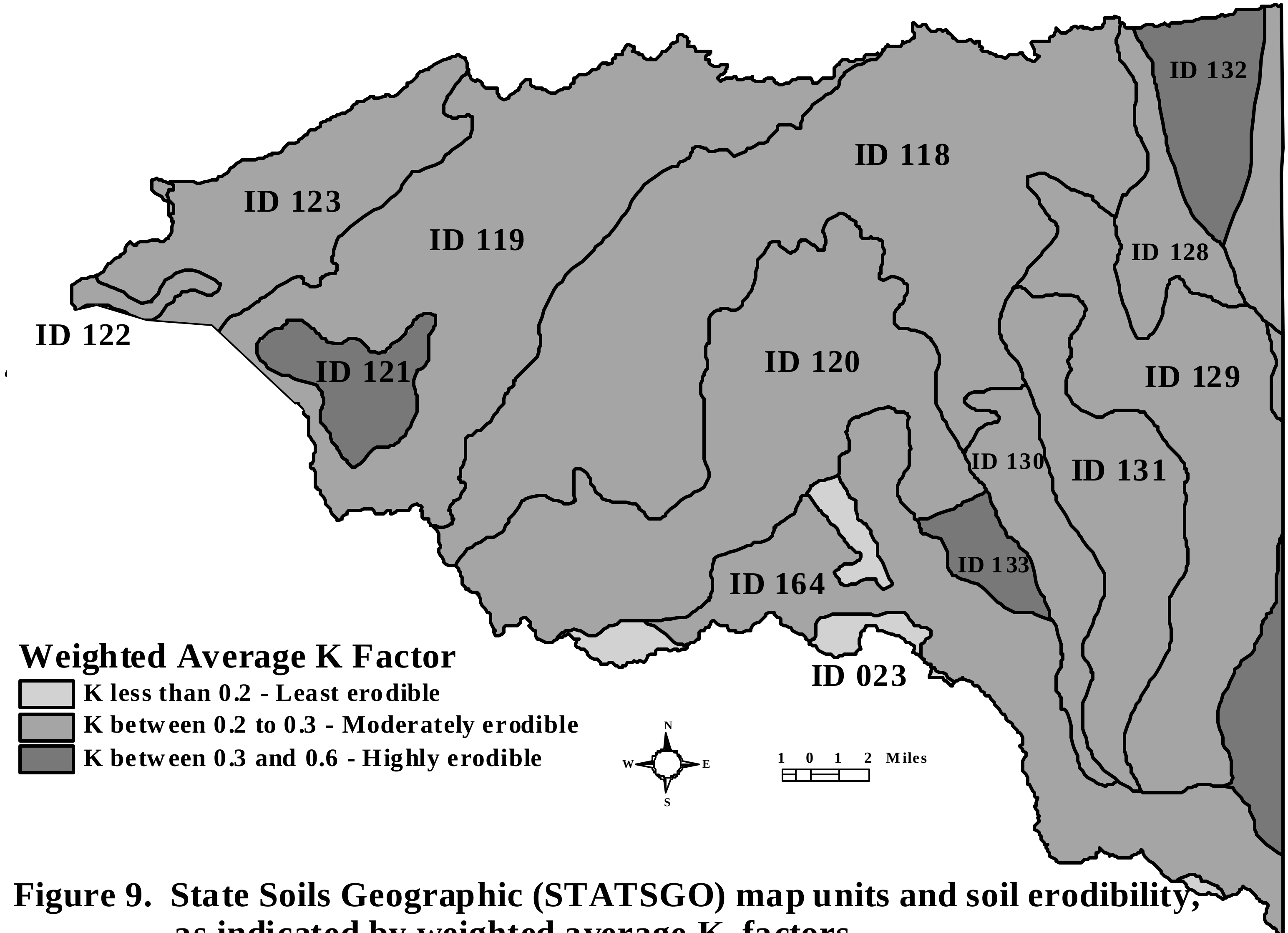

Figure 9. State Soils Geographic (STATSGO) map units and soil erodibility, as indicated by weighted average K factors.

The potential natural vegetation of the Middle Rockies ecoregion is Douglas fir,western spruce-fir, and alpine meadow plant communities. On portions of the Caribou-Targhee National Forest that occur within the Teton Subbasin in Idaho, lodgepole pine and Douglas fir communities dominate the forested landscape. In the Teton subsection of the forest, Douglas fir is increasing through succession, and conifers are invading riparian areas and mountain meadows due to fire suppression (USDA 1997b). Detailed information regarding plant communities on the forest is contained in the *Targhee National Forest Ecological Unit Inventory* (Bowerman *et al.* 1999).

A defining feature of the Teton Subbasin is the extensive wetland complex associated with the upper Teton River. In 1993, the U.S. Fish and Wildlife Service published an atlas of National Wetlands Inventory maps for Teton County using aerial photographs taken in 1980 (Peters *et al.* 1993). Nine percent of Teton County was identified as wetlands, and almost all of the wetlands (26,757 acres) were located in the Teton Valley in an area bounded by the Teton River on the west, Highway 33 on the east and north, and Highway 31 on the south. East and north of Highway 33, wetlands were mapped in the Trail Creek, Teton Creek, South Leigh Creek, Spring Creek, and Badger Creek subwatersheds.

On the Caribou-Targhee National Forest, aquatic influence zones associated with waterbodies and wetlands are managed to provide a high level of aquatic protection and maintain ecological functions. Mass wasting has been identified as the principal ecological concern affecting riparian quality in both the Teton and Big Hole Mountains subsections of the forest. Principal management concerns affecting riparian quality include high levels of dispersed recreation, horse, and off-highway vehicle use; trails and roads in close proximity to or within riparian areas and associated stream crossings; and areas of overuse by domestic and wild ungulates (USDA 1997a). Wildlife management indicator species associated with riparian and aquatic habitats in the Teton Subbasin include the spotted frog and harlequin duck; the indicator species for fisheries is the Yellowstone cutthroat trout (USDA 1997b). One of the objectives specified in the *1997 Revised Forest Plan for the Targhee National Forest* (USDA 1997a) for fisheries, water and riparian resources in the Teton Subbasin is to improve stream channel stability ratings to good or excellent by 2007 on the following streams where natural conditions allow improvement: Teton Creek, North Leigh Creek, Fox Creek, Kiln Creek, Packsaddle Creek, Horseshoe Creek, Superior Creek, North Fork Mahogany Creek, Mahogany Creek, Henderson Creek, Patterson Creek, and Murphy Creek.

Fisheries

Salmonid species indigenous to the Teton Subbasin include cutthroat trout (*Oncorhynchus clarki*) and mountain whitefish (*Prosopium williamsoni)*. Salmonids introduced to the Snake River drainage and commonly found in the Teton Subbasin include rainbow trout (*Oncorhynchus mykiss sp.*) and brook trout (*Salvelinus fontinalus*), although the Forest Service reports that brown trout (*Salmo trutta*) and lake trout (*Salvelinus namaycush*) also occur in the subbasin (USDA 1997a). Non-salmonid species known to occur in the subbasin include sculpin (*Cottus sp.*), longnose dace (*Rhinichthys cataractae*), speckled dace (*Rhinichthys osculus*), Utah sucker (*Catostomus ardens*), Utah chub (*Gila atraria*), and redside shiner (*Richardsonius balteatus)* (USDA 1997a, DEQ data).

The Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*) is the only trout subspecies indigenous to the Teton Subbasin. Historically, the Yellowstone cutthroat trout occurred throughout the Snake River drainage upstream of Shoshone Falls (Behnke 1992, as cited in Gresswell 1995) but currently occupies only 45 percent of its historic range in Idaho (USDA 1997b). It is recognized as a species of special concern by the Idaho Department of Fish and Game (IDFG), which means the species is either low in numbers, limited in distribution, or has suffered significant population reductions due to habitat losses (IDFG 1996). The U.S. Fish and Wildlife Service (USFWS) was petitioned to list the Yellowstone cutthroat trout as threatened under the Endangered Species Act, but in February 2001, USFWS concluded that the petition did not provide substantial biological information to indicate that listing was warranted.

The decline of Yellowstone cutthroat trout throughout its range has been attributed primarily to hybridization resulting from introductions of rainbow trout and nonnative stocks of Yellowstone and other subspecies of cutthroat trout (Gresswell 1995). In the Teton Subbasin, reproductive isolation between cutthroat and rainbow trout has apparently prevented hybridization in most areas (Schrader 2000a). Yellowstone cutthroat trout spawn in tributaries of the Teton River, whereas rainbow trout spawn in the mainstem of the river (Schrader 2000a). Research in another eastern Idaho subbasin indicated that Yellowstone cutthroat trout spawn in headwater reaches of tributary streams in May and June, whereas rainbow trout spawn in lower reaches from winter through spring (Thurow 1982, as cited in Gresswell 1995).

Preservation of the genetic integrity and population viability of wild native cutthroat trout was the first objective of the IDFG 1996-2000 fisheries management plan for the Teton River drainage (IDFG 1996). This effort began in 1988 when the IDFG initiated the Teton River Fishery Enhancement Program to improve angling opportunities by restoring fish habitat lost following collapse of the Teton dam and due to cumulative changes in land use practices. According to the *1996-2000 Fisheries Management Plan* (IDFG 1996), the river supported a self-sustaining cutthroat trout fishery prior to collapse of the dam. More than half of the population was concentrated below the dam site, approximately 30 percent was concentrated within the canyon, and approximately 20 percent was concentrated in the upper valley. The overall catch rate for cutthroat trout in 1974 and 1975 was 1.34 and 1.31 fish/hour, but in 1980 the catch rate had fallen to 0.74 fish/hour. Projects to improve riparian habitat and reduce sediment delivery to the river and tributaries were initiated, fish passage at culverts and canal diversions was improved, stocking of rainbow trout outside enclosed impoundments was discontinued, and harvest of rainbow and brook trout was encouraged (IDFG 1996). A comprehensive report of enhancement program activities conducted from 1987 through 1999 is currently being written, and will include information regarding population surveys, fish movement, age and growth, whirling disease, black spot disease, fish stocking, creel surveys, habitat surveys, and habitat projects (Schrader 2000a).

A four-year study that focused on the Teton Canyon fishery was co-funded by the BOR and IDFG and concluded in 2000. An important feature of this study was the use of radiotelemetry to obtain information regarding fish life history, movement, and habitat use patterns. The preliminary results of the study are available as a progress report (Schrader 2000b), and some results are presented in subsequent sections of this report. Complementary studies of the geologic, geomorphic, and hydraulic conditions (Randle *et al.* 2000) and summer river water temperatures (Bowser 1999) of the Teton Canyon upstream from the Teton Dam site were also conducted by the BOR from 1997 to 1999. These studies are also discussed in greater detail elsewhere in this report.

In addition to long-term studies conducted by the IDFG, the Forest Service has conducted extensive surveys to document populations of Yellowstone cutthroat trout on the Caribou-Targhee National Forest. In 1998, the Forest Service conducted cutthroat trout population surveys in several streams in the Teton Subbasin. The Forest Service has also prepared a draft habitat conservation assessment for Yellowstone cutthroat trout, which is intended to define the habitat conditions necessary for long-term persistence of the species (USDA 1997b).

Recognizing the importance of Yellowstone cutthroat trout throughout the Henry's Fork basin, the Henry's Fork Watershed Council established a native trout subcommittee to enhance coordination and cooperation among all entities concerned with the status of cutthroat trout. The subcommittee is composed of representatives of state and federal resource agencies, private groups, water users, and independent scientists. The basic charter of the subcommittee is to 1) identify and assess populations of native trout in the Henry's Fork basin, 2) plan for native trout protection and restoration if needed, and 3) monitor recovery and overall health of identified cutthroat trout populations.

The potential success of efforts currently being expended by management agencies to bolster native cutthroat trout populations in the Teton Subbasin has been reinforced by the first quantitative analysis of the status of fisheries and aquatic habitats in the entire Greater Yellowstone Ecosystem. Van Kirk (1999) compiled and assessed information available for each of the eight-digit hydrologic units within the Greater Yellowstone Ecosystem, then quantified the current status of the native and nonnative populations of salmonids within each subbasin and the aquatic habitat and watershed integrity of the subbasin. The author concluded that although the abundance of native trout in the Teton Subbasin has been reduced due to habitat degradation, the distribution of native trout makes the Teton Subbasin one of seven subbasins in the Greater Yellowstone Ecosystem where significant opportunities for restoration of Yellowstone cutthroat trout still exist.

The distribution of Yellowstone cutthroat trout in the Teton Subbasin is indicated by the results of electrofishing conducted by DEQ from 1995 through 1999 as part of its Beneficial Use Reconnaissance Program (BURP) sampling. These results are summarized in Table 9; complete data are available from DEQ. All of the sampling sites were located on wadeable tributaries of the Teton River, with most streams located in the upper subbasin. Almost all salmonids collected during these surveys were cutthroat trout or brook trout even though rainbow trout, cutthroat trout x rainbow trout hybrids, and mountain whitefish are relatively abundant in the mainstem Teton River (Schrader 2000b). At the time of sampling, all fish were identified to genus and species, and their total lengths were measured and recorded to permit determination of age classes. According to BURP protocol (DEQ 1996b), specimens of fish were routinely submitted to a taxonomist for verification of field identifications. Cutthroat trout were identified only as *Oncorhynchus clarki*, though it is assumed that they belong to the subspecies, *Oncorhynchus clarki bouvieri*, or Yellowstone cutthroat trout. For development of the 1998 §303(d) list, the beneficial use of salmonid spawning was assessed as full support if three age classes of one salmonid species, including juveniles (i.e., fish less than 100 mm in length), were present, or if at least two age classes of one salmonid species were present and the associated habitat index score was 73 (DEQ 1998b).

Table 9. The results of electrofishing surveys conducted from 1995 to 1999 in the Teton Subbasin by the Idaho Department of Environmental Quality. The number of age classes and presence of juvenile fish are reported for cutthroat trout and brook trout. More than three age classes is indicated by a + sign, absence of a fish species is indicated by a – sign, and the presence of juvenile fish (i.e., fish less than 100 mm in length) is indicated by the notation, /J.

	No. of Age Classes		
Stream	Cutthroat Trout	Brook Trout	Other Salmonid and Non-salmonid Species Collected; Miscellaneous Comments
Badger Creek	1	-	
Bitch Creek	2/J	-	Sculpin
Calamity Creek	2	-	
Canyon Creek	2/J	2+	Sculpin, longnose dace, speckled dace
Carlton Creek	1	-	Rainbow trout; 2 age classes
Darby Creek	3+/J	-	Collected near Caribou-Targhee National Forest
Darby Creek	-	2	Sculpin; collected near confluence with Teton River
Drake Creek	-	3/J	
Dry Creek	-	-	
Fish Creek	1	4/J	Mottled sculpin, Paiute sculpin
Fox Creek	-	3/J	Collected near Caribou-Targhee National Forest
Fox Creek	-	-	Sampled below Highway 33
Game Creek	-	2+	
Henderson Creek	-	-	
Hinckley Creek	-	-	
Horseshoe Creek	4/J	4/J	Sculpin; collected on Caribou-Targhee National Forest in 1996
Horseshoe Creek	3/J	2	Sculpin; collected on Caribou-Targhee National Forest in 1998

Stream	No. of Age Classes Cutthroat Trout	 Brook Trout	Other Salmonid and Non-salmonid Species Collected; Miscellaneous Comments
Horseshoe Creek	-	2	Collected below Caribou-Targhee National Forest boundary
Horseshoe Creek, North Fork	2/J	-	
Little Pine Creek	-	3+/J	
Mahogany Creek	2+/J	2+/J	
Marlow Creek	-	-	
Middle Twin Creek	-	-	
Mike Harris Creek	-	3/J	
Milk Creek	-	-	
Moody Creek	3/J	1	Sculpin, speckled dace, longnose dace, redside shiner
Moose Creek	-	-	
Murphy Creek	2	4/J	Sculpin
North Leigh Creek	-	4/J	Sculpin
North Moody Creek	-	2+/J	
North Twin Creek	3/J	2/J	
Packsaddle Creek	-	3/J	Collected on Caribou-Targhee National Forest
Packsaddle Creek, North Fork	-	3+/J	
Ruby Creek	-	2+/J	
Sheep Creek	-	2+/J	
South Leigh Creek	5+/J	-	Sculpin; collected near Idaho-Wyoming boundary
South Leigh Creek	-	-	Sampled below Highway 33
South Moody Creek	2+/J	2+/J	Unidentified juvenile salmonid
South Twin Creek	-	-	
Spring Creek	-	3/J	Longnose dace; collected near headwaters
Spring Creek	-	-	Sampled below Highway 33
Trail Creek	-	-	
Teton Creek	2/J	-	Sculpin; collected below Highway 33
Warm Creek	-	1/J	Paiute sculpin, speckled dace, sucker
Woods Creek	-	1/J	Mottled sculpin, Paiute sculpin, redside shiner
Wright Creek	-	-	

CULTURAL CHARACTERISTICS OF THE TETON SUBBASIN

Land Ownership and Land Use

Approximately 75% of the land in the Teton Subbasin west of the Idaho-Wyoming border is privately owned (Figure 10). Private lands comprise 66.5% of Teton County, Idaho; 72.5% of Madison County; and less than 25% of the portion of Teton County, Wyoming, located within Teton Subbasin. The state of Idaho manages 8% of the land in the Teton Subbasin, the majority of which (7.4%) is located in Madison County; federally managed lands comprise 33% of Teton County and 20% of Madison County (IAC 1996). The vast majority of federally owned land in the subbasin is managed by the Caribou-Targhee National Forest The Targhee National Forest was consolidated with the Caribou National Forest during the time this document was being written. The Targhee National Forest is now officially the Caribou-Targhee National Forest. The BOR manages the Teton Canyon from approximately Badger Creek to the Teton Dam site; the BLM manages several parcels of land, the largest of which are located in the North Leigh and Trail Creek watersheds.

The principal land use within the subbasin is cultivated agriculture (Figure 11). The National Agricultural Statistics Service reports that in 1997, 470 farms operated in Madison County and 270 farms operated in Teton County, Idaho, for a total farm acreage of 355,495 (NASS 2000). Additional statistics indicate a decline in both total farm acreage and operators in the five-year period from 1992 to 1997 (Table 10). Only 236 of the 470 farms in Madison County operated as full-time farms in 1997, representing an 18% decline from 1992. Similarly, only 156 of the 270 farms in Teton County operated as full-time farms in 1997, representing a 4% decline from 1992. Beef and dairy cattle numbers remained relatively stable from 1992 to 1997, but swine and sheep production declined dramatically. In Madison County, the number of farms reporting milk cows declined from 36 in 1992 to 21 in 1997, while in Teton County, the number of farms reporting milk cows declined from 27 to 26 (NASS 2000). While total farm acreage declined, harvested acreage and irrigated acreage increased slightly. In Madison County, the numbers of acres planted in barley, wheat and potatoes were about equal. In Teton County, the numbers of acres planted in barley were about twice the number planted in hay, which in turn were about twice the number planted in either wheat or potatoes. Land use in the small portion of Fremont County contained within the Teton Subbasin is comparable to land use in Teton County.

Land use on the forest is guided by forest wide standards and guidelines, subsection direction, and management prescriptions specified in the 1997 Caribou-Targhee National Plan (USDA 1997a). Portions of three subunits of the Caribou-Targhee National Forest are included within the Teton Subbasin: the Island Park Subsection (M331Aa), which overlaps the Bitch Creek subwatershed; the Teton Range Subsection (M331Db), which overlaps the eastern portion of the subbasin in Wyoming; and the Big Hole Mountains Subsection (M331Dk), which overlaps the Trail Creek subwatershed west to, and including, the Moody Creek subwatershed (USDA 1997a).

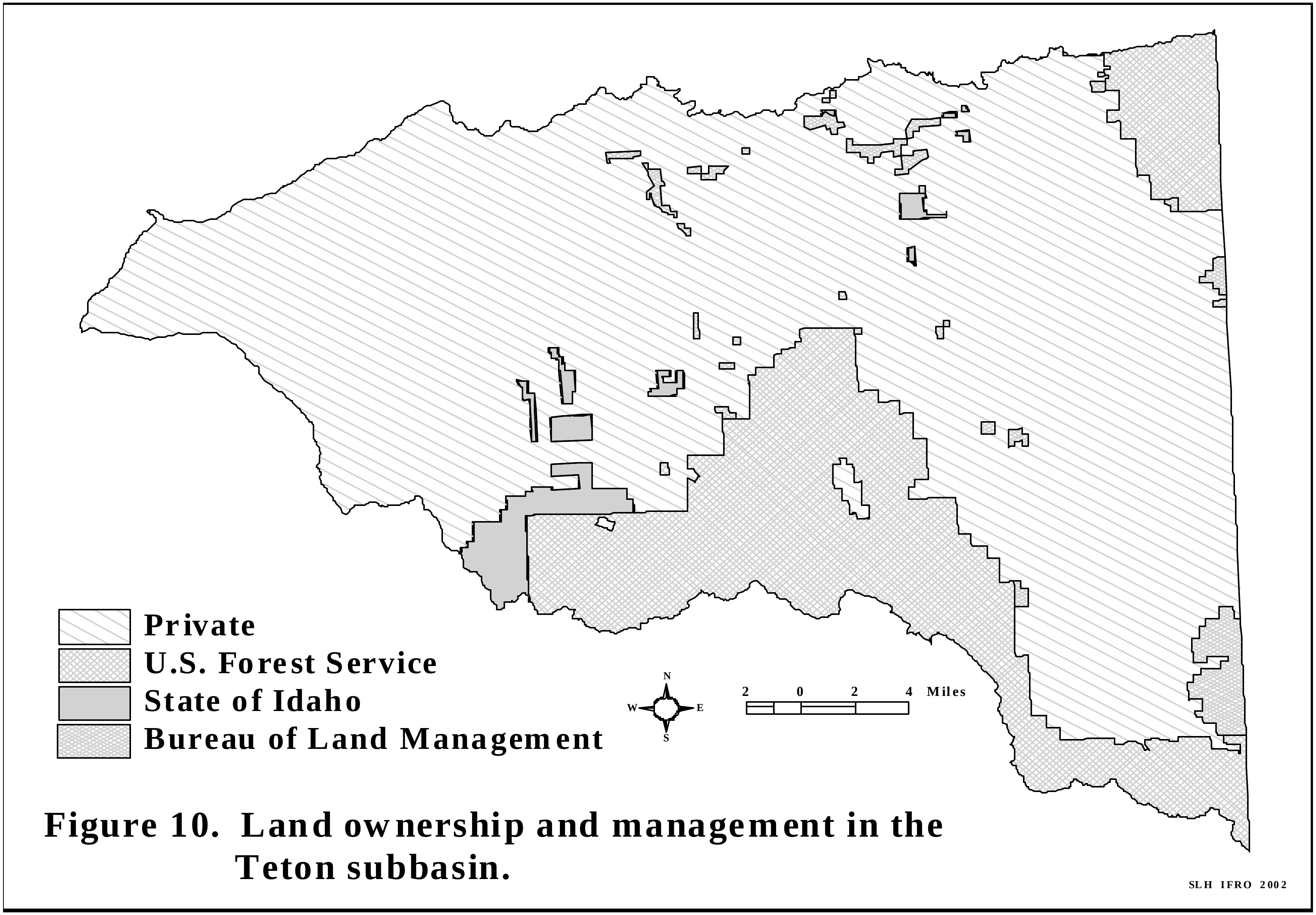

Figure 10. Land ownership and management in the Teton subbasin.

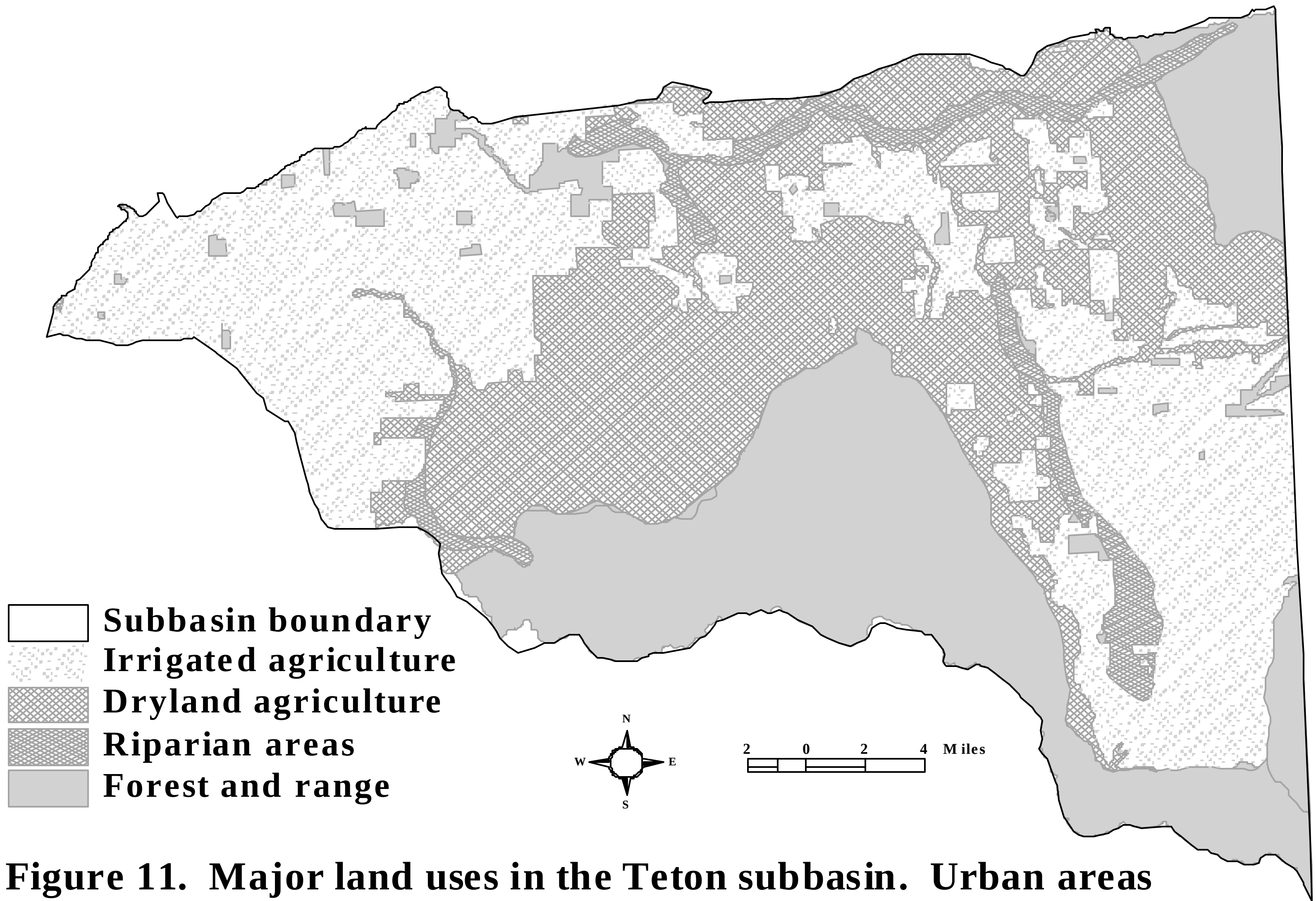

Figure 11. Major land uses in the Teton subbasin. Urban areas and rural housing developments are not shown.

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Table 10. Agricultural statistics for Madison and Teton Counties, Idaho, for 1992 and 1997[1].

Parameter	Madison County		Teton County	
	1992	1997	1992	1997
Farms	505	470	257	270
Average farm size (acres)	444	474	524	491
Operators reporting farming as principal occupation (%)	57.0	50.2	63.0	57.8
Total farm acreage (acres)	224,369	222,817	134,788	132,678
Total cropland (acres)	177,049	174,147	108,283	101,862
Total harvested cropland (acres)	144,280	147,243	71,504	76,919
Irrigated land (acres)	127,851	128,649	51,358	57,273
Market value of crops ($1,000)	64,249	73,134	20,193	22,864
Market value of livestock and poultry, and products ($1,000)	8,950	7,340	6,495	5,921
Beef cows	7,824	7,104	6,598	7,477
Milk cows	1,715	1,521	1,323	1,172
Hogs and pigs inventory	1,936	123	34	60
Sheep and lambs inventory	3,254	461	D	182
Layers and pullets, broilers	D	D	D	323
Wheat for grain (acres)	37,443	45,270	9,268	4,529
Barley for grain (acres)	52,421	47,500	36,648	43,906
Potatoes (acres)	39,402	40,045	5,673	7,166
Hay – Alfalfa, other (acres)	16,179	15,890	20,014	21,914

[1]Source: NASS 2000.

[2]D: Withheld to avoid disclosing data for individual farms.

In addition to the watershed cataloging systems previously described in this assessment, the forest has designated principal watersheds that generally do not correspond to the subwatersheds shown in Figure 5 because they end at the forest boundary. The management prescriptions for each subsection and corresponding principal watersheds are listed in Table 11.

Land use on the Caribou-Targhee National Forest in the eastern portion of the subbasin, most of which is located in Wyoming, is determined primarily by its status as wilderness and grizzly bear habitat (USDA 1997a). Much of the forest is within the Jedediah Smith

Table 11. Management prescriptions for, and principal watersheds within, subsections of the Caribou-Targhee National Forest located within the Teton Subbasin, as specified by the 1997 Forest Plan (USDA 1997a).

Subsection	Major Prescription Areas	Principal Watershed Number and Name
Island Park	5.3.5 Grizzly Bear Habitat 5.4 Elk Summer Range	0211 Badger Creek (Idaho)
Teton Range	1.1.6 Wilderness, Opportunity Class I 2.6.5 Grizzly Bear Bechler Bear Management Unit 2.7 Elk and Deer Winter Range 3.2(b) Semi-Primitive Motorized 5.3.5 Grizzly Bear Habitat Out Core 5.4(c) Elk Deer Summer Range	021W Badger Creek (Wyoming) 020 Leigh Creeks 019 Teton Creek 018 Darby-Fox Creeks 017W Trail Creek (Wyoming)
Big Hole Mountains	2.1.2 Visual Quality Maintenance 2.7(a) Elk Deer Winter Range 5.1.3(b) Timber Management No Clearcut 5.1.4(b) Timber Management Big Game	0171 Trail Creek (Idaho) 022 Mahogany Creek 023/024 Canyon and Moody Creeks

Wilderness Area, which has experienced limited timber harvest but receives relatively heavy recreational use with about 60,000 visits per year. Grand Targhee Ski and Summer Resort is adjacent to the wilderness area, and is a major destination of tourists. Because much of the area is managed for grizzly bear habitat, domestic sheep grazing is being phased out. A fire management plan is to be completed by 2007 to improve bighorn sheep habitat. Objectives for fisheries, water, and riparian resources include improvement of "stream stability ratings to good or excellent by 2007 where natural conditions allow on Teton Creek, North Leigh Creek, South Leigh Creek, Moose Creek, Trail Creek, Fox Creek, and Kiln Creek where instability is management-caused" (USDA 1997a).

Management on the forest in the Big Hole Mountains is directed toward opportunities for motorized and nonmotorized recreation, reducing risks from insect and disease attack with timber management while improving big game habitat, and use of prescribed fire to improve ecosystem health. Grazing occurs on this subsection of the forest, but data on livestock numbers grazed and grazing rotations has not been obtained. Objectives for fisheries, water, and riparian resources include improvement of "stream stability ratings to good or excellent by 2007 where natural conditions allow on ...Packsaddle, Horseshoe, North Fork Mahogany, Main Mahogany, Henderson, Patterson, and Murphy Creeks" (USDA 1997a).

Population and Land Use

Based on United States census data, the population of the Teton Subbasin in 1990 totaled 27,113. Rexburg, the Madison County seat, is the largest urban area in the subbasin, followed by Driggs, the seat of Teton County. In 1990, more than 87% of the population of the subbasin resided in Madison County, and recent information indicates that the population of Madison County has remained relatively stable (Johnson undated). But in 2001, Rick's College in Rexburg, formerly a two-year college, was converted to Brigham Young University-Idaho. The population of the Rexburg area will increase as the university adds faculty and staff to accommodate an initial expansion of the student population from 8,600 students to 11,600 students (BYU 2001).

Although the population of Teton County made up a small proportion of the entire population of the subbasin in 1990, its population increased dramatically in the past decade, particularly in the Teton Valley corridor extending from south of Victor to north and east of Driggs. An assessment of trends in rural residential development in counties located within the boundaries of the greater Yellowstone ecosystem was recently completed by the Sierra Club Grizzly Bear Ecosystems Project (Johnson undated). Data indicative of development (i.e., septic permits, well logs, and building permits) were analyzed for Teton and Fremont Counties for the years 1975 through 1998, but according to Johnson (undated), data for Madison County were unavailable without direct inspection of county files and plat books. The area of Fremont County currently undergoing significant development is not located in the Teton Subbasin, so information for Teton County will be emphasized here.

The average population of all counties within the greater Yellowstone ecosystem increased 15% from 1990 to 1998, but the population of Teton County, Idaho, increased 59.6%. The population of Teton County, Wyoming, which is also within the Teton Subbasin, was second in growth among greater Yellowstone ecosystem counties with an increase of 26.8%. By comparison, the percentage change in population growth for the entire United States was 8.7%. On an annual basis, the growth rate of Teton County, Idaho, from 1990 to 1996 was 8.4%, compared to a national average of 0.9%.

The impact of population growth is evident in changing land use. According to Johnson (undated), approximately 4,000 acres in Teton County were subdivided during the 15-year period from 1975 through 1990. An additional 4,000 acres were subdivided during the six-year period from 1991 through 1997, for an average of almost 700 acres per year. The number of subdivisions created each year increased from one in 1975 to a high of 24 in 1995, for an approximate total of 150 by 1997.

Johnson (undated) found that in Idaho, water well permits did not reliably indicate rural residential trends, so septic permits were used as indicators instead. The number of individual septic permits issued annually in Teton County increased from slightly less than 50 in 1983 to a peak of approximately 180 in 1995. A total of approximately 1,300 individual septic permits were issued in the county from 1983 to 1998. However, individual septic permits do not reflect total new construction because subdivisions have three options for treating domestic wastewater: 1) connection to a municipal system, 2) construction of a community septic system, or 3) individual septic systems. Most homes in subdivisions in the Teton Valley will utilize individual septic systems, though a recently proposed development near Victor, which includes 540 housing units, intends to discharge wastewater to the regional municipal treatment system (Kirkpatrick 2000).

The municipal wastewater treatment system at Driggs was recently upgraded after 32 years of operation to allow for regionalization of wastewater treatment, and a collection system extending from Driggs to Victor was completed in 1999. This project was strongly supported by DEQ and District 7 Health Department because of concerns that sewage effluent was being allowed to seep into ground water, that septic systems in Victor were failing or had failed, and that effluent was being discharged directly to ground water (Forsgren 1998). All 350 septic systems in Victor are scheduled for conversion to the municipal system, but it is unknown how many of the systems between Victor and Driggs will be converted (Kirkpatrick 2000). The total number of individual septic systems currently in use in the Teton Valley is unknown, but according to the USDA (1969), the engineering properties of soils in the Teton Valley "pose severe limitations for septic tank systems."

An alternative to subdivision that has conserved substantial undeveloped acreage in the Teton Valley is acquisition of the landowner's development rights through a conservation easement. The landowner retains title to the property, but the easement restricts in perpetuity the type and amount of development that can occur on the property. Since 1995, the Teton Regional Land Trust, a nonprofit organization serving the Upper Snake River Valley, has obtained conservation easements on 2,725 acres in Teton County and 80 acres in Madison County, and has obtained a fee title on an additional 40 acres in Teton County (Whitfield 2000).

Planning

Goals for future growth and development in the Teton Subbasin are described in the *Madison Comprehensive Plan, December 16, 1996* and the *Teton County, Idaho, Comprehensive Plan, Amended March 11, 1996.* Ordinances that currently apply to land use include zoning and subdivsion ordinances for Teton County and the cities of Rexburg, Driggs, and Victor. Guidance for development in the small portion of Fremont County that occurs within the subbasin is subject to the *Fremont County Comprehensive Plan, 1997 Edition* and *Fremont County Development Code, 1997 Edition.*

The goals and objectives of the comprehensive plans for Madison and Teton counties are indicative of the distinctively unique economies of the lower and upper portions of the Teton Subbasin. The comprehensive plan for Madison County emphasizes the importance of agriculture to the local economy, and gives high priority to preservation of agricultural land, water supply, and the infrastructure that supports irrigated agriculture. A policy to protect and preserve the agricultural base of Teton County is specified in the Teton County comprehensive plan, but the plan also emphasizes policies to preserve and protect natural resource, recreational, and scenic values. Development guidelines are specified for wetland areas and for "critical areas of concern" such as the Teton River and many of its tributaries, hazardous areas (e.g., floodplains), and the Teton County Scenic Corridor System. There appears to be greater emphasis on the protection of surface and ground water quality in the Teton County comprehensive plan as compared to the Madison County plan, but that may be in part because of differences in floodplain mapping. A Flood Insurance Rate Map was published for Madison County by the Federal Emergency Management Agency in 1978. The Madison comprehensive plan recommends that construction and storage of hazardous chemicals within the floodplain be prohibited. Flood-prone areas in Teton County have not been mapped, though the plan recommends adoption of floodplain zoning regulations.

As noted in the previous section, almost one-quarter of the land area of the subbasin is managed by the Caribou-Targhee National Forest. Thus, forest planning is an integral component of subbasin planning. In 1997, the Forest Service issued its revised forest plan (USDA 1997a) and environmental impact statement (USDA 1997b) for management of the Caribou-Targhee National Forest through the year 2007. The plan addresses ecological components, physical elements, biological elements, forest use and occupation, and production of commodity resources. Because of the influence of the forest on the economics of Teton County, the Teton County comprehensive plan recommends "maximum cooperation and equal treatment of issues that are of mutual concern in future planning."

In 1992, the Idaho Water Resource Board (IWRB) issued the Henry's Fork Basin component of the Comprehensive State Water Plan "...in keeping with [the Board's] constitutional and legislative charge to formulate and implement a state water plan" (IWRB 1992). The plan designated approximately 48 miles of streams in the Teton Subbasin for state "recreational" or "natural" protection. All of the designated stream reaches are within the upper subbasin, and include the Teton River from Trail Creek to Felt Dam; portions of Teton, Fox, and Badger Creeks; and all of Bitch Creek downstream of the Idaho border (Figure 12).

A state recreational or natural waterway is defined by Idaho Code § 42-1731 as one that possesses outstanding fish and wildlife, recreation, geologic, or aesthetic values. A recreational waterway may include man-made development in the waterway or riparian area; a natural waterway is free of substantial man-made development in the waterway and in the riparian area. Idaho Code § 42-1734A(6) prohibits the following activities within the stream channel or below the high water mark on natural waterways: constructing or expanding dams or impoundments; constructing hydropower projects; constructing water diversion works; dredging or placer mining; altering the stream bed; and extracting mineral or sand and gravel from the stream bed (IWRB 1992).

The IWRB also maintains minimum streamflows on two stream segments within the Teton Subbasin. A minimum streamflow is the amount of water flow necessary to protect fish and wildlife habitat, aquatic life, navigation, transportation, recreation, water quality, or aesthetic beauty. Under Chapter 15, Title 42 of Idaho Code, in-stream uses can be protected under water rights held by the IWRB in trust for the people of the state of Idaho (IWRB 2001). Minimum streamflow water rights are appropriated only to the board, but any person, association, or government agency may request that the board file an application with the IDWR for such rights. At the request of IDFG, the IWRB obtained minimum streamflows on the following stream segments in the Teton Subbasin:

1. Nine miles of the Teton River beginning at the confluence of Bitch Creek and the Teton River, continuing upstream to the intersection of the Teton River with the Highway 33 bridge (SESW, Section 23, T6N, R44E); permit number 22-7369; priority date June 19, 1981; for 106 cfs year-round for fish.

2. Six miles of Bitch Creek beginning at the confluence of Bitch Creek and the Teton River, continuing upstream to the intersection of Bitch Creek and Highway 32 (NENW, Section 20, T7N, R44E); permit number 22-7370; priority date June 19, 1981; for 28 cfs.

It is important to note that a minimum streamflow water right does not guarantee that a stream will contain water. Minimum streamflows may not interfere with senior water rights, and in a drought year or when flows are low, all flow may legally be diverted for senior rights, leaving no water for minimum streamflow (IWRB 2001).

WATER QUALITY CONCERNS IN THE TETON SUBBASIN

Water Quality Standards

Water quality standards are legally enforceable rules consisting of three parts: designated uses of waters, numeric or narrative criteria to protect those uses, and an antidegradation policy. Each state has authority to develop water quality standards with guidance and oversight from EPA. Any state that fails to issue standards adequate to achieve the goals and purposes of the CWA is subject to federal water quality standards promulgated by EPA (Adler 1995). Idaho's water quality standards are published as section 58.01.02 of Idaho's administrative rules (*IDAPA 58.01.02 - Water Quality Standards and Wastewater Treatment Requirements*).

Designated Uses The beneficial uses for which the surface waters of Idaho are to be protected are defined in the following excerpt from IDAPA 58.01.02.100:

01. Aquatic Life.

a. Cold water: water quality appropriate for the protection and maintenance of a viable aquatic life community for cold water species.

b. Salmonid spawning: waters which provide or could provide a habitat for active self-propagating populations of salmonid fishes.

c. Seasonal cold water: 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.

d. Warm water: water quality appropriate for the protection and maintenance of a viable aquatic life community for warm water species.

e. Modified: water quality appropriate for an aquatic life community that is limited due to one or more conditions set forth in 40 CFR 131.10(g) which preclude attainment of reference streams or conditions.

02. Recreation.

a. Primary contact recreation: 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.

b. Secondary contact recreation: 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.

Natural and Recreational Waterways

1. *Teton River: Trail Creek to Highway 33 (14 miles)*
2. *Fox Creek: Springs to mouth (2.5 miles)*
3. *Teton Creek: Springs near Highway 33 to mouth (3 miles)*
4. *Teton River: Highway 33 to Felt Dam (11 miles)*
5. *Badger Creek: Springs to mouth (3 miles)*
6. *Bitch Creek: Idaho border to railroad trestle (5 miles)*
7. *Bitch Creek: Railroad trestle to Highway 32 (2 miles)*
8. *Bitch Creek: Highway 32 to mouth (7.5 miles)*

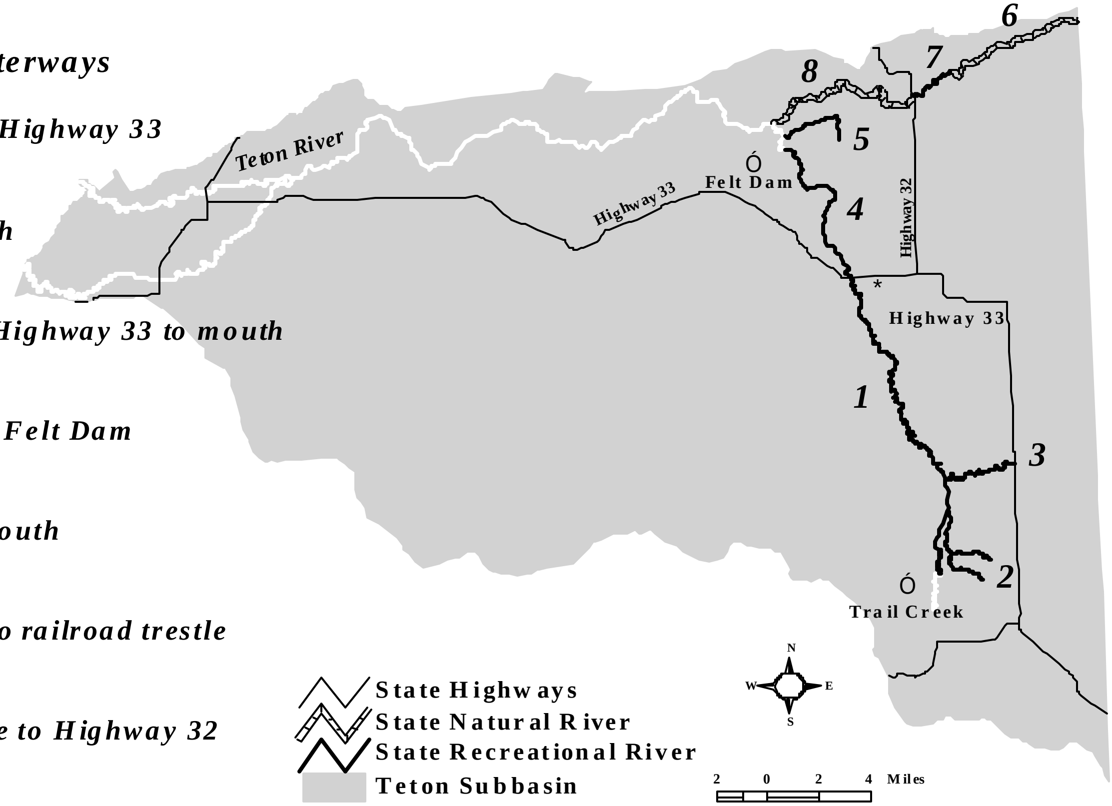

Figure 12. Stream segments designated as State Natural and State Recreational waters by the Idaho Water Resource Board (IWRB 1992).

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03. Water Supply.

a. Domestic: water quality appropriate for drinking water supplies.

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.

c. Industrial: water quality appropriate for industrial water supplies. This use applies to all surface waters of the state.

04. Wildlife Habitat. Water quality appropriate for wildlife habitats. This use applies to all surface waters of the state.

05. Aesthetics. This use applies to all surface waters of the state.

The phrase, "this use applies to all surface waters of the state," indicates that the beneficial use is *designated* for all surface waters and, conversely, that all surface waters are *designated* for protection of that particular beneficial use. For example, the water quality standards specify that the beneficial uses of agricultural water supply, industrial water supply, wildlife habitat, and aesthetics apply to all surface waters of the state, so all surface waters of the state are designated for those uses.

According to Section 39-3604 of Idaho Code, the beneficial uses of the surface waters of the state must be designated and specifically listed in the rules of the Department of Environmental Quality. Designations of the beneficial uses of most of the state's major rivers, lakes, and reservoirs were incorporated into Idaho's water quality standards in 1998. Section 58.01.02.150 lists the designations of the major surface waters in the Upper Snake hydrologic basin, and includes designations for the entire Teton River, including the North and South Forks. The North and South Forks of the Teton River are designated for cold water aquatic life, salmonid spawning, and secondary contact recreation. The mainstem of the river is designated for cold water aquatic life, salmonid spawning, primary contact recreation, drinking water supply, and Special Resource Water (Table 12). Although the mainstem is designated a drinking water supply, there are no community drinking water systems currently using the Teton River as a source, and although some households may use Teton River water for domestic purposes such as drinking, cooking, and bathing, such users have not been documented. A Special Resource Water is defined in the standards as a specific segment or body of water that is recognized as needing intensive protection to 1) preserve outstanding or unique characteristics; or 2) maintain a current beneficial use (IDAPA 58.01.02.003.96). The basis for designating the Teton River a Special Resource Water is documented in the *Comprehensive State Water Plan, Henry's Fork Basin*, published in 1992 by the IWRB.

Table 12. Excerpt of *IDAPA 58.01.02 - Water Quality Standards and Wastewater Treatment Requirements*, showing surface waters in the Teton Subbasin for which beneficial uses have been designated.

Unit	Waters	Aquatic Life[1]	Recreation[2]	Other[3]
US-1	South Fork Teton River - Teton River Forks to Henry's Fork	COLD SS	SCR	
US-2	North Fork Teton River - Teton River Forks to Henry's Fork	COLD SS	SCR	
US-3	Teton River - Teton Dam to Teton River Forks	COLD SS	PCR	DWS SRW
US-4	Teton River - Canyon Creek to Teton Dam	COLD SS	PCR	DWS SRW
US-17	Teton River - Milk Creek to Canyon Creek	COLD SS	PCR	DWS SRW
US-19	Teton River - Badger Creek to Milk Creek	COLD SS	PCR	DWS SRW
US-20	Teton River - Spring Creek to Badger Creek	COLD SS	PCR	DWS SRW
US-21	Teton River - Mahogany Creek to Spring Creek	COLD SS	PCR	DWS SRW
US-25	Teton River - Patterson Creek to Mahogany Creek	COLD SS	PCR	DWS SRW
US-27	Teton River - source to Patterson Creek	COLD SS	PCR	DWS SRW

[1]Aquatic life beneficial uses include cold water (COLD) and salmonid spawning (SS).
[2]Recreation beneficial uses include secondary contact recreation (SCR) and primary contact recreation (PCR).
[3]Other beneficial uses include drinking water supply (DWS) and Special Resource Water (SRW).

The beneficial uses of the majority of surface waters in the Teton Subbasin, which are not addressed in Table 12, are addressed in subpart 101 of the water quality standards, entitled "Nondesignated Surface Waters." This section states, "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." This rule, and the aquatic life and recreation uses listed above, are intended to address the "fishable" and "swimmable" goals of the CWA. Subpart 101 also states that because most of Idaho's waters are presumed to support cold water aquatic life and primary or secondary contact recreation, criteria to protect these uses apply to all undesignated waters unless DEQ determines that other beneficial uses are more appropriate. For example, a stream fed by a warm spring may support a healthy, self-sustaining population of cold water fish despite temperatures that sometimes exceed criteria to protect cold water aquatic life. After reviewing relevant data, DEQ may determine that it is more appropriate to apply criteria that protect seasonal cold water aquatic life instead of criteria that protect cold water aquatic life.

Water Quality Criteria Water quality criteria specify the physical, chemical, and biological conditions that must be met to achieve and protect a designated use. Idaho's water quality criteria are organized into general surface water criteria, numeric criteria for toxic substances; surface water quality criteria for use designations; standards for waters discharged from dams, reservoirs, and hydroelectric facilities; and site-specific surface water quality criteria (Appendix E). *General Surface Water Criteria* (IDAPA 58.01.02.200) are narrative criteria specifying that the surface waters of the state shall be free from the following pollutants in concentrations found to impair beneficial uses: hazardous materials; toxic substances; deleterious materials; radioactive materials; floating, suspended, or submerged matter; excess nutrients; oxygen-demanding materials; and sediment. *Numeric Criteria for Toxic Substances for Waters Designated for Aquatic Life, Recreation, or Domestic Water Supply Use* (IDAPA 58.01.02.210) references the National Toxics Rule (40 CFR 131.36(b)(1)) and specifies the manner in which the rule is incorporated into Idaho's standards. *Surface Water Quality Criteria For Aquatic Life Use Designations* (IDAPA 58.01.02.250), *Surface Water Quality Criteria For Recreation Use Designations* (IDAPA 58.01.02.251), and *Surface Water Quality Criteria For Water Supply Use Designations* (IDAPA 58.01.02.252) specify numeric criteria protective of the stated use.

Aquatic life uses are protected by numeric criteria for pH, dissolved gas, total chlorine residual, dissolved oxygen, un-ionized ammonia, temperature, turbidity, and intergravel oxygen. Recreational uses are protected by limits on concentrations of the fecal bacterium, *E. coli*. Domestic water supplies are protected by limits on radioactive materials and turbidity. Water quality criteria for the beneficial uses of agricultural and industrial water supplies, wildlife habitats, and aesthetics are generally satisfied by general surface water criteria (IDAPA 58.01.02.252 and IDAPA 58.01.02.253). *Site-Specific Surface Water Quality Criteria* (IDAPA 58.01.02.275) describes the procedures for modifying criteria through site-specific analyses and confirms that site-specific criteria supersede criteria for specific use designations. And finally, *Dissolved Oxygen Standards for Waters Discharged from Dams, Reservoirs, and Hydroelectric Facilities* (IDAPA 58.01.02.276) specifies the concentrations of dissolved oxygen below existing facilities and below facilities where significant fish spawning occurs. Violations of water quality criteria constitute violations of water quality standards except under circumstances specified at 58.01.02.080 (Appendix E).

Antidegradation Policy Idaho's antidegradation policy (IDAPA 58.01.02.051) states that "existing instream water uses and the level of water quality necessary to protect existing uses shall be maintained and protected," and that the water quality of Outstanding Resource Waters "...shall be maintained and protected from the impacts of nonpoint source activities." The policy makes provisions for degradation when "...necessary to accommodate important economic or social development in the area in which the waters are located," though water quality must continue to support beneficial uses.

Water Quality Limited Segments A water quality-limited waterbody is defined by state statute as "...a water body identified by the Department, which does not meet applicable water quality standards, ...[and therefore] require[s] the development of a TMDL..." (IDAPA 58.01.02.003.115). When Idaho's TMDL development schedule was finalized in 1997, the waterbodies considered subject to TMDL development were those identified in Idaho's 1994 §303(d) list (EPA 1997). This list was promulgated by the EPA, as directed by the U.S. District Court for the Western District of Washington, after the court found that the list submitted by the state of Idaho and approved by the EPA was underinclusive (W.D. Wa. Slip op., April 14, 1996). The §303(d) list developed by the EPA was based on the following information provided by the state: a list of 62 waters originally submitted by Idaho, lists of stream segments of concern contained in Idaho Basin Status Reports, Idaho's 1992 § 305(b) report, forest plans developed by the U.S. Forest Service, and comments submitted by the public (EPA 1994).

1996 §303(d) List As required by the CWA, Idaho submitted a biennial revision of the §303(d) list to the EPA in 1996. The 1996 list was substantively identical to the 1994 list except that spelling, numbering, and boundary errors had been corrected. Information to support the listing of stream segments was obtained from the *1991 Upper Snake River Basin Status Report* (DEQ 1991) or the *1992 Idaho Water Quality Status Report* (DEQ 1992). Portions of these and other reports are discussed in Appendix F to explain how and why specific stream segments in the Teton Subbasin were included in Idaho's 1994 and 1996 §303(d) lists.

1998 §303(d) List To develop its 1998 §393(d) list, DEQ implemented a waterbody assessment process based on BURP data collected by the agency from 1994 through 1996 (DEQ 1996b). Two stream segments that appeared on the 1996 §303(d) list, Teton Creek and the South Fork Teton River, were assessed as fully supporting their beneficial uses and were removed from the 1998 list. Conversely, a stream segment that had not appeared on the 1996 §303(d) list, North Leigh Creek, was assessed as not supporting its beneficial uses and was added to the 1998 list (Table 13). These deletions and additions were approved by the Region 10 Office of EPA on May 1, 2000. For the purpose of developing the Teton Subbasin TMDL, waterbodies on the 1998 §303(d) list are addressed in this assessment. The locations of listed stream segments are shown in Figure 13.

Pollutants and Applicable Water Quality Criteria

The following pollutants were identified on the 1998 §303(d) list as responsible for, or contributing to, impaired water quality conditions in the Teton Subbasin: sediment, flow alteration, nutrients, habitat alteration, and thermal modification (i.e., temperature). Sediment was identified as a pollutant affecting nine stream segments, flow alteration affected five segments, nutrients and habitat alteration each affected three segments, and thermal modification (i.e., temperature) affected two segments (Table 13). A pollutant was not identified for North Leigh Creek, a stream that was added to the 1998 §303(d) list because it was assessed as water quality impaired using BURP data. Although the BURP assessment process can determine that a beneficial use is not supported, it cannot identify the pollutant responsible.

State water quality criteria that directly pertain to sediment, nutrients, and temperature are listed in Table 14. An exceedance of any criterion constitutes a violation of water quality standards except in the following circumstances: 1) when DEQ issues a short-term exemption for activities that are essential to the protection or promotion of public interest and are unlikely to cause long-term injury of beneficial uses, and 2) in the case of temperature, when the air temperature exceeds the ninetieth percentile of the seven-day average daily maximum temperature calculated over the historic record at the nearest weather reporting station (*IDAPA 58.01.02.080).* A criterion for turbidity is included among the criteria for sediment because sediment suspended in the water column is usually a major component of turbidity. Other state criteria that may indirectly pertain to a pollutant are shown in Appendix E.

There are no state water quality criteria that pertain to flow alteration or habitat alteration, and it is DEQ's policy that TMDLs will not be developed for these pollutants. Among the assumptions used to compile Idaho's 1998 §303(d) list, DEQ asserts that flow alteration and habitat alteration are 1) not defined by the CWA as pollutants, and 2) unsuitable for TMDL development (DEQ 1998b). The capacity of a waterbody to support aquatic life is initially determined by the presence of water and secondarily by the quality of that water. However, the relationship between flow apportionment and water quality is clearly addressed in Idaho's water quality standards (IDAPA 58.01.02.050.01) as follows:

> The adoption of water quality standards and the enforcement of such standards is not intended to conflict with the apportionment of water to the state through any of the interstate compacts or decrees, or to interfere with the rights of Idaho appropriators, either now or in the future, in the utilization of the water appropriations which have been granted them under the statutory procedure...

Table 13. Excerpt of the 1998 §303(d) list showing water quality impaired waterbodies in the Teton Subbasin.

Waterbody	WQLS[1] Number	Boundaries	Pollutant(s)	Stream Miles
Badger Creek	2125	Highway 32 to Teton River[2]	Sediment	8.51
Darby Creek	2134	Highway 33 to Teton River	Sediment Flow alteration	3.48
Fox Creek	2136	Wyoming Line to Teton River	Sediment Temperature[3] Flow alteration	9.18
Horseshoe Creek	2130	Confluence of North and South Forks to Teton River[4]	Flow alteration	7.03
Moody Creek	2119	Forest boundary to Teton River	Nutrients	25.38
North Leigh Creek	5230	Wyoming line to Spring Creek	Unknown[5]	4.90
Packsaddle Creek	2129	Headwaters to Teton River	Sediment Flow alteration	9.88
South Leigh Creek	2128	Wyoming line to Teton River	Sediment	11.30
Spring Creek	2127	Wyoming line to Teton River	Sediment Temperature Flow alteration	12.60
Teton River (Teton Valley Segment)	2116	Highway 33 to Bitch Creek	Sediment Habitat alteration Nutrients	10.10
Teton River	2118	Headwaters to Trail Creek	Habitat alteration	2.65
Teton River	2117	Trail Creek to Highway 33	Sediment Habitat alteration	20.00
North Fork Teton River	2113	Forks to Henry's Fork, Snake River	Sediment Nutrients	14.64

[1]WQLS: Water quality limited segment. The last three digits of this number correspond to the Pacific Northwest Rivers Study number used in the 1996 §303(d) list to identify segments.
[2]The boundaries of Badger Creek were shown as "R45ET6NS10 to first tributary" on the 1996 list. This change reduced the listed distance of Badger Creek by 3.83 stream miles.
[3]The pollutant, "Temperature," was shown "Thermal alteration" on the 1996 list.
[4]The change in boundaries of Horseshoe Creek from the 1996 list is an apparent clerical error.
[5]A pollutant was not identified for segments assessed as water quality impaired using BURP data.

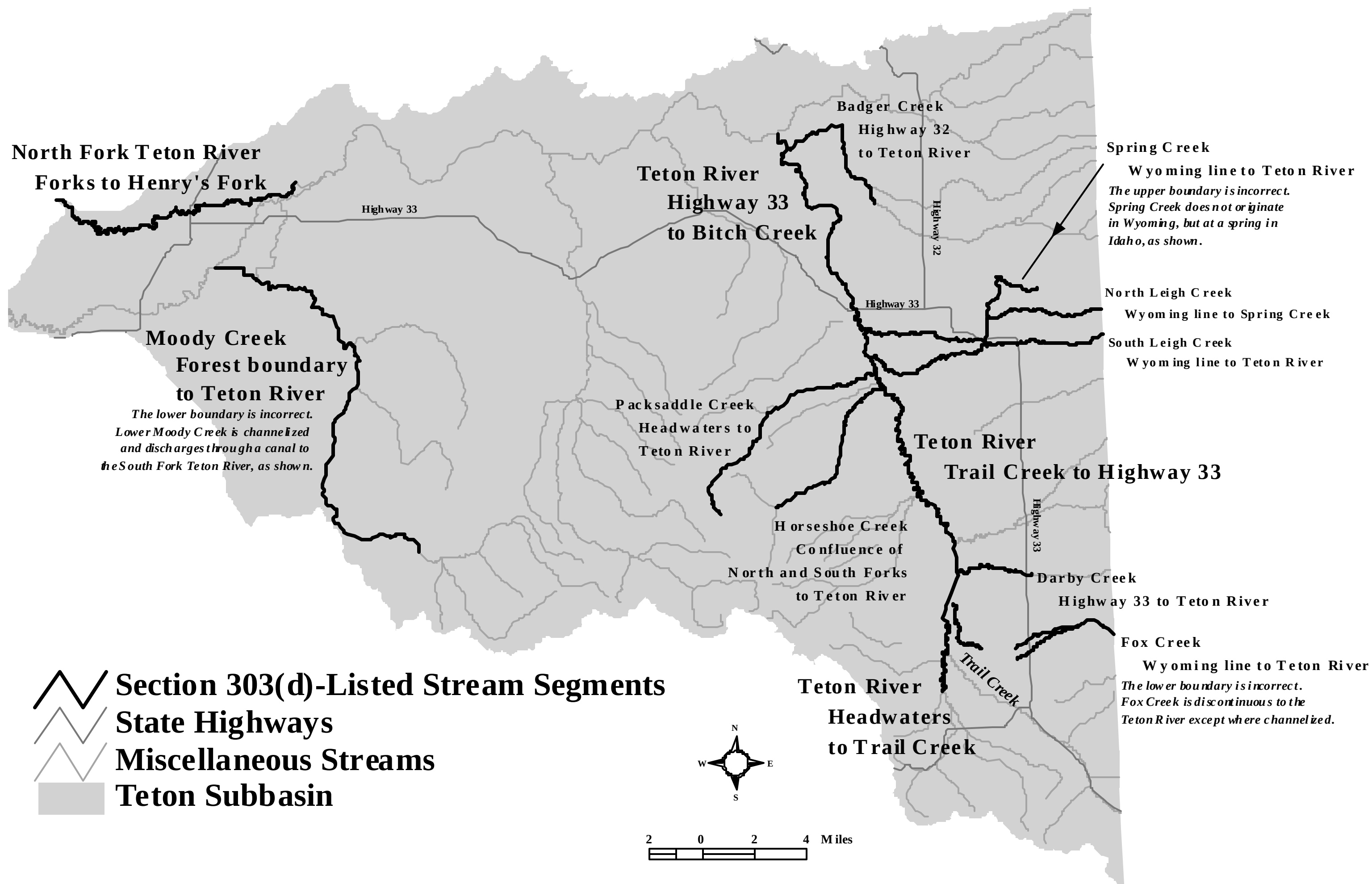

Figure 13. Section 303(d)-listed stream segments in the Teton subbasin. Segment boundaries and explanations of boundaries are shown below the stream names.

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Pollutant Targets

Because Idaho's water quality criteria for sediment and nutrients are narrative, as opposed to numeric, recognizing that violations of these criteria have occurred is a two-step process. First, it must be determined that a beneficial use has been impaired, and second, a cause-and-effect relationship between the pollutant and impairment of the beneficial use must be established. In contrast, temperature criteria are numeric, so recognizing a criterion violation is relatively simple when temperature data are available.

One objective of this assessment is to determine whether the pollutants identified on the §303(d)-list are in fact responsible for impaired water quality so that a TMDL for the pollutants can be established. This can most easily be accomplished by comparing data for sediment and nutrients to a numeric value that is generally considered to be protective of beneficial uses. In the absence of state numeric criteria, Idaho DEQ has proposed numeric *targets* for use in TMDL development (Table 15). Targets for sediment were recommended by Rowe *et al.* (1999) based on a review of published scientific literature, technical reports, and water quality criteria adopted by Montana, Wyoming, Utah, Nevada, Oregon,

Washington, and British Columbia. The sediment targets listed in Table 15 are just a few of the possible targets recommended by Rowe *et al.* (1999), and were selected for this assessment because they are consistent with available data. The targets listed for nutrients are also based on a review of the scientific literature, and are intended to prevent "biological nuisance" or "excessive plant growth in streams" (Essig 1998).

To provide a context for the significance of these targets, the biological effects of sediment and nutrients are discussed below, along with explanations of various methods for analyzing these pollutants.

Sediment

Sediment is the most common stream pollutant nationwide, both in terms of the quantity delivered on an annual basis and the number of stream miles affected (Waters 1995). In relatively undisturbed watersheds, streams constantly assimilate sediment delivered through natural geological processes. Sediment is considered a pollutant only when it is produced at accelerated rates and in excessive amounts by human activities. Activities that commonly accelerate sediment production are row cropping, livestock grazing in riparian areas, timber harvest, mining, road construction, residential and industrial development, stream channelization, and stream bed alteration (Waters 1995). All of these activities currently occur or have occurred in the Teton Subbasin.

Table 14. Water quality criteria pertaining to pollutants shown in Idaho's 1998 §303(d) list of water quality limited waterbodies.

Pollutant	Water Quality Criteria Excerpted From IDAPA 58.01.02
Sediment	200. GENERAL SURFACE WATER QUALITY CRITERIA. 08. Sediment. Sediment shall not exceed quantities specified in Sections 250 or 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.
Flow Alteration	None
Nutrients	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.
Habitat Modification	None
Thermal Modification (Temperature)	250. SURFACE WATER QUALITY CRITERIA FOR USE CLASSIFICATIONS. 02. Cold Water. Waters designated for cold water aquatic life are to exhibit the following characteristics: b. Water temperatures of twenty-two (22) degrees C or less with a maximum daily average of no greater than nineteen (19) degrees C. e. Salmonid spawning: ii. Water temperatures of thirteen (13) degrees C or less with a maximum daily average no greater than nine (9) degrees C. 03. Seasonal Cold Water. Between the summer solstice and autumn equinox, waters designated for seasonal cold water aquatic life are to exhibit the following characteristics. For the period from autumn equinox to summer solstice the cold water criteria will apply. b. Water temperatures of twenty-seven (27) degrees C or less as a daily maximum with a daily average of no greater than twenty-four (24) degrees C.

Table 15. Water quality targets for sediment (Rowe *et al*. 1999) and nutrients (Essig 1998).

Pollutant	Target
Sediment	Turbidity Not greater than 50 NTU[1] instantaneous or 25 NTU for more than 10 consecutive days above baseline background, per existing Idaho water quality standard; chronic levels not to exceed 10 NTU at summer base flow Total suspended solids Not to exceed 80 milligrams per liter (mg/L), regardless of season Subsurface sediment For those streams with subsurface fine sediment (i.e., particles less than 6.3 mm in diameter) less than 27%, do not exceed the existing fine sediment volume level; for streams that exceed the 27% threshold, reduce subsurface sediment to a 5-year mean not to exceed 27% with no individual year to exceed 29%; concentration of subsurface sediment <0.85 mm should not exceed 10%
Nutrients	Total phosphorus Less than 0.1 mg/L in flowing streams to prevent biological nuisance Total nitrate as N Less than 0.3 mg/L Total nitrogen as N Less than 0.6 mg/L

[1]Nephelometric turbidity unit

Sediment Terminology Sediment is defined as "particulate matter that has been transported by wind, water or ice and subsequently deposited" (Lincoln *et al.* 1993). Consequently, sediment is sometimes used to refer to stream channel substrate materials that range in size from microscopic particles to boulders. But as a nonpoint source pollutant, sediment typically refers to small soil and rock particles mobilized and transported to streams by runoff from land surfaces or by erosive forces acting on exposed streambanks. Larger particles such as cobbles and boulders are not considered pollutants because they are generally beneficial to stream organisms (Waters 1995).

Instream sediment is classified according to the manner in which it is transported. Sediment particles transported in the water column are referred to as suspended sediment; particles transported along the bed or very close to the bed are referred to as bed load. The USGS specifically defines bed load as particles that roll, slide, or skip along the stream bed or within 0.25 feet of the stream bed (Brennan *et al.* 2000). The sizes of particles that are transported in suspension or as bed load depend on factors such as the gradient of the stream bed and water velocity. According to Waters (1995), suspended sediment is usually comprised of particles less than 62 micrometers (µm) (0.062 mm) in size. MacDonald *et al.* (1991) describe particles smaller than 62 µm as wash load, which they define as particles that are washed into streams during runoff events, are smaller than stream bed materials, and remain suspended in the water column the entire length of the fluvial system. These authors also acknowledge that the concept of wash load is rarely used by fluvial geomorphologists and fisheries biologists. Citing other authors, they conclude that for streams in the Pacific Northwest, particles less than 100 µm (0.1 mm) in diameter are typically transported as suspended sediment; particles between 0.1 and 1 mm in diameter are typically transported as bedload, but can be transported as suspended load during turbulent, high flow events; and particles larger than 1 mm are typically transported as bedload (Everest *et al.* 1987 and Sullivan *et al.* 1987, as cited in MacDonald *et al.* 1991).

Although the smallest sediment particles generally remain suspended in the water column of a stream, some suspended sediment is deposited and becomes part of the stream channel substrate. A variety of classification systems have been proposed to standardize terminology used to describe substrate sediment, but none has been universally adopted by stream ecologists and fisheries biologists to describe substrate sediment. Most classification systems are based on the Udden grade scale and Wentworth naming convention, and associate ranges of particle sizes with descriptive terms such as clay, silt, sand, gravel, cobble, and boulder (Table 16). The Udden scale uses 1 mm as a fixed reference, and all size categories smaller or larger are determined by sequential halving or doubling of the 1-mm reference. In a paper describing techniques for studying benthic invertebrates, Cummins (1962, as cited in Waters 1995) described a substrate classification system consisting of eleven categories based on the Wentworth scale. The EPA protocol for in-stream rapid bioassessment includes a substrate classification system that appears to be based on Cummins' system but contains only seven size categories (Plafkin *et al.*1989). Platts *et al.* (1983) classified substrate materials into six categories, and assigned the descriptive terms, "fine sediment - large" to particles 0.83 to

4.71 mm in size and "fine sediment - fine" to particles less than 0.83 mm in size. But Platts *et al.* (1983) also recommended that specialists working with stream channel substrates adopt a classification system based on terminology of the American Geophysical Union, which is similar to that used in the Udden and Wentworth scales. Researchers studying the effects of sediment on egg incubation and fry emergence have often classified substrate materials using a series of sieves of successively smaller mesh size. This provides a relatively rapid and reproducible method of quantifying substrate particle sizes without performing tedious or elaborate particle size measurements. For example, McNeil and Ahnell (1964) used Tyler sieves with mesh openings of 26.26 mm, 13.33 mm, 6.68 mm, 3.33mm, 1.65 mm, 0.833 mm, 0.417 mm, 0.208 mm, and 0.104 mm to study the relationship between sizes of spawning bed materials and salmon spawning success. The mesh sizes given in mm correspond to the following mesh sizes in inches: 1.03 inch, 0.52 inch, 0.26 inch, 0.13 inch, 0.06 inch, 0.03 inch, 0.016 inch, 0.008 inch, and 0.004 inch. They implicitly defined materials passing through a 0.833-mm mesh as "silts and fine sands" and "fine particles," and demonstrated the relationship between these materials and the permeability of spawning beds.

Table 16. **Classification of stream substrate materials by particle size (Lane 1947, as cited in Platts *et al.* 1983).**

Category	Size Range (mm)	Size Range (inches)
Very large boulders	4,096 - 2,048	160 - 80
Large boulders	2,048 -1,024	80 - 40
Medium boulders	1,024 - 512	40 - 20
Small boulders	512 - 256	20 - 10
Large cobbles	256 - 128	10 - 5
Small cobbles	128 - 64	5 - 2.5
Very coarse gravel	64 - 32	2.5 - 1.3
Coarse gravel	32 - 16	1.3 - 0.6
Medium gravel	16 - 8	0.6 - 0.3
Fine gravel	8 - 4	0.3 - 0.16
Very fine gravel	4 - 2	0.16 - 0.08
Very coarse gravel	2 - 1	0.08-0.04
Coarse sand	1.0 - 0.5	0.04-0.02
Medium sand	0.50 - 0.25	0.02-0.01
Fine sand	0.250 - 0.125	0.010 -0.005
Very fine sand	0.125 - 0.062	0.0050 - 0.0025
Coarse silt	0.062 - 0.031	--
Medium silt	0.031 - 0.016	--
Fine silt	0.016 - 0.008	--
Very fine silt	0.008 - 0.004	--
Coarse clay	0.002 - 0.004	--
Medium clay	0.001 - 0.002	--
Fine clay	0.0005 - 0.0010	--
Very fine clay	0.0005 - 0.00024	--

Bjornn *et al.* (1974 and 1977, as cited in Waters 1995) showed that the availability of physical habitat for juvenile salmonids in streams with granitic substrates was reduced when cobble-sized substrate was embedded by sediment, which the authors defined as substrate less than 6.35 mm in diameter. Tappel and Bjornn (1983) classified fines into two size categories, less than 9.5 mm and less than 0.85 mm, and developed a model using those substrate sizes to predict survival to emergence of five trout species. In a review of the effects of fine sediment in salmonid redds, Chapman (1988) concluded that most researchers use the terms “fine sediment” or “fines” to indicate particles smaller than about 6 mm in diameter. As these studies illustrate, the terms “sediment” and “fine sediment” have been assigned to a large range of particle sizes by researchers attempting to demonstrate a relationship between a defined particle size class and impaired spawning. Many of the size thresholds identified in these studies correspond to the mesh openings in U.S. Standard Sieves (Table 17).

According to Bjornn *et al.* (1998), research regarding salmonid reproductive success has focused on the effects of sediment particles as large as 9.5 mm because of an interest in evaluating the effects of logging and road-building in the Idaho Batholith, an area characterized by granitic soils and relatively large sediment particles. They noted that "[t]he effects of silt and clay-sized particles, that erode from sedimentary and metamorphic deposits, ...has not been studied extensively." They conducted a laboratory study of the effects of sediment less than 0.25 mm (250 µm) on the incubation and emergence of salmonid embryos, and concluded that:

> There may not be a single measure of fine sediments that can be used universally to predict survival or assess quality of stream beds used for spawning. ...we provided evidence that embryo survival can vary depending on the size and amount of fine sediments in the egg pocket; 6-7% of the <0.25 mm fines reduced survival from 80% to 20%, whereas with fine granitic sediments (<6.35 mm with few fines smaller than 0.25 mm), fines had to make up more than 20% of the substrate to reduce survival (Irving and Bjornn 1984).

This conclusion is particularly relevant to the type of sediment deposited in the streams of the Teton Subbasin where soils originate from volcanic and sedimentary materials, not granitic materials. The predominant soils in the Teton Subbasin are loams consisting of clay, silt, and sand, and in some locations, gravels.

The Biological Effects of Sediment in Streams Studies of the biological effects of sediment in North American streams were recently reviewed and summarized by Waters (1995) and Rowe *et al*. (1999). Populations of aquatic organisms have developed a variety of strategies for coping with intermittent increases in the concentrations of suspended sediment and bedload sediment, otherwise they would not persist in streams subjected to seasonal fluctuations in sediment load. But when streams are subjected to excessive sediment loads, aquatic organisms and communities of organisms may be affected in a variety of ways (Table 18).

According to Waters (1995), "[t]he influence of sediment deposition on the productivity of benthic organisms as food for fish is one of the most critical problems affecting stream fisheries." The abundance of benthic invertebrates is highest in stream substrates that consist of a heterogeneous mixture of gravel, pebbles, and cobbles; abundance is lowest in homogeneous substrates consisting of sand, silt, or large boulders and bedrock. Deposition of sediment can reduce the heterogeneity of substrate by filling the interstitial or open spaces around substrate particles.

Table 17. Categories of stream substrate materials and corresponding sieve by particle size.

Classification Based on Sediment Terminology of the American Geophysical Union (Lane 1947, as cited in Platts *et al.* 1983)		Corresponding Tyler Screen or U.S. Standard Sieve Number			
		Tyler Screens		U.S. Standard	
Category	Size Range (mm)	Mesh	Size of Opening (mm)	No.	Size of Opening (mm)
Fine gravel	8 - 4	8	2.36	--[1]	--
Very fine gravel	4 - 2	9	2.00	10	2.00
Very coarse gravel	2 - 1	16	1.00	18	1.00
Coarse sand	1.0 - 0.5	32	0.500	35	0.500
Medium sand	0.50 - 0.25	60	0.250	60	0.250
Fine sand	0.250 - 0.125	115	0.125	120	0.125
Very fine sand	0.125 - 0.062	250	0.063	230	0.063
Coarse silt	0.062 - 0.031	<400	0.038	--	--

[1]No corresponding U.S. Standard Sieve

Embeddedness, defined by Waters (1995) as "the fraction of substrate surfaces fixed into surrounding sediment," reduces the amount of habitat available to larval insects of the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). Collectively, these insects are referred to as "EPT," and are the primary food for foraging fish. As embeddedness increases, the percentage of the benthic insect community composed of EPT declines, and the percentage of burrowing insects such as *Hexagenia* (burrowing mayfly), chironomids (midges), and oligochaetes (worms) increases (Waters 1995). Because these burrowing insects are not available to fish, the food base for fish is diminished. Furthermore, the occurrence in Rocky Mountain streams of *Tubifex tubifex*, the worm host of the parasite that causes whirling disease, is strongly predicted by low percentages of EPT in the insect community (Gustafson 1998).

Waters (1995) and MacDonald *et al.* (1991) reviewed the effects of suspended sediment on stream organisms, on the physical characteristics of water and channel morphology, and on beneficial uses such as drinking water supply. Because suspended sediment reduces light penetration through the water column, photosynthesis by aquatic plants is diminished and primary production is reduced. Invertebrate drift (i.e., downstream movement of invertebrates following detachment from the substrate) increases, possibly because of reduced food availability. According to Waters (1995), a major sublethal effect of high suspended solids is the loss of visual capability in fish, leading to reduced feeding and depressed growth. The ability of juvenile coho salmon to capture prey has been shown to be reduced by concentrations of 300 to 400 milligrams per liter (mg/L) suspended sediment (Noggle 1978 as cited in MacDonald *et al.*1991).

Table 18. The biological effects of excess sediment in streams (adapted from Waters 1995).

Primary Producers • Photosynthesis is reduced by suspended sediment which increases turbidity and reduces light penetration through the water column. Sustained, reduced photosynthesis and primary production would probably reduce production of invertebrates and fish, but these effects have not been documented.
Invertebrates • Drift (i.e., downstream movement of invertebrates in the water column) increases, presumably because suspended sediment decreases light penetration through the water column. Prolonged periods of high suspended sediment may deplete benthic invertebrate populations. • Insect habitat is reduced by increasing embeddedness (i.e., “the fraction of substrate surfaces fixed into surrounding sediment”). Habitat reduction reduces the total numbers of insects belonging to the orders Ephemeroptera, Plecoptera, and Trichoptera. These insects, known collectively as EPT, occupy the interstitial spaces within the stream bed and are a primary food for foraging fish. • Insect habitat changes from heterogeneously sized substrate to homogeneously sized fine sediments. Available habitat for EPT declines, reducing food available to fish, and habitat for burrowing insect larvae such as chironomids and oligochaetes increases.
Fish • Salmonids avoid turbid water and water containing high concentrations of suspended sediment. Concentrations of suspended sediment that trigger avoidance behavior probably vary among species and life stages. Avoidance may cause stream segments or entire streams to be devoid of fish. • Salmonids exposed to varying concentrations of suspended sediment may experience a variety of sublethal effects including depressed growth rate due to inability of fish to see and capture prey, gill-flaring and reduced respiration, reduced tolerance to disease and toxicants, physiological stress, and altered behavior. • Developing fish embryos and sac fry suffocate when the movement of water and oxygen into the interstitial spaces of redd gravels is impeded. This occurs most commonly in high-elevation streams in which downwelling water forces sediment into the interstitial spaces between gravels, preventing movement of oxygenated water around the embryos. • Emergence of fry from the redd is prevented by impenetrable, densely consolidated substrate materials. Although embryo development and hatching are successful, reproductive failure occurs because fry cannot move from the redd to the water column. • Winter survival of fry is diminished by the loss of protective interstitial spaces in riffles. “Severe reductions in year-class strength occur when a cohort of salmonid fry faces stream riffles heavily embedded by sediment deposits.” • Growth of juveniles is reduced because rearing habitat in pools is lost. “When heavy deposits [of sediment] eliminate pool habitat, reduced growth and loss of populations result.”

Salmonids are generally known to prefer clear stream waters, and studies have demonstrated that several species actively avoid waters containing high concentrations of suspended sediment. Other sublethal effects such as gill damage, respiratory distress, reduced tolerance to disease and toxicants, and physiological stress have also been documented. Suspended sediment may indirectly affect aquatic organisms by increasing heat absorption and raising water temperatures, though this effect may be offset by higher reflectance and reduced heat absorption by substrate materials (MacDonald *et al.* 1991). Although effects on stream channel morphology are considered minor, some studies have shown that increased concentrations of suspended sediment cause increased water velocity and steeper channel gradient. The suitability of surface water as a drinking water source may be impaired by suspended sediment for aesthetic reasons and because high concentrations reduce the efficacy of water treatment. The suitability of water as an agricultural and industrial supply may also be impaired because of the damage suspended sediment may cause to irrigation pipes and sprinklers and hydroelectric turbines.

Measurement of Sediment As previously stated, Idaho's water quality standards do not contain numeric criteria for suspended sediment or total suspended solids (TSS), but criteria have been established for turbidity. Turbidity is an optical property of water and a measure of the light scattered and absorbed by suspended sediment, colored organic compounds, and microscopic organisms (APHA 1992). Although a relationship exists between suspended sediment and turbidity, establishing a direct correlation between the two measurements is difficult because turbidity is affected by the sizes, shapes, and refractive indices of the materials in suspension. Nevertheless, turbidity is frequently used as a surrogate measure of suspended solids because of the relative ease with which it can be measured. Although the effect of turbidity on the beneficial use of cold water aquatic life is not well characterized, turbidity is known to reduce the effectiveness of water disinfection, thereby interfering with the beneficial use of surface water as a drinking water supply.

Turbidity measurements were originally based on the Jackson candle turbidimeter, and analytical results were expressed in Jackson turbidity units (JTUs). Because of poor sensitivity at low turbidities, this method was replaced in the 1980s by the nephelometric method that gives results in nephelometric turbidity units (NTUs) (APHA 1992). Turbidity is also sometimes reported as formazin turbidity units (FTUs) (Salvato 1992) because formazin is used as a standard for calibration. There is no direct relationship between NTU or FTU readings and JTU readings, so data collected using these methods cannot be directly compared (Salvato 1992).

The numeric criteria for turbidity, as specified in *IDAPA 58.01.21 - Water Quality Standards and Wastewater Treatment Requirements*, pertain to streams designated for cold water aquatic life and domestic drinking water uses. But because none of the streams in the Teton Subbasin have been designated as domestic water supplies, the only turbidity criterion that pertains to the subbasin is as follows:

> For cold water aquatic life use designations (*IDAPA 58.01.21.250.02.d*): Turbidity, below any applicable mixing zone set by the Department, shall not exceed background turbidity by more than fifty (50) NTU for more than ten (10) consecutive days.

Title 40, Part 136 of the Code of Federal Regulations lists inorganic test procedures approved for analysis of pollutants. Neither sediment nor suspended sediment is specifically listed as a parameter for which a method has been approved, so the method commonly used by laboratories is EPA method 160.2 for analysis of nonfilterable residue (EPA 1983) or *Standard Methods* 2450 D for analysis of TSS (APHA 1992). Another method used by some laboratories is the American Society for Testing and Materials designation D3977-80, "Standard practice for determining suspended-sediment concentration in water samples." According to these procedures, water is filtered through a glass microfiber filter that retains particles larger than approximately 1.5 mm in diameter (Pharoah 2000). The filter is dried at approximately 105 ^{o}C and weighed to obtain the mass of sediment, in milligrams, per volume of water sampled, in liters. Because of the relatively low drying temperature, the weight of the material on the filter includes organic, as well as inorganic material. The primary difference between the procedures is in regard to the volume of sample or subsample filtered.

An accurate and reliable method for measuring suspended sediment, particularly for the purpose of TMDL development, is currently being investigated by the USGS (Gordon and Newland, undated). The USGS has determined that significant differences in analytical results can occur using the methods cited above because of differences in the volume of sample analyzed and procedures for subsampling. Some of these procedures were originally developed for evaluating the efficacy of wastewater treatment, not for analysis of natural stream waters. Another factor that must be considered when analyzing for TSS or suspended sediment is the procedure used to collect the sample in the field. The USGS specifies that water intended for analysis of suspended sediment should be collected with a depth-integrating sampler at several vertical locations in the stream cross section (Brennan *et al.* 2000).

Subsurface sediment is measured by removing a portion of the stream bed substrate, separating substrate particles into various size classes, then determining the percentage of particles within each size class. Herron (1999) measured substrate sediment in streams in the Salmon River basin using a modification of the procedure described by McNeil and Ahnell (1964). He then used the results as the basis for some of the first sediment TMDLs developed in Idaho. Subsurface fine sediment was defined as less than 6.35 mm (0.25 inches), and targets of less than 28% subsurface fine sediment to a depth of 4 inches were specified in the TMDLs (DEQ 1999c). The procedure used to measure subsurface fine sediment is described in Appendix G.

The BURP protocol defines fine sediment as particles less than 6 mm in size. As part of the habitat assessment protocol conducted at sites selected for BURP sampling, the percentage of fine sediment in the stream bed is determined using a modified version of the Wolman pebble count. This procedure was originally developed to assess the hydrologic features of streams, and has been widely recommended as an efficient and reproducible means of evaluating the suitability of stream substrates for aquatic life (Mebane 2000). The BURP protocol specifies measurement of a minimum of 50 surface particles encountered at equidistant intervals across the width of the stream at three riffle locations (DEQ 1996a). Initially, pebble counts were made across the bankfull width of the stream, but beginning in 1997 pebble counts were made across the wetted width of the stream only. Counts of pebbles across the entire bankfull transect include counts of particles in the streambanks that are only submerged by water at high flows.

This procedure skews the count toward a high percentage of fine sediment because streambanks are usually composed of finer particles than the stream bed. An analysis of data from more than 200 BURP locations across Idaho showed that percentages of fine sediment measured across the bankfull width of streams averaged 45%, whereas percentages of fine sediment measured across the wetted width of the stream averaged only 25% (Mebane 2000). But regardless of whether pebble counts were conducted for bankfull or wetted stream width, the data showed a statistically significant inverse correlation between the percentage of surface fine sediment and the richness of EPT species (Mebane 2000).

Embeddedness is another parameter monitored during the habitat evaluation phase of BURP sampling. Embeddedness is defined by Hayslip (1993) as the degree to which boulders, rubble, or gravel in riffles are surrounded by fine sediment less than 6.35 mm (0.25 inch) in diameter. The size threshold for fine sediment specified by Hayslip (1993) is slightly larger than the size threshold specified by the modified Wolman pebble count (6 mm), and is another example of the variety of ways in which fine sediment is defined. Embeddedness is a qualitative measure of fish and macroinvertebrate habitat quality, with 0-25% embeddedness considered optimal, 25-50% embeddedness considered sub-optimal, 50-75% embeddedness considered marginal, and more than 75% embeddedness considered poor. Each BURP site receives an embeddedness score between 0 and 20, which is combined with ten other habitat parameter scores to obtain a habitat index (HI) score.

Nutrients

Excessive concentrations of nutrients, specifically nitrogen and phosphorus, may diminish water quality and impair beneficial uses through the process of eutrophication. Very simply, eutrophication occurs when excess nutrients stimulate the growth of primary producers such as algae and aquatic macrophytes. The plant biomass produced is greater than the amount that can be utilized by consumers such as invertebrates and fish. The accumulated biomass decomposes, and dissolved oxygen is consumed more quickly than it can be replenished by other processes. The process of eutrophication has been well documented in lakes and reservoirs, but is less well understood in the flowing waters of streams and rivers.

The Biological Effects of Nutrients Depletion of dissolved oxygen is just one of many chemical and biological effects that may occur when excessive nutrient concentrations disrupt the equilibrium between energy production and utilization. These effects can limit the capacity of a surface water to support its beneficial uses, as described in Table 19. Idaho’s water quality standards address these effects through narrative and numeric criteria. Narrative criteria address floating, suspended, or submerged matter; excess nutrients; and oxygen-demanding materials. Numeric criteria address dissolved oxygen, ammonia, and turbidity (Table 19). Numeric criteria specific for nitrogen and phosphorus have not been developed because concentrations that are excessive can only be defined within the context of the physical, chemical, and biological attributes of the aquatic system affected.

The macronutrients nitrogen (N) and phosphorus (P) are essential for plant growth; if they are not available in adequate amounts and in the necessary proportions, plant growth is limited. The chemical forms of nitrogen and phosphorus that are most readily utilized by plants are dissolved ammonium (NH_4^+), dissolved nitrate (NO_3-), and dissolved orthophosphorus (PO_4^{-3}). Fresh water algae and macrophytes typically contain nitrogen and phosphorus in a ratio of seven parts nitrogen to one part phosphorus (7 N:1 P), but average river water contains a ratio of 23 parts nitrogen to less than one part phosphorus (23 N:<1 P) (Wetzel 1983). Mitsch and Gosselink (1993) cite data indicating that the "average" concentration of nitrogen in rivers world-wide is 0.2 mg/L and the "average" concentration of phosphorus is 0.02 mg/L. These concentrations are comparable to a ratio of 10 N: 1P which is much lower than that cited by Wetzel (1983). Because phosphorus is much less abundant than nitrogen in fresh water, phosphorus is the growth-limiting nutrient in most inland lakes and rivers. Thomas *et al.* (1999) cited studies which indicate that growth of aquatic algae is phosphorus limited in waters in which the ratio exceeds 20 N:1 P, but is nitrogen limited in waters in which the ratio is less than 10 N:1 P.

Very few researchers have attempted to define the concentrations of nitrogen and phosphorus that stimulate aquatic plant production in fresh waters. Rupert (1996) states that 0.3 mg/L NO_2 + NO_3 as N is the "critical limit" for growth stimulation in the presence of adequate phosphorus, and 0.05 mg/L orthophosphorus is the "critical limit" in the presence of adequate nitrogen. Other researchers have recommended 0.3 mg/L NO_3 or 0.6 mg/L total nitrogen as targets not to be exceeded in fresh water streams and rivers, but there does not appear to be a consensus in the literature that this concentration is the absolute maximum that can occur in all fresh waters without causing nuisance plant growth (Essig 1998). The EPA has not promulgated a criterion for total phosphorus, but it has published information that may support development of such a criterion (EPA 1986). To prevent development of biological nuisance and to control accelerated or cultural eutrophication, the EPA "Gold Book" states that "total phosphates as phosphorus (P) should not exceed 50 ìg/L (0.05 mg/L) in any stream at the point where it enters any lake or reservoir, nor 25 ìg/L (0.025 mg/L) within the lake or reservoir." But for flowing waters not discharging directly to lakes or impoundments, the "Gold Book" cites Mackenthun (1973) in recommending 100 ìg/L (0.1 mg/L) total phosphorus as a desired goal for preventing plant nuisances.

Table 19. The primary and secondary effects of nutrient enrichment and the beneficial uses affected (after Geldreich 1996).

Primary Effects of Nutrient Enrichment	Secondary Effects of Nutrient Enrichment	Beneficial Uses Affected
Periodic growth of substantial populations of blue-green algae (*Anabaena flos-aquae*, *Microcystis aeruginosa*, *Oscillatoria* spp., and *Aphanizomen flos aquae*)	Toxins produced by blue-green algae may cause illness or death in mammals, birds, and fish, and skin irritation in humans.	Domestic water supply Agricultural water supply Aquatic life Primary contact recreation Secondary contact recreation
Development of mats of algae and increased growth of macrophytes	Increased growth of bacteria in water distribution systems due to nutrients released by decomposing algae; formation of methane, hydrogen sulfite and reductive compounds of iron and manganese, which may affect water treatment and distribution systems; depletion of dissolved oxygen due to plant decomposition; fish suffocation due to oxygen depletion; fish toxicity due increased concentrations of ammonia.	Domestic water supply Aquatic life
Increased production of phytoplankton, zooplankton, bacteria, and fungi	Organisms produce taste and odor compounds that reduce palatability; organisms resistant to disinfection may enter potable water supply; increased turbidity reduces effectiveness of water disinfection systems; decreased stability of communities and populations of aquatic organisms, including fish.	Domestic water supply Aquatic life

The only nitrate criterion established by the EPA is 10 mg/L for drinking water; there is no criterion for the protection of aquatic life. The EPA criteria to protect against eutrophication caused by phosphate phosphorus are as follows: 0.025 mg/L or less in lakes, 0.05 mg/L where streams enter lakes, and 0.1 mg/L in streams that do not flow into lakes (EPA 1986).

Measurement of Nutrients Nitrogen and phosphorus exist in several molecular forms. Some forms are water soluble while others are transported in water adsorbed to particles of soil or organic materials. Organic forms of nutrients contain carbon and hydrogen and are frequently derived from plant or animal tissue; inorganic nutrients are mineralized.

Nitrogen is often reported as total Kjeldahl nitrogen (TKN) or total nitrogen (TN). Total Kjeldahl nitrogen includes organic nitrogen and total ammonia. Total ammonia includes the un-ionized form (NH_3), which is toxic to fish, and ionized ammonia or ammonium (NH_4^+), which is not toxic to fish and is utilized as a nutrient by plants. Ionized ammonia is the prevalent form in natural waters, but the concentration of unionized ammonia increases rapidly with even small increases in pH and temperature. Total nitrogen includes TKN and nitrite plus nitrate (NO_2 + NO_3). Although NO_3 is the form available to plants, most water quality analyses are performed for NO_2 + NO_3. And because NO_2 is readily oxidized to NO_3 in surface waters, the concentration of NO_2 + NO_3 in surface water is generally assumed to consist primarily of NO_3. This assumption is made because of the time-consuming nature of NO_3 analyses. To obtain an accurate measurement of NO_3 in water, the sample must first be analyzed for NO_2, then for NO_2 + NO_3. The concentration of NO_2 is then subtracted from the concentration of NO_2 + NO_3 to give the concentration of NO_3. Even when NO_2 is present in detectable concentrations, it is a very small fraction of the total concentration of NO_2 + NO_3. Therefore, for the purpose of this assessment, it is appropriate to use the results NO_2 + NO_3 analyses as an approximation of NO_3 concentrations in surface waters.

The forms of phosphorus that are frequently reported for water are total phosphorus and orthophosphorus. Analysis of total phosphorus is performed on an unfiltered water sample and therefore includes dissolved phosphorus, dissolved orthophosphorus, phosphorus adsorbed to solids and soil particles, and phosphorus contained in organic material such as plant cells. When concentrations of suspended solids are low, total phosphorus may consist almost entirely of dissolved phosphorus. The concentrations of total phosphorus and dissolved phosphorus in a sample are usually much greater than the concentration of orthophosphorus, which is also referred to as orthophosphate or phosphate phosphorus.

SUMMARY AND ANALYSIS OF WATER QUALITY DATA

Beneficial Use Reconnaissance Program Data

Water quality can be monitored by measuring specific physical and chemical parameters or by assessing support of beneficial uses. Measurement of physical and chemical parameters is labor-intensive and relatively expensive, and the number of parameters that can be monitored as indicators of water quality is enormous. These constraints on water quality monitoring are just some of the factors that contributed to the development and implementation of the BURP by DEQ in the early 1990s. The purpose of BURP is to obtain data that reflect the cumulative effects of water quality on the biological component of the stream ecosystem, thereby providing a means of determining whether aquatic life beneficial uses are supported. If the beneficial use of cold water aquatic life is supported, DEQ assumes that other uses, which require less stringent water quality conditions (e.g., industrial and agricultural water supply), are also supported.

The BURP protocol focuses on benthic macroinvertebrate community sampling for the following reasons: 1) benthic macroinvertebrates are relatively immobile and therefore constantly subjected to the effects of water quality; 2) the structure of the macroinvertebrate community can indicate both the presence of detrimental water quality conditions such as excessive nutrients as well as the absence of beneficial water quality conditions such as organic carbon; 3) macroinvertebrates respond to the cumulative effects of water quality, including synergistic and antagonistic effects of pollutants; and 4) macroinvertebrate communities respond relatively quickly to changes in water quality. The numbers and types of macroinvertebrates found are used to calculate a macroinvertebrate biotic index (MBI) score. An MBI score greater than or equal to 3.5 indicates “full support” of cold water aquatic life; an MBI score less than or equal to 2.5 indicates “not full support” of cold water aquatic life; and an MBI score between 2.5 and 3.5 indicates that the support status “needs verification.”

The support status of cold water aquatic life and salmonid spawning beneficial uses are influenced by physical factors such as water quantity and habitat structure, as well as water quality. Although DEQ has no authority relative to water quantity, it must determine 1) whether support of a beneficial use is impaired because of water quality or habitat conditions, and 2) the sources of pollutants that may be degrading water quality. Therefore, the BURP protocol also includes measurement of physical parameters such as cobble embeddedness, streambank stability, riparian vegetation, and woody debris in the area of the stream sampled for macroinvertebrates. These measurements are incorporated to produce a HI score, which is used to supplement the MBI score to assess support of the aquatic life beneficial use.

The support status of a waterbody assessed as "needs verification" on the basis of an MBI score can be verified using the HI score and/or the reconnaissance index of biotic integrity, a qualitative measure of a fish assemblage. Data to evaluate fish assemblages have been obtained from IDFG, the U.S. Forest Service, or BLM, and have been collected by DEQ using electrofishing techniques. If the HI score does not indicate habitat impairment or the fish assemblage is not impaired, the stream is reassessed as fully supporting the beneficial use of cold water aquatic life. Because the Teton Subbasin is located in two ecoregions, HI scores greater than 88 indicate non-impaired habitat conditions for streams located in the Snake River Basin/High Desert Ecoregion, and HI scores greater than 80 indicate non-impaired conditions for streams in the Middle Rockies Ecoregion (DEQ 1996b).

The support status of the beneficial use of salmonid spawning is also determined using fisheries data. Full support of salmonid spawning is indicated by the presence of three size classes of a single salmonid species, including young-of-year (i.e., fish less than 100 mm in length).

In 1997, DEQ completed the first cycle of waterbody assessments based primarily on BURP data. These data were collected from 1994 through 1996 on wadeable streams located in all subbasins of the state. The assessment process, which is described elsewhere (DEQ 1996a, 1998b), was used to determine whether a waterbody supported the beneficial uses of cold water aquatic life and salmonid spawning. This process was the basis for developing Idaho's 1998 §303(d) list of water quality impaired waterbodies requiring TMDL development. The guidance for assessing the support status of beneficial uses has recently been revised (Grafe *et. al* 2002). Assessments of the beneficial uses of waterbodies sampled from 1997 through 2000 will now be performed.

Forty-two wadeable streams have been sampled at 71 sites in the Teton Subbasin using the BURP protocol (Figure 14). A preliminary analysis of this data was performed to determine whether the relationship between macroinvertebrates and surface sediment demonstrated by Mebane (2000) using BURP data collected statewide also could be shown for the Teton Subbasin. As previously discussed, Mebane (2000) found a statistically significant inverse correlation between the percentage of fine surface sediment and the richness of EPT species. Using BURP data for the Teton Subbasin shown in Appendix H, analyses were performed to determine whether MBI scores were correlated with percentages of fine sediment, and whether percentages of EPT were correlated with percentages of fine sediment. The percentages of surface fines were divided into four categories: less than 6 mm measured in the bankfull channel, less than 6mm measured in the wetted channel, less than 1 mm measured in the bankfull channel, and less than 1 mm measured in the wetted channel. Analyses were performed using VassarStats, a statistical program available on the Internet at http://faculty.vassar.edu/~lowry/corr_stats.html, and significance was indicated by a one-tailed p value of less than 0.05.

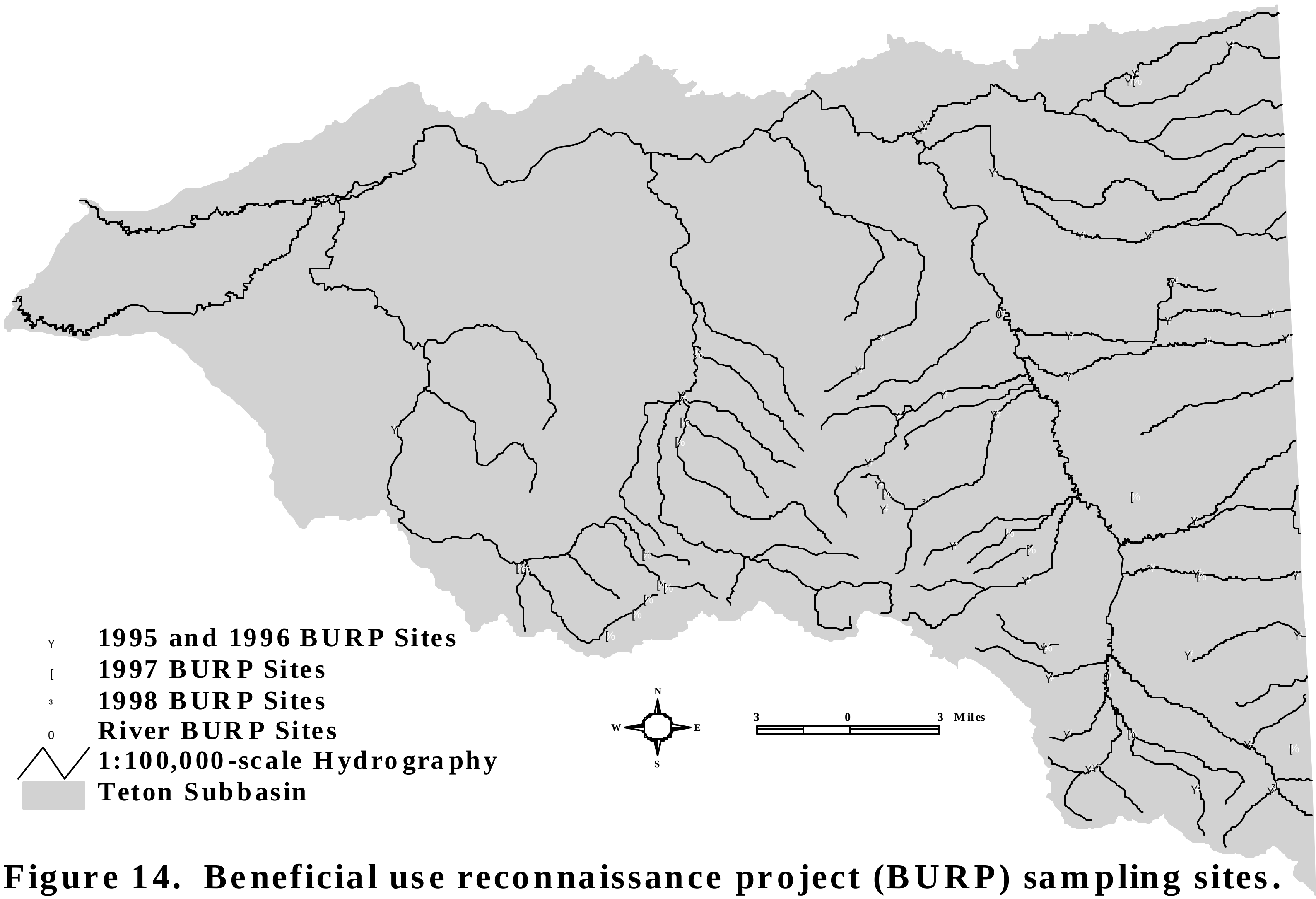

Figure 14. Beneficial use reconnaissance project (BURP) sampling sites.

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These analyses indicated that the percentage of fine sediment measured in the wetted width of the stream channel is a better predictor of desirable macroinvertebrate communities in the Teton Subbasin than the percentage of fine sediment measured in the bankfull width of the channel. Both MBI scores and percentages of EPT were negatively correlated with percentages of surface fines less than 6 mm and less than 1 mm when surface fines were measured in wetted channels, but statistically significant relationships were not observed between the same parameters when surface fines were measured in bankfull channels (Figures 15 and 16). Future measurements of surface fines in the Teton Subbasin, whether conducted as part of the BURP protocol or any other assessment procedure, should be performed in the wetted width of the stream channel.

Based on the relationship between surface fine sediment and MBI score or percentages of EPT, it appears that measurement of surface fine sediment may be a useful method for monitoring the effectiveness of implementation projects for restoring the beneficial use of cold water aquatic life in Teton Subbasin streams. It is important to note, however, that high MBI scores may occur at sites with very high percentages of surface sediment and low percentages of EPT may occur at sites with very low percentages of surface sediment. The correlations between surface fines and MBI score or percentage EPT was slightly stronger when using fines less than 1 mm than when using fines less than 6 mm (Figures 15 and 16), indicating that this size class is most detrimental to the invertebrate community.

Embeddedness does not appear to be as reliable as percentage of surface fine sediment for predicting the quality of the macroinvertebrate community, as represented by the MBI score or percentage of EPT. The correlation between MBI scores and embeddedness ratings was not statistically significant although the correlation between percentages of EPT and embeddedness was significant (Figure 17).

National Pollutant Discharge Elimination System Permit Program

Routine analysis of water quality is legally required under the National Pollutant Discharge Elimination System (NPDES) permit program for discharges of point source pollutants to surface waters. Only two NPDES permits have been issued in the Teton Subbasin in Idaho, and both are for municipal wastewater treatment facilities. These facilities are located in Rexburg (NPDES permit number ID0023817), which discharges effluent into the South Fork Teton River, and Driggs (NPDES permit number ID0020141), which discharges to Woods Creek, a wetlands complex about five miles from the Teton River. These facilities report the results of the following wastewater analyses to DEQ on a monthly basis: biological oxygen demand (BOD), pH, TSS, fecal coliform bacteria, flow, and total residual chlorine. It is important to note that these analyses are performed on the effluent discharged, not on the stream water receiving the effluent, and violations are determined according to the facility's specific NPDES permit requirements, not according to state water quality standards for surface waters. The results of these analyses are reported to EPA Region 10, which has primacy over the NPDES permit program, and to the Idaho Falls Regional Office of DEQ.

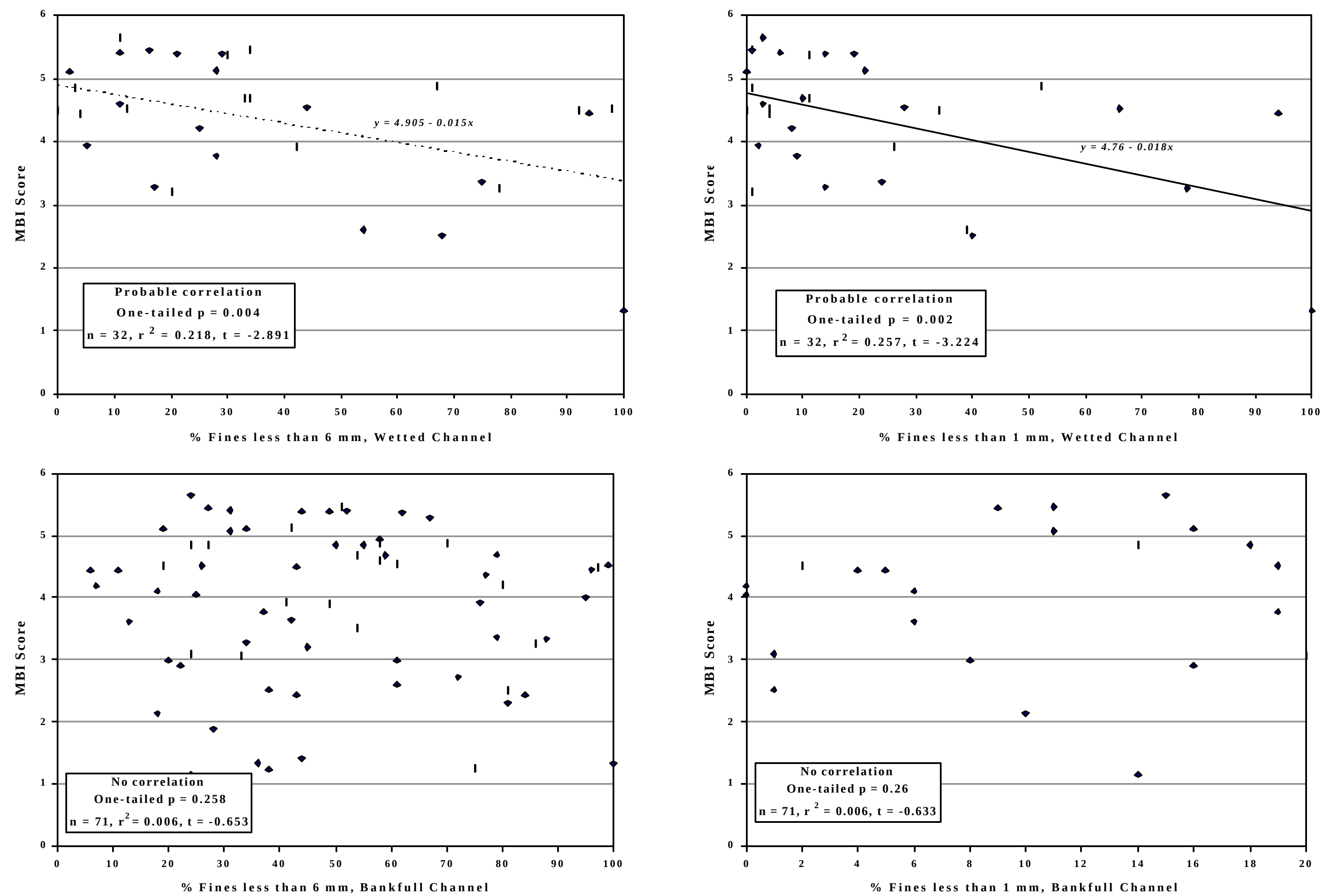


Figure 15. Macroinvertebrate biotic index (MBI) scores plotted against the percentages of fine substrate sediment less than 6 mm or 1 mm in size, as measured in wetted and bankfull channels. The MBI scores are negatively correlated with percentages of fine sediment measured in wetted channels, but are not correlated with percentages of fine sediment measured in bankfull channels.

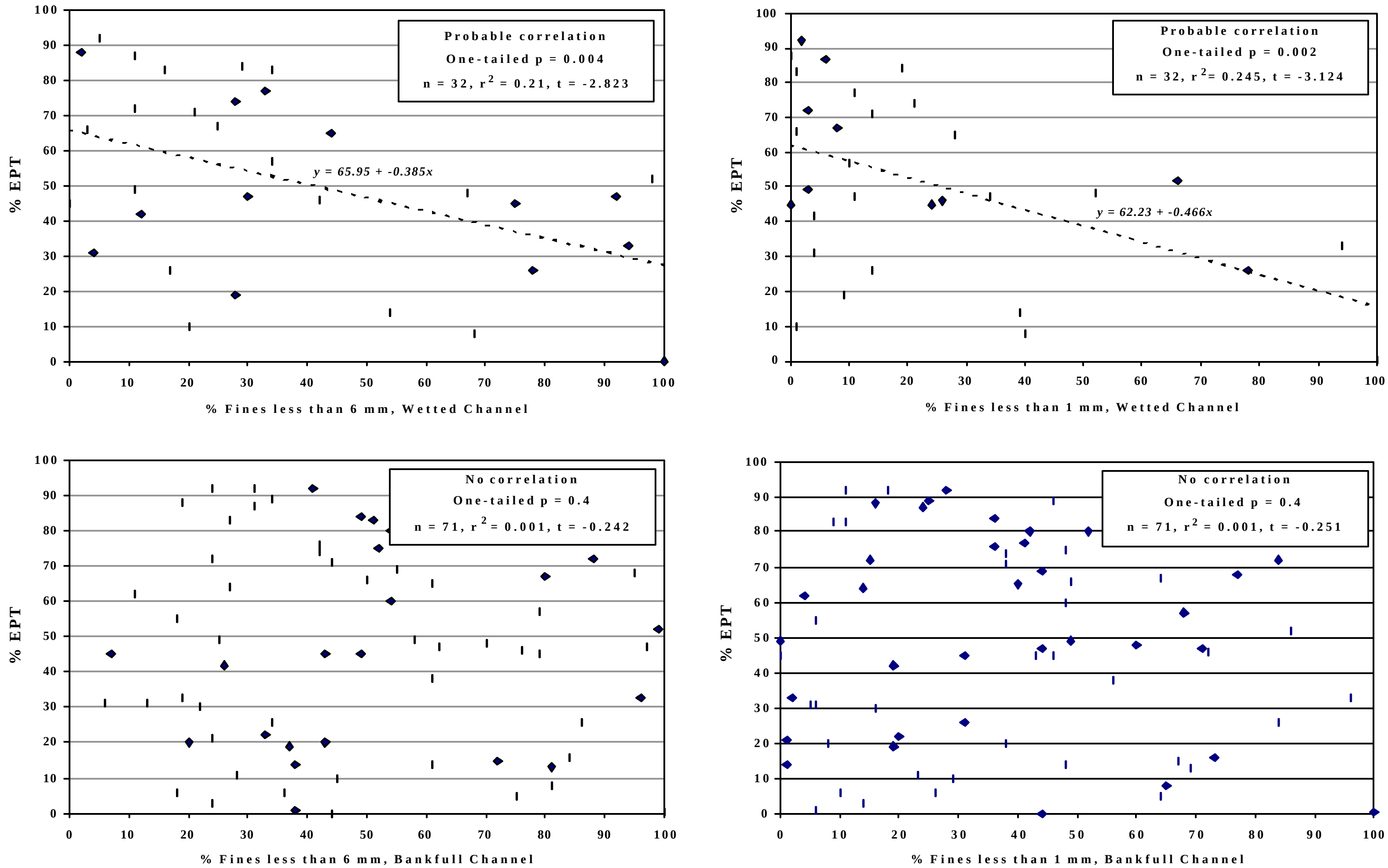
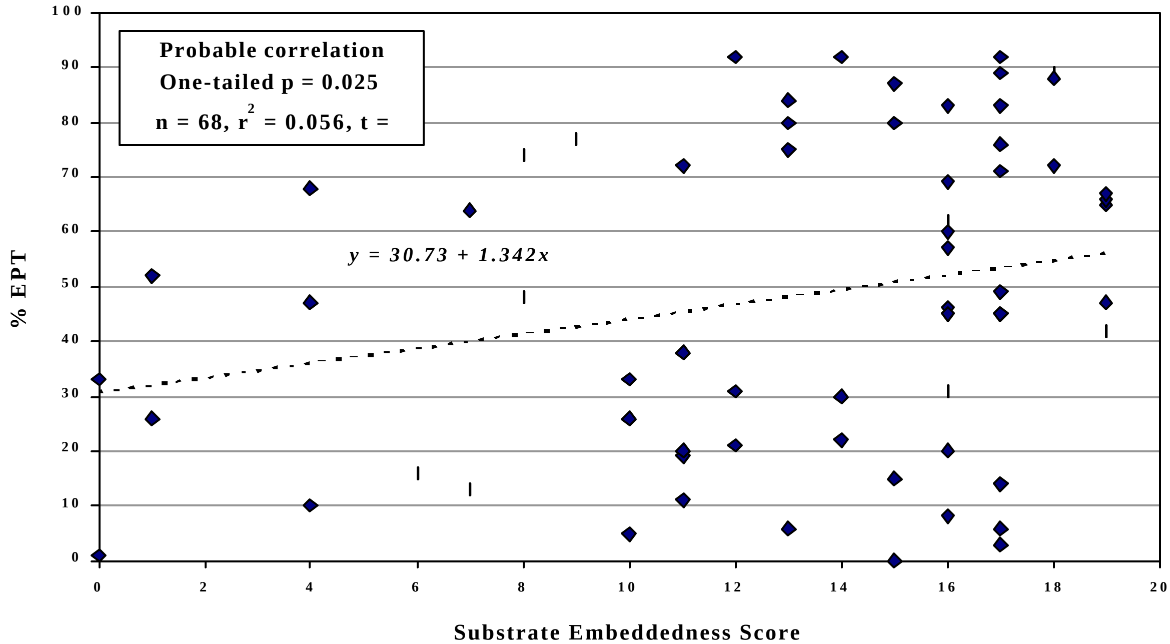


Figure 16. Percentages of insects belonging to the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT) plotted against the percentages of fine substrate sediment less than 6 mm or 1 mm in size, as measured in wetted and bankfull channels. The percentages of EPT are negatively correlated with percentages of fine sediment measured in wetted channels, but are not correlated with percentages of fine sediment measured in bankfull channels.



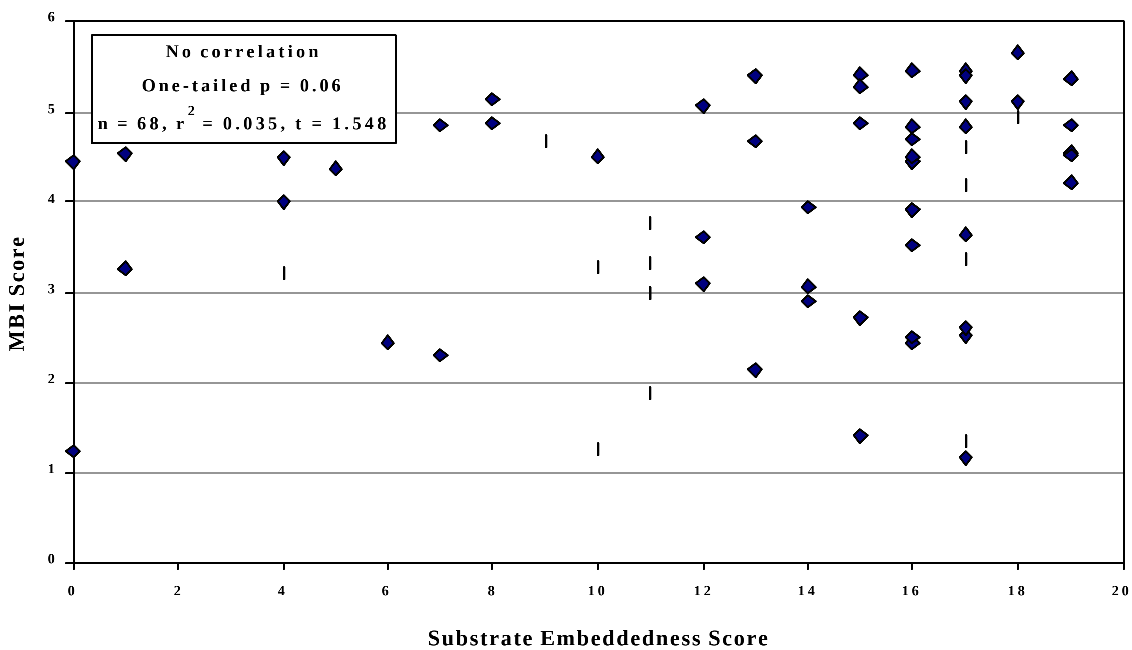


Figure 17. The relationships between percentages of insects belonging to the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT) and embeddedness, and macroinvertebrate biotic index (MBI) scores and embeddedness. Embeddedness is scored qualitatively with 0 indicating the most-embedded substrate and 20 indicating the least-embedded substrate.

The wastewater treatment facility at Grand Targhee Ski and Summer Resort, located east of Driggs in Wyoming, went on line in 1998 and received NPDES permit number WY-24708 from the state of Wyoming, which has primacy for the program. The plant discharges about 20,000 gallons per day in winter and less than 8,000 gallons per day in summer to Dry Creek, a dry channel. The effluent discharged to Dry Creek infiltrates into the channel substrate before the Dry Creek channel converges with another stream (Woodward 2002). None of these wastewater discharges is expected to influence §303(d) listed waters in the subbasin.

In addition to analyses performed on its effluent, the Rexburg municipal wastewater treatment facility is also required to analyze water from the receiving stream (i.e., South Fork Teton River) for temperature, pH, and ammonia nitrogen. Samples for analyses are collected both upstream and downstream of the point of effluent discharge to determine the effect of the discharge on ambient water quality.

Because the Rexburg facility is considered a major discharger (i.e., discharges more than one million gallons of effluent per day), it is also required to perform whole effluent toxicity tests twice yearly. The results of tests conducted in May and November of 1998 and 1999 indicated that the effluent did not contain toxic chemicals in amounts or combinations sufficient to produce short-term chronic toxicity to the invertebrate cladoceran, *Ceriodaphnia dubia,* or the vertebrate fish, *Pimephales promelas* (fathead minnow). Again, it is important to note that the toxicity tests are performed using the effluent discharged by the facility, not the receiving water in the South Fork Teton River, to ensure that toxic chemicals in toxic amounts are not discharged to the river.

Water Column Data

Data for specific water quality parameters such as nitrate, suspended sediment, and temperature were sparse or nonexistent for most surface waters in the Teton Subbasin when this assessment began in 1999. Sources of data included 1) a habitat recovery study conducted from 1976 to 1980 on the North Fork Teton River (SCS 1982), 2) suspended sediment data measured from April 1977 through September 1978 by the USGS at the *North Fork Teton River at Teton, Idaho* gage, 3) water quality data measured intermittently from 1977 to 1996 by the USGS at the *Teton River near St. Anthony* gage, 4) water quality studies conducted by DEQ in the late 1980s (Drewes 1987, 1988, 1993), and 5) baseline nutrient and TSS data collected from 1995 through 1998 by the TSCD for a 15-year water quality improvement project on Bitch Creek. Additional reports (Clark 1994; TSCD 1990, TSCD 1991) and databases (EPA STORET, EPA BASINS model) were reviewed but were found to contain data that were originally reported in the sources cited above. During the course of this assessment, additional nutrient data became available from researchers at Idaho State University and the INEEL (Thomas *et al.* 1999, Manguba 1999, Minshall 2000), and temperature data became available from IDFG (Schrader 2000a) and the BOR (Bowser 1999).

In June and July 1999, DEQ measured turbidity at several stream locations throughout the subbasin, including §303(d)-listed streams. The frequency and distribution of sampling was insufficient to adequately characterize 'background turbidity,' but the analyses provided general information regarding turbidity values during a period of relatively high streamflow. Whenever possible, water samples were collected using a DH-48 depth-integrated sampler, though some samples were simply collected by submerging a sample bottle in the water column. Samples were analyzed using a Hach 2100P portable turbidimeter. The results of these analyses are discussed in the following section along with other data for sediment.

To supplement the limited amount of data available for §303(d)-listed stream segments, DEQ issued a contract in the summer of 2000 for water quality monitoring at 27 sites (Figure 18). Depending on flow conditions, sites were sampled in June, July, and August for TKN, nitrate nitrogen, TSS, stream temperature, pH, conductivity, turbidity, and discharge. Temperature data loggers were placed in streams listed for temperature (Fox Creek and Spring Creek), and subsurface fine sediment was measured in streams listed for sediment (Badger Creek, Darby Creek, Fox Creek, Packsaddle Creek, South Leigh Creek, and Spring Creek). Water depth prevented sampling of subsurface fine sediment in segments of the Teton River that were also listed for sediment. Sampling procedures and analytical methods are described by Blew (undated), and the results of water analyses are presented in Appendix I and discussed in subsequent sections of this report.

Sediment Data

Suspended sediment was measured at least once each month from March 1993 through September 1996 in the Teton River at the *Teton River near St. Anthony* gage. These results did not indicate that consistently high concentrations of sediment were being transported within the depth of the water column sampled. The average concentration of suspended sediment during this period was 8 mg/L while the maximum and minimum values were 38 mg/L and 1 mg/L, respectively (Appendix J). The greatest calculated mass of sediment discharged per day was 306 tons on May 25, 1993, which also corresponded to the highest measured flow of 3,650 cfs.

The results of TSS measured in 1995, 1996, 1997, and 1998 in Bitch Creek at the forest boundary and above its confluence with the Teton River indicated that the target concentration of 80 mg/L is occasionally exceeded during periods of relatively high discharge (Appendix K, Table K-3). Concentrations of 82, 85, and 90 mg/L TSS were measured at the mouth of Bitch Creek in May 1997, May 1996, and June 1995 when discharges were 300 cfs, 443 cfs, and 252 cfs, respectively. However, high discharge did not necessarily correspond to high TSS concentrations. For example, the highest discharge recorded (836 cfs), corresponded with a TSS concentration of 67 mg/L, and a discharge of 433 cfs corresponded with a TSS concentration of only 14 mg/L. Although TSS concentrations were generally higher at the mouth than at the forest boundary, this pattern was not always observed. In April 1997, TSS at the forest boundary was 35 mg/L and only 12 mg/L at the mouth. From mid-July through October, when discharges remained below 200 cfs, concentrations of TSS remained below approximately 10 mg/L. The results of TSS analyses in §303(d)-listed streams in June, July, and August 2000 were consistent with the results for Bitch Creek, with TSS concentrations ranging from less than detection to 27 mg/L (Appendix I).

The results of the limited turbidity data available for the Teton Subbasin indicate that most streams are unlikely to violate Idaho’s turbidity criterion except during extreme runoff events or under conditions where sediment is actively resuspended in the water column. Ten turbidity samples collected at the USGS *Teton River near St. Anthony* gage from 1992 to

1996 ranged from only 0.3 to 6.4 NTU (Appendix J). The results of 35 turbidity analyses conducted by DEQ at 15 sites in June and July of 1999 ranged from 2 NTU to 34 NTU, with a median value of 9 NTU (Table 20). The turbidities measured in June, July, and August of 2000 by DEQ in §303(d)-listed streams ranged from 0.4 to 11 NTU (Appendix I). These values were well below the instantaneous target of 50 NTU above background.

The turbidity of water in Moody Creek in 1999 was exceptionally high when compared to all other sampling sites in the Teton Subbasin. Turbidity values at two sites in the natural stream channel were 57 NTU and 204 NTU. These sites were located near the lower end of the Moody Creek subwatershed, less than five miles upstream of the point at which Moody Creek is channelized. The turbidity of the stream water at the second site may have originated from the Enterprise Canal, which discharges to the stream approximately 500 meters upstream from the sampling site. Just below the second sampling site and approximately two miles east of the South Fork Teton River, the natural channel of Moody Creek has been straightened. The stream s flow is channeled directly to the South Fork or is diverted to the Woodmansee Johnson Canal. The turbidity of Moody Creek water below the point at which the stream is channelized was 70 NTU. This was a decrease of 130 NTU in a distance of approximately two stream miles. Materials causing turbidity were either settling out of the water column, or turbidity was diluted by inflows to Moody Creek from the Teton and East Teton Canals.

The relatively low values for total suspended sediment, TSS, and turbidity indicate that monitoring these parameters on a monthly or even weekly basis is unlikely to detect critical periods of sediment delivery and instream sediment transport. In 1985, 1986, and 1987, TSCD and Soil Conservation Service staff closely monitored runoff in the Milk Creek drainage and determined that high sediment loads were detected in streams for only a few hours following a major rain or runoff event (Smart 2000). If these parameters are incorporated into implementation monitoring plans, efforts should be made to sample at least twice each week during periods of runoff and, when possible, during heavy rain events.

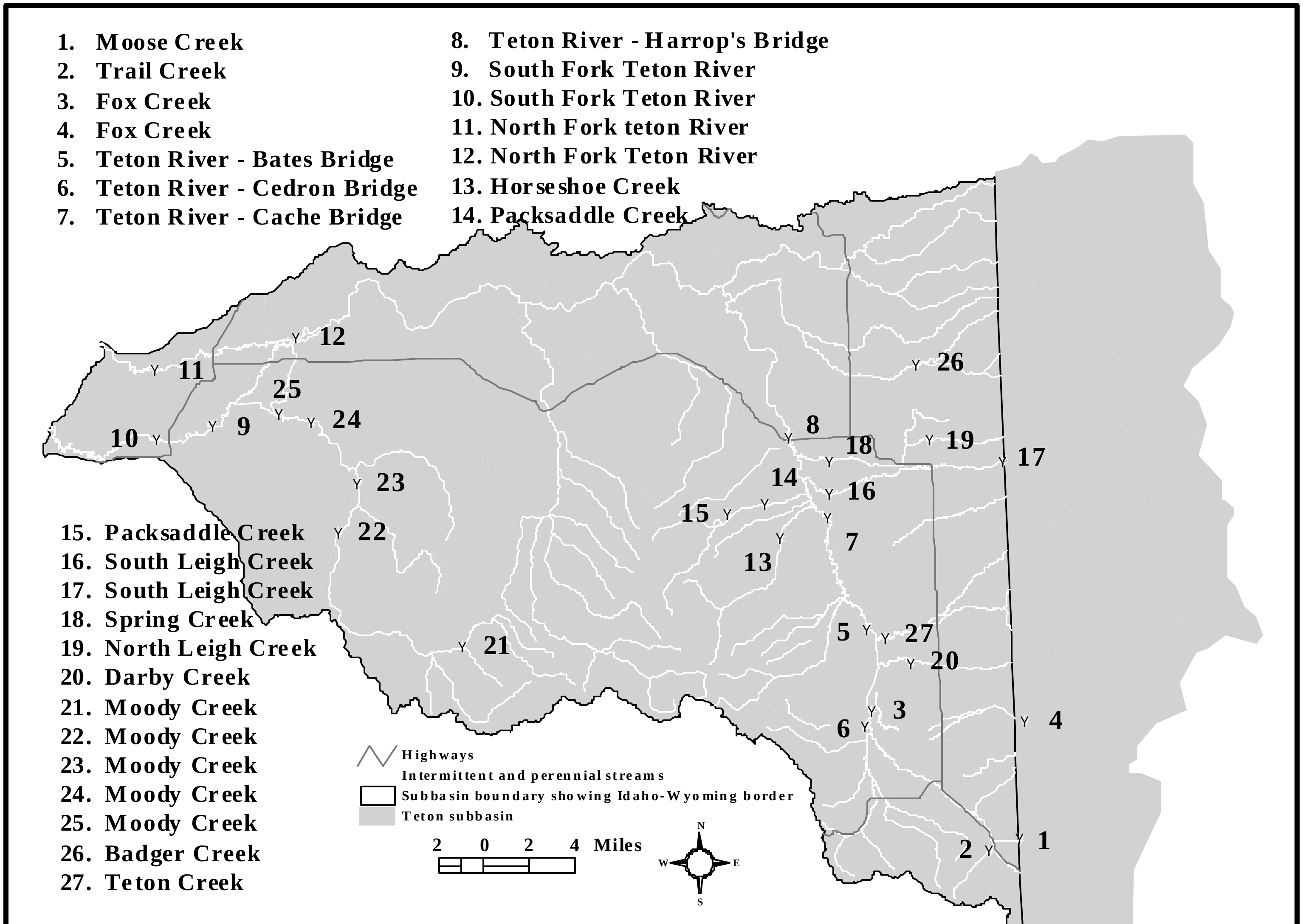


Figure 18. Approximate locations of DEQ water quality sampling sites in 2000.

Table 20. Results of turbidity measurements performed in the Teton Subbasin in 1999.

Stream	Location	Date Sampled	Turbidity (NTU)[1]
Little Pine Creek	Blanchard Road (T3N R45E S19)	6-9-99	32
Warm Creek	South of Highway 31 on 1000S	6-9-99	17
Moose Creek	First bridge on Caribou-Targhee NF[2] (T42N R118W S32)	6-9-99	3
Fox Creek	Trail head on Caribou-Targhee NF (T42N R118W S5)	6-23-99	15
Fox Creek	~1 mile west of Caribou-Targhee NF boundary (T4N R46E S30)	6-23-99	21
Fox Creek	East of Highway 33 near 550S, 50W (T4N R45E S25)	6-9-99	2
Fox Creek	East of Highway 33 near 550S, 50W (T4N R45E S25)	6-23-99	26
Fox Creek	0.15 miles west of Highway 33 on 600S (R45E T4N S26)	6-23-99	22
Darby Creek	0.8 mile east of Caribou-Targhee NF boundary (R118W T43N S20)	6-23-99	4
Darby Creek	~2 miles west of Caribou-Targhee NF boundary (R45E T4N S13)	6-9-99	3
Spring Creek	Tributary of Teton Creek; Stateline Road (R46E T5N S32)	6-9-99	15
Spring Creek	Tributary of Teton Creek; Stateline Road (R46E T5N S32)	6-9-99	15
Spring Creek	Tributary of Teton Creek; west of Highway 33 and east of frontage road	6-9-99	34
Teton Creek	Stateline Road (R118W T44N S30)	6-9-99	3
Teton Creek	Stateline Road (R118W T44N S30)	6-23-99	5
Teton Creek	West side of Highway 33 at bicycle path (R45E T4N S2)	6-23-99	12
South Leigh Creek	East side of Highway 33 (R45E T6N S35)	7-1-99	3
South Leigh Creek	0.5 mile east, 0.5 mile north of Cache Bridge (R45E T5N S6)	7-1-99	4
North Leigh Creek	Below twin culverts on west side of 100E between 600N and 700N (R45E T6N S25)	7-1-99	7
Spring Creek	East of Tetonia on 650N (R45E T6N S27)	7-1-99	6
Spring Creek	1.5 miles west of Tetonia (R45E T6N S 30)	7-1-99	8
Badger Creek	~2.5 miles east of Felt (R45E T6N S10)	7-1-99	3
Badger Creek	2 miles north of Felt, 2.5 miles west of Highway 32 (R44R T7N S26)	7-1-99	6
Horseshoe Creek	Near confluence with Teton River (R44E T5N S12)	7-1-99	7
Packsaddle Creek	~0.5 mile northeast of Caribou-Targhee NF boundary (R44E T5N S8)	7-1-99	4
Teton River	Bates Bridge (R45E T4N S5)	6-23-99	11
Teton River	Rainer Campground (R45E T5N S13)	7-1-99	8
Teton River	Cache Bridge (R45E T5N S12)	7-1-99	13
Teton River	Harrop s Bridge at Highway 33 (R44E T6N S23)	7-1-99	8
Moody Creek	Moody Creek Elbow (R41E T6N S34)	6-10-99	57
Moody Creek	0.5 mile south of 2000N, 6000E (R41E T6N S17)	6-10-99	204
Moody Creek	Intersection of 2000N, 4000E (R40E T6N S12)	6-10-99	70
North Fork Teton R.	~1.5 miles west of Forks (R40E T7N S36)	6-10-99	14

Stream	Location	Date Sampled	Turbidity (NTU)[1]
South Fork Teton R.	North of Teton (R41E T7N S31)	6-10-99	16
South Fork Teton R.	1 mile south and 0.5 mile east of Sugar City on 2000N (R40E T6N S10)	6-10-99	17
South Fork Teton R.	In Rexburg at USGS[3] gage (R40E T6N S20)	6-10-99	29
South Fork Teton R.	West of Rexburg on Hibbard Road (R39E T6N S24)	6-10-99	22

[1]Nephelometric turbidity unit
[2]U.S. Forest Service
[3]U.S. Geological Survey

Nutrient Data

Water samples collected by the USGS at gage station 13055000, *Teton River near St. Anthony*, were analyzed for nutrients twice in water years 1976, 1980, and 1981; bimonthly in water year 1990; approximately monthly in water years 1993, 1994, and 1995; and monthly from April through October in 1999. These samples were consistently analyzed for total phosphorus and dissolved $NO_2 + NO_3$ (Appendix J), and sometimes for dissolved phosphorus, dissolved orthophosphorus, dissolved NO_2, and/or dissolved ammonia.

Water quality data from the *Teton River near St. Anthony* gage station indicate that total phosphorus concentrations originating in the subbasin upstream of the North and South Forks of the Teton River are well below the value of 0.1 mg/L recommended by the EPA for streams that do not flow into lakes. More than 96% of samples contained less than 0.05 mg/L total phosphorus, and only 2% contained concentrations greater than 0.1 mg/L. One of these samples, collected in October 1977, contained more than ten times the typical concentration, indicating that it was an aberrant measurement. In contrast, the concentrations of dissolved $NO_2 + NO_3$ equaled or exceeded the target concentration of 0.3 mg/L in more than half (38 of 72) of the samples analyzed. Concentrations of $NO_2 + NO_3$ ranged from 0.06 to 1.0 mg/L, and fluctuated in a regular pattern over time. Figure 19 illustrates this pattern using data collected from December 1992 through September 1996: concentrations of $NO_2 + NO_3$ are highest from October through April, decline to their lowest levels in June, then begin to increase slightly in August and September. An analysis of data from all years showed that concentrations   0.3 mg/L were measured during all months except June.

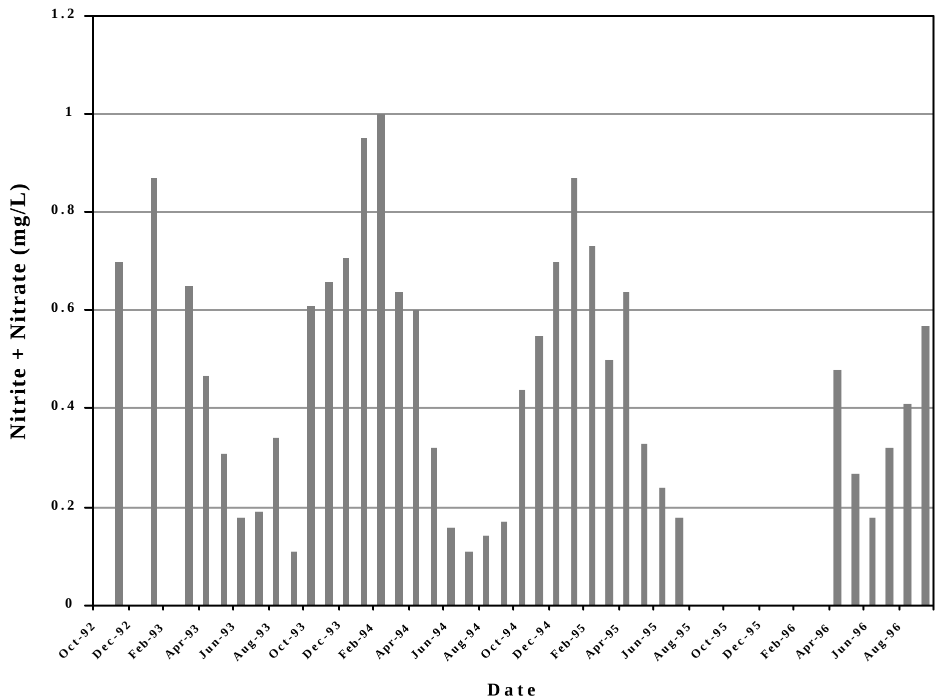


Figure 19. Concentrations of NO_2 + NO_3 in samples of water collected from December 1992 through September 1996 by the U.S. Geological Survey at the *Teton River near St. Anthony* gage station.

Nutrient data for other locations also indicate that concentrations of phosphorus in the subbasin are below the criterion of 0.1 mg/L set by the EPA, whereas concentrations of NO_2 + NO_3 often exceed the target of 0.3 mg/L. The largest data set for any location other than the *Teton River near St. Anthony* gage has been collected by the TSCD as part of the South Bitch Creek State Agricultural Water Quality Project (SAWQP). This project includes a long-term water quality monitoring component for the purpose of evaluating the effectiveness of agricultural best management practices in the Bitch Creek subwatershed. Water samples were collected approximately twice monthly, when sites were accessible, from May 1995 through May 1998 to establish baseline water quality conditions. More than 60 samples were collected upstream of cultivated agricultural lands at the forest boundary and downstream at the mouth of Bitch Creek near its confluence with the Teton River (Appendix K). The results of monitoring indicate that:

1. Concentrations of total phosphorus ranged from <0.01 mg/L to 0.1 mg/L in Bitch Creek at the forest boundary, and from <0.01 to 0.13 mg/L in Bitch Creek at its mouth. Concentrations in only three percent of the samples exceeded 0.1 mg/L, and concentrations in only 21% of the samples exceeded the detection level of 0.05 mg/L.

2. Concentrations of total phosphorus in Bitch Creek at the forest boundary were comparable to concentrations at the mouth, indicating that agriculture was not a significant source of phosphorus in the subwatershed. Two samples (3%) collected at each site exceeded 0.1 mg/L total phosphorus, 10 of 60 (16.7%) samples collected at the forest boundary equaled or exceeded 0.05 mg/L total phosphorus, and 16 of 62 (25.8%) samples collected at the mouth equaled or exceeded 0.05 mg/L total phosphorus.

3. Concentrations of $NO_2 + NO_3$ were generally higher in water collected at the mouth of Bitch Creek than in water collected at the forest boundary, indicating that agricultural practice is a source of nitrogen in the subbasin. More than 80 percent of the samples collected at the forest boundary contained concentrations less than 0.1 mg/L $NO_2 + NO_3$, compared with only 23% of the samples collected at the mouth. Concentrations ranged from <0.1 mg/L to 1.23 mg/L at the forest boundary and from 0.03 mg/L to 1.94 mg/L at the mouth. By comparison, median $NO_2 + NO_3$ concentrations in surface water collected from the Snake River at Flagg Ranch, Wyoming, an area considered unaffected by all nitrogen sources except precipitation and domestic septic systems, was less than 0.1 mg/L as N, and median total nitrogen concentration was only about 0.35 mg/L (Clark 1994, as cited in Rupert 1996).

4. Because more than 80 percent of the samples collected at the forest boundary contained concentrations of less than 0.1 mg/L $NO_2 + NO_3$, the concentrations in four samples collected at this site in September and October 1995 (1.18 mg/L, 0.55 mg/L, 1.23 mg/L, and 0.41 mg/L) appear anomalous. Less than two weeks before and after these samples were collected, concentrations of $NO_2 + NO_3$ were less than 0.05 mg/L. Furthermore, the abrupt increase and decrease in concentrations did not occur at the same time in 1996. Drewes (1993) reported a concentration of 1.1 mg/L $NO_2 + NO_3$ in a sample collected on Bitch Creek at the forest boundary. But a sample collected the same day from the mouth of Bitch Creek contained only 0.003 mg/L, indicating the possibility that the samples were incorrectly labeled or the results inaccurately reported. The validity of these results is important because concentrations measured downstream in samples collected on the same dates (1.94 mg/L, 1.65 mg/L, and 1.73 mg/L) were substantially higher than concentrations measured at any other time on Bitch Creek. If these results were correct, they indicate sources of nitrogen other than cultivated agriculture.

5. Data collected at the forest boundary and the mouth of Bitch Creek show the same trend in concentrations of $NO_2 + NO_3$ as the data collected at the USGS gage station, but because the peak concentrations at the forest boundary are much lower than at the mouth, this trend is less apparent (Figure 20).

6. Concentrations of $NO_2 + NO_3$ in samples collected at the mouth of Bitch Creek generally exceeded 0.3 mg/L from August through November and February through April (sampling was not conducted in December or January because sites were inaccessible), and were less than 0.3 mg/L from May through July (Figure 20). This trend differs from the trend observed for samples collected at the *Teton River near St. Anthony* gage in that June was the only month in which all Teton River samples contained concentrations less than 0.3 mg/L.

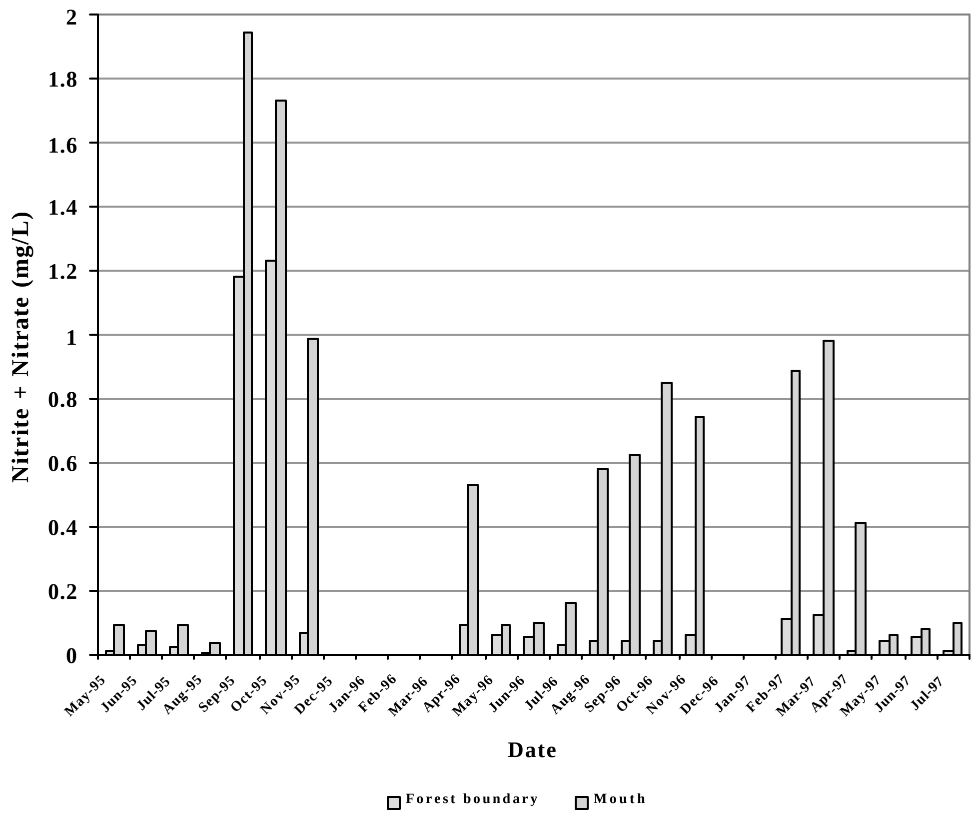


Figure 20. Concentrations of $NO_2 + NO_3$ in samples of water collected from Bitch Creek at the National Forest boundary and mouth from May 1995 through May 1998.

Concentrations of $NO_2 + NO_3$ greater than 0.3 mg/L have been reported for a variety of sampling locations along the Teton River, including the upper Teton River and North Fork Teton River. The Soil Conservation Service sampled the Teton River upstream of the North and South Forks near the location of the *Teton River near St. Anthony* gage, and downstream of the forks at four locations. This sampling was done as part of a study to evaluate habitat recovery within the channel of the North Fork following collapse of the Teton Dam (SCS 1982). Samples were collected on 18 days over a period of 44 months, but only three of those days occurred during May, June, and July, the months during which the lowest $NO_2 + NO_3$ concentrations were observed for samples collected at the *Teton River near St. Anthony* gage. Results of analyses were reported for NO_2 separately from NO_3, as opposed to combined $NO_2 + NO_3$. Fewer than 25% of the samples contained concentrations of less than 0.3 mg/L NO_3, though the low number of samples collected during summer months may have skewed this result. It is interesting to note that concentrations of NO_3 were sometimes lower at downstream sites, despite contributions of irrigation return flows from the Farmers Friend, Fall River, Wilford, and Salem Union Canals. Concentrations of orthophosphorus were greater than 0.1 mg/L on three occasions (December 27, 1976; January 3, 1977; and July 3, 1980), but generally concentrations were much less than 0.05 mg/L.

Concentrations of NO_3 in samples collected at several locations in the upper Teton River over a period of 13 years show the same trends as concentrations in samples collected by the USGS at the *Teton River near St. Anthony* gage. Drewes (1987 and 1993) collected samples of Teton River water at five sites located from above the confluence of Horseshoe Creek (Cache Bridge) to below the confluence of Canyon Creek (Appendix L, Table L-1). Only six of 37 samples contained concentrations of $NO_2 + NO_3$ less than 0.3 mg/L, and four of these samples were collected in June. Approximately ten years later, Manguba (1999), Thomas *et al.* (1999), and Minshall (2000) collected samples at several locations on the Teton River, including two sampled by Drewes (Cache Bridge and Harrop s Bridge). Once again, their data indicate that concentrations of $NO_2 + NO_3$ in the Teton River typically exceed 0.3 mg/L in all months except June. The concentrations of $NO_2 + NO_3$ reported for 1997 often exceeded 1 mg/L, and the highest concentration of $NO_2 + NO_3$ reported for the entire Teton Subbasin (2.14 mg/L) was for a sample collected in September 1997 at Bates Bridge (Appendix L, Table L-1). Because these data are for sites extending from the upper Teton River to the lower Teton River, they also reveal that concentrations of $NO_2 + NO_3$ in the Teton River appear to decrease in a downstream direction, with lowest concentrations occurring in the North and South Forks of the Teton River (Tables 21 and 22).

Most of the nutrient data available for tributaries of the Teton River were reported by Drewes (1987, 1988, and 1993), and are for samples collected from 1986 through 1990 (Appendix L, Tables L-2 and L-3). Precipitation, runoff, and surface water flows were considered below average during this period, and numerous data gaps occurred because lack of flow precluded sample collection. However, a comparison of data reported by the TSCD (Appendix K) and Drewes (Appendix L, Table L-2) show similarities for samples collected at Bitch Creek near the confluence with the Teton River for all months except October. The TSCD reported $NO_2 + NO_3$ concentrations ranging from 0.74 mg/L to 1.73 mg/L in October of 1995 and 1996, whereas Drewes reported a concentration of only 0.003 mg/L in October 1988.

Coincidentally, the concentration of $NO_2 + NO_3$ reported by Drewes (1993) for a sample collected on the same date on Bitch Creek at the forest boundary was 1.13 mg/L (Appendix L, Table L-2). This value is consistent with concentrations reported by the TSCD for Bitch Creek at the confluence with the Teton River, and indicates that the results reported by Drewes (1993) for Bitch Creek in October may have been transposed or the samples incorrectly labeled when they were collected. Assuming this interpretation is correct, the data shown in Table 22 and Appendix L, Table L-2 indicate that 1) concentrations of $NO_2 + NO_3$ increased in Badger Creek between the forest boundary and its confluence with the Teton River in a manner similar to that which occurred in Bitch Creek, 2) the $NO_2 + NO_3$ concentration exceeded 0.3 mg/L in Canyon Creek only once during a period of more than 36 months, 3) $NO_2 + NO_3$ concentrations in Canyon Creek did not fluctuate seasonally in the same manner as concentrations in Bitch or Badger Creeks, and 4) $NO_2 + NO_3$ concentrations were typically far below 0.3 mg/L in streams originating in the Big Hole Mountains (Horseshoe, Packsaddle, Milk, and Canyon Creeks) and in Spring and South Leigh Creeks.

Table 21. Concentrations of NO_3 (mg/L as N) in samples collected from Fox Creek and the upper Teton River in 1997, 1998, and 1999.[1] Concentrations of NO_3 greater than 0.3 mg/L are highlighted with italic type.

Date	Fox Creek near Confluence with Teton River	Teton River at Bates Bridge	Teton River at Rainer Campground	Teton River at Cache Bridge	Teton River at Highway 33 (Harrop's Bridge)
6/4/97		0.21		0.09	0.03
6/25/97		*0.38*		0.22	0.17
7/16/97		*0.53*		*0.58*	*0.62*
8/6/97		*1.53*		*0.93*	*0.94*
8/27/97		*1.50*		*0.91*	*0.83*
9/17/97		*2.14*		*1.05*	*1.02*
10/8/97		*1.38*		*1.23*	*1.07*
3/4/98		*1.65*		*1.01*	*0.68*
4/29/98		*1.22*		*0.39*	*0.57*
8/1/98	*0.85*		*0.86*		*0.51*
6/99	*0.789*		0.266		0.022
8/12/99	*1.192*		*0.842*		*0.590*
10/3/99	*1.154*				*0.312*

[1]Data for Teton River at Bates Bridge, Teton River at Cache Bridge, and Teton River at Highway 33 (Harrop's Bridge) prior to 8/1/98 from INEEL (Manguba 1999); 8/1/98 data from Thomas *et al*. (1999); all other data from Minshall (2000).

Table 22. Concentrations of NO_3 (mg/L as N) in samples collected from the Teton River Canyon and North and South Forks Teton River in 1998 and 1999.[1] Concentrations of NO_3 greater than 0.3 mg/L are highlighted with italic type.

Date	Teton River at Spring Hollow	Teton River at Teton Dam Site	South Fork Teton River	North Fork Teton River
8/1/98	*0.66*	*0.54*	0.29	0.22
6/99	0.157	0.156	0.128	0.184
8/12/99	*0.806*	*0.694*	*0.475*	
10/3/99		*0.801*		

[1]8/1/98 data from Thomas *et al*. (1999); all other data from Minshall (2000).

The seasonal changes in $NO_2 + NO_3$ concentrations indicate that concentrations decrease when water temperatures are warm and plants are using available nitrogen and flows are at their highest levels and dominated by snowmelt. Conversely, concentrations increase when 1) low temperatures limit plant growth and utilization of nitrogen, 2) decomposition of accumulated plant material is releasing nitrogen to the water column, and 3) low surface water flows combined with recharge of ground water from the previous runoff may allow the release of ground water and its nitrogen to the river channel.

Sources of Nitrogen in the Teton Subbasin Rupert (1996) analyzed nitrogen input and loss for the upper Snake River Basin, and calculated the amount of residual nitrogen produced in each county within the basin in 1990. He based his analysis on assumptions that included the following:

1. The primary nonpoint sources of nitrogen input to the basin are cattle manure, fertilizer, legume crops, precipitation, and domestic septic systems.

2. Precipitation is the only major source of naturally occurring nitrate (NO_3) in the basin and contains from 0.18 to 0.27 mg/L total N.

3. The average dairy cow produces between 0.41 and 0.59 lb/day total nitrogen, the average beef cow produces between 0.34 and 0.43 lb/day total nitrogen, alfalfa produces between 60 lb/acre and 225 lb/acre total nitrogen, and domestic septic systems produce between 0.01 and 0.04 lb per person per day total nitrogen.

4. Nitrogen loss occurs through storage and application of cattle manure, crop uptake, and decomposition of previous-year nonleguminous crop residue.

Because of insufficient data, processes involving native vegetation were not considered in the analysis, nor were losses due to denitrification of fertilizer or domestic septic system effluent.

Carryover of total nitrogen from previous years was not included in the analysis, though the author noted that carryover could cause all of the residual nitrogen estimates to increase.

The mean, maximum, and minimum residual nitrogen values calculated by Rupert (1996) for counties located in and around the Teton Subbasin, and for counties within the upper Snake River Basin that produced the highest (Twin Falls) and lowest (Power) residual nitrogen values are listed in Table 23. Based on mean residual nitrogen values for Madison County and Teton County, Idaho, approximately 4,408 tons of excess nitrogen were produced in the Teton Subbasin in 1990. According to Rupert (1996), "[t]his residual total nitrogen is available for runoff to surface water or leaching to ground water." He also noted that in three out of four counties where mean values of residual nitrogen were highest (Cassia, Gooding, and Twin Falls), eutrophication in the Snake River was evident and ground water from many wells contained anomously high nitrate concentrations.

Table 23. Approximate ranges of residual nitrogen estimated by Rupert (1996) for counties in the Teton Subbasin for water year 1990. Counties with the highest (Twin Falls) and lowest (Power) residual amounts of nitrogen in the upper Snake River Basin are shown for comparison.[1]

County	Mean Residual Nitrogen		Maximum Residual Nitrogen		Minimum Residual Nitrogen	
	Millions of Kilograms	Tons[2]	Millions of Kilograms	Tons	Millions of Kilograms	Tons
Madison	2	2,204	4.5	4,959	-0.5	-551
Teton, ID	2	2,204	3.75	4,133	0.25	276
Teton, WY	4	4,408	5	5,510	3	3,306
Fremont	2.5	2,755	5.75	6,337	-0.75	-827
Twin Falls	8.75	9,643	16	17,632	1	1,102
Power	-2.5	2,755	1.25	1,378	-6.25	6,888

[1]Rupert (1996) displayed data graphically instead of numerically, so the data shown in this table are approximations of values contained in Figure 4 of his report.
[2]Calculated by multiplying amount in kilograms by 1.102×10^{-3}.

For the entire upper Snake River Basin, Rupert (1996) calculated that 45 percent of residual nitrogen originated from fertilizer, 29 percent originated from cattle manure, 19% originated from legume crops, 6 percent originated from precipitation, and less than 1% originated from domestic septic systems. But he observed that input from fertilizer, cattle manure, and legume crops varied widely among counties, reflecting differences in land use practices, cropping patterns, and numbers of dairies and feedlots. For the six-county region that included Madison County and Teton County, Idaho, approximately 58% of residual nitrogen originated from fertilizers, 19% originated from cattle manure, 19% from legume crops, less than 5% from precipitation, and less than 1% from domestic septic systems. Rupert (1996) combined Fremont, Madison, Teton (ID), Jefferson, Bonneville, and Bingham Counties into “Central Counties.” Teton, Sublette, and Lincoln Counties, Wyoming, and Caribou, Bannock, and Power Counties, Idaho, were combined into the “Southern and Eastern Counties.” For the six-county region that includes Teton County, Wyoming, approximately 26% of residual nitrogen originated from fertilizers, 40% originated from cattle manure, 21% originated from legume crops, 13% originated from precipitation, and much less than 1% originated from domestic septic systems. Rupert’s estimate of the amount of nitrogen originating from fertilizer in Teton County, Idaho, compares well with the estimate made in the *Teton River Basin Study* (TSCD 1992). Based on the assumption that each ton of cropland-generated sediment contained three pounds of nitrogen, the *Teton River Basin Study* (TSCD 1992) estimated that 226 tons of nitrogen were generated from cropland in the area of the Teton Subbasin upstream of, and including, the Badger Creek and Packsaddle Creek subwatersheds. The amount of residual nitrogen in the Teton River Basin originating from fertilizer was calculated by dividing the residual nitrogen for Teton County, Idaho (Table 23) by half to adjust for acreage. This figure was multiplied by Rupert's figure of 58 percent to adjust for the amount of nitrogen originating from fertilizer. The results ranged from 80 to 1,199 tons with a mean of 639 tons. The amount of sediment-associated nitrogen estimated in the *Teton River Basin Study* was within this range although it was only about one-third of the mean value (i.e., 226 tons/639 tons). These results indicate that the amount of nitrogen originating from fertilizer in the Teton Subbasin is probably somewhat less than the percentage estimated by Rupert (1996).

Clark (1994), in an analysis of nutrient data collected in the upper Snake River Basin from 1980 through 1989, observed that "concentrations of nitrite plus nitrate were largest in samples collected at the mouths of tributary drainage basins with a large amount of agricultural activity." Concentrations of $NO_2 + NO_3$ at stations categorized as "unaffected or minimally affected by urban or agricultural land use" ranged from 0.025 to 0.65 mg/L as N, whereas concentrations at stations categorized as "agriculturally affected" ranged from 0.125 to 3.2 mg/L as N (Table 24). Furthermore, seasonal variations in concentrations of $NO_2 + NO_3$ differed between these two categories of sampling stations. The median $NO_2 + NO_3$ concentrations increased from 0.1 mg/L in winter (January to March) to 0.14 mg/L in spring (April to June) at unaffected stations, but decreased from 1.4 mg/L to 1 mg/L at affected stations (Table 24).

Clark (1994) speculated that residual nitrogen flushed from soils during snowmelt was responsible for the increased springtime concentration of $NO_2 + NO_3$ at agriculturally unaffected stations, and that "the combined effects of dilution from increased streamflow and uptake of excess nitrogen by aquatic plants" was responsible for the decreased springtime concentrations at affected stations. Furthermore, he states that:

> As streamflows decrease later in the summer, ground water, which is a source of nitrogen to streams in part of the Snake River Basin, becomes an increasingly important component of streamflow, and nitrite plus nitrate and total nitrogen concentrations in the water column increase. In addition, aquatic plants die and mineralize, contributing additional nitrogen to streams.

Table 24. Median seasonal concentrations of $NO_2 + NO_3$ reported by Clark (1994) for "agriculturally unaffected" and "agriculturally affected" sampling stations in the upper Snake River Basin, and median seasonal concentrations of $NO_2 + NO_3$ calculated for three sampling stations within the Teton Subbasin.

Sampling Station	Median Concentration of $NO_2 + NO_3$ (mg/L as N)[1] [10th, 90th Percentile] or {Range} (n)			
	Jan. - March	April - June	July - Sep.	Oct. - Dec.
Unaffected Stations[2]	0.1 [0.1, 0.45] (48)	0.14 [0.1, 0.65] (49)	0.1 [0.05, 0.25] (59)	0.1 [0.025, 0.2] (46)
Affected Stations[3]	1.4 [0.7, 3.2] (77)	1 [0.25, 1.5] (84)	1.65 [0.125, 2] (89)	1.75 [0.75, 2.7] (74)
Bitch Creek at Mouth[4]	0.89 [0.52, 1.0] (15)	0.11 [0.06, 0.58] (33)	0.28 [0.09, 1.65] (15)	0.92 [0.74 - 1.73] (6)
Teton River at Highway 33[5]	0.68 (1)	0.1 [0.02 - 0.57] (4)	0.73 [0.51 - 1.02] (6)	0.69 [0.31 - 1.07] (2)
Teton River at St. Anthony[6]	0.73 [0.5, 1] (11)	0.22 [0.1, 0.48] (28)	0.26 [0.08, 0.57] (22)	0.61 [0.09, 0.71] (11)

[1]Clark (1994) displayed data graphically instead of numerically, so data shown in this table are approximations of values contained in Figures 23 and 24 of his report.
[2]Examples of stations categorized as "unaffected or minimally affected by urban or agricultural land use" are the Snake River near Flagg Ranch, WY, and Rock Creek near Rock Creek, ID.
[3]Examples of stations categorized as "agriculturally affected" are the Henry's Fork near Rexburg, Blackfoot River near Blackfoot, and Rock Creek near Twin Falls.
[4]Calculated using data contained in Appendix K
[5]Calculated using data contained in Appendix L, Table L-1
[6]Calculated using data contained in Appendix J

Therefore, according to Clark (1994), the concentration of $NO_2 + NO_3$ in surface water in the upper Snake River Basin appears to be a function of its concentration in ground water. Precipitation, surface runoff, and aquatic plant growth and senescence are secondary factors that modify the concentration of $NO_2 + NO_3$ in surface water on a seasonal basis.

The median seasonal concentrations of $NO_2 + NO_3$ at three sampling locations in the Teton Subbasin were calculated using the data shown in Table 21, Appendix J, and Appendix K. The results are listed in Table 24 along with the concentrations reported by Clark (1994) for agriculturally affected and unaffected stations. As expected, the seasonal concentrations of $NO_2 + NO_3$ for sites in the Teton Subbasin correspond most closely to concentrations for agriculturally affected stations, with the highest median concentrations occurring in the fall and winter and the lowest concentrations occurring in the spring. The median concentration of $NO_2 + NO_3$ in samples collected from the Teton River at Highway 33 was highest from July through September whereas at Bitch Creek and the Teton River near St. Anthony, concentrations of $NO_2 + NO_3$ remained similar to springtime concentrations. Although this comparison was based on relatively few samples from the Highway 33 site, these results indicated that the hydrological, chemical, and biological processes that influence nitrogen concentrations in surface water upstream of Highway 33 differ from the processes that influence concentrations downstream.

Because of the contribution of spring flows to surface water flows in the upper Teton Subbasin, it is reasonable to assume that concentrations of nitrate in ground water strongly influence surface water quality. From the headwaters of the Teton River to the confluence of Badger Creek, all of the streams that discharge to the river year-round are spring-fed. Data collected by DEQ for public drinking water wells in the Teton Subbasin show that concentrations of nitrate in ground water east of Harrop's Bridge at Highway 33 range from less than detection level (0.05 mg/L as N) to 3 mg/L as N. The maximum nitrate concentrations measured in water samples from eleven wells were less than 1 mg/L as N, whereas the maximum concentrations in water samples from nine wells ranged from 1 mg/L to 3 mg/L as N. These values are consistent with concentrations measured in the Teton River, and indicate that the springs supplying surface water flows originate in the same aquifers that supply drinking water.

Downstream of Harrop's Bridge in the vicinity of Rexburg, nitrate concentrations in water samples taken from public drinking water systems are generally much higher than in the Teton Valley. These concentrations range from 1.5 mg/L to 11 mg/L as N (Figure 21). Concentrations in surface water in the vicinity of Rexburg are not as high as concentrations in ground water because the direction of water movement is from the surface down to the aquifer instead of from the aquifer up to the surface. Protection of ground water from nitrate contamination is important because of the potential human health effects, particularly in infants. The maximum contaminant level (MCL) for nitrate in drinking water, established by the EPA to protect human health, is 10 mg/L as N. As discussed in an earlier section of this assessment, the concentration of nitrate that may produce ecological effects in surface water is only about one-tenth of the MCL.

Fate of Residual Nitrogen in the Teton Subbasin Rupert (1996) described the fate of excess nitrogen in the region of the upper Snake River Basin between Milner Dam and King Hill as follows:

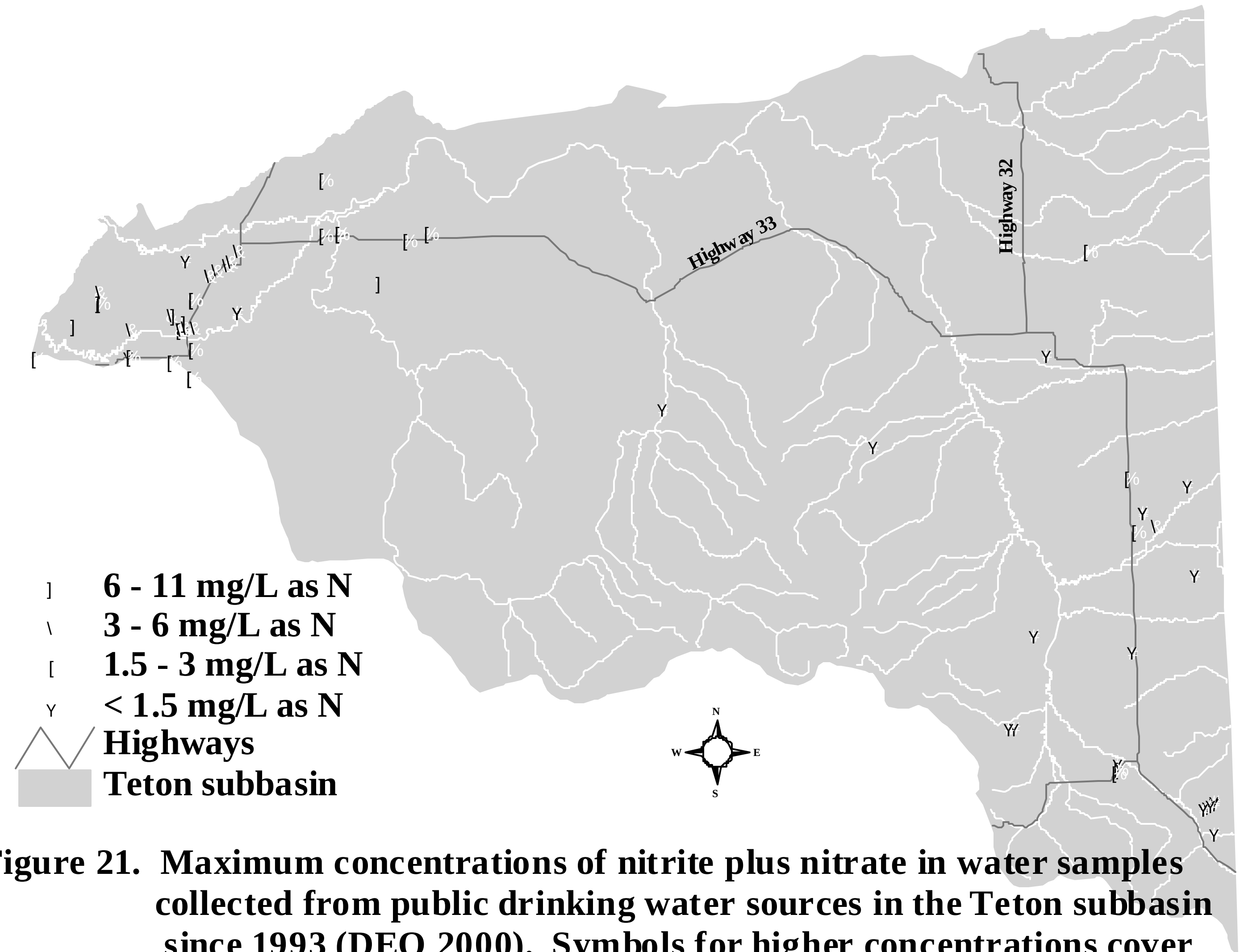


Figure 21. Maximum concentrations of nitrite plus nitrate in water samples collected from public drinking water sources in the Teton subbasin since 1993 (DEQ 2000). Symbols for higher concentrations cover symbols for lower concentrations.

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> This excess nitrogen probably is utilized by aquatic vegetation in the Snake River, stored as nitrogen in soil, stored as nitrate in the ground water, and utilized by noncrop vegetation. Falter and Carlson (1994...) showed that aquatic vegetation removes nitrogen from the water column in the Snake River. Clark (1994) also suggested that aquatic vegetation removes nitrogen in the river during the growing season. Some of the nitrogen supplied by cattle manure, fertilizer, legume crops, precipitation, and domestic septic systems can be stored in the soil and is not available for runoff or leaching to surface and ground water. Another fraction of this nitrogen can leach to ground water and eventually be discharged through the springs. Additional nitrogen is utilized by vegetation other than cultivated crops, such as vegetation growing along irrigation canals and riverbanks. Nitrogen can also be lost through additional denitrification processes not accounted for in this report.

This description is applicable to excess nitrogen in the Teton Subbasin, though it must be expanded to include the influence of extensive wetlands in the Teton Valley. The U.S. Fish and Wildlife Service has classified 9% of Teton County as wetlands (Peters *et al.* 1993).

According to Mitsch and Gosselink (1993), "wetlands serve as sources, sinks, or transformers of chemicals, depending on the wetland type, hydrologic conditions, and the length of time the wetland has been subjected to chemical loading." It's possible for the wetlands along the Teton River to function as sinks and sources of nitrogen, depending on hydrologic conditions. In a study of a riverine marsh in Wisconsin (Klopatek 1977), concentrations of nitrogen followed a predictable seasonal trend. Concentrations decreased during the algae and macrophyte growing season and increased in the fall when nitrogen was presumably released from decaying plants. The data indicate nitrogen concentrations in the Teton River decrease an order of magnitude from the upper river near Fox Creek to the lower reaches of the North and South Forks. Possible reasons for this include a net loss of nitrogen to the wetland communities of the upper Teton Valley and dilution by surface water.

Although it is difficult to quantify the amount of nitrogen moving between environmental compartments such as soil and water, elevated ground water concentrations clearly indicate that nitrogen applied to soils in the Teton Subbasin has migrated to the aquifers underlying the subbasin. According to Parliman (2000), concentrations of nitrate in Idaho's ground water prior to land and water development were probably less than 1 mg/L as N. Sampling conducted from 1995 through 1999 indicated that the median concentration of nitrate in Idaho ground water was 1.4 mg/L as N, and ranged from less than 0.5 mg/L to 100 mg/L as N. Samples collected from wells and springs throughout the Teton Subbasin during the same period produced concentrations as high as 38 mg/L as N in the lower subbasin near Rexburg (Parliman 2000). Throughout Idaho, DEQ has designated 33 ground water quality management areas because of the degraded quality of aquifers used as drinking water sources. Four management areas are located in the Henry's Fork basin; two of these overlap the Teton Subbasin. One area extends from Ashton into the northwest corner of Teton County; another is centered in the Hibbard area near Rexburg (DEQ 2001).

Temperature Data for the Teton Canyon Segment of the Teton River

The most highly altered stream segment in the Teton Subbasin extends through the Teton Canyon from Bitch Creek to the Teton Dam site. This area was the location of the first phase of the Teton Basin Project, which was intended to accomplish the following goals: 1) supply supplemental water to 111,210 acres of irrigated land in the Fremont-Madison Irrigation District, 2) produce hydroelectricity, 3) provide for recreation at the reservoir, 4) mitigate project-caused losses of fish and wildlife, and 5) control flooding (Stene 1996). The 17-mile-long reservoir behind Teton Dam began filling on October 3, 1975. When the dam failed on June 5, 1976, the reservoir was only 22.6 feet below the planned maximum elevation, and water behind the dam reached a depth of 272 feet. As the dam collapsed, approximately 250,000 acre-feet of water and 4 million cubic yards of embankment material flowed past the dam structure in only six hours (Randle *et al.* 2000).

The rapid drawdown of the reservoir activated more than 200 landslides along the reservoir rim. About 1,460 acres of canyon slopes were submerged by the reservoir and 500 acres, or 34 percent, failed. Approximately 3.6 million cubic feet of material moved downslope to the canyon floor, with some material reaching and blocking the river or burying the original river channel. In addition to the Teton River Canyon, approximately three miles of the canyon of lower Canyon Creek were also affected by the dam's collapse (Randle *et al.* 2000).

From 1997 through 1999, the BOR conducted studies of the Teton River between the Teton Dam site and the Felt Dam Powerhouse, 19 miles upstream of the dam site. The objectives of the studies were to document the current physical and biological condition of the Teton River and canyon, and to provide technical information to aid the BOR in directing management of BOR lands. Data collected during the studies include the following: new aerial and ground photographs, measurements of riverbed topography, water-surface elevations, preliminary particle size analysis of landslide material, and bed-material particle size distributions (Randle *et al.* 2000); air and water temperatures (Bowser 1999); and information regarding the riparian vegetation community (Beddow 1999, as cited in Randle *et al.* 2000).

The effects of the landslides on river and canyon morphology are described by Randle *et al.* (2000) as follows:

> Within the study reach from Bitch Creek to Teton Dam, the Teton River canyon is narrowest at the upstream end and tends to become progressively wider in the downstream direction. As the canyon widens out, terraces along both banks of the river widen out also. Upstream from the confluence with Canyon Creek, the Teton River canyon was narrow enough that the 1976 landslide debris fans typically reached the river channel. Those debris fans formed new rapids in some locations and enlarged pre-existing riffles in other locations. ...27 rapids or riffles and pools have persisted in the reach upstream from Canyon Creek (17 rapids and 1 riffle between Canyon Creek [river mile 5] and Spring Hollow [river mile 12.1] and 7 rapids and 2 rapid and riffle combinations upstream from Spring Hollow). Landslides also deposited debris in river-channel pools upstream from some of these rapids. Downstream from Canyon Creek, the Teton River canyon was wide

> enough that the landslide debris was deposited on the surface of the adjacent river terraces and typically did not reach the river channel. Therefore, the river channel was not significantly constricted by landslides downstream from Canyon Creek, and the hydraulics are relatively the same as in predam conditions.
>
> The 1976 landslides had the greatest impact on the Teton River channel in the 2-mile reach upstream from Canyon Creek, between [river mile] 5.3 and [river mile] 7.4. In this reach, there is no evidence of deep pools having been present in 1972. However, there are four new major rapids and pools (24, 25, 26, and 27) in this reach today, with pool depths ranging from 8 to 19 feet.

Changes in river morphology were also caused by excavation of the channel and terraces for materials to construct the dam (Randle *et al.* 2000). Approximately 1.1 miles upstream from the dam site, the river was characterized by a meandering channel and broad, flat terraces. The gravel terraces were excavated, creating two deep pools connected by a narrow channel. These pools are commonly referred to as borrow ponds and currently contain a total volume of 1,000 acre-feet of water. The downstream pond has a maximum depth of 43 feet and a maximum top width of 380 feet. The upstream pond has a maximum depth of 36 feet and a maximum top width of 760 feet. A portion of the river's flow bypasses the borrow ponds through a diversion channel that runs parallel to the ponds.

Bureau of Reclamation scientists speculated that the borrow ponds and numerous pools created by landslides had caused river water temperatures to increase (Bowser 1999). They tested this hypothesis in 1998 by deploying 20 temperature data loggers from Badger Creek to the bottom of the borrow ponds. Three data loggers recorded air temperatures and 17 recorded water temperatures from July 23 to September 9, 1998. Some of the data were unusable because the temperature loggers were affected by solar radiation or did not remain submerged in water. However, the data were sufficient for Bowser (1999) to conclude that

> [i]n general the new data shows a 2- to 4-degree Fahrenheit temperature rise between the Bitch Creek logger and the logger at the downstream end of the second borrow pond. ...[T]he majority of the temperature increase is approximately between data logger number 1 (upstream of rapid 14/downstream of pool 14) downstream from the 90 degree bend and data logger number 10 at Canyon Creek, rather than from the borrow ponds as might be suspected. This correlates with hydraulic modeling data that suggests this reach has by far experienced the greatest increase in water surface elevation compared to the pre-dam condition. In fact, the data suggests that the borrow ponds may actually lower water temperature as it passes through....

Randle *et al.* (2000) determined that the travel time of water flowing through the Teton Canyon from Bitch Creek to the confluence with Canyon Creek, with a typical July discharge of 1,000 cfs, has increased from eight hours prior to dam construction to 14 hours currently. They attribute this increase primarily to the formation of pool 4 and to the formation of new, large rapids between river miles 5.3 and 7.4. They also conclude that the travel time of water has not changed in the reach between Canyon Creek and the borrow ponds. Bowser (1999) reported a total travel time of 21 hours between Bitch Creek and the Teton Dam site for a discharge of 1,000 cfs.

According to Randle *et al.* 2000, "the construction and subsequent failure of Teton Dam has likely increased summer river water temperatures by 1 to 2 degrees F." This increase in river water temperature was attributed to increased travel time and the loss of riparian vegetation. Woody vegetation, including extensive cottonwood riparian forests, was removed from the reservoir area before it began filling with water. Following the collapse of Teton Dam, the reservoir basin was reseeded with reed canary grass (*Phalaris arundinacea*) to control surface erosion. Currently, the riparian area consists almost entirely of reed canary grass and is generally devoid of the types of riparian and woody vegetation that would shade the river from incident solar radiation.

The temperature data collected by the BOR in 1998 were analyzed by DEQ for violations of Idaho's temperature criteria for cold water aquatic life. Electronic data files were provided to DEQ by Mr. Steven Bowser of the Technical Service Center of the BOR. The numbers and dates of violations of the 22 ^{o}C instantaneous criterion and 19 ^{o}C daily average criterion were tabulated, then compared with the 90th percentile value for the maximum seven-day average air temperature. Because air temperatures influence water temperatures, *IDAPA 58.01.02.080.04* states that "exceeding the temperature criteria [for aquatic life use designations] will not be considered a water quality violation when the air temperature exceeds the 90th percentile of the seven (7) day average daily maximum air temperature calculated in yearly series over the historic record measured at the nearest weather reporting station." The seven-day average maximum air temperatures were calculated using historical data from the BOR's AgriMet station at Rexburg, accessed via the Internet at http://agrimet.pn.usbr.gov/%7Edataaccess/webarcread3.exe. Using data from 1987 through 2000, the 90th percentile of the seven-day average daily maximum air temperature was calculated to be 92.3^{o}F (33.5^{o}C). Based on records collected by the BOR at Spring Hollow (data logger 7), air temperatures exceeded this value on July 23, 26, 27, 28, and 31; August 6, 7, 13, 14, and 31; and September 5, 1998 (Appendix M). Therefore, exceedances of water quality criteria that occurred on these days were not in violation of water quality standards

Thirty-six temperature criteria exceedances occurred in 1998, but only half of these exceedances were violations of water quality standards (Table 25). The 18 violations occurred at only three locations, and 15 violations occurred between August 9 and August 18. Bowser (1999) noted that the water temperatures collected were directly and immediately influenced by air temperatures, as data loggers that did not remain submerged or were submerged but exposed to sunlight may have recorded inaccurately high temperatures. He also cautioned against making direct comparisons between data logger locations or among individual logger data over time due to differences in shading and submergence depth due to changing water surface profiles over time.

Table 25. Exceedances and violations of cold water aquatic life criteria in the Teton River Canyon, as determined using data provided by the Bureau of Reclamation.

Data Logger	Location	Number of Temperature Criteria Exceedances		Number of Temperature Criteria Violations[1]	
		22 °C Instantaneous	19 °C Daily Average	22 °C Instantaneous	19 °C Daily Average
6	Immediately Upstream of Confluence of Bitch Creek	9	0	7	0
BR-1	Spring Hollow	0	0	0	0
5	1st below Spring Hollow	0	0	0	0
3	2nd below Spring Hollow	0	0	0	0
8	3rd below Spring Hollow	0	0	0	0
NFB-2	4th below Spring Hollow	0	0	0	0
BR-HNT	5th below Spring Hollow	0	0	0	0
NFB-3	Linderman Dam	0	0	0	0
CC-2	1st below Linderman Dam	0	0	0	0
NFB-1	2nd below Linderman Dam	0	0	0	0
BR-4	3rd below Linderman Dam	Could not be determined: Data logger missing			
1	4th below Linderman Dam	0	0	0	0
CC-4	5th below Linderman Dam	0	2	0	0
4	6th below Linderman Dam	0	2	0	0
10	7th below Linderman Dam	8	9	5	3
DC-1	Top of Borrow Ponds	Could not be determined: Temperature exceeded 50 °C (122 °C) on August 4 and 13, indicating that data logger was not submerged and was affected by solar radiation			
BR-3	Teton Dam site	0	6	0	3

[1]A criterion exceedance that occurs on a date when air temperature exceeds 92.3 °C is not considered a violation of Idaho's water quality standards. See text for further explanation

ANALYSIS OF WATER QUALITY DATA FOR §303(D)-LISTED SEGMENTS

Badger Creek

The Badger Creek subwatershed covers an area of approximately 60 square miles or 37,587 acres. About 40% of the subwatershed is in Wyoming, and this portion is located entirely within the boundaries of the Caribou-Targhee National Forest. The remaining portion of the subwatershed, which is located in Idaho, consists of approximately 80% privately owned agricultural land and 20% public lands managed by the Caribou-Targhee National Forest, Idaho Department of Lands, BLM, or BOR.

The elevation of Badger Creek drops by half as it flows from headwaters in the Jedediah Smith Wilderness Area to its confluence with the Teton River. The South Fork of Badger Creek originates at an elevation of more than 9,000 feet, less than one-quarter mile west of the border of Grand Teton National Park. Approximately 3.5 miles west of the Idaho-Wyoming border, at an elevation of about 6,300 feet, the South Fork converges with the North Fork to form the mainstem of Badger Creek. Badger Creek continues to drop in elevation, though much more gradually as it flows in a west-northwesterly direction through rolling, gently sloping soils. Bull Elk Creek, a major tributary, enters Badger Creek at an elevation of 5,900 feet, just upstream of the point at which Badger Creek drops into a narrow canyon. Over its final 3 to 4 miles, Badger Creek drops almost 600 feet in elevation, and enters the Teton River at an elevation of approximately 5,300 feet.

Land use in the Badger Creek subwatershed was described by the TSCD (1991) as follows: approximately 68% rangeland and forest (25,374 acres); 20% non-irrigated cropland (7,466 acres); 12% irrigated cropland (4,537 acres); and less than 1% urban and farmstead development, pasture, and water. Based on the distribution of acres among treatment units, approximately 19% of the cropland had an average erosion rate of less than 10 tons/acre/year, 55% had an average erosion rate of 10 to 20 tons/acre/year, and 26% had an average erosion rate of 20 to 24 tons/acre/year.

§303 (d)-Listed Segment Approximately 5 miles of Badger Creek appeared on the 1996 §303(d) list, and sediment was listed as the pollutant of concern (Figure 22). The upper boundary of this segment was described as R45E T6N S10, which is a range, township and section location; the lower boundary was described as the first tributary, which has been interpreted as Bull Elk Creek (Figure 22). The basis for selecting the upper boundary was not documented, but approximately 0.5 mile below the western boundary of section 10, the USGS 7.5-minute map of the Tetonia Quadrangle shows that flow in Badger Creek changes from perennial to intermittent. It is possible that the upper boundary was intended to correspond to this location (NW1/4, SW1/4, S9, R45E, T6N). The segment of Badger Creek described in the 1996 §303(d) list extends from its upper boundary approximately 2.5 miles west-northwest toward the town of Felt and Highway 32, and ends approximately 2.5 miles northwest of Felt. In 1995, BURP samples were collected in the vicinity of the upper boundary of the segment, at the approximate midpoint of the segment, and at a location approximately one stream mile below the lower boundary of the segment (Figures 23-25).

The results of BURP sampling and assessment indicated that the beneficial use of cold water aquatic life was supported within the segment listed, but was not supported below the segment. The MBI score at the upstream sampling site (4.05) indicated full support of cold water aquatic life. The MBI score at the middle sampling location (2.52) indicated that support of cold water aquatic life needed verification, but the assessment was upgraded to full support because the HI score (104) indicated full support. The MBI score at the downstream site (1.24) indicated that the beneficial use of cold water aquatic life was not supported. Based on these BURP results, the boundaries of the listed segment of Badger Creek were revised on the 1998 § 303(d) list. The upper boundary was moved 1.5 miles downstream to Highway 32 and the lower boundary was moved approximately four miles downstream to the confluence of Badger Creek with the Teton River.

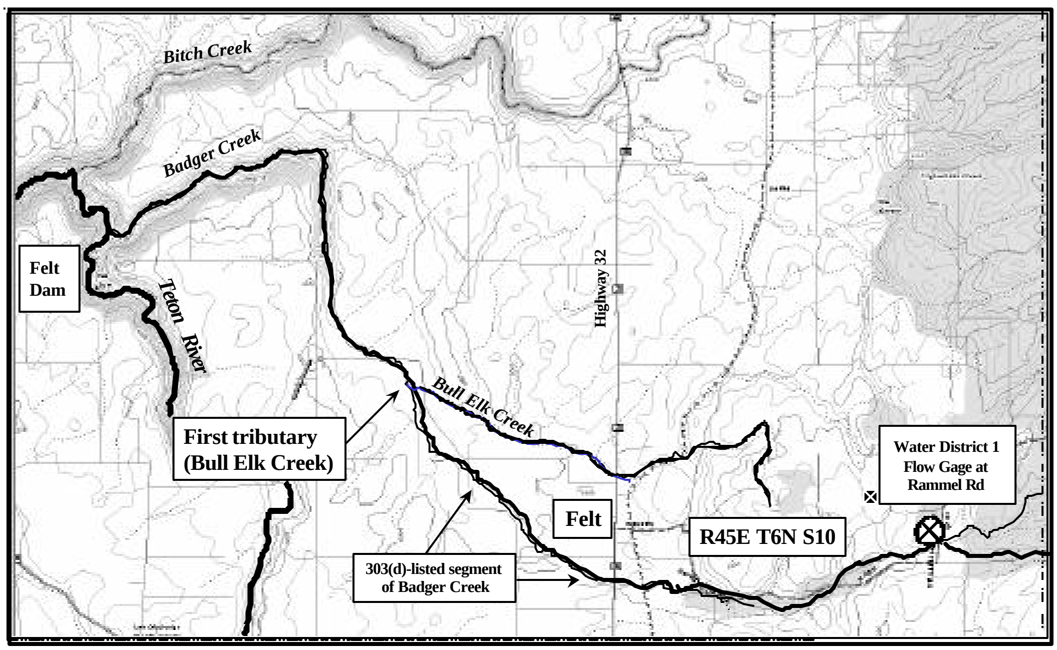

Figure 22. Boundaries of the segment of Badger Creek identified on Idaho's 1996 section 303(d) list. Pollutant of concern was sediment.

Flow Surface water flows in the Badger Creek subwatershed follow the pattern previously described for drainages at the base of the Teton Range. Most streams are intermittent, flows are primarily determined by winter snowpack, and springs are important contributors to surface water flow, especially in lower Badger Creek. According to USGS 7.5-minute maps, the only stream segments within the Badger Creek subwatershed that flow perennially are South Badger Creek from its headwaters to its confluence with the North Fork of Badger Creek and Badger Creek from the confluence of the North and South Forks to a point downstream approximately two miles. Although Bull Elk Creek is a major tributary of Badger Creek, its flow is intermittent.

Water District 1 measures flow in Badger Creek at Rammel Mountain Road, immediately downstream of the confluence of the North and South Forks. Flows are determined using a current meter or by comparing staff gage heights to an index. Measurements of flow are recorded on an irregular basis throughout the irrigation season, generally from May or June through September or August, and have not been recorded for the winter months from December through March. Flows are also measured at five other locations in the Badger Creek subwatershed, but these measurements are for water diverted from Badger Creek and are not necessarily indicative of instream flows. The flows measured in Badger Creek at Rammel Mountain Road from 1980 through 1998 are summarized in Figure 26. Because flows may change substantially from the beginning to the end of each month, the data shown in the figure are averages of measurements taken during 3-, 10- or 11-day periods.

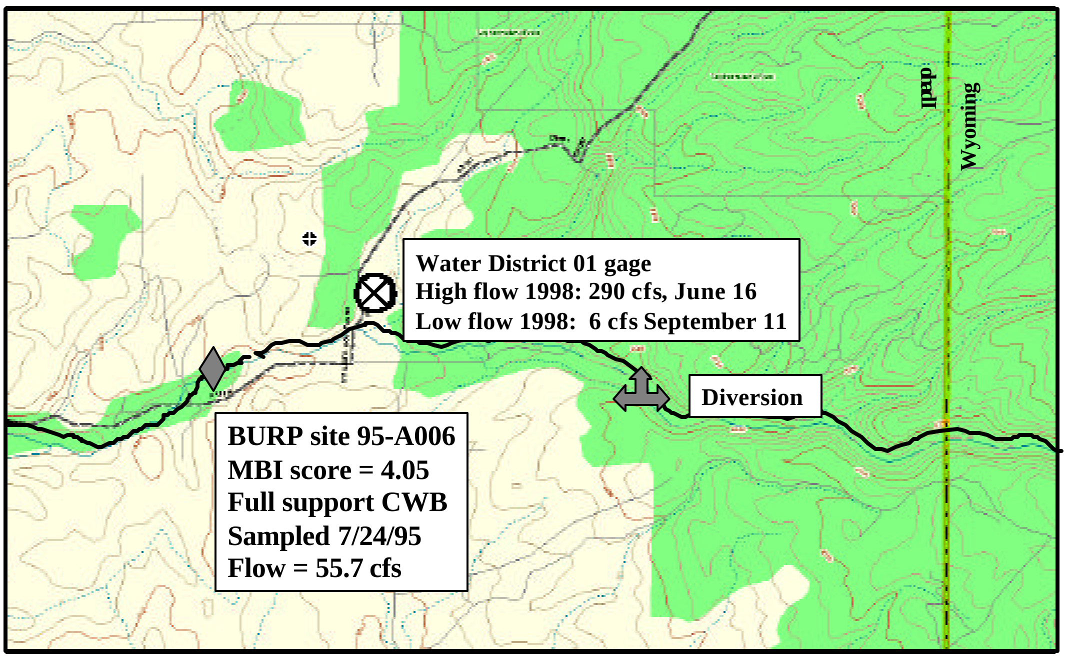

Figure 23. Data collection sites on upper Badger Creek.

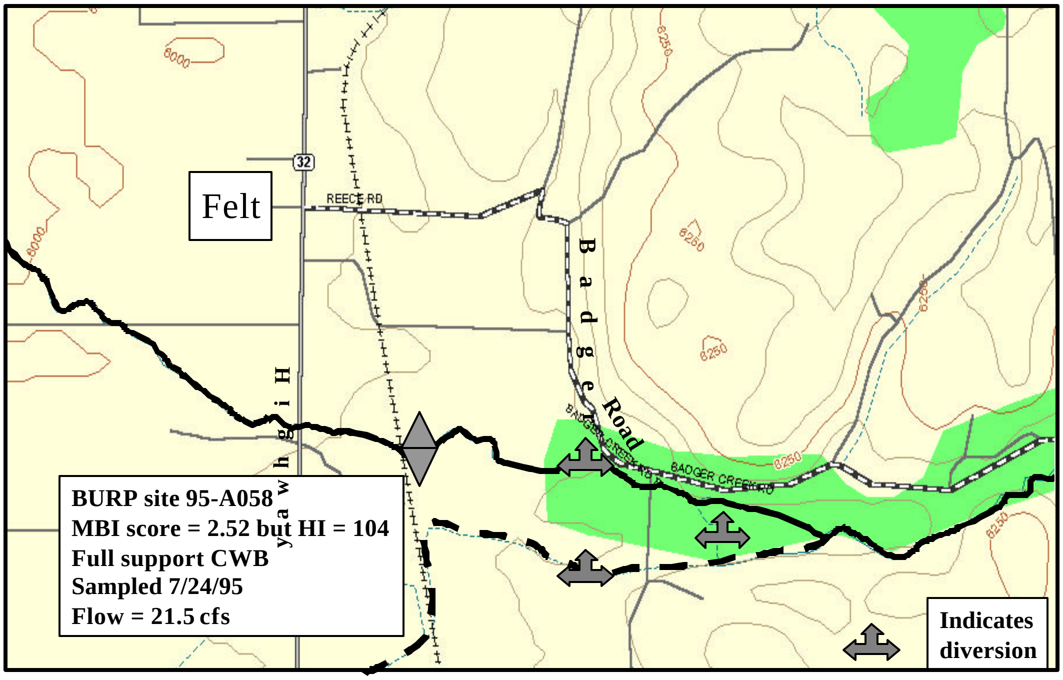

Figure 24. Data collection sites and locations of major diversions on middle Badger Creek near Felt.

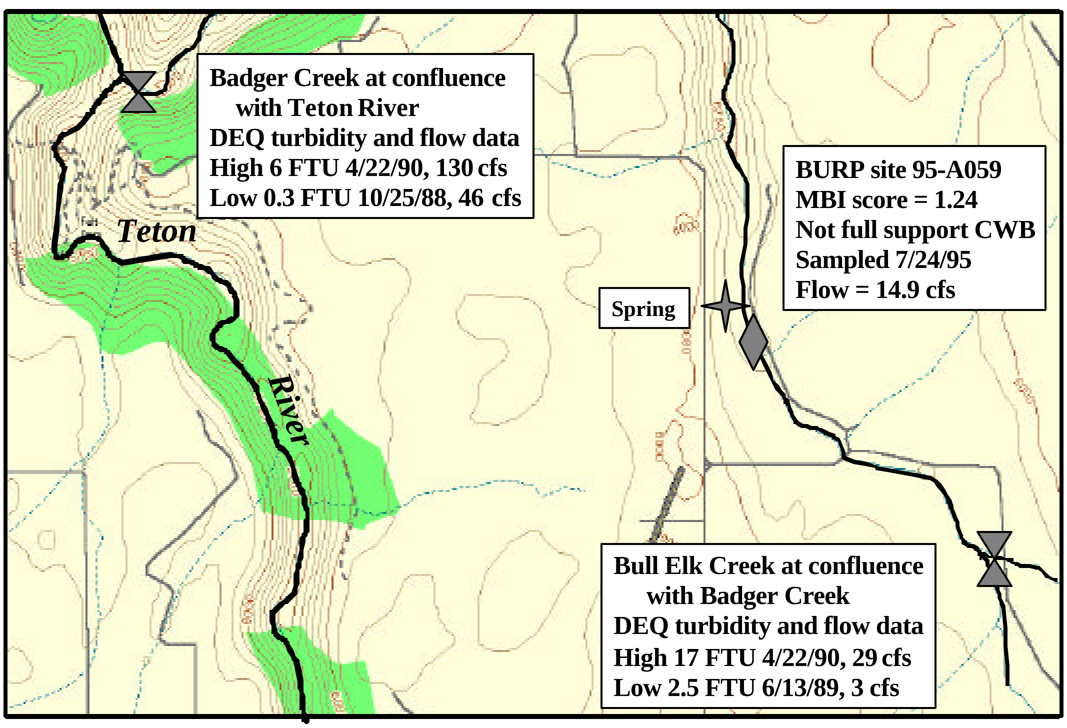

Figure 25. Data collection sites on lower Badger Creek and Bull Elk Creek

Flow records from 1980 through 1998 indicate that 1) maximum or peak flows occur in May or June, with average monthly flows of 180 cfs in May, 164 cfs in June, 46 cfs in July, and 10 cfs in August; 2) maximum flows may vary as much as an order of magnitude among years, as indicated by the records for June 1983 (425 cfs) and June 1994 (45 cfs); 3) flows typically decline to less than 10 cfs by mid-August, and continue to decline through October; and 4) water may be diverted from Badger Creek for irrigation from the beginning of May through August, though the greatest demand for water is in June and July (Carlson 1980-1998).

Average flows ranged from 106 to 208 cfs for the 10-day periods in May and June, from 25 to 67 cfs for the 10-day periods in July, from 6 to 9 cfs for the ten-day periods in August, and from 3 to 7 cfs for the 10-day periods in September and October. As shown in Figure 26, average flows increase rapidly in early May, remain relatively high until late June, and decline steadily through July and August. The lowest flow measured was 0.5 cfs in October 1989 and September 1990.

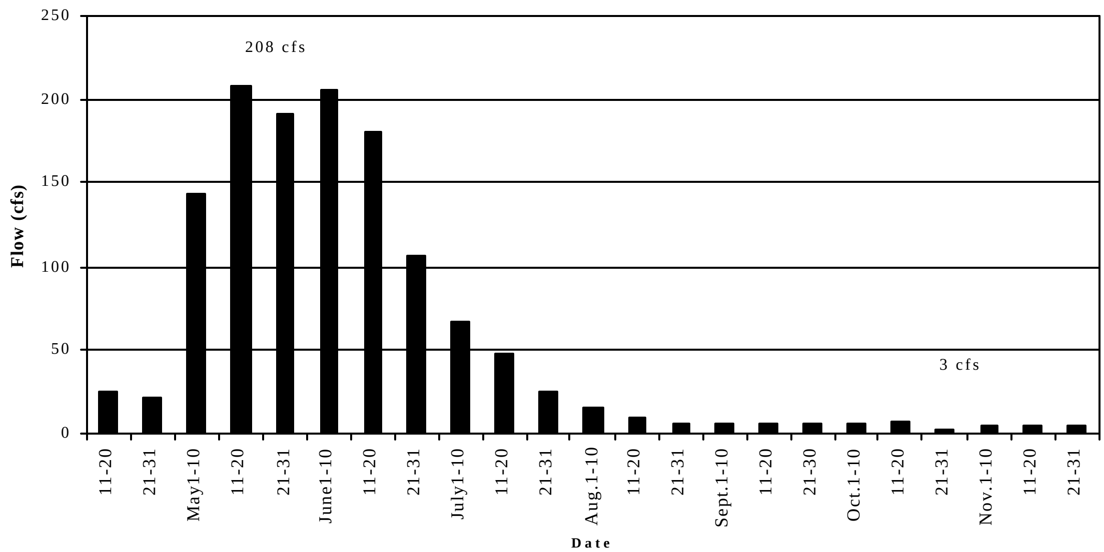

Figure 26. Eighteen-year average flows measured on Badger Creek at Rammel road.

Although flow records indicate that water usually persists in Badger Creek at Rammel Road even in October, local residents and the NRCS District Conservationist report that Badger Creek downstream of Rammel Road is typically dry from mid-August through April because the small amount of water that remains in the channel at base flow infiltrates into the porous soils of the stream channel. Just upstream of Rammel Road, the soils are Badgerton loams, which are excessively drained and have low water capacity. The Wiggleton loams predominate throughout the middle segment of Badger Creek. In the vicinity of the confluence of Bull Elk Creek, the Wiggleton loams are replaced by Rammel and Judkins series soils that, while permeable, are underlain by bedrock at a depth of 20 to 40 inches (USDA 1969). Local residents also report that there is typically no flow in Badger Creek throughout the summer from the area in which water is diverted (Figure 23) to a location downstream of the confluence of Bull Elk Creek where a spring restores instream flow (Figure 25).

The lack of flow in Badger Creek is supported by thermograph data collected by IDFG in 1996. Flows were average or above average in 1996, with the peak recorded flow of 335 cfs occurring in early June. A thermograph deployed on May 21 in Badger Creek below the confluence of Bull Elk Creek recorded water temperatures on an hourly basis until July 21, when the stream apparently became dry (Schrader 2000a). The flow measured at Rammel Road three days later on July 24 was 15 cfs, indicating that flows measured at Rammel Road are not representative of flows further downstream.

The Teton Canyon Water Quality Planning Project (TSCD 1991) identified 12,003 critical acres for treatment within the Badger/Bull Elk subwatershed. At the time the planning project was written, 161 acres were being treated and 11,842 acres remained to be treated. Critical acres were defined as "those cropland and non-cropland acres where the annual estimated soil erosion rate from sheet, rill, and gully and wind erosion exceeds the USDA estimated tolerable soil loss for a soil series" (TSCD 1991).

Water Quality Data In conjunction with the Teton Canyon Watershed Area planning study initiated by the TSCD in the late 1980s, DEQ attempted to collect bimonthly water quality data from October 1988 through May 1990 at three locations in the Badger Creek subwatershed: Badger Creek at the Caribou-Targhee National Forest boundary, Bull Elk Creek immediately above its confluence with Badger Creek, and Badger Creek immediately above its confluence with the Teton River. However, because of the absence of flow or inaccessibility of sampling sites, data were collected at all three locations on only six occasions beginning in April 1989 (Drewes 1993).

Because the water quality samples collected by DEQ were obtained during "continuing dry weather conditions," the results were not considered indicative of "the true potential for agricultural impacts on water quality" (Drewes 1993). Within that context, the data support the following observations:

1. Excessive concentrations of sediment were not transported to the mouths of Badger or Bull Elk Creek during the period of study. The highest values for nonfilterable residue (36 mg/L at the forest boundary and 56 mg/L on Bull Elk Creek) were well below the target of 80 mg/L suspended solids; the highest value for turbidity (17 FTU on Bull Elk

Creek) was well below the target of 50 NTU. In making comparisons to targets, the assumption are that measurement of total nonfilterable residue will produce a result comparable to measurement of total suspended solids, and measurement of FTUs will produce a result comparable to measurement of NTUs.

2. The conductivities of samples collected from Badger Creek at the forest boundary were similar to conductivities of samples collected at the mouth of Bull Elk Creek, but were generally one-half to one-fourth the conductivities of samples collected at the confluence of Badger Creek with the Teton River. Because conductivity is an indicator of the concentration of dissolved solids (i.e., salts) in water, the differences in conductivities may have indicated that salts were accumulating in surface water from upland sources as the water flowed through the subwatershed. The differences in conductivities may also indicate that water at the mouth of Badger Creek originated from ground water instead of snowmelt.

3. Concentrations of NO_2 + NO_3 (nitrite plus nitrate), which is essentially a measure of NO_3 in surface water, were highest in water collected from the mouth of Badger Creek, again indicating that nitrogen was accumulating as water flowed through the subwatershed or that the water in the lower subwatershed was from a ground water source. Regardless of the source, the concentrations of nitrate in five of seven water samples collected from Badger Creek at its mouth exceeded the target of 0.3 mg/L (i.e., the concentration that may cause excessive plant growth in streams), averaging 0.52 mg/L. Nitrate concentrations in samples collected from Bull Elk Creek exceeded 0.3 mg/L in April 1989 and April 1990, and the average concentration of the remaining four samples was 0.22 mg/L. In contrast, the average concentration of nitrate in samples collected at the forest boundary was 0.04 mg/L.

4. Concentrations of total phosphorus twice exceeded the target of 0.1 mg/L in Bull Elk Creek, but were below the detection limit of 0.05 mg/L in all samples collected at the forest boundary and at the confluence of Badger Creek with the Teton River. Because total phosphorus generally measures undissolved phosphorus adsorbed to soil particles, these results indicate that soil and associated phosphorus were being transported in Bull Elk Creek, but not in Badger Creek. Furthermore, the contribution of phosphorus to Badger Creek by Bull Elk Creek was either diluted or did not reach lower Badger Creek. The absence of detectable total phosphorus in lower Badger Creek also indicates that the source of water in Badger Creek at this location was ground water.

5. Except in one instance, fecal coliform bacteria concentrations were far below the concentrations that would have violated Idaho’s water quality criteria for secondary contact recreational use (800 colonies/100 mL). It is difficult to interpret the significance of the extremely high concentration of fecal coliform in Bull Elk Creek in June 1989 (19,000 colonies/100 mL) because follow-up samples were not collected. When fecal coliform concentrations were measured throughout the Teton Subbasin by DEQ in 1999, the highest concentration measured was 663 colonies/100 mL, indicating that the value obtained in 1989 was anomalous.

Drewes (1993) described the Badger Creek subwatershed as the most "intensely" farmed of all subwatersheds in the Teton Canyon Watershed Area, and attributed the high concentrations of nitrogen to addition of nitrogen fertilizers. Although it is disputable that Badger Creek was more intensively farmed than other subwatersheds, the sources of elevated nitrogen were very likely grazing, growth of alfalfa hay, and/or application of nitrogen fertilizers. Cropland accounted for 32% of land use in the Badger Creek subwatershed, 42% in the Canyon Creek watershed, and 68% in the Milk Creek watershed (TSCD 1991).

The only continuous temperature data for Badger Creek was collected by IDFG in 1996 from May 21 to July 21, when the stream apparently became dry (Schrader 2000a). Temperatures did not exceed the water quality criteria for cold water aquatic life (i.e., less than 22°C instantaneous with a maximum daily average less than 19°C). Salmonid spawning criteria were exceeded from mid-June through July (Figure 27), but spawning does not occur at this time.

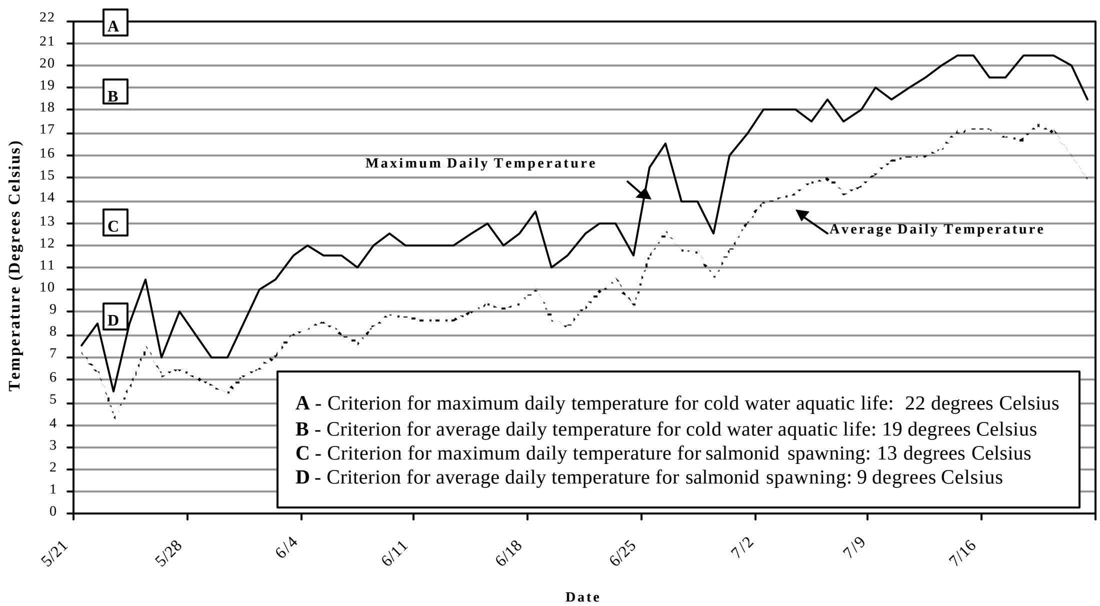

Figure 27. Water temperatures in Badger Creek from May 21 through July 22, 1996 (Schrader 2000).

Fisheries Recent fisheries information is available for Badger Creek, but only for portions that are upstream of the segment that appears on the 1998 §303(d) list. In August 1998, DEQ confirmed the presence of cutthroat trout in Badger Creek below Rammel Road by electrofishing BURP site 95-A006 (Figure 23). One pass was made through a 100-m reach, and two cutthroat trout (*Oncorhynchus clarki*), 100 to 119 mm in length, were captured. No other fish of any species were observed. In accordance with DEQ protocol, an effort was made to electrofish all BURP sites on Badger Creek. The absence of electrofishing data for the two downstream sites on Badger Creek indicates there was no flow at these sites on August 4, 1998 when the electrofishing occurred.

Fisheries data were also collected in 1998 by the Caribou-Targhee National Forest on South Badger Creek above the forest boundary. Techniques used to conduct the survey included electrofishing from the forest boundary to the wilderness boundary and snorkeling above the wilderness boundary. Cutthroat trout was the only fish species observed in 25 sampling sites spanning more than 7 miles of stream. The number of fish in size classes ranging from less than 50 mm to 250 mm indicate that the population is self-sustaining. According to notes made by the forest biologist, South Badger Creek had the highest occurrence of Yellowstone cutthroat trout of any of the streams sampled in 1998. A fish habitat survey was also conducted on South Badger Creek above the forest boundary in 1991 (Raleigh Consultants 1991). The section surveyed extended 9.4 miles from the forest boundary to a "small cascade and waterfall," and had an average gradient of 2.59%, average width of 4.7 m, and average depth of 0.2 m. The narrative report of the survey included the following observations of stream condition:

> ...Scattered log jams and beaver dams have caused water to overflow the banks in several places causing channel cutting. The upper section has several springs and some marshy ground that adds silt to the stream. ... [The stream] appeared to be in relatively good condition for a small, moderate gradient stream. There were sheep grazing in the lower section with little noticeable adverse affects to the stream, streambanks, or riparian area. The beaver dam areas and some log jams were causing minor bank cutting and side channels along the stream but it was not extensive or severe.

Regarding fisheries, the report stated:

> A sparse population of trout of all age classes (fry, juvenile, and adult) were seen throughout the reach. ... Two species of trout may be present in the stream. The observer reported brook trout and a species without a white leading edge on the pectoral fins...either cutthroat or rainbow trout.

Stocking records available from IDFG show that Badger Creek was stocked with more than 300,000 Kokanee (October spawner) fry in 1975; more than 100,000 cutthroat fry in 1976; and more than 11,000 rainbow/cutthroat hybrids in 1981 (http://www.state.id.us/fishgame/catalog1.htm). Despite stocking and the report of brook trout in 1991 (Raleigh 1991), no trout other than cutthroat were observed by either DEQ or the Forest Service in 1998.

The BLM, which manages less than a quarter section of land on North Badger Creek and half section of land at the mouth of Badger Creek, conducted site visits in 1994 to verify water rights and conduct stream health evaluations (Kotansky 1999). In 1997, BLM contracted with the Riparian and Wetland Research Program of the University of Montana to conduct a more thorough stream health evaluation on North Badger Creek. Data forms from 1994 indicate that flow in the North Fork of Badger Creek was 0.04 cfs on August 11, and flow in Badger Creek near the confluence with the Teton River was 38 cfs on August 24. The conductivity of water in the North Fork was 50 micro mhos per centimeter (ìmhos/cm); conductivity in Badger Creek near the confluence was 220 ìmhos/cm. There were no grazing or other impacts noted for either of the areas, and the riparian vegetation on the North Fork was described as excellent while the riparian vegetation on Badger near the confluence was naturally poor due to the steep walls of the canyon and large rocks lining the streambanks. The health inventory conducted on North Badger Creek in 1997 indicated that the streambank was well armored and the stream was healthy and in proper functioning condition, with scores of 98% "without Pfankuch" and 94% "with Pfankuch" (BLM data files). The tree and forb community was described as subalpine fir (*Abies lasiocarpa*) and claspleaf twistedstalk (*Streptopus amplexifolius*) with high regeneration of Douglas fir. This portion of the stream was not a source of sediment.

Discussion Because of the natural flow regime of Badger Creek, it is unlikely that the beneficial uses of cold water aquatic life and salmonid spawning can be supported year-round throughout the segment that appears on the 1998 §303(d) list. In the absence of multi-year flow data collected within this segment, this conclusion is supported by the observations of local residents, which are in turn supported by flow data collected at Rammel Road. These data indicate that flows were uncharacteristically high when BURP samples were collected in 1995. The peak flow occurred in 1995 on June 15, but based on the 18-year flow record, peak flows occur after June 10 only one year in three. Also, the flow measured at Rammel Road on July 27, three days after the DEQ BURP samples were collected, was 8 cfs higher than the 18-year average for late July.

In 1999, the Henry's Fork Watershed Council Water Quality Subcommittee recommended that Badger Creek be divided into six segments for the purpose of designating beneficial uses for state water quality standards (Appendix D). The boundaries of the segments correspond with the Idaho-Wyoming state line, the locations of irrigation diversions, the confluence of the north and south forks of Badger Creek, and the location of a spring which significantly influences flow. One segment consists of the entire North Fork of Badger Creek. The South Fork of Badger Creek downstream of the state line is divided into two segments at the point at which water is diverted to the Haden Canal. The mainstem of Badger Creek is divided into three segments: 1) the confluence of the forks to a diversion spillway approximately 1 mile downstream, 2) the diversion spillway to a spring approximately 5 miles downstream and 1 mile below the confluence of Bull Elk Creek, and 3) the springs to the confluence with the Teton River. The segments recommended for the mainstem of Badger Creek are based on the presence or absence of instream flow volumes adequate to support beneficial uses. The upper and lower segments typically contain water; the middle segment typically does not. The recommendations of the Watershed Council are supported by information provided by local residents and resource managers and flow data collected by Water District 1. Additional BURP sampling by DEQ is required to adequately assess the status of beneficial uses in these segments.

Conclusions Conclusions regarding the water quality status of Badger Creek are listed below.

1. Available data do not link sediment to impaired beneficial uses in the segment of Badger Creek that appeared on the 1998 §303(d) list. In the absence of sufficient data to indicate that sediment is *not* a source impaired water quality, a TMDL for sediment is warranted based on the *Teton Canyon Water Quality Planning Project* prepared in 1991 by the Teton Soil Conservation District (TSCD 1991).

2. Discharge in the segment of Badger Creek that appeared on the 1998 §303(d) list is intermittent from Highway 32 to the springs downstream of the confluence of Bull Elk Creek. The biological indices used by DEQ to assess the beneficial uses of cold water aquatic life and salmonid spawning were developed using data collected for aquatic insect or fish communities sampled in perennially flowing reference streams. Similar species diversity and other community measures cannot be expected to occur in channels that periodically become dry. Therefore, it is not appropriate for DEQ to use data collected using the BURP protocol to assess beneficial use support in the mainstem of Badger Creek below Highway 32.

3. For the purpose of assessing beneficial use support using data collected according to the BURP protocol, DEQ should sample only in the following segments of Badger Creek: 1) the confluence of the forks to a diversion spillway approximately one mile downstream, and 2) the springs downstream of the confluence of Bull Elk Creek to the confluence of Badger Creek with the Teton River.

4. Water quality in the segment of the mainstem of Badger Creek below the diversion spillway is protected by numeric criteria when the channel contains water; turbidity during runoff should be monitored to determine whether this criterion, as an indicator of sediment, is exceeded.

5. To support beneficial uses, the water quality targets for sediment shown in Table 15 should not be exceeded at any location in Badger Creek.

Darby Creek

Darby Creek originates at an elevation of approximately 9,600 feet within the Jedediah Smith Wilderness Area on the western slope of the Teton Mountain Range. As Darby Creek flows west through the Caribou-Targhee National Forest to the Idaho-Wyoming state line, it drops more 3,000 feet in elevation over a distance of approximately 7 miles. From the state line, it drops only 400 feet in elevation as it flows another 6 miles almost due west to its confluence with the Teton River.

More than two-thirds of the 19,780 acres that comprise the Darby Creek subwatershed, as delineated in the *Teton River Basin Study* (USDA 1992), are located on the Caribou-Targhee National Forest in Wyoming. The forest boundary divides the subwatershed from east to west, and either coincides with the Wyoming-Idaho state line or is located less than one-quarter mile east of the state line. Therefore, almost all of the subwatershed east of the state line is federally owned, and all of the subwatershed west of the state line is privately owned. Forest lands are used for recreation, motorized travel, and elk and deer winter range; private lands are used for rangeland, irrigated cropland, and residential development (USDA 1992 and 1997a).

From the wilderness boundary to the forest boundary and state line, Darby Creek is classified by the Forest Service as ecological unit *2609-PIEN Cryaquolls, 2 to 8 percent slopes,* which is described by Bowerman *et al.* (1999) as follows:

> This unit is on cold, moist floodplains in the forested zone ... topography is characterized by low to high gradient (2-8 percent) floodplains in U-shaped mountain valleys ... microrelief on the floodplain is very broken and irregular ... seasonal variation in stream flow is dominated by snow melt runoff ... braided channels and confined meanders are common ... beaver dams are infrequent.

The potential natural vegetation community is Engelmann spruce/fragrant bedstraw and Engelmann spruce/field horsetail, but present vegetation also includes red osier dogwood, willow, and alder communities. Soils may extend to a depth of 60 inches and are composed of fine sandy loam, stratified silt loam to gravelly sandy loam, and stratified gravelly sandy loam to extremely cobbly coarse sand. The soils have a very slow infiltration rate when thoroughly wet due to a high shrink-swell potential and/or permanent high water table, and therefore have a high runoff potential. Flooding is frequent and lasts from April through July due to snowmelt. Susceptibility to water erosion is relatively low, as indicated by a K_w of 0.15; soil loss tolerance is moderate, as indicated by a T value of 3.

The portion of the Darby Creek subwatershed located in Idaho is an alluvial floodplain overlain by wind-deposited loess. From the state line to just west of Highway 33, the soils are level to gently sloping and well drained; west of the highway to the Teton River the soils are nearly level and poorly drained.

Flow Approximately 1 mile east of the forest boundary, the channel of Darby Creek becomes braided, and according to the USGS 7.5-minute topographic map, streamflow changes from perennial to intermittent. The braided channels diverge east of Highway 33 into three channels that pass beneath the highway. Approximately 1.5 miles west of the highway, perennial flow in each of these channels is restored through spring flows and/or subsurface flows. The northernmost channel is no longer considered a channel of Darby Creek, but is instead labeled Dick Creek on the topographic map. The middle channel becomes the mainstem of Darby Creek and receives year-round flow from a spring located at SW1/4 SE1/4 S10 T4N R45. The southernmost channel converges with the mainstem approximately 0.5 miles above the confluence of Darby Creek with the Teton River.

Discharges in Darby Creek are measured by Water District 1 at a bridge approximately 1.5 miles upstream of the Idaho-Wyoming state line. Eighteen-year average flow data indicate that high flows of approximately 180 cfs occur throughout June, rapidly decline in July to approximately 30 cfs by August 1, then continue to decline to 1 cfs by the end of November (Figure 28). Downstream of the Darby Creek gage, diverted flows are measured in the Winger, Hill, Todd, and Cannon canals in Wyoming, and the Cherry Grove canal in Idaho.

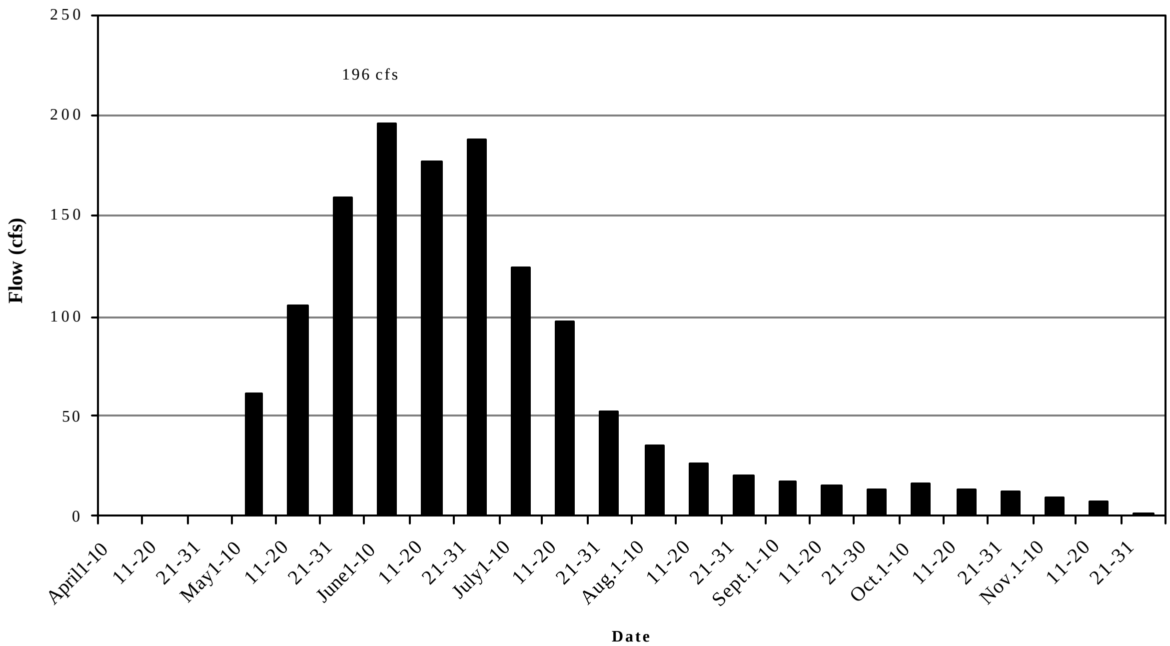

Figure 28. Eighteen-year average discharge measurements for Darby Creek

Water flows continuously in Darby Creek from the state line to Highway 33 only four-to-six weeks during the summer (Schiess personal communication). Most streamflow is typically diverted for irrigation in Wyoming, but flow diversion is not the primary reason for the intermittent nature of Darby Creek. Six to eight years ago irrigators in the lower valley called for water and upstream diversions were discontinued. Flow in the main channel extended west of Highway 33 at night but receded east of the highway during the day, and continuous flow throughout the mainstem to the Teton River did not occur (Schiess personal communication). Because the water could not reach irrigators downstream, the upstream diversions were allowed to resume. In September 1998, the Caribou-Targhee National Forest conducted a cutthroat trout inventory of Darby Creek, and notations regarding flow in the sample reach immediately upstream of the forest boundary stated that the lower section was dewatered due to irrigation diversions and low base flow.

§303(d)-Listed Segment The segment of Darby Creek shown on the 1998 §303(d) list extends from Highway 33 to the Teton River, a distance of slightly more than 3 miles (Figure 29). The pollutants of concern are sediment and flow alteration. The results of BURP sampling conducted in 1995 indicated that the beneficial use of cold water aquatic life was supported in Darby Creek at the Idaho-Wyoming state line (MBI of 4.84 at site 95-B053), but was not supported in the mainstem of Darby Creek immediately downstream of Highway 33 (MBI of 1.41 at site 95-B007). A third site, just upstream of the confluence of Darby Creek with the Teton River, was visited in 1995 could not be sampled because the stream reach did not contain riffles. The low MBI score obtained at the site downstream of Highway 33 was responsible for Darby Creek remaining on the 1998 §303(d) list. In 1997, an attempt was made to resample this site, but records show that the site sampled in 1997 was in the channel that becomes Dick Creek, not in the mainstem of Darby Creek (Figure 30).

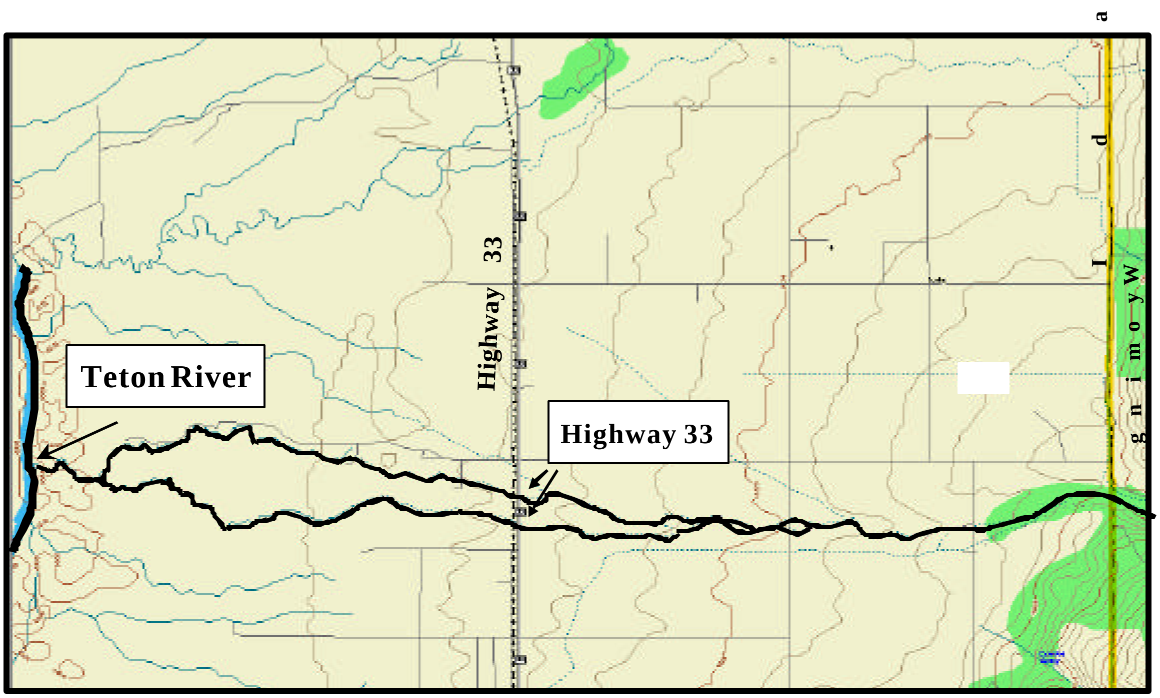

Figure 29. Boundaries of the segment of Darby Creek which appeared on Idaho's 1998 section 303(d) list.

Because a downstream site on Darby Creek was not sampled in 1995, sampling of the lower reach was conducted again in 1997 (97-L073) and 1998 (98-E003) on the mainstem upstream of its confluence with the southern channel (Figure 30). The MBI score for the 1997 sample (3.36) fell within the "needs verification" range, and combined with the low habitat index score (59), the site was assessed as "not full support" for cold water aquatic life. The same area of the stream was sampled again in 1998, and while the MBI score (4.55) indicated "full support" for cold water aquatic life, the habitat index score (63) remained low. Some of the factors that contributed to the poor habitat index scores were highly embedded substrate (greater than 75%), high percentages of surface fines (86% and 96%), and less than 30% of potential plant biomass remaining along streambanks.

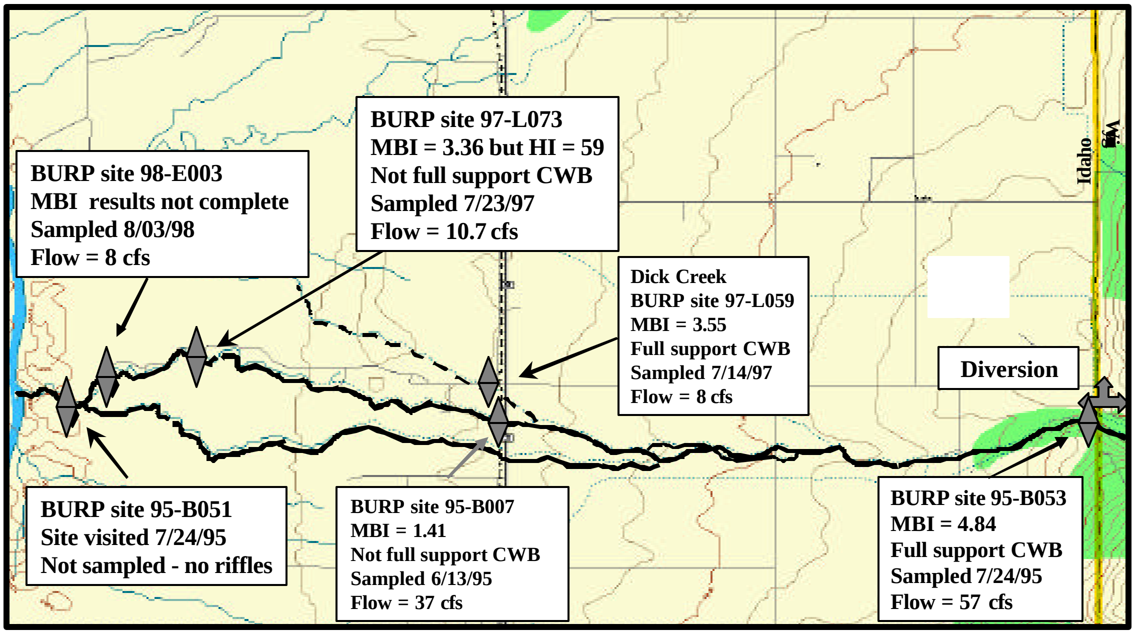

Figure 30. Data collection sites on Darby Creek

Resource Problems Identified by the USDA and TSCD The *Teton River Basin Study* (USDA 1992) estimated that the total sediment yield from agricultural lands in the Darby Creek subwatershed was 2,601 tons/year. Of that amount, 65% originated from streambanks and 35% originated from land use. Implementing structural practices, identified as Alternative 2 in the *Teton River Basin Study* (USDA 1992), was expected to reduce the total sediment yield to 1,581 tons/year by reducing streambank erosion by 52% and land use erosion by 16%. The majority of the agricultural land located in the subwatershed occurs within treatment units 12 or 10/11, with small portions occurring in treatment units 4, 8, and 9. The causes of resource problems identified for treatment unit 12 were overgrazing of uplands, season of use by livestock, roads, overland runoff/surface and gully erosion, and urbanization/home building. The causes of resource problems identified for treatment unit 10/11 were overgrazing in the riparian area; removing stream-side shrubs, trees, and other vegetation; straightening sections of stream channel; improper culvert placement; flooding; stream evolution; reduced sub-water flows; poorly controlled flood irrigation systems; and erosion of uplands (USDA 1992).

Water Quality Data The results of water quality sampling conducted by DEQ in 2000 did not indicate high concentrations of suspended sediment in Darby Creek at the location and times sampled (Appendix I). Samples were collected approximately 300 feet west of Highway 33 on the mainstem of Darby Creek, in an area that corresponded to BURP site 95-B007 (Figure 30). The maximum concentration of TSS (3.1 mg/L) was far below the designated target of 80 mg/L, and maximum turbidity (8.4 NTU) was far below the criterion specified in Idaho's water quality standards (i.e., not greater than 50 NTU above background). Turbidity values measured in June 1999 showed a small increase from the forest boundary (4 NTU) to the site below the highway (11 NTU), but again, these values were far below the water quality criterion.

Evidence of excessive sediment deposition in Darby Creek was provided by the results of subsurface sediment analyses performed at the sampling site downstream of Highway 33. Approximately 12% of particles were less than 0.85 mm in diameter and 37% were less than 6.3 mm in diameter. These values exceed the targets for subsurface fine sediment shown in Table 15 by 2% for particles less than 0.85 mm and by 12% for particles less than 6.3 mm.

The only other analytical data found for Darby Creek were reported in a letter from DEQ to the Caribou-Targhee National Forest for water samples collected in 1980. The samples are described in the letter as "Darby Creek above Spring" and "Darby Spring," though exact sampling locations are not specified. Despite the lack of information regarding sampling locations, the analytical results for nutrients and suspended solids are shown in Table 26 because these data may be useful for evaluating long-term water quality trends if the location of the sampling sites can be confirmed. Concentrations of nutrients measured in Darby Spring water were generally lower than in water taken from Darby Creek above the spring, with one notable exception. The concentration of NO_2 + NO_3 was higher in the spring water (0.147 mg/L) than in the surface water (0.098 mg/L), though it is impossible to evaluate the significance of these results on the basis of only one sample. Nitrate concentrations measured in Darby Creek below Highway 33 in 2000 were similar to the values measured in 1980, ranging from below detection level to 0.09 mg/L (Appendix I).

Table 26. Water quality data for Darby Creek reported in a letter dated October 6, 1980, from the Idaho Division of Environment to the Targhee National Forest.

Water Quality Parameter	Darby Creek above Spring	Darby Spring
Ammonia (mg/L as N)	0.014	0.009
NO_2 + NO_3 (mg/L as N)	0.098	0.147
Total phosphorus (mg/L as P)	0.05	< 0.01
Orthophosphate (mg/L as P)	0.003	< 0.01
Suspended solids (mg/L)	< 2	< 2

Fisheries Fisheries data for Darby Creek were recently collected by the Caribou-Targhee National Forest and DEQ, and fisheries habitat was assessed on the forest in 1991 (Raleigh Consultants 1991). Cutthroat trout were present throughout the stream reaches sampled on the forest, and ranged in size from 50 to 300 mm. One brook trout and one rainbow trout were also captured during the forest survey. Darby Creek was electrofished below the forest boundary by DEQ in 1996 at BURP site 95-B052. Most water had been diverted from the stream channel, but three year classes of cutthroat trout were collected, mostly from a large pool. Based on these data, the segment of Darby Creek from the forest boundary to Highway 33 was assessed as fully supporting salmonid spawning. Site 97-L073 was electrofished as a representative site for the stream segment from Highway 33 to the Teton River, and only two brook trout and two sculpin were collected. These results did not indicate that salmonid spawning was supported, but local residents report that they have observed brook trout spawning in Darby Creek as far upstream as the spring west of Highway 33.

Discussion Darby Creek consists of two hydrologically distinct segments. The source of water in the upper segment is snowmelt runoff; the source of water in the lower segment is upwelling subsurface water and a spring located approximately 1 mile west of Highway 33. In late May, June, and early July, runoff is usually sufficient to provide flow from the headwaters of Darby Creek to the Teton River. Otherwise, the channel in the vicinity of Highway 33 is dry. In 1999, the Henry's Fork Watershed Council Water Quality Subcommittee recommended that the boundary separating Darby Creek into two segments be changed from Highway 33 to the spring west of the highway. From the spring upstream to approximately one mile east of the forest boundary, the flow in Darby Creek is intermittent and heavily diverted during the irrigation season. Downstream of the spring, flow in Darby Creek appears to be relatively constant though discharge has not been measured. When DEQ assessed Darby Creek for the 1998 §303(d) list, the assessment of "not full support" for cold water aquatic life was based on sampling conducted at a site downstream of Highway 33 that is apparently dry most of the year. Based on flow, this site is more representative of Darby Creek upstream of Highway 33 than it is of Darby Creek downstream of Highway 33. Similarly, the assessment of the segment upstream of Highway 33 as "full support" for both cold water aquatic life and salmonid spawning was based on sampling conducted at a site just below the forest boundary and above a major diversion. This site is probably more representative of Darby Creek upstream of the forest boundary than it is of Darby Creek downstream of the forest boundary.

Conclusions Conclusions regarding the water quality status of Darby Creek are listed below.

1. Discharge in the segment of Darby Creek that appeared on the 1998 §303(d) list is intermittent from Highway 33 to the spring west of Highway 33, but the segment downstream of the spring is sufficient to support aquatic life uses at all times. Although the beneficial uses of this segment of Darby Creek have not yet been assessed, the MBI scores for samples collected in 1997 and 1998 are "fair" to "very good" while HI scores indicate impairment due to sediment deposition. Development of a total maximum daily load for sediment is appropriate.

2. Discharge in the segment of Darby Creek from the Idaho-Wyoming state line to the spring west of Highway 33 is intermittent. The biological indices used by DEQ to assess the beneficial uses of cold water aquatic life and salmonid spawning were developed using data collected for aquatic insect or fish communities sampled in perennially flowing reference streams. Similar species diversity and other community measures cannot be expected to occur in channels that periodically become dry. Therefore, it is not appropriate for DEQ to use data collected using the BURP protocol to assess beneficial use support in Darby Creek upstream of the spring west of Highway 33.

3. For the purpose of assessing beneficial use support using data collected according to the BURP protocol, DEQ should sample only in the segment of Darby Creek from the spring west of Highway 33 to the confluence of Darby Creek with the Teton River.

4. Water quality in the segment of Darby Creek between the diversion near the Idaho-Wyoming state line and the spring west of Highway 33 is protected by numeric criteria when the channel contains water, and turbidity during runoff should be monitored to determine whether this criterion, as an indicator of sediment, is exceeded.

5. To support beneficial uses, the water quality targets for sediment shown in Table 15 should not be exceeded at any location in Darby Creek.

6. While Darby Creek is impaired due to flow alteration, a TMDL for flow will not be developed. The EPA does not believe that flow (or lack of flow) is a pollutant as defined by section 502(6) of the CWA. DEQ is not required to establish TMDLs for waterbodies impaired by pollution but not pollutants, so it is the policy of the state of Idaho to not develop TMDLs for flow alteration.

Fox Creek

Fox Creek originates at an elevation of almost 9,500 feet in the Jedediah Smith Wilderness Area on the western slope of the Teton Mountain Range. As it flows west toward the Caribou-Targhee National Forest boundary and Idaho-Wyoming state line, it drops approximately 2,800 feet in elevation over a distance of 7 miles. From the state line, it flows north and west less than 2 miles before it branches into several intermittent channels. West of Highway 33, perennial flow is restored by springs, and Fox Creek flows an additional 2 miles before reaching the Teton River.

Slightly less than half of the 15,429 acres that comprise the Fox Creek subwatershed, as delineated in the *Teton River Basin Study* (USDA 1992), are located on the Caribou-Targhee National Forest in Wyoming. The forest boundary divides the subwatershed from east to west, and coincides with the Wyoming-Idaho state line. Approximately 1,500 acres west of the state line are managed by the BLM, but all other land in Idaho is privately owned. Forest lands are used for recreation, motorized travel, and elk and deer winter range; private lands are used for rangeland, irrigated cropland, forest, and residential development (USDA 1992 and 1997a).

From the wilderness boundary to the forest boundary and state line, Fox Creek is classified by the Forest Service as ecological unit "2609-PIEN Cryaquolls, 2 to 8 percent slopes," which is described by Bowerman *et al.* (1999) below.

> This unit is on cold, moist floodplains in the forested zone ... topography is characterized by low to high gradient (2-8 percent) floodplains in U-shaped mountain valleys ... microrelief on the floodplain is very broken and irregular ... seasonal variation in stream flow is dominated by snow melt runoff ... braided channels and confined meanders are common ... beaver dams are infrequent.

The potential natural vegetation community is Engelmann's spruce/fragrant bedstraw and Engelmann's spruce/field horsetail, but present vegetation also includes red osier dogwood, willow, and alder communities. Soils may extend to a depth of 60 inches and are composed of fine sandy loam, stratified silt loam to gravelly sandy loam, and stratified gravelly sandy loam to extremely cobbly coarse sand. The soils have a very slow infiltration rate when thoroughly wet due to a high shrink-swell potential and/or permanent high water table, and therefore have a high runoff potential. Flooding is frequent and lasts from April through July due to snowmelt. Susceptibility to water erosion is relatively low, as indicated by a K_w of 0.15; soil loss tolerance is moderate, as indicated by a T value of 3.

The portion of the Fox Creek subwatershed located in Idaho is an alluvial floodplain overlain by wind-deposited loess. From the state line to west of Highway 33, the soils are level to gently sloping and well drained; from 0.5 miles to 1.5 miles west of the highway to the Teton River, the soils are nearly level and poorly drained.

Flow According to the USGS 7.5-minute topographic map, Fox Creek branches into two channels approximately 1.6 miles west of the forest boundary and flow changes from perennial to intermittent. These channels branch again, and four intermittent channels are shown on the topographic map passing beneath Highway 33. On some 1:100,000-scale maps and GIS coverages, Fox Creek is incorrectly shown to terminate west of the highway. But on the topographic map at 1:24,000-scale, one of the channels splits into two branches immediately west of the highway then rejoins after perennial flow is restored in each branch by springs located approximately 1.5 miles west of the highway. This channel has apparently been straightened and flows parallel to a county road until it empties into a channel that arises from springs west of the highway. The second channel then converges with another channel that arises west of the highway at Tonk's Spring. At this point, the Fox Creek channel is well defined, and it continues to receive discharge from other small, spring-fed channels as it flows toward the Teton River. Near its confluence with the Teton River, the channel of Fox Creek becomes wide and shallow. Downstream of the point at which Fox Creek joins the Teton River, the channel width of the river appears to double.

In the late 1970s, a pipeline was installed on Fox Creek less than 0.5 miles below the forest boundary in the vicinity of the North Fox Creek Canal diversion. The pipeline provides water for a sprinkler irrigation system that serves much of the Fox Creek subwatershed, and the North Fox Creek Canal is no longer used to provide water for flood irrigation. Water District 1 currently reports discharge at five stream or diversion locations: 1) the pipeline diversion, 2) a gage located on Fox Creek downstream of the pipeline and immediately upstream of the Center Canal diversion, 3) the Center Canal, 4) the Parrish Canal, and 5) Fox Creek (a location that is apparently upstream from all diversions). The eighteen-year flow averages shown in Figure 31 were calculated using values reported for Fox Creek.

Discharge from Fox Creek is low relative to other Teton River tributaries that originate in the Teton Mountains. The maximum average discharge for Fox Creek (87 cfs) is less than half the maximum average for Darby Creek (196 cfs) or North Leigh Creek (216 cfs), and less than one-third the maximum average for South Leigh Creek (272 cfs). In August, more than half of the discharge in Fox Creek is diverted to the pipeline and the remainder is diverted to the Center and Parrish Canals. Like Darby Creek, Fox Creek appears to flow continuously from its headwaters to the Teton River only for a few weeks in June and July when snowmelt at higher elevations in the subwatershed produce the highest stream discharges.

Fox Creek near the Teton River marks the lower boundary of Foster Slough, a large wetland complex that extends north to Darby Creek. Foster Slough is also shown on the USGS 7.5-minute topographic map as a distinct channel that flows into the Teton River above Darby Creek. The *Teton River Basin Study* (USDA 1992) shows Foster Slough as a distinct 3,548-acre subwatershed, though the topographic map shows channels connecting Fox Creek and the Foster Slough channel.

§303(d)-Listed Segment The segment of Fox Creek shown on the 1998 §303(d) list extends from the Idaho-Wyoming state line to the Teton River (Figure 32). The pollutants of concern are sediment, temperature, and flow alteration.

The results of BURP sampling conducted in 1995 indicated that the beneficial use of cold water aquatic life was supported in Fox Creek approximately 0.6 mile below the Idaho-Wyoming state line (MBI of 5.07 at site 95-A094), but was not supported 0.5 mile downstream of Highway 33 (MBI of 2.99 at site 95-B050) (Figure 32).

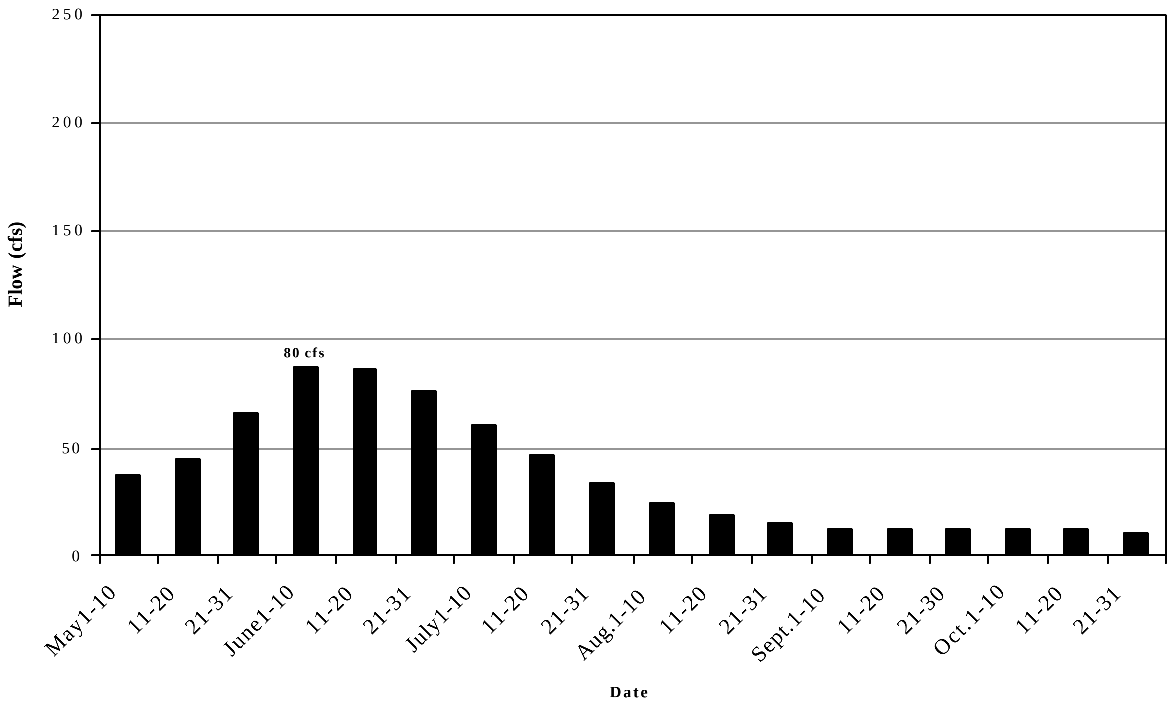

Figure 31. Eighteen-year average discharge measurements for Fox Creek.

The BURP sampling sites were not directly comparable because the upper site was located in the Middle Rockies ecoregion in Douglas-fir forest, while the lower site was located in the Snake River Plain ecoregion where grasses and cottonwood trees dominated the riparian vegetation. The HI score for the upper site (86) exceeded the value considered to support cold water aquatic life in the Middle Rockies ecoregion (81), but the HI score for the lower site (60) was far below the value considered to support cold water aquatic life in the Snake River Plain ecoregion (89). Factors that contributed to the poor HI score at the lower site included banks that were less than 75% stable, almost 50% substrate embeddedness, and 61% surface fines less than 6 mm in diameter.

The BURP site sampled downstream of the highway (site 95-B050) would probably have been dry in an average-flow year. According to 18-year flow data, average maximum discharge (87 cfs) occurs in Fox Creek in the first 10 days of June. In 1995, the maximum discharge that was measured (116 cfs) occurred on July 11, approximately two weeks before the BURP site was sampled.

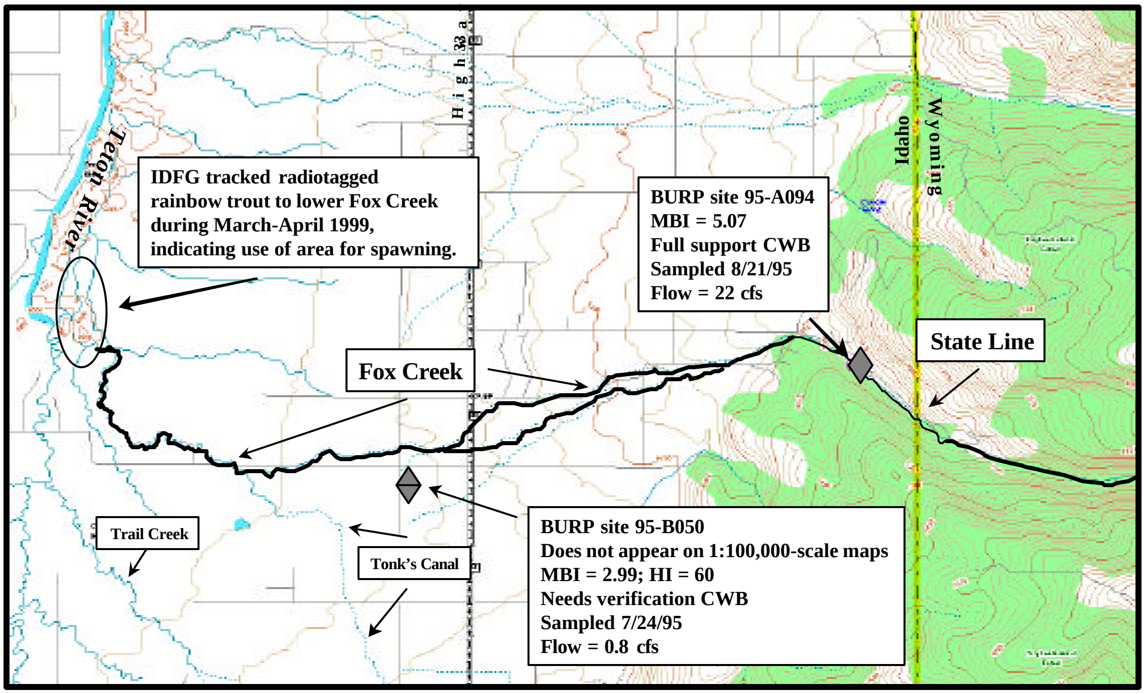

Figure 32. Data collection sites on Fox Creek and boundaries of the segment of Fox Creek identified on Idaho's 1996 section 303(d) list of water quality-impaired water bodies. Pollutants of concern included sediment, flow alteration, and temperature modification.

Resource Problems Identified by the USDA and TSCD The *Teton River Basin Study* (USDA 1992) estimated that the total sediment yield from agricultural lands in the Fox Creek subwatershed was 3,336 tons/year. Of that amount, 57% originated from streambanks and 43% originated from land use. Implementing structural practices, identified as Alternative 2 in the *Teton River Basin Study* (USDA 1992), was expected to reduce total sediment yield to 2,040 tons/year by reducing streambank erosion by 43% and land use erosion by 33%. The majority of the agricultural land located in the subwatershed occurs within treatment units 9, 10/11, and 12, with a small portion occurring in treatment units 2 and 6. The sources of resource problems identified for treatment unit 9 were sheet, rill, gully, wind and irrigation-induced erosion caused by pulverized soil surface conditions following potato harvest, spring barley seedbeds that lack adequate surface residues, fall disking, over-tilled mechanical summer fallow, up and downhill potato planting, soil compaction, and over application of irrigation water. The causes of resource problems identified for treatment unit 10/11 were overgrazing in the riparian area; removing stream-side shrubs, trees, and other vegetation; straightening sections of stream channel; improper culvert placement; flooding; stream evolution; reduced sub-water flows; poorly controlled flood irrigation systems; and erosion of uplands. The causes of resource problems identified for treatment unit 12 were overgrazing of uplands, season of use by livestock, roads, overland runoff/surface and gully erosion, and urbanization/home building (USDA 1992).

Water Quality Data With the exception of temperature data collected by IDFG beginning in 1996, there were no water quality data available for Fox Creek when this assessment started. In 1998 and 1999, researchers at Idaho State University measured high concentrations of nitrate (greater than 0.79 mg/L) in water samples collected from Fox Creek near its confluence with the Teton River (Thomas *et al.* 1999, Minshall 2000). Because of these results, DEQ performed additional sampling at this site and an upstream site in 2000. Unlike sampling conducted on other streams by DEQ in 2000, the sampling sites on Fox Creek did not correspond to BURP sites sampled in 1995. The upper sampling site in 2000 was located on the Caribou-Targhee National Forest where the road ends; the lower sampling site was located upstream of the confluence of Fox Creek with the Teton River.

The results of water quality sampling conducted by DEQ in 2000 did not indicate high concentrations of suspended sediment in Fox Creek at the locations and times sampled, but they did confirm high concentrations of nitrate at the downstream site (Appendix I). The maximum concentration of TSS (5.1 mg/L) was far below the designated target of 80 mg/L, and maximum turbidity (3.1 NTU) was far below the criterion specified in Idaho's water quality standards (i.e., not greater than 50 NTU above background). Nitrate concentrations at the upper sampling site ranged from 0.07 to 1.1 mg/L whereas concentrations at the lower sampling site ranged from 0.87 to 1.09 mg/L (Appendix I). These concentrations were approximately three times greater than the target of 0.3 mg/L.

The discharge data collected for these sites provide additional evidence that the hydrologic regimes of the upper and lower segments of Fox Creek are controlled by different factors. Discharge measured at the lower site was 57 cfs on June 14, 2000, and 56 cfs on August 21, 2000, indicating a consistent source of water such as spring flow. At the upper site, water velocity precluded discharge measurements during the first three site visits, but discharge was only 12 cfs during the last visit on August 21. Because discharge was much less in upper Fox Creek (12 cfs) than in lower Fox Creek (56 cfs), the source of flow in the lower creek could not have been upstream surface water. However, surface flows in upper Fox Creek are believed to contribute to flows in lower Fox Creek indirectly by replenishing ground water flows that recharge springs.

Subsurface sediment was analyzed in 2000 at the lower Fox Creek site. Ninety-five percent of particles were less than 0.85 mm in diameter and 100% were less than 6.3 mm in diameter. These values exceed the targets for subsurface fine sediment shown in Table 15 by 85% for particles less than 0.85 mm and by 73% for particles less than 6.3 mm. However, these targets may be unachievable for lower Fox Creek because it is a spring-fed, low-gradient, depositional stream channel that originates in a wet meadow in silty clay loam soil.

According to data collected by IDFG in 1996, 1997 and 1998 (Schrader 2000a) and by DEQ in 2000, temperatures in lower Fox Creek do not exceed Idaho's criteria for cold water aquatic life (i.e., 22^{o}C or less with a maximum daily average no greater than 19^{o}C) (Figures 33-36). However, the 13^{o}C temperature maximum for salmonid spawning was exceeded in all years, usually from the beginning of May or June through the end of October (Figures 33-36). A radiotagged rainbow trout hybrid was found spawning in lower Fox Creek during the last two weeks of March 1999, indicating that this segment is used by early spring spawners (Schrader 2000a).

Because the discharge in lower Fox Creek originates from springs, water temperatures remain fairly constant throughout the year. In fact, Fox Creek and other spring-fed tributaries of the Teton Valley section of the Teton River are considered important wintering areas for fish because they serve as thermal refuges (USDA 1992). In streams such as the upper portion of Badger Creek, where discharge is controlled by snowmelt, water temperatures tend to increase as air temperatures increase (Figure 27). But as shown in Figures 33 through 36, water temperatures in a spring-fed stream increase in the spring and decrease in the fall in response to air temperatures, but remain relatively constant throughout the summer. In the four years during which temperature data were collected, maximum daily water temperatures ranging between 17 ^{o}C and 20 ^{o}C occurred between mid-July and mid-August when average daily air temperatures reach their maximum in Teton Valley (Table 1). However, these maximum temperatures were also reached in late April of 1998 (Figure 35) and mid-May of 2000, indicating that something other than air temperature was influencing water temperature. The most dramatic changes in water temperature in lower Fox Creek apparently coincided with periods of extreme runoff when snowmelt actually reached the area where the thermographs were located. For example, the maximum discharge measured in Fox Creek in 1998 upstream of diversions near the forest boundary was 112 cfs on June 30. This corresponded to a drop in maximum daily temperature in lower Fox Creek from 14 ^{o}C to 9 ^{o}C (Figure 35).

Based on available data, it is not possible to conclude that fish have completed spawning in lower Fox Creek before temperature criteria for salmonid spawning are exceeded. Salmonid spawning probably occurs in Fox Creek no later than the end of April. Salmonid spawning temperature criteria were not exceeded until the end of May in 1996 (Figure 33), the beginning of May in 1997 (Figure 34), and the middle of April in 1998 (Figure 35). However, because maximum average air temperatures are approximately equivalent to water temperatures at this time of year, water temperatures in lower Fox Creek appear to be determined at its source, which is a spring. Before concluding that a load allocation for temperature is appropriate, the period of salmonid spawning in lower Fox Creek must be better defined and additional temperature data must be collected closer to the spring source to determine the natural temperature regime of this segment of the stream.

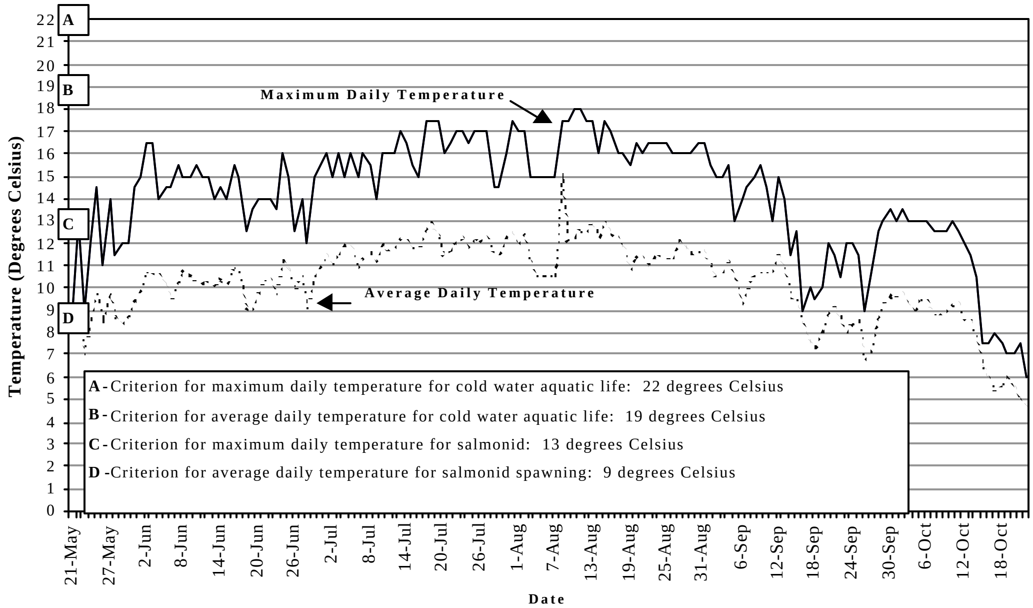

Figure 33. Fox Creek water temperatures from March 20 through October 21, 1996 (Schrader 2000).

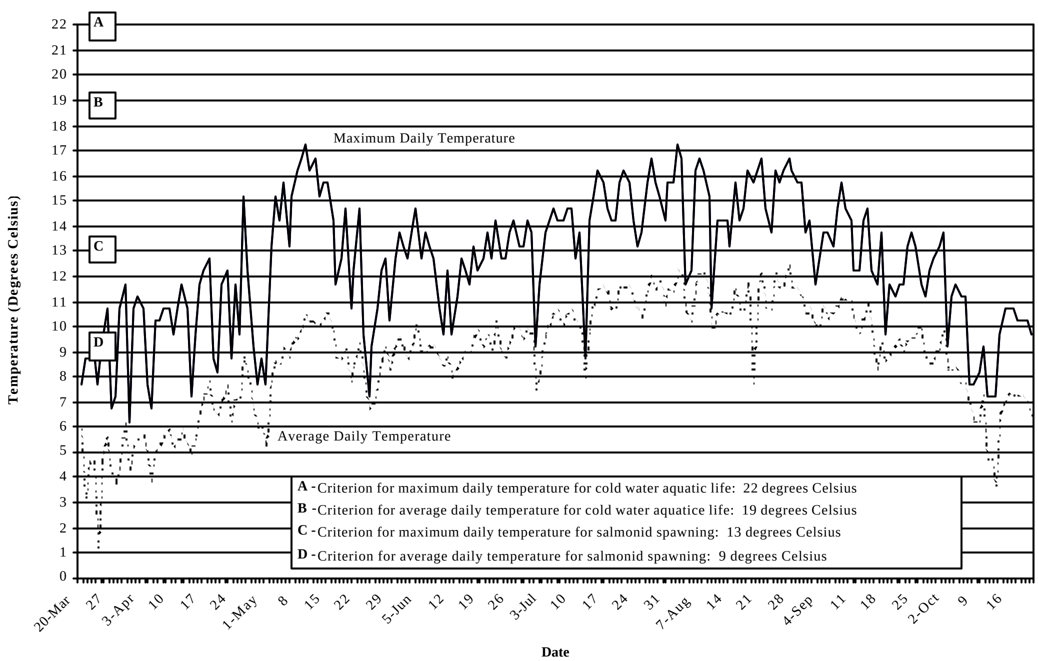

Figure 34. Fox Creek water temperatures from March 20 through October 21, 1997 (Schrader 2000).

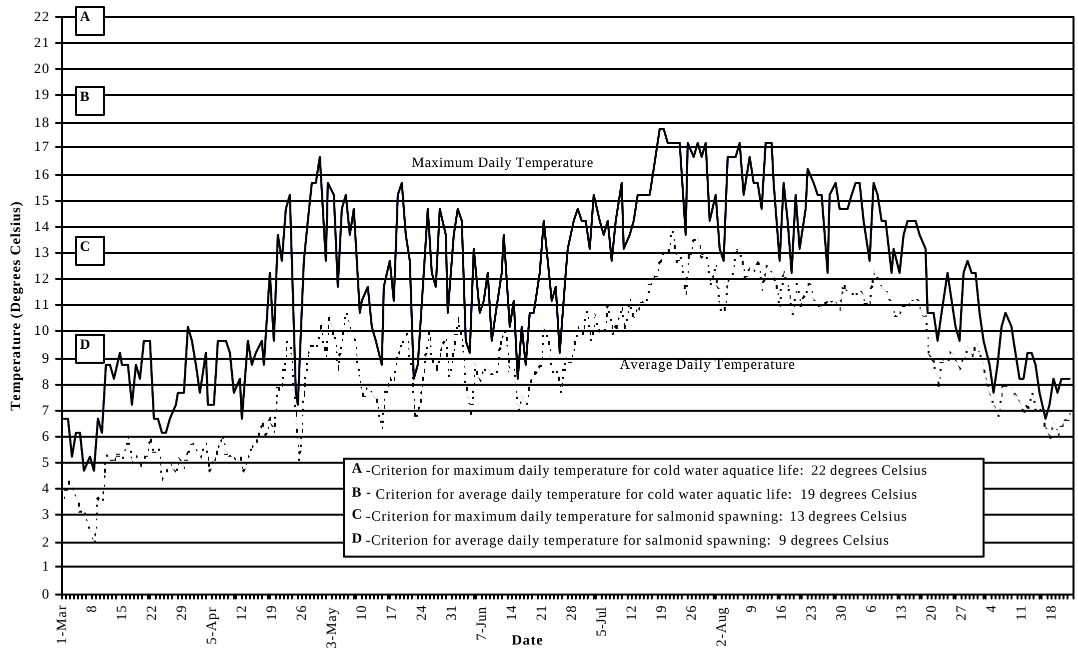

Figure 35. Fox Creek water temperatures from March 1 through October 21, 1998 (Schrader 2000)

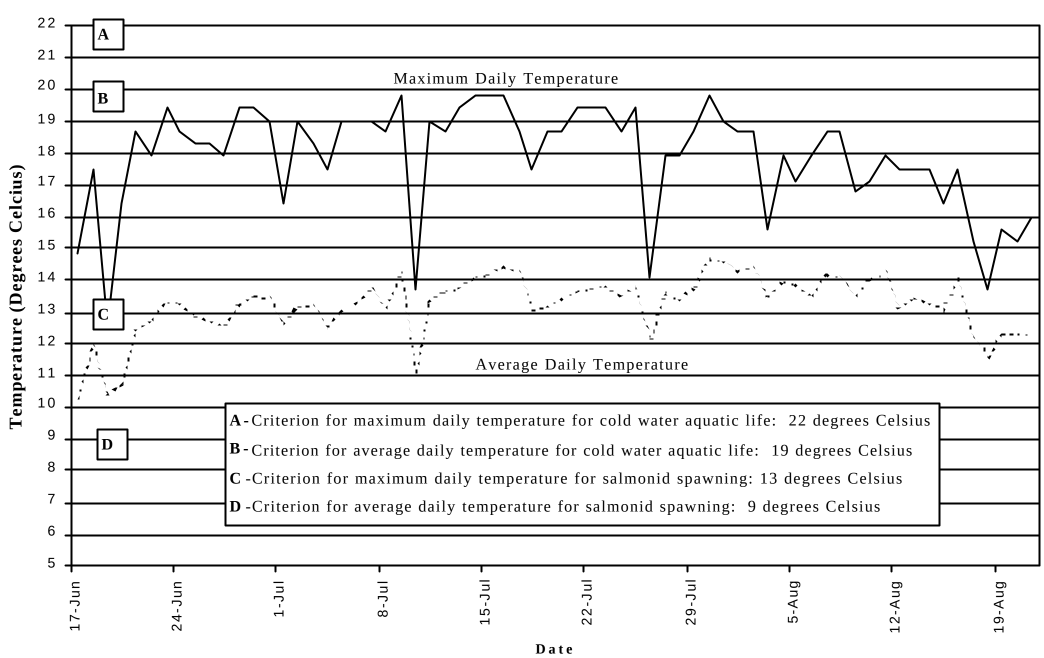

Figure 36. Fox Creek temperatures from June18 through August 21, 2000.

Fisheries Fisheries data for Fox Creek were recently collected by the Caribou-Targhee National Forest and DEQ, and fisheries habitat was assessed on the forest in 1980. In August 1998, Forest biologists surveyed Fox Creek from the forest boundary to the wilderness boundary for cutthroat trout. None were collected, but brook trout were present in every stream unit electrofished. Upper Fox Creek below the forest boundary was electrofished by DEQ in 1996 at BURP site 95-A094, and three year classes of brook trout, including juveniles, were collected. Based on these data, Fox Creek was assessed as fully supporting salmonid spawning.

Data collected by IDFG indicates that lower Fox Creek is used by fish in the Teton River for spawning in early spring. A radiotagged rainbow trout hybrid was found spawning in lower Fox Creek during the last two weeks of March 1999 (Schrader 2000a). Lower Fox Creek immediately west of the Highway 33 was electrofished by DEQ in July 1997 at BURP site 95-B050. No fish were collected, but because this site is upstream of springs that restore perennial flow to Fox Creek, it was probably not an appropriate location for sampling. The stream channel contained water at this location in 1997 because relatively high runoff persisted into late July.

An 8-foot-high concrete dam extends across the width of Fox Creek just above the forest boundary in the vicinity of a privately owned limestone quarry. This dam was apparently built to create a settling pond for the quarry, and in 1980 was filled in to a depth of 6 or 7 feet. In 1980, the fisheries biologist for the Caribou-Targhee National Forest reported that the dam blocked fish passage, though the presence of brook trout below the dam in 1996 indicates that it blocks upstream passage only.

Discussion Like Darby Creek, Fox Creek consists of two hydrologically distinct segments. The source of water in the upper segment is snowmelt runoff; the source of water in the lower segment is upwelling subsurface water and springs located approximately one mile west of Highway 33. For a few weeks during the summer, runoff may be sufficient to provide flow from the headwaters of Fox Creek to the Teton River. Otherwise, the channel in the vicinity of Highway 33 is dry. In 1999, the Henry's Fork Watershed Council Water Quality Subcommittee recommended separating Fox Creek into three segments (Appendix D). The first segment extends from the forest boundary to the North Fox Creek Canal, the second extends from the North Fox Creek Canal to the location of springs that recharge lower Fox Creek, and the third extends from the springs to the Teton River. The first and third segments contain water on a perennial basis; the second segment contains water on an intermittent basis. When DEQ assessed Fox Creek for the 1998 § 303(d) list, the assessment of "not full support" for cold water aquatic life was based on sampling conducted at a site downstream of Highway 33 that is probably dry most of the year. Additional data indicate that the beneficial uses of cold water aquatic life and salmonid spawning are supported in upper Fox Creek upstream of the pipeline and lower Fox Creek downstream of the springs.

Conclusions Conclusions regarding the water quality status of Fox Creek are listed below.

1. Discharge in the segment of Fox Creek that appeared on the 1998 §303(d) list is intermittent from North Fox Creek Canal to the springs west of Highway 33. However, the segments from the forest boundary to North Fox Creek Canal and from the springs west of Highway 33 to the confluence of Fox Creek with the Teton River are sufficient to support aquatic life uses year-round.

2. Discharge in the segment of Fox Creek assessed as not supporting cold water aquatic life is intermittent. The biological indices used by DEQ to assess the beneficial uses of cold water aquatic life and salmonid spawning were developed using data collected for aquatic insect or fish communities sampled in perennially flowing reference streams. Similar species diversity and other community measures cannot be expected to occur in channels that periodically become dry. Therefore, it was not appropriate for DEQ to use data collected using the BURP protocol to assess beneficial use support at this site.

3. For the purpose of assessing beneficial use support using data collected according to the BURP protocol, DEQ should sample only in two segments of Fox Creek: from the forest boundary (and Idaho-Wyoming state line) to the North Fox Creek Canal and the springs west of Highway 33 to the confluence of Fox Creek with the Teton River.

4. Water quality in the intermittent segment of Fox Creek is protected by numeric criteria when the channel contains water, and turbidity during runoff should be monitored to determine whether this criterion, as an indicator of sediment, is exceeded.

5. To support beneficial uses, the water quality targets for sediment shown in Table 15 should not be exceeded at any location in Fox Creek.

6. Development of a TMDL for sediment is appropriate based on subsurface sediment data collected in 2000 and information collected by the TSCD in the early 1990s (USDA 1992). However, because of the low-gradient, depositional character of lower Fox Creek, the subsurface sediment targets of 10% for particles less than 0.85 mm and 27% for particles less than 6.3 mm may be too low and may need to be adjusted for TMDL implementation.

7. The temperature TMDL for Fox Creek has been rescheduled for the end of 2002.

8. While Fox Creek is impaired due to flow alteration, a TMDL for flow will not be developed. The EPA does not believe that flow (or lack of flow) is a pollutant as defined by section 502(6) of the CWA. DEQ is not required to establish TMDLs for waterbodies impaired by pollution but not pollutants, so it is the policy of the state of Idaho to not develop TMDLs for flow alteration.

Horseshoe Creek

Horseshoe Creek is impaired due to flow alteration. However, the EPA does not believe that flow (or lack of flow) is a pollutant as defined by section 502(6) of the CWA. DEQ is not required to establish TMDLs for waterbodies impaired by pollution but not pollutants, so it is the policy of the state of Idaho to not develop TMDLs for flow alteration. Horseshoe Creek is not impaired by any other pollutants, so no TMDLs will be established for this creek.

Moody Creek

Moody Creek originates on the northeastern slope of the Big Hole Mountains and is the only major tributary of the South Fork Teton River. From the confluence of North Moody Creek and South Moody Creek on the Caribou-Targhee National Forest, the mainstem flows north and west 16 miles through a basalt canyon that reaches depths of 400 feet. After exiting the canyon, Moody Creek's natural channel is replaced by almost 2 miles of ditches and canals that direct its flow into irrigation canals or the South Fork Teton River.

The Moody Creek drainage has been divided into two watersheds: Moody Creek and Parkinson (Figure 6). Together, these watersheds drain an area of 172 square miles or 110,549 acres. Approximately 11% of this area is managed by the Caribou-Targhee National Forest, 8% is managed by the Idaho Department of Lands, and the remainder is privately owned. Public lands are used for grazing, timber production, recreation, motorized travel, and elk and deer winter range (USDA 1997a); private lands are used primarily as irrigated and nonirrigated cropland.

North Moody Creek, South Moody Creek, and the mainstem of Moody Creek on the Caribou-Targhee National Forest are located within ecological units 2606, 2609, and 1224 (Bowerman *et al.* 1999). Unit 2606 is a moist floodplain characterized by a flat bottom, moderate gradient, and frequent flooding. Seasonal variation in streamflow is dominated by snowmelt. Unit 2609 is characterized by low to high gradient (2-8 percent) floodplains in U-shaped mountain valleys. The soils have a very slow infiltration rate when thoroughly wet due to a high shrink-swell potential and/or permanent high water table, and therefore have a high runoff potential. Flooding is frequent and lasts from April through July due to snowmelt. Susceptibility to water erosion is relatively low, as indicated by a K_w of 0.15. Unit 1224 is characterized by summits with rolling to hilly slopes and incised drainageways. Soils are very deep, slowly permeable, and susceptibility to water erosion is relatively high, as indicated by a K_w of 0.43.

On privately owned land, soils on either side of Moody Creek Canyon are deep, well-drained silt loams on level, gently sloping, strongly rolling, or hilly topography (USDA 1981).

Flow The USGS maintained staff and crest-stage gages on Moody Creek from 1979 through 1986 at a location approximately 8.5 miles downstream of the forest boundary and 8.5 miles upstream of the South Fork Teton River. Peak discharges occurred between late April and early June and ranged from 145 cfs to 528 cfs (Figure 37). Discharges less than 10 cfs generally occurred from July or August through February. According to the *U.S. Geological Survey Water-Data Report ID-81-1*, almost all of the flow in Moody Creek was sometimes diverted for irrigation upstream of the gage, so the discharge data were not necessarily representative of the natural flow regime of Moody Creek.

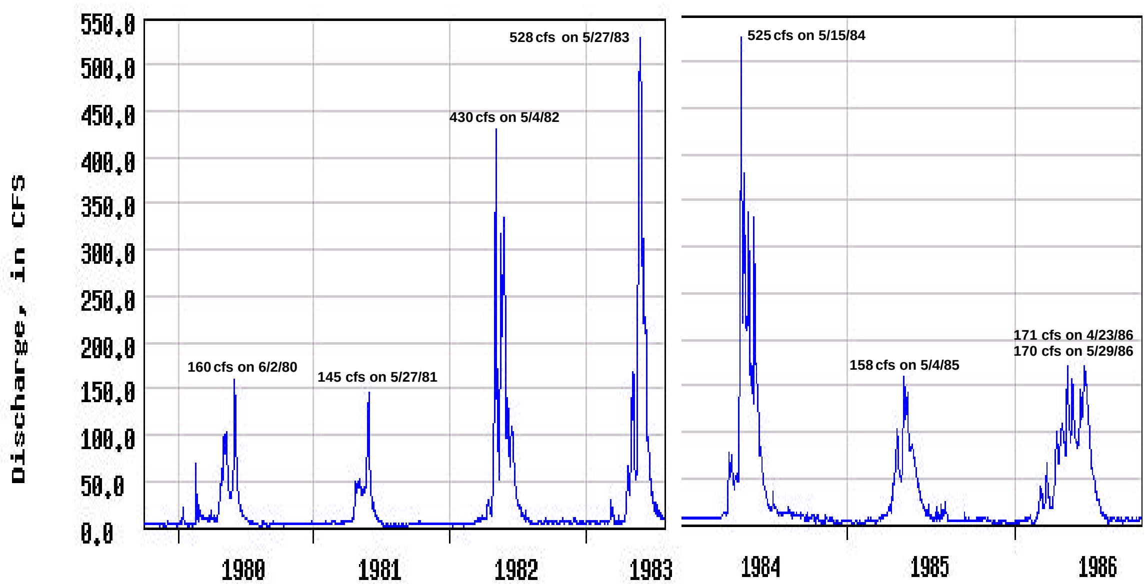

Figure 37. Daily mean discharges recorded from 10/1/79 to 7/31/83 and 1/1/83 to 9/30/86 at U.S. Geological Survey gage station 13055319, *Moody Creek near Rexburg Id.* Graphs were downloaded from the Idaho NWIS-W Data Retrieval page at http://waterdata.usgs.gov/nwis-w/id.

Flow in lower Moody Creek is highly modified by irrigation withdrawals and returns. According to Cleve Bagley of the NRCS field office in Rexburg, flow from Moody Creek reaches the South Fork Teton River during spring runoff and possibly in winter when discharge is sufficient. From April 1 to November 1 flow may be diverted at three locations, though all water rights are reduced by one-half after June 20. The first major diversion is located at T5N R41E S21, upstream of the USGS gage location and Woods Crossing. This diversion was responsible for the flow alteration described in the *U.S. Geological Survey Water-Data Report ID-81-1*. The second diversion is located almost 9 miles downstream from the first and has a diversion rate of 6.4 cfs. The third diversion is the Woodmansee Johnson Canal, which intersects with the channelized portion of Moody Creek approximately one mile east of the South Fork Teton River. All of the flow remaining in the channel may be diverted into the canal at this point.

A four-mile segment of lower Moody Creek upstream of the third diversion is usually dewatered after July (Huskinson personal communication). Water is present in the lower half of this segment because of irrigation return flows from the Enterprise Canal, East Teton Canal, and Teton Canal.

§303(d)-Listed Segment The segment of Moody Creek shown on the 1998 §303(d) list extends from the forest boundary to the Teton River. As explained above, Moody Creek discharges to the South Fork Teton River, not the mainstem Teton River, so the lower boundary was incorrectly identified. Because flow from Moody Creek discharges to the South Fork via a canal instead of a natural stream channel, it is not consistent with Idaho's water quality standards to identify the South Fork Teton River as the lower boundary for the purpose of assessing the support status of aquatic life beneficial uses. Furthermore, because a segment of lower Moody Creek is dewatered by legal appropriations of streamflow, the lower boundary should be located at a point upstream from this segment. Additional monitoring of Moody Creek will be required to determine the correct boundary location. The pollutant of concern shown on the 1998 § 303(d) list for Moody Creek was nutrients.

Three locations on Moody Creek were selected for BURP sampling in 1995 based on a review of USGS 7.5-minute topographic maps. The lower site was not sampled because it did not contain riffles. It was later determined that this site was inappropriate anyway because it was located on the Woodmansee Johnson Canal, not Moody Creek. The upper site, which was located on North Moody Creek, was not sampled because it was in a beaver complex. The middle site, located near Woods Crossing (Figure 38), produced an MBI score (3.07) within the "needs verification" range and a HI score (83) less than the value considered to support cold water aquatic life in the Snake River Plain ecoregion (89). It was subsequently determined that this site was approximately 2 miles downstream from the first major diversion on Moody Creek. Discharge at the time the site was sampled on August 21, 1995, was 3.8 cfs, and it is not known whether water was being diverted upstream.

In 1997, BURP sampling was conducted on three additional sites, all of which were upstream of the forest boundary and the confluence of North Moody and South Moody Creeks. The site on North Moody Creek (97-L015) produced one of the highest MBI scores in the Teton Subbasin (5.45), but the HI score was low (80). On South Moody Creek, the site furthest upstream (97-L014) produced high MBI (4.55) and HI (102) scores despite its location immediately downstream from its headwaters at a series of springs. The downstream site (97-M016) produced slightly lower MBI (3.92) and HI (91) scores. The beneficial use support status of these sites have not yet been assessed, but if they had been according to guidelines used to develop the 1998 §303(d)-list (DEQ 1998b), they would have been assessed as fully supporting cold water aquatic life.

Scores for substrate embeddedness and percentage of substrate fine sediment did not indicate that sediment was a greater problem downstream than upstream. Substrate embeddedness was rated optimal at the site on North Moody Creek and at the upstream site on South Moody Creek, and sub-optimal at the downstream site on South Moody Creek and at the site on Moody Creek near Woods Crossing. But the percentage of substrate fine sediment less than 1 mm in size was only 20% at the site on Moody Creek near Woods Crossing compared to 38% at the site on North Moody Creek, 72% at the upstream site on South Moody Creek, and 28% at the downstream site on South Moody Creek. The percentage of stable banks was less than the target of 80% at the site on North Moody Creek (71% stability on the left bank) and at the downstream site on South Moody Creek (56% stability on the left bank; 67% stability on the right bank).

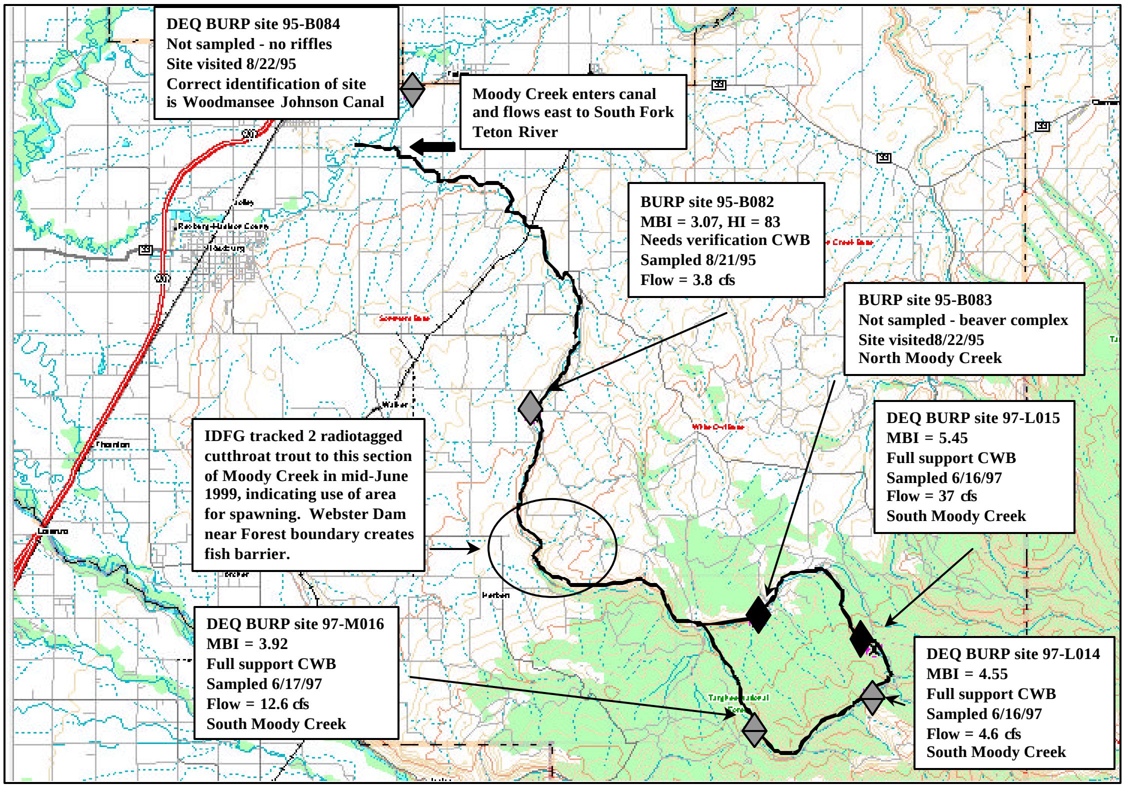

Figure 38. Data collection sites on Moody Creek and North and South Moody Creeks.

Resource Problems Moody Creek was originally placed on Idaho's §303(d) list because it was listed as an impaired stream segment in *The 1992 Idaho Water Quality Status Report* (DEQ 1992). Pastureland treatment and animal holding/management areas were identified by DEQ as sources of nitrate, the pollutant responsible for impairment. These land uses are essentially limited to the grazing lands located on the Caribou-Targhee National Forest and state endowment lands. Private lands are used for irrigated and nonirrigated crop production, and 17% of private farmland, particularly in the upper watershed, is currently enrolled in the Conservation Reserve Program (Figure 39). The segment of Moody Creek identified as impaired was below the forest boundary, implicating state endowment lands and private lands as the sources of nutrients.

Most of the endowment lands adjacent to the forest have been leased long-term by the Lyman Creek Grazing Association though income is also received from logging. In 1999, an assessment of the 6,125-acre allotment was conducted as part of the 10-year lease-renewal process (Hancock 2000). Proper functioning condition estimates were made for Moody Creek, State Creek, and an unnamed tributary of State Creek, and all were found to be in proper functioning condition. The high quality of the riparian areas appears to be due to two factors. First, most of Moody Creek is located in a canyon that is generally inaccessible to cattle, and second, an off-stream stock watering system was implemented in the early 1990s. Working with the NRCS field office in Rexburg, the Lyman Creek Grazing Association installed a water storage tank, pumphouse, and nine watering troughs to encourage cattle to remain away from streams and springs. Resource concerns identified in the assessment included 1) grazing use following timber harvest, 2) damage to riparian areas caused by off-road recreational vehicles, and 3) spotted knapweed in Moody Creek Canyon. The Idaho Department of Lands has addressed the problem of off-road vehicle damage by prosecuting offenders and building fences around susceptible areas.

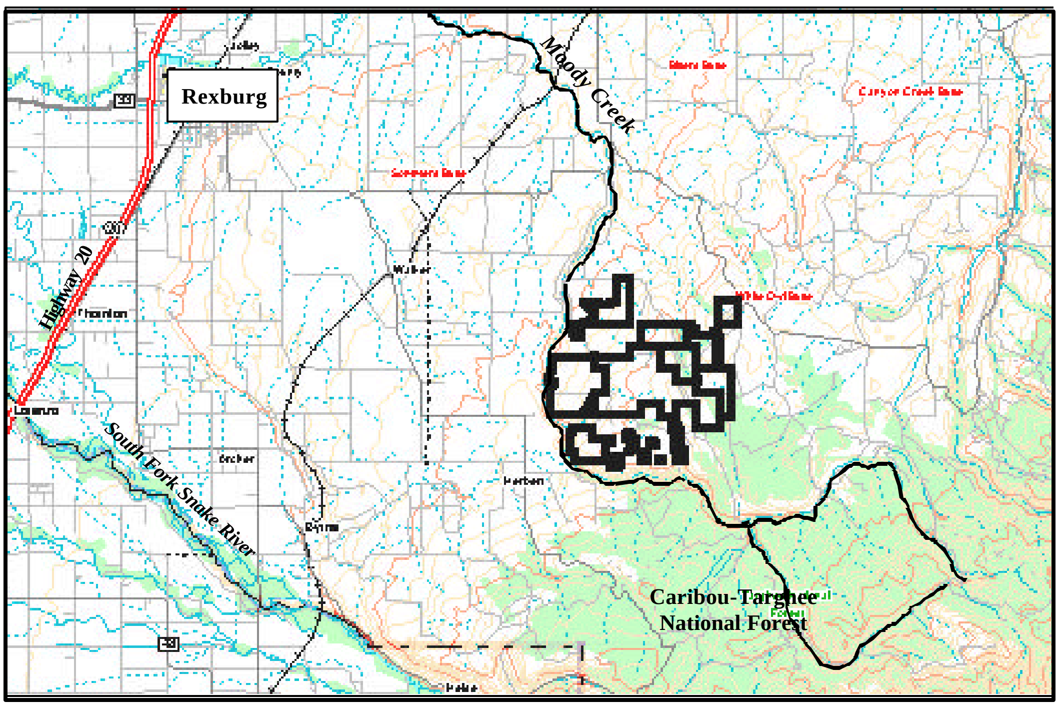

Figure 39. Cultivated lands in the middle Moody Creek watershed that are currently enrolled in the U.S. Department of Agriculture Conservation Reserve Program (CRP).

Turbidity measurements made at three locations on lower Moody Creek on June 10, 1999, were the highest recorded in the Teton Subbasin. At the elbow of Moody Creek, turbidity was 57 NTU, downstream of the Enterprise Canal turbidity was 204 NTU, and at the intersection with the Woodmansee Johnson Canal, turbidity was 70 NTU. These results indicated that sediment was being transported from some point upstream of the Elbow of Moody Creek and that additional sediment was being introduced to Moody Creek downstream of the Elbow, probably via the Enterprise Canal. Subsequent driving tours of North Moody and South Moody Creeks indicated that sediment was originating on the forest. Extensive streambank erosion was observed on North Moody Creek downstream of the confluence of Sheep Creek. Staff from

DEQ and the Caribou-Targhee National Forest toured the South Moody Creek, Fish Creek, and Hinckley Creek areas on August 3, 1999. Several sources of sediment and pathways for sediment delivery to streams were identified. These included, but were not limited to, road gullies caused by plugged or undersized culverts, severe downcutting in Fish Creek due to a hanging culvert, and gullies in temporary roads in clearcut areas east of Hinckley Creek.

Water Quality Data Nitrate concentrations did not exceed the target concentration of 0.3 mg/L in any of the Moody Creek water samples collected by DEQ in 2000. Samples were collected at five locations (Figure 40): North Moody Creek on the National Forest (site 21), approximately 2 miles below the first major diversion at Woods Crossing (site 22), approximately 4 miles upstream of the Enterprise Canal at the Elbow of Moody Creek (site 23), approximately 500 m below the Enterprise Canal (site 24), and approximately 0.5 miles below the Teton Canal (site 25). The lowest concentrations of nitrate were measured in North Moody Creek and ranged from less than detection level to 0.04 mg/L. Concentrations remained low at the two downstream sites, ranging from less than detection level to 0.13 mg/L at Woods Crossing and the Elbow of Moody Creek. The highest concentration of nitrate (0.29 mg/L) was measured downstream of the Enterprise Canal in August when flow in Moody Creek at this location was probably derived entirely from the canal's discharge. Concentrations of nitrate at the lowest site were the highest measured in June, and exceeded the concentrations measured at the closest upstream site by 0.11 to 0.19 mg/L. These results indicated that nitrate was introduced either from the East Teton and Teton Canals or from land use in the final 2 miles of Moody Creek.

The highest concentration of TSS measured in the Teton Subbasin in 2000 was measured in a sample collected from Moody Creek at Woods Crossing on August 24. However, this concentration (26.7 mg/L) was well below the designated target of 80 mg/L, and all other concentrations ranged from less than detection level to 16.4 mg/L. Concentrations of suspended solids increased from approximately 5 mg/L at the upstream sites on Moody Creek to 15 and 16 mg/L at the downstream sites on June 15, but a similar pattern of increasing concentration downstream was not observed on any other sampling date. The high turbidity values measured in 1999 were not measured in 2000, and maximum turbidity (7.8 NTU) was far below the criterion specified in Idaho's water quality standards (i.e., not greater than 50 NTU above background).

Water temperatures measured in 2000 exceeded the instantaneous criterion of 22 ^{o}C for cold water aquatic life on two occasions: on July 27 at the Elbow of Moody Creek (23.5 ^{o}C) and on August 24 below the Enterprise Canal (22.2 ^{o}C). At the most upstream site on North Moody Creek, two instantaneous temperature measurements exceeded 19 ^{o}C, the maximum daily average criterion for cold water aquatic life. These data indicate that long-term temperature monitoring is warranted in both the upper and lower reaches of the Moody Creek subwatershed.

Fisheries Brook trout and Yellowstone cutthroat trout occur throughout Moody Creek and in North and South Moody Creeks. Webster Dam, located approximately 1.5 miles downstream of the forest boundary and immediately upstream of the state endowment lands boundary, is considered a barrier to upstream fish migration (Schrader 2000a). This dam was built at the turn of the century to create a reservoir on Moody Creek, but an adjudication claim on the water rights issued in 1903 have not been filed (Olenichak 2000). According to Schrader (2000a) and Hancock (2000), the reservoir has filled with sediment and resembles a wet meadow.

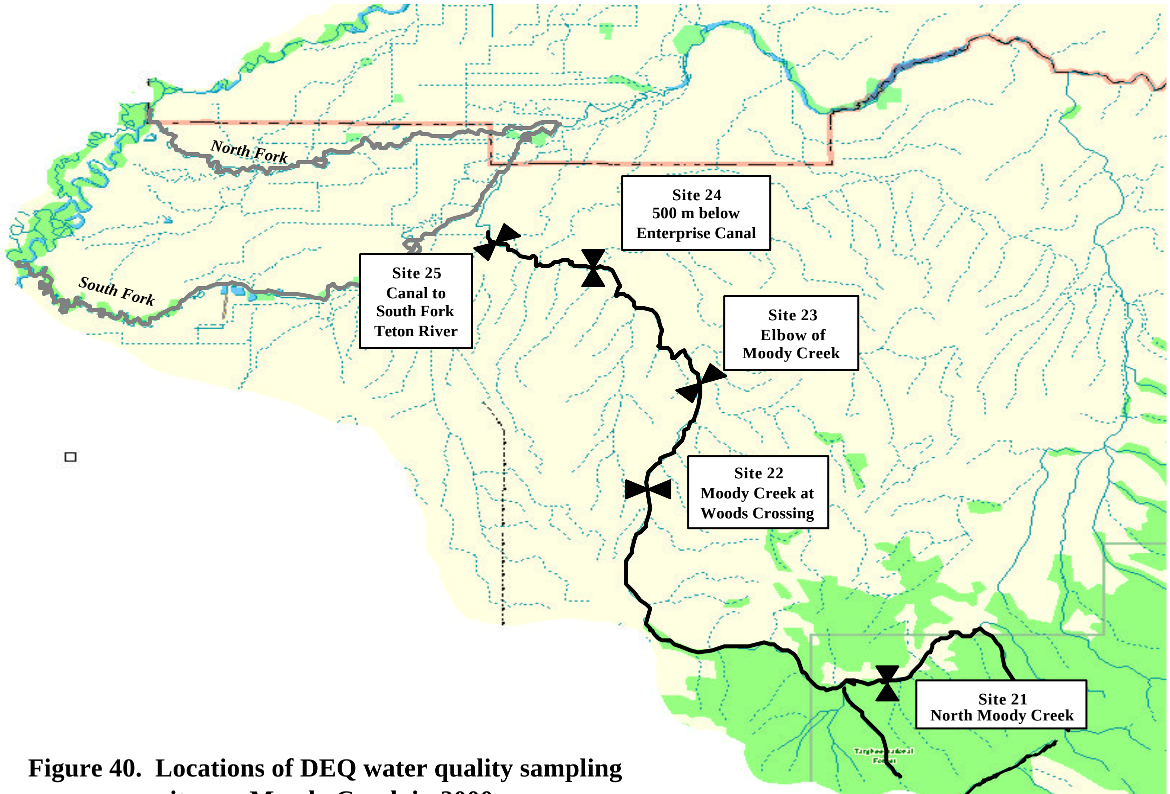

Figure 40. Locations of DEQ water quality sampling sites on Moody Creek in 2000.

Four locations in the Moody Creek watershed were recently electrofished by DEQ. Three year classes of brook trout, including juveniles, were collected on North Moody Creek at BURP site 97-L015 in September 1997. On the same day, two year classes of both brook trout and cutthroat trout were collected on South Moody Creek at BURP site 97-L014. South Moody Creek at BURP site 97-M016 was electrofished in July 1999, but no fish were collected. Moody Creek upstream of Woods Crossing was electrofished in September 1996 and one brook trout, 3 cutthroat trout, 76 sculpin, 71 speckled dace, 19 longnose dace, and 94 redshine shiners were collected. The length of the brook trout was between 170 and 179 mm; the lengths of the cutthroat trout were less than 100 mm and between 230 and 309 mm. According to the assessment process used to develop the 1998 §303(d) list (DEQ 1998b), these data support an assessment of full support for the beneficial use of salmonid spawning in North Moody Creek but not in South Moody Creek or the mainstem of Moody Creek.

During the study of the Teton Canyon fishery conducted by IDFG, two radiotagged cutthroat trout were observed to swim upstream from the South Fork Teton River into Moody Creek. These fish were located above Woods Crossing near the lower boundary of the state endowment lands during the week of June 17, 1999, where they are believed to have spawned (Schrader 2000a). Additional fish population and habitat survey data were collected by IDFG in the early 1990s and are currently being compiled (Schrader 2000a).

Data Collected Following Public Review of the Draft *Teton Subbasin Assessment and Total Maximum Daily Load (TMDL)* Since the draft version of this document was submitted for public comment in March 2001, a substantial amount of water quality and stream channel data have been collected and submitted to DEQ for use in the TMDL development process. At the request of the Madison Soil and Water Conservation District, the Idaho Association of Soil Conservation Districts has conducted bimonthly water quality sampling at three locations on lower Moody Creek since April 2001. During the summer of 2001, staff from the Caribou-Targhee National Forest surveyed the headwaters of Moody Creek as part of the forest's Yellowstone cutthroat trout management program.

The sampling locations and parameters measured by DEQ in 2000 and by Idaho Association of Soil Conservation Districts in 2001 were similar (Figures 40 and 40a), but the frequency of sampling and the analysis of phosphorus in 2001 provide a more representative data set than that obtained in 2000.

The results of water quality sampling for the period from April 18, 2001 to January 16, 2002, are summarized as follows:

1. Discharge: Discharge reached a maximum of approximately 30 cfs on both May 1 and May 16 at the upper and middle sites, and reached a maximum of 40 cfs on May 16 at the lower site (Figure 40b). This result indicates that a source or sources other than upstream flow contributed to the discharge, and therefore water quality, at the lower site. This conclusion is also supported by discharge measurements made in June, July, and August when discharge was at its lowest at the upper site. Sources of flow at the lower site may include subwater, but it is more likely that discharge is supplemented by discharge from irrigation canals. Discharge at the lower site dropped from 30 to 40 cfs on May 16 to 0.5 to 3 cfs on May 31, probably due to decreased runoff and diversion of water for irrigation. Flow was altered in August at the middle site by construction of a beaver dam, and samples were not collected at any of the sites in December or January because the stream was frozen.

2. Total Suspended Solids: The target concentration for TSS recommended by DEQ to protect water quality is less than 80 mg/L (Table 15). The highest concentrations of TSS in Moody Creek were measured at the upper and middles sites on May 16 and at the lower site on May 1, and generally corresponded to dates with high discharge measurements (Figure 40b). The TSS values on these dates ranged from 57 to 174 mg/L, as compared to a range of 3 to 33 mg/L on all other dates. However, it is notable that the concentration of TSS at the lower site was only 16 mg/L on the day that discharge was highest (i.e., 40 cfs). This result is consistent with the conclusion based on flow data that indicate the primary source of water at this site is not Moody Creek.

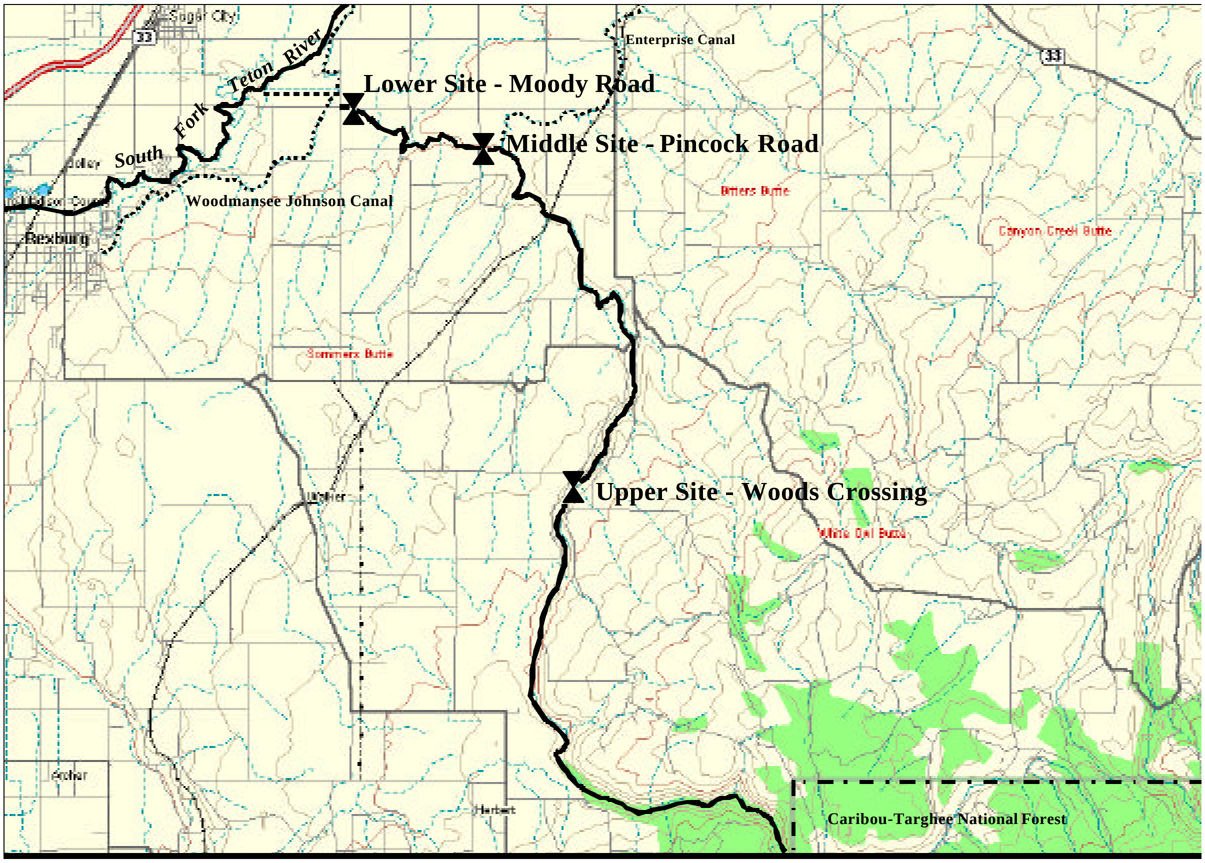

Figure 40a. Locations of Idaho Assocation of Soil Conservation Districts water quality sampling in 2001.

3. Nitrogen: The concentration of $NO_2 + NO_3$ in every sample analyzed was less than the detection level of 0.05 mg/L with only one exception. This exception occurred on May 16 when a concentration of 0.81 mg/L $NO_2 + NO_3$ was measured at the lower site. Again, this result indicates that the primary source of water at the lower site was not Moody Creek, and that nitrate is not. contributing to nutrient enrichment in Moody Creek. However, the results of analyses performed in 2000, and the results of ammonia analyses performed in 2001, cast doubt on the validity of the $NO_2 + NO_3$ results. Only three of 12 samples collected in 2001 did not contain detectable concentrations of NO_2 + NO_3 (Appendix I), but seven samples contained concentrations ranging from 0.11 mg/L to 0.29 mg/L. Furthermore, the concentrations of ammonia measured at the middle and lower sites in 2001 exceeded 0.1 mg/L on several dates (Figure 40b). These ammonia concentrations are more consistent with concentrations found in effluent from municipal wastewater treatment facilities than with concentrations found in natural surface waters. Ammonia is generally not detectable in natural surface waters because it rapidly dissipates to the atmosphere under ambient conditions of dissolved oxygen and pH. It appears that the 2001 results may have been transcribed (i.e., ammonia reported as NO_2 + NO_3 and $NO_2 + NO_3$ reported as ammonia), or that the results reported for ammonia were actually the results of an analysis of ammonia plus organic nitrogen.

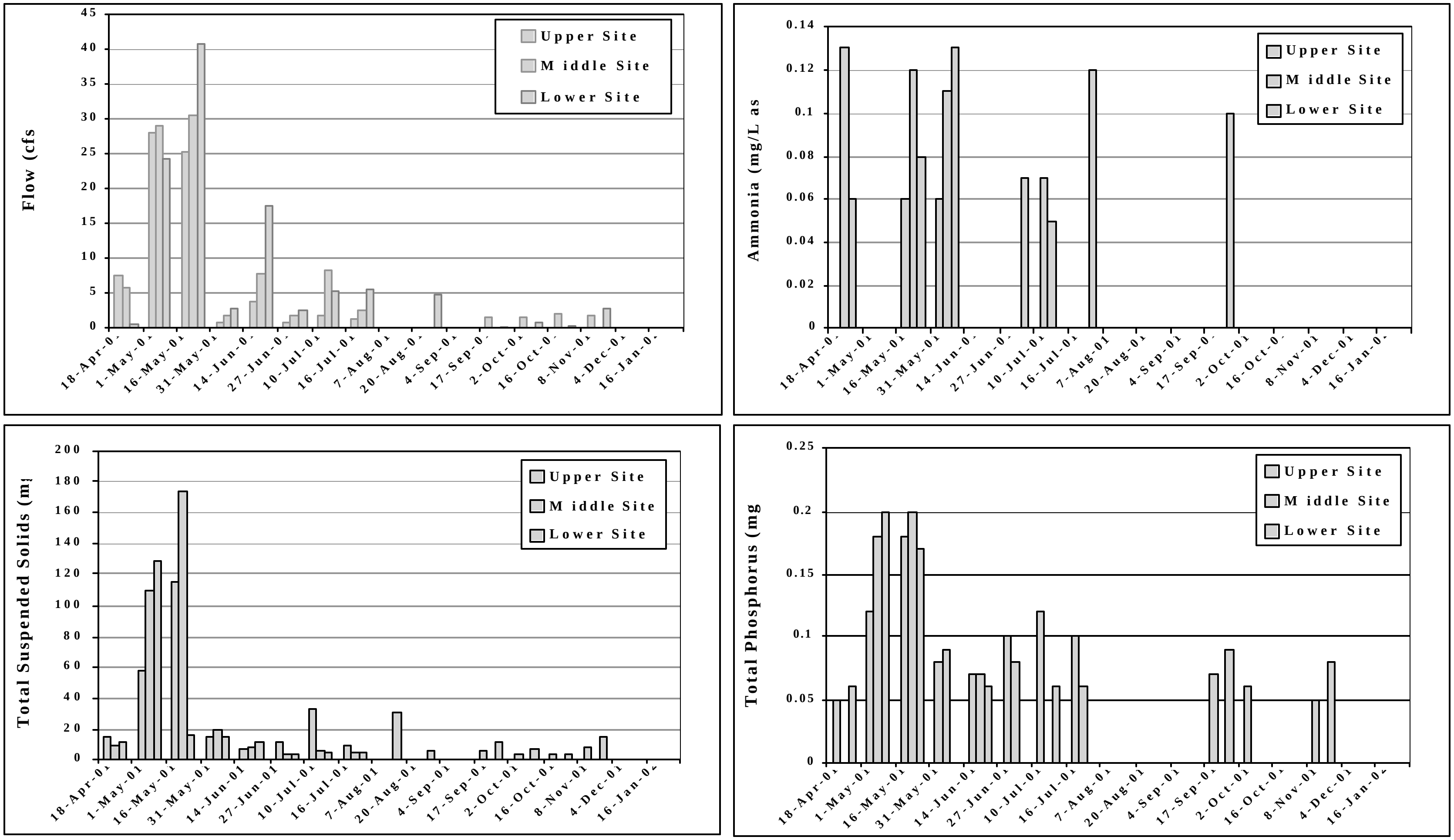

Figure 40b. Results of selected water quality analyses performed on samples collected at three locations on Moody Creek in 2001 (Fischer 2002) . Samples were not collected at the middle site from 7 August through 8 November because the stream had been dammed by beavers.

4. Total Phosphorus: As shown in Table 15, the concentration of total phosphorus in flowing streams should remain below 0.1 mg/L to prevent biological nuisance. The concentrations of total phosphorus measured at all locations in Moody Creek in 2001 were generally below this level except on May 1 and May 16, when maximum discharges and maximum TSS concentrations were also measured (Figure 40b). The concentration of total phosphorus also exceeded 0.1 mg/L at the upper site on July 10 when an abrupt increase in TSS was also recorded. These results indicate that total phosphorus in the water column is associated with sediment suspended in the water column during runoff. It is possible that elevated concentrations of total phosphorus in Moody Creek results from naturally elevated concentrations of phosphorus in soil and not from agricultural activity.

5. Temperature: The instantaneous temperature criterion of 22 ^{o}C for cold water aquatic life was exceeded by 0.1 ^{o}C on July 10 at the middle sampling site. In addition, instantaneous temperature measurements exceeded the maximum daily average criterion for cold water aquatic life (19 ^{o}C) on at least one date at each sampling site. As indicated by the sampling results obtained in 2000, these data also indicate that temperature monitoring using thermographs is warranted at several locations on Moody Creek.

Several sources of sediment in the upper Moody Creek subwatershed were identified during fish habitat surveys conducted by the Forest Service. The surveys was conducted on Moody Creek, North and South Moody Creeks, Ruby Creek, and Fish Creek (Figure 40c) using the R1/R4 fish habitat inventory described by Overton *et al.* (1997). At the request of DEQ, survey crews also performed stream erosion inventories using a worksheet developed by Terril Stevenson, geologist with the Idaho state office of the NRCS. The stream erosion inventory consists of six factors that are indicative of the susceptibility of streambanks to erosion: evidence of bank erosion, ability of banks to withstand erosion caused by flow, bank cover, channel stability, channel substrate, and deposition of sediment. Scores for each factor are summed, and a cumulative score ranging from 0 to 4 indicates slight erosion, a score ranging from 5 to 8 indicates moderate erosion, and a score ranging from 9 to 13 indicates severe erosion.

The stream erosion inventories were performed on sections of the stream considered by the field crew to be representative of the entire reach. Almost half of the narrative fish survey reports provided by the Forest Service included descriptions of sources of sediment and recommendations for reducing sediment loads (Table 27). Sources of sediment included streambank erosion due to grazing, off-road vehicle use in riparian areas, ATV use in riparian areas, proximity of roads to stream reaches, un-improved stream crossings, and insufficient vegetative cover on steep slopes. The streambanks in nine of the 16 reaches for which cumulative erosion ratings were reported were moderately eroding, five were slightly eroding, and two were severely eroding. According to the survey data sheets provided by the Forest Service, the instantaneous temperature criterion of 22 ^{o}C for cold water aquatic life was matched on reach 2 of North Moody Creek on June 27 and was exceeded by 3 ^{o}C on August 6 on reach 5 of South Moody Creek.

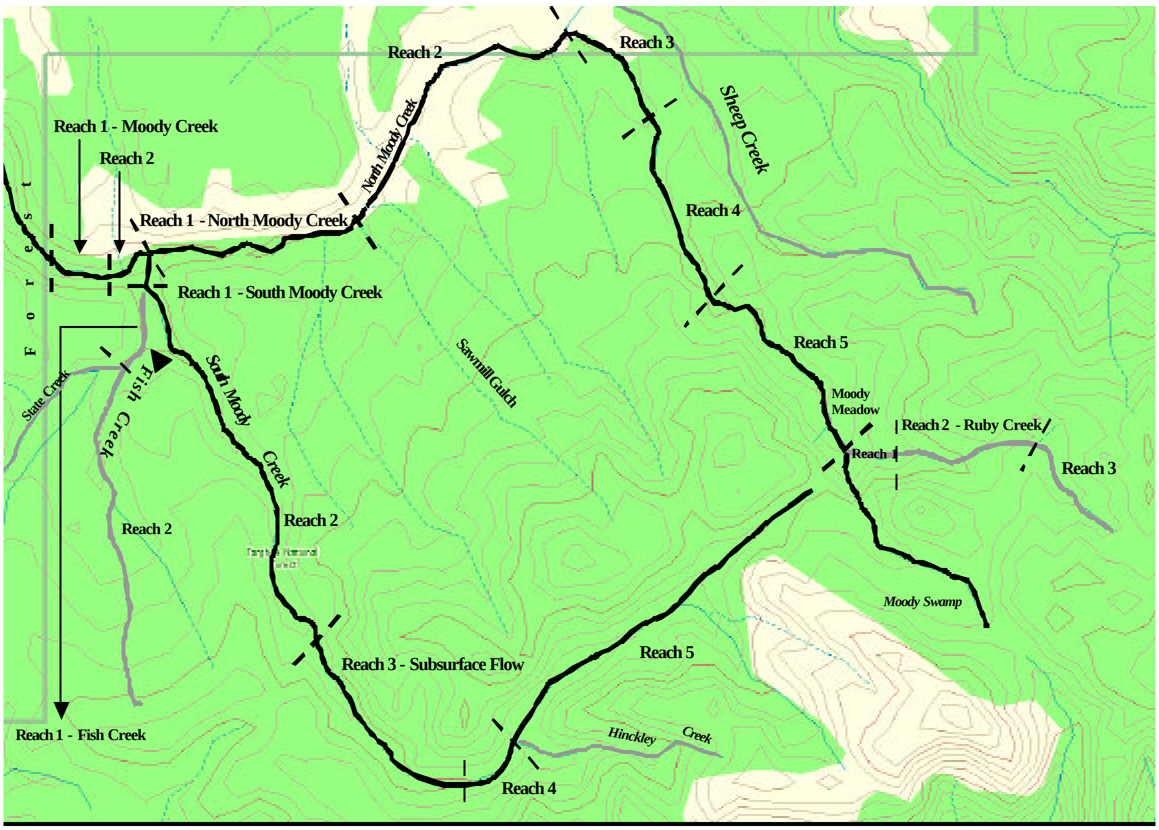

Figure 40c. Boundaries of reaches on North Moody, South Moody, Ruby, and Fish Creeks that were surveyed by the Caribou-Targhee National Forest in 2001 as part of the Forest's Yellowstone cutthroat trout management program.

Table 27. Summary results of the fish habitat inventory conducted in the Moody Creek subwatershed in 2001 by the Caribou-Targhee National Forest.

Stream	Reach Number and Boundaries	Survey Narrative Comments and Recommendations	Cumulative Erosion Rating[1]
Moody Creek	1 - Forest boundary upstream to spring	Generally in good condition due to valley confinement and healthy riparian zone. Where disturbances had occurred, streambanks were damaged and unstable. Exclude cattle and ATVs from sensitive riparian areas.	8
Moody Creek	2 – Spring to confluence of North and South Moody Creeks	High ATV activity and grazing contributing to streambank erosion. Restrict access to the riparian area by cattle and ATVs.	8
North Moody Creek	1 – Confluence of North and South Moody Creeks to Sawmill Gulch	Lack of vegetation on steep, south-facing slope is a pathway for sediment delivery to the stream. Exclude cattle and off-road vehicles from the riparian area. Address recreation impacts. Close illegal vehicle trails. Monitor upland grazing, particularly on south-facing slopes.	5
North Moody Creek	2 – Sawmill Gulch to confluence of Sheep Creek	Protect sensitive riparian areas from overuse by cattle and campers. Exclude ATVs from off-trail activities.	10
North Moody Creek	3 – Confluence of Sheep Creek to change in channel type	Much of the stream is in good condition and appears to be healing past damage.	5
North Moody Creek	4 – Change in channel type to change in channel type	Best condition observed. Riparian area healing, banks stabilizing, fine sediments decreasing. Exclude cattle from sensitive riparian areas.	5
North Moody Creek	5 – Change in channel type to confluence with Ruby Creek	Generally good condition but sediment delivery from road likely. Relocate segments of the riparian road to reduce sediment delivery.	1
Ruby Creek	1 – Confluence with North Moody Creek to tributary	Temperature 10 degrees lower in Ruby Creek than in North Moody Creek, apparently because of lush vegetation. Identify opportunities to reduce sediment delivery from FS Road 218 to the stream.	2
Ruby Creek	2 – Tributary to tributary	Habitat and temperature optimal, but no fish observed.	2
Ruby Creek	3 – Unspecified	Habitat and temperature optimal, but no fish observed.	1
South Moody Creek	1 – Confluence of North and South Moody Creeks to confluence of Fish Creek	Area heavily used by livestock and recreationists. Exclude cattle from the riparian areas, close dispersed campsites, delineate campsites to reduce impacts on riparian areas, increase enforcement of off-road vehicle use, restrict off-road vehicle access in riparian areas and stream channels.	7
South Moody Creek	2 – Confluence of Fish Creek to area of subsurface flow	Much of the riparian vegetation has been damaged by severe overuse. Livestock grazing and recreational activities within the riparian zone should be limited. Enforcement of motorized vehicle use is required. Dispersed camping areas should be relocated.	7
South Moody Creek	4 – Area of subsurface flow to confluence with Hinckley Creek	Sediment levels increased due to high recreational use and proximity to FS Road 218. Investigate opportunities to relocate FS Road 218 away from stream, exclude livestock from riparian area, restrict off-road vehicle use and enforce regulations, provide a bridge at designated road crossing.	8
South Moody Creek	5 – Confluence of Hinckley Creek to headwaters	Investigate opportunities to relocate FS Road 218 away from stream, exclude livestock from riparian area, enforce off-road vehicle regulations.	-
Fish Creek	1	Livestock and ATVs should be excluded from the riparian area to protect and restore the riparian area and aquatic habitat.	6
Fish Creek	3	Livestock and ATVs should be excluded from the riparian area to protect and restore the riparian area and aquatic habitat.	3
Fish Creek	4	Livestock and ATVs should be excluded from the riparian area to protect and restore the riparian area and aquatic habitat.	11

[1]A score of 0-4 indicates slight erosion, a score of 5-8 indicates moderate erosion, and a score of 9 or greater indicates severe erosion.

Discussion The results of data provided by the Idaho Association of Soil Conservation Districts and Forest Service indicate that TMDLs for sediment and temperature are warranted for Moody Creek from the headwaters to the point at which Moody Creek becomes indistinguishable from the Woodmansee Johnson Canal during the irrigation season. This point should be determined by DEQ in consultation with representatives of the Woodmansee Johnson Canal Company, Fremont-Madison Irrigation District, Madison Soil and Water Conservation District, and the NRCS Rexburg field office. Because sediment and temperature for Moody Creek were not specified on Idaho's 1998 §303(d) list, load allocations for these pollutants may be developed after completion of the current TMDL schedule. This will provide time to collect temperature data using in-stream thermographs, and to identify sources contributing to elevated temperature (e.g., areas of inadequate stream shading). Because of the thorough nature of the documentation collected by the Forest Service in 2001, it may be possible to develop sediment load allocations for North Moody Creek, South Moody Creek, and Fish Creek by the end of 2002 or early 2003.

To develop a load allocation for the segment of Moody Creek downstream of the confluence of North and South Moody Creeks, additional water quality data must be obtained. Ideally, turbidity and TSS should be monitored during runoff in the following reaches: Moody Creek on state endowment lands, Moody Creek upstream and downstream of Webster Dam, Moody Creek between Webster Dam and Woods Crossing, and Moody Creek between Woods Crossing and the Woodmansee Johnson Canal. In addition, sampling should be conducted at locations downstream of intermittent discharges and canals. Such sampling will require a significant investment in personnel and equipment to reach the sites.

Conclusions Conclusions regarding the water quality status of Moody Creek are listed below.

1. A load allocation for nutrients (i.e., total phosphorus) is scheduled for completion by the end of 2002. Additional sampling must be performed to determine the background concentrations of total phosphorus in the Moody Creek subwatershed in order to determine whether a load allocation is warranted. If it is warranted, the load allocation will be developed using data collected by the Idaho Association of Soil Conservation Districts in 2001, and data that will be collected by the Idaho Association of Soil Conservation Districts and DEQ in 2002. Efforts will be made to develop a coordinated sampling program with the Madison Soil and Water Conservation District, Idaho Association of Soil Conservation Districts, DEQ, and possibly the Caribou-Targhee National Forest and Idaho Department of Lands.

2. Regardless of when load allocations are developed, the following stream segments and pollutants will be added to Idaho's 2002 §303(d) list: Moody Creek from the confluence of North and South Moody Creeks to the Woodmansee Johnson Canal (sediment and temperature), North Moody Creek (sediment and temperature); South Moody Creek (sediment and temperature), and Fish Creek (sediment).

Packsaddle Creek

Packsaddle Creek originates on the Caribou-Targhee National Forest on the east slope of the Big Hole Mountains. The headwaters of North Fork Packsaddle Creek drain from an elevation of approximately 8,000 feet to Packsaddle Lake at an elevation of 7,350 feet. From the lake, North Fork Packsaddle Creek flows more than 2 miles east where it joins South Fork Packsaddle Creek. South Fork Packsaddle Creek receives flow from streams originating in several canyons at elevations as high as 8,200 feet, and flows more than 3 miles in a northeasterly direction to its confluence with North Fork Packsaddle Creek. From the confluence of the forks approximately one-quarter mile upstream of the forest boundary, the Packsaddle Creek channel continues more than 3 miles to its confluence with the Teton River.

Almost all of the 7,008 acres that comprise the Packsaddle Creek subwatershed, as delineated in the *Teton River Basin Study* (USDA 1992), are located on the Caribou-Targhee National Forest in Wyoming. Below the forest boundary, the subwatershed is limited to a small area north and south of the stream channel. Forest lands are managed for elk and deer winter range, semi-primitive motorized recreation, and timber commodity resource development (USDA 1997a). Grazing also occurs on the forest, and two abandoned coal mines are located in the South Fork Packsaddle Creek drainage. Private lands are used for irrigated and nonirrigated cropland and rangeland (USDA 1992). A 240-acre subdivision, Packsaddle Creek Estates, is located immediately north and east of the forest boundary.

On the National Forest, the Packsaddle Creek subwatershed encompasses several ecological units (Bowerman *et al.* 1999). North Fork Packsaddle Creek occurs in ecological unit 1315, which is characterized by hilly slopes and incised drainageways. Summits support forest canopies of mixed conifers and quaking aspen. Soils are very deep and well drained with a moderate-to-high soil erodibility. South Fork Packsaddle Creek occurs in ecological units 1303, 1315, and 1576. These units include unstable and stable foothills and mountains and rolling slopes. Vegetation varies from sagebrush steppe to mixed conifers. Soils are very deep, well drained, and moderately erodible, though mass movements are common in unit 1303. Lower South Fork Packsaddle Creek and the mainstem of Packsaddle Creek are in unit 2606. This is a moist floodplain characterized by a flat bottom, moderate gradient, and frequent flooding. Seasonal variation is dominated by snowmelt.

On privately owned agricultural land, three soil associations occur on between the forest boundary and the Teton River (USDA 1969). These are distinguished in part by slope and contour, ranging from sloping to gently undulating to level. All soils are well drained.

Flow Both the North and South Fork Packsaddle Creeks are shown as perennial streams on USGS 7.5-minute topographic maps. The forks join to form the mainstem of Packsaddle Creek approximately 0.25 miles above the forest boundary. From the confluence of the forks to approximately 1.5 miles downstream of the forest boundary, Packsaddle Creek is shown as perennial. The final 2 miles of Packsaddle Creek above its confluence with the Teton River are shown as intermittent.

In the late 1970s, a pipeline was installed on Packsaddle Creek 0.5 miles downstream from the forest boundary. The pipeline is oriented north to south, and distributes water to lateral channels oriented east to west. From approximately June 1 to September 15, most of the water is diverted from Packsaddle Creek to the pipeline. A small volume of water may continue downstream approximately 0.75 miles, but the channel then becomes dry approximately 10 months of the year. Continuous flow from the headwaters of Packsaddle Creek to the Teton River may occur during spring runoff before water is diverted to the pipeline.

Water District 1 measures discharge in Packsaddle Creek at the pipeline and presumably before it is diverted into the pipeline. Eighteen-year average flow data indicate that high flows of approximately 38 cfs occur in mid-May, slowly decline in June to approximately 14 cfs, then continue to decline to 2 cfs by the end of November (Figure 41).

§303(d)-Listed Segment The segment of Packsaddle Creek shown on the 1998 § 303(d) list extends from its headwaters to the Teton River (Figure 42). The pollutants of concern are sediment and flow alteration.

The results of BURP sampling conducted in 1995 and 1996 indicated that the beneficial use of cold water aquatic life was supported in South Fork Packsaddle Creek (MBI of 3.91 at site 95-B003) and North Fork Packsaddle Creek (MBI of 5.11 at site 96-Z032), but not in the mainstem of Packsaddle Creek (MBI of 2.44 at site 95-B005). The MBI score for North

Fork Packsaddle Creek was among the highest in the Teton Subbasin, and the HI scores for all three sites (111 at site 95-B003, 112 at site 96-Z032, and 106 at site 95-B003) far exceeded the score considered to support cold water aquatic life in this ecoregion (89).

Scores for substrate embeddedness and percentage of substrate fine sediment did not indicate that sediment was a greater problem downstream than upstream. Substrate embeddedness was rated optimal at the site on the north fork and sub-optimal at the site on the south fork and the mainstem. The percentage of surface fine sediment less than 1 mm in size was lowest at the site on the north fork (25%), highest at the site on the south fork (46%), and intermediate at the site on the mainstream (38%). Bank stability exceeded 99% at each site and bank cover exceeded 90%.

Resource Problems Identified by the USDA and TSCD The *Teton River Basin Study* (USDA 1992) estimated that the total sediment yield from agricultural lands in the Packsaddle Creek subwatershed was 3,589 tons/year. Of that amount, 69% originated from land use and 31% originated from streambanks. Implementing structural practices, identified as Alternative 2 in the *Teton River Basin Study* (USDA 1992), was expected to reduce total sediment yield to 1,430 tons/year by reducing land use erosion by 22% and streambank erosion by 57%. The agricultural land located in the subwatershed occurs within treatment units 4, 9, and 12. Sediment and nutrient transport during critical erosion periods was identified as the resource problem in treatment unit 4. The causes of resource problems identified for treatment unit 9 included sheet, rill, gully, wind, and irrigation-induced erosion caused by pulverized soil surface conditions following potato harvest, spring barley seedbeds that lack adequate surface residues, fall disking, over-tilled mechanical summer fallow, up and downhill potato planting, soil compaction, and

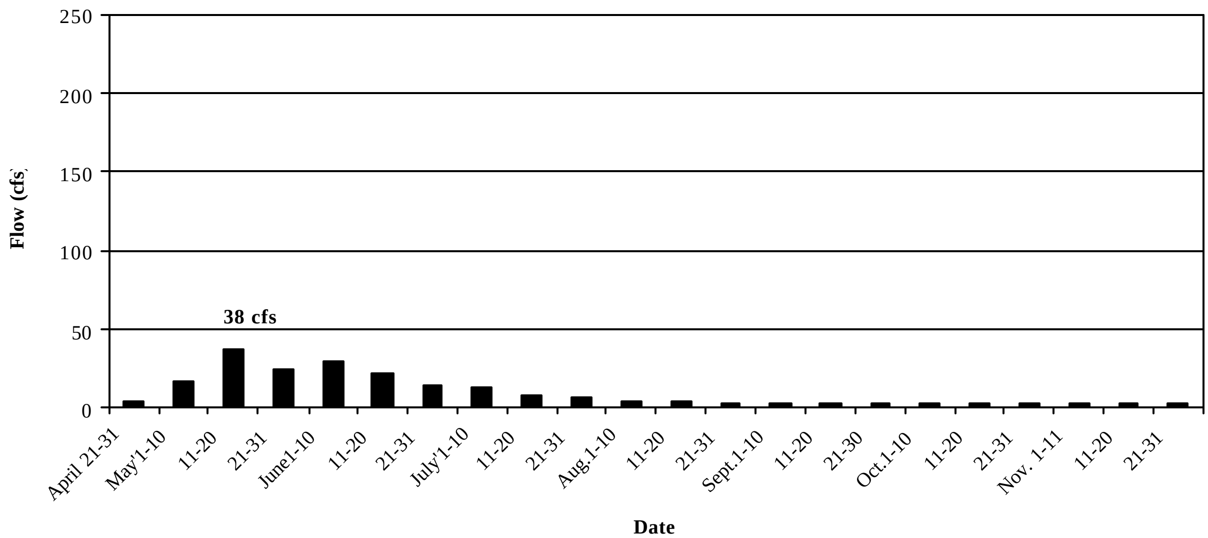

Figure 41. Eighteen-year average discharge measurements for Packsaddle Creek.

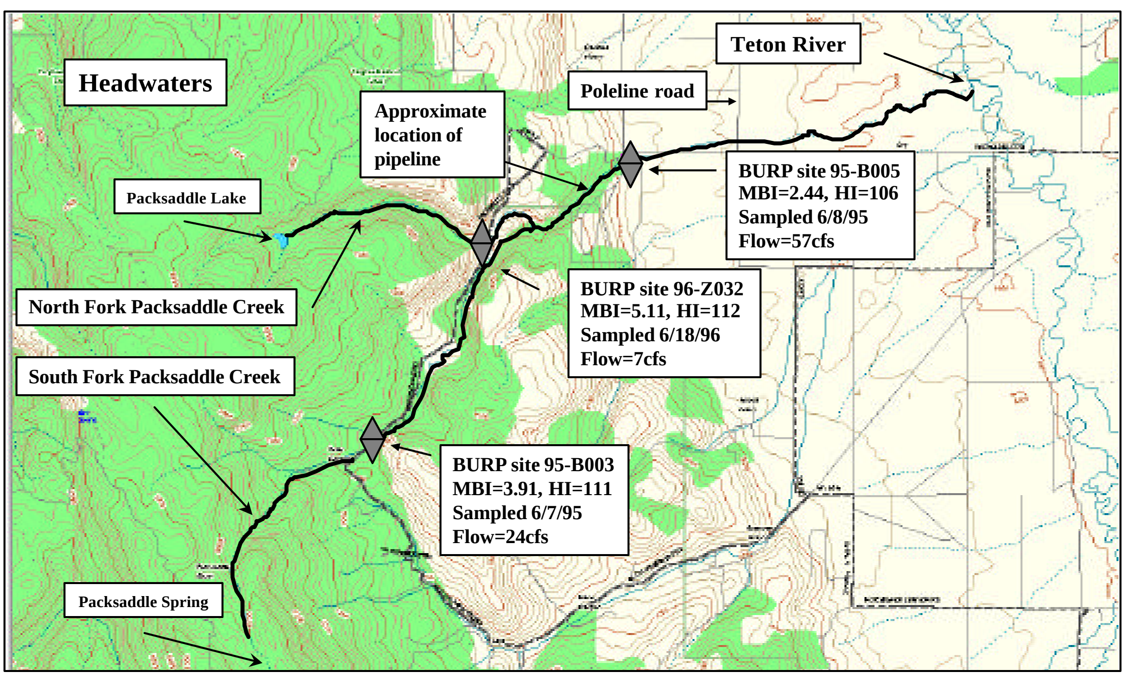

Figure 42. Data collection sites on Packsaddle Creek and boundaries identified on Idaho's 1996 section 303(d) list of water quality-impaired water bodies. Pollutants of concern included sediment and flow alteration.

over application of irrigation water. The causes of resource problems in treatment unit 12 were overgrazing of uplands, season of use by livestock, roads, overland runoff/surface and gully erosion, and urbanization/home building.

Water Quality Data The locations sampled by DEQ in 2000 did not correspond to the BURP sites sampled in 1995 or 1996. Because of the limited amount of time available to travel between sites, only two sites were sampled. The upstream site was located at a bridge downstream of the forest boundary and upstream of any cultivated land. The downstream site was located one mile downstream of the pipeline diversion on the west side of Poleline Road.

The results of water quality sampling did not indicate high concentrations of suspended sediment in Packsaddle Creek at the locations and times sampled (Appendix I).   The maximum concentration of TSS measured at the upstream site on June 13, 2000, (2.9 mg/L) was far below the designated target of 80 mg/L. The maximum turbidity value (3.5 NTU), which was measured at the upstream site on June 26, was also far below the criterion specified in Idaho's water quality standards (i.e., not greater than 50 NTU above background). On June 13, the concentration of nitrate at the downstream site was 4.16 mg/L. This value is so high that it indicates the presence of a concentrated source of nitrogen, a sampling error, or an analytical error. There were no additional nitrate analyses performed for this site because the stream was dry on all subsequent visits. Nitrate concentrations at the upstream site were very low, ranging from 0.03 mg/L to 0.06 mg/L.

The downstream site was dry on three of four sampling dates, which supports observations that the channel is dry in this reach most of the year. Discharge was less than 2 cfs on June 13, 2000, and 0 cfs on June 26, July 26, and August 22. During the same period, discharge at the upstream site decreased from less than 3 cfs to 0.5 cfs.

The amounts of subsurface sediment measured in 2000 at the upstream sampling site exceeded target values. The cumulative percentage of particles smaller than 0.85 mm was 13% and the cumulative percentage of particles smaller than 6.3 mm was 34%. These values exceed the target for particles less than 0.85 mm by 3% and the target for particles less than 6.3 mm by 17%.

Samples of water from Packsaddle Creek at its confluence with the Teton River were collected by DEQ on seven dates in 1989 and 1990 (Drewes 1993). Discharge decreased from 36 cfs in May to 1 cfs in June 1989, indicating that flow was continuous from the headwaters to the river. The highest turbidity value was measured on the same date as the highest discharge, but it was only 5.5 FTU. Total suspended sediment concentrations were not measured but low turbidity values indicated that large concentrations of suspended sediment were not being transported to the river. Phosphorus, orthophosphate, and NO_2 + NO_3 concentrations were all less than 0.06 mg/L, indicating that excessive concentrations of nutrients were not being transported to the river from Packsaddle Creek.

Fisheries Packsaddle Creek was electrofished in September 1996 by DEQ at BURP site 96-Z032 on North Fork Packsaddle Creek and 100 m upstream from BURP site 95-B003 on lower Packsaddle Creek. Three age classes of brook trout, including young-of-the-year, were collected at both sites. Based on these results, Packsaddle Creek and North Fork Packsaddle Creek were assessed as supporting salmonid spawning.

The Caribou-Targhee National Forest electrofished North Fork and South Fork Packsaddle Creeks in July 1998. Brook trout and cutthroat trout were collected in both creeks, though brook trout appeared to be the dominant salmonid species.

Discussion Packsaddle Creek does not flow year-round from its headwaters to the Teton River. Discharge data collected in 1989 and 1990 at the confluence of Packsaddle Creek with the Teton River indicated that flows were sufficient to reach the Teton River in April, May, and June. Most of the flow in Packsaddle Creek is diverted from June to September to a pipeline located downstream of the forest boundary. When DEQ assessed Packsaddle Creek for the 1998 §303(d) list, the assessment of "not full support" for cold water aquatic life was based on sampling conducted at a site downstream of the pipeline. This site was sampled in early June when discharge was 56 cfs, indicating that flow had not yet been diverted to the pipeline. At a later time in the year, this site would probably have been dry.

Because of the typically dry condition of Packsaddle Creek below the pipeline, in 1999 the Henry's Fork Watershed Council Water Quality Subcommittee recommended that Packsaddle Creek be divided into two segments for the purpose of assessing beneficial uses. The upper segment extends from the headwaters of the North and South Fork Packsaddle Creeks to the pipeline; the lower segment extends from the pipeline to the Teton River. Fisheries and BURP data indicate that upper Packsaddle Creek supports the beneficial uses of cold water aquatic life and salmonid spawning. Flow data and observations by local residents indicate that lower Packsaddle Creek cannot support these beneficial uses because it is usually dry.

Conclusions Conclusions regarding the water quality status of Packsaddle Creek are listed below.

1. Discharge in the segment of Packsaddle Creek that appeared on the 1998 §303(d) list is intermittent from the pipeline diversion to the confluence of the channel with the Teton River. The biological indices used by DEQ to assess the beneficial uses of cold water aquatic life and salmonid spawning were developed using data collected for aquatic insect or fish communities sampled in perennially flowing reference streams. Similar species diversity and other community measures cannot be expected to occur in channels that periodically become dry. Therefore, it was not appropriate for DEQ to use data collected using the BURP protocol to assess beneficial use support of Packsaddle Creek below the pipeline diversion.

2. For the purpose of assessing beneficial use support using data collected according to the BURP protocol, DEQ should sample only from the headwaters of North Fork and South Fork Packsaddle Creeks to the pipeline diversion.

3. Water quality in the segment of Packsaddle Creek downstream of the pipeline diversion is protected by numeric criteria when water is in the channel, and turbidity during runoff should be monitored to determine whether this criterion, as an indicator of sediment, is exceeded.

4. To support beneficial uses, the water quality targets for sediment shown in Table 15 should not be exceeded at any location in Packsaddle Creek.

5. Development of a TMDL for sediment is appropriate based on subsurface sediment data collected in 2000 and information collected by the TSCD in the early 1990s (USDA 1992). Although Packsaddle Creek has been assessed as supporting its beneficial uses at two locations upstream of the pipeline diversion, it appears to be a source of sediment for the Teton River.

6. While Packsaddle Creek is impaired due to flow alteration, a TMDL for flow will not be developed. The EPA does not believe that flow (or lack of flow) is a pollutant as defined by section 502(6) of the CWA. DEQ is not required to establish TMDLs for waterbodies impaired by pollution but not pollutants, so it is the policy of the state of Idaho to not develop TMDLs for flow alteration.

South Leigh Creek

South Leigh Creek originates at an elevation of approximately 8,200 feet in the Jedediah Smith Wilderness Area. From its headwaters at South Leigh Lakes and Granite Basin Lakes, the creek flows slightly north and west to the forest boundary, dropping approximately 1,700 feet in elevation over a distance of 8 miles. From the forest boundary, the creek drops only 650 feet more in elevation over an additional 10 miles before reaching the Teton River.

According to the *Teton River Basin Study* (USDA 1992), the South Leigh Creek subwatershed is 20,551 acres in size. Slightly more than half of the subwatershed is located in Wyoming on the Caribou-Targhee National Forest, less than one-tenth of the subwatershed is located in Wyoming on privately owned land, and the remainder of the subwatershed is located in Idaho on privately owned land. In Idaho, the subwatershed is characterized by gently sloping, well-drained soils that formed in alluvium and loess, and is used primarily for irrigated cropland. Within approximately 1 mile of the Teton River, the soil becomes nearly level, is poorly drained, and is used for rangeland (USDA 1969, USDA 1992).

Flow South Leigh Creek is shown on USGS 7.5-minute topographic maps as a perennial stream from its headwaters to the Idaho-Wyoming state line. From the state line west for a distance of approximately 8 miles, streamflow is shown as intermittent. Perennial flow is restored in the final mile of the stream, apparently due to subsurface and spring flows.

Water District 1 measures flow in South Leigh Creek near the Idaho-Wyoming state line from May through October or November. Based on 18-year flow data, average flow doubles from early May to early June when it reaches an average maximum of approximately 225 cfs (Figure 43). Average flow declines slightly during middle and late June but remains at approximately 200 cfs. In early July, average flows begin to decline at a faster rate, dropping to approximately 50 cfs during the last 10 days of July. From mid-August through November, average flows remain between approximately 10 and 15 cfs.

Water is diverted from South Leigh Creek at two locations upstream of the Water District 1 gage. The largest volume of water is diverted to the Hogg Canal less than 0.5 miles upstream of the state line. In a relatively high flow year such as 1996, when 380 cfs was measured on June 15 at the gage on South Leigh Creek, 55 cfs was measured in the Hogg Canal.

In a relatively low-flow year such as 1987, when 70 cfs was measured on June 13 at the gage on South Leigh Creek, 35 cfs was measured in the Hogg Canal. The Kilpack Canal also diverts water upstream of the Water District 1 gage, but the amount usually ranges from only 1 to 5 cfs. In Idaho, Water District 1 measures flow in the Desert, Gale-Moffat, Bell-

McCracken, Breck, Sorenson, and Cook diversions. The amount of water removed from South Leigh Creek by these diversions at any time is highly variable, and may range up to 25 cfs.

§303(d)-Listed Segment The segment of South Leigh Creek shown on the 1998 §303(d) list includes all of the creek in Idaho, extending from the Idaho-Wyoming state line to the Teton River (Figure 44). The pollutant of concern is sediment. Beneficial Use Reconnaissance Program sampling was conducted at two sites on South Leigh Creek in 1995. Based solely on MBI scores, the support status of cold water aquatic life at the upstream site located near the Idaho-Wyoming state line was assessed as “needs verification” and the support status at the lower site, located 7 miles downstream of the state line, was assessed as “not full support” (Figure 45). The HI score at the upper site was relatively high (96) and indicated that habitat was probably not responsible for limiting development of the macroinvertebrate community. In contrast, the HI score at the lower site (78) was far below the value considered to support macroinvertebrates in the ecoregion (89). Substrate embeddedness at each of these sites was ranked as sub-optimal, but the percentage of surface fines less than 6 mm in diameter was 20% or less at each location.

In 1998, a site located less than 1 mile downstream of the Idaho-Wyoming state line was sampled and produced among the highest MBI (4.98) and HI (100) scores recorded for the Teton Subbasin. If these scores had been assessed according to guidelines used to prepare the 1998 §303(d) list, the status of cold water aquatic life would have been assessed as “full support.” Substrate embeddedness at this site was ranked optimal and the percentage of subsurface fines less than 6 mm in diameter was only 6%.

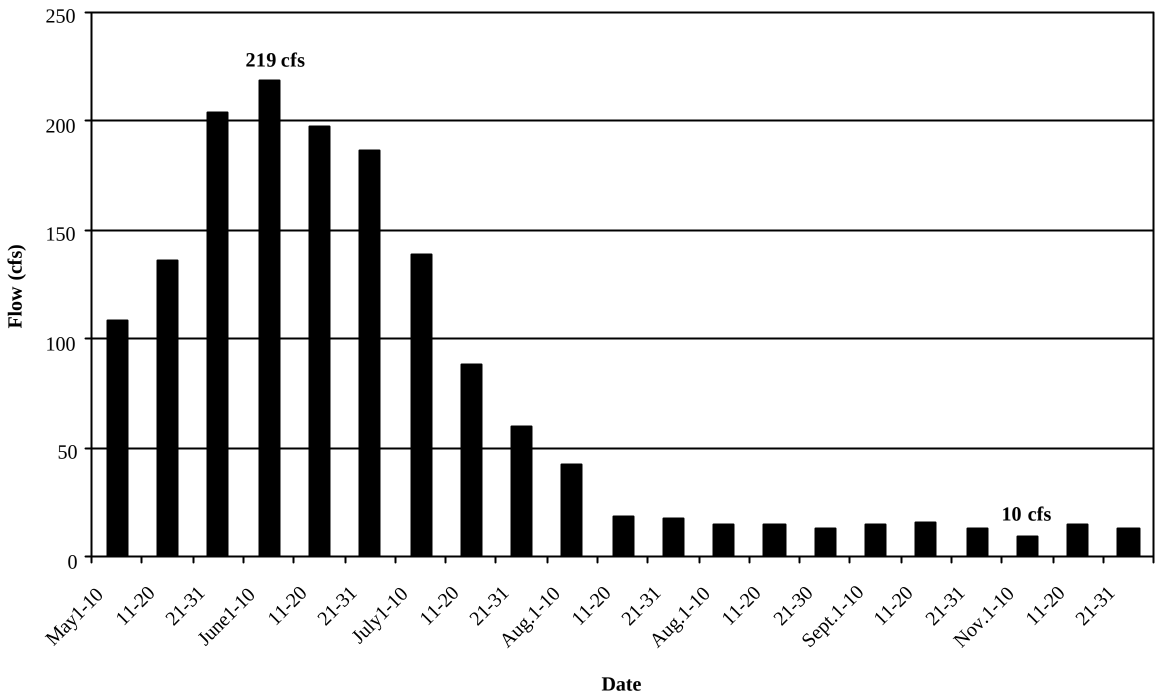

Figure 43. Eighteen-year discharge measurments for South Leigh Creek.

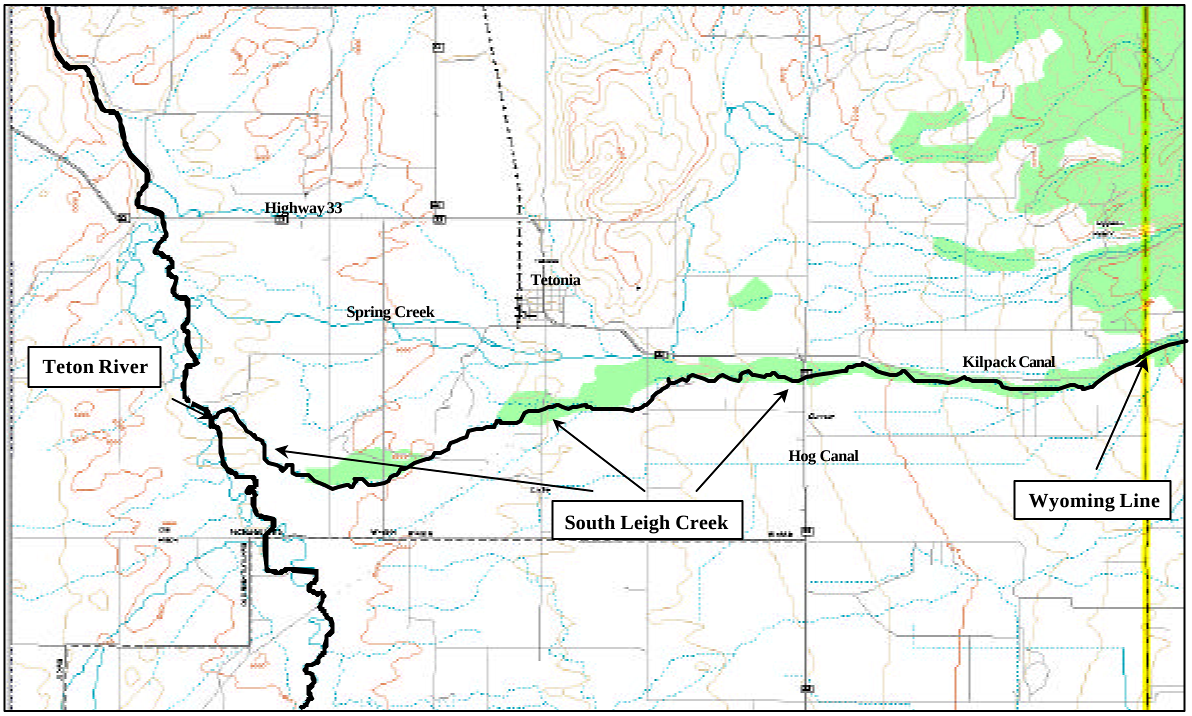

Figure 44. Boundaries of the segment of South Leigh Creek identified on Idaho's 1996 section 303(d) list of water quality-impaired water bodies. Pollutant of concern included sediment.

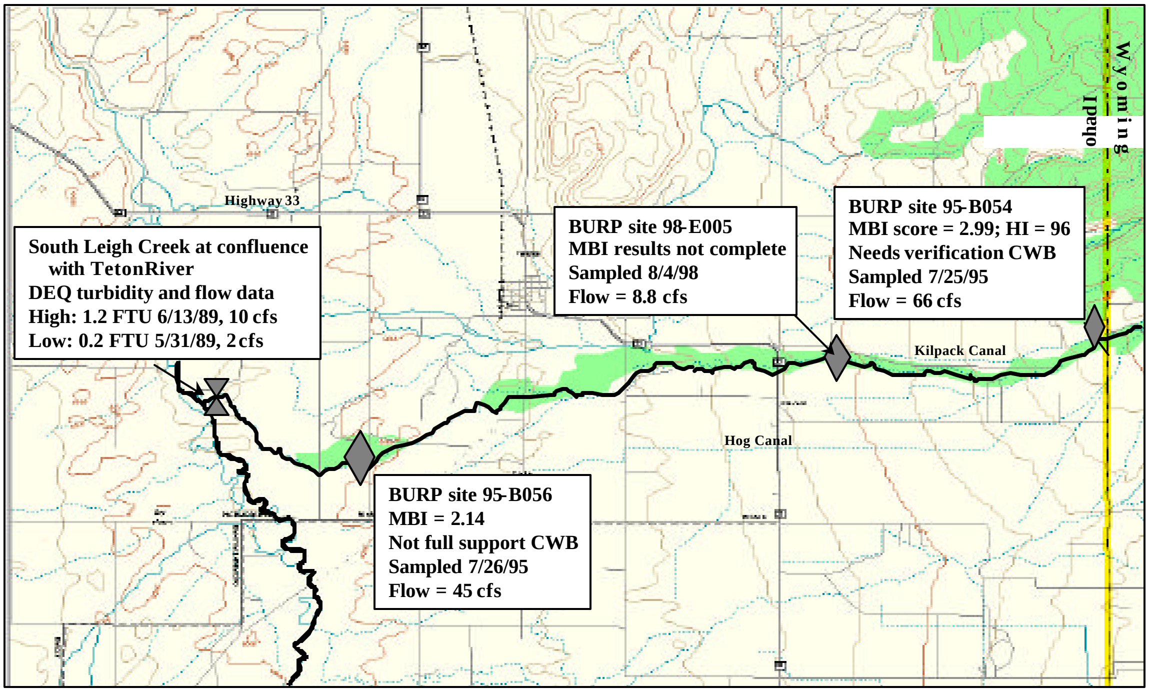

Figure 45. Data collection sites on South Leigh Creek

Resource Problems Identified by the USDA and TSCD The *Teton River Basin Study* (USDA 1992) estimated that the total sediment yield from agricultural lands in the South Leigh Creek subwatershed was 15,228 tons/year. Of that amount, 81% originated from land use and 19% originated from streambanks. Implementing structural practices, identified as Alternative 2 in the *Teton River Basin Study* (USDA 1992), was expected to reduce total sediment yield to 10,359 tons/year by reducing land use erosion by 31% and streambank erosion by 35%. The majority of the agricultural land located in the subwatershed occurs within treatment units 9 or 12, with small portions occurring in treatment units 6, 7, and 10/11. The causes of resource problems in treatment unit 9 were identified as sheet, rill, gully, wind, and irrigation-induced erosion caused by pulverized soil surface conditions following potato harvest, spring barley seedbeds that lack adequate surface residues, fall disking, over-tilled mechanical summer fallow, up and downhill potato planting, soil compaction, and over application of irrigation water. The causes of resource problems identified for treatment unit 12 were overgrazing of uplands, season of use by livestock, roads, overland runoff/surface and gully erosion, and urbanization/home building (USDA 1992).

Water Quality Data The results of water quality sampling conducted by DEQ in 2000 did not indicate high concentrations of suspended sediment in South Leigh Creek at the locations and times sampled (Appendix I). The locations sampled corresponded to BURP sites 95-B054 and 95-B056 (Figure 45). The maximum concentration of TSS measured at the upstream site on June 14 (16.4 mg/L) was far below the designated target of 80 mg/L. The maximum turbidity value (1.2 NTU), which was also measured at the upstream site on June 14, was also far below the criterion specified in Idaho's water quality standards (i.e., not greater than 50 NTU above background).

The decrease in concentration of TSS from the upstream site (16.4 mg/L) to the downstream site (0.8 mg/L) on June 14 indicated that sediment may have been deposited in the stream bed between these locations. The decrease in flow from 94 cfs at the upstream site to 22 cfs at the downstream site would have facilitated sediment loss from the water column.

The data collected in 2000 confirm that water does not always flow from the state line to the lower sampling site. At the state line, flow decreased from 94 cfs on June 14 to 8 cfs on August 22. At the downstream site, flow decreased from 22 cfs on June 14, to 3 cfs on June 27, and finally 0 cfs on July 26 and August 22. In 1995, BURP sampling was conducted at the upper site on July 25 and at the lower site on July 26. Flows at these locations were 66 cfs and 45 cfs, respectively. In contrast, on July 26, 2000, the flow at the upper site was only 11 cfs and, at the lower site, 0 cfs.

Subsurface sediment analyses performed at both sampling sites in 2000 clearly indicated that sediment deposition was greater at the downstream site than at the upstream site. At the site located near the state line, the cumulative percentage of particles smaller than 0.85 mm was 9%, whereas the cumulative percentage at the downstream site was 21%. Similarly, the cumulative percentage of particles smaller than 6.3 mm at the upstream site was 27% and the cumulative percentage at the downstream site was 42%. Sediment particle sizes at the upstream site are within the targets shown in Table 23, but sediment particle sizes at the downstream site exceed the target for particles less than 0.85 mm by 11% and the target for particles less than 6.3 mm by 15%.

Samples of water from South Leigh Creek at its confluence with the Teton River were collected by DEQ on four dates in 1989 (Drewes 1993). Flows ranged from 2 to 10 cfs and turbidity values were less than 1.2 FTU (i.e., less than approximately 1.2 NTU). Total suspended solids concentrations were not measured but low turbidity values indicate that large concentrations of suspended sediment were not being transported to the river. Phosphorus and orthophosphate concentrations were below detection levels and $NO_2 + NO_3$ concentrations were less than 0.09 mg/L, indicating that excessive concentrations of nutrients were also not being transported to the river from South Leigh Creek.

Fisheries South Leigh Creek was electrofished by DEQ at the BURP site located near the state line (95-B054) in 1996 and at the BURP site located 0.5 miles upstream of the Highway 33 bridge (98-E005) in 1998. Thirty-one cutthroat trout ranging in size from 30 to 319 mm and two sculpin were collected at the upstream site near the state line; no fish were collected at the downstream site near the Highway 33 bridge. Based on the number of year classes collected at the upstream site, South Leigh Creek was assessed as supporting salmonid spawning.

The Caribou-Targhee National Forest electrofished South Leigh Creek in August 1998 from the forest boundary upstream almost to the boundary of the Jedediah Smith Wilderness Area. Nineteen subsamples produced 242 cutthroat trout ranging in size from less than 50 mm to more than 300 mm, and neither brook trout nor rainbow trout were collected.

Discussion The hydrologic regime of South Leigh Creek is similar to that of Darby Creek, though the point at which the South Leigh Creek channel becomes dry is less well defined. The main source of water in upper South Leigh Creek is snowmelt runoff; the source of water in lower South Leigh Creek is upwelling subsurface water and a spring or springs located approximately 1 mile upstream of South Leigh Creek's confluence with the Teton River. In late May, June, and early July, runoff is usually sufficient to provide flow from the headwaters of South Leigh Creek to the Teton River. Otherwise, the channel is dry from at least 8 to 9 miles west of the state line. In 1996, the Henry's Fork Watershed Council Water Quality Subcommittee recommended that South Leigh Creek be divided into two segments at the location of the spring that restores flow to the lower channel (i.e., SE1/4 NE1/4 S1 T5N R44E). From the spring upstream to the Idaho-Wyoming state line, the flow in South Leigh Creek is intermittent and heavily diverted during the irrigation season. Downstream of the spring, flow in South Leigh Creek appears to be relatively constant.

Conclusions Conclusions regarding the water quality status of South Leigh Creek are listed below.

1. The capacity of South Leigh Creek to support the beneficial uses of cold water aquatic life and salmonid spawning in the segment below the state line probably varies on a yearly basis depending on flow conditions. Flow in the segment downstream of the spring appears to be sufficient to support aquatic life uses at all times, and BURP sampling should be conducted on this segment to assess beneficial use support status. Habitat index scores, one MBI score, and fisheries data for the segment of South Leigh Creek between the state line and Highway 33 indicate that cold water aquatic life and salmonid spawning were fully supported. The reason for the indeterminant MBI score obtained in 1995 is

unknown but may have been related to high flow conditions. The limited amount of water column sampling conducted on South Leigh Creek has not detected the transport of excessive concentrations of suspended sediment. This is consistent with the observations of local residents who report that the water in South Leigh Creek is always very clear and the substrate visible. However, subsurface sampling indicated that deposition of fine sediment has occurred approximately 8 miles downstream of the state line where the stream bed was confirmed dry in July 2000. Developing a TMDL for sediment is appropriate, though stream segments must be better defined by DEQ for the purpose of assessing beneficial uses.

2. To protect beneficial uses, the water quality targets for sediment shown in Table 15 should not be exceeded at any location in South Leigh Creek.

3. The results of recent fish sampling indicate that South Leigh Creek supports a self-sustaining population of cutthroat trout. Because there are no known fish barriers between privately owned land and federal land, fish probably migrate extensively between these areas, limited only by the extent of downstream flow. The absence of brook trout and rainbow trout in all of the samples collected also indicates that the intermittent nature of South Leigh Creek downstream of the state line may limit upstream migration of fish from the Teton River to the upper segment of South Leigh Creek.

North Leigh Creek and Spring Creek

North Leigh Creek and Spring Creek are discussed together because both are located in the Spring Creek subwatershed, as delineated in the *Teton River Basin Study* (USDA 1992). The subwatershed is divided from east to west by the Idaho-Wyoming state line, and approximately half of its 27,962 acres are located on the Caribou-Targhee National Forest in Wyoming. With the exception of small parcels of privately owned land in Wyoming and land near the state line that is managed by BLM, the remaining acreage is located in Idaho and is privately owned.

North Leigh Creek is a tributary of Spring Creek and originates at an elevation of approximately 8,200 feet on the Jedediah Smith Wilderness. From its headwaters above Green Lake, it flows slightly north and west to the forest boundary, dropping approximately 1,700 feet in elevation over a distance of ten miles. From the forest boundary, it flows 0.5 miles to the Idaho-Wyoming state line, and another 3.5 miles to its confluence with Spring Creek (Figure 46).

The USGS 7.5-minute topographic map shows Spring Creek originating at a small, spring-fed pond located less than 3 miles west of the state line and approximately 1.5 miles north of the point at which North Leigh Creek enters it. From the pond, the channel flows northwest approximately 0.5 miles where it converges with an intermittent channel flowing from the north. From this point, Spring Creek flows almost directly south, passes beneath Highway 33, then flows west toward the Teton River over a total distance of approximately 7.5 miles (Figure 46).

In Idaho, the Spring Creek subwatershed is characterized by gently sloping, well-drained soils that formed in alluvium and loess, and is used in almost equal parts as rangeland, irrigated and non-irrigated cropland, and irrigated pastureland. Within approximately 2 miles of the Teton River, the soil becomes nearly level, is poorly drained, and is used for pastureland and rangeland (USDA 1969, USDA 1992).

Flow North Leigh Creek is shown as a perennial stream on USGS 7.5-minute topographic maps from its headwaters to approximately 0.5 miles west of the state line. At this point it branches into Middle Leigh and North Leigh Creeks, and both channels are shown as intermittent as they flow directly west almost 4 miles to Spring Creek (Figure 46).

Water District 1 measures flow in North Leigh Creek approximately 0.2 mile above the state line from April or May through October or November. Based on 18-year data, average flow almost triples from the first week of May to the first week of June, when it reaches a maximum of approximately 210 cfs (Figure 47). By mid-August, average flow returns to approximately 10 cfs. North Leigh Canal, the first of five diversions monitored by Water District 1, is located downstream of the North Leigh Creek gage just east of the state line. Four diversions occur within the next 3 stream miles in Idaho: Weaver Ditch, Si Canal (also referred to as the SI Canal or the Edison and Ricks Canal), Center Canal, and Hubbard Ditch. Most water is diverted to the North Leigh Canal, followed by the Center Canal and Hubbard Ditch. The amount of water diverted at each location is quite variable, but generally does not exceed 20 cfs.

The intermittent nature of lower North Leigh Creek was confirmed by sampling conducted by DEQ in 2000 at the bridge immediately upstream from the confluence of North Leigh Creek with Spring Creek. Discharge decreased from 50 cfs on June 14, to 20 cfs on June 27, to 0 cfs on July 26. The channel was also dry when it was visited on August 22. Spring Creek is shown on the USGS 7.5-minute topographic map as perennial from its origin to the Teton River.

Flow has slowed somewhat due to an increased number of beaver dams and ponds in the reach of Spring Creek upstream of North Leigh Creek and downstream almost to Highway 33 (Breckenridge personal communication, Thomas personal communication). They also have observed that the Spring Creek channel occasionally becomes dry from approximately 1 mile west of Tetonia to 2.5 miles west of Tetonia. DEQ sampled Spring Creek at a location approximately 1.5 miles west of Tetonia in 2000. On August 22, the last day sampled, the channel still contained water and discharge was 1.75 cfs.

Water District 1 measures flow in Spring Creek below Highway 33 and at nine downstream diversions. The chart of 18-year flow data for Spring Creek is similar in shape to the chart for North Leigh Creek, but the average flows are generally 30 cfs lower in Spring Creek than in North Leigh until the first week of July when the averages become nearly equal (Figures 47 and 48).

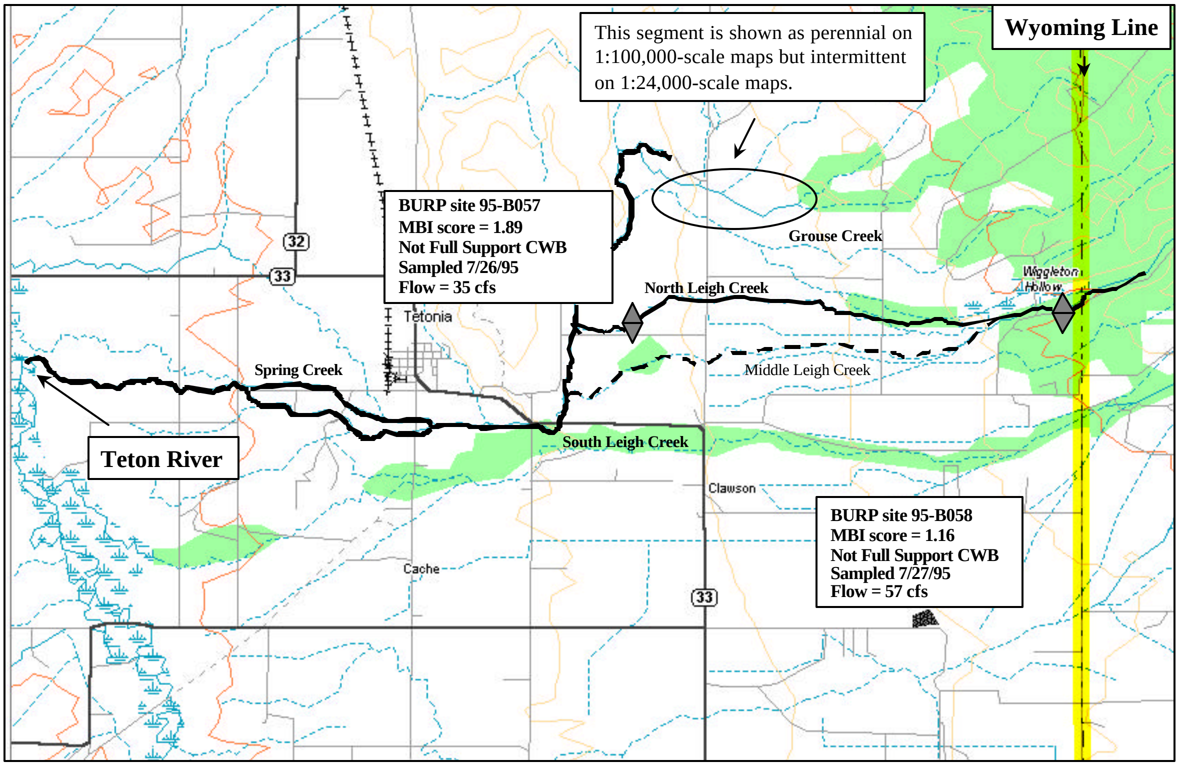

Figure 46. Boundaries of the segment of Spring Creek identified on Idaho's 1998 section 303(d) list of water quality-impaired water bodies, and locations of BURP sites on North Leigh Creek.

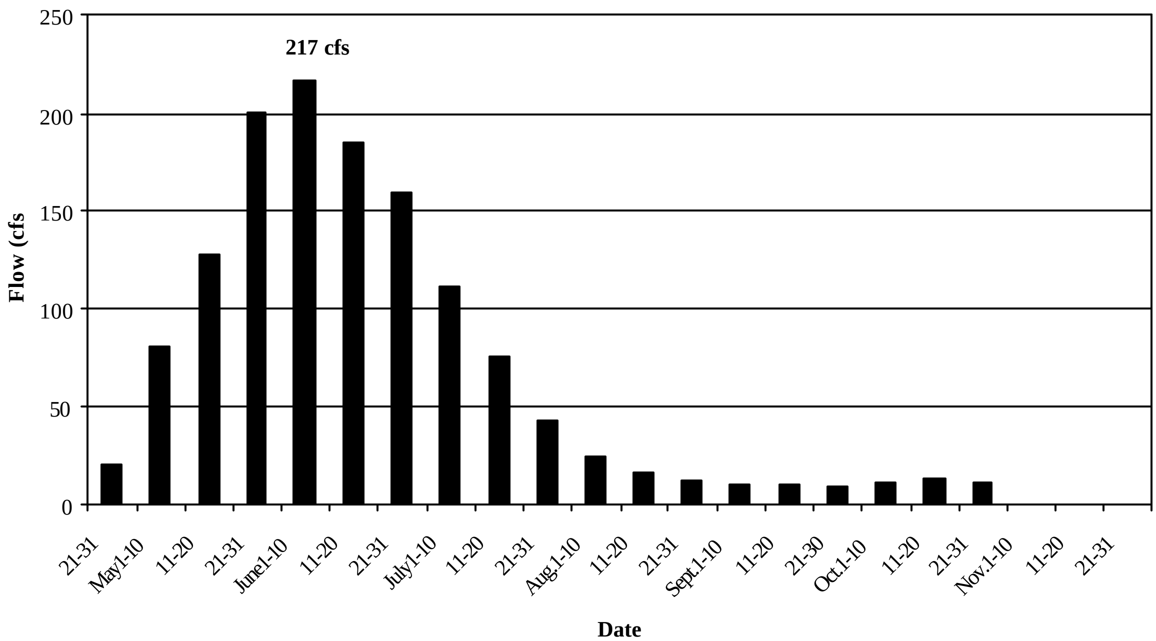

Figure 47. Eighteen-year average flows measured on North Leigh Creek.

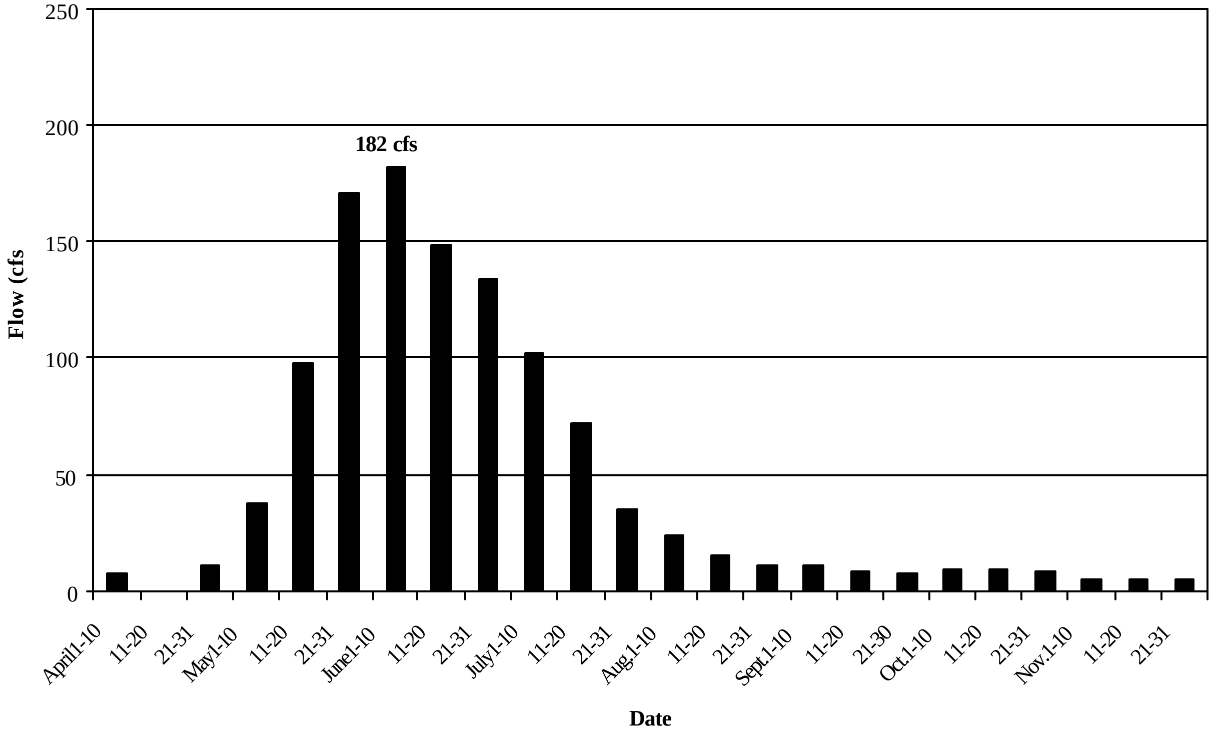

Figure 48. Eighteen-year discharge measurements for Spring Creek.

§303(d)-Listed Segment The segment of North Leigh Creek shown on the 1998 § 303(d) list extends from the Idaho-Wyoming state line to Spring Creek (Figure 46), and the pollutant of concern is unknown because the stream was added to the 1998 list based on an assessment of BURP data collected in 1995. The segment of Spring Creek shown on the 1998 §303(d) list extends from the Idaho-Wyoming state line to the Teton River. The upper boundary is incorrect because, as explained above, Spring Creek originates almost 3.5 miles west of the state line (Figure 49). This error occurred because the segment was defined using a 1:100,000-scale map which incorrectly shows Spring Creek originating in headwater streams located east and west of the Idaho-Wyoming state line. The pollutants of concern for Spring Creek are sediment, flow alteration, and temperature.

The MBI scores obtained by DEQ in 1995 indicated that the beneficial use of cold water aquatic life was not supported at the BURP sites sampled in North Leigh Creek or Spring Creek (Figures 46 and 49). The site sampled on North Leigh Creek just below the state line produced the lowest MBI score in the Teton Subbasin (1.16) despite a relatively high HI score (103). The lower site on North Leigh Creek, just above its confluence with Spring Creek, also produced a low MBI score (1.89) but relatively high HI score (102). The MBI score for the upstream site on Spring Creek (1.26) was also well below the limit for support of cold water aquatic life (3.5) and the HI score (86) was slightly below the value considered adequate to support cold water aquatic life (89). The BURP results for Spring Creek were much improved at the downstream site, with an MBI score (2.99) within the "needs verification" and an HI score (94) adequate to support cold water aquatic life. A second upstream site was sampled on Spring Creek in 1997, but the MBI remained low (1.31) and the HI score (50) was the lowest measured in the Teton Subbasin. The low MBI scores for all sites were caused primarily by high numbers of sediment-tolerant flies (*Simulium sp.* and Chironomidae). This result was unexpected for the North Leigh Creek site near the state line (95-B058) because of stream channel type, good HI score, and flow conditions. Substrate embeddedness at this site was rated optimal, the percentage of fine sediment less than 6 mm was only 24%, and the percentage of fine sediment less than 1 mm was 14%. Conditions at the downstream site (95-B057) were only slightly more conducive to sediment-tolerant macroinvertebrates. Embeddedness was rated sub-optimal, percentage of fine sediment less than 6 mm increased to 28%, and percentage of fine sediment less than 1 mm in diameter increased to 23%.

The substrate characteristics of upper Spring Creek are much more likely to produce an abundance of sediment-tolerant macroinvertebrates. Spring Creek originates in a low-gradient meadow in silty clay loam soil. Flow is relatively constant because the stream is spring-fed, which contributes to the development of low-gradient, depositional stream channels. At BURP site 95-B024, which was located below the outlet of the pond that supplies most of the flow in Spring Creek, 75% of the substrate was less than 6 mm in diameter and 64% was less than 1 mm in diameter. At BURP site 97-M152, which was in a channel that received one-tenth the flow of the other channel (0.4 cfs), 100% of the substrate was less than 1 mm in diameter. Moving downstream, the amount of substrate sediment decreases, possibly due to increased flow, greater flow fluctuations, changes in soil type, and entrapment of fine sediment in beaver ponds. At the downstream BURP site on Spring Creek (95-B055), the percentage of surface fine sediment was only 22%. However, even under these conditions, the MBI score did not indicate support of cold water aquatic life.

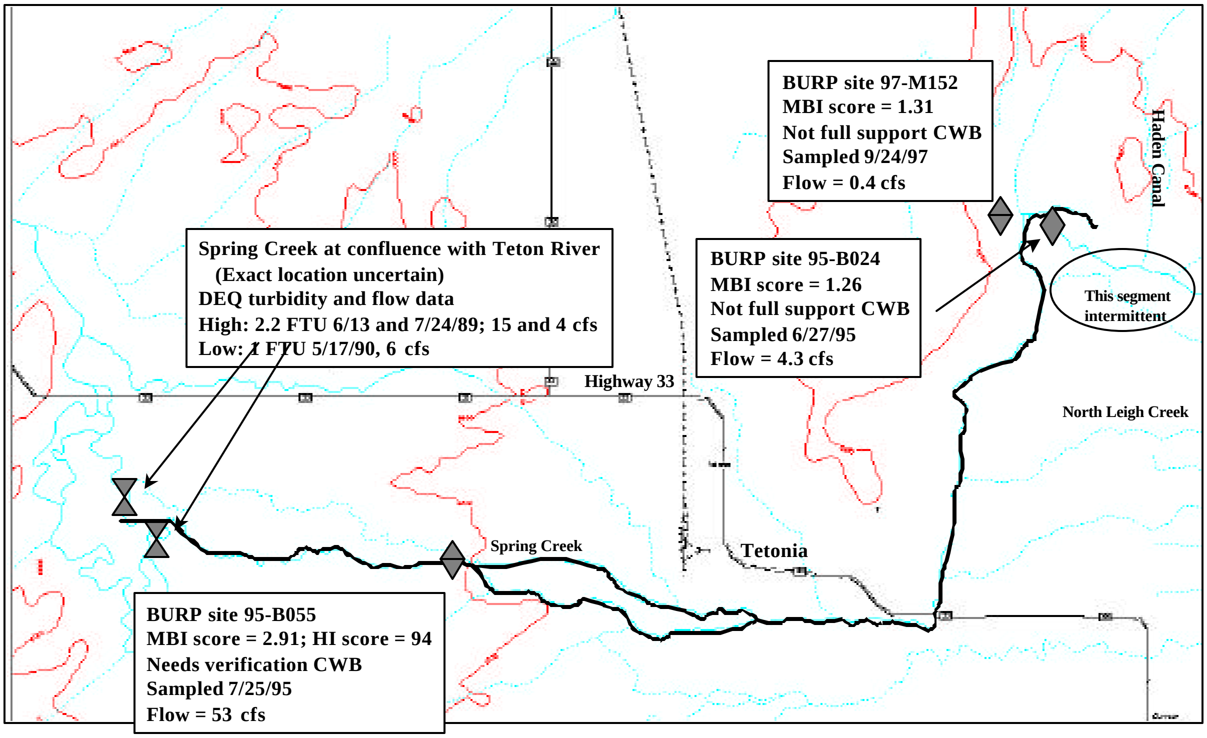

Figure 49. Data collection sites on Spring Creek.

Resource Problems Identified by the USDA and TSCD The *Teton River Basin Study* (USDA 1992) estimated that the total sediment yield from agricultural lands in the Spring Creek subwatershed was 20,844 tons/year. Of that amount, 82% originated from land use and 18% originated from streambanks. Implementing structural practices, identified as Alternative 2 in the *Teton River Basin Study* (USDA 1992), was expected to reduce total sediment yield to 14,211 tons/year by reducing land use erosion by 31% and streambank erosion by 35%. The majority of the agricultural land located in the subwatershed occurs within treatment units 9, 12, 4, or 10/11 with small portions occurring in treatment units 1,5,6, and 7. The causes of resource problems in unit 9 were identified as sheet, rill, gully, wind, and irrigation-induced erosion caused by pulverized soil surface conditions following potato harvest, spring barley seedbeds that lack adequate surface residues, fall disking, over-tilled mechanical summer fallow, up and downhill potato planting, soil compaction, and over application of irrigation water. The causes of resource problems identified for treatment unit 12 were overgrazing of uplands, season of use by livestock, roads, overland runoff/surface and gully erosion, and urbanization/home building. The cause of resource problems in treatment unit 4 was identified as transport of sediment and nutrients to surface waters during high-runoff events; the causes of resource problems identified for treatment unit 10/11 were overgrazing in the riparian area; removing stream-side shrubs, trees, and other vegetation; straightening sections of stream channel; improperly placing culverts; flooding; stream evolution; reduced sub-water flows; poorly controlled flood irrigation systems; and upland erosion (USDA 1992).

Water Quality Data The results of water quality sampling conducted by DEQ in 2000 did not indicate high concentrations of suspended sediment in North Leigh Creek near its confluence with Spring Creek, or in Spring Creek at BURP site 95-B055 (Appendix I). The maximum concentrations of TSS measured in North Leigh Creek (4.5 mg/L) and Spring Creek (12.1 mg/L) on June 14 were far below the designated target of 80 mg/L. The maximum turbidity values, 2.2 NTU for North Leigh Creek and 5.4 NTU for Spring Creek, were also far below the criterion specified in Idaho's water quality standards (i.e., not greater than 50 NTU above background).

Flow data collected in 2000 confirmed the intermittent status of North Leigh Creek but not Spring Creek. Discharge decreased from 50 cfs on June 14, to 20 cfs on June 27, to 0 cfs on July 26 and August 22 in North Leigh Creek at its confluence with Spring Creek. The discharge in Spring Creek at the downstream sampling site was less than 2 cfs the last day of sampling.

An analysis of subsurface sediment at the lower Spring Creek sampling site, as measured in 2000, indicated that sediment deposition has occurred. The cumulative percentage of particles smaller than 0.85 mm was almost 20% and the cumulative percentage of particles smaller than 6.3 mm was 42%. These values exceeded the targets shown in Table 15 by 10% for particles less than 0.85 mm and by 15% for particles less than 6.3 mm.

Because temperature is a pollutant of concern for Spring Creek, a temperature data logger was placed in the vicinity of BURP site 95-B055 from June to August 2000. Temperatures exceeded the maximum daily criterion for cold water aquatic life almost daily from mid-July through mid-August, and the average daily criterion on three day (Figure 50). The stream is wide and shallow in the area where the data logger was placed, and is almost devoid of riparian vegetation. These factors almost certainly contribute to high water temperatures. However, because the stream

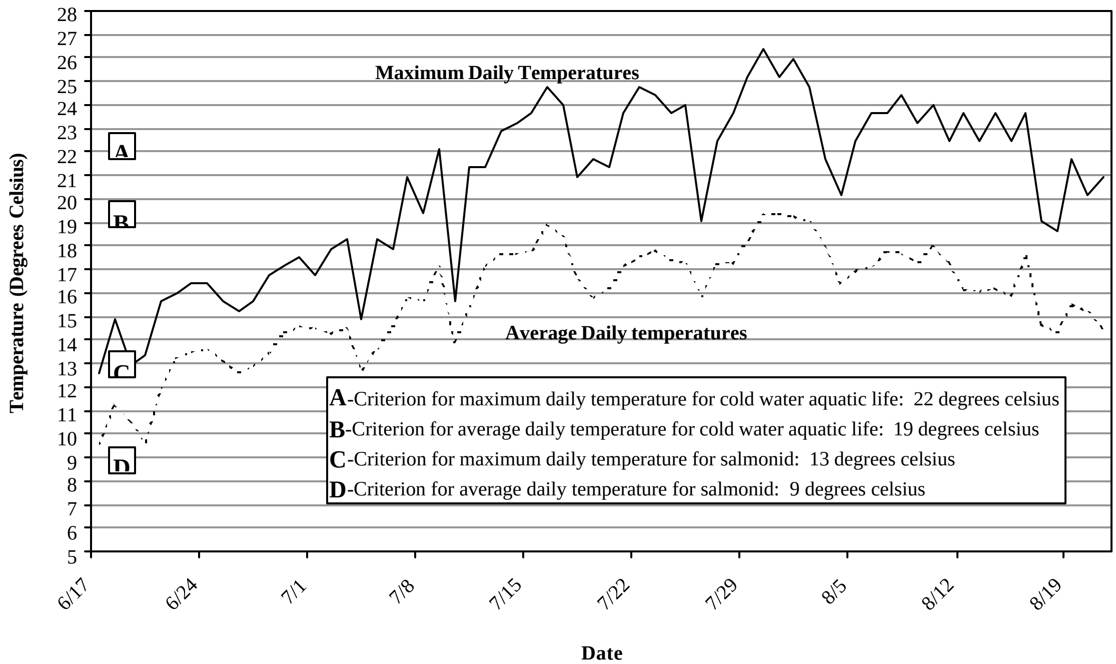

Figure 50. Water temperatures collected in Spring Creek from June 17 through August 21, 2000.

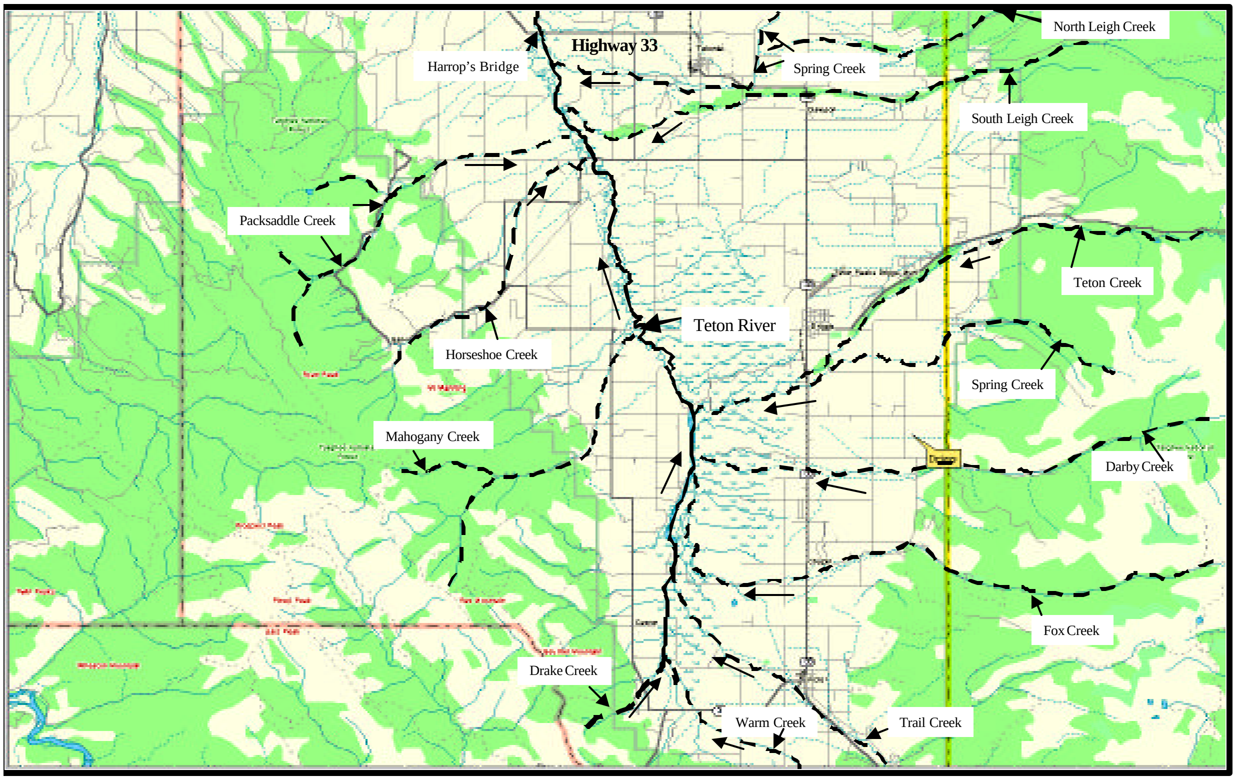

Figure 51. Teton River from the headwaters to Highway 33 (Harrop's Bridge).

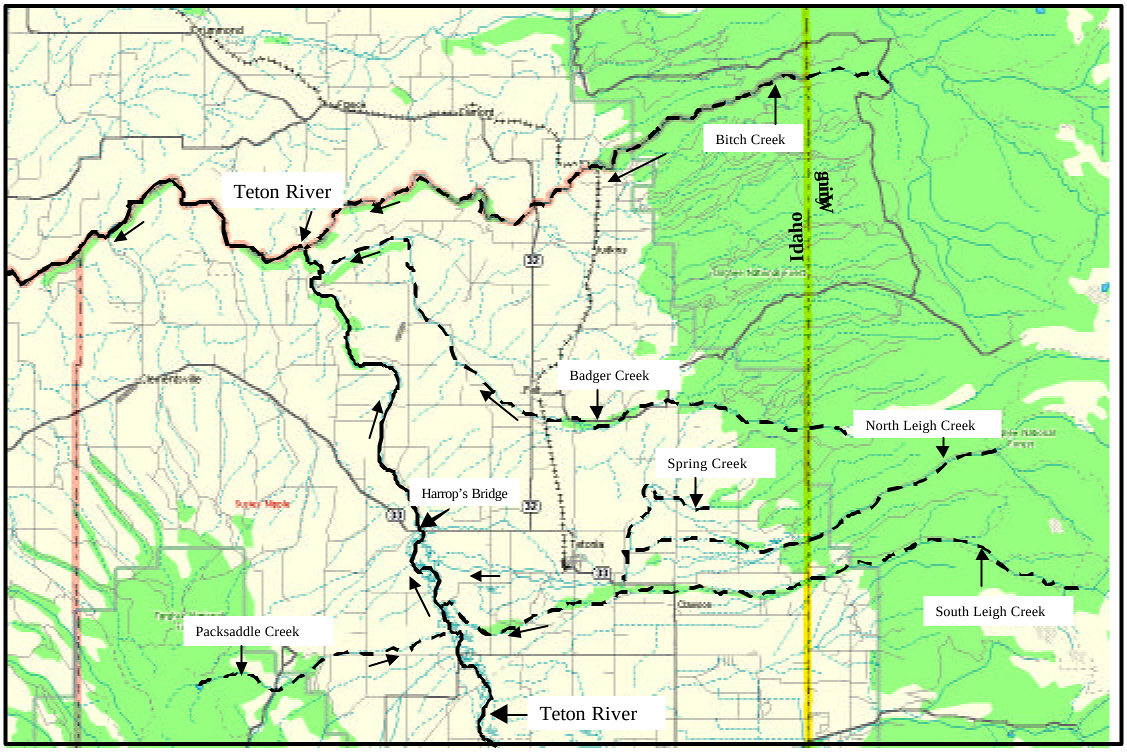

Figure 52. Teton River from Highway 33 (Harrop's bridge) to Bitch Creek.

originates at a spring, it is possible that the temperature of the water is naturally higher than temperatures in streams that receive snowmelt. Additional temperature monitoring throughout the stream reach of Spring Creek should be conducted to determine the factors contributing to temperature criteria exceedances.

Samples of water from Spring Creek at its confluence with the Teton River were collected by DEQ on seven dates from 1988 to 1990 (Drewes 1993). Flows ranged from 2 to 15 cfs and turbidity values were less than 2.2 FTU (i.e., less than approximately 2.2 NTU). Total suspended solids concentrations were not measured but low turbidity values indicate that large concentrations of suspended sediment were not being transported to the river. Phosphorus and orthophosphate concentrations were at or below 0.05 mg/L and NO_2 + NO_3 concentrations were less than 0.16 mg/L, indicating that excessive concentrations of nutrients were also not being transported to the river from Spring Creek. However, the fecal coliform bacteria analysis on July 24 exceeded the primary contact recreation criterion of 500 colonies/mL by 1,700 colonies/mL.

Fisheries North Leigh Creek was electrofished by DEQ at BURP site 95-B058 in 1996; Spring Creek was electrofished by DEQ at BURP site 95-B024 in 1996 and at BURP site 97-M152 in 1997. Four year classes of brook trout, including juveniles, and one sculpin were collected in North Leigh Creek near the state line. Three year classes of brook trout, including juveniles, and 16 longnose dace were collected in Spring Creek approximately 200 yards downstream of the headwater pond. These data were sufficient to assess both streams as fully supporting the beneficial use of salmonid spawning (DEQ 1998). Spring Creek was also electrofished in the intermittent channel that converges with the pond outlet, but no fish were collected.

Discussion Sediment in North Leigh Creek appears to be originating in Wyoming, as indicated by data at the Idaho-Wyoming state line. The boundaries of North Leigh Creek must be reconfigured on the basis of perennial flow for the purpose of assessing beneficial uses.

The beneficial uses of Spring Creek upstream of North Leigh Creek should be assessed separately from the segment downstream. The BURP protocol may not be appropriate for assessing the upper segment of Spring Creek.

Temperatures regularly exceeded water quality criteria in lower Spring Creek in June, July, and August 2000 (Figure 50). The stream in this area is very wide and shallow with little shade. However, the temperature of Spring Creek water may naturally be higher than other streams in the Teton Valley because it flows relatively far from its spring source. Additional temperature monitoring in the upstream segments of Spring Creek should be conducted. The downstream extent of Spring Creek from the point at which temperature was monitored is unknown and should be better characterized

Conclusions Conclusions regarding the water quality status of North Leigh Creek and Spring Creek are listed below.

1. It is appropriate to develop a TMDL for sediment for Spring Creek (which includes North Leigh Creek as a tributary), though stream segments must be better defined by DEQ for the purpose of assessing beneficial uses.

2. To support beneficial uses, the water quality targets for sediment shown in Table 15 should not be exceeded at any location in Spring Creek or North Leigh Creek.

3. A temperature TMDL for Spring Creek is warranted, but has been rescheduled for the end of 2002.

4. While Spring Creek is impaired due to flow alteration, a TMDL for flow will not be developed. The EPA does not believe that flow (or lack of flow) is a pollutant as defined by section 502(6) of the CWA. DEQ is not required to establish TMDLs for waterbodies impaired by pollution but not pollutants, so it is the policy of the state of Idaho to not develop TMDLs for flow alteration.

Teton River

The listed segments of the Teton River (Headwaters to Trail Creek, Trail Creek to Highway 33, and Highway 33 to Bitch Creek) together comprise the Teton Valley segment of the river. According to the Water Quality Subcommittee of the Henry's Fork Watershed Council, the Teton River begins at the confluence of Drake and Warm Creeks. Both of these small streams originate at springs or in small drainages on the north slope of the Big Hole Mountains, and converge on privately owned land at the south end of Teton Valley (Figure 51).

Approximately 2 miles downstream, Trail Creek enters the river from the southeast. Trail Creek originates on the Caribou-Targhee National Forest in the Teton Mountains and delivers substantial flows to the river during spring runoff. During the irrigation season, Trail Creek is diverted to the Trail Creek canal and pipeline. The pipeline was installed about 30 years ago and provides water to a sprinkler irrigation system that serves approximately 7,000 acres in the upper Teton Valley near Victor.

Major tributaries of the Teton River originating in the Teton Mountains are Trail Creek (including Moose and Game Creeks), Fox Creek, Darby Creek, Teton Creek, South Leigh Creek, Badger Creek, and Bitch Creek (Figures 51 and 52). Spring Creek originates at a spring below the Teton Mountains but receives mountain runoff from North Leigh Creek. Major tributaries of the Teton River originating in the Big Hole Mountains include Mahogany Creek, Twin Creek, Horseshoe Creek, and Packsaddle Creek (Figures 51 and 52).

In the upper Teton Valley, the Teton River is a low-gradient stream that flows through silty clay loam. In the lower Teton Valley, the river has downcut through volcanic deposits to form a steep-walled, basalt-lined canyon. Land use in the upper Teton Valley consists primarily of rangeland on the extensive wet meadows east of the Teton River, and irrigated and nonirrigated cropland on elevated slopes east of the wetlands and west of the river. In the lower valley, the river channel is confined below rolling irrigated and nonirrigated cropland.

Flow Discharge has been measured on the upper Teton River since 1961 at USGS gage station 13052200, *Teton River above South Leigh Creek near Driggs, ID*. This gage is located on the southeast side of Cache Bridge in the east channel of the river. The drainage area at this point is approximately 335 square miles and includes major tributaries upstream of Horseshoe Creek. As of water year 1999, recorded discharges ranged from 54 cfs on November 23,1977, to 2,980 cfs on June 11, 1997 (Brennan *et al.*1999). Discharges typically range from lows between 100 and 200 cfs in December, January, and February to highs between 1,000 and 2,000 cfs in May and June. Maximum discharges less than 600 cfs were recorded in 1966 and 1992 (Figure 53).

Flow data on Teton River tributaries and diversions from tributaries are measured during the irrigation season by Water District 1. The highest average discharges are for Teton Creek and Trail Creek at more than 400 cfs; intermediate discharges occur in Darby, South Leigh, North Leigh, and Badger Creeks at approximately 200 cfs; and low discharges occur in Horseshoe and Packsaddle Creeks at less than 50 cfs.

§303(d)-Listed Segments Three segments of the Teton River appeared on the 1998 §303(d) list: headwaters to Trail Creek, Trail Creek to Highway 33, and Highway 33 to Bitch Creek. Habitat alteration was listed as a pollutant of concern for all three segments, sediment was listed as a pollutant of concern for the segments from Trail Creek Highway 33 and from Highway 33 to Bitch Creek, and nutrients were listed as the pollutant of concern for the segment from Highway 33 to Bitch Creek.

In 1997, DEQ began collecting BURP data in nonwadeable streams and rivers as part of a field validation study of the Idaho River Index (IRI) developed by researchers at Idaho State University (Royer and Minshall 1996). Beneficial Use Reconnaissance Program protocols for sampling river macroinvertebrates, algae, fish, physicochemical parameters, and habitat are currently proposed for incorporation into DEQ's biologically based approach to assessing the status of beneficial uses (Grafe *et al.* 2002).

Sampling was conducted in the Teton River on three occasions to collect data for the field validation study. Sites at Harrop's Bridge were sampled in 1997 (97-Q002) and 1998 (98-P004), and a site located approximately 2 miles upstream of the confluence of Trail Creek (98-P003) was sampled in 1998. An analysis of the macroinvertebrate data collected at these sites using the procedures described by Royer and Mebane (2000), indicate that the ecological condition of all three sites was good (Table 28). Both sites sampled in 1998 received the maximum IRI score possible of 23, whereas the site sampled in 1997 received a score of 19. Scores between 16 and 23 indicate good ecological condition, scores between 13 and 16 indicate intermediate ecological condition, and scores less than 13 indicate poor ecological condition (Royer and Mebane 2000).

An analysis of periphyton collected at the time the Teton River sites were sampled provides a slightly different interpretation of ecological condition from that provided by the macroinvertebrate data. Periphyton, or algae growing on the surface of rocks, was collected and submitted for analysis by Frank Acker of The Academy of Natural Sciences in Philadelphia.

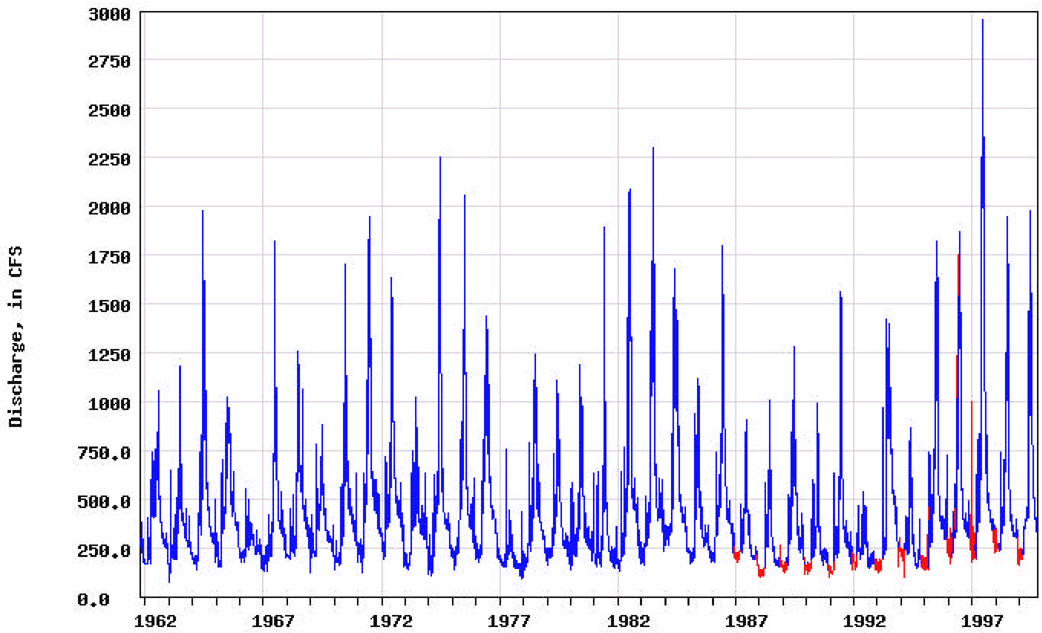

Figure 53. Discharge data recorded from 1961 through 1999 at USGS gage 13052200, *Teton River above South Leigh Creek near Driggs, ID.*
Source: USGS data retrieval site at http://waterdata.usgs.gov/nwis-w/ID

Table 28. Idaho River Index scores for three Teton River sites sampled by DEQ (after Royer and Mebane 2000).

Idaho River Index Parameters and Scores	Sampling Site		
	Harrop's Bridge (97-Q002)	Upstream of Trail Creek (98-P003)	Harrop's Bridge (98-P004)
METRICS			
Number of Taxa	26	68	80
Number of EPT[1] Taxa	13	24	32
Percent Elmidae	3.6	6.9	9.0
Percent Dominant Taxa	32	23	20
Percent Predators	3.3	8.8	4.4
METRIC SCORE			
Number of Taxa	5	5	5
Number of EPT Taxa	3	5	5
Percent Elmidae	5	5	5
Percent Dominant Taxon	5	5	5
Percent Predators	1	3	3
IRI Score	19	23	23
PERCENTAGE OF MAXIMUM POSSIBLE SCORE	83	100	100

[1] Insects of the orders Ephemeroptera, Plecoptera, and Trichoptera

Based on criteria developed for the state of Montana that incorporate factors such as number of diatom valves, diversity of diatom valves, and number of deformed diatom valves, Acker (1999) concluded that the sites indicated full support of aquatic life uses with only minor impairment. His specific comments, based only on visual inspection of slides of diatoms, are as follows:

> At Harrop's Bridge (97-Q002): Physical disturbance noted by the moderately large populations of *Achnanthes minutissima*. In addition, nutrient enrichment is indicated.
>
> Upstream of Trail Creek (98-P003): A simpler flora than [Salmon River, lower Clayton], indicating this site/river was subjected to more natural or anthropogenic stress. This is probably a smaller river. An abundance of *Navicula* and *Nitzschia* (~ 40% of the cells) may indicate a moderate siltation problem. Minor nutrient enrichment is indicated.
>
> At Harrop's Bridge (98-P004): Site is subject to more disturbance than [upstream of Trail Creek]. Not as much sedimentation. Plankton diatoms (*F. crotonensis*) indicate stream impoundment. Minor nutrient enrichment evident.

Resource Problems Identified by the USDA and TSCD According to the *Teton Canyon SAWQP Erosion-Sedimentation Evaluation* (Stevenson 1990a) and the *Teton River Basin Study* (USDA 1992), the total sediment yield to the Teton Valley segment of the river at the time of studies was 183,912 tons/year, including 159,677 tons/year from land use and 24,235 tons/year from streambank erosion. Sediment delivery from the Teton Canyon subwatershed, which is located south and west of the Badger Creek subwatershed, was not estimated and is not included in the total yield. This subwatershed contains intermittent and ephemeral streams, but no major tributaries to the Teton River. The sediment yield from approximately upstream of Harrop's Bridge was 110,183 tons/year from land use and 19, 695 tons/year from streambank erosion. Sediment yield downstream of Harrop's Bridge to the confluence included the contribution from the Badger Creek subwatershed, which was 49,494 tons/year for land use and 4,540 tons/year for streambanks. Implementing structural practices was expected to reduce the sediment yield from upstream of Harrop's Bridge by at least 29% and by 30% from downstream of Harrop's Bridge.

The USDA (1992) assumed that each ton of cropland-generated sediment (i.e., sediment from land uses) contained 3 pounds of nitrogen. Based on this assumption, the total amount of nitrogen yield to the Teton Valley segment of the river was 479,031 pounds/year. By reducing sediment yield approximately 30%, nitrogen yield would also be reduced by approximately 30%.

Water Quality Data The water quality data available for the Teton River is discussed in detail in the segment of this assessment entitled, "Nutrient Data."

Fisheries The Teton River fishery appears to be less robust in the Teton Canyon (Bitch Creek to the Teton Dam site) section of the river than the Teton Valley section and the lower section (the section downstream of the Teton Dam site, including the North and South Forks). Preliminary analyses of electrofishing data collected by IDFG in 1999 produced the following results (Schrader 2000b):

1. Of 1,534 trout captured, 657 were captured in the Teton Valley section, 572 were captured in the canyon section, and 305 were captured in the lower section. Trout species included Yellowstone cutthroat trout, wild and hatchery rainbow trout, rainbow trout x cutthroat trout hybrids, and eastern brook trout. Approximately 2 miles of the Teton Valley section were electrofished, 6 miles of the canyon section were electrofished, and 1.25 miles of the lower section were electrofished. The catch per mile was about 328 trout for the Teton Valley section, 95 trout for the canyon section, and 244 trout for the lower section.

2. The total catch rate for trout was highest in the lower section (102 trout/hour), intermediate in the Teton Valley section (82 trout/hour), and lowest in the canyon section (41 trout/hour).

3. Of the 3,016 mountain whitefish and suckers collected, the catch per mile was about 398 in the Teton Valley, 310 in the canyon section, and 286 in the lower section.

4. The total catch rate for mountain whitefish and suckers was highest in the canyon section (134 fish/hour), intermediate in the lower section (119 fish/hour), and lowest in the Teton Valley section (100 trout/hour).

Electrofishing in the canyon section was limited by deep pools and fast-flowing rapids, and most fish were captured near rapids or in pool 24 below Linderman Dam.

Discussion Despite preliminary data indicating that cold water aquatic life beneficial uses of the Teton River upstream of Harrop's Bridge are supported, the process used to interpret these data have not officially been adopted by DEQ. Although specific instances of nuisance aquatic vegetation have not been reported, the measured concentrations of nitrate in the upper Teton River are high relative to other rivers in eastern Idaho. Given the wetland conditions of the upper river (refer to section entitled, "Fate of Residual Nitrogen in the Teton Subbasin") the possible consequences of these concentrations are currently unknown.

Conclusions Conclusions regarding the water quality status of the Teton River are listed below.

1. Development of TMDLs for sediment and nutrients are appropriate.

2. To support beneficial uses, the water quality targets for sediment and nutrients shown in Table 15 should not be exceeded at any location in the Teton Valley segment of the Teton River.

3. All three segments of the Teton Valley portion of the Teton River are listed for habitat alteration. While degraded habitat is evidence of impairment, waterbodies are not considered impaired by pollution that is not a result of the introduction or presence of a pollutant. Since TMDLs are not required for waterbodies impaired by pollution but not a pollutant, the state of Idaho does not develop TMDLs for habitat alteration.

North Fork Teton River

Approximately 16 river miles upstream from the confluence of the Teton River with the Henry's Fork, the Teton River divides into two channels. On USGS topographic maps, the northernmost channel is labeled "Teton River" and the southernmost channel is labeled "South Teton River." But these channels are most commonly known as the North and South Forks of the Teton River.

The forks of the Teton River are located in the Rexburg watershed (Figure 6), which is 48 square miles or 30,598 acres in area. With the exception of small parcels of land managed by BLM, IDFG, or the cities of Rexburg and Sugar City, all land is privately owned. The predominant land uses are agriculture and urban development. The watershed formed on the floodplain of the Teton River and on the floodplain and terraces of the Henry's Fork River. Soils are deep, fine-textured, nearly level, and moderately to very poorly drained.

The channels of the North and South Forks of the Teton River diverge north of the city of Teton (Figure 54). From approximately 1 mile upstream of the forks, the river channel is strictly confined by levees which continue on either side of the North Fork Teton River for approximately 4 miles downstream of the forks. The channel in the area of the levees is also lined with rip rap consisting of boulder-sized material. Much of this material was put into place during channel restoration work conducted by the Army Corps of Engineers at the request of the Soil Conservation Service following collapse of the Teton Dam in 1976 (USACE 1977).

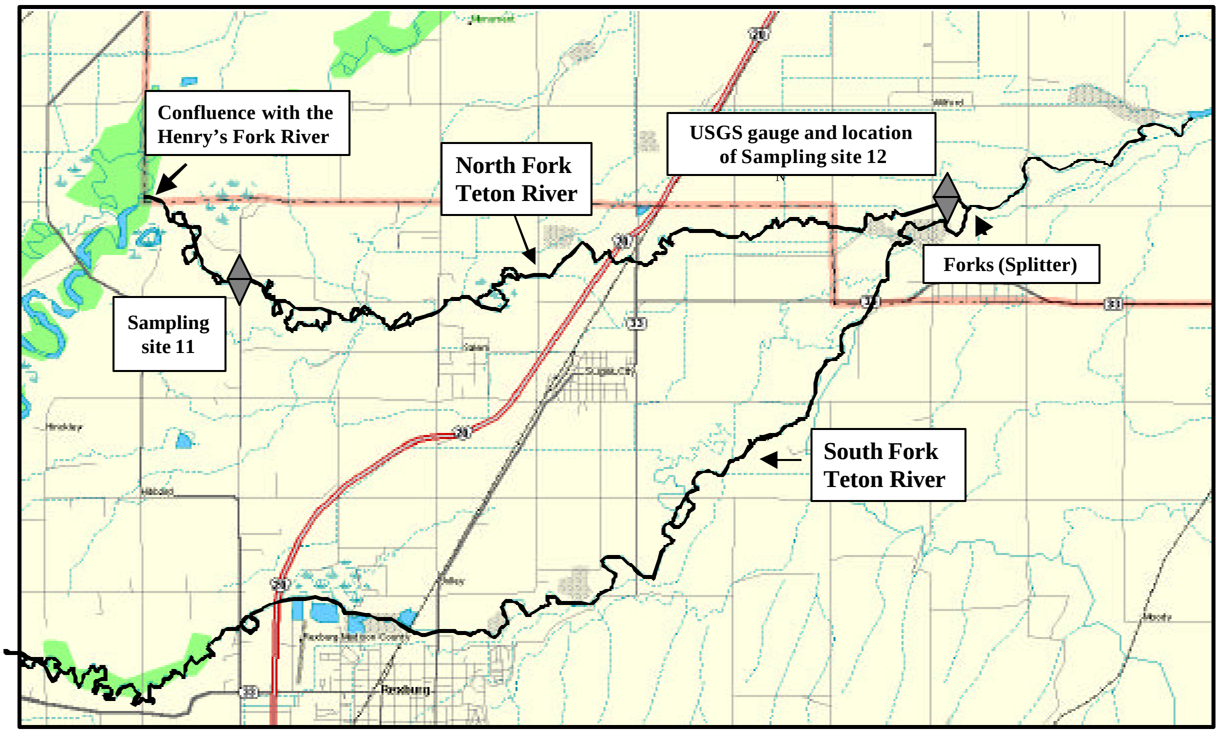

Figure 54. North Fork of the Teton River showing boundaries and locations of sites sampled by DEQ in 2000.

Flooding following collapse of the dam caused extensive structural damage to the North Fork Teton River channel and significantly altered the riparian area by destroying cottonwood and other large deciduous trees. From August to December 1976, water was diverted from the North Fork Teton River to facilitate clean up and to restore its capacity for carrying flood flows (USDA 1982).

Flow Discharge in the North Fork Teton River has been measured discontinuously since 1908 by the USGS at gage 13055198, *North Fork Teton River at Teton, ID.* The gage is located north of the city of Teton and approximately 0.5 miles downstream of the point at which the north and south forks diverge (Figure 55). The range of daily discharge values from 1977 to 1999 was 5 to 2,500 cfs.

Flow from the mainstem Teton River to the north and south forks is controlled by a structure known as the splitter. This concrete structure, located at the point at which the forks diverge, has four regulating gates on the South Fork Teton River and two on the North Fork Teton River. The structure was built shortly after the 1976 Teton Dam flood under the direction of Fremont County with funds from the Federal Emergency Management Act. The splitter replaced a concrete apron on the South Fork Teton River that had holes for steel pins in front of which flashboards were placed to make a removable dam. The water is regulated by the Fremont-Madison Irrigation District to supply water to meet downstream irrigation demands.

During the irrigation season, water in the North Fork Teton River may originate from the Teton River, the Henry's Fork River, or exchange wells. Irrigation return or supplemental flows are supplied from the Henry's Fork River via the Consolidated Farmer's Friend and Salem Union Canals (Figure 56). Water is diverted from the North Fork Teton River to the Pincock-Byington Canal, the Teton Island Feeder, the Salem Union B Stock Canal (formerly the North Salem Agriculture and Milling Canal), the Roxana Canal, the Island Ward Canal, and the Saurey-Somers Canal. Some of the diverted water discharges to the South Fork Teton River or returns via drains to the North Fork Teton River (Bagley 2001 and FMID 1992). The Teton Island Feeder sometimes takes all of the water in the North Fork Teton River, but flow is restored below the diversion by subwater and return flows (Swensen 1998). The distance and time that the channel is dewatered has not been well documented, but in 1979, a 1-mile section was dewatered for two weeks because of irrigation diversions (USDA 1982).

§303(d)-Listed Segment The North Fork Teton River is §303(d)-listed from the forks to the Henry's Fork River. The pollutants of concern are sediment and nutrients.

The beneficial uses of the North Fork Teton River have not been assessed by DEQ using BURP data. Two sites were visited in September 1995 by a BURP sampling crew, but samples were not collected because the channel was not wadeable at either location.

Resource Problems The North Fork Teton River was originally placed on Idaho's §303(d) list because it was listed as an impaired stream segment in *The 1992 Idaho Water Quality Status Report* (DEQ 1992). Irrigated crop production, pastureland treatment, and channelization were identified by DEQ as sources of impairment; siltation/sedimentation and nutrients, including nitrate, were identified as pollutants.

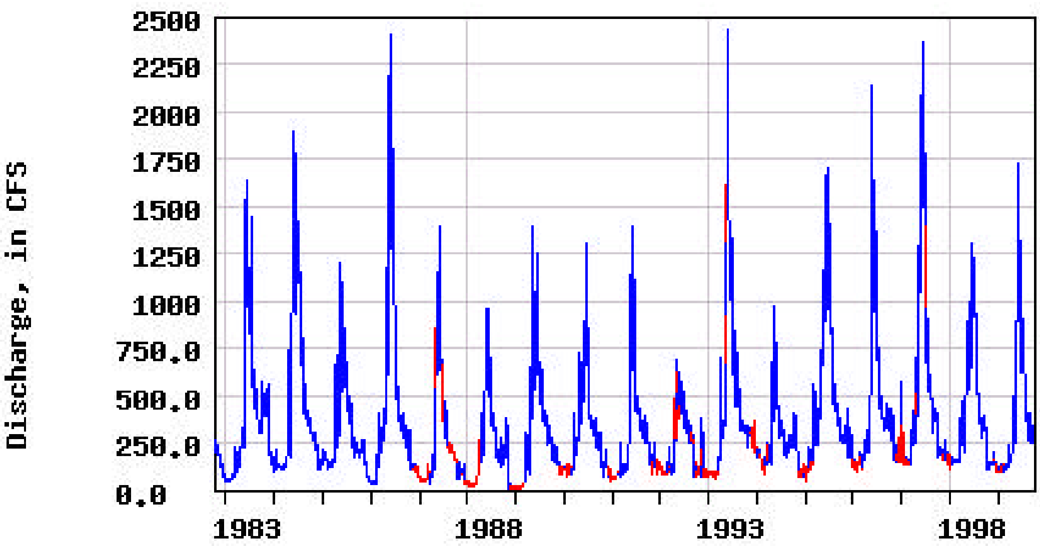

Figure 55. Discharge data recorded or estimated since 1982 at USGS gage 13055198, *North Fork Teton River at Teton, ID.* Source: USGS data retrieval site at http://waterdata.usgs.gov/nwis-w/ID.

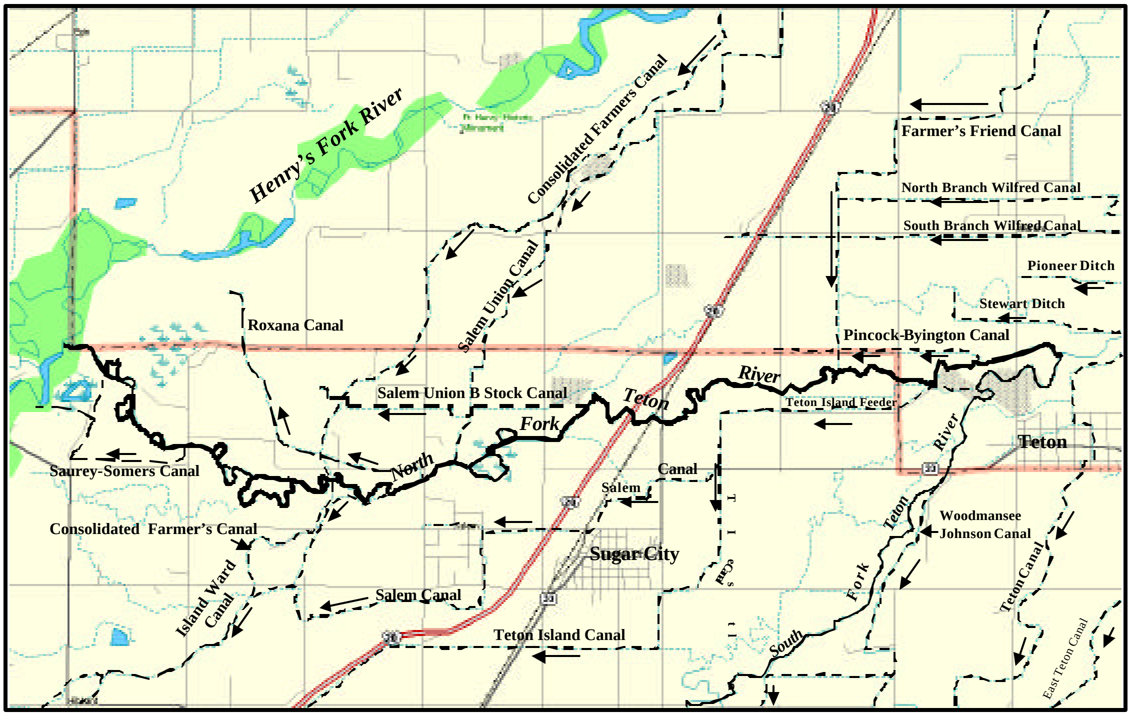

Figure 56. North Fork of the Teton River showing irrigation diversions and irrigation return flows.

Water Quality Data Water quality and benthic macroinvertebrate data were collected by researchers affiliated with Idaho State University at four sites on the North Fork Teton River from December 1976 through July 1980 (USDA 1982) and again at one site in August 1998 (Thomas *et al.* 1999). Limited analyses were performed on a water sample collected in June 1999 (Minshall 2000) and on samples collected by DEQ at two locations on four dates in summer 2000 (Appendix I).

Nitrate concentrations measured in samples of water collected from the North Fork Teton River in 1998, 1999, and 2000 ranged from 0.06 to 0.29 mg/L, remaining below the target of less than 0.3 mg/L. However, all of these samples were collected during the summer months when nitrate concentrations in the Teton Subbasin normally reach their lowest levels. Data collected during all seasons from 1976 to 1980 showed that nitrate concentrations were less than 0.32 mg/L in July and August and more than 0.6 mg/L in late December and January. Although these data were collected more than 20 years ago, recent data collected upstream of the North Fork Teton River at the *Teton River near St. Anthony* gage indicate that these nitrate concentrations are probably representative of current conditions.

Nitrate data collected at two sites on the North Fork Teton River in August 2000 appear to reflect the influence of flow diversions and returns on nitrate concentrations during the irrigation season. Concentrations of nitrate in the North Fork Teton River should approximate the concentrations measured at the *Teton River near St. Anthony* gage. In August 1993, concentrations of $NO_3 + NO_2$ ranged from 0.26 to 0.35 mg/L; in August 1994, the concentration was 0.14 mg/L; and in August 1996, the concentration was 0.41 mg/L. In August 2000, the concentration of nitrate was 0.29 mg/L at the upstream site, but only 0.06 mg/L at the downstream site. The lower concentration at the downstream site indicates that the nitrate concentration was diluted as water was diverted from the North Fork Teton River to canals and replaced by supplemental water and irrigation returns from the Henry's Fork or exchange wells.

The results of water quality sampling conducted by DEQ in 2000 did not indicate high concentrations of suspended sediment in the North Fork Teton River at the locations and times sampled (Appendix I). The maximum concentration of TSS (9.5 mg/L) was far below the designated target of 80 mg/L, and maximum turbidity (7.9 NTU) was far below the criterion specified in Idaho's water quality standards (i.e., not greater than 50 NTU above background). Substrate particle size was measured at four sites on eight occasions from November 1976 to August 1980 (USDA 1982). These data were intended to show changes in particle size distribution following flood restoration work, and therefore provide a good baseline for evaluating the amount of sediment deposited in the North Fork Teton River since that time. Substrate particle size data could not be collected at the sites sampled by DEQ in 2000 because of the depth of water in the channel, so no comparison was made.

Fisheries Despite occasional dry conditions, recent data collected by IDFG show that trout migrate between the Henry's Fork to the canyon area of the Teton River via the North Fork Teton River. Preliminary analysis of 1998-1999 radiotelemetry data indicated that one cutthroat trout and two rainbow trout hybrids migrated from the North Fork Teton River to spawn in the Henry's Fork (Schrader 2000b). None of the 79 radiotagged fish monitored during the study appeared to spawn in the North Fork Teton River. Electrofishing of an approximate 2-mile section of the North Fork Teton River immediately upstream of its confluence with the Henry's Fork produced a catch rate of 149 trout per hour and 141 mountain whitefish and suckers per hour (Schrader 2000b). The catch rate for trout in the North Fork Teton River was higher than in the South Fork Teton River or sections of the Teton River between Bitch Creek and the Teton Dam site.

Discussion The support status of aquatic life beneficial uses in the North Fork Teton River have not been assessed by DEQ because the depth of water in the channel at the time sampling was attempted precluded use of the wadeable stream BURP protocol. Thomas *et al.* (1999) collected macroinvertebrates in 1998 approximately one mile upstream of the confluence of the North Fork Teton River with the Henry's Fork. They assessed the data using the Idaho Medium River Index developed by Royer and Minshall (1996). This Index rates ecological condition on a scale of 0 to 30, with scores less than 19 indicating poor conditions, scores of 19 to 26 indicating medium ecological conditions, and scores of 26 to 30 indicating good ecological conditions. The score for the North Fork Teton River indicated that its condition was at the transition between poor and medium. Fisheries data collected by IDFG indicate that trout and mountain whitefish occur in relatively large numbers in the lower two miles of the North Fork Teton River, and that cutthroat trout and rainbow trout hybrids migrate from the Canyon area of the Teton River through the North Fork Teton River to spawn in the Henry's Fork (Schrader 2000b). Salmonid spawning is a designated beneficial use of the North Fork Teton River, but this use was not observed during the IDFG study.

Analytical values for suspended sediment and turbidity during the summer of 2000 were well below the numeric criteria for these parameters. But it is unlikely that excessive sediment in the water column would occur except during infrequent, high-flow events. Therefore, the most appropriate indicator of sediment impairment is concentrations of substrate surface and subsurface sediment, but water depths precluded measurement of these parameters in 2000. Although substrate sediment has not been quantified, control of streambank erosion to reduce property loss is an ongoing concern for landowners, indicating that large amounts of sediment are delivered to the North Fork Teton River through streambank erosion. High rates of streambank erosion on the North Fork Teton River are caused by at least three factors. First, large sections of streambank are unstable because the large woody vegetation that was removed from the riparian area by the Teton flood and flood restoration work has not regenerated. Second, large fluctuations in flow during spring runoff and the irrigation season contribute to channel downcutting, bank cutting, and bank sloughing. Third, channelization of the Teton River above the forks and channelization of the North Fork Teton River below the forks has increased the velocity of water flowing downstream, causing significant movement of streambanks as the stream attempts to reestablish a natural channel and floodplain. These factors necessitate a whole-stream approach to restoration because efforts to stabilize isolated sections of streambank without addressing all streambanks will perpetuate the erosion problem.

Plans to conduct nutrient sampling and a streambank erosion inventory on the North Fork Teton River are currently being developed by the Madison Soil and Water Conservation District, the Rexburg field office of the NRCS, the Idaho Association of Soil Conservation Districts, and DEQ. Sampling for nutrients will permit a more thorough evaluation of flow diversion and supplementation on nitrogen concentrations, and data collected during the streambank erosion inventory will form the basis for developing a sediment TMDL.

Conclusions Conclusions regarding the water quality status of North Fork Teton River are listed below.

1. TMDLs for sediment and nutrients are appropriate.

2. To support beneficial uses, the water quality targets for sediment and nutrients shown in Table 15 should not be exceeded at any location in the North Fork Teton River.

Teton Creek

Teton Creek from Highway 33 to the Teton River appeared on the 1996 §303(d) list, but was removed from the 1998 list because of BURP collected by DEQ in 1995. The Water Quality Subcommittee of the Henry's Fork Watershed Council objected to this change, citing the inadequacy of data used to delist the segment, and asked that DEQ include a review of water quality data and information for Teton Creek in this assessment.

The Teton Creek subwatershed is one of the largest in the upper Teton Subbasin, encompassing an area of 33,260 acres (Figure 7). The North and South Forks of Teton Creek receive discharge from numerous intermittent and perennial channels originating at elevations of up to 10,000 feet. The forks, which are approximately 4 and 6 miles in length, converge at an elevation of 7,000 feet. From the forks, the mainstem of Teton Creek drops less than 1,000 feet in elevation as it flows 16 miles southwest to its confluence with the Teton River.

The forest boundary and Wyoming-Idaho state line divide the Teton Creek subwatershed from east to west. Approximately 12 miles of Teton Creek are located on the Caribou-Caribou-Targhee National Forest in Wyoming, almost 2 miles are located on private land in Wyoming, and 9 miles are located on private land in Idaho. Approximately three-quarters of the subwatershed, as delineated in the *Teton River Basin Study* (USDA 1992), is managed by the Forest Service, slightly more than 1 square mile is managed by the BLM, and the remainder is privately owned. Forest lands are managed for elk and deer winter range, primitive and semi-primitive backcountry recreation, motorized travel, and developed recreation (i.e., the Grand Targhee Ski and Summer Resort). Private lands are used for rangeland, irrigated cropland, and residential development, particularly near the incorporated city of Driggs and unincorporated community of Alta, Wyoming (USDA 1992 and 1997a).

Several ecological units are represented within the Teton Creek subwatershed on the Caribou-Targhee National Forest, and Teton Creek traverses four of them (Table 29). The steep topography, unstable soils, and wet conditions of higher elevations make the upper portion of the subwatershed a source of relatively high background levels of sediment. At lower elevations, the subwatershed consists of an alluvial floodplain overlain by wind-deposited loess. From the state line to just west of Highway 33, the soils are level to gently sloping and well drained; west of the highway to the Teton River the soils are nearly level and poorly drained.

Flow In the 1870s, explorers of the region surrounding the newly created Yellowstone National Park considered Teton Creek a river and major tributary of what was then known as Pierre's River (Thompson and Thompson 1981). Pierre's River was subsequently renamed the Teton River, the North Fork of Pierre's River was renamed Bitch Creek, and what was then known as the Teton River was renamed Teton Creek. Teton Creek remains a major tributary of the upper Teton River, flowing almost 23 miles from its headwaters near the eastern boundary of the Jedediah Smith Wilderness Area to its confluence with the Teton River southwest of Driggs. Based on early survey maps and remnants of cottonwood riparian forest, it appears that flow in Teton Creek was perennial prior to diversion of water for irrigation.

Like most streams originating on the west flank of the Teton Mountain Range, flow in Teton Creek is shown on USGS 7.5-minute topographic maps as perennial from its headwaters to the eastern edge of the Teton Valley. Approximately 1 mile east of the forest boundary, the channel of Teton Creek becomes braided. The main channel continues to be shown as perennial until it reaches the Grand Teton Canal headworks approximately 0.25 miles east of the Idaho-Wyoming border at Alta, Wyoming. In 1977, the approximate maximum diversion at this structure was 320 cfs. At this point, streamflow in the braided channels of Teton Creek changes from perennial to intermittent. The braided channels converge approximately 4 stream miles east of Highway 33. Perennial flow is restored to the channel immediately east of Highway 33. West of the highway, the channel receives flow from numerous unnamed spring creeks and continues to enlarge in size until it reaches the Teton River immediately upstream of Bates Bridge.

Discharge in Teton Creek and associated canals is measured by Water District 1 at the following locations: above all diversions in Wyoming; in Mill Creek, a tributary of Teton Creek in Wyoming; in North, South, and Waddell Canals in Wyoming; in the Grand Teton Canal in Wyoming; in Teton Creek below Grand Teton Canal in Idaho; in Central Canal at the Idaho-Wyoming state line in Idaho; and in Price-Fairbanks Canal in Idaho. Eighteen-year average discharge data for Teton Creek above all diversions indicate that maximum discharge exceeds 450 cfs throughout June, rapidly declines in July to less than 100 cfs by August 1, then continues to decline to less than 20 cfs by the end of November (Figure 56a).

Below the diversions near the Idaho-Wyoming border, the maximum discharge is less than 350 cfs and drops throughout the irrigation season to less than 5 cfs in September (Figure 56b). There are no long-term discharge records for Teton Creek west of Highway 33. In 2000, the discharge measured by DEQ upstream of the confluence of Teton Creek with the Teton River was 54.6 cfs on July 25 and 39.1 cfs on August 21 (Appendix I).

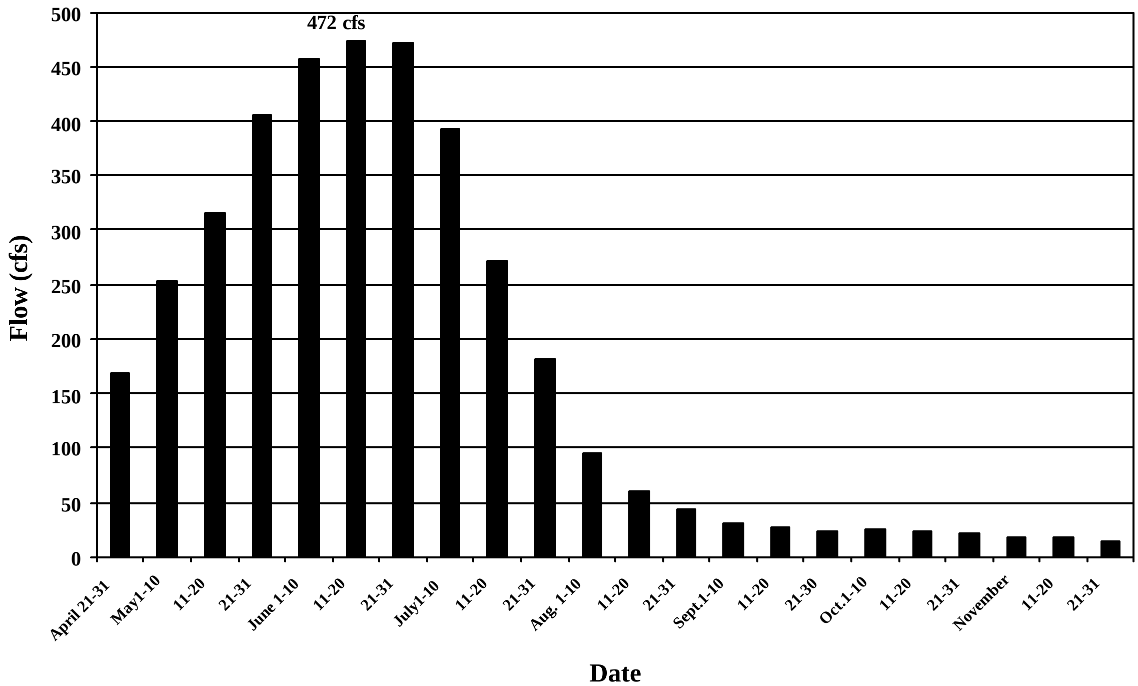

Figure 56a. Eighteen-year average discharge measurements for Teton Creek above all diversions.

A new headgate was installed on Grand Teton Canal 15 years ago (Christensen personal communication). Since then, water has not crossed the state line from Idaho into Wyoming in the original Teton Creek channel during the irrigation season from early May to the beginning of September (Christensen personal communication). Because water is present in the channel between the state line and Highway 33 only during runoff, aquatic life is generally not present in this section of Teton Creek (Christensen personal communication).

According to records maintained by the U.S. Army Corps of Engineers, more than half of the Teton Creek stream channel between the Idaho-Wyoming state line and Highway 33 has been heavily altered by dredging and gravel mining since at least the early 1980s. Some of these stream channel activities either did not require authorization from a regulatory agency or were performed without appropriate authorization. The apparent objectives of the channel alterations were to prevent overbank flooding during runoff, thereby maintaining the value of real estate in the floodplain of Teton Creek (Brochu 2002).

§303(d)-Listed Segment Teton Creek from Highway 33 to the Teton River appeared on the 1996 §303(d) list because of information contained in *The 1992 Idaho Water Quality Status Report* (Table 13) (DEQ 1992). The pollutants considered responsible for impaired water quality were sediment originating from streambank modification and destabilization, and nutrients, including nitrate, originating from pastureland treatment (Appendix F). The segment of Teton Creek shown on the 1996 §303(d) list extends a distance of slightly more than 4 stream miles (Figure 56c).

Based on BURP data collected in 1995, DEQ assessed Teton Creek as supporting its beneficial uses, and removed it from the 1998 §303(d) list. The results of BURP sampling conducted in 1995 indicated that the beneficial use of cold water aquatic life was supported in Teton Creek immediately west of Highway 33 (MBI of 3.61 at site 95-A112) (Figure 56c). Sampling was attempted at two other sites in 1995, but the site downstream of the Idaho-Wyoming state line was dry (95-A095), and the site near the confluence of the creek with Teton River did not contain riffles suitable for sampling (95-B053). Additional BURP sampling in 1997 also indicated that the beneficial use of cold water aquatic life was supported in Teton Creek downstream of the Idaho-Wyoming state line (MBI of 5.87 at site 97-L076). However, discharge records show that the site sampled is typically dry. The stream channel contained water in 1997 because it was a record year for runoff. The discharges measured in Teton Creek peaked in early June at 930 cfs above all diversions and at 848 cfs below Grand Teton Canal. Both of these values are more than twice the eighteen-year average discharges recorded for these locations (Figure 56a). The BURP sampling result obtained in 1997 is therefore not representative of typical conditions, and should not be used to assess beneficial use support.

Table 29. Descriptions of the ecological units traversed by Teton Creek on the Caribou-Targhee National Forest (after Bowerman *et al.* 1999).

Ecological Unit Symbol and Ecological Type Name	Summary Description	Management Considerations and Limitations
1316—ABLA/VAGL, PAMY Koffgo – ABLA/THOC Koffgo – Rock Outcrop Complex, 40 to 70 percent slopes	"....on mountains in the mid portion of the forested zone. ...occurs in glacial troughs, cirques and on the north side of topographically dominant peaks and ridges. Very steep slopes supporting open canopy forests that are frequently dissected by avalanche chutes... [R]ock outcrops and rubble land characterize the landscape. Mixed conifers are represented in the forest canopy. Communities dominated by tall shrubs or subalpine forbs are supported in the avalanche chutes. Mass movements are present in some areas." Average annual precipitation 32 inches; average annual air temperature 35 ^{o}C; elevations from 7,200 to 9,800 feet; geology: mixed.	• Slopes have potential for mass movement • High potential for avalanches • Foot and saddlestock trails, fencing, and use of heavy equipment for woodland harvest severely limited because of slopes
1414—ABLA/VASC, PIAL Winegar – CALE4 Oxyaquic Cryochrepts – Rock Outcrop complex, 4 to 15 percent slopes	"...on cirque floors in the cold, moist portion of the forested zone. ...characterized by rolling slopes that support a mosaic of open canopy forests and riparian communities dominated by subalpine forbs. Scoured rock outcrops and intermittent or perennial streams and ponds are common." Average annual precipitation 45 inches; average annual air temperature 32 ^{o}F; elevations from 9,000 to 9,900 feet; geology: igneous and metamorphic.	• Use of heavy equipment severely limited because soils are too rocky • Fencing and camping severely limited by wetness • Foot and saddlestock trails severely limited because of wetness and because soils erode easily
1999—Valleys, 4 to 25 percent slopes	"...on valleys in the mid portion of the forested zone. ...characterized by stream terraces, ground moraines and mountain footslopes on the floor of glacial troughs. A mosaic of communities dominated by mixed conifers, quaking aspen, mountain shrubs and subalpine or mesic forbs are common. Runout areas for avalanches commonly dissect the unit." Average annual precipitation 28 inches; average annual air temperature 36 ^{o}F; elevations from 6,800 to 8,000 feet; geology: mixed.	• High potential for avalanches; runouts are common • Debris flow or flashflood runout areas are common; high potential for debris flows or flash floods from adjacent south-facing mountain sideslopes during heavy rain events
2609—PIEN Cryaquolls, 2 to 8 percent slopes	"...on cold, moist floodplains in the forested zone. ...characterized by low to high gradient (2 to 8 percent) floodplains in U-shaped mountain valleys. The floodplains vary in width from 40 to 800 feet and streams vary in width from 1 to 15 feet. Microrelief on the floodplain is very broken and irregular. Rosgen stream types A3 and B3 are commonly represented. The streams are perennial or intermittent and seasonal variation in streamflow is dominated by snowmelt runoff. Braided channels and confined meanders are common. Medium to large debris affects up to 30 percent of the active stream channels. Beaver dams are infrequent." Average annual precipitation 25 inches; average annual air temperature 36 ^{o}F; elevations 5,600 to 7,800 feet; geology: alluvium.	• Dynamic riparian systems respond to subtle changes in management or conditions within the ecological unit and on adjacent uplands • Has the potential for frequent flooding of long duration during peak snowmelt period from April through July • Heavy equipment and off-road vehicle use and fencing severely limited by wetness; windthrow hazard severe because of wetness

Resource Problems Identified by the USDA and TSCD The *Teton River Basin Study* (USDA 1992) estimated that the total sediment yield from agricultural lands in the Teton Creek subwatershed was 6,416 tons/year. Of that amount, 68% originated from streambanks and 32% originated from land use. Implementing structural practices, identified as Alternative 2 in the *Teton River Basin Study* (USDA 1992), was expected to reduce total sediment yield to 4,686 tons/year by reducing streambank erosion by 33% and land use erosion by 14%. The majority of agricultural land located in the subwatershed occurs within treatment units 10/11 and 9, with smaller portions in treatment units 12 and 6. Treatment units 10/11 are riparian lands intermixed with upland areas along the Teton River; treatment unit 9 is irrigated cropland with shallow soils. The causes of resource problems identified for treatment units 10/11 were overgrazing in the riparian area; removing stream-side shrubs, trees, and other vegetation; straightening sections of stream channel; improper culvert placement; flooding; stream evolution; reduced sub-water flows; poorly controlled flood irrigation systems; and upland erosion. The causes of resource problems identified for treatment unit 12 were overgrazing of uplands, season of use by livestock, roads, overland runoff/surface and gully erosion, and urbanization/home building (USDA 1992).

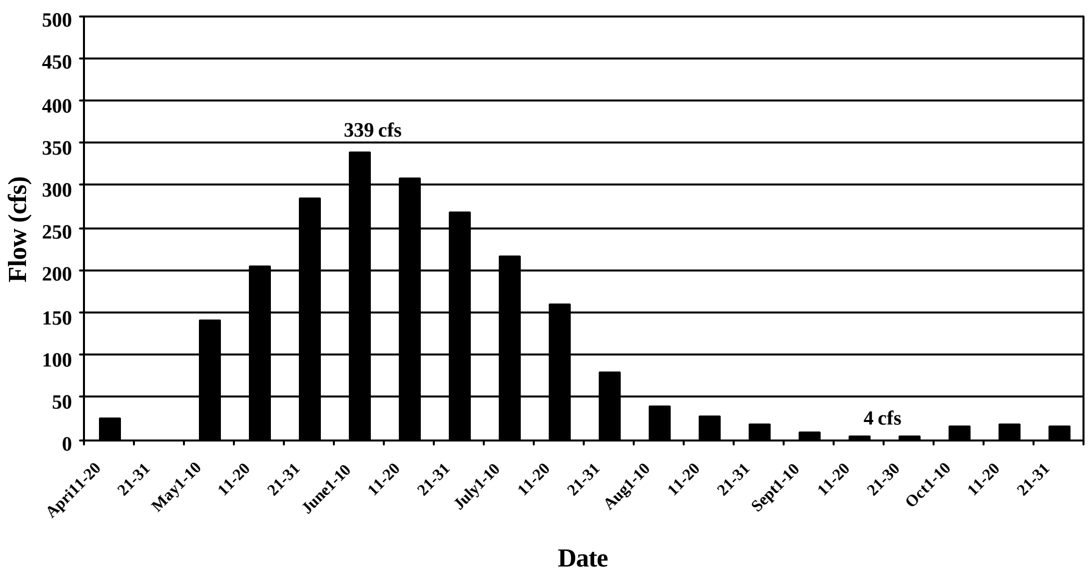

Figure 56b. Eighteen-year average discharge measurements for Teton Creek below diversions near the Idaho-Wyoming border.

The Caribou-Targhee National Forest identified mass wasting as the principal ecological concern affecting riparian quality in the Teton Range (USDA 1997b). In 1985, a mass wasting event occurred on the forest in the Teton Creek subwatershed, sending a large volume of sediment down Teton Creek. This event remains a source of elevated concentrations of sediment in Teton Creek (Christensen personal communication). In 1998, Forest Service biologists conducted a fish survey on Teton Creek and noted that sediment transport was heavy, leaving the water with a green cast. This sediment was apparently glacial in origin.

Water Quality Data Water quality samples were collected by DEQ approximately 1 stream mile above the confluence of Teton Creek with the Teton River on three dates in 2000. Nitrate concentrations were among the highest measured at any location in the subbasin, and increased from 0.92 mg/L on June 26 to 1.64 mg/L on July 25 to 2.13 mg/L on August 21 (Appendix I). These concentrations were higher than the concentrations measured in the Teton River upstream and downstream of the confluence of Teton Creek, indicating that the Teton Creek subwatershed is a source of nitrate. Specific conductance, an indicator of dissolved solids, increased from 180 ìsiemens/cm in June to 260 ìsiemens/cm in July and August, but these results are consistent with other spring-fed streams in Teton Valley.

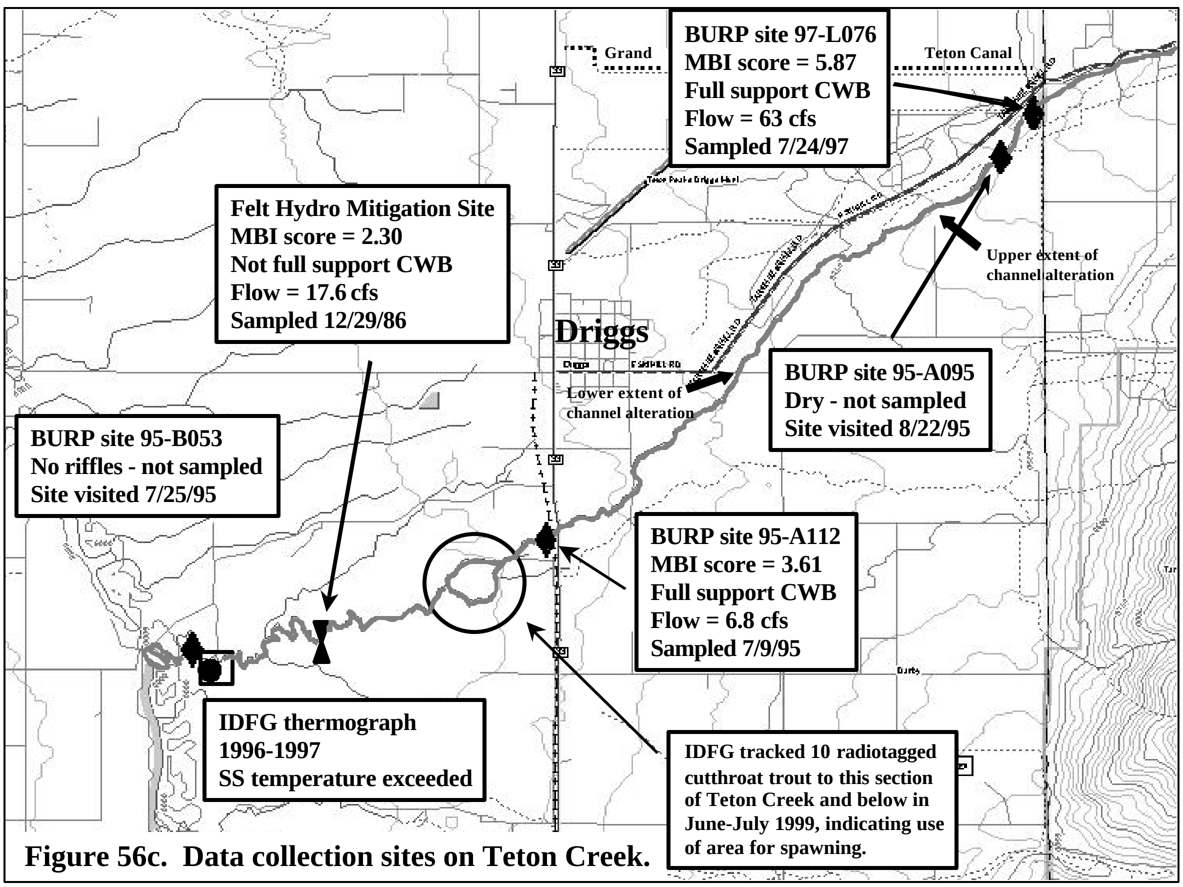

Figure 56c. Data collection sites on Teton Creek.

Neither elevated suspended solids nor increased turbidity was detected at the DEQ sampling location in 2000. The maximum concentration of TSS (3.1 mg/L) was far below the designated target of 80 mg/L, and maximum turbidity (3.1 NTU) was far below the criterion specified in Idaho's water quality standards (i.e., not greater than 50 NTU above background). Turbidity values measured in June 1999 showed a small increase from the state line (3 and 5 NTU) to the site west of the highway near the bicycle path (12 NTU), but again, these values were far below the water quality criterion.

Temperature data were collected by IDFG in 1996 and 1997 at the same location sampled by DEQ in 2000 (i.e. approximately 1 stream mile above the confluence of Teton Creek with the Teton River).

Fisheries Fisheries data for Teton Creek were collected by DEQ in 1996 and 1997, and by the Caribou-Targhee National Forest in 1998. In September 1996, DEQ electrofished a 120-m reach of Teton Creek approximately 150 m below Highway 33. Three year classes of Yellowstone cutthroat trout were collected, including 132 young-of-the-year. In July 1997, a segment of Teton Creek immediately below the Idaho-Wyoming state line was electrofished, but no fish were collected. Three stream reaches were electrofished on the National Forest, but only five cutthroat and rainbow trout were collected, compared to more than 20 brook trout.

Teton Creek below Highway 33 is considered the most important cutthroat trout spawning tributary in the Teton Subbasin (USDA 1992, Schrader 2000a). In 1988, IDFG counted 955 potential spawning sites in 2.8 miles of channel upstream of the confluence with Teton River. In 1998 and 1999, 10 of 79 radiotagged cutthroat trout spawned immediately downstream of Highway 33 (Schrader 2000b).

Felt Hydroelectric Project: Off-site Mitigation on Teton Creek During construction of an access road to the Felt Dam and powerhouse site in 1985, a "substantial amount of material (boulders) was side-cast into the Teton River and Badger Creek" (ERI 1986). The Federal Energy Regulatory Commission (FERC) temporarily halted construction until plans for removing rocks from the streams, stabilizing soils, and replanting slopes could be developed.

The Felt Hydroelectric Project was eventually completed, but not before legal action was taken against Bonneville Pacific Corporation by the EPA, Army Corps of Engineers, and state of Idaho for violations of the CWA at the Felt site and two sites in Twin Falls County (see *United States of America and State of Idaho v. Bonneville Pacific Corporation,* Stipulation and Consent Decree, Civil No. 87 4073). The consent decree stipulated that Bonneville Power Corporation complete all the measures specified in Attachment I, *Mitigation Requirements, Felt Hydroelectric Project, Teton River, Teton County, Idaho.* These measures included upland mitigation for loss of large game habitat, breaking and clearing of rock in Badger Creek to ensure adequate fish access/passage, on-site upland restoration for erosion control, on-site riparian restoration on Badger Creek and the Teton River, and off-site mitigation for approximately 6,500 square feet of aquatic habitat and 6,500 square feet of riparian habitat eliminated from Badger Creek and the Teton River.

The IDFG recommended Teton Creek as the location for off-site mitigation. A remedial study of the site was conducted in 1986 (ERI 1986), streambank stabilization and riparian revegetation were completed in 1987, and monitoring of the treated site and a downstream control site was conducted for five years (ERI 1992). After five years, the percentage of fine sediment in substrate decreased at the treated site but increased at the control site. Vegetation cover at the treatment site increased 10-20% and embeddedness decreased 20-25%.

The results of the Felt Hydroelectric/Teton Creek mitigation project are especially valuable because monitoring was conducted over a five-year period, the treatment site was compared with an untreated control site, and both physical and biological parameters were measured. Data contained in project reports provide a good basis for assessing future water quality implementation projects on Teton Creek.

Discussion Teton Creek consists of two hydrologically distinct segments. The source of water in the upper segment is snowmelt runoff; the source of water in the lower segment is upwelling subsurface water and springs located immediately west of Highway 33. Because of the unique hydrologic characteristics of these two segments, the Henry's Fork Watershed Council Water Quality Subcommittee recommended in 1999 that Teton Creek be separated into two segments for the purpose of assessing beneficial uses (Appendix D). Due to the absence of flow in the segment of Teton Creek from the Idaho-Wyoming state line to Highway 33, this segment cannot support aquatic life. However, historic and ongoing stream channel alteration in this segment has the potential to significantly degrade water quality in the lower segment from Highway 33 to the Teton River. This segment is the most important Yellowstone cutthroat trout spawning tributary in the Teton Subbasin, and must be monitored carefully for changes in water and substrate quality.

SUMMARY OF PAST AND PRESENT POLLUTION CONTROL EFFORTS

Agricultural Water Quality Projects

In the 1980s and early 1990s, the TSCD, Madison Soil and Water Conservation District (MSWCD), and Yellowstone Soil Conservation District made several efforts to procure funding for implementation of water quality projects through the State Agricultural Water Quality Project (SAWQP). At that time, DEQ administered the SAWQP, though projects were approved jointly by DEQ and the Idaho Soil Conservation Commission (SCC). The application process involved the following steps:

1. The district applied for funding to develop a planning project final report.

2. The district developed a planning project final report using technical support of the NRCS and SCC. The planning project final report was a thoroughly detailed study that included descriptions of the topography, climate, land use, soils, wildlife resources, water quality, and the local economy of the project area; descriptions of treatment units and appropriate best management practices; a cost analysis of the project, including comparisons of treatment alternatives; and a plan for implementation.

3. If the planning project final report was approved by DEQ and SCC, the district submitted an application to fund an implementation project.

4. The district developed a plan of operations for the implementation project, which, if approved, became part of the SAWQP grant agreement.

Several projects received funding for planning, but did not receive funding for implementation. The numerous planning documents produced for unfunded projects are valuable references that contain extensive information regarding land use, agricultural practices, characterization of nonpoint-source pollution originating on agricultural lands, and proposals for pollution mitigation. Copies of most of these documents are available only from the conservation districts, NRCS field offices, SCC, or DEQ.

Planning projects for Milk Creek, Canyon Creek, and Teton Canyon were funded in the mid-1980s. In conjunction with the planning projects, DEQ provided technical assistance to the districts by performing water quality monitoring in the project areas. The Milk Creek Water Quality Project (TSCD 1987), West Canyon Creek Planning Project AG-P-13 (MSWCD 1988), and Teton Canyon Water Quality Planning Project (TSCD 1991) all include water quality data that were also published as DEQ water quality status reports (Drewes 1987, 1988, and 1993). The Teton and Madison Conservation Districts proposed an East Canyon Creek Planning Project, but it was not completed because technical assistance from DEQ was not available. The area covered by these projects included the Teton River subwatershed from the mouth of Horseshoe Creek to the mouth of Canyon Creek, and the Canyon Creek, Milk Creek, Packsaddle Creek, Horseshoe Creek, Bitch Creek, and Badger Creek subwatersheds (Ray 1999).

An implementation grant application for the Teton River subwatershed (TSCD 1990) was submitted in draft form in 1990. This subwatershed was identified by the TSCD as its highest priority for implementation, and included the Teton River drainage downstream of the mouth of Horseshoe Creek to the mouth of Canyon Creek, exclusive of the subwatersheds included in the Teton Canyon Water Quality Planning Project (TSCD 1991). An implementation grant was awarded for the portion of the Teton River subwatershed south of the mouth of Badger Creek, and in 1991, the Packsaddle Creek subwatershed was added to the project, described in *Plan of Operations: Teton River Implementation Project*. More than $1.5 million was obligated to this project for a 10-year period extending from April 1991 to April 2001 (Ray 1999).

Because the Teton Canyon Water Quality Planning Project incorporated the Milk Creek and West Canyon Creek project areas, implementation funding for the latter projects was deferred, though it is unclear whether a request for implementation funds for the former project was ever made. DEQ correspondence indicates that the Madison SWCD was advised in 1988 that a request for implementation funding of the Canyon Creek project could be submitted after the Teton Canyon Planning Project was completed. An implementation grant application for North Canyon Creek was submitted by Madison SWCD and TSCD in 1994, but the project did not receive SAWQP funding (Ray 1999).

In 1992, the Teton River Basin Study (USDA 1992) was completed at the request of the Teton SCD by the USDA Soil Conservation Service and Forest Service in cooperation with the IDFG. The study area encompassed the Teton River drainage south of Harrop's Bridge at Highway 33, and, with the exception of the Packsaddle Creek subwatershed, did not coincide with the areas addressed by the Teton Canyon planning project or the Teton River implementation project. The study was completed in anticipation of funding through the Watershed Protection and Flood Prevention Act (Public Law 83-566), administered by the USDA. Before the draft preauthorization report for funding could be completed, SAWQP funding for the Teton River Sub-Watershed Project and another project on Bitch Creek was approved, and implementation of the Teton River Basin Study was deferred because of the limited availability of NRCS staff (Ray 1999).

Application for funding of the Bitch Creek project was submitted jointly by the Teton and Yellowstone Soil Conservation Districts in 1994. This application consisted of a SAWQP implementation grant for the Bitch Creek subwatershed portion of the Teton Canyon Water Quality Planning Project. Grants were awarded to the Yellowstone Soil Conservation District for the north side of the drainage and to the TSCD for the south side of the drainage. The *Plan of Operations: Bitch Creek South Implementation Project* (TSCD 1995) included provisions for a long-term water quality monitoring plan administered by the TSCD.

The Bitch Creek implementation project is unique because it is the only project in eastern Idaho to incorporate long-range monitoring to assess project effectiveness. The objectives of the Bitch Creek monitoring plan (Robinson undated) are to 1) determine the effectiveness of best management practices for reducing sediment and nutrient loading, and improving the status of beneficial uses in Bitch Creek, 2) determine the effect of cropland practices on nutrient concentrations in ground water, and 3) determine the contribution of sediments and nutrients from the Caribou-Targhee National Forest to the total load delivered to Bitch Creek. The project began in 1994 and extends through 2009. Monitoring data collected to date are reported elsewhere in this assessment.

The Teton River Riparian Area Demonstration Project, initiated by the TSCD in 1991, was also intended to include long-term monitoring. The project addressed the effects of livestock grazing on water quality at three locations in the upper Teton River watershed, and was apparently funded with SAWQP and §319 nonpoint-source pollution control monies. DEQ records indicate that best management practices were implemented on the Teton River, but with the exception of initial data gathering on Spring and Warm Creeks in 1991, the monitoring plan was not implemented. The planned monitoring approach was based on an early version of BURP, so water quality parameters were not analyzed.

A major source of funding currently utilized by the Conservation Districts in the Teton Subbasin is the USDA Environmental Quality Incentives Program (EQIP). The Teton, Madison, and Yellowstone districts applied for a $1.85 million multi-year grant in 1998. The program requires a 25% cost share by the landowner, and in the first year of the program, 19 landowners applied for a total of $293,406. The three-district area was awarded only $190,000 in funding; however, which reduced the number of participating landowners to approximately 12 (Ray 1999).

The water quality improvement projects currently being implemented by conservation districts and the NRCS in the Teton Subbasin are summarized in Table 30.

Table 30. Water quality improvement projects currently being implemented in the Teton Subbasin by the Teton Soil Conservation District, Madison Soil and Water Conservation District, and Yellowstone Soil Conservation District.[1]

Project Name	Funding Source and Project Number	Grant Period	Watershed Acres Addressed by Project	Funds Obligated
Teton River Implementation Project	State Agricultural Water Quality Project, AG 32	October 1, 1991 to September 30, 2006	35,320	$1,587,676
Bitch Creek South Implementation Project	State Agricultural Water Quality Project, AG 40	December 20, 1994 to December 20, 2009	53,553	$417,891
USDA Environmental Quality Incentives Program	USDA Natural Resources Conservation Service	1999 to Unknown	Dependent on Funding	$190,000 in 1999
Teton River Riparian Demonstration Project	State Agricultural Water Quality Project and §319, AG-RD-1	April 10, 1991 to April 9, 2001	318	$44,761

[1]Source: Ray 1999.

Future Management Study of the Teton Dam Reservoir Area

More than 20 years after collapse of the Teton Dam, the Fremont-Madison Irrigation District concluded that reconstruction of the dam was economically unfeasible (Swensen 1998). At about the same time, the BOR began evaluating what could or should be done to mitigate the landscape effects caused by the downstream movement of 250,000 acre feet of water and 4,000,000 cubic yards of embankment in a period of only six hours (Randle *et al.* 2000). Consistent with its future management study plan (Randle and Bauman 1997), the BOR has

1. Completed a flood frequency and flow duration analysis for the Teton River basin (England 1998)

2. Documented the geologic, geomorphic and hydraulic conditions of the Teton River upstream of the dam site (Randle *et al.* 2000)

3. Evaluated changes in water temperature in the Teton River from Badger Creek to the dam site using historical data and data collected in 1997 (Bowser 1999)

4. Cooperated with IDFG in a four-year study of the current status of the Teton Canyon fishery (Schrader 2000a).

The findings of the studies referenced above are discussed in several other sections of this report. In general, it should be noted that these studies were conducted to determine the present condition of lands managed by the BOR. Funding has been requested for the 2002 fiscal year to develop a 10-year Resource Management Plan (RMP) for the Teton Canyon. The goals of the RMP are 1) to create a balance of resource development, recreation, and protection of natural and cultural resources for the lands and waters being managed, and 2) to outline for the BOR, the public, and other management agencies the policies and actions that will be implemented (Stout 2000). The RMP will form the basis for future management of the Teton Dam reservoir area by the BOR, which will in turn influence water quality in the Teton River downstream of Badger Creek.

Mahogany Creek Watershed Analysis

The Teton Ranger District of the Caribou-Targhee National Forest completed an analysis of the Mahogany Creek Principal Watershed (022) in 2001. The watershed includes portions of streams within the forest boundary on the east and north slopes of the Big Hole Mountains. The major streams included in the watershed area are Milk, Packsaddle, Horseshoe, Twin, Mahogany, Patterson, Drake, and Murphy Creeks. Historic Forest Service documents and files were reviewed to determine the resources and ecosystem functions of the watershed. Future desired conditions for the watershed will then be developed based on this review, the forest plan, and public preferences. The analysis will be used as an internal planning document, though it will be subject to the National Environmental Policy Act process before any recommendations are implemented (Davy 2000).

Preliminary results of the analysis indicated that several streams were historically inhabited by beaver, and that erosion and stream sedimentation could possibly be reduced by their reintroduction (Mabey 2000). A survey to assess the general condition of Teton River tributaries, and their suitability or need for beaver reintroduction, was conducted by the Forest Service from June 21 through August 21, 2000. Streams surveyed included those in the Mahogany Creek Principal Watershed and several streams that originate in the Teton and Snake River Ranges (e.g., Darby, Badger, Moose and Trail Creeks). The survey received financial support from the Greater Yellowstone Coordinating Committee and Idaho DEQ, and technical support from the Driggs field office of the NRCS and the TSCD (Blandford 2000). The survey was conducted on approximately 80 miles of streams to determine where beavers might improve riparian and hydrologic conditions. According to Blandford (2000), such improvements would be expected to improve fish habitat, increase late-summer streamflows, reduce stream channel erosion and degradation, and increase sediment storage.

Methods used to conduct the survey were described by Blandford (2000). The streams surveyed were broken into half-mile units, and each unit was walked in its entirety when possible or warranted. A Beaver Transplant Compatibility Matrix form consisting of social, biological/ecological, and habitat suitability parameters was completed for each unit. Stream characteristics were evaluated in comparison to the following guidelines specified in the forest plan: bank stability greater than 80 percent, stream temperature less than 16^{o}C, frequency of woody debris greater than 20 pieces/mile, frequency of pools at least one per five to seven channel widths. The percentage of fine sediment by weight in substrate samples taken from areas considered suitable for spawning was determined using the method described by Grost and Hubert (1991). Streams originating in the Teton Range were also observed and sampled for substrate sediment, but complete surveys were not conducted. These streams included Darby, Teton, South Leigh, North Leigh, and Badger Creeks.

The results of the survey indicate that the following streams provide suitable beaver habitat and would benefit from stream modifications made by beaver colonies: North Moody Creek, the South Fork of Packsaddle Creek, the North Fork of Mahogany Creek, Patterson Creek, Little Pine Creek, and Trail Creek. The survey also produced information indicating that grazing, unauthorized all-terrain vehicle (ATV) travel, failure of culverts, and proximity of roads to stream channels have contributed to stream channel instability, erosion, and sedimentation. The following recommendations and findings are excerpted from the report by Blandford (2000), and include specific management actions that should be implemented by the Forest Service:

> **North Moody Creek** was observed to have a film of fine sediment deposited on the margins and out towards the middle of the stream indicative of a higher than normal sediment load. The following parameters were also not meeting expected values: temperatures of 23.5 ^{0}C, four units had banks that were less than 80% stable, pool frequency was also less than expected. North Moody is ecommended for beaver transplants after grazing issues have been resolved.
>
> **Milk Creek** bank stability is rated at 60% with evidence of repeated overgrazing for several years based on the utilization and form of the willows. Under proper management, this could be a future introduction site.
>
> **South Fork of Packsaddle** is a site recommended for re-introduction. In 1988, there was a "successful" effort to eradicate beaver from this drainage. Units 4 and 5 in this drainage are the sites of an inactive but still stable complex of dams. Re-introduction is recommended to ensure the continued stability of this site and allow further expansion of the beaver complex and riparian zone.
>
> The mainstem of **Horseshoe Creek** is suffering from active erosion and bank instability, and the channel has entrenched 2-4 feet. A wide valley bottom and dense willows make this excellent beaver habitat. There is currently one complex of nine dams on the mainstem at the forest boundary that was built this fall. If these dams do not withstand spring runoff reinforcement of dams will need to be considered. There appears to be enough habitat for two more complexes on the mainstem. Spot data indicates that water temperatures may exceed 16 ^{0}C.

A stream capture event was also documented 100 yards upstream of the confluence of the South Fork Teton River and Horseshoe Creek. A culvert has failed and an old road has captured the stream channel. Severe erosion is occurring in about 150 feet of channel due to unauthorized ATV use.

Mahogany Creek is highly unstable in the lower half of Unit 1 due to removal of beaver in an effort to control collection of water at the diversion. Re-colonization of beaver in this area would be beneficial in restoring stream stability. Options need to be evaluated to determine if there are measures that could be taken to meet the needs of the irrigators to divert water and still maintain channel stability. The **North Fork of Mahogany** is a site where introduction is recommended due to entrenchment and potential beaver migration barriers.

Patterson Creek is recommended for introduction in Units 1 and 2. Bank stability in this stream is low at 75-80%. Overgrazing along this stream is evidenced by browsed willows, bank instability, and forb dominated meadows. There are also numerous trail crossings with related instability.

Little Pine Creek has a healthy beaver complex in Unit 1. Unit 2 has an abandoned beaver complex with a headcut that has proceeded upstream 800’ and is now 6’ deep. For the time being the headcut has been arrested at the site of an old beaver dam. Without beaver activity at this old complex, the headcut will continue to migrate upstream. Unit 2 had a bank stability rating of 75%. A high temperature of 16 ^{0}C was recorded indicating the guidelines are probably exceeded.

Trail Creek has been impacted by road construction including straightening in several areas some of which have caused entrenchment. In addition, culverts draining inside ditches on the pass itself are causing gullies on the fill slopes with the resultant fine materials being deposited into trail creek. There are two known sites where single beaver dams occur. As previously mentioned at least one beaver was trapped this fall. Introduction of beavers is recommended, as there are no beaver complexes present or signs of reproducing family units. Units 4 and 5 are the best sites for introduction.

Mail Cabin Creek has been captured by a road or trail at its confluence with Trail Creek and is contributing sediment. This site needs to be evaluated for repair.

The results of the substrate sediment sampling conducted during the survey confirmed that stream sediment originates on the National Forest in several subwatersheds throughout Teton Valley, and that sediment sources are not confined to privately owned lands. Blandford (2000) considered substrate consisting of more than 25% particles smaller than 4 mm by weight to be “likely above natural levels” and “spawning impaired.” Six samples were collected in each of 23 stream segments, and the average equaled or exceeded 25% fine sediment in eleven of the segments, including the following: South Fork Packsaddle Creek (29%), South Fork Horseshoe

Creek (26%), North Twin Creek (31%), North Fork Mahogany Creek (29%), Mahogany Creek above trailhead (29%), Mahogany Creek below trailhead (27%), Trail Creek at Coal Creek (30%), Moose Creek (25%), Teton Creek below campground (25%), North Leigh Creek below trailhead, and Badger Creek.

TETON SUBBASIN TOTAL MAXIMUM DAILY LOADS

INTRODUCTION

The goal of a TMDL is to restore an impaired waterbody to a condition that meets state water quality standards and supports designated beneficial uses. A TMDL is the sum of the individual wasteload allocations for point sources of a pollutant, load allocations for nonpoint sources and natural background levels, and a margin of safety. Because of the variety of ways in which nonpoint source pollutants may enter a waterbody, a TMDL must also address seasonal variations in pollutant loading and critical conditions that contribute to pollutant loading.

The approach used to develop a TMDL incorporates several assumptions regarding our knowledge of natural systems and human-caused changes in natural systems. Some of these assumptions are:

1. The amount of a pollutant that can be assimilated by a waterbody without violating water quality standards and impairing beneficial uses is known and can be quantified.

2. Natural background levels of a pollutant are known or can be determined.

3. Violations of water quality standards or impairments of beneficial uses can be directly linked to a single pollutant.

4. The data required to develop a load for a particular waterbody is available or can be readily obtained.

None of these assumptions were valid for waterbodies in the Teton Subbasin. Region 10 EPA acknowledges the uncertainty associated with these assumptions, and has proposed an adaptive management strategy for addressing this uncertainty (EPA 2000).

An adaptive management TMDL emphasizes near-term actions to improve water quality and can be employed when data only weakly quantify links between sources, allocations, and in-stream targets (EPA 2000). As explained in the subbasin assessment portion of this document, limited water quality data were available for the §303(d)-listed stream segments in the Teton Subbasin. Although LAs have been developed for most of these segments, these allocations are based on information gathered more than 10 years ago. Due to improved farming practices (e.g., elimination of summer fallow in the Teton Valley) and changes in land use, pollutant sources and resource concerns have changed somewhat. An adaptive management strategy makes provisions for addressing the effects that these and future changes may have on LAs during the implementation phase of the TMDL.

The adaptive management strategy will be incorporated into the TMDL implementation plan developed by designated management agencies. The designated roles of numerous government agencies in implementing Idaho's nonpoint source management program and TMDLs are described in the *Idaho Nonpoint Source Management Plan* (DEQ 1999b). An implementation plan for privately owned agricultural lands will be developed by the Soil Conservation Commission and Idaho Association of Soil Conservation Districts in cooperation with the Madison Soil and Water Conservation District, TSCD, and the Yellowstone Soil Conservation District, with technical support from the affiliated field offices of the NRCS. Implementation plans for publicly owned lands in the Teton Subbasin will be the responsibilities of the Idaho Department of Lands, U.S. Forest Service, BLM, and BOR. Within 18 months of approval of the *Teton Subbasin Assessment and Total Maximum Daily Load (TMDL)* by the EPA, the Idaho Falls Regional Office of DEQ will review each implementation plan and facilitate coordination among designated agencies to integrate the plans into a single, comprehensive implementation plan.

To conform with an adaptive management strategy (EPA 2000, EPA 2001), the implementation plan will include the following elements:

1. An action plan for implementing best management practices to address specific pollutants and pollutant sources. The action plan will include goals, milestones for achieving goals and consequences if milestones are not met. The plan will also include a description of expected improvements and an explanation of how improvements will restore water quality or beneficial uses.

2. A monitoring plan to "...assess progress toward goals and to gather additional information to better characterize pollutant sources and pathways, so as to improve the system of pollutant controls for a watershed information" (EPA 2000). The monitoring plan will include clearly stated, testable hypotheses for assessing the effectiveness of best management practices (EPA 2001).

3. An evaluation plan for "...the periodic review of monitoring results and milestone attainment" (EPA 2000).

4. An estimate of the costs of the implementation plan and possible funding sources.

In adopting an adaptive management strategy for the *Teton Subbasin TMDL Implementation Plan*, the Idaho Falls Regional Office of DEQ and the designated management agencies agree to the following concepts, which were adapted from the *Upper Grande Ronde River Sub-Basin Total Maximum Daily Load (TMDL)*, published by the Oregon Department of Environmental Quality in April 2000:

1. The goal of the CWA and IDAPA 58.01.02 is that water quality standards shall be met or that all feasible steps will be taken towards achieving the highest quality water attainable. This is a long-term goal in many watersheds, particularly where nonpoint-source pollutants are the main concern, but implementation must commence as soon as possible.

2. Total Maximum Daily Loads (TMDLs) are numerical loadings that are set to limit pollutant levels such that in-stream water quality standards are met. The Department recognizes that TMDLs are values calculated from mathematical models and other analytical techniques designed to simulate and/or predict very complex physical, chemical and biological processes. Models and techniques are simplifications of these complex processes and, as such, are unlikely to produce an exact and accurate prediction of how streams and other waterbodies will respond to the application of various management measures. It is for this reason that the TMDL has been established with a margin of safety.

3. Implementation Plans are designed to reduce pollutant loads from nonpoint sources to meet TMDLs. The Department recognizes that it may take some period of time, from several years to several decades, after full implementation before management practices in an Implementation Plan become fully effective in reducing and controlling nonpoint-source pollution. In addition, the Department recognizes that technology for controlling nonpoint-source pollution is, in many cases, in the development stages and that it may take one or more iterations before effective techniques are found. It is possible that after application of best management practices, some TMDLs or their associated surrogates cannot be achieved as originally established.

4. The Department also recognizes that, despite the best and most sincere of efforts, natural events beyond the control of humans may interfere with or delay attainment of the TMDL and/or its associated surrogates. Such events could be, but are not limited to, floods, fire, insect infestations, and drought. Likewise, the Department recognizes that the rate of adoption of some best management practices by agricultural producers may be affected by economic factors beyond the control of producers. Severe and unusual economic stress in the agricultural economy may delay the implementation of best management practices within the watershed.

5. Pollutant surrogates may be defined as alternative targets in the Implementation Plan for meeting the TMDL. The purpose of the surrogates is not to bar or eliminate human access or activity in the basin or its riparian areas. However, it is the expectation that the Implementation Plan will address how human activities will be managed to achieve the surrogates.

6. The Department intends to regularly review progress of the Implementation Plan to achieve the goal of the TMDL, which is restoration and maintenance of beneficial uses. If and when the Department determines that a Plan has been fully implemented, that best management practices have reached maximum expected effectiveness and a TMDL or its interim targets have not been achieved, the Department shall reopen the TMDL and adjust it or its interim targets as necessary to support beneficial uses.

7. The implementation of TMDLs and the associated management plans is generally enforceable by the Department, other state agencies and local government. However, it is envisioned that sufficient initiative exists to achieve water quality goals with minimal enforcement. Should the need for additional effort emerge, it is expected that the designated agencies will work with land managers to overcome impediments to progress through education, technical support or enforcement. Enforcement may be necessary in instances of insufficient action towards progress. This could occur first through direct intervention from designated management agencies, and secondarily through DEQ. The latter may be based in Departmental Orders to implement management goals leading to water quality standards.

8. In employing an adaptive management approach to the Implementation Plan of this TMDL, DEQ has the following expectations and intentions:

    a) Subject to available resources, the Idaho Falls Regional Office of DEQ will review the progress of the TMDL and Implementation Plan on a regular basis. This review will be conducted with assistance from the Henry's Fork Watershed Council, acting in its designated role as Watershed Advisory Group (WAG) to DEQ;

    b) The Department expects that each management agency will also monitor and document its progress in implementing the provisions of its component of the Implementation Plan. This information will be provided to DEQ for its use in reviewing the TMDL;

    c) As the Implementation Plan is executed, DEQ expects that management agencies will develop benchmarks for attainment of TMDL surrogates, which can then be used to measure progress; and

    d) Where implementation of the TMDL or effectiveness of management techniques are found to be inadequate, DEQ expects management agencies to revise the components of the Implementation Plan to address these deficiencies.

CONCLUSIONS

One of the objectives of the subbasin assessment was to determine water quality management needs in the Teton Subbasin, including identification of waterbodies that:

1. Require development of a TMDL

2. May be removed from the 1998 §303(d) list because they are not impaired

3. May be deferred for TMDL development until a later date

4. Are not subject to TMDL development because the pollutant responsible for impairment is habitat modification or flow alteration

5. Are candidates for §303(d) listing

Based on information contained in the subbasin assessment, sediment TMDLs have been developed for Badger, Darby, Fox, Packsaddle, South Leigh, and Spring (including North Leigh) Creeks; for the Teton River from Trail Creek to Bitch Creek; and for the North Fork Teton River (Table 31). Nutrient TMDLs have also been developed for the Teton River from Highway 33 to Bitch Creek and the North Fork Teton River. Three TMDLs were rescheduled and will be completed for submittal to EPA by December 31, 2002. The rescheduled TMDLs are Moody Creek for nutrients, and Fox and Spring Creeks for temperature.

Segments of waterbodies that will be added to Idaho's 2002 §303(d) list of water quality impaired waterbodies requiring TMDL developments are shown in Table 32. According to the draft settlement agreement issued by DEQ for public review and comment on January 25, 2002 (available on the Internet at http://www2.state.id.us/deq/water/water1.htm#TMDLs), TMDLs for these waterbodies will not be due to the EPA until after the current scheduled TMDLs are completed in 2007. It is possible that instead of developing a temperature TMDL for the Teton Canyon section of the Teton River, the beneficial use of this segment will be redesignated from cold water aquatic life to seasonal cold water aquatic life. This determination will also be deferred until after completion of the current TMDL schedule.

SEDIMENT TMDLS

Loading Capacity

A sediment yield study conducted in 1992 indicated that natural sediment yields for the upper Teton River, headwaters to Spring Creek, were 32,600 tons/year (USDA 1992). This value is similar to the upper Teton River's water column carrying capacity of TSS (28,758 tons/year) based on an average annual flow of 409 cfs (USGS Station #13052200) and a TSS target of 80 mg/L. The USDA (1992) study also predicted the 1992 current sediment yield for this portion of the Teton River, which we will presume is the existing load in this TMDL. Under this assumption, the loading capacity for this upper portion of Teton River is somewhere in between the natural yield of 32,600 tons/year and the 1992 current yield of approximately 180,000 tons/year predicted in the USDA (1992) study.

Loading rates for most listed tributaries to the upper Teton River were also described in the USDA (1992) study. Sediment reductions in these tributaries are related to the overall sediment reductions necessary for the river itself.

Table 31. Status of TMDL development for stream segments in the Teton Subbasin that appeared on Idaho's 1998 §303(d) list.

Waterbody (WQLS#) and Boundaries	Pollutant(s)	Actions
Badger Creek (2125) Highway 32 to Teton River	Sediment	Allocate sediment load; reassess beneficial use support in segments that are not naturally dry or dewatered by legal diversions.
Darby Creek (2134) Highway 33 to Teton River	Sediment Flow alteration	Allocate sediment load; reassess beneficial use support in segments that are not naturally dry or dewatered by legal diversions. No TMDL for flow alteration per DEQ policy.
Fox Creek (2136) Wyoming Line to Teton River	Sediment Temperature Flow alteration	Allocate sediment load; reassess beneficial use support in segments that are not naturally dry or dewatered by legal diversions. Reschedule temperature TMDL until December 31, 2002, and continue monitoring. No TMDL for flow alteration per DEQ policy.
Horseshoe Creek (2130) Confluence of North and South Forks to Teton River	Flow alteration	No TMDL for flow alteration per DEQ policy. Change lower boundary to lower extent of perennial flow in future §303(d) list.
Moody Creek (2119) National Forest boundary to Teton River	Nutrients	Reschedule nutrient TMDL until December 31, 2002. Change upper boundary of listed segment to confluence of North and South Moody Creeks and lower boundary to Woodmansee Johnson Canal in future §303(d) list.
North Leigh Creek (5230) Wyoming line to Spring Creek	Unknown [1]	Assessment based on BURP data inappropriate because of intermittent flow. No TMDL required. However, watershed is part of Spring Creek in TMDL analysis.
Packsaddle Creek (2129) Headwaters to Teton River	Sediment Flow alteration	Allocate sediment load; reassess beneficial use support in segments that are not naturally dry or dewatered by legal diversions. Change lower boundary of listed segment to pipeline diversion in future §303(d) list. No TMDL for flow alteration per DEQ policy.
South Leigh Creek (2128) Headwaters to Teton River	Sediment	Allocate sediment load; reassess beneficial use support in segments that are not naturally dry or dewatered by legal diversions. Change upper boundary of segment to springs on west side of Highway 33 in future §303(d) list.
Spring Creek (2127) Wyoming line to Teton River	Sediment Temperature Flow alteration	Allocate sediment load. Reschedule temperature TMDL until December 31, 2002 and continue monitoring flow. Reassess beneficial use support in segments that are not naturally dry or dewatered by legal diversions. Change upper boundary of segment to North Leigh Creek and lower boundary to point at which flow becomes intermittent in future §303(d) list.
Teton River (2116) Highway 33 to Bitch Creek	Sediment Habitat alteration Nutrients	Allocate sediment and nutrient loads. No TMDL for habitat alteration per DEQ policy.
Teton River (2118) Headwaters to Trail Creek	Habitat alteration	No TMDL for habitat alteration per DEQ policy.
Teton River (2117) Trail Creek to Highway 33	Sediment Habitat alteration	Allocate sediment load. No TMDL for habitat alteration per DEQ policy.
North Fork Teton River (2113) Forks to Henry's Fork	Sediment Nutrients	Allocate sediment and nutrient loads.

[1]A pollutant source was not identified for segments added to the 1998 list because they were assessed as water quality impaired using BURP data.

Table 32. Stream segments that will be added to Idaho's 2002 §303(d) list of water quality impaired waterbodies requiring development of TMDLs.

Waterbody and Boundaries	Pollutant(s) of Concern	Basis for Listing
Moody Creek Confluence of North and South Moody Creeks to the Woodmansee Johnson Canal	Sediment Temperature	Caribou-Targhee National Forest fish habitat inventory data; Madison Soil and Water Conservation District water quality data; DEQ data
North Moody Creek Headwaters to confluence with South Moody Creek	Sediment Temperature	Caribou-Targhee National Forest fish habitat inventory data; DEQ data
South Moody Creek Headwaters to confluence with North Moody Creek	Sediment Temperature	Caribou-Targhee National Forest fish habitat inventory data; DEQ data
Fish Creek Headwaters to confluence with South Moody Creek	Sediment	Caribou-Targhee National Forest fish habitat inventory data; DEQ data
Teton River Confluence of Badger Creek to Teton Dam site	Temperature	BOR data collected in 1998 (Bowser 1999)

In order to complete this TMDL, the natural sediment yield will be used as an indicator of load differences. However, in no way should it be concluded that the natural yield is the loading capacity. An adaptive management approach will be used to provide reductions in sediment loadings based on usage of best management practices, coupled with data collection and monitoring to determine the loading point at which beneficial uses are fully supported in the river.

As part of the process of determining loading capacity and beneficial use support, sediment related targets will be used to provide evidence of sediment load reductions. In particular, percent fines, cobble embeddedness, and percent bank stability will be monitored and compared to existing data in an effort to monitor trends in sediment reduction.

Sediment Targets

The goal of the sediment TMDL is to restore and maintain the beneficial uses of cold water aquatic life and salmonid spawning by achieving the following targets: reduce the percentage of subsurface sediment in potential spawning areas to 27% or less for particles less than 6.3 mm in diameter and 10% or less for particles less than 0.85 mm in diameter, and increase streambank stability to 80% or more in any 100-meter (328-foot) section. Measurement of subsurface sediment can readily be accomplished in wadeable streams, but it is probably not possible to measure subsurface fine sediment in the Teton River because of the depth of the water column. Targets that can be measured in the water column have therefore also been proposed. These include turbidity not greater than 50 NTU instantaneous or 25 NTU for more than 10 consecutive days above baseline background, per existing Idaho water quality standards; chronic turbidity levels not to exceed 10 NTU at summer base flow; and TSS not to exceed 80 mg/L. These targets do not preclude the use of alternative surrogate measures and benchmarks for monitoring reductions in sediment yield to the Teton River and its tributaries during the implementation phase of the TMDL.

Existing Loading

The USDA (1992) study produced an estimate of current sediment yield for the upper Teton River at 179,683 tons/year (Table 33). This estimate is based on the universal soil loss equation analysis for sheet and rill erosion on croplands (about 20% of the land area) and PSIAC (1968) methods for non-croplands (USDA 1992). Included in the analysis, but not reported, were estimates from timber cutting operations, roads and trails, livestock use, and mass wasting. Estimates of streambank erosion sediment yields are itemized separately in Table 33. The method estimated a quantity for sediment yield for each subwatershed area. A percentage of the sediment was then transported through the subwatershed to its outlet on the Teton River. Additionally, drainage patterns, overbank flooding, ponding, lack of sufficient flow, and irrigation diversions were all considered in assignment of sediment delivery ratios for each subwatershed.

Note that Table 33 provides estimates of loadings of sediment for the listed streams of Darby Creek, Fox Creek, Horseshoe Creek, Spring Creek (including North Leigh Creek), South Leigh Creek, Packsaddle Creek, and the upper Teton River to Highway 33. Listed streams for sediment not addressed in this 1992 study include the Teton River from Highway 33 to Bitch Creek, Badger Creek, and the North Fork Teton River.

Sediment yields for Badger Creek can be estimated based on relative size. The Badger Creek watershed is 37,587 acres in size, which is about 26% larger than the adjacent Spring Creek/North Leigh Creek watershed (27,962 acres, USDA 1992). If it were assumed that the two watersheds would have similar soils and land use, then sediment yields from Badger Creek would equal 26% more than Spring Creek, or 26,263 tons/year. If Badger Creek adds an additional 26,263 tons/year to the upper Teton River, then the total existing sediment yield to the Teton River from the headwaters to Bitch Creek is 205,946 tons/year. More data is being collected during the summer of 2002 to refine the estimate of sediment loadings to Badger Creek.

Table 33. Estimates of sediment yield for tributaries to the Upper Teton River, headwaters through Spring Creek (USDA 1992). Streams in bold are §303(d) listed for sediment.

Watershed Name (USDA 1992)	Current Yield (tons/year)			Alternative 2 (tons/year)			Alternative 3 (tons/year)		
	Land Use	Stream-bank	Total	Land Use	Stream-bank	Total	Land Use	Stream-bank	Total
Rammel Hollow	16,735		16,735	10,475		10,475	8,757		8,757
Spring Creek	17,148	3,696	20,844	11,820	2,391	14,211	10,610	1,417	12,027
S. Leigh Creek	12,311	2,917	15,228	8,477	1,882	10,359	6,994	1,275	8,269
Packsaddle Cr.	2,486	1,103	3,589	1,951	479	2,430	1,739	185	1,924
Dry Hollow	5,973		5,973	3,709		3,709	3,161		3,161
Horseshoe Cr.	18,517	2,188	20,705	14,816	1,367	16,183	12,723	542	13,265
No Name	11,293		11,293	7,713		7,713	5,963		5,963
Dry Creek	17,925	362	18,287	11,469	362	11,831	9,527	362	9,889
Teton Creek	2,024	4,392	6,416	1,738	2,948	4,686	1,538	1,890	3,428
Spring Creek II	3,073		3,073	2,253		2,253	1,817		1,817
Twin Creeks	4,457	1,641	6,098	3,355	1,026	4,381	2,979	367	3,346
Mahogany Cr.	4,210	1,746	5,956	3,635	1,208	4,843	3,407	665	4,072
Teton River	5,736		5,736	4,375		4,375	3,628		3,628
Foster Slough	227		227	194		194	173		173
Darby Creek	907	1,694	2,601	760	821	1,581	648	46	694
Bouquet Creek	1,502	336	1,838	1,329	157	1,486	1,244	89	1,333
Patterson Creek	2,122	506	2,628	1,869	375	2,244	1,759	263	2,022
Trail Creek	10,715	2,823	13,538	8,922	1,985	10,907	8,238	983	9,221
Fox Creek	1,430	1,906	3,336	960	1,080	2,040	817	132	949
Game Creek	1,807		1,807	1,743		1,743	1,678		1,678
Moose Creek	2,997	892	3,889	2,890	892	3,782	2,783	892	3,675
Drake Creek	968		968	635		635	554		554
Little Pine Cr.	2,406	1,100	3,506	2,165	908	3,073	2,057	526	2,583
Warm Creek	3,713	1,699	5,412	2,930	617	3,547	2,635	78	2,713
Totals	**150,682**	**29,001**	**179,683**	**110,183**	**18,498**	**128,681**	**95,429**	**9,712**	**105,141**

Sediment loading to the North Fork Teton River is also unknown. Presumably, sediment delivered to the upper Teton River may pass through and a certain percentage is delivered to the North Fork and the South Fork as upstream contribution. It is not known how much additional sediment Bitch Creek, Milk Creek, and Canyon Creek may add to the Teton River on its way to the North Fork diversion. However, for the purposes of this TMDL, it is assumed that deposition and diversion of sediment may offset additional sediment loading to the Teton River from these streams. Therefore, all the sediment loaded into the upper Teton River as estimated by the USDA (1992) study, plus our estimate from Badger Creek, will be transported to the North and South Forks of the Teton River. Because 40% of the average annual flow (see Figure 4) is diverted to the North Fork from the main Teton River, it is estimated that 40% of the 1992 current sediment yield will also be carried to the North Fork (40% of 205,946 tons/yr. = 82,378 tons/yr.). Additionally, streambank erosion from the North Fork Teton River was estimated in 2001 (see below) to be 7,144 tons/year (Table 34). Therefore, the existing sediment load to the North Fork is estimated to be 89,522 tons/year (82,378 + 7,144).

Load Allocations

Although there are two NPDES-permitted discharges (city of Driggs and Grand Targee Ski Area) above the Teton River, their influence is considered negligible. Driggs' discharge is to Woods Creek, a wetland complex 5 miles from the Teton River. The ski area's discharge is to a dry channel and all the effluent flow seeps into the ground before reaching any surface water. It is not expected that any sediment would reach the river from these sources. Hence, the wasteload allocation is considered to be zero. However, this is not to suggest that these discharges are not allowed to increase or that there is no reserve for future growth. They simply do not discharge to the listed streams.

All allocations will be directed towards nonpoint sources as a whole. Load allocations are derived for watersheds as a whole and are not derived for specific nonpoint sources.

The USDA (1992) study identified two "treatment" scenarios for the reduction of sediment yields in the upper subbasin. Alternative 2 (Table 33) included only nonstructural (e.g., conservation tillage practices, filter strips, grazing systems, etc.) techniques or best management practices for the control of erosion from nonpoint sources. Alternative 3 included both structural and non-structural best management practices. These practices include conservation tillage, chiseling and subsoiling, cross-slope farming, permanent vegetative cover, filter strips, fencing, planned grazing systems, streambank protection, pasture management, and proper grazing use. The application of these practices was anticipated to protect 75% of cropland acres in the Teton Valley, to reduce erosion rates to one and one-half times tolerable (T) levels, and to adequately protect all streambank erosion sites that can be treated with a combination of management or vegetative establishment practices (USDA 1992).

The current yield estimates from the study were 82% greater than natural yields (Table 35). Alternative 3, if implemented, would reduce this sediment yield estimate to 69% over natural levels.

The first phase of the TMDL would be to implement all of the structural and non-structural best management practices envisioned in Alternative 3 (USDA 1992). Implementing this phase would result in a 41% reduction in sediment yields (from 179,683 to 105,141 tons/year) for the upper Teton River, headwaters to (and including) Spring Creek (Table 36). If the same reduction potential is applied to the remaining portion of the Teton River to Bitch Creek, then total sediment yields need to be reduced from 205,946 to 121,508 tons/year. Sediment reductions estimated under Alternative 3 for other listed streams are also presented in Table 36. If the sediment loading to the North Fork Teton River is similarly reduced by 41%, the load allocation for the North Fork will be 52,818 tons/year (41% reduction of 89,522 tons/year).

Table 34. Summary of streambank erosion inventory data for all reaches of the North Fork Teton River.

Reach	Direct Reach Length (ft)	Stream Reach Length (ft)	Ratio of Stream to Direct Reach Length	Total Bank Length (ft)	Total Eroding Bank Length (ft)	Area of Eroding Bank (sq. ft)	Percentage of Total Bank Length Eroding (%)	Erosion Rate for Stream Reach (tons/year)
1	3,712	3,974	1.1	7,948	1,601	6,154	20	310
2	1,118	1,661	1.5	3,322	869	3,919	26	180
3	1,512	2,651	1.8	5,302	1,163	4,183	22	195
4	1,506	1,604	1.1	3,208	721	3,893	22	123
5	2,588	3,865	1.5	7,730	2,654	9,221	34	491
6	2,775	4,487	1.6	8,974	3,152	16,421	35	628
7	2,650	2,859	1.1	5,718	1,689	7,772	30	936
8	3,145	6,607	2.1	13,214	1,721	8,639	13	214
9	1,528	2,348	1.5	4,696	1,450	7,172	31	262
10	3,045	5,217	1.7	10,434	3,436	16,960	33	836
11	3,350	4,900	1.5	9,800	3,067	12,551	31	654
12	1,468	1,718	1.2	3,436	390	1,560	11	80
13	1,356	1,474	1.1	2,948	211	759	7	39
14	4,012	4,563	1.1	9,126	1,511	7,180	17	180
15	1,601	2,606	1.6	5,212	3,303	18,726	63	1,104
16	5,110	5,630	1.1	11,260	642	2,370	6	131
17	6,805	9,486	1.4	18,972	5,976	29,748	31	780
Total	**47,281**	**65,650**		**131,300**	**33,556**	**157,228**		**7,144**

Table 35. Estimates of sediment yield above natural conditions for the Upper Teton River, headwaters to Spring Creek.

Yield Scenarios	Sediment Yields (tons/year)	Percent over Natural Yield
Current (1992) Yield	179,683	82%
Alternative 2	128,681	75%
Alternative 3	105,141	69%
Natural Yield	32,600	--

Table 36. Estimated sediment reductions for §303(d) listed streams.

Subwatershed	WQLS[1] Number	Current Yield (tons/year)	Alternative 3 Yield (tons/year)	Reduction
North Fork Teton River	2113	89,522	52,818	41%
Upper Teton River to Bitch Creek	2116	205,946	121,508	41%
Upper Teton River to Spring Creek	2117 2118	179,683	105,141	41%
Badger Creek	2125	26,263	16,367	38%
Spring Creek	2127 5230	20,844	12,027	42%
South Leigh Creek	2128	15,228	8,269	46%
Packsaddle Creek	2129	3,589	1,924	46%
Horseshoe Creek	2130	20,705	13,265	36%
Darby Creek	2134	2,601	694	73%
Fox Creek	2136	3,336	949	72%

[1]Water quality limited segment

Sediment related targets will be monitored and beneficial uses will be assessed to determine the effects of such reductions. If beneficial uses are not fully supported and targets are not realized by this implementation, then further reductions will be necessary.

Margin of Safety

The margin of safety is considered implicit in the design of the sediment TMDL. Successive refinement following initial reductions will lead to the determination of loading capacity. An margin of safety associated with initial reductions would be meaningless, especially if further reductions are necessary to attain beneficial uses.

Seasonal Variation and Critical Time Periods in Sediment Loading

Sediment introduction into streams is pulsed and episodic in nature. It is likely that the majority of sediment moves with the spring snowmelt runoff and spring rains. However, these events can be variable in occurrence, with some springs wetter than others, and the timing of spring may vary depending on the variable weather. Also, much sediment can move in single catastrophic events that may not occur every year. By addressing average annual loadings, this variability is largely avoided. However, it must be realized that in any given year, sediment loadings may be much lower or much higher than the average loading predicted.

Streambank Erosion for the North Fork Teton River

The sediment load allocation for the North Fork Teton River was based on an estimate of the amount of sediment currently delivered to the channel from upstream contributions and through the process of streambank erosion. As explained in the subbasin assessment section of this document, sediment delivery from land surfaces in the North Fork Teton River subwatershed is negligible. Slopes are very low and the stream channel is constrained by levees in many areas. Loss of property has been a serious issue for landowners whose property borders sections of the river that were not reinforced following flooding caused by the collapse of the Teton Dam

The streambank erosion inventory was conducted from June 2001 through October 2001, as permission to access the river was obtained from landowners. All landowners granted permission, and streambanks along the 14-mile distance of the river were directly observed and measured except for a short distance in the final reach near the confluence with the Henry's Fork River where dense riparian vegetation prevented walking along the streambanks and water depths prevented walking through the stream channel. The erosion inventory was completed by personnel from the Idaho Association of Soil Conservation Districts and DEQ using procedures described in the *Stream Visual Assessment Protocol* (USDA 1998) and *Rapid Assessment Point Method* (USDA 2001).

Before direct measurements of the streambanks were made, the river channel was divided into 17 reaches based on the following criteria, as determined using 7.5-minute topographic maps and aerial photographs: locations of levees, roads, bridges, irrigation diversions, and canal discharges; and locations where the river channel had been modified or remained relatively natural. Crews of at least two people walked each stream reach. One person drew a diagram of the reach denoting streambank condition, locations of eroding streambanks, vegetation, locations of levees and roads, land use practices, and other relevant information. Another crew member measured the length and height of eroding banks in feet using a stadia rod. If the bank was on the opposite side of the channel and could not be reached by wading, the length and height of the eroding bank was estimated. For very long banks, height was measured at several points and an average bank height was recorded. Photographs of the banks were made for a permanent record of condition at the time of measurement.

An erosion rate for each streambank was calculated in pounds of soil per year by according to the following equation:

Erosion Rate (pound/year) = Area of eroding bank (square feet)
x Average lateral recession rate (feet/year)
x Soil bulk density (pound/cubic feet)

The area of eroding bank was calculated from measurements of bank height and length as described in the previous paragraph. The soil bulk density was determined by first determining the soil series for the streambank from soil survey maps and matching it to the soil bulk density listed in Table 37. The average lateral recession rate was determined by examining photographs and field notes and assigning the corresponding recession category using the descriptions shown in Table 38. The average recession rate that corresponded with the recession category was used to calculate erosion rate. For example, the average lateral recession rate for a steambank that met the description of severe recession was 0.4 feet/year, and the average lateral recession rate for a steambank that met the description of very severe recession was 1.25 feet/year. The erosion rate for each stream reach was then converted from pounds/year to tons/year by dividing by 2,000 pounds/ton. The erosion rates for each stream reach were then summed to obtain the erosion rate for the North Fork Teton River.

Table 37. Bulk densities of soils in the North Fork Teton River subwatershed.[1]

Soil Series	Texture	% Sand	% Clay	Bulk Density (g/cm^3)	Bulk Density (lb/ft^3)
Annis	Silty clay loam	10	27	1.31	81.8
Bannock	Loam	40	20	1.41	88.0
Blackfoot	Loam and silty clay loam	35	17	1.42	88.6
Labenzo	Silt loam	40	10	1.51	94.3
St. Anthony	Sandy loam shifting to sandy clay loam	65	20	1.46	91.1
Wardboro	Sandy loam shifting to loam	76	9	1.59	99.3
Withers	Silty clay loam	19	28	1.32	82.4

[1]Bulk densities were calculated by estimating the percentage of sand and clay in the soil, then inserting these numbers into the hydraulic properties calculator provided by K.E. Saxton of the USDA, Pullman, WA at Internet site http://www.bsyse.wsu.edu/saxton/soilwater/soilwater.htm?30,195.

The cumulative erosion rate for all reaches of the North Fork Teton River was 7,144 tons/year (Table 34). This value appears to be reasonable when compared to the load allocations for streambanks shown in Table 33.

Table 38. Descriptions and quantitative values for categories of lateral recession rates.

Category	Description	Lateral Recession Rate (feet/year)	Average Recession Rate (feet/year)	Lateral Recession Rate (inches/year)	Average Recession Rate (inches/year)
Slight	Some bare bank but erosion not readily apparent. No vegetative overhang. No exposed tree roots. Bank height minimal.	0.01 - 0.05	0.03	0.12 - 0.6	0.36
Moderate	Bank is predominantly bare with some vegetative overhang. Some exposed tree roots. No slumping evident.	0.06 - 0.2	0.13	0.72 - 2.4	1.56
Severe	Bank is bare with very noticeable vegetative overhang. Many tree roots exposed and some fallen trees. Slumping or rotational slips are present. Some changes in cultural features, such as missing fence posts and realignment of roads.	0.3 - 0.5	0.4	3.6 - 6	4.8
Very Severe	Bank is bare and vertical or nearly vertical. Soil material has accumulated at base of slope or in water. Many fallen trees and/or extensive vegetative overhang. Cultural features exposed or removed or extensively altered. Numerous slumps or rotational slips present.	0.5 - 2.0	1.25 (1.5 in original citation)	6 - 24	18
Extremely Severe	Bank is bare and vertical. Soil material has accumulated at base of slope and oftentimes still contains living grass or other vegetative material. Extensive cracking of the earth parallel to the exposed face above the bank. Generally evidence of "block-size" material that has either recently fallen in or is about to fall in. Can be "pillars" of soil materials that have already been loosened by stream and indicate imminent failure into the stream. Trees have been undercut and lie in stream, often with rootballs intact. (These rates should be verified with several observations or with actual streambank monitoring.)	2.0 - 5.0	3.5	24 - 60	42

NUTRIENT TMDLS

Loading Capacity and Targets

The North Fork Teton River, the upper Teton River (Highway 33 to Bitch Creek), and Moody Creek are §303(d) listed for nutrient pollution. The nutrient TMDL for Moody Creek will be completed by December 31, 2002, after nutrient data are collected during the summer of 2002.

The average annual flow of the upper Teton River at USGS Station #13052200 is 409 cfs (see Figure 4). Additional flow is added to the river from South Leigh Creek, Spring Creek, Badger Creek, and smaller tributaries by the time it gets to the Highway 33 to Bitch Creek segment. There are only two years of data (1975 and 1976) at USGS Station #13054200, Teton River below Badger Creek. Average annual flow for those two years was 750 cfs. Presumably average annual flows for the Teton River, Highway 33 to Bitch Creek segment, is somewhere between 409 cfs and 750 cfs. We conservatively estimate average annual flow to be the halfway point between these two measured values or 575 cfs.

A total phosphorus target of 0.1 mg/L (see Table 15) was used to determine a loading capacity of 113,202 pounds/year total phosphorus in the upper Teton River, Highway 33 to Bitch Creek. Likewise, a nitrate target of 0.3mg/L was used to determine a loading capacity of 339,606 pounds/year nitrate nitrogen in the same segment. The loading capacity for each is reduced by 10% for a margin of safety. Thus, the total phosphorus loading capacity will be 101,882 pounds/year, and the nitrogen loading capacity will be 305,645 pounds/year.

The average annual flow for the North Fork Teton River is 336 cfs (Figure 4). Using the same targets, the loading capacity for nitrogen and phosphorus in the North Fork is 198,448 pounds/year and 66,149 pounds/year, respectively. Reduced by a 10% margin of safety, the capacities become 178,603 pounds/year nitrate nitrogen and 59,534 pounds/year total phosphorus.

Existing Loading

Floyd Bailey, an agronomist referenced in the USDA (1992) study on upper Teton River sediment yield, indicated that each ton of cropland-generated sediment would contain about 3.0 pounds of nitrogen and 2.8 pounds of phosphorus. If we assume that 80% of the sediment delivered to a stream is cropland sediment (based on the ratio of land use to streambank yields), then the amount of nitrogen and phosphorus introduced into the upper Teton River (Highway 33 to Bitch Creek segment) is 494,270 pounds/year of nitrogen and 461,319 pounds/year of phosphorus. The existing load of nitrogen and phosphorus to the North Fork Teton River is 214,853 pounds/year nitrogen and 200,529 pounds/year of phosphorus. For simplicity, it is assumed that these parameters are equivalent to nitrate nitrogen and total phosphorus.

Load Allocation

Although there are two NPDES-permitted discharges (city of Driggs and Grand Targee Ski Area) above the Teton River, Highway 33 to Bitch Creek segment, their influence is considered negligible. Driggs discharge is to Woods Creek, a wetland complex 5 miles from the Teton River. The ski area's discharge is to a dry channel and all the effluent flow seeps into the ground before reaching any surface water. It is not expected that any nutrients would reach the river from these sources. Hence, the wasteload allocation is considered to be zero. However, this is not to suggest that these discharges are not allowed to increase or that there is no reserve for future growth. They simply do not discharge to the listed streams.

The entire allocation is attributed to nonpoint sources as a whole. No effort has been made to separate sources for load allocations. Because of the relationship between nutrient additions and sediment additions from land use, it is assumed that methods to reduce sediment pollution will likewise reduce nutrient pollution. Load reductions needed to meet target levels of nitrogen and phosphorus are on the order of 8% to 38% and 67% to 78%, respectively (Table 39).

Table 39. Load reductions necessary to meet loading capacity (minus 10% margin of safety) for the North Fork and upper Teton River (Highway 33 to Bitch Creek).

	Load Capacity (lb./yr.)	Existing Load (lb./yr.)	Reduction
North Fork Teton River (WQLS[1] Number = 2113)			
Nitrogen (nitrate)	198,448	214,853	8%
Total Phosphorus	66,149	200,529	67%
Upper Teton River, Highway 33 to Bitch Creek (WQLS Number = 2116)			
Nitrogen (nitrate)	305,645	494,270	38%
Total Phosphorus	101,882	461,319	78%

[1]Water quality limited segment

Margin of Safety

A 10% margin of safety has been used in the calculation of loading capacity to adjust for uncertainty related to nutrient load calculations.

Seasonal Variation and Critical Time Periods in Nutrient Loading

Phosphorus moves off the land with sediment. Thus, like sediment, phosphorus introduction into streams is pulsed and episodic in nature. It is likely that the majority of nutrients move with the spring snowmelt runoff and spring rains. However, these events can be variable in occurrence, as some springs are wetter than others. The timing of spring runoff may also vary depending on the variable weather. In addition, large quantities of sediment and nutrients can move in single catastrophic events that may not occur every year. By addressing average annual loadings, this variability is largely avoided. However, it must be realized that in any given year, nutrient loadings may be much lower or much higher than the average loading predicted.

The seasonal variations and critical time periods that influence loading of nitrogen associated with cropland-generated sediment are the same as those described above for phosphorus and have been included into the estimates for annual yields. Based on data reviewed in the subbasin assessment, nitrate loading is also influenced by seasonal plant growth and senescence. Instream concentrations of nitrates decrease during periods of optimal aquatic plant growth and increase during periods when plant growth is minimal and when plant material is decaying. In the Teton River upstream of the listed segment, nitrate concentrations may drop below 0.3 mg/L only in June, whereas in the lower Teton River, nitrate concentrations usually drop below 0.3 mg/L from May to September.

PUBLIC PARTICIPATION

The Teton subbasin assessment and TMDLs were developed with the cooperation and participation of the Henry's Fork Watershed Council as the designated Watershed Advisory Group; local, state, and federal agencies; and interested citizens throughout the basin and region over a three year period commencing in 1998.

The draft version of the *Teton Subbasin Assessment and Total Maximum Daily Load* report was available for public comment from March 5, 2001, through May 7, 2001. The draft was mailed to members of the Henry's Fork Watershed Council Water Quality Subcommittee and other interested parties. Copies were made available for review at the following locations: Valley of the Tetons Library in Victor, Victor City Hall, Teton County Courthouse in Driggs, USDA Service Center in Driggs, Madison Library District in Rexburg, Idaho Falls Public Library, and the DEQ Regional Office in Idaho Falls.

A public meeting to discuss the content of the Teton subbasin assessment and TMDL occurred on March 15, 2001, at DEQ's Idaho Falls Regional Office. A presentation regarding the TMDL was made on April 17, 2001, at the Henry's Fork Watershed Council meeting in Driggs, and an open house to discuss the TMDL was held the same day at the USDA Service Center in Driggs. Public notices advertising the availability of the draft, major conclusions, and request for comments were published in the *Idaho Falls Post Register*, *Teton Valley News*, and the *Rexburg Standard Journal* newspapers the duration of the comment period.

Comment were received from the Henry's Fork Watershed Council, Idaho Department of Lands-Eastern Idaho Area Office, USDA Caribou-Targhee National Forest-Teton Basin Ranger District, U.S. Department of the Interior Bureau of Reclamation-Snake River Area Office, and EPA Region 10 Idaho Operations Office.

A response to comments was prepared and will be provided under separate cover as an addendum to this document. The final *Teton Subbasin Assessment and Total Maximum Daily Load* was submitted to EPA in July 2002. The rescheduled portion is scheduled for submittal to EPA in December 2002 after public review and comment.

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GLOSSARY

§303(d)	Refers to section 303 subsection "d" of the Clean Water Act. 303(d) requires states to develop a list of waterbodies 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.
Ambient	General conditions in the environment. 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 (Armantrout 1998, EPA 1996).
Anadromous	Fish, such as salmon and sea-run trout, that live part or the majority of their lives in the salt water but return to fresh water to spawn.
Anaerobic	Describes the processes that occur in the absence of molecular oxygen and describes the condition of water that is devoid of molecular oxygen.
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 58.01.02.003.56).
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.
Bedload	Material (generally sand-sized or larger sediment) that is carried along the streambed by rolling or bouncing.
Beneficial Use	Any of the various uses of water, including, but not limited to, aquatic biota, 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 waterbodies in Idaho. BURP protocols address lakes, reservoirs, and wadeable streams and rivers
Best Management Practices (BMPs)	Structural, nonstructural, and managerial techniques that are effective and practical means to control nonpoint source pollutants.
Biological Oxygen Demand	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.
Biota	The animal and plant life of a given region.
Biotic	A term applied to the living components of an area.
Clean Water Act (CWA)	The Federal Water Pollution Control Act (commonly known as 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.
Community	A group of interacting organisms living together in a given place.
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. EPA 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.
Depth Fines	Percent by weight of particles of small size within a vertical core of volume of a streambed or lake bottom sediment. The upper size threshold for fine sediment for fisheries purposes varies from 0.8 to 6.5 mm depending on the observer and methodology used. The depth sampled varies but is typically about one foot (30 cm).
Designated Uses	Those water uses identified in state water quality standards that must be achieved and maintained as required under the Clean Water Act.
Discharge	The amount of water flowing in the stream channel at the time of measurement. Usually expressed as cubic feet per second (cfs).

Dissolved Oxygen	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. Their presence is often indicative of fecal contamination.
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 waterbody.
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.
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 Geologic Institute 1962).
Erosion	The wearing away of areas of the earth's surface by water, wind, ice, and other forces.
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).
Fauna	Animal life, especially the animals characteristic of a region, period, or special environment.
Fecal Coliform Bacteria	Bacteria found in the intestinal tracts of all warm-blooded animals or mammals. Their presence in water is an indicator of pollution and possible contamination by pathogens (also see Coliform Bacteria).

Flow	See Discharge.
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 (EPA 1997).
Fully Supporting but Threatened	An intermediate assessment category describing waterbodies that fully support beneficial uses, but have a declining trend in water quality conditions, which if not addressed, will lead to a "not fully supporting" status.
Geographical Information Systems (GIS)	A georeferenced database.
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.
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 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.

Influent	A tributary stream.
Inorganic	Materials not derived from biological sources.
Instantaneous	A condition or measurement at a moment (instant) in time.
Intergravel Dissolved Oxygen	The concentration of dissolved oxygen within spawning gravel. Consideration for determining spawning gravel includes species, water depth, velocity, and substrate.
Intermittent Stream	1) A stream that flows only part of the year, such as when the ground water table is high or when the stream receives water from springs or from surface sources such as melting snow in mountainous areas. The stream ceases to flow above the streambed when losses from evaporation or seepage exceed the available stream flow. 2) A stream that has a period of zero flow for at least one week during most years.
Interstate Waters	Waters that flow across or form part of state or international boundaries, including boundaries with Indian nations.
Irrigation Return Flow	Surface (and subsurface) water that leaves a field following the application of irrigation water and eventually flows into streams.
Land Application	A process or activity involving application of wastewater, surface water, or semi-liquid material to the land surface for the purpose of treatment, pollutant removal, or ground water recharge.
Limiting Factor	A chemical or physical condition that determines the growth potential of an organism. This can result in a complete inhibition of growth, but typically results in less than maximum growth rates.
Load Allocation	A portion of a waterbody'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.
Loading Capacity	A determination of how much pollutant a waterbody 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.
Macroinvertebrate	An invertebrate animal (without a backbone) large enough to be seen without magnification and retained by a 500ìm 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 — An implicit or explicit portion of a waterbody's loading capacity set aside to allow the uncertainly about the relationship between the pollutant loads and the quality of the receiving waterbody. 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.

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, 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 waterbody.

Mouth — The location where flowing water enters into a larger waterbody.

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 — A condition indistinguishable from that without human-caused disruptions.

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

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 — A concept and an assessment category describing waterbodies that have been studied, but are missing critical information needed to complete an assessment.

Not Attainable	A concept and an assessment category describing waterbodies that demonstrate characteristics that make it unlikely that a beneficial use can be attained (e.g., a stream that is dry but designated for salmonid spawning).
Not Fully Supporting	Not in compliance with water quality standards or not within the range of biological reference conditions for any beneficial use as determined through the *Water Body Assessment Guidance* (Grafe et al. 2002).
Not Fully Supporting Cold Water	At least one biological assemblage has been significantly modified beyond the natural range of its reference condition (EPA 1997).
Nuisance	Anything which 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.
Organic Matter	Compounds manufactured by plants and animals that contain principally carbon.
Oxygen-Demanding Materials	Those materials, mainly organic matter, in a waterbody 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	Disease-producing organisms (e.g., bacteria, viruses, parasites).
Perennial Stream	A stream that flows year-around in most years.
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 waterbody. 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.

Point Source	A source of pollutants characterized by having a discrete conveyance, such as a pipe, ditch, or other identifiable "point" of discharge into a receiving water. Common point sources of pollution are industrial and municipal wastewater.
Pollutant	Generally, any substance introduced into the environment that adversely affects the usefulness of a resource or the health of humans, animals, or ecosystems.
Pollution	A very broad concept that encompasses human-caused changes in the environment which alter the functioning of natural processes and produce undesirable environmental and health effects. This includes human-induced alteration of the physical, biological, chemical, and radiological integrity of water and other media.
Population	A group of interbreeding organisms occupying a particular space; the number of humans or other living creatures in a designated area.
Reach	A stream section with fairly homogenous physical characteristics.
Reconnaissance	An exploratory or preliminary survey of an area.
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 waterbody.
River	A large, natural, or human-modified stream that flows in a defined course or channel, or 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	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 Fines	Sediments of small size deposited on the surface of a streambed or lake bottom. The upper size threshold for fine sediment for fisheries purposes varies from 0.8 to 605 mm depending on the observer and methodology used. Results are typically expressed as a percentage of observation points with fine sediment.
Surface Runoff	Precipitation, snow melt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of nonpoint source pollutants in rivers, streams, and lakes. Surface runoff is also called overland flow.
Surface Water	All water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors that are directly influenced by surface water.
Suspended Sediments	Fine material (usually sand size or smaller) that remains suspended by turbulence in the water column until deposited in areas of weaker current. These sediments cause turbidity and, when deposited, reduce living space within streambed gravels and can cover fish eggs or alevins.
Taxon	Any formal taxonomic unit or category of organisms (e.g., species, genus, family, order). The plural of taxon is taxa (Armantrout 1998).
Threatened Species	Species, determined by the U.S. Fish and Wildlife Service, which are likely to become endangered within the foreseeable future throughout all or a significant portion of their range.
Total Maximum Daily Load (TMDL)	A TMDL is a waterbody's loading 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. TMDL = Loading Capacity = Load Allocation + Wasteload Allocation + Margin of Safety. 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 waterbodies and/or pollutants within a given watershed.
Total Dissolved Solids	Dry weight of all material in solution in a water sample as determined by evaporating and drying filtrate.

Total Suspended Solids (TSS)	The dry weight of material retained on a filter after filtration. Filter pore size and drying temperature can vary. American Public Health Association Standard Methods (Greenborg, Clescevi, and Eaton 1995) call for using a filter of 2.0 micron or smaller; a 0.45 micron filter is also often used. This method calls for drying at a temperature of 103-105 °C.
Toxic Pollutants	Materials that cause death, disease, or birth defects in organisms that ingest or absorb them. The quantities and exposures necessary to cause these effects can vary widely.
Tributary	A stream feeding into a larger stream or lake.
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	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 waterbody.
Waterbody	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 waterbodies for which one or more water quality criterion is not met or beneficial uses are not fully supported. Water quality limited segments may or may not be on a §303(d) list.
Water Quality Limited Segment (WQLS)	Any segment placed on a state's §303(d) list for failure to meet applicable water quality standards, and/or is not expected to meet applicable water quality standards in the period prior to the next list. These segments are also referred to as "§303(d) listed."
Water Quality Management Plan	A state or area-wide waste treatment management plan developed and updated in accordance with the provisions of the Clean Water Act.
Water Quality Standards	State-adopted and EPA-approved ambient standards for waterbodies. The standards prescribe the use of the waterbody 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 waterbody.
Waterbody Identification Number (WBID)	A number that uniquely identifies a waterbody in Idaho 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. Section 303(d) of the Federal Water Pollution Control Act (Clean Water Act) as Amended, 33 U.S.C. §1251 *et seq.*

(d)(1)(A) Each State shall identify those waters within its boundaries for which the effluent limitations required by section 301(b)(1)(A) and section 301(b)(1)(B) are not stringent enough to implement any water quality standard applicable to such waters. The State shall establish a priority ranking for such waters, taking into account the severity of the pollution and the uses to be made of such waters.

(B) Each State shall identify those waters or parts thereof within its boundaries for which controls on thermal discharges under section 301 are not stringent enough to assure protection and propagation of a balanced indigenous population of shellfish, fish, and wildlife.

(C) Each State shall establish for the waters identified in paragraph (1)(A) of this subsection, and in accordance with the priority ranking, the total maximum daily load, for those pollutants which the Administrator identifies under section 304(a)(2) as suitable for such calculation. Such load shall be established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety that takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality.

(D) Each State shall estimate for the waters identified in paragraph (1)(D) of this subsection the total maximum daily thermal load required to assure protection and propagation of a balanced, indigenous population of shellfish, fish, and wildlife. Such estimates shall take into account the normal water temperatures, flow rate, seasonal variations, existing sources of heat input, and the dissipative capacity of the identified water or parts thereof. Such estimates shall include a calculation of the maximum heat input that can be made into each such part and shall include a margin of safety which takes into account any lack of knowledge concerning the development of thermal water quality criteria for such protection and propagation in the identified water or parts thereof.

(2) Each State shall submit to the Administrator from time to time, with the first such submission not later than one hundred and eighty days after the date of publication of the first identification of pollutants under section 304(a)(2)(D), for his approval the water identified and the loads established under paragraphs (1)(A), (1)(B), (1)(C), and (1)(D) of this subsection. The Administrator shall either approve or disapprove such identification and load not later than thirty days after the date of submission. If the Administrator approves such identification and load, such State shall incorporate them into its current plan under subsection (e) of this section. If the Administrator disapproves such identification and load, he shall not later than thirty days after the date of such disapproval identify such waters in such State and establish such loads for such waters as he determines necessary to implement the water quality standards applicable to such waters and upon such identification and establishment the State shall incorporate them into its current plan under subsection (e) of this section.

(3) For the specific purpose of developing information, each State shall identify all waters within its boundaries which it has not identified under paragraph (1)(A) and (1)(B) of this subsection and estimate for such waters the total maximum daily load with seasonal variations and margins of safety, for those pollutants which the Administrator identifies under section 304(a)(2) as suitable for such calculation and for thermal discharges, at a level that would assure protection and propagation of a balanced indigenous population of fish, shellfish, and wildlife.

(4) Limitations on Revision of Certain Effluent Limitations--

(A) Standard Not Attained--For waters identified under paragraph (1)(A) where the applicable water quality standard has not yet been attained, any effluent limitation based on a total maximum daily load or other waste load allocation established under this section may be revised only if (i) the cumulative effect of all such revised effluent limitations based on such total maximum daily load or waste load allocation will assure the attainment of such water quality standard, or (ii) the designated use which is not being attained is removed in accordance with regulations established under this section.

(B) Standard Attained--For waters identified under paragraph (1)(A) where the quality of such waters equals or exceeds levels necessary to protect the designated use for such waters or otherwise required by applicable water quality standards, any effluent limitation based on a total maximum daily load or other waste load allocation established under this section, or any water quality standard established under this section, or any other permitting standard may be revised only if such revision is subject to and consistent with the antidegradation policy established under this section.

Appendix B. Background Information Regarding Development of the Idaho TMDL Schedule. Adapted from: Idaho Sportsmen's Coalition v. Browner, No. C93-943WD, (W.D. Wash. 1997) Stipulation and Proposed Order on Schedule Required by Court, April 7, 1997.

In 1993, two Idaho environmental groups filed suit in Federal Court against the U.S. Environmental Protection Agency (EPA) for violations of §303(d) of the Clean Water Act (CWA). The groups alleged that EPA improperly approved Idaho's 1992 §303(d) list because the list did not identify all waters violating state water quality standards [see *Idaho Sportsmen's Coalition v. Browner,* Case No. C93-943WD (W.D. Wash.)]. The plaintiffs also alleged that Idaho had failed to develop a sufficient number of total maximum daily loads (TMDLs) for Idaho's listed waters.

In April 1994, the court issued an order granting partial summary judgement to plaintiffs on their challenge to the list [see *Idaho Sportsmen's Coalition v. Browner, Id.* (W.D. Wash. April 14, 1994)]. The Court found that EPA's approval of Idaho's 1992 §303(d) list was arbitrary and capricious, because EPA "failed to offer a rational explanation for its approval of a list containing only thirty-six bodies of water" when there was "evidence showing that hundreds of waters were impaired or threatened". The court ordered EPA to publish a new list. In October 1994, EPA published a §303(d) list for Idaho that included 962 waterbodies.

In May 1995, the court ruled that EPA must establish a "complete and reasonable schedule" with the state of Idaho for TMDL development, as required by 40 CFR 130.7(d)(1). The court's May 1995 order described a reasonable schedule encompassing all listed waters as follows:

> "Such a schedule may provide more specific deadlines for the establishment of a few TMDLs for well-studied water quality limited segments in the short-term, and set only general planning goals for long term development of TMDLs for water quality limited segments about which little is known…"

In May 1996, DEQ and EPA proposed a TMDL development schedule for Idaho to the court. This proposal included a short-term schedule that provided specific dates to complete TMDLs for 41 water quality limited waters on the 1994 §303(d) list over a four-year period. The proposal also included a long-term plan, which consisted of additional evaluation of water quality for listed waters and a basin management approach to TMDL development for each of the six administrative basins in Idaho. EPA indicated that all required TMDLs would be completed within a 25-year time frame.

On September 26, 1996, the court found that the proposed schedule for TMDL development in Idaho "violates the CWA [Clean Water Act] because of two flaws. The first is its extreme slowness. ... The second flaw is that the proposed schedule makes no provision for TMDL development for the full list of Idaho WQLSs [water quality limited segments]". The remedy ordered by the court remanded the matter back to EPA with directions to:

> "establish with Idaho ... a complete and duly adopted reasonable schedule for the development of TMDLs for all waterbodies designated as WQLSs in Idaho. The present record, ... suggests that a completion time of approximately five years would be reasonable."

Appendix C. Active and Discontinued Gage Stations Operated by the U.S. Geological Survey in the Teton Subbasin.[1]

Station Name	Station Number	Drainage Area (mi^2)	Period of Record	Maximum Discharge and Date[2]	Maximum Unit Discharge (cfs/mi^2)[1]
Trail Creek near Victor, ID	13051000	47.6	1946-1952	445 cfs 6/7/52	9.3
Teton Creek near Driggs, ID	13051500	33.8	1946-1952	ND[3]	ND
Teton River near Driggs, ID	13052000	303	1935-1940	1,480 cfs 6/2/36	4.9
Teton River above South Leigh Creek near Driggs, ID	13052200	335	1962-Present	2,980 cfs 6/11/97	8.9
Horseshoe Creek near Driggs, ID	13052500	11.7	1946-1952	ND	ND
Packsaddle Creek near Tetonia, ID	13053000	6.8	1946-1950	58 cfs 5/19/49	8.5
Spring Creek near Tetonia, ID	13053500	--	1947-1949	10 cfs 3/19/47	--
Teton River near Tetonia, ID	13054000	471	1930-1957	1,900 cfs 6/28/45	4.0
Teton River below Badger Creek near Newdale, ID	13054200	547	1974-1977	2,700 cfs 7/7/75	4.9
Bitch Creek near Lamont, ID	13054300	80.9	1974-1977	1,880 cfs 7/7/75	23.2
Canyon Creek near Newdale, ID	13054500	68	1920-1939	457 cfs 5/21/25	6.7
Canyon Creek at Highway 33 near Newdale, ID	13054600	79.9	1974-1977	694 cfs 6/8/75	8.7
Teton Reservoir near Newdale, ID	13054800	851	1976	ND	ND
Teton River below Teton Dam near Newdale, ID	13054805	851	1974-1977	1,290 cfs 4/9/77	1.5
Teton River near St. Anthony	13055000	890	1890-Present	11,000 cfs 2/12/62	12.4
North Fork Teton River at Teton, ID	13055198	--	1908 1977-Present	2,590 cfs 5/22/93	ND
North Fork Teton River at Auxiliary Bridge, near Teton, ID	13055210	--	1977-1978	ND	ND
North Fork Teton River at Powerline Road, near Teton, ID	13055230	--	1977-1978	ND	ND
North Fork Teton River at Bridge, near Sugar City, ID	13055250	--	1977-1978	ND	ND
North Fork Teton River at Highway Bridge, near Salem, ID	13055270	--	1977-1978	ND	ND
North Fork Teton River at Last Bridge, near Salem, ID	13055300	--	1977-1978	ND	ND
Moody Creek near Rexburg, ID	13055319	--	1980-1983 1984-1986	ND	ND
South Fork Teton River at Rexburg, ID	13055340	--	1981-Present	3,410 cfs 5/16/84	ND
Diversion from Teton River between St. Anthony Gage and Mouth	13055500	--	1919-1977	ND	ND

[1]Sources for active and inactive stations: USGS data files available on the Internet at http://idaho.usgs.gov/swdata/active.gages.html and http://idaho.usgs.gov/swdata/disc.sw.list.html
[2]Source: England 1998
[3]ND: Not determined

Appendix D. Waterbody Units Comprising the Teton Subbasin: Recommendations Submitted by the Henry's Fork Watershed Council.

The Division of Environmental Quality revised IDAPA 16.01.02 in April 2000 to incorporate a waterbody identification system for the purpose of designating beneficial uses. The Henry's Fork Watershed Council reviewed the boundaries of waterbody units proposed for the entire Henry's Fork basin and submitted the following recommendations for the Teton Subbasin to the Division of Environmental Quality on August 2, 1999, as part of the official public record. After considering the public comments regarding Docket No. 16.01.02-9704, the DEQ Administrator issued a final version of the proposed rule. The final version, which is shown in Table 7 of the body of this document, was adopted by the Board of Health and Welfare on November 18, 1999, and by the Idaho State Legislature in 2000. At the same time, the legislature promoted the Division of Environmental Quality to a cabinet-level department, and the numbering assigned to rules pertaining to the department changed from IDAPA 16 to IDAPA 58.

Table D-1. Recommendations received by DEQ from the Henry's Fork Watershed Council for boundaries of waterbody units in the Teton Subbasin.

Unit	Waters
US-1	South Fork Teton River - Teton River Forks to confluence with Henry's Fork
US-2	North Fork Teton River -Teton River Forks to confluence with Henry's Fork
US-3	Teton River - Teton Dam to Teton River Forks
US-4	Teton River - Canyon Creek to Teton Dam
US-5	Moody Creek - confluence of North and South Fork Moody Creeks to canal
US-6	South Fork Moody Creek - source to confluence with North Fork Moody Creek
US-7	North Fork Moody Creek - source to confluence with South Fork Moody Creek
US-8	Canyon Creek - Warm Creek to confluence with Teton River
US-9	Canyon Creek - source to Warm Creek
US-10	Calamity Creek - source to confluence with Canyon Creek
US-11	Warm Creek - source to confluence with Canyon Creek
US-12	Teton River - Milk Creek to Canyon Creek
US-13	Milk Creek - source to confluence with Teton River
US-14	Teton River - Felt Dam Outlet to Milk Creek
US-15	Teton River - normal elevation of Felt Dam pool (5,530 feet) to Felt Dam Outlet
US-16	Teton River - Highway 33 bridge to normal elevation of Felt Dam pool (5530 feet)
US-17	Teton River - Cache Bridge (NW1/4 NE1/4 S1 T5N R44E) to Highway 33 bridge
US-18	Packsaddle Creek - pipeline diversion (NE1/4 S8 T5N R44E) to confluence with Teton River
US-19	Packsaddle Creek - source to pipeline diversion (NE 1/4 S8 T5N R44E)
US-20	Teton River - Teton Creek to Cache Bridge (NW1/4 NE1/4 S1 T5N R44E)
US-21	Horseshoe Creek - pipeline diversion (SE1/4 NW1/4 S27 T5N R44E) to confluence with Teton River *[Note: this is incorrect because there is no pipeline on Horseshoe Creek]*
US-22	Horseshoe Creek - source to pipeline diversion (SE1/4 NW1/4 S27 T5N R44E) *[Note: this is incorrect because there is no pipeline on Horseshoe Creek]*
US-23	Twin Creek - source to confluence with Teton River

Unit	Waters
US-24	Mahogany Creek - pipeline diversion (NE1/4 S14 T4N R44E) to confluence with Teton River
US-25	Mahogany Creek - source to pipeline diversion (NE1/4 S14 T4N R44E)
US-26	Teton River - Trail Creek to Teton Creek
US-27	Henderson Creek - source to sink
US-28	Teton River - confluence of Warm Creek and Drake Creek to Trail Creek
US-29	Patterson Creek - pump diversion (SE1/4 S 31 T4N R44E) to confluence with Teton River
US-30	Patterson Creek - source to pump diversion (SE1/4 S 31 T4N R44E)
US-31	Grove Creek - source to sink
US-32	Drake Creek - source to confluence with Warm Creek
US-33	Little Pine Creek - source to confluence with Warm Creek
US-34	Warm Creek - source to confluence with Drake Creek
US-35	Trail Creek - Trail Creek pipeline diversion (SW1/4 SE1/4 S19 T3N R46E) to confluence with Teton River
US-36	Game Creek - source to confluence with Trail Creek
US-37	Game Creek - Idaho/Wyoming border to pipeline diversion (SW1/4 SW1/4 S17 T3N R46E)
US-38	Trail Creek - Idaho/Wyoming border to Trail Creek pipeline diversion (SW1/4 SE1/4 S19 T3N R46E)
US-39	Moose Creek - Idaho/Wyoming border to confluence with Trail Creek
US-40	Fox Creek - SE1/4 SW 1/4 S28 T4N R45E to confluence with Teton River, including Spring Creek tributaries
US-41	Fox Creek - North Fox Creek Canal (NW1/4 S29 T4N R46E) to SE1/4 SW 1/4 S28 T4N R45E
US-42	Fox Creek - Idaho/Wyoming border to North Fox Creek Canal (NW1/4 S29 T4N R46E)
US-43	Foster Slough Spring Creek complex - south to Fox Creek and north to Darby Creek
US-44	Darby Creek - SW1/4 SE1/4 S10 T4N R45 to confluence with Teton River, including Spring Creek tributaries
US-45	Darby Creek - Idaho/Wyoming border to SW1/4 SE1/4 S10 T4N R45
US-46	Dick Creek Spring Creek complex - south to Darby Creek and north to Teton Creek
US-47	Teton Creek - Highway 33 bridge to confluence with Teton River, including Spring Creek tributaries
US-48	Teton Creek - Idaho/Wyoming border to Highway 33 bridge
US-49	Driggs Springs Spring Creek complex - located between Teton Creek and Woods Creek
US-50	Woods Creek - source to confluence with Teton River, including Spring Creek tributaries and Spring Creek complex north of Woods Creek to latitude 43^{o}45' 30"
US-51	Dry Creek - Idaho/Wyoming border to sinks (SE1/4 NE1/4 S12 T5N R45E)
US-52	South Leigh Creek - SE1/4 NE1/4 S1 T5N R44E to confluence with Teton River
US-53	South Leigh Creek - Idaho/Wyoming border to SE1/4 NE1/4 S1 T5N R44E
US-54	Spring Creek - North Leigh Creek to confluence with Teton River
US-55	Spring Creek - spring to North Leigh Creek, including Spring Creek complex north of Spring Creek to latitude 43^{o}49'55"
US-56	North Leigh Creek - Idaho/Wyoming border to confluence with Spring Creek
US-57	Badger Creek - spring (NW1/4 SW1/4 S26 T7N R44E) to confluence with Teton River
US-58	Badger Creek - diversion (NW1/4 SW1/4 S9 T6N R45E) to spring (NW1/4 SW1/4 S26 T7N R44E)
US-59	Badger Creek - confluence of North and South Forks Badger Creek to diversion (NW1/4 SW1/4 S9 T6N R45E)

Unit	Waters
US-60	South Fork Badger Creek - diversion (NE1/4 NE1/4 S12 T6N R45E) to confluence with North Fork Badger Creek
US-61	South Fork Badger Creek - Idaho/Wyoming border to diversion at NE of NE quarter of T6N R45E S12
US-62	North Fork Badger Creek - Idaho/Wyoming border to confluence with South Fork Badger Creek
US-63	Bitch Creek - Swanner Creek to confluence with Teton River
US-64	Swanner Creek - Idaho/Wyoming border to confluence with Bitch Creek
US-65	Bitch Creek - Idaho/Wyoming border to Swanner Creek

Appendix E. Water Quality Criteria

The following criteria were excerpted from *IDAPA 58.01.02 Water Quality Standards and Wastewater Treatment Requirements*.

080. VIOLATION OF WATER QUALITY STANDARDS.

01. **Discharges Which Result In Water Quality Standards Violation**. No pollutant shall be discharged from a single source or in combination with pollutants discharged from other sources in concentrations or in a manner that:

    a. Will or can be expected to result in violation of the water quality standards applicable to the receiving waterbody or downstream waters; or

    b. Will injure designated or existing beneficial uses; or

    c. Is not authorized by the appropriate authorizing agency for those discharges that require authorization.

02. **Short Term Activity Exemption**. The Department or the Board can authorize, with whatever conditions deemed necessary, short term activities even though such activities can result in a violation of these rules;

    a. No activity can be authorized by the provisions of Subsection 080.02 unless:

        i. The activity is essential to the protection or promotion of public interest;
        ii. No permanent or long term injury of beneficial uses is likely as a result of the activity.

    b. Activities eligible for authorization by Subsection 080.02 include, but are not limited to:

        i. Wastewater treatment facility maintenance;
        ii. Fish eradication projects;
        iii. Mosquito abatement projects;
        iv. Algae and weed control projects;
        v. Dredge and fill activities;
        vi. Maintenance of existing structures;
        vii. Limited road and trail reconstruction;
        viii. Soil stabilization measures;
        ix. Habitat enhancement structures; and
        x. Activities which result in overall enhancement or maintenance of beneficial uses.

03. **E. coli Standard Violation**. A single water sample exceeding an E. coli standard does not in itself constitute a violation of water quality standards, however, additional samples shall be taken for the purpose of comparing the results to the geometric mean criteria in Section 251 as follows:

a. Any discharger responsible for providing samples for E. coli shall take five (5) additional samples in accordance with Section 251.

b. The Department shall take five (5) additional samples in accordance with Section 251 for ambient E. coli samples unrelated to dischargers' monitoring responsibilities.

04. **Temperature Exemption**. Exceeding the temperature criteria in Section 250 will not be considered a water quality standard violation when the air temperature exceeds the ninetieth percentile of the seven (7) day average daily maximum air temperature calculated in yearly series over the historic record measured at the nearest weather reporting station.

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.

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.

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.

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.

04. **Radioactive Materials.**

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.
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.

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.

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.

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.

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.

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

01. **General Criteria**. The following criteria apply to all aquatic life use designations:

a. Hydrogen Ion Concentration (pH) values within the range of six point five (6.5) to nine point five (9.5);

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;

c. Total chlorine residual.

i. One (1) hour average concentration not to exceed nineteen (19) ug/l.
ii. Four (4) day average concentration not to exceed eleven (11) ug/l.

02. **Cold Water.** Waters designated for cold water aquatic life are to exhibit the following characteristics:

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

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

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

c. Ammonia

i. One (1) hour average concentration of un-ionized ammonia (as N) is not to exceed (0.43/A/B/2) mg/l, where:

A = 1 if the water temperature (T) is greater than or equal to 20 degrees C (if T > 30 degrees C site-specific criteria should be defined), or
A = 10power(0.03(20-T)) if T is less than twenty (20) degrees C, and
B = 1 if the pH is greater than or equal to 8 (if pH > 9.0 site-specific criteria should be defined); or
B = (1 + 10power(7.4-pH))/1.25 if pH is less than 8 (if pH 6.5 site-specific criteria should be defined).

ii. Four-day average concentration of un-ionized ammonia (as N) is not to exceed (0.66/A/B/C) mg/l, where:

A = 1.4 if the water temperature (T) is greater than or equal to 15 degrees C (if T > 30 degrees C site-specific criteria should be defined), or
A = 10power(0.03(20-T)) if T is less than fifteen (15) degrees C, and
B = 1 if the pH is greater than or equal to 8 (if pH > 9.0 site-specific criteria should be defined), or
B = (1 + 10power(7.4-pH))/1.25 if pH is less than 8 (if pH 6.5 site-specific criteria should be defined), and
C = 13.5 if pH is greater than or equal to 7.7, or
C = 20(10power(7.7-pH)/(1 + 10power(7.4-pH))) if the pH is less than 7.7.

d. 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.

e. Salmonid spawning: waters designated for salmonid spawning are to exhibit the following characteristics during the spawning period and incubation for the particular species inhabiting those waters:

i. Dissolved Oxygen.
(1) Intergravel Dissolved Oxygen.
(a) One (1) day minimum of not less than five point zero (5.0) mg/l.
(b) Seven (7) day average mean of not less than six point zero (6.0) mg/l.
(2) Water-Column Dissolved Oxygen.
(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.
ii. Water temperatures of thirteen (13) degrees C or less with a maximum daily average no greater than nine (9) degrees C.

iii. Ammonia

(1) One (1) hour average concentration of un-ionized ammonia is not to exceed the criteria defined at Subsection 250.02.c.i.

(2) Four (4) day average concentration of un-ionized ammonia is not to exceed the criteria defined at Subsection 250.02.c.i.

03. **Seasonal Cold Water**. Between the summer solstice and autumn equinox, waters designated for seasonal cold water aquatic life are to exhibit the following characteristics. For the period from autumn equinox to summer solstice the cold water criteria will apply:

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

i. The bottom twenty percent (20%) of water depth in natural lakes and reservoirs where depths are thirty-five (35) meters or less.

ii. The bottom seven (7) meters of water depth in natural lakes and reservoirs where depths are greater than thirty-five (35) meters.

iii. Those waters of the hypolimnion in stratified lakes and reservoirs.

b. Water temperatures of twenty-seven (27) degrees C or less as a daily maximum with a daily average of no greater than twenty-four (24) degrees C.

c. Ammonia.

i. One (1) hour average concentration of un-ionized ammonia is not to exceed the criteria defined at Subsection 250.02.c.i.

ii. Four (4) day average concentration of un-ionized ammonia is not to exceed the criteria defined at Subsection 250.02.c.ii.

04. **Warm Water.** Waters designated for warm water aquatic life are to exhibit the following characteristics:

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

i. The bottom twenty percent (20%) of the water depth in natural lakes and reservoirs where depths are thirty-five (35) meters or less.

ii. The bottom seven (7) meters of water depth in natural lakes and reservoirs where depths are greater than thirty-five (35) meters.

iii. Those waters of the hypolimnion in stratified lakes and reservoirs.

b. Water temperatures of thirty-three (33) degrees C or less with a maximum daily average not greater than twenty-nine (29) degrees C.

c. Ammonia.

i. One (1) hour average concentration of un-ionized ammonia (as N) is not to exceed (0.43/A/B/2) mg/l, where:

A = 0.7 if the water temperature (T) is greater than or equal to 25 degrees C (if T > 30 degrees C site-specific criteria should be defined), or
A = 10power(0.03(20-T)) if T is less than 25 degrees C, and
B = 1 if the pH is greater than or equal to 8 (if pH > 9.0 site-specific criteria should be defined), or
B = (1 + 10power(7.4-pH))/1.25 if pH is less than 8 (if pH <_6.5 site-specific criteria should be defined).

ii. Four-day average concentration of un-ionized ammonia (as N) is not to exceed (0.66/A/B/C) mg/l, where:

A = 1.0 if the water temperature (T) is greater than or equal to 20 degrees C (if T > 30 degrees C site-specific criteria should be defined), or
A = 10power(0.03(20-T)) if T is less than 20 degrees C, and)
B = 1 if the pH is greater than or equal to 8 (if pH > 9.0 site-specific criteria should be defined), or
B = (1 + 10power(7.4-pH))/1.25 if pH is less than 8 (if pH <_6.5 site-specific criteria should be defined), and
C = 13.5 if pH is greater than or equal to 7.7, or
C = 20(10power(7.7-pH)/(1 + 10power(7.4-pH))) if the pH is less than 7.7.

05. **Modified**. Water quality criteria for modified aquatic life will be determined on a case-by-case basis reflecting the chemical, physical, and biological levels necessary to fully support the existing aquatic life community. These criteria, when determined, will be adopted into this rule.

251. SURFACE WATER QUALITY CRITERIA FOR RECREATION USE DESIGNATIONS.

01. **Primary Contact Recreation**. Waters designated for primary contact recreation are not to contain E. coli bacteria significant to the public health in concentrations exceeding:

a. A single sample of four hundred six (406) E. coli organisms per one hundred (100) ml; or

b. 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 five (5) days over a thirty (30) day period.

02. **Secondary Contact Recreation**. Waters designated for secondary contact recreation are not to contain E. coli bacteria significant to the public health in concentrations exceeding:

a. A single sample of five hundred seventy-six (576) E. coli organisms per one hundred (100) ml; or

b. 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 five (5) days over a thirty (30) day period.

252. SURFACE WATER QUALITY CRITERIA FOR WATER SUPPLY USE DESIGNATION.

01. **Domestic.** Waters designated for domestic water supplies are to exhibit the following characteristics:

a. Radioactive materials or radioactivity not to exceed concentrations specified in Idaho Department of Environmental Quality Rules, IDAPA 58.01.08, "Rules Governing Public Drinking Water Systems".

b. Small public water supplies (Surface Water).

i. The following Table identifies waters, including their watersheds above the public water supply intake (except where noted), which are designated as small public water supplies.

[Discontinuous]

ii. For those surface waters identified in Subsection 252.01.b.i. turbidity as measured at the public water intake shall not be:

(1) Increased by more than five (5) NTU above natural background, measured at a location upstream from or not influenced by any human induced nonpoint source activity, when background turbidity is fifty (50) NTU or less.
(2) Increased by more than ten percent (10%) above natural background, measured at a location upstream from or not influenced by any human induced nonpoint source activity, not to exceed twenty-five (25) NTU, when background turbidity is greater than fifty (50) NTU.

02.**Agricultural**. Water quality criteria for agricultural water supplies will generally be satisfied by the water quality criteria set forth in Section 200. Should specificity be desirable or necessary to protect a specific use, "Water Quality Criteria 1972" (Blue Book), Section V, Agricultural Uses of Water, EPA, March, 1973 will be used for determining criteria. This document is available for review at the Idaho Department of Environmental Quality, or can be obtained from EPA or the U.S. Government Printing Office.

03. **Industrial**. Water quality criteria for industrial water supplies will generally be satisfied by the general water quality criteria set forth in Section 200. Should specificity be desirable or necessary to protect a specific use, appropriate criteria will be adopted in Sections 2502 or 275 through 298.

253. SURFACE WATER QUALITY CRITERIA FOR WILDLIFE AND AESTHETICS USE DESIGNATIONS.

01. **Wildlife Habitats**. Water quality criteria for wildlife habitats will generally be satisfied by the general water quality criteria set forth in Section 200. Should specificity be desirable or necessary to protect a specific use, appropriate criteria will be adopted in Sections 2503 or 275 through 298.

02. **Aesthetics**. Water quality criteria for aesthetics will generally be satisfied by the general water quality criteria set forth in Section 200. Should specificity be desirable or necessary to protect a specific use, appropriate criteria will be adopted in Sections 2503 or 275 through 298.

Appendix F. Documents Used to Support Additions to Idaho's 1994 § 303(d) List for the Teton Subbasin.

Information to support the addition of stream segments in the Teton Subbasin to the 1994 §303(d) list promulgated by the U.S. Environmental Protection Agency (EPA) was obtained from the *1991 Upper Snake Basin Status Report* (DEQ 1991) and the *1992 Idaho Water Quality Status Report* (DEQ 1992). The portions of these reports that pertain to the Teton Subbasin are below.

Upper Snake River Basin Status Report, An Interagency Summary for the Basin Area Meeting Implementing the Antidegradation Agreement, 1991. This report (DEQ 1991) was cited as the document that supports listing the Teton River from Trail Creek to Bitch Creek. According to the report, stream segments of concern were designated after basin area meetings held in 1989, as required by Idaho's Antidegradation Agreement. Responsible agencies were assigned to monitor these segments and report the results at the 1991 basin area meetings. The report summarized these monitoring results in a table entitled, *Stream Segments of Concern, Information Revised November 1991*. The following information excerpted from the table shows that DEQ, the responsible agency for these stream segments, concluded that the beneficial uses of cold water biota and salmonid spawning were only partially supported in the Teton River from Trail Creek to Bitch Creek because of the effects of agricultural land use (Table F-1). The report does not attribute the support status of the segments to specific pollutants.

Table F-1. Excerpt from the *1991 Upper Snake River Basin Status Report* (DEQ 1991), showing stream segments of concern in the Teton Subbasin.

Waterbody Name PNRS[1] Number Boundaries	Use Support Status[2]	Purpose for Designation
Teton River 116.00 Highway 33 to Bitch Creek	Partial support of cold water biota and salmonid spawning; full support of agricultural water supply and secondary contact recreation	Ag/Grazing[3]
Teton River 117.00 Trail Creek to Highway 33	Partial support of cold water biota and salmonid spawning; full support of domestic and agricultural water supply and primary and secondary contact recreation	Ag/Grazing
Teton River 118.00 Headwaters to Trail Creek	Partial support of salmonid spawning; full support of agricultural water supply and secondary contact recreation	Ag/Grazing

[1]Pacific Northwest Rivers Study
[2]Support status was determined by Idaho DEQ through "office compilation of existing monitoring and beneficial use data≅ for Aindirect monitoring of parameters indicative of instream attainable uses." Assessments were "...based on information other than site-specific water quality data [which]...may include information on land use, modeling and complaints along with best professional judgment.
[3]Ag/Grazing is not defined in the original document, but it is presumed to indicate either cultivated agriculture or grazing.

In addition to these monitoring results, John Heimer of the Idaho Department of Fish and Game authored a report on stream segments of concern in the Upper Snake Basin that was included in the basin status report. Based on cutthroat trout catch rates, he concluded that beneficial uses in the Teton River drainage were only partially supported due to "deteriorated habitat and water quality conditions."

A status report on Idaho's State Agricultural Water Quality Program, which was also included in the basin status report, summarized the water quality-related activities of the Soil Conservation Districts, the Idaho Soil Conservation Commission, and the United States Department of Agriculture Soil Conservation Service (Table F-2). Although it is not specified in the report, the column listing beneficial uses presumably lists beneficial uses the projects are intended to protect or restore.

Table F-2. Excerpt from the *1991 Upper Snake River Basin Status Report* (DEQ 1991), showing the status of agricultural water quality projects in the Teton Subbasin.

Waterbody Name PNRS[1] Number Boundaries	Project Name Project Number[2] Status	Beneficial Use [3]	Pollutant
Teton River 115.00 Bitch Creek to Teton Dam Site	Teton River SAWQP AG-32 Implementation	Salmonid spawning	Sediment
Teton River 116.00 Highway 33 to Bitch Creek	Teton River SAWQP AG-32 Implementation	Salmonid spawning	Sediment Nutrients
Teton River 117.00 Trail Creek to Highway 33	Teton River SAWQP AG-32 Implementation	Salmonid spawning	Sediment
Teton River 117.00 Trail Creek to Highway 33	Teton River CRBS Plan	Salmonid spawning	Sediment
Trail Creek No PNRS number assigned Headwaters to Teton River	Trail Creek PL566 Completed	Not specified	Not specified

[1]Pacific Northwest Rivers Study
[2]SAWQP: State Agricultural Water Quality Program; CRBS: Cooperative River Basin Study; PL566: Small Watershed Program
[3]Though not specified in the report, it is assumed that the project is intended to protect or restore the beneficial use listed in this column.

The 1992 Idaho Water Quality Status Report. This report was the second in a series of reports produced by DEQ following amendment of the federal Clean Water Act in 1987. Sections 305(b) and 319 of the Water Quality Act, which was the name given to the amended Clean Water Act by Congress, required states to 1) complete a statewide water quality assessment, 2) develop a management program for controlling nonpoint source pollution affecting both surface water and ground water, and 3) submit a biennial report to the EPA on the status of water quality statewide (DEQ 1989). Streams in the Teton Subbasin were listed in the following appendices of *The 1992 Idaho Water Quality Status Report* (DEQ 1992): Appendix A, “Streams in Which Beneficial Uses were Supported, Partially Supported, or Threatened” (Table F-3), and Appendix D, “Streams in Which Beneficial Uses Required Further Assessment” (Table F-4).

Most of the information contained in *The 1992 Idaho Water Quality Status Report* was first reported in the *Idaho Water Quality Status Report and Nonpoint Source Assessment, 1988* (DEQ 1989). The 1988 report was based on information solicited by DEQ from “...local, state, and federal agencies, as well as interest groups, industry, Indian tribes, and citizens” (DEQ 1989). For the Teton Subbasin, Appendix A of the 1988 report which lists stream segments “...assessed as not fully supporting a beneficial use” is identical to Appendix D of the 1992 report which lists “impaired stream segments requiring further assessment” (Table F-4).

All of the stream segments identified in the *1991 Upper Snake Basin Status Report* as stream segments of concern (Table F-1), and most of the segments that appeared in *The 1992 Idaho Water Quality Status Report* (Tables F-3 and F-4), were incorporated into the 1994 §303(d) list. However, four of the stream segments listed in *The 1992 Idaho Water Quality Status Report* were not identified in the §303(d) list as water quality impaired. These segments include all of Canyon and Mahogany Creeks, and segments of the Teton River from Bitch Creek to the Teton Dam site and from the dam site to the North and South Forks. Documentation explaining the reasons these segments were not included in the 1994 §303(d) list apparently does not exist.

Table F-3. Excerpt of Appendix A of *The 1992 Idaho Water Quality Status Report* (DEQ 1992) showing the status of beneficial uses of stream segments in the Teton Subbasin.

Waterbody	PNRS[1] Number	Description	Pollutant Source	Magnitude of Pollutant	Status of Beneficial Uses
Teton River	113.00	Moody R [*sic*] to mouth	Irrigated crop production	Moderate	Drinking water and agricultural water supported; partial support of cold water biota and salmonid spawning; support of primary and secondary contact recreation threatened
Teton River	116.00	Badger Creek to Bitch Creek	None cited	Not determined	Partial support of cold water biota and salmonid spawning
Teton River	117.00	Unnamed to Leigh Creek	None cited	Not determined	Partial support of cold water biota and salmonid spawning; support of primary and secondary contact recreation threatened
Teton River	117.00	Mahogany Creek to Unnamed	None cited	Not determined	Partial support of cold water biota and salmonid spawning
Teton River	117.00	Teton Creek to Mahogany Creek	None cited	Not determined	Partial support of cold water biota and salmonid spawning; support of primary and secondary contact recreation threatened
Teton River	117.00	Trail Creek to Fox Creek	None cited	Not determined	Partial support of cold water biota and salmonid spawning
Moody R [*sic*]	119.00	Unnamed to mouth	Pasture land	Moderate	Drinking water and agricultural water supported; partial support of cold water biota and salmonid spawning; primary and secondary contact recreation supported
Bitch Creek	123.00	Swanner Creek to mouth	None cited	Not determined	Partial support of cold water biota and salmonid spawning
Spring Creek	127.00	Headwaters to mouth	Pasture land	Not determined	Drinking water and agricultural water supported; partial support of cold water biota; no support of salmonid spawning; support of primary and secondary contact recreation threatened
Mahogany Creek	131.00	Headwaters to mouth	None cited	Not determined	Partial support of cold water biota and salmonid spawning; support of primary and secondary contact recreation threatened

[1]Pacific Northwest Rivers Study

Table F-4. Excerpt of Appendix D of *The 1992 Idaho Water Quality Status Report* showing impaired stream segments in the Teton Subbasin requiring further assessment.

Waterbody	PNRS[1] Number	Boundaries	Submitted by[2]	Pollutant	Major Source	Magnitude of Effect	Status of Beneficial Uses
Teton River	114.00	Teton Dam site to Teton Forks	DEQ	Siltation/sedimentation	Irrigated crop production Channelization	Moderate High	Partial support of cold water biota and salmonid spawning; support of primary and secondary contact threatened
Teton River	115.00	Bitch Creek to Teton Dam site	DEQ	Siltation/sedimentation	Non-irrigated crop production Channelization	Moderate High	Partial support of cold water biota and salmonid spawning
Teton River	115.00	Bitch Creek to Teton Dam site	BLM	Siltation/sedimentation Other habitat alterations	Non-irrigated crop production Dam construction	Moderate High	Not supporting cold water biota and salmonid spawning
Teton River	117.00	Trail Creek to Highway 33	IDFG	Siltation/sedimentation Thermal modification	Pastureland treatment Removal of riparian vegetation	High High	Partial support of cold water biota and salmonid spawning; support of primary and secondary contact threatened
Canyon Creek	121.00	Pincock Hot Spring to Teton River	DEQ	Siltation/sedimentation Flow alteration	Non-irrigated crop production Flow regulation/modification	High Moderate	Partial support of cold water biota and salmonid spawning; support of primary and secondary contact threatened
Canyon Creek	122.00	Headwaters to Pincock Hot Spring	IDFG	Siltation/sedimentation Flow alteration Unspecified Siltation/sedimentation Thermal modification	Pastureland treatment Dam construction Flow regulation/modification Removal of riparian vegetation Removal of riparian vegetation	Low High High Low Low	Partial support of cold water biota and salmonid spawning
Badger Creek	125.00	R45ET6NS10 to first tributary	DEQ	Siltation/sedimentation	Non-irrigated cropland	Moderate	Partial support of cold water biota and salmonid spawning; support of primary and secondary contact threatened
Spring Creek	127.00	Wyoming line to Teton River	IDFG	Siltation/sedimentation Flow alteration Siltation/sedimentation Thermal modification	Pastureland treatment Flow regulation/modification Removal of riparian vegetation Removal of riparian vegetation	Low High Low Low	Partial support of cold water biota; no support of salmonid spawning

Waterbody	PNRS[1] Number	Boundaries	Submitted by[2]	Pollutant	Major Source	Magnitude of Effect	Status of Beneficial Uses
Leigh Creek	128.00	Wyoming line to Teton River	DEQ	Siltation/sedimentation	Non-irrigated cropland	Moderate	Partial support of cold water biota and salmonid spawning; support of primary and secondary contact threatened
Packsaddle Creek	129.00	Headwaters to Teton Creek	IDFG	Siltation/sedimentation Flow alteration Thermal modification Siltation/sedimentation Thermal modification	Pastureland treatment Flow regulation/modification Flow regulation/modification Removal of riparian vegetation Removal of riparian vegetation	Low High High Low Low	Partial support of cold water biota; no support of salmonid spawning
Horseshoe Creek	130.00	Headwaters to Teton Creek	IDFG	Flow alteration	Flow regulation/modification	High	Support of cold water biota threatened; partial support of salmonid spawning
Teton Creek	132.00	Highway 33 to Teton River	DEQ	Nutrients, including nitrate Siltation/sedimentation	Pastureland treatment Streambank modification/destabilization	Moderate Moderate	Partial support of cold water biota and salmonid spawning; support of primary and secondary contact threatened
Darby Creek	134.00	Highway 33 to Teton River	IDFG	Siltation/sedimentation Flow alteration Flow alteration	Pastureland treatment Flow regulation/modification Removal of riparian vegetation	High High High	Support of cold water biota threatened; partial support of salmonid spawning
Fox Creek	136.00	Wyoming line to Teton River	IDFG	Siltation/sedimentation Thermal modification Flow alteration Siltation/sedimentation Thermal modification Flow alteration	Pastureland treatment Flow regulation/modification Flow regulation/modification Removal of riparian vegetation Removal of riparian vegetation Removal of riparian vegetation	High High High High High	Support of cold water biota threatened; partial support of salmonid spawning
Teton River, N & S Forks	113.00	Teton Forks to Henry s Fork	DEQ	Siltation/sedimentation Nutrients, including nitrate Siltation/sedimentation	Irrigated crop production Pastureland treatment Channelization	Moderate Moderate Moderate	Partial support of cold water biota and salmonid spawning; support of primary and secondary contact threatened
Moody Creek	119.00	Forest boundary to Teton River	DEQ	Nutrients, including nitrate Nutrients, including nitrate	Pastureland treatment Animal holding/management areas	Moderate Moderate	Partial support of cold water biota and salmonid spawning; support of primary and secondary contact threatened

[1]Pacific Northwest Rivers Study
[2]DEQ: Idaho Department of Health and Welfare Division of Environmental Quality; BLM: United States Department of the Interior Bureau of Land Management; IDFG: Idaho Department of Fish and Game

Appendix G. Subsurface Fine Sediment Sampling Methods (Adapted From DEQ 1999b)

Site Selection

Sample sites selected displayed characteristics of gravel size, depth, and velocity required by salmonids to spawn and were determined to be adequate spawning substrate by an experienced fisheries biologist. Samples were collected during periods of low discharge, as described in McNeil and Ahnell (1964) to minimize loss of silt in suspension within the core sampling tube. Sample sites were generally in the lower reach of streams where spawning habitat was determined to exist.

Field Methods

A 12 inch stainless steel open cylinder is worked manually as far as possible, at least 4 inches, into spawning substrate without allowing flowing water to top the core sampling tube. Samples of bottom materials were removed by hand, using a stainless steel mixing bowl, to a depth of at least 4 inches and placed into buckets. After solids were removed from the core sampling tube and placed into buckets, the remaining suspended material was discarded. It is felt that this fine material would be removed through the physical action of excavating a redd and would not be a significant factor with regard to egg to fry survival. Additionally, rinsing of sieves to process the sample results in some loss of the fraction below the smallest (0.053 mm) mesh size.

Samples were placed wet into a stack of sieves and were separated into 10 size classes by washing and shaking them through nine standard Tyler sieves having the following square mesh openings (in mm): 63, 25, 12.5, 6.3, 4.75, 2.36, 0.85, 0.212, 0.053. Silt passing the finest screen was discarded.

The volume of solids retained by each sieve was measured after the excess water drained off. The contents of each of the sieves were placed in a bucket filled with water to the level of a spigot for measurement by displacement. The water displaced by solids was collected in a plastic bucket and transferred to a 2,000 ml graduated cylinder and measured directly.   Water displaced by solids retained by the smaller diameter sieves was also collected in a plastic bucket and measured in a 250 ml graduated cylinder. Variation in sample volumes was caused by variation in porosity and core depth. All sample fractions were expressed as a percentage of the sample with and without the 63 mm fraction.

Three sediment core samples were collected at each sample site and grouped together by fractions 6.3 mm and greater and 4.75 mm to 0.53 mm. The results for a particular site are the percentage of 4.75 mm to 0.53 mm as a percent of the total sample. Standard deviation is calculated for estimates including and excluding particles 63 mm and above.

Appendix H. Selected Parameters Measured and Support Status of Aquatic Life as Determined by Beneficial Use Reconnaissance Program Protocol

Table H-1. Selected parameters measured at sites in the Teton Subbasin by the Department of Environmental Quality using the Beneficial Use Reconnaissance Project protocol.

Stream	Sample Site ID Number	Duplicate Sample Site ID	Date Sampled	Flow (cfs)	Eco[1]	Elev[2] (feet)	SO[3]	Rosgen ST[4]	MBI[5] Score	HI[6] Score	BU SS[7]	Width to Depth Ratio	Bank Stability (%)		Bank Cover (%)	
													Left Bank	Rt. Bank	Left Bank	Rt. Bank
Badger Creek	95-A006		7/24/95	56	SR	6150	3	C	4.05	101	FS	52.6	92	92	69	41
Badger Creek	95-A058		7/24/95	21	SR	6070	3	C	2.52	104	NV	29	90	90	45	50
Badger Creek	95-A059		7/24/95	15	SR	5640	3	B	1.24	83	NFS	44	91	91	68	51
Bitch Creek	95-A098	96-Z131	8/23/95	83	MR	5950	2	C	3.10	80	NA	33.3	70	84	45	61
Bitch Creek	96-Z131	95-A098	8/20/96	57	MR	5970	2	B	4.19	92	NA	43.9	96	100	17	6
Bitch Creek	95-A099	96-Z130	8/23/95	101	SR	5350	4	C	4.51	68	FS	52.6	92	64	21	10
Bitch Creek	96-Z130	95-A099	8/20/96	66	SR	5350	4	B	4.44	93	FS	84.3	100	100	40	10
Calamity Creek	97-L016		6/16/97	20	SR	6050	2	C	4.54	90	NA	7.3	92	46	2	34
Canyon Creek	95-A117		9/20/95	15	SR	5800	3	F	4.85	85	FS	17.1	80	60	85	88
Carlton Creek	97-L017		6/17/97	3	SR	5980	1	C	5.46	88	NA	14.6	78	76	64	73

Stream	Sample Site ID Number	Duplicate Sample Site ID	Date Sampled	Flow (cfs)	Eco[1]	Elev[2] (feet)	SO[3]	Rosgen ST[4]	MBI[5] Score	HI[6] Score	BU SS[7]	Width to Depth Ratio	Bank Stability (%) Left Bank	Bank Stability (%) Rt. Bank	Bank Cover (%) Left Bank	Bank Cover (%) Rt. Bank
Darby Creek	95-B052		7/24/95	57	SR	6460	2	A	4.84	104	FS	15.1	100	100	70	94
Darby Creek	95-B007		6/13/95	38	SR	6140	2	B	1.41	108	NFS	10.6	100	100	100	100
Darby Creek	97-L073	98-E003	7/23/97	11	SR	6020	2	C	3.26	59	NA	9.1	100	100	21	48
Darby Creek	98-E003	97-L073	8/3/98	8	SR	6000	2	C	4.67	63	NA	11	91	92	91	92
Darby Creek	95-B051		7/24/95		SR	6000	2	Site visited but not sampled because of lack of stream riffles								
Darby/Dick Creek	97-L059		7/14/97	8	SR	6120	2	B	3.28	113	NA	10.6	97	100	92	85
Drake Creek	96-Z017		6/10/96	6	SR	6440	1	B	4.94	110	FS	19.8	98	99	98	99
Dry Creek	96-Z033		6/19/96	0.3	SR	6600	1	B	1.35	95	NA	33.4	100	97	4	18
Fish Creek	97-M015		6/17/97	16	MR	6000	1	C	5.41	105	NA	11.6	72	53	74	75
Fox Creek	95-A094		8/21/95	22	SR	6560	1	B	5.07	88	FS	14.9	100	78	10	14
Fox Creek	95-B050		7/24/95	1	SR	6100	1	B	2.99	60	NFS	21.3	75	72	75	70
Game Creek	97-L058		7/14/97	73	MR	6680	2	C	4.52	115	NA	9.3	82	100	73	78

Stream	Sample Site ID Number	Duplicate Sample Site ID	Date Sampled	Flow (cfs)	Eco[1]	Elev[2] (feet)	SO[3]	Rosgen ST[4]	MBI[5] Score	HI[6] Score	BU SS[7]	Width to Depth Ratio	Bank Stability (%)		Bank Cover (%)	
													Left Bank	Rt. Bank	Left Bank	Rt. Bank
Henderson Creek	96-Z024	97-L074	6/13/96	1.8	MR	6350	1	A	3.33	83	NA	6	99	100	99	100
Henderson Creek	97-L074	96-Z024	7/23/97	1.8	MR	6360	1	A	4.69	99	NA	14.7	76	78	97	98
Hillman Creek	96-Z034		6/19/96	2	SR	6740	1	B	4.00	89	FS	5.8	96	95	96	95
Hinckley Creek	97-M013		6/16/97	4.5	MR	6200	1	B	4.88	75	NA	60	100	100	97	100
Horseshoe Creek	98-E002		8/3/98	10	MR	6460	3	C	5.65	126	NA	14.1	100	100	100	100
Horseshoe Creek	95-B004		6/7/95	3	MR	6440	3	C	2.44	78	NFS	4.2	95	90	100	100
Horseshoe Creek	95-B006	98-E001	6/13/95	37	SR	6015	3	C	2.30	70	NFS	5.3	30	60	100	95
Horseshoe Creek	98-E001	95-B006	7/7/98	7	SR	6015	3	C	3.77	108	NA	7.8	88	82	96	94
Horseshoe Creek North Fork	97-L057		7/14/97	1.6	MR	6740	1	A	5.37	115	NA	10.9	77	81	76	75
Little Pine Creek	96-Z025		6/13/96	2.6	SR	6280	3	B	4.68	101	FS	9.1	100	100	100	98
Mahogany Creek	96-Z121		8/14/96	9	MR	6340	2	F	5.40	95	FS	19.9	100	100	84	95
Marlow Creek	97-M012		6/16/97	7.5	MR	6800	2	A	5.39	83	NA	21.4	75	90	66	90

Stream	Sample Site ID Number	Duplicate Sample Site ID	Date Sampled	Flow (cfs)	Eco[1]	Elev[2] (feet)	SO[3]	Rosgen ST[4]	MBI[5] Score	HI[6] Score	BU SS[7]	Width to Depth Ratio	Bank Stability (%) Left Bank	Bank Stability (%) Rt. Bank	Bank Cover (%) Left Bank	Bank Cover (%) Rt. Bank
Middle Twin Creek	97-L065		7/16/97	0.6	MR	6175	1	A	4.49	99	NA	2.3	88	91	90	89
Mike Harris Creek	96-Z029		6/18/96	18	SR	6730	2	C	4.37	93	FS	5.8	95	97	94	97
Milk Creek	96-Z031		6/18/96	2.3	SR	7410	1	B	4.88	92	FS	13.3	93	87	88	89
Milk Creek	98-E004		8/4/98	0.7	SR	6660	1	B	3.21	73	NA	43.8	80	67	80	75
Moody Creek	95-B083		8/22/95		SR	5960	2	Site visited but not sampled because of beaver complex (no stream riffles)								
Moody Creek	95-B082		8/21/95	4	SR	5240	3	C	3.07	83	NV	32.3	85	88	50	73
Moody Creek	95-B084		8/22/95		SR	4922	3	Site visited but not sampled because of lack of stream riffles								
Moose Creek	97-M077		7/24/97	95	MR	6750	2	B	5.11	104	NA	21.7	100	100	100	100
Morris Creek	97-L066		7/16/97	0.1	MR	5880	1	A	4.60	113	NA	16.5	100	92	97	95
Murphy Creek	96-Z027		6/17/96	1.4	SR	6200	1	B	4.84	109	FS	10.7	96	97	96	98
North Leigh Creek	95-B058		7/27/95	57	SR	6440	1	B	1.16	103	NFS	27.8	83	92	66	79
North Leigh Creek	95-B057		7/26/95	35	SR	6140	1	C	1.89	102	NFS	23.8	96	96	86	81

Stream	Sample Site ID Number	Duplicate Sample Site ID	Date Sampled	Flow (cfs)	Eco[1]	Elev[2] (feet)	SO[3]	Rosgen ST[4]	MBI[5] Score	HI[6] Score	BU SS[7]	Width to Depth Ratio	Bank Stability (%)		Bank Cover (%)	
													Left Bank	Rt. Bank	Left Bank	Rt. Bank
North Moody Creek	97-L015		6/16/97	37	MR	6560	2	B	5.39	80	NA	22.6	71	98	69	87
North Twin Creek	96-Z023		6/12/96	4	SR	6760	1	B	5.28	107	FS	6.7	100	100	100	100
Packsaddle Creek	95-B003		6/7/95	24	SR	6929	2	B	3.91	111	FS	5.3	100	100	100	100
Packsaddle Creek	95-B005		6/8/95	57	SR	6140	2	F	2.44	106	NFS	13.4	100	100	90	995
Packsaddle Creek North Fork	96-Z032		6/18/96	7	SR	6540	1	A	5.11	112	FS	10.2	100	99	90	97
Patterson Creek	96-Z018		6/10/96	13	SR	6240	1	B	3.52	104	FS	9.2	95	98	95	98
Pole Canyon Creek	96-Z028		6/17/96	7	SR	6750	1	A	3.64	91	FS	13.5	100	100	94	78
Ruby Creek	97-M011		6/16/97	29	MR	6800	1	A	4.85	113	NA	4.1	87	87	100	100
Sheep Creek	97-L013		6/16/97	2	MR	6555	1	C	4.21	106	NA	22.9	100	95	100	95
South Leigh Creek	95-B054		7/25/95	66	SR	6480	2	B	2.99	96	NV	19.5	100	100	92	70
South Leigh Creek	98-E005		8/4/98	9	SR	6220	2	C	4.44	100	NA	49.3	92	56	92	66
South Leigh Creek	95-B056		7/26/95	45	SR	5980	2	C	2.14	78	NFS	37.7	100	100	67	86

Stream	Sample Site ID Number	Duplicate Sample Site ID	Date Sampled	Flow (cfs)	Eco[1]	Elev[2] (feet)	SO[3]	Rosgen ST[4]	MBI[5] Score	HI[6] Score	BU SS[7]	Width to Depth Ratio	Bank Stability (%) Left Bank	Bank Stability (%) Rt. Bank	Bank Cover (%) Left Bank	Bank Cover (%) Rt. Bank
South Moody Creek	97-L014		6/16/97	4	MR	6825	1	B	3.92	102	NA	5.6	100	100	88	91
South Moody Creek	97-M016		6/17/97	13	MR	6300	2	B	3.94	91	NA	12.3	56	67	62	74
South Twin Creek	97-L064		7/16/97	0.4	MR	6110	1	B	4.53	66	NA	14.7	71	75	46	71
Spring Creek	95-B024		6/27/95	4	SR	6200	2	F	1.26	86	NFS	6.7	0	0	95	80
Spring Creek	97-M152		9/24/97	0.4	SR	6170	1	E	1.33	50	NA	31.4	100	100	100	100
Spring Creek	95-B055		7/25/95	53	SR	5980	2	F	2.91	94	NV	19.6	100	100	100	100
State Creek	97-M014		6/17/97	2.5	MR	5900	2	B	4.5	112	NA	14.5	100	86	100	100
Sweet Hollow Creek	96-Z030		6/18/96	1.5	SR	6360	1	B	2.72	95	NA	6.9	100	100	100	100
Teton Creek	97-L076		7/24/97	63	MR	6560	1	B	5.45	91	FS	23.8	97	95	75	67
Teton Creek	95-A095		8/22/95		SR	6330	1	Site visited but not sampled - dry channel								
Teton Creek	95-A112		9/7/95	7	SR	6080	1	C	3.61	95	FS	47.7	89	100	70	24
Teton Creek	95-B053		7/25/95		SR	6000	2	Site visited but not sampled - slow, deep water								
North Fork Teton	95-A108		9/6/95		SR	4940		Site visited but not sampled - deep water								

Stream	Sample Site ID Number	Duplicate Sample Site ID	Date Sampled	Flow (cfs)	Eco[1]	Elev[2] (feet)	SO[3]	Rosgen ST[4]	MBI[5] Score	HI[6] Score	BU SS[7]	Width to Depth Ratio	Bank Stability (%)		Bank Cover (%)	
													Left Bank	Rt. Bank	Left Bank	Rt. Bank
North Fork Teton River	95-A111		9/6/95		SR	4850		Site visited but not sampled - deep water								
South Fork Teton River	95-A100		8/24/95	97	SR	4930		C	4.11	81	FS	33.8	94	100	17	38
South Fork Teton River	95-A113		9/7/95		SR	4825		Site visited but not sampled - deep water								
Trail Creek	98-E006		8/4/98	36	MR	6520	2	B	5.13	97	NA	17.3	100	95	100	100
Warm Creek Teton County	97-L063		7/16/97	19	MR	6140	1	E	2.61	97	NA	14.8	100	100	100	100
Warm Creek Madison County	97-L018		6/17/97	3.6	SR	5890	2	D	3.36	69	NA	23.5	100	100	71	18
Woods Creek	97-L071		7/22/97	0.6	SR	5950	2	E	2.51	113	NA	6.2	100	100	100	96
Wright Creek	97-L019		6/17/97	7	SR	5835	1	G	4.68	101	NA	3.9	51	71	55	71

[1]Ecoregion: Snake River Basin/High Desert (SR) or Middle Rockies (MR)
[2]Elevation
[3]Stream order
[4]Rosgen stream type
[5]Macroinvertebrate Biotic Index (MBI)
[6]Habitat Index (HI)
[7]Beneficial use support status: full support (FS), not full support (NFS), needs verification (NV), not assessed (NA)

Table H-2 The support status of cold water aquatic life as determined for stream sites sampled using the Beneficial Use Reconnaissance Program protocol, and the results of corresponding measurements of substrate embeddedness and percentage of fine sediment at sampled sites. Sampling sites located in §303(d)-listed segments are shown in *italics*.

Stream	Sample Site ID Number	Cold Water Aquatic Life Support Status as Assessed for the 1998 §303(d) List[1]	MBI Score[2]	% EPT[3]	Embeddedness[4]				Percentage of Bankfull Substrate Consisting of Fine Sediment Particles:[5]		
					0-25%	25-50%	50-75%	>75%			
					Optimal: Score1 6-20	Sub-optimal: Score 11-15	Marginal: Score 6-10	Poor: Score 0-5	< 6 mm Diameter	< 2.5 mm Diameter	< 1 mm Diameter
Badger Creek	95-A006	Full Support	4.05	49	NA[6]	NA	NA	NA	25	25	0
Badger Creek	*95-A058*	*Not Full Support*	*2.52*	*14*	*17*				*38*	*20*	*1*
Badger Creek	*95-A059*	*Not Full Support*	*1.24*	*1*				*0*	*38*	*20*	*6*
Bitch Creek	95-A098	Full Support	3.10	21		12			24	16	1
Bitch Creek	96-Z131	Full Support	4.19	45	17				7	6	0
Bitch Creek	95-A099	Full Support	4.51	33			10		19	12	2
Bitch Creek	96-Z130	Full Support	4.44	62	16				11	11	4
Calamity Creek	97-L016	Not Assessed	4.54	65	19				61 (44)	45 (29)	40 (28)
Canyon Creek	95-A117	Full Support	4.85	64			7		27	22	14

Stream	Sample Site ID Number	Cold Water Aquatic Life Support Status as Assessed for the 1998 §303(d) List[1]	MBI Score[2]	% EPT[3]	Embeddedness[4]				Percentage of Bankfull Substrate Consisting of Fine Sediment Particles:[5]		
					0-25%	25-50%	50-75%	>75%			
					Optimal: Score1 6-20	Sub-optimal: Score 11-15	Marginal: Score 6-10	Poor: Score 0-5	< 6 mm Diameter	< 2.5 mm Diameter	< 1 mm Diameter
Carlton Creek	97-L017	Not Assessed	5.46	83	17				51 (34)	26 (10)	11 (1)
Darby Creek	95-B052	Full Support	4.84	92	17				24	23	18
Darby Creek	*95-B007*	*Not Full Support*	*1.41*	*0*		*15*			*44*	*44*	*44*
Darby Creek	*97-L073*	*Not Assessed*	*3.26*	*26*				*1*	*86 (78)*	*84 (78)*	*84 (78)*
Darby Creek	*98-E003*	*Full Support*	*4.45*	*33*				*0*	*96 (94)*	*96 (94)*	*96 (94)*
Darby Creek	*95-B051*	*Not Sampled - Wetland*									
Darby/Dick Creek	*97-L059*	*Not Assessed*	*3.28*	*26*			*10*		*34 (17)*	*31 (14)*	*31 (14)*
Drake Creek	96-Z017	Full Support	4.94	89	18				58	54	46
Dry Creek	96-Z033	Not Full Support	1.35	6	17				36	30	26
Fish Creek	97-M015	Not Assessed	5.41	87		15			31 (11)	26 (8)	24 (6)

Stream	Sample Site ID Number	Cold Water Aquatic Life Support Status as Assessed for the 1998 §303(d) List[1]	MBI Score[2]	% EPT[3]	Embeddedness[4]				Percentage of Bankfull Substrate Consisting of Fine Sediment Particles:[5]		
					0-25%	25-50%	50-75%	>75%			
					Optimal: Score 16-20	Sub-optimal: Score 11-15	Marginal: Score 6-10	Poor: Score 0-5	< 6 mm Diameter	< 2.5 mm Diameter	< 1 mm Diameter
Fox Creek	*95-A094*	*Full Support*	*5.07*	*92*		*12*			*31*	*21*	*11*
Fox Creek	*95-B050*	*Needs Verification*	*2.99*	*38*		*11*			*61*	*61*	*56*
Game Creek	97-L058	Not Assessed	4.52	42	19				26 (12)	23 (11)	19 (4)
Henderson Creek	96-Z024	Not Assessed	3.33	72		11			88	84	84
Henderson Creek	97-L074	Not Assessed	4.69	57	16				79 (34)	68 (10)	68 (10)
Hillman Creek	96-Z034	Full Support	4.00	68				4	95	90	77
Hinckley Creek	97-M013	Not Assessed	4.88	48			8		70 (67)	64 (59)	60 (52)
Horseshoe Creek	*95-B004*	*Not Full Support*	*2.44*	*16*			*6*		*84*	*81*	*73*
Horseshoe Creek	*95-B006*	*Not Full Support*	*2.30*	*13*			*7*		*81*	*79*	*69*

Stream	Sample Site ID Number	Cold Water Aquatic Life Support Status as Assessed for the 1998 §303(d) List[1]	MBI Score[2]	% EPT[3]	Embeddedness[4]				Percentage of Bankfull Substrate Consisting of Fine Sediment Particles:[5]		
					0-25%	25-50%	50-75%	>75%			
					Optimal: Score16-20	Sub-optimal: Score 11-15	Marginal: Score 6-10	Poor: Score 0-5	< 6 mm Diameter	< 2.5 mm Diameter	< 1 mm Diameter
Horseshoe Creek	98-E001	Not Assessed	3.77	19		11			37 (28)	26 (17)	19 (9)
North Fork Horseshoe Creek	98-E002	Not Assessed	5.65	72	18				24 (11)	22 (9)	15 (3)
North Fork Horseshoe Creek	97-L057	Not Assessed	5.37	47	19				62 (30)	45 (12)	44 (11)
Little Pine Creek	96-Z025	Full Support	4.68	80		13			54	47	42
Mahogany Creek	96-Z121	Full Support	5.40	75		13			52	49	48
Marlow Creek	97-M012	Not Assessed	5.39	84		13			49 (29)	43 (24)	36 (19)
Middle Twin Creek	97-L065	Not Assessed	4.49	47				4	97 (92)	84 (62)	71 (34)
Mike Harris Creek	96-Z029	Full Support	4.37	78				5	77	74	65

Stream	Sample Site ID Number	Cold Water Aquatic Life Support Status as Assessed for the 1998 §303(d) List[1]	MBI Score[2]	% EPT[3]	Embeddedness[4] 0-25%	25-50%	50-75%	>75%	Percentage of Bankfull Substrate Consisting of Fine Sediment Particles:[5]		
					Optimal: Score1 6-20	Sub-optimal: Score 11-15	Marginal: Score 6-10	Poor: Score 0-5	< 6 mm Diameter	< 2.5 mm Diameter	< 1 mm Diameter
Milk Creek	96-Z031	Not Assessed	4.88	80		15			58	54	52
Milk Creek	98-E004	Not Assessed	3.21	10				4	45 (20)	36 (6)	29 (1)
Moody Creek	*95-B082*	*Needs Verification*	*3.07*	*22*		*14*			*33*	*31*	*20*
Moody Creek	95-B084	Not Sampled - No Riffles – Not Moody Creek - Correct identification is Woodmansee Johnson Canal									
Moose Creek	97-M077	Not Assessed	5.11	88	18				19 (2)	19 (2)	16 (0)
Morris Creek	97-L066	Not Assessed	4.60	49	17				58 (11)	51 (6)	49 (3)
Murphy Creek	96-Z027	Full Support	4.84	69	16				55	49	44
North Leigh Creek	95-B058	Not Full Support	1.16	3	17				24	22	14
North Leigh Creek	95-B057	Not Full Support	1.89	11		11			28	26	23
North Moody Creek	95-B083	Not Sampled – Beaver Complex									

Stream	Sample Site ID Number	Cold Water Aquatic Life Support Status as Assessed for the 1998 §303(d) List[1]	MBI Score[2]	% EPT[3]	Embeddedness[4]				Percentage of Bankfull Substrate Consisting of Fine Sediment Particles:[5]		
					0-25%	25-50%	50-75%	>75%			
					Optimal: Score1 6-20	Sub-optimal: Score 11-15	Marginal: Score 6-10	Poor: Score 0-5	< 6 mm Diameter	< 2.5 mm Diameter	< 1 mm Diameter
North Moody Creek	97-L015	Not Assessed	5.39	71	17				44 (21)	41 (19)	38 (14)
North Twin Creek	96-Z023	Not Assessed	5.28	80		15			67	60	59
Packsaddle Creek	*95-B003*	*Full Support*	*3.91*	*45*		*16*			*49*	*48*	*46*
Packsaddle Creek	*95-B005*	*Not Full Support*	*2.44*	*20*		*16*			*43*	*42*	*38*
North Fork Packsaddle Creek	96-Z032	Full Support	5.11	89	17				34	27	25
Patterson Creek	96-Z018	Full Support	3.52	60	16				54	52	48
Pole Canyon Cr	96-Z028	Full Support	3.64	76	17				42	39	36
Ruby Creek	97-M011	Not Assessed	4.85	66	19				50 (3)	49 (1)	49 (1)
Sheep Creek	97-L013	Not Assessed	4.21	67	19				80 (25)	67 (11)	64 (8)

Stream	Sample Site ID Number	Cold Water Aquatic Life Support Status as Assessed for the 1998 §303(d) List[1]	MBI Score[2]	% EPT[3]	Embeddedness[4]				Percentage of Bankfull Substrate Consisting of Fine Sediment Particles:[5]		
					0-25%	25-50%	50-75%	>75%			
					Optimal: Score1 6-20	Sub-optimal: Score 11-15	Marginal: Score 6-10	Poor: Score 0-5	< 6 mm Diameter	< 2.5 mm Diameter	< 1 mm Diameter
South Leigh Creek	***95-B054***	***Needs Verification***	***2.99***	***20***		***11***			***20***	***16***	***8***
South Leigh Creek	***98-E005***	***Not Assessed***	***4.44***	***31***	***16***				***6 (4)***	***6 (4)***	***5 (4)***
South Leigh Creek	***95-B056***	***Not Full Support***	***2.14***	***6***		***13***			***18***	***14***	***10***
South Moody Creek	97-L014	Not Assessed	3.92	46	16				76 (42)	72 (26)	72 (26)
South Moody Creek	97-M016	Not Assessed	3.94	92		14			41 (5)	37 (5)	28 (2)
South Twin Creek	97-L064	Not Assessed	4.53	52				1	99 (98)	95 (89)	86 (66)
Spring Creek	*95-B024*	*Not Full Support*	*1.26*	*5*			*10*		*75*	*69*	*64*
Spring Creek	*97-M152*	*Not Assessed*	*1.33*	*0.3*	*NA*	*NA*	*NA*	*NA*	*100*	*100 (100)*	*100 (100)*
Spring Creek	*95-B055*	*Needs Verification*	*2.91*	*30*		*14*			*22*	*19*	*16*

Stream	Sample Site ID Number	Cold Water Aquatic Life Support Status as Assessed for the 1998 §303(d) List[1]	MBI Score[2]	% EPT[3]	Embeddedness[4] 0-25%	25-50%	50-75%	>75%	Percentage of Bankfull Substrate Consisting of Fine Sediment Particles:[5]		
					Optimal: Score16-20	Sub-optimal: Score 11-15	Marginal: Score 6-10	Poor: Score 0-5	< 6 mm Diameter	< 2.5 mm Diameter	< 1 mm Diameter
State Creek	97-M014	Not Assessed	4.5	45	16				43 (0)	43 (0)	43 (0)
Sweet Hollow Creek	96-Z030	Needs Verification	2.72	15		15			72	69	67
Teton Creek	97-L076	Full Support	5.45	83	16				27 (16)	22 (13)	9 (1)
Teton Creek	95-A095	Not Sampled - Stream Channel Dry									
Teton Creek	95-A112	Full Support	3.61	31		12			13	7	6
Teton Creek	95-B053	Not Sampled - Slow, Deep Water/No Riffles									
North Fork Teton River	*95-A108*	*Not Sampled - Deep Water*									
North Fork Teton River	*95-A111*	*Not Sampled - Deep Water*									
South Fork Teton River	95-A100	Full Support	4.11	55	NA	NA	NA	NA	18	12	6
South Fork Teton River	95-A113	Not Sampled - Deep Water									
Trail Creek	98-E006	Not Assessed	5.13	74			8		42 (28)	43 (28)	38 (21)

Stream	Sample Site ID Number	Cold Water Aquatic Life Support Status as Assessed for the 1998 §303(d) List[1]	MBI Score[2]	% EPT[3]	Embeddedness[4]				Percentage of Bankfull Substrate Consisting of Fine Sediment Particles[5]		
					0-25%	25-50%	50-75%	>75%			
					Optimal: Score16-20	Sub-optimal: Score 11-15	Marginal: Score 6-10	Poor: Score 0-5	< 6 mm Diameter	< 2.5 mm Diameter	< 1 mm Diameter
Warm Creek, Teton County	97-L063	Not Assessed	2.61	14	17				61 (54)	54 (45)	48 (39)
Warm Creek, Madison County	97-L018	Not Assessed	3.36	45	17				79 (75)	48 (41)	31 (24)
Woods Creek	97-L071	Not Assessed	2.51	8	16				81 (68)	71 (51)	65 (40)
Wright Creek	97-L019	Not Assessed	4.68	77			9		59 (33)	41 (12)	41 (11)

[1]BURP data collected in 1995 and 1996 were assessed according to the process described in *1998 §303(d) List* (DEQ 1998b) to determine beneficial use support status; data collected in 1997 and 1998 have not yet been assessed.
[2]Macroinvertebrate biotic index score. An MBI 3.5 indicates full support of cold water aquatic life; an MBI 2.5 indicates cold water aquatic life is not supported (i.e., not full support); an MBI between 2.5 and 3.5 indicates that additional data is required to verify support status (i.e., needs verification).
[3]The percentage of macroinvertebrates belonging to the orders Ephemeroptrera, Plecoptera, and Trichoptera (EPT), which are important food sources for fish. An inverse correlation between % EPT and percentage of fines less than 6 mm has been demonstrated for all BURP sites throughout the state (Mebane 2000).
[4]Embeddedness is a qualitative estimate of the degree to which larger substrate particles in stream riffles are surrounded by fine substrate particles less than 6.35 mm in diameter. Embeddedness is estimated by assigning a score of 0 to 20, with 0 indicating maximum embeddedness and 20 indicating minimum embeddedness.
[5]Calculated using modified Wolman pebble count data. Prior to 1997, pebble counts were conducted across the bankfull width of the stream channel and included particles in the streambanks. Beginning in 1997, pebble counts were conducted 1) across the bankfull width and 2) within the wetted width of the channel. Numbers not enclosed in parentheses are for counts conducted across the bankfull width of the stream; numbers enclosed in parentheses are for counts conducted across the wetted width of the stream channel.
[6]NA indicates there are no numbers in any of the four embededness columns. Empty cells in these columns indicate there is at least one number in one of the four columns.

Appendix I. Analytical Results of Water Quality Samples Collected by DEQ in June, July, and August 2000.

Stream	Site	Date	Discharge (cfs)	pH (su)	Stream Temperature (degrees C)	Specific Conductance (microsiemens/cm)	Total Suspended Solids (mg/L)	Turbidity (NTU)	Total Kjeldahl Nitrogen (mg/L as N)	Nitrate (mg/L as N)
Badger Creek	26	6/14/00	NS	NS	NS	NS	NS	NS	NS	NS
(at Rammel Road)		6/27/00	44.1	7.8	12.1	20	1.6	0.9	0.1	0
		7/26/00	4.2	8	17.3	65	1.1	0.8	0.1	0.02
		8/22/00	0.0							
Darby Creek	20	6/13/00	41.9	8.6	6.7	180	3.1	8.4	0.2	0.09
(west of Highway 33)		6/26/00	2.9	7.8	11.2	170	2	1.3	0	0.03
		7/25/00	0.3	7.6	10	315	0.3	0.9	0	0
		8/21/00	0.0							
Fox Creek	4	6/14/00		8.3	5.2	150	2.8	2	0.1	0.11
(on forest)		6/26/00		8.3	7.1	125	1.8	1.4	0	0.07
		7/25/00		8.4	10.5	150	0	0.4	0.2	0.08
		8/21/00	12.3	8.5	10.4	140	0.8	0.9	0.1	0.09
Fox Creek	3	6/14/00	57.3	8.1	7.7	260	5.1	3.1	0.2	1.07
(IDFG access)		6/26/00	68.8	8.5	15	295	3.3	1	0.2	0.87
		7/25/00	51.9	8.7	18.8	200	4.7	1		
		8/21/00	56.2	8.2	9.6	330	0.4	1.2	0.2	1.09
Horseshoe Creek	13	6/13/00	13.9	8.4	10.3	310	6.1	4.4	0	0.02
(below forest boundary)		6/26/00	8.3	8.5	16.6	290	5.1	3.5	0.1	0
		7/26/00	5.5	8.3	14.5	300	7	5.7	0.2	0
		8/22/00	3.4	8.2	12.8	330	3.5	3.8	0	0
Moody Creek	22	6/15/00		8.5	17.2	140	5.3	2.7	0.2	0.08
(at Woods Crossing)		6/28/00		8.5	20.2	130	8.3	2	0.2	0.03
		7/27/00		8	18.7	180	14.4	2.1	0.2	0.06
		8/24/00		8.1	18.2	230	26.7	4.7	0.2	0.02
Moody Creek	23	6/15/00	2.0	8.4	18.9	135	4.9	3.4	0.2	0
(at Elbow of Moody		6/28/00		8.1		150	12.7	9.8	0.3	0
Creek)		7/27/00	1.2	8.4	23.5	230	13	11	0.2	0.13
		8/24/00	1.2	8.4	19.9	260	0.4	3.7	0.2	0.08
Moody Creek	24	6/15/00	19.7	8.4	16	90	15.2	7.8	0.2	0

Stream	Site	Date	Discharge (cfs)	pH (su)	Stream Temperature (degrees C)	Specific Conductance (microsiemens/cm)	Total Suspended Solids (mg/L)	Turbidity (NTU)	Total Kjeldahl Nitrogen (mg/L as N)	Nitrate (mg/L as N)
(500 m below Enterprise Canal)		6/28/00	3.4	8.2	18.2	140	6.7	4.6	0.2	0.03
		7/27/00	2.9	8.2	21	150	4	4.4	0.2	0.23
		8/24/00	8.9	8.3	22.2	180	7.4	4	0.2	0.29
Moody Creek	25	6/15/00		8.6		150	16.4	6.9	0.2	0.11
		6/28/00		8.4		175	13	4.9	0.4	0.22
		7/27/00		8.4		165	7.8	4	0.4	0.23
		8/24/00		8.4		190	0	5	0.2	0.19
Moose Creek (on forest)	1	6/13/00		8.4	5.7	220	8.9	4	0	0.16
		6/26/00		8.4	7.2	170	3.6	1.4	0	0.14
		7/25/00		8.4	9.7	150	1.6	1.4	0.1	0.15
		8/21/00	47.7	8.5	12.6	170	1.6	1.2	0	0.11
North Fork Teton River (north of city of Teton)	12	6/15/00		8.5		200	5	7.9	0.2	0.18
		6/27/00		8.8		130		2.3	0.2	0.17
		7/27/00		8.4		160	2.2	1.9	0.3	0.22
		8/24/00		8.5		210	0.28	3.3	0.2	0.29
North Leigh Creek (near confluence with Spring Creek)	19	6/14/00	49.7	8.1	7.3	115	4.5	2.2	0.2	0.04
		6/27/00	20.2	8	11.1	110	2.1	1.4	0.1	0
		7/26/00	0.0							
		8/22/00	0.0							
North Fork Teton River (near Henry's Fork)	11	6/15/00		8.3	13.8	165	9.5	4.3	0.2	0.14
		6/28/00		8.8	22.2	160	1.3	1.3	0.2	0.3
		7/27/00		8.6		190	3.8	2.3	0.2	0.25
		8/24/00		9		250	9	4.7	0.2	0.06
North Moody Creek (on forest)	21	6/15/00	6.6	8.4	18.2	60	8.8	5.4	0.2	0
		6/28/00	4.6	8.3	16.4	60	3.3	4	0.2	0
		7/27/00	2.1	8.4	19.2	85	4.1	1.9	0.2	0.04
		8/24/00	1.2	8.4	19.5	100	8.4	2	0.3	0
Packsaddle Creek (below forest boundary)	15	6/13/00	2.9	8.2	11.5	100	2.9	2.7	0.1	0.03
		6/26/00		8.1	14.4	130	1.2	3.5	0.1	0.04
		6/26/00	0.2	7.8	12.7	140	1.1	0.6	0.1	0.06
		8/22/00	0.5	7.8	12.7	120	0	0.6	0	0.04
Packsaddle Creek	14	6/13/00	1.9	8.5	14.9	110	2.3	5.2	0.2	4.16

Stream	Site	Date	Discharge (cfs)	pH (su)	Stream Temperature (degrees C)	Specific Conductance (microsiemens/cm)	Total Suspended Solids (mg/L)	Turbidity (NTU)	Total Kjeldahl Nitrogen (mg/L as N)	Nitrate (mg/L as N)
(Poleline Road)		6/26/00	0.0							
		7/26/00	0.0							
		8/22/00	0.0							
South Fork Teton River	9	6/14/00		8.8	16	200	4.5	3.1	0.2	0.2
(USGS gage in Rexburg)		6/28/00	0.0	8.6	19.3	190	3.4	2.2	0.2	0.09
		7/27/00								
		8/24/00	0.0							
South Fork Teton River	10	6/14/00		8.9	16.8	175	2.8	3	0.3	0.21
(southwest of golf course)		6/28/00		9	23.8	195	1.5	1.8	0.3	0.06
		7/27/00		8		440	3.5	2	0.9	0.18
		8/24/00		7.9		420	2.5	1.6	0.4	3.27
South Leigh Creek	17	6/14/00	94.3	8.2	5.5	80	16.4	1.2	0.2	0.07
(at state line)		6/27/00	61.1	8.2	9.5	60	0.8	0.9	0.1	0
		7/26/00	10.9	8.4	13.9	180	1.2		0.1	0
		8/22/00	7.8	8.5	13.1	200	0	0.5	0.1	0.03
South Leigh Creek	16	6/14/00	21.7	8.2	10.1	165	0.8	0.9	0.2	0.04
(west of Highway 33)		6/27/00	2.6	7.9	16	180	0.5	0.5	0	0
		7/26/00	0.0							
		8/22/00	0.0							
Spring Creek	18	6/14/00		9.9	12	195	12.1	5.4	0.3	0.17
(west of Highway 33)		6/27/00	15.9	8.2	14.2	190	5	2.5	0.2	0.16
		7/26/00	2.5	8.6	18.4	270	3.2	2.9	0.3	0.03
		8/22/00	1.8	8.7	18.8	250	1.7	1.7	0.2	0
Teton Creek	27	6/14/00	NS	NS	NS	NS	NS	NS	NS	NS
(near confluence with Teton River)		6/26/00		8.5	14.7	185	3.1	3.1	0.1	0.92
		7/25/00	54.6	8.7	18.8	260	1.8	1.3	0.3	1.64
		8/21/00	39.1	8.4	10.9	260	1.8	1.6	0.2	2.13
Teton River	6	6/14/00		8.3	6.9	265	15.5	5.4	0.2	0.41
(Cedron Bridge)		6/26/00		8.6	14.6	250	2.4	2.9	0.2	0.55
		7/25/00		8.6	17.7	300	4	2.2	0.2	0.93
		8/21/00		8.5	17.5	320	3	1.8	0.3	0.98
Teton River	5	6/13/00		8.3	9.8	285	12.6	5.2	0.2	0.41
(Bates Bridge)		6/26/00		8.8	18.3	250	1.7	1.5	0.2	0.46

Stream	Site	Date	Discharge (cfs)	pH (su)	Stream Temperature (degrees C)	Specific Conductance (microsiemens/cm)	Total Suspended Solids (mg/L)	Turbidity (NTU)	Total Kjeldahl Nitrogen (mg/L as N)	Nitrate (mg/L as N)
		7/25/00		8.8	22.5	270	1.7	1.8	0.3	0.61
		8/22/00		8.3	15.6	240	2.8	2.9	0.3	0.67
Teton River	7	6/13/00		8.2	12.3	235	24.6	7.1	0.3	0.51
(Cache Bridge)				8.4		265	6.1	2.6	0.2	0.53
				8.4	18.5	290	2.3	1.2	0.2	0.68
				8.4	16.3	290	2.9	3.6	0.2	0.75
Teton River	8	6/14/00		10.2	16.4	200	9.7	2.6	0.3	0.21
(Harrop's Bridge)		6/27/00		8.5	17.8	250	2.7	1.2	0.3	0.18
		7/27/00		8.3	19	310	2.1	2.1	0.4	0.47
		8/22/00		8.5	17.6	270	1.3	1.3	0.3	0.59
Trail Creek	2	6/13/00	45.5	8.3	6.6	300	7.2	3.2	0	0.13
(on forest)		6/26/00	36.0	8.5	7.8	240	4	2.2	0	0.11
		7/25/00	18.8	8.6	12	180	2.5	1.5	0	0.08
		8/21/00	18.9	8.6	16.2	240	5.4	2.1	0.2	0.05
Duplicate										
(collected at Horseshoe	28	6/13/00					6.5		0	0.02
Creek site 13)		6/26/00					5.9		0.1	0
		7/26/00					6.8		0.1	0
		8/22/00					3.9		0.1	0
Field Blanks										
(de-ionized water)	29	6/15/00					0		0.1	0
		6/28/00					0		0	0
		7/25/00					0.3		0.1	0
		8/22/00					0.3		0.1	0

Appendix J. Selected Water Quality Parameters Measured at USGS gage 13055000, *Teton River near St. Anthony*.

Water Year	Month	Date Sampled	Flow (cfs)	Dissolved $NO_2 + NO_3$ (mg/L)	Total P (mg/L)	Suspended Sediment (mg/L)	Suspended Sediment Discharge (Tons/day)	Turbidity (NTU)
October 1977 – September 1978	Oct	19	291	8.20	0.87			
October 1979 – September 1980	Jan	17	480	0.63	0.03			
	May	28	1790	0.17	0.12			
October 1980 – September 1981	Oct	1	526	0.24	0.04			
	July	9	1020	0.08	0.03			
October 1989 – September 1990	Nov	17	494	0.60	<0.01	2		
	Jan	22	352	0.80	0.01			
	March	12	485	0.70	0.03	13	18	
	May	28	1160	0.10	0.01	6	19	
	July	30	862	0.10	0.02			
	Sept	24	633	0.20	<0.01	2	4.1	
October 1992 – September 1993	Nov	16	387	0.70	<0.01	3	3.1	0.7
	Jan	28	383	0.87	<0.01			
	March	16	356	0.65	0.03	6	5.8	4.8
	April	14	469	0.47	0.01	8	10	
		28	510	0.36	0.02	8	11	
	May	5	1200	0.30	0.02	16	52	
		12	1150	0.31	0.02	14	43	4.5
		19	3110	0.19	0.04	29	244	
		25	3650	0.18	0.02	31	306	
	June	2	3470	0.14	<0.01	23	215	
		9	2580	0.22	0.01	18	125	
		16	2450	0.18	<0.01	13	86	
		23	2870	0.14	0.03	25	194	
		30	2040	0.19	0.01	10	55	
	July	7	1890	0.25	0.04	20	102	
		14	1410	0.19	0.02	13	49	
		21	1230	0.26	<0.01	15	50	
		28	1760	0.30	0.03	6	29	
	Aug	4	1060	0.26	<0.01	4	11	
		11	1010	0.30	0.01	5	14	
		18	962	0.34	0.05	10	26	
		25	982	0.35	0.02	4	11	
	Sept	15	748	0.11	0.02	3	6.1	0.3
October 1993 – September 1994	Oct	20	576	0.61	<0.01	4	6.2	
	Nov	17	682	0.66	<0.01	5	9.2	
	Dec	15	664	0.71	<0.01	2	3.6	
	Jan	12	433	0.95	<0.01	4	4.7	
	Feb	16	359	1.00	0.01	38	37	
	March	16	574	0.64	0.03	20	31	
	April	13	495	0.60	0.01	11	15	
	May	2	774	0.32	0.03	8	17	
	June	24	1270	0.26	0.04	8	27	
		13	979	0.16	0.03	11	29	

Water Year	Month	Date Sampled	Flow (cfs)	Dissolved $NO_2 + NO_3$ (mg/L)	Total P (mg/L)	Suspended Sediment (mg/L)	Suspended Sediment Discharge (Tons/day)	Turbidity (NTU)
October 1993 – September 1994	June	29	796	0.09	<0.01	7	15	
	July	20	632	0.11	0.02	5	8.5	
	Aug	17	618	0.14	<0.01	9	15	
	Sept	7	668	0.17	<0.01	6	11	
October 1994 – September 1995	Oct	6	763	0.44	0.01	7	14	
	Nov	2	389	0.55	<0.01	3	3.2	
	Dec	6	361	0.70	<0.01	38	37	
	Jan	10	361	0.87	0.03	6	5.8	
	Feb	15	413	0.73	<0.01	6	6.7	
	March	15	710	0.50	0.02	14	27	
	April	11	715	0.64	<0.01	10	19	
	May	9	1340	0.33	0.04	15	54	
		23	2710	0.24	0.05	27	198	
	June	13	3130	0.24	0.03	36	304	
	July	5	3010	0.18	0.02	12	98	
October 1995 – September 1996	April	17	763	0.48	0.04	17	35	4.5
	May	28	2910	0.27	0.03	28	220	6.4
	June	28	2680	0.18	<0.01	10	72	2
	July	23	1120	0.32	<0.01	5	15	1.5
	Aug	23	772	0.41	<0.01	4	8.3	0.8
	Sept	25	814	0.57	<0.01	1	2.2	0.4

Appendix K. Concentrations of Nitrogen, Total Phosphorus, and Suspended Solids Collected from the Mouth of Bitch Creek and Where Bitch Creek Crosses the National Forest Boundary

Table K-1. Concentrations of $NO_2 + NO_3$ and Kjeldahl nitrogen in samples collected from Bitch Creek at the mouth of Bitch Creek and the National Forest boundary.

	$NO_2 + NO_3$ (mg/L as N)								Kjeldahl Nitrogen (mg/L as N)							
	1995		1996		1997		1998		1995		1996		1997		1998	
Date	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth
2-12							0.11	0.82							0.27	0.35
2-18					0.11	0.89							0.10	0.16		
2-19							0.09	0.92							0.22	0.64
3-1							0.08	0.93							0.12	0.22
3-7							0.10	0.88							0.17	0.21
3-13					0.12	0.98							0.06	0.12		
3-14							0.08	0.93							0.15	0.27
3-17							0.06	0.77							0.15	0.25
3-18				1.02	0.12	0.89						0.20	0.11	0.16		
3-20					0.13	0.88							0.2	0.21		
3-28				1.05	0.05	0.49						0.24	0.13	0.21		
3-29							0.08	0.52							0.12	0.21
3-31							0.08	0.54							0.18	0.26
4-1					0.08	0.59							0.32	0.34		
4-4					0.06	0.58							0.12	0.28		
4-7							0.05	0.58							0.28	0.43
4-11					0.01	0.41							0.23	0.26		
4-15			0.09	0.53	0.01	0.34					0.22	0.28	0.12	0.20		
4-16							0.03	0.51							0.28	0.40
4-18					0.25	0.03							0.38	0.27		

Date	$NO_2 + NO_3$ (mg/L as N)								Kjeldahl Nitrogen (mg/L as N)							
	1995		1996		1997		1998		1995		1996		1997		1998	
	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth
4-22					0.02	0.13							0.40	0.42		
4-23							0.09	0.24							0.30	0.56
4-25					0.01	0.08							0.18	0.21		
4-28							0.05	0.21							0.58	0.40
4-30			0.04	0.33							0.14	0.31				
5-2					0.03	0.18							0.25	0.28		
5-6					0.02	0.10							0.36	0.10		
5-8							0.05	0.11							0.42	0.42
5-9					0.07	0.12							0.37	0.45		
5-13					0.07	0.07							0.11	0.30		
5-15	0.01	0.094	0.06	0.09	0.04	0.06			0.20	0.2	0.52	0.53	0.30	0.42		
5-21					0.05	0.07							0.21	0.26		
5-30	0.035	0.05	0.09	0.14	0.06	0.07			0.30	0.4	0.3	0.50	0.12	0.30		
6-3					0.06	0.28							0.43	0.13		
6-11			0.05	0.10	0.04	0.06					0.24	0.33	0.17	0.19		
6-20	0.032	0.076			0.05	0.08			0.3	0.2			0.025	0.10		
6-26	0.026	0.066	0.04	0.11	0.03	0.10			0.20	0.6	0.22	0.37	0.37	0.27		
7-2					0.01	0.11							0.31	0.21		
7-9			0.028	0.157							0.27	0.23				
7-14					0.01	0.11							0.13	0.18		
7-18	0.021	0.088			0.01	0.10			0.10	0.10			0.17	0.18		
7-23			0.02	0.28							0.22	0.26				
7-31	0.0025	0.185							0.20	0.2						
8-5			0.04	0.47							0.15	0.19				

Date	$NO_2 + NO_3$ (mg/L as N)								Kjeldahl Nitrogen (mg/L as N)							
	1995		1996		1997		1998		1995		1996		1997		1998	
	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth
8-14	0.0025	0.038							0.06	0.19						
8-20			0.04	0.58							0.28	0.26				
8-28	0.02	0.615							0.34	0.18						
9-5			0.03	0.66							0.12	0.16				
9-11	1.18	1.94							0.18	0.23						
9-17			0.04	0.62							0.09	0.15				
9-25	0.55	1.65							0.50	0.66						
10-3			0.04	0.76							0.12	0.17				
10-12	1.23	1.73							0.90	0.20						
10-17			0.04	0.85							0.11	0.16				
10-23	0.41	1.04							0.14	0.09						
11-5	0.064	0.986	0.06	0.74					0.15	0.19	0.08	0.13				

Table K-2. Concentrations of total phosphorus in samples collected from the mouth of Bitch Creek and at the National Forest boundary.

	Total Phosphorus (mg/L as P)							
	1995		1996		1997		1998	
Date	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth
2-12							0.017	0.021
2-18					0.009	0.019		
2-19							0.017	0.029
3-1							0.0025	0.015
3-7							0.0025	0.013
3-13					0.012	0.02		
3-14							0.006	0.006
3-17							0.005	0.014
3-18				0.045	0.011	0.019		
3-20					0.024	0.023		
3-28				0.027	0.018	0.037		
3-29							0.022	0.028
3-31							0.016	0.024
4-1					0.02	0.04		
4-4					0.016	0.031		
4-7							0.02	0.03
4-11					0.02	0.03		
4-15			0.024	0.037	0.017	0.025		
4-16							0.029	0.034
4-18					0.048	0.035		
4-22					0.07	0.084		
4-23							0.086	0.086
4-25					0.032	0.063		
4-28							0.095	0.06
4-30			0.027	0.038				
5-2					0.021	0.033		
5-6					0.026	0.044		
5-8							0.03	0.088
5-9					0.042	0.072		
5-13					0.033	0.047		
5-15	0.025	0.035	0.084	0.13	0.063	0.086		
5-21					0.021	0.033		

	Total Phosphorus (mg/L as P)							
	1995		1996		1997		1998	
Date	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth
5-30	0.053	0.05	0.019	0.059	0.033	0.045		
6-3					0.043	0.051		
6-11			0.046	0.067	0.017	0.019		
6-20	0.098	0.038			0.013	0.013		
6-26	0.024	0.105	0.015	0.02	0.011	0.013		
7-2					0.016	0.01		
7-9			0.012	0.015				
7-14					0.007	0.0025		
7-18	0.054	0.019			0.0025	0.007		
7-23			0.011	0.013				
7-31	0.013	0.022						
8-5			0.009	0.012				
8-14	0.014	0.015						
8-20			0.03	0.021				
8-28	0.012	0.013						
9-5			0.009	0.014				
9-11	0.012	0.029						
9-17			0.006	0.012				
9-25	0.006	0.032						
10-3			0.008	0.013				
10-12	0.017	0.011						
10-17			0.01	0.016				
10-23	0.012	0.02						
11-5	0.009	0.016	0.007	0.014				

Table K-3. Concentrations of total suspended solids in samples collected from the mouth of Bitch Creek and at the National Forest boundary.

	Discharge (cfs)								Total Suspended Solids (mg/L)							
	1995	1995	1996	1996	1997	1997	1998	1998	1995	1995	1996	1996	1997	1997	1998	1998
Date	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth
2-12							14	24							2	2
2-18					26	36							1	2		
2-19							13	23							2	2
3-1							36	52							2	2
3-7							41	58							2	2
3-13					25	35							1	1		
3-14							37	53							2	2
3-17							15	24							2	2
3-18				45	40	56						1	3	1		
3-20					37	52							2	2		
3-28				59	58	80						1	6	4		
3-29							65	93							6	3
3-31							38	54							7	3
4-1					52	72							4	4		
4-4					45	55							1	2		
4-7							29	79							2	2
4-11					33	54							7	9		
4-15			68	131	48	63					5	8	3	3		
4-16							46	78							2	4
4-18					127	176							29	12		
4-22					96	134							35	12		
4-23							132	186							6	21
4-25					81	112							4	10		
4-28							204	288							2	2
4-30			125	219							10	5				
5-2					75	104							7	8		
5-6					78	109							6	11		
5-8							226	319							9	28

	Discharge (cfs)								Total Suspended Solids **(mg/L)**							
	1995	1995	1996	1996	1997	1997	1998	1998	1995	1995	1996	1996	1997	1997	1998	1998
Date	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth	Forest	Mouth
5-9					114	159							9	37		
5-13					180	250							15	22		
5-15	309	321	310	443	216	300			3	6	53	85	54	82		
5-21					257	357							18	24		
5-30	285	297	365	522	254	353			44	41	12	46	42	44		
6-3					313	435							52	64		
6-11			585	836	341	473					42	67	57	50		
6-20	262	271			276	384			17	14			46	66		
6-26	250	252	303	433	166	231			18	90	7	14	4	1		
7-2					144	200							6	6		
7-9			222	317							3	5				
7-14					116	161							2	2		
7-18	220	221			96	133			29	10			3	1		
7-23			132	181							3	4				
7-31	177	179							1	4						
8-5			93	107							1	1				
8-14	88	99							2	1						
8-20			57	66							10	4				
8-28	39	76							1	1						
9-5			49	65							1	1				
9-11	46	56							1	1						
9-17			50	62							1	2				
9-25	40	56							1	1						
10-3			37	45							1	2				
10-12	46	56							1	3						
10-17			25	31							1	1				
10-23	24	55							3	3						
11-5	20	54	22	32					2	2	1	1				

Appendix L. Concentrations of Nutrients in Samples Collected from the Teton River.

Table L-1. Concentrations of $NO_2 + NO_3$ or NO_3 in samples collected from the upper Teton River 1986 - 1990. Concentrations of $NO_2 + NO_3$ or NO_3 greater than 0.3 mg/L are highlighted with *italic* type.

Date	Teton River above Horseshoe Creek[1] $NO_2 + NO_3$ (mg/L as N)	Teton River at Highway 33 (Harrop's Bridge)[1] $NO_2 + NO_3$ (mg/L as N)	Teton River above Confluence of Milk Creek[2] NO_3 (mg/L as N)	Teton River below Confluence of Milk Creek[2] NO_3 (mg/L as N)	Teton River 0.1 mile above the Confluence of Canyon Creek[3] $NO_2 + NO_3$ (mg/L as N)	Teton River 0.2 mile below the Confluence of Canyon Creek[3] $NO_2 + NO_3$ (mg/L as N)
5/14/86				*0.519*		
6/11/86			0.141			
7/10/86				*0.455*		
4/6/87					*0.611*	*0.567*
4/14/87					*0.732*	*0.771*
5/5/87					*0.321*	0.289
5/29/87					0.226	0.233
7/7/87					*0.358*	*0.368*
10/25-26/88	*0.55*	*0.33A*[4]				
11/28-29/88	*0.58*	*0.43*				
2/27-28/89	*0.75*	*0.71A*				
3/13-14/89	*0.62*	0.314				
3/27-28/89	*0.58*	*0.42A*				*0.66*
4/10-11/89	*0.87*	*0.58A*				*0.57*
4/25-26/89	*0.86*	*0.60A*				*0.51*
5/30-31/89	*0.34*	*0.37*				*0.33*
6/12-13/89	0.13	0.15A				0.26
6/26/89						*0.39*
7/24-25/89	*0.52*	*0.50A*				*0.38*
2/20/90	*0.95*					
4/11-12/90	*0.58*	*0.35A*				*0.48*

Date	Teton River above Horseshoe Creek[1] $NO_2 + NO_3$ (mg/L as N)	Teton River at Highway 33 (Harrop's Bridge)[1] $NO_2 + NO_3$ (mg/L as N)	Teton River above Confluence of Milk Creek[2] NO_3 (mg/L as N)	Teton River below Confluence of Milk Creek[2] NO_3 (mg/L as N)	Teton River 0.1 mile above the Confluence of Canyon Creek[3] $NO_2 + NO_3$ (mg/L as N)	Teton River 0.2 mile below the Confluence of Canyon Creek[3] $NO_2 + NO_3$ (mg/L as N)
4/22-23/90	*0.44*	*0.22A*				0.25
5/16-17/90		0.05K[5]				0.005K

[1]Source: Drewes (1993) [2]Source: Drewes (1988) [3]Source for 1987 data: Drewes (1987); source for 1989-90 data: Drewes (1993).
[4]A: Represents average of more than one value. [5]K: Non-ideal analytical range.

Table L-2. **Concentrations of orthophosphorus (ortho P) and $NO_2 + NO_3$ (mg/L as N) in samples collected from Teton River tributaries since 1988. Concentrations of $NO_2 + NO_3$ or NO_3 greater than 0.3 mg/L are highlighted with *italic* type.**

Date	Fox Creek near Confluence with Teton River[1]		Horseshoe Creek near Confluence with Teton River[2]		Packsaddle Creek near Confluence with Teton River[2]		Spring Creek near Confluence with Teton River[2]		South Leigh Creek near Confluence with Teton River[2]	
	Ortho P (mg/L as P)	$NO_2 + NO_3$ (mg/L as N)	Ortho P (mg/L as P)	$NO_2 + NO_3$ (mg/L as N)	Ortho P (mg/L as P)	$NO_2 + NO_3$ (mg/L as N)	Ortho P (mg/L as P)	$NO_2 + NO_3$ (mg/L as N)	Ortho P (mg/L as P)	$NO_2 + NO_3$ (mg/L as N)
10/25-26/88							0.001K[3]	0.001K		
4/25-26/89			0.006	0.10	0.016	0.06				
5/30-31/89			0.006	0.007	0.030	0.04	0.042	0.16	0.001K	0.03
6/12-13/89			0.001K	0.003	0.001K	0.002	0.001K	0.10	0.001K	0.09
6/26/89					0.001K	0.001K				
7/24-25/89							0.001K	0.16	0.001K	0.02
4/11-12/90			0.01	0.005K	0.033	0.005K				
4/22-23/90			0.005K	0.02	0.027	0.009				
5/16-17/90			0.007		0.015	0.005K	0.006	0.005K		
8/1/98	0.017	*0.85*								
6/99	0.009	*0.789*								
8/12/99	0.008	*1.192*								
10/3/99	<0.001	*1.154*								

[1]Source for 1998 data: Thomas *et al*. (1999); source for 1999 data: Minshall (2000)
[2]Source: Drewes (1993) [3]K: Non-ideal analytical range.

Table L-3. Concentrations of orthophosphorus (ortho P) and $NO_2 + NO_3$ (mg/L as N) in samples collected from Teton River tributaries from 1986 to 1990. Concentrations of $NO_2 + NO_3$ or NO_3 greater than 0.3 mg/L are highlighted with *italic* type.

	Badger Creek at Forest Boundary[1]		Bull Elk Creek at Confluence with Badger Creek[1]		Badger Creek at Confluence with Teton River[1]		Bitch Creek at Forest Boundary[1]		Bitch Creek at Confluence with Teton River[1]		Milk Creek at Highway 33[2]		Canyon Creek at Confluence with Teton River[3]	
Date	Ortho P (mg/L as P)	$NO_2 + NO_3$ (mg/L as N)	Ortho P (mg/L as P)	$NO_2 + NO_3$ (mg/L as N)	Ortho P (mg/L as P)	$NO_2 + NO_3$ (mg/L as N)	Ortho P (mg/L as P)	$NO_2 + NO_3$ (mg/L as N)	Ortho P (mg/L as P)	$NO_2 + NO_3$ (mg/L as N)	Ortho P (mg/L as P)	NO_3 (mg/L as N)	Ortho P (mg/L as P)	$NO_2 + NO_3$ (mg/L as N)
4/29/86												0.081		
5/14/86												0.069		
5/28/86												0.006		
6/11/86												0.004		
6/25/86												0.010		
3/31/87													0.062	0.230
4/6/87													0.005	0.144
4/14/87													0.069	0.152
5/5/87													0.042	0.048
5/29/87													0.067[4]	0.074
7/7/87													0.017	0.100
10/25-26/88					0.007	*0.95*	0.005K[5]	*1.13*	0.001K	0.003				
2/28/89													0.009	0.04
3/27/89													0.001K	0.07
4/11/89													0.001K	0.11
4/25-26/89	0.005	0.25	0.029	*0.58*	0.011	*0.58*			0.010	0.28			0.022	0.18
5/30-31/89	0.003	0.02	0.017	0.06	0.004	0.29	0.006	0.03	0.001K	0.07			0.010	0.06
6/12-13/89	0.001K	0.006	0.026	0.03	0.001K	0.27	0.001K	0.04					0.001K	0.05
6/26/89									0.001K	0.08			0.003	*0.42*
7/24-25/89	0.001K	0.01			0.001K	*0.88*	0.002	0.001K	0.001K	0.24				

Date	Badger Creek at Forest Boundary [1]		Bull Elk Creek at Confluence with Badger Creek[1]		Badger Creek at Confluence with Teton River[1]		Bitch Creek at Forest Boundary [1]		Bitch Creek at Confluence with Teton River[1]		Milk Creek at Highway 33[2]		Canyon Creek at Confluence with Teton River[3]	
	Ortho P (mg/L as P)	NO_2 + NO_3 (mg/L as N)	Ortho P (mg/L as P)	NO_2 + NO_3 (mg/L as N)	Ortho P (mg/L as P)	NO_2 + NO_3 (mg/L as N)	Ortho P (mg/L as P)	NO_2 + NO_3 (mg/L as N)	Ortho P (mg/L as P)	NO_2 + NO_3 (mg/L as N)	Ortho P (mg/L as P)	NO_3 (mg/L as N)	Ortho P (mg/L as P)	NO_2 + NO_3 (mg/L as N)
2/20/90	0.002A[6]	0.10A												
4/11-12/90	0.007	0.02	0.041	*0.51*	0.005K	*0.60*	0.010	0.03					0.023	0.005K
4/22-23/90	0.006	0.05	0.041	0.14	0.010	0.29	0.005 K	0.05					0.019	0.05
5/16-17/90	0.005K	0.005K	0.015	0.005K	0.005K	*0.50*	0.005K	0.005K					0.008	0.005K

[1]Source: Drewes (1993) [2]Source: Drewes (1988) [3]Source for 1987 data: Drewes (1987); source for 1989-90 data: Drewes (1993).
[4]A: Represents average of more than one value. [5]K: Non-ideal analytical range. [6]A: Represents average of more than one value

Appendix M. Determination of Temperature Criteria Violations in the Teton River Canyon.

1. The 90th percentile value for the maximum seven-day average air temperature was calculated using historical data available from the BOR AgriMet station at Rexburg. The maximum seven-day average air temperatures and the dates they occurred in 1987 through 2000 are listed in Table M-1.

Table M-1. Maximum seven-day average temperature.

Year	*MAXIMUM SEVEN-DAY AVERAGE TEMPERATURE*		Dates
	°Celsius	°Fahrenheit	
1987	29.8	85.6	July 24 – 30
1988	31.8	89.2	June 19 – 25
1989	33.3	91.9	July 25 – 31
1990	33.2	91.7	August 4 – 10
1991	31.4	88.6	August 8 – 14
1992	32.8	91.1	August 8 – 14
1993	27	80.6	September 5 – 11
1994	33.6	92.4	August 2 – 8
1995	30.4	86.7	August 22 – 28
1996	32.3	90.1	August 8 – 14
1997	31.5	88.7	August 20 – 26
1998	32.6	90.7	August 5 – 11
1999	30.4	86.7	August 17 – 23
2000	34.4	93.9	July 27 – August 2

The 90th percentile value based on these maximum seven-day average air temperatures is 33 °C (92.3 °F).

2. Three air temperature data loggers were deployed by the BOR in the canyon reach of the Teton River. Temperatures recorded by data loggers 2 and 9 exceeded 45 °C (113 °F), indicating that the loggers were directly exposed to sunlight and data were not representative ambient air temperatures. Data logger 7 was located in a tree at Spring Hollow and was apparently shaded from direct sunlight. The temperatures recorded by this data logger were therefore used to determine which dates the 90th percentile value for the maximum seven-day average air temperature was exceeded. These dates are highlighted in Table M-2, and indicate the dates when exceedances of cold water aquatic life temperature criteria are not considered violations of Idaho's water quality standards.

Table M-2. Data logger daily temperatures.

Date	High for Day		Low for Day		Average for Day	
	°C	°F	°C	°F	°C	°F
7/19/98	39.7	103.5	24.8	76.6	31.7	89.0
7/20/98	**34.4**	**93.9**	**19.8**	**67.6**	**24.7**	**76.4**
7/21/98	33.2	91.8	11.8	53.2	22.1	71.7
7/22/98	33.2	91.8	10.6	51.1	21.7	71.1
7/23/98	**34.9**	**94.8**	**15.6**	**60.1**	**23.2**	**73.8**
7/24/98	29.1	84.4	14.4	57.9	19.9	67.8
7/25/98	32.8	91.0	12.2	54.0	21.0	69.7
7/26/98	**35.3**	**95.5**	**11.8**	**53.2**	**22.0**	**71.6**
7/27/98	**36.6**	**97.9**	**15.6**	**60.1**	**23.6**	**74.4**
7/28/98	**33.6**	**92.5**	**12.9**	**55.2**	**21.2**	**70.2**
7/29/98	30.3	86.5	12.2	54.0	19.5	67.1
7/30/98	30.3	86.5	11.8	53.2	20.5	68.8
7/31/98	**34.9**	**94.8**	**11.4**	**52.5**	**18.9**	**66.1**
8/1/98	25.6	78.1	10.6	51.1	17.0	62.6
8/2/98	26.8	80.2	9.8	49.6	17.8	64.0
8/3/98	29.5	85.1	8.7	47.7	18.7	65.6
8/4/98	31.1	88.0	9.4	48.9	19.3	66.7
8/5/98	32.8	91.0	11.4	52.5	21.1	70.0
8/6/98	**34.9**	**94.8**	**11.4**	**52.5**	**22.9**	**73.1**
8/7/98	**33.6**	**92.5**	**13.3**	**55.9**	**22.4**	**72.4**
8/8/98	32.8	91.0	10.6	51.1	22.1	71.7
8/9/98	33.2	91.8	10.6	51.1	20.8	69.4
8/10/98	31.5	88.7	9.1	48.4	18.8	65.9
8/11/98	32.8	91.0	10.6	51.1	20.4	68.7
8/12/98	32.8	91.0	12.9	55.2	21.9	71.5
8/13/98	**33.6**	**92.5**	**11.4**	**52.5**	**21.4**	**70.5**
8/14/98	**33.6**	**92.5**	**12.2**	**54.0**	**21.6**	**70.9**
8/15/98	30.7	87.3	9.8	49.6	17.7	63.8
8/16/98	30.7	87.3	12.6	54.7	20.5	68.9
8/17/98	29.5	85.1	11.4	52.5	19.4	66.9
8/18/98	27.2	81.0	13.7	56.7	18.9	66.0
8/19/98	28.3	82.9	11	51.8	17.9	64.1
8/20/98	29.9	85.8	9.8	49.6	18.5	65.3
8/21/98	30.3	86.5	10.2	50.4	16.8	62.2
8/22/98	29.5	85.1	9.4	48.9	18.4	65.0
8/23/98	28.7	83.7	7.8	46.0	17.7	63.9
8/24/98	26.8	80.2	5.4	41.7	15.0	59.1
8/25/98	31.5	88.7	5.4	41.7	18.5	65.3
8/26/98	26.4	79.5	10.6	51.1	18.6	65.4
8/27/98	27.6	81.7	6.6	43.9	16.3	61.3
8/28/98	31.5	88.7	7.4	45.3	18.1	64.7
8/29/98	32.3	90.1	9.8	49.6	19.5	67.0
8/30/98	31.9	89.4	11	51.8	19.7	67.4
8/31/98	**33.6**	**92.5**	**10.2**	**50.4**	**20.2**	**68.4**
9/1/98	31.9	89.4	8.7	47.7	19.1	66.4

Date	High for Day		Low for Day		Average for Day	
	°C	°F	°C	°F	°C	°F
9/2/98	31.9	89.4	10.6	51.1	19.4	66.9
9/3/98	33.2	91.8	11.4	52.5	20.2	68.3
9/4/98	33.2	91.8	10.2	50.4	21.1	69.9
9/5/98	**34**	**93.2**	**13.7**	**56.7**	**21.7**	**71.0**
9/6/98	27.9	82.2	14.8	58.6	19.5	67.0
9/7/98	30.3	86.5	12.6	54.7	20.1	68.2
9/8/98	27.6	81.7	14.4	57.9	18.4	65.0
9/9/98	21.7	71.1	12.9	55.2	16.1	61.0
9/10/98	24.4	75.9	16.8	62.2	19.9	67.7