UPPER HENRY'S FORK SUBBASIN ASSESSMENT

Final

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Hydrologic Unit Code	17040202	*Pollutants of Concern*	Dissolved Oxygen, Sediment
1996 Water Quality-Limited Waterbodies	Henry's Lake Henry's Fork	*Major land uses*	Agriculture, Recreation Forestry, Recreational Development
	(Buffalo River to Riverside Reach)	*Area*	1,068 square miles
Beneficial Uses Affected	Cold Water Biota Salmonid Spawning	*Population (1990)*	3,285

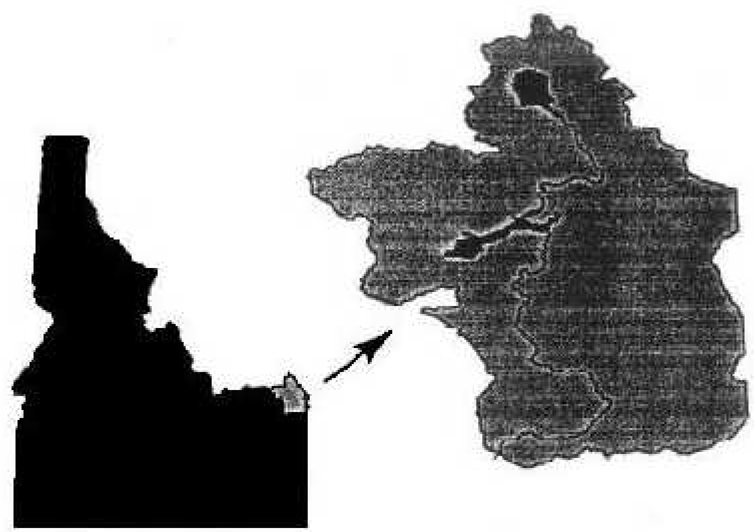


Figure 1. Location of the Upper Henry's Fork subbasin, origin of the Henry's Fork of the Snake River.

Introduction

The Upper Henry's Fork subbasin, located in northeastern Idaho, is the origin of the Henry's Fork of the Snake River (Figure 1). The subbasin encompasses 1,068 square miles, including 30 square miles in Wyoming and 60 square miles in Yellowstone National Park (USEPA 1998; Whitehead 1978). The northern extent of the subbasin is bounded by the continental divide, which also delineates the boundary between Idaho and Montana. For the purpose of this assessment, the eastern boundary of the subbasin ends at the Idaho border although the natural subbasin boundary, which is marked topographically by the Yellowstone Plateau, meanders east and west of the Idaho-Wyoming state line. The western and southern extent of the subbasin does not coincide with any political boundaries but is instead marked by the northeastern extent of the Snake River Plain geologic formation.

The subbasin is located within the Greater Yellowstone Ecosystem and possesses many of the unique geological, scenic, recreational, and wildlife attributes for which Yellowstone National Park is valued. The majority of the subbasin is managed by the U.S. Forest Service (USFS), and the economy of the region has historically been based on livestock grazing and timber production, with cultivated agriculture limited to the most southern edge of the subbasin. Irrigated agricultural lands outside the subbasin are supplied with water stored in two subbasin reservoirs: Henry's Lake and Island Park. A large and growing population of rural summer residents are concentrated in the Henry's Lake and Island Park regions, but most permanent residents live at the southern-most end of the subbasin at Ashton.

The quality of surface waters within the subbasin is generally good, with almost half of the water derived from springs in nearly pristine condition. The northern portion of the subbasin is geologically rich in phosphorus, and the highly enriched waters of Henry's Lake support a trophy trout fishery. The Henry's Fork fishery has an international reputation among flyfishers, and anglers drawn to the area are increasingly important to the local economy.

Nomenclature: Henrys or Henry's?

The Henry's Fork of the Snake River and other similarly named features within the subbasin were named for Andrew Henry. A partner in the Missouri Fur Company, Henry lead a party of eighty trappers in 1810 from the Three Forks area of Montana south through the basin that would eventually carry his name. The party over-wintered near the current location of the town of St. Anthony, and left the region soon thereafter (Brooks 1986). According to U.S. Geological Survey (USGS) maps and hydrologic cataloging system, Henry's is spelled without the apostrophe that indicates possessive case; the Idaho Water Resource Board followed the same convention when writing the water plan for the Henry's Fork basin (IWRB 1992). In common usage, the name is spelled as a possessive noun, and that is the convention followed in this report.

Authorization and Purpose

This subbasin assessment was prepared pursuant to the Idaho 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 (USEPA) Water Quality Planning and Management Regulations (40 CFR Part 130.7).

Legislative efforts to protect the quality of the nation's waters began almost a century ago with passage of the Rivers and Harbors Act in 1899. This act, which prohibited the deposition of waste materials in or on the banks of navigable waters and their tributaries, was followed by the Federal Water Pollution Control Acts (FWPCA) of 1912, 1948, and 1972, and the Water Quality Act of 1965 (Foster 1985). The FWPCA of 1972 was amended by the Clean Water Act of 1977 and is commonly known as the Clean Water Act (CWA). The CWA underwent additional major revision in 1987.

The objective of the 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 "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 USEPA. With oversight from the USEPA, the states are then responsible for developing a total maximum daily load (TMDL) for the pollutant or pollutants responsible for impairment of each waterbody (USEPA 1996).

The goal of the TMDL is to restore the impaired waterbody to a condition which meets state water quality standards. According to the USEPA (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).

An eight-year schedule for development of TMDLs in Idaho was finalized in 1997 by the Idaho Department of Health and Welfare, Division of Environmental Quality (DEQ), and the Region 10 Office of the USEPA. Background information regarding development of this schedule is contained in Appendix B.

Idaho's TMDL development schedule describes the mechanism for completing TMDLs for 962 waterbodies identified in Idaho's 1994 § 303(d) list. Twelve waterbodies, which are severely polluted or subject to further impairment, have been identified for short-term, high-priority TMDL development. All remaining waterbodies, including those within the Upper Henry's Fork subbasin, are being addressed through development of subbasin TMDLs.

The subbasin TMDL is a three-step process that includes 1) preparation of a subbasin assessment, 2) development of a TMDL or Watershed Management Plan, and 3) development of 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 identification of those waterbodies that a) require development of a TMDL, b) may be removed from the 1994 § 303(d) list because they are not impaired, c) may be removed from the 1994 § 303(d) list because nonpoint source management and control activities are planned or have been implemented, or d) are candidates for § 303(d) listing.

If the subbasin assessment demonstrates that a waterbody identified on Idaho's 1994 § 303(d) list is not water quality-impaired and does not require development of a TMDL, DEQ will develop a revised § 303(d) list which excludes that waterbody. If the USEPA approves the revised list, a TMDL will not be developed for the excluded waterbody. Conversely, if the subbasin assessment demonstrates that a waterbody is water quality-impaired, the waterbody will be included on the next § 303(d) list prepared for submission to USEPA. Development of a TMDL or management and control plan for newly listed waterbodies will be delayed 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.

Acknowledgments

Many people contributed to this document. We are especially grateful to all the participants of the Henry's Fork Watershed Council who gave much of their time and energy to provide valuable information and guidance during the subbasin assessment and document review processes. We also extend our thanks to members of the Upper Snake Basin Advisory Group for their guidance.

Although by acknowledging particular individuals, we risk excluding some one who should not be excluded, we wish to name those whose extra efforts were particularly appreciated. We are especially grateful for the information, data, hours of discussion and review, assistance and recommendations provided by the following members of the Council's Water Quality Subcommittee: Ken Beckman, Lyn Benjamin, Bob Breckenridge, Jan Brown, Mark Gamblin, Bob Martin, Brad Orme, Dave Rydalch, Ronna Simon, Dale Swensen, and Rob Van Kirk. Our thanks to the following individuals who reviewed the draft version of this document and offered suggestions for improving it: Ken Beckman, Natural Resources Conservation Service; Bill Bradford, Idaho Area Soil Conservation Districts; Jan Brown, Henry's Fork Foundation; Don Essig, DEQ; Jeannie Fullen, Hemy's Lake Foundation; John R. Macmillan, Upper Snake Basin Advisory Group; Dirk Mace and Board of Supervisors, Yellowstone Soil Conservation District; Dave Rydaich, North Fork Reservoir Company; Ronna Simon, Targhee National Forest; Rob Van Kirk, Department of Biological Sciences, Idaho State University; and Leigh Woodruff, U.S. Environmental Protection Agency. Finally, we are grateful to those who provided information whenever requested: Dennis Dunn and Paul Meyer, Idaho Department of Water Resources; David Frederick, INEEL Oversight Program; Tom Herron, DEQ; Karen Lords, Fremont County Planning and Zoning; Alan May and Trent Stumph, Idaho Nature Conservancy; and Jerry Woods, District Seven Health Department.

Physical Characteristics of the Upper Henry's Fork Subbasin

Climate

The climate of the Upper Henry's Fork subbasin is generally considered the harshest in the state because of cold winter temperatures. The record low statewide temperature of -60°F was recorded at Island Park in 1943 (Abramovich et al. 1998). According to long-term records collected at National Weather Service and Natural Resource Conservation Service (NRCS) climate stations, average monthly temperatures range from a minimum of approximately 2°F at Island Park in January to a maximum of 81°F at Ashton in July (Table 1). Temperature extremes for the subbasin recorded from 1961 to 1990 include a low of -54°F at Island Park in 1982 and highs of 96°F at Island Park and Ashton in 1961 (ISCS 1998). The number of days that exceed a minimum temperature of 32°F is generally less than 40 at Island Park and less than 70 at Ashton, making the growing season throughout the subbasin relatively brief (Tables 2 and 3).

Winter and spring weather patterns throughout Idaho are influenced by westerly winds from the Pacific Ocean. The relatively warm, moist Pacific air masses often encounter cold, stationary continental air masses along the axis of the Rocky Mountains. As the Pacific air masses are forced to rise over the colder continental air masses and mountain crests, water vapor cools, condenses, and precipitates as snow. Beginning in May or June, Idaho's precipitation patterns are influenced by a ridge of subtropical high pressure that develops along the west coast. Because the air mass flowing southeastward from this ridge over the Pacific Northwest is dry, the state receives relatively little precipitation throughout the summer months. These seasonal precipitation patterns are reflected in values for seasonal humidity and incident sunlight in the Upper Henry's Fork subbasin. Average relative humidity is 65 to 70 percent in winter but only 30 percent in summer; possible sunshine is only 40 percent in winter but 70 percent in summer (Ross and Savage 1967).

Monthly precipitation records for the Upper Henry's Fork subbasin are also consistent with regional weather patterns. Most annual precipitation falls as snow, and precipitation is at its lowest levels from July through October (Table 1). Because of the differences in mean monthly temperature between the central and southern portions of the subbasin, Island Park receives more than twice as much snow as Ashton, but only 50 percent more total precipitation.

The variations in temperature and precipitation throughout the subbasin are due primarily to variations in elevation. Generally, as elevation decreases, annual snowfall and total precipitation decrease. Because the general slope of the subbasin is toward the southwest, the southern portion of the subbasin is driest. Mean annual precipitation decreases from 46 inches at the White Elephant snow telemetry (Snotel) station located in the northcentral portion of the subbasin at 7710 feet, to 31 inches at the Island Park Snotel station located in the central

Table 1. Summary of climate data collected from February 1, 1937 to June 30, 1997 at Island Park[1] and from August 1, 1948 to June 30, 1997 at Aston[2].

Period	Average Maximum Temperature (ºF)		Average Minimum Temperature (ºF)		Average Total Precipitation (Inches)		Average Total Snowfall (Inches)		Average Snow Depth (Inches)	
	Island Park	Ashton	Island Park	Ashton	Island Park	Ashton	Island Park	Ashton	Island Park	Ashton
January	25.9	27.9	1.9	9.2	3.76	2.11	47.6	22.5	38	19
February	31.6	33.3	4.0	12.7	3.14	1.81	37.5	16.7	48	23
March	37.9	40.5	9.5	18.6	2.58	1.57	29.4	11.2	49	17
April	48.0	53.1	21.1	28.1	1.93	1.45	12.0	4.5	30	2
May	59.5	64.9	31.1	36.3	2.44	2.10	4.1	1.5	3	0
June	68.8	73.3	37.7	42.5	2.72	1.74	0.4	0.0	0	0
July	78.5	81.5	42.7	46.9	1.29	0.89	0.4	0.0	0	0
August	77.9	80.5	40.6	45.0	1.47	1.07	0.1	0.0	0	0
September	68.1	71.1	32.8	37.6	1.62	1.18	1.2	0.1	0	0
October	54.8	58.6	25.1	29.4	1.86	1.40	6.5	2.5	1	0
November	36.7	40.1	14.6	19.9	2.69	2.00	24.8	13.6	8	2
December	27.3	29.7	5.2	11.1	3.55	2.22	45.0	23.1	25	11
Annual	51.3	54.6	22.3	28.1	29.05	19.54	208.9	95.8	17	6

[1]Source: Western Regional Climate Center @ http://www.wrcc.sage.dri.edu/cgi-bin/cliRECtM.pl?idisla
[2]Source: Western Regional Climate Center @ http://www.wrcc.sage.dri.edu/cgi-bin/cliRECtM.pl?idasht

Table 2. Length of growing season: probabilities of the number of days that Island Park and Ashton that will exceed minimum temperatures of 24ºF, 28ºF, and 32ºF.[1]

Probablility[2]	Number of days greater than 24ºF		Number of days greater than 28ºF		Number of days greater than 32ºF	
	Island Park	Ashton	Island Park	Ashton	Island Park	Ashton
9 years in 10	100	125	53	88	37	63
5 years in 10	122	153	83	119	58	89
1 year in 10	144	180	112	150	78	115

[1]Source: State Climate Services, Biological and Agricultural Engineering Department, University of Idaho, Moscow.
[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 Island Park and Ashton.[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 24ºF		equal to or less than 28ºF		equal to or less than 23ºF	
	Island Park	Ashton	Island Park	Ashton	Island Park	Ashton
1 year in 10	June 10 September 5	May 16 September 11	July 3 August 14	June 11 August 29	July 14 August 5	June 28 August 19
2 years in 10	June 3 September 10	May 11 September 18	June 26 August 20	June 3 September 5	July 8 August 11	June 21 August 26
5 years in 10	May 20 September 20	April 30 October 1	June 12 September 1	May 20 September 17	June 28 August 22	June 8 September 7

[1]Source: State Climate Services, Biological and Agricultural Engineering Department, University of Idaho, Moscow.
[2]Based on data collected from 1961 to 1990.

basin at 6290 feet, to 19 inches at the Aston climate station located at the southern end of the subbasin at 5300 feet.

According to Whitehead (1978), spring snowmelt is the major source of runoff to streams and recharge to aquifers in the Upper Henry's Fork subbasin. He reported that at Ashton, annual mean streamflow generally reflected annual mean precipitation, and estimated that the annual mean discharge from the subbasin was approximately 50 percent of the subbasin's annual mean precipitation. However, the relation between annual streamflow and precipitation observed by Whitehead at Ashton does not appear to occur at all locations within the subbasin. An analysis of the relation between annual precipitation and discharge at Island Park failed to support Whitehead's generalization that streamflow reflects precipitation, and further analysis of this relationship is warranted (Benjamin and Van Kirk 1998).

Geology

The *Geologic Map of Idaho* (IDL 1978) shows forty distinct geologic units within the Upper Henry's Fork subbasin. These units include metamorphic rock formed during the Pre-Cambrian Era more than 4.5 billion years ago; shallow and deep marine materials deposited during the Paleozoic and Mesozoic Eras more than 245 and 65 million years ago; debris left by the Bull Lake glaciation 130,000 years ago (Good and Pierce 1996); and a variety of volcanic materials formed as recently as 10,000 years ago. Whitehead (1978) organized all of these units into five categories based on his knowledge of their water-bearing characteristics. The locations of the geologic units identified by Whitehead are shown in Figure 2; their descriptions and water-bearing characteristics are shown in Table 4. Three of these units, Plateau Rhyolite, Basalt, and Yellowstone Group, formed during geologically recent volcanic events that are responsible for many of the unusual topographic features of the subbasin.

Island Park, the central portion of the Upper Henry's Fork subbasin, constitutes a geological transition area between the northeastern end of the Snake River Plain and the western margin of the Yellowstone Plateau (Christiansen and Embree 1987; Figure 3). Several theories have been developed to explain the origin of these features, but the one generally favored involves a process that began millions of years ago in an area approximately 300 miles southwest of the subbasin.

Ten to seventeen million years ago, a volcanic system located in what is now southwestern Idaho began migrating in a northeastern direction at an estimated rate of 4.5 mm per year (Link and Phoenix 1996) or 2 to 4 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 heart in the earth's mantle, the Snake River

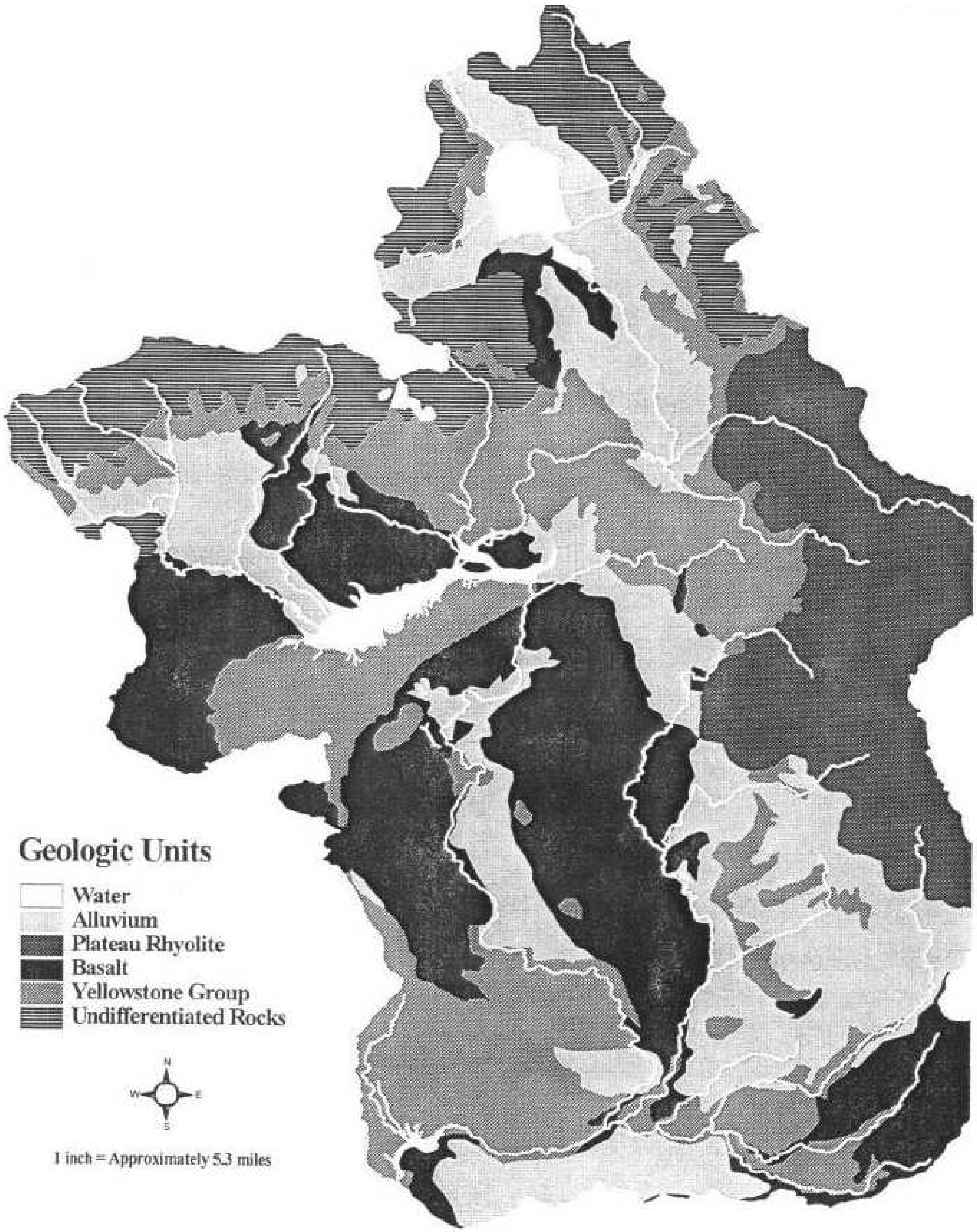
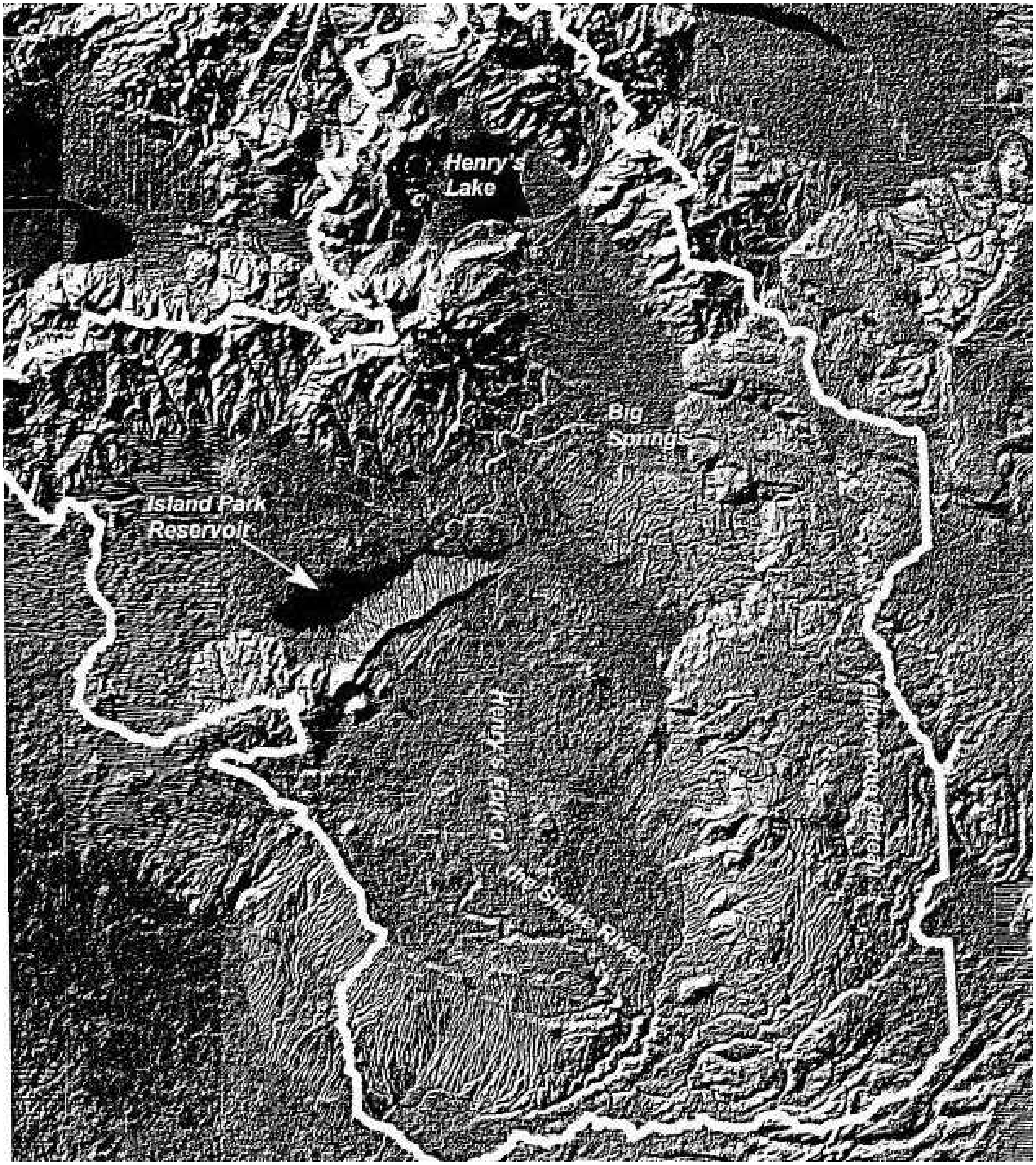


Figure 2. Geologic units within the Upper Henry's Fork subbasin, categorized according to their water-bearing characteristics (Whitehead 1978).

Table 4. Descriptions of generalized geologic units in the Upper Henry's Fork subbasin and their water-bearing characteristics (after Whitehead (1978) and Christiansen and Embree (1987)).

Geologic Unit	Description	Water-bearing Characteristics
Alluvium	Alluvium, colluvium, landslide and glacial materials deposited 10.000 years before present (yr. B.P.), consisting chiefly of unconsolidated silt, sand, and gravel.	*Yields adequate supplies of water fro domestic and stock use. Very few irrigation wells are present in the area, but yields should be adequate for restricted irrigation use, at most places, from properly constructed wells.* – Whitehead 1978
Plateau Rhyolite	Rhyolitic ash-flow tuffs of the West Yellowstone, Summit Lake, and Buffalo Lake flows during the third volcanic cycle responsible for production of the Yellowstone Plateau (6-700,000 yr. B.P.). Light grey, dense, lithoidal, fine grained to aphanatic. Angular to round phenocrysts of quartz, sanidine, clinopyroxene, orthopyroxene, fayalite, and sphene make up about 25 percent of volume of rocks.	*Generally unknown. …the area contains no wells; but the unit has good permeability, as indicated by the rapid percolation of surface runoff to the subsurface and the presence of large springs downgradient at its base. No well-defined stream patterns on its surface. Important to the basin's water-yielding capability.* – Whitehead 1978
Basalt	Includes the Snake River Group and Falls River Basalt of the third volcanic cycle, and Warm River and Shotgun Valley basalts of the second volcanic cycle. Flows consist chiefly of olivine basalt. Generally, the younger basalts are of the aa and pahoehoe types, and older basalts are of the pahoehoe type.	*Yields abundant water for most uses. An important aquifer in parts of the area.* – Whitehead 1978
Yellowstone Group	Rhyolotic ash-flow tuffs of the first (2 million yr. B.P.), second (1.3 million yr. B.P.) and third (6-700,000 yr. B.P.) volcanic cycles, which produced the Huckleberry Ridge, Mesa Falls, and Lava Creek formations. Phenocrysts of quartz, sanidine, and oligoclase are common; phenocrysts of clinopyroxene, fayalite, hornblende, chevkinite, allanit (?), apatite, and zircon are less common.	*Generally yields adequate supplies of water for domestic and stock use in this area. Highly permeable at places. But in other places, the unit is tightly welded and will not yield adequate supplies of water for irrigation use. Important to the basin's water-yielding capability.* – Whitehead 1978
Undifferentiated rocks	Igneous volcanic rocks formed less than 65 million years ago, and sedimentary and metamorphic rocks formed more than 65 million years ago. The volcanic rocks occupy a 15-aquare mile area centered on Sawtell Peak and another that extends from Mount Two Top to Reas Pass. Sedimentary and metamorphic consisting of limestone, dolomite, sandstone, siltstone, and quartzose sandstone are exposed along the Continental Divide.	*Unknown, but will probably yield enough water at most places for domestic and stock use.* – Whitehead 1978



C. Mebane IDEQ-IFRO 1998

Figure 3. Shaded relief topography of the Upper Henry's Fork subbasin. The outline shows the approximate location of the subbasin boundry within Idaho.

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 1995) 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. The last eruption occurred 600,000 years ago, and thermal and seismic activity centered beneath the Yellowstone Plateau indicate that future eruptions are likely.

The Island Park basin formed during three cycles of eruption of the Yellowstone volcano (Christiansen and Embree 1987). The first cycle, approximately two million years ago, erupted a volume of more than 588 cubic miles of volcanic material and formed the Huckleberry Ridge caldera which extends 56 miles from the west side of Island Park to the Central Plateau of Yellowstone National Park. The second cycle, approximately 1.3 million years ago, erupted a minimum volume of 67 cubic miles of material, and formed the Henry’s Fork caldera which is about 18 miles in diameter. This caldera, nestled against the northwest wall of the Huckleberry Ridge caldera, is commonly known as the Island Park caldera. According to Christiansen and Embree (1987), Island Park caldera is actually a basin formed by the first- and second-cycle eruptions 700,000 years apart. The third eruption cycle, approximately 0.6 million years ago, formed the Yellowstone caldera and was followed by the rhyolitic lava flows from the Yellowstone Plateau that formed the eastern margin of Island Park.

Remnants of the eruption cycles are readily identified in road cuts and canyon walls and as topographic features (Christiansen and Embree 1987). The roadcut on U.S. highway 20-191, 3.3 miles north of Ashton, exposes gray Huckleberry Ridge Tuff (rock formed of volcanic ash), deposited during the first eruption cycle. This rock is overlain by a thin layer of loess deposited during the 700,000-year interval between eruption cycles. Above the loess is a layer of pink, partially welded Mesa Falls Tuff deposited during the second eruption cycle. Approximately 7.3 miles north of Ashton, U.S. highway 20-191 crosses the rim of Big Bend Ridge, which is the margin of the first-cycle caldera and now forms the southern and western rim of the Island Park basin. A series of valleys and ridges parallel to Big Bend Ridge represents slumped fault blocks created by partial collapse of Big Bend Ridge during formation of the Henry's Fork caldera. From nine miles north of Ashton, where the highway reaches the basin floor, northward to Thurmon Ridge, roadcuts expose the upper Pleistocene Gerrit Basalt and Snake River Group basalts that form the floor of the Island Park basin. Thurmon Ridge, which forms the northwestern rim of the basin, is a segment of the second-cycle Henry's Fork caldera and is composed of Mesa Falls Tuff. Bishop Mountain, at the southern end of Thurmon Ridge, was formed by lava flows that postdate the Huckleberry Falls lava and predate the Mesa Falls eruptions. At Upper Mesa Falls, the walls of the gorge expose Gerrit Basalt and Lava Creek Tuff from the Yellowstone caldera, and Mesa Falls Tuff from the Henry's Fork caldera. Huckleberry Ridge Tuff; Mesa Falls Tuff, and Lava Creek Tuff comprise the Yellowstone Group of rhyolitic ash-flow tuffs referred to by Whitehead (1978).

Topography

Elevations within the Upper Henry's Fork subbasin span a range of approximately 5,000 feet. The highest elevations occur along the northern boundary of the subbasin; the lowest elevations occur along the southern boundary of the subbasin near Ashton, and along the canyon floors of the Henry's Fork River, Warm River, and Robinson Creek (Figure 4)[1]. The average elevation of the subbasin is 6,700 feet above mean sea level (Whitehead 1978).

Two mountain ranges define the northern boundary of the subbasin: the Eastern Centennial Mountains and the Henry's Lake Mountains. The Eastern Centennial Mountains comprise a narrow, east-west trending range that extends from the western boundary of the subbasin to Red Rock Pass. The highest points in the Centennial Mountains are Taylor Mountain (9,820 feet) at the western end and Mount Jefferson (10,203 feet) at the eastern end. Beginning five miles west of Henry's Lake at Red Rock Pass, the Henry's Lake Mountains form an arc that extends around and southeast of the lake to the Madison Plateau of Yellowstone National Park. Black Mountain (10,237 feet) and Targhee Peak (10,280 feet), the highest elevational points in the subbasin, are located in the Henry's Lake Mountains approximately four miles north of Henry's Lake. Sawtell Peak, south of Henry's Lake and north of Island Park Reservoir, is a

[1]Appendix C shows the names of the U.S. Geological Survey 7.5 minute series topographic maps used to develop Figure 4.

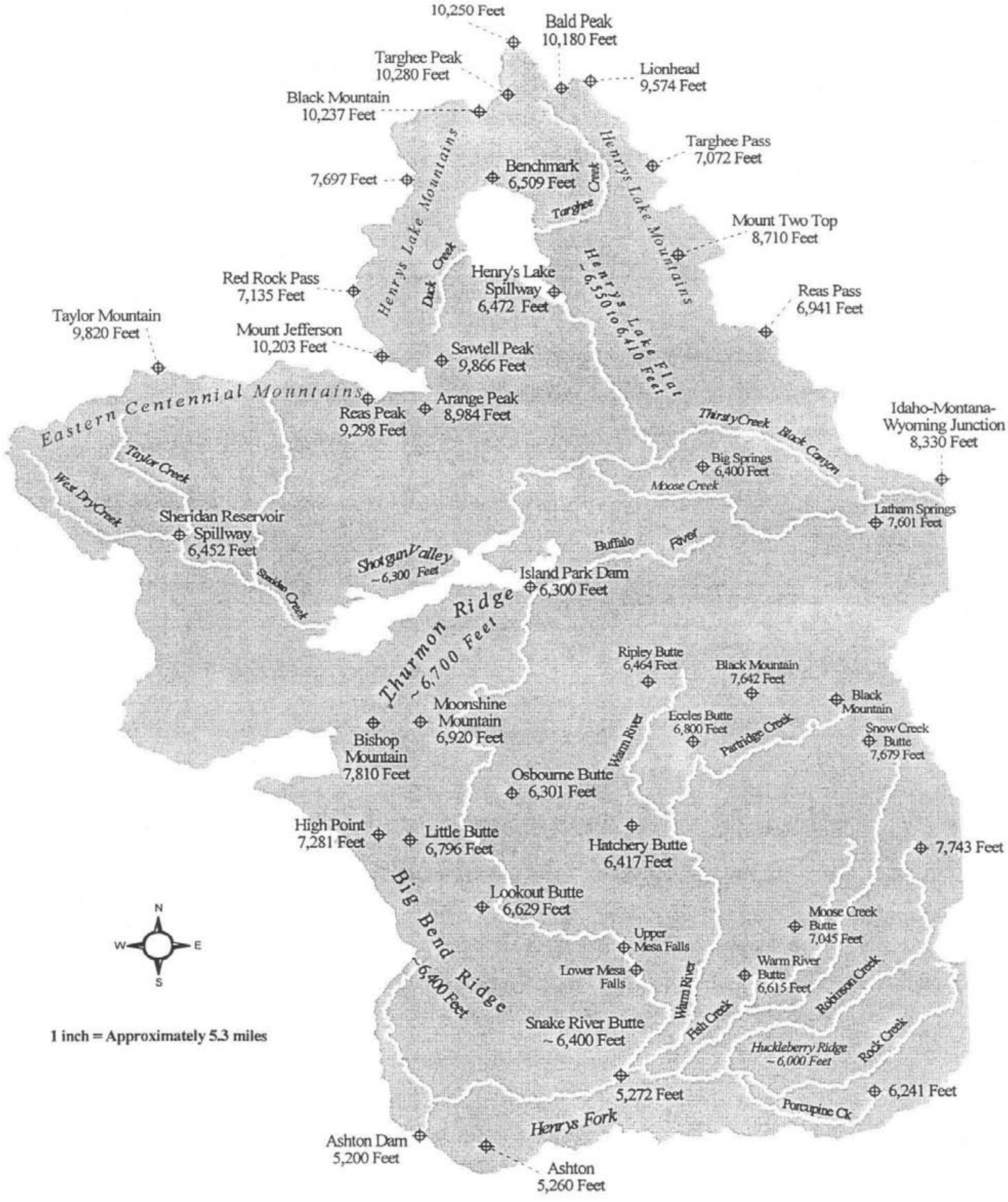


Figure 4. Topographic features of the Upper Henry's Fork subbasin.

prominent landmark in the upper portion of the subbasin. Major highways traverse the Henry’s Lake Mountains and subbasin boundary at Raynolds Pass (6,836 feet) on the west and at Targhee Pass (7,072 feet) on the east.

Elevations at the base of both the Centennial and Henry’s Lake Mountains drop to approximately 6,500 feet although the elevational transition from the Henry’s Lake Mountains is more abrupt than the transition from the Centennial Mountains. Peak elevations of more than 10,000 feet decline to approximately 6,500 feet at Henry’s Lake and Henry’s Lake Flat over a horizontal distance of less than two miles in some areas. In contrast, similar elevational changes from the Centennial Mountains to Sheridan Reservoir and Island Park Reservoir occur over a horizontal distance of at least five miles.

The eastern portion of the subbasin, which transects the Yellowstone Plateau, reaches an elevation of 8,330 feet at the northern boundary where the state lines of the Idaho, Montana, and Wyoming intersect (Figure 4). The average elevation of the Plateau declines gradually from north to south and east to west, with topographic relief provided by numerous bluffs and buttes.

One of the most distinctive topographic features of the Upper Henry’s Fork Subbasin is commonly known as the Island Park Caldera, though according to Christiansen and Embree (1987), the feature is actually a basin formed by three overlapping calderas. The basin covers an area of approximately 18 miles from west to east and 23 miles from north to south. Thurmon Ridge and Big Bend Ridge, which are remnants of two distinct calderas, form the northwestern and southern rims of the basin. These ridges are easily recognizable both from the ground and on topographic and relief maps (Figure 3). The eastern edge of the basin is less pronounced but extends toward the Yellowstone Plateau.

The cycle of volcanic activity that caused the collapse of the area now known as Island Park basin, also caused the formation of elevated features such as vents and domes (Christiansen and Embree 1987). Basalt erupted through High Point, one of several vents extending 30 miles west onto the Snake River Plain, and rhyolitic lava flows created Bishop Mountain and Osborne Butte.

As the Henry’s Fork flows south through Island Park basin, it carves a gorge through the basalt that forms the floor of the basin. From Henry’s Lake Outlet to river mile 72, directly west of Osborne Butte, the river loses less than seven feet of elevation per mile traveled. Between river mile 72 and its confluence with the Warm River, the Henry’s Fork narrows and downcuts through the basin floor, losing more than 55 feet of elevation per mile. Over a six-mile stretch, the Henry’s Fork drops 35 feet over Sheep Falls, 114 feet over Upper Mesa Falls, and 65 feet over Lower Mesa Fails (IWRB 1992). Below Lower Mesa Falls near Snake River Butte, the walls of the canyon reach more than 600 feet above the surface of the river. But as the river continues southwest at the base of Snake River Butte, the canyon walls become less rugged and the elevational loss moderates until the river exits the subbasin at Ashton Dam at an elevation of 5,200 feet.

Hydrography and Hydrology

The Henry's Fork River flows 45 river miles from the outlet of Henry's Lake to the southern boundary of the Upper Henry's Fork subbasin at Ashton Dam. After exiting the subbasin, the river continues in a southwesterly direction for 79 miles through the Lower Henry's Fork subbasin before reaching its confluence with the South Fork of the Snake River. Near Menan Buttes in Madison County, the Henry's Fork and South Fork join to form the Snake River. In his description of the water resources of the Upper Henry's Fork subbasin, Whitehead (1978) described the outlet of Henry's Lake as the origin of the Henry's Fork. In 1992, the Idaho Water Resource Board wrote that Big Springs is usually described as the origin of the main stem of the Henry's Fork river. The reason for this discrepancy is the relative contribution of each source to total flow within the river. Because the average mean discharge of Henry's Lake (~54 cfs) is lower and less consistent than the discharge of Big Springs (~205 cfs), many consider the latter to be the principle source of flow for the river.

The Upper Henry's Fork subbasin drains an area of 1068 square miles, including 30 square miles in Wyoming and 60 Square miles in Yellowstone National Park (Whitehead 1978). Discharge data for the subbasin have' been collected by the USGS near Ashton discontinuously since 1890. Continuous record-keeping by the Survey began as early as 1920, with six gaging stations currently operating throughout the subbasin (Figure 5). Annual mean discharges below Ashton Dam range from 996 cfs to 2,361 cfs, which corresponds to an average annual runoff of approximately 1.1 million acre-feet or 1,052 acre-feet per square mile of area drained (USGS 1996). This runoff volume is almost twice that produced by either the Henry's Fork downstream near Rexburg, which drains 2,920 sq mi, or the South Fork near Lorenzo, which drains 5,810 square miles[2].

Whitehead (1978) determined that almost 42 percent of the average discharge of the Henry's Fork near Ashton originates from springs located at the base of the Yellowstone Plateau. He found that Big Springs Creek, Buffalo River, and Warm River obtained most of their water from headwater springs and springs along their channels. He performed single measurements of

[2]Calculated using the following data: 1,095,000 acre-feet annual runoff and 1,040 sq mi drainage area at Henry's Fork near Ashton Dam; 2,996,000 acre-feet annual runoff and 5,810 sq mi drainage area at Snake River at Lorenzo; and 1,504,000 acre-feet annual runoff and 2,920 sq mi drainage area at Henrys Fork near Rexburg (USGS 1996).

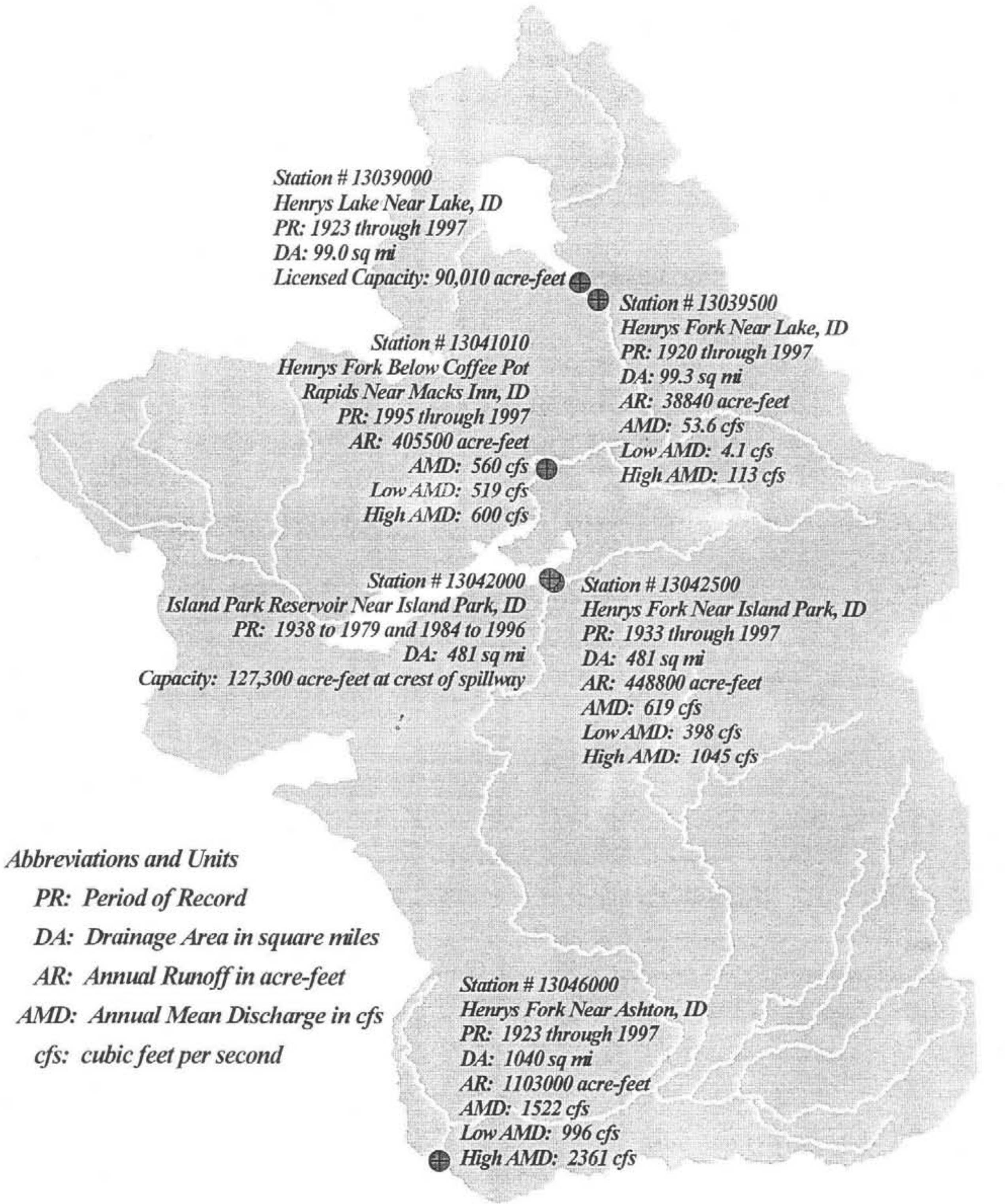


Figure 5. Locations of current U.S. Geological Survey surface-water stations and summaries of data for the period of record.

(Sources: Capacity of Henry's Lake provided by D. Rydalch, Deputy Watermaster and Preident, North Fork Reservoir Company; all other information from U.S. Geological Survey Water-Data Reports ID-96-1 and ID-97-1.)

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the discharges of 21 springs, and reported that Big Springs (205 cfs) and Warm River Springs (200 cfs) were the largest springs in the subbasin. Seven of 22 springs described by Whitehead (1978) were considered thermal because their temperatures exceeded 12°C.

The United States Geological Survey (USGS) identifies the Upper Henry's Fork subbasin as hydrologic unit code (HUC) 17040202. This eight-digit code indicates the location of the subbasin within successively smaller hydrologic units (USGS 1998). The first two digits of the code specify the region in which the subbasin is located; the third and fourth digits specify the subregion; the fifth and sixth digits specify the accounting unit; and the seventh and eighth digits specify the cataloging unit. Thus, the Upper Henry's Fork 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 west by the Beaver-Camas Creek cataloging unit (HUC 17040214) and on the southwest and south by the Lower Henry's Fork cataloging unit (HUC 17040203) (Figure 6).

Cataloging units are further subdivided by the USGS into 10-digit watersheds and 12-digit subwatersheds (Ulery 1998). The Upper Henry's Fork subbasin contains nine watersheds defined by the following waterbodies: Ashton Reservoir, Lower Henry's Fork, Island Park Reservoir, Sheridan Reservoir, Henry's Lake, Thirsty Creek, Buffalo River, Warm River, and Robinson Creek. These watersheds are identified by 10-digit hydrologic unit codes (Figure 7) and can be further divided into subwatersheds identified by 12-digit codes. As discussed in other sections of this assessment, each watershed is characterized by geologic and topographic features that influence other characteristics such as hydrologic regime and land use.

Another cataloging system referenced in this document is the Pacific Northwest Rivers System (PNRS). Unlike the USGS system which catalogs watersheds, this system catalogs waterbodies and segments of waterbodies. Idaho's Water Quality Standards and § 303(d) list identify waterbodies using PNRS identification numbers.

Soils

A soil survey of the western part of Fremont County was published by the United States Department of Agriculture (USDA) in cooperation with other federal and state agencies in 1993 (USDA 1993). The survey area included nearly all of Fremont County with the exception of the Targhee National Forest and Harriman State Park. In the area of Fremont County located within the Upper Henry's Fork subbasin, survey data are limited to private and state-owned lands, and lands managed by the Bureau of Land Management. These lands occur within six of the nine watersheds in the Upper Henry's Fork subbasin, and are concentrated around Henry's Lake, Ashton, and Marysville; on Henry's Lake Flat; around and north of Island Park Dam, including

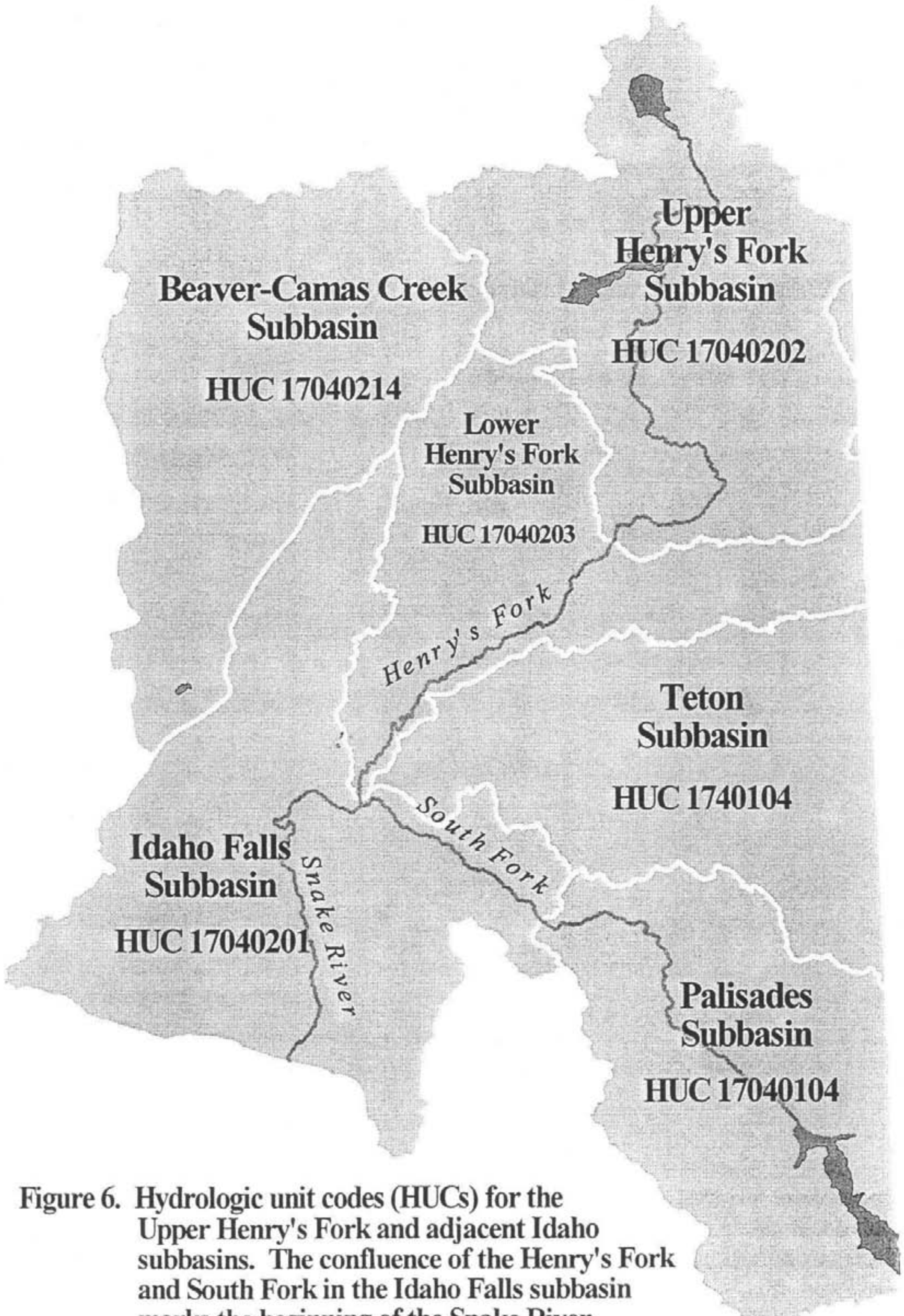

Figure 6. Hydrologic unit codes (HUCs) for the Upper Henry's Fork and adjacent Idaho subbasins. The confluence of the Henry's Fork and South Fork in the Idaho Falls subbasin marks the beginning of the Snake River.

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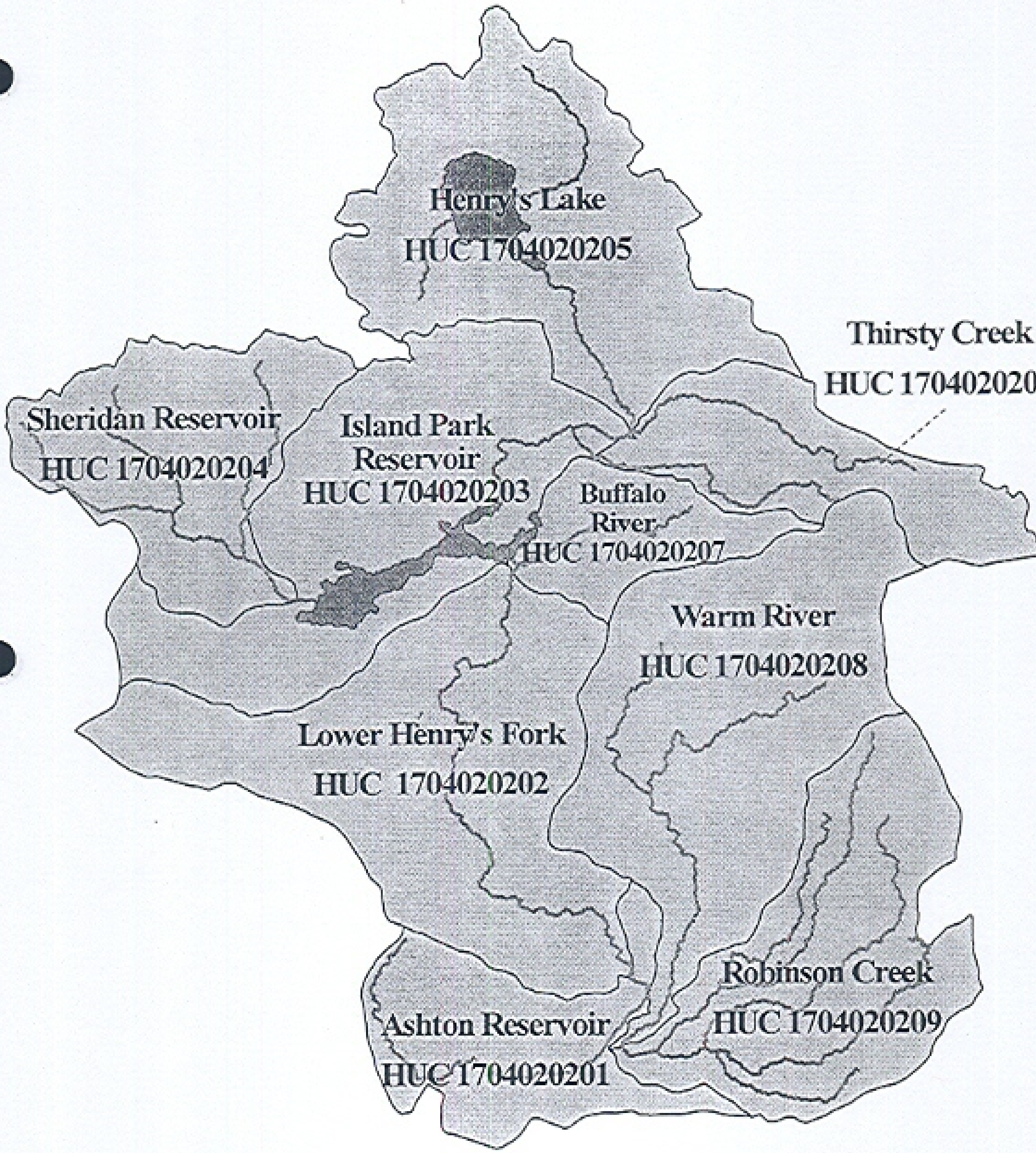

Figure 7. Names and hydrologic unit codes (HUCs) of watersheds within the Upper Henry's Fork subbasin. The waterbodies shown appear on maps scaled 1:250,000.

Shotgun Valley; and east of Island Park between the Buffalo and Warm Rivers. Soils on the Targhee National Forest are described in a recently released draft ecological unit inventory (USDA 1997a). A summary of the Fremont County inventory was prepared for this document, but time constraints precluded preparation of a comparable summary of the Targhee National Forest inventory.

Twelve general soil map units, each representing a distinct pattern of soils, relief and drainage, are identified in the Fremont County survey document. Four units are located entirely within the Upper Henry’s Fork subbasin, four are partially within the subbasin, and four are entirely outside the subbasin. General soil map units are subdivided into detailed soil map units which are identified on soil survey sheets. Tables listing general and detailed map units for the following watersheds are contained in Appendix D: Ashton Reservoir, Lower Henry’s Fork, Island Park Reservoir, Sheridan Reservoir, Henry’s Lake, and Buffalo River. The tables also list waterbodies adjacent to map units and provide information regarding slope and elevation, erosion hazard, major uses, and dominant vegetation or crop. A discussion of the soils of each watershed and their potential influence on water quality is presented below.

The Ashton Reservoir Watershed includes general map units 5 (Marystown-Robinlee-Greentimber), 6 (Rexburg-Ririe-Kucera), and 7 (Rin-Tetonia-Greys). These units are “deep and very deep” (5, 6) or “very deep” (7), “nearly level to moderately steep” (5, 6, 7), “well-drained soils formed in loess” (6, 7) “underlain by glacial deposits” (5). General map unit 5 is divided into 11 detailed map units; general unit 6 is divided into 18 detailed units; general unit 7 is divided into 5 detailed units. General units 5 and 6 contain several detailed units defined as prime farmland, i.e., “soils that are best suited to food, seed, forage, fiber, and oilseed crops [and] ...have properties that favor the economic production of sustained high yields of crops.” With the exception of three detailed units in general unit 6, the erosion hazard of each detailed unit adjacent to, a waterbody is “severe to very severe” or “very severe” due to slopes of up to 60%. These units are used for woodland, grazable woodland, or rangeland. The exceptions are units adjacent to Ashton Reservoir and the Henry’s Fork which are characterized by “moderate” erosion hazard with slopes of 1-8%. The units adjacent to Ashton Reservoir are grazed; the unit adjacent to the Henry’s Fork is irrigated and nonirrigated cropland.

The northwestern edge of the Lower Henry’s and Island Park watersheds includes general map unit 11 (Katseanes-Vadnais-Rock Outcrop), described as “very shallow, deep, and very deep, nearly level to very steep, well-drained soils formed in alluvium.” The major uses are rangeland, summer homesites, woodland, and grazable woodland. The only waterbodies in this unit are unnamed perrenial ponds and reservoirs in an area characterized by “slight” erosion hazard.

The central portion of the Island Park Watershed and the southeast corner of the Sheridan

Creek Watershed include general map unit 4 (Shotgun-Fourme-Henryslake) which is "moderately deep and very deep, nearly level and gently sloping, very cold, well-drained and poorly drained soils formed in loess and alluvium". All but one of the detailed map units within general unit 4 are adjacent to waterbodies in Island Park Watershed, and half of the units are adjacent to waterbodies in Sheridan Creek Watershed. Erosion hazards are "slight" or "moderate" except for the folloing three units: 41, which is adjacent to portions of Island Park Reservoir and Yale Creek and has a "severe" erosion hazard with slopes up to 15%; 127, which is adjacent to Yale Creek and has a "very severe" erosion hazard with slopes up to 30%; and 41, which is adjacent to Schneider and Willow Creeks and has a "severe" erosion hazard with slopes up to 15%. The uses of these units are limited to woodland, grazable woodland, and summer homesites.

Henry's Lake Watershed includes general unit 2 (Fourme-Raynoldson-Trude), which is "very deep, nearly level, very cold, well-drained soils formed in alluvium", unit 3 (Bootjack-Chickcreek), which is "very deep, nearly level, very cold, poorly drained soils formed in alluvium", and unit 12 (Raynoldson-Kitchell-Lionhead), which is "very deep, gently sloping to very steep, very cold, well-drained soils formed in residuum and alluvium." "Severe" erosion hazards and slopes up to 15% exist in unit 2, detailed map units 83 and 41, which are adjacent to Henry's Lake, Ingals Creek, Rock Creek, Timber Creek, and Rock Creek. "Very severe" erosion hazards and slopes up to 55% exist in general units 3 and l2, detailed map units 61, 47 and 126, which are adjacent to Howard Creek, Dry Fork of Targhee Creek, Targhee Creek, and Garner Springs. Major uses in these uses are, rangeland, pasture, summer homesites, woodland, and grazable woodland.

Buffalo River Watershed includes general unit 3, and Warm River Watershed includes general unit 2. The only "severe" erosion hazard exists in detailed map unit 125 adjacent to the Buffalo River. This unit has a slope up to 15% and is used for woodland, grazable understory, and homesites.

Surveyed land in the central and northern part of the subbasin is used as range; surveyed land in the southern part of the subbasin is used as irrigated and nonirrigated cropland. The use of rangeland is limited mainly by short growing seasons and wet soils in spring. All soils are saturated during spring runoff and while most areas are dry by mid-June, low-lying areas in Island Park are not dry until July. Crop production is limited by short growing seasons and the hazards of wind and water erosion. Water erosion caused by spring runoff is a particular hazard in the survey area and recommended conservation practices include minimum tillage, chiseling, terracing, establishing grassed waterways, and maintaining permanent plant cover.

Urban development in the Ashton area is limited by depth to bedrock. Summer home and recreational development in the Island Park area is limited by high water tables near streams and depressions, and shallow soil depths on ridges and knolls. Recreational development around Island Park is limited by high water tables which in turn limit the availability of suitable sites for sanitary facilities in campgrounds.

Biological Characteristics of the Upper Henry's Fork Subbasin

The biological characteristics of the Upper Henry's Fork subbasin are well described in several reports issued within the last decade. Environmental assessments were written for the Island Park Hydroelectric Project (ERI 1988) and an associated modification of Island Park Dam (ERI 1995*).* The Targheee National Forest issued a draft *Ecological Unit Inventory* (USDA 1997a) and its *Final Environmental Impact Statement*, *1997 Revised Forest Plan* (USDA 1997b). The Conservation Data Center at Idaho Department of Fish and Game released a conservation strategy for wetlands located in the Henry's Fork basin (Jankovsky-Jones 1996), and vegetation along streams in the Henry's Lake watershed were surveyed and reported by the Natural Resources Conservation Service and Soil Conservation Commission (YSCD 1995*).* Studies of the ecology and management of trumpeter swans and the aquatic macrophyte communities which support them are listed in the bibliography, and Van Kirk *et al.* (1997) recently reported on the status of Yellowstone cutthroat trout in the subbasin. The following information extracted from these documents is extremely limited and gives only a cursory overview of the plant and wildlife species and communities found in the Upper Henry's Fork subbasin.

The Upper Henry's Fork subbasin is located within the Middle Rocky Mountain Steppe-Coniferous Forest-Alpine Meadow Province described by Bailey (1995). The vegetation of Targhee National Forest is 37 percent lodgepole pine and 17 percent lodgepole/Douglas-fir mix, and the forested landscape in subsections occurring in the Upper Henry's Fork subbasin range from 70 to•93 percent (USDA l997b). The environmental impact statement for the 1997 revised forest plan described the following ecological concerns for riparian areas in the Upper Henry's Fork subbasin: 1) expansion of upland vegetation into riparian areas due to past over-utilization and/or drop in water table levels, and 2) death of willows and lack of willow regeneration. Wildlife management indicator species associated with aquatic and riparian habitats in the Upper Henry's Fork subbasin include the bald eagle, trumpeter swan, spotted frog, and common loon. Approximately 80 percent of the Rocky Mountain Population of trumpeter swans winters on the Henry's Fork and the Madison River in Montana. The Yellowstone cutthroat trout is the only indigenous trout within the subbasin and is used by Targhee National Forest as a fisheries management indicator species. Wildlife management indicator species associated with terrestrial habitats in the subbasin include elk, grizzly bear, wolverine, fisher, American marten, northern goshawk, red squirrel, flammulated owl, boreal owl, great gray owl, and eight species of cavity-nesting birds.

The abundance of springs in the subbasin support instream and wetland communities of aquatic plants and animals that are relatively unique in the state. The *Conservation Strategy for Henrys Fork Basin Wetlands* (Jankovsky-Jones 1996) identifies 18 wetland sites that "represent relatively intact systems where simple measures, such as livestock management, creation of buffers, and education, can accomplish resource goals for a minimal amount of labor and material costs." These wetlands are grouped into four management categories based on the following criteria: 1) habitat diversity, 2) presence of state rare plant community, plant or animal species, 3) extent to which a site has been altered from natural conditions, and 4) likelihood of continued existence of biota within the site. Class I Sites are in near-pristine condition and often provide habitat for high concentrations of state rare plant or animal species; Class II Sites differ from Class I based on condition and biological significance; Reference Sites represent high-quality assemblages of common community types where changes in management paractices can be documented; and Habitat Sites have moderate to outstanding wildlife values but management of human influences may be necessary to maintain natural communities. These sites, along with their protection status and ownership, are listed in Table 5.

Table 5. Wetland sites in the Upper Henry's Fork subbasin that have been categorized by the Idaho Conservation Data Center (after Jankovsky-Jones 1996).

Site	Category[1]	Protection Status	Ownership[2]
Big Springs-Henry's Fork Confluence	Class I	None	USFS
East Shore Henry's Fork	Class I	Partial	BLM, IPR, PVT
Ingals Creek Fen	Class I	None	PVT
Targhee Creek	Class I	Partial	USFS
Woods Creek Fen	Class I	None	PVT
Blue Spring Creek	Class II	None	IDL
Hatchery Butte	Class II	None	USFS
Henry's Lake White Spruce	Class II	None	PVT
Sheep Falls	Class II	None	USFS
Thurmon Creek	Class II	Full	USFS
Tom's Creek/Buffalo River Wetlands	Class II	None	USFS, IDL
Fish Creek Springs	Reference	None	USFS
Flat Ranch	Reference	Full	TNC
Hotel Creek	Reference	None	USFS
Lucky Dog Ranch	Reference	Full	TNC
Willow Creek Headwaters	Reference	None	USFS
Boundary Pond	Habitat	None	USFS
Icehouse Creek	Habitat	Partial	IPR, PVT
Mesa Marsh	Habitat	None	USFS
Stamp Meadows	Habitat	None	USFS
Warm River Dams	Habitat	None	USFS

[1]See text for explanation.
[2]U.S. Forest Service (USFS); Bureau of Land Management (BLM); Idaho Department of Parks and Recreation (IPR); Private (PVT); Idaho Department of Lands (IDL); The Nature Conservancy (TNC).

Cultural Characteristics of the Upper Henry's Fork Subbasin

Land Ownership and Land Use

Almost 86 percent of the Upper Henry's Fork subbasin is publicly owned (Figure 8). Targhee National Forest occupies 73 percent of the subbasin, and four percent is within Yellowstone National Park. Five percent of subbasin lands are managed by the Idaho Department of Lands (IDL) or the Idaho Department of Parks and Recreation (IDPR). The Bureau of Land Management (BLM) is responsible for three percent of the subbasin, and two percent is covered by water. Only 12 percent of the subbasin is privately owned. Private ownership is concentrated around Henry's Lake and on Henry's Lake Flat, in the Shotgun Valley and Sheridan Reservoir area, and at the southern edge of the subbasin near Ashton.

Consistent with the pattern of landownership, 82 percent of the subbasin is used as forest, 8 percent as range, and 6 percent as irrigated cropland or pasture (Figure 9). Major paved highways include U.S. Route 20-19 1 and State Route 287. Major forest roads include the Kilgore-Yale Road and the Mesa Falls Highway, which is currently being reconstructed. The entire Targhee National Forest contains 1,985 miles of roads, many of which were built in the mid-1970s for timber salvage (USDA 1997b). The forest has begun to restrict access and reclaim roads in the Upper Henry's Fork subbasin, but these efforts have not been well-received by all forest users.

Population Distribution

Incorporated areas in the Upper Henry's Fork subbasin include Ashton, an agricultural community, and Island Park, a resort community. According to 1990 census data, the population of the county subdivision that includes Ashton was 2,503; the population of the county subdivision that includes Island Park was 782; and the population of the incorporated city of Island Park was 159. Warm River, with a 1990 population of 10, is the only other incorporated area within the subbasin.

The population distribution of Fremont County began shifting from small towns to rural areas in the 1970s (YSCD 1995*)*. The 1990 census indicated that 40 percent of all Fremont County housing units were in the Island Park area, and 87 percent of these were occupied seasonally. The trend in vacation and second-home construction continues, as evidenced by the number of septic permits issued for the area by District Seven Health Department (Woods, 1998). On average, 46 permits were issued annually from 1983 to 1989, and 100 were issued annually from 1990 to 1997. From 1993 through 1997, Fremont County Planning and Building recorded 774 subdivision lots and 898 building permits for the Island Park Planning Area (Lords 1998).

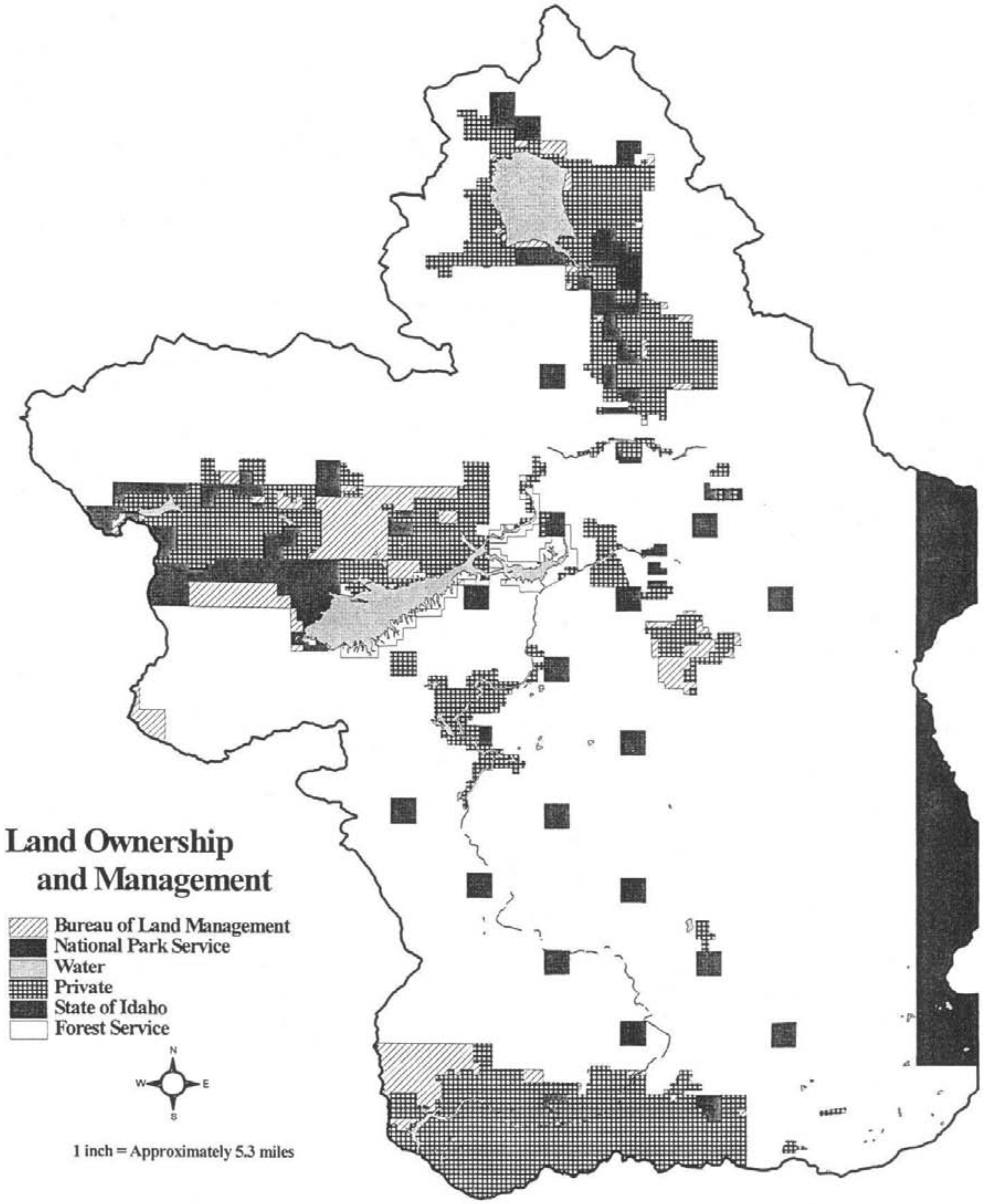

Figure 8. Land ownership and management in the Upper Henry's Fork subbasin.

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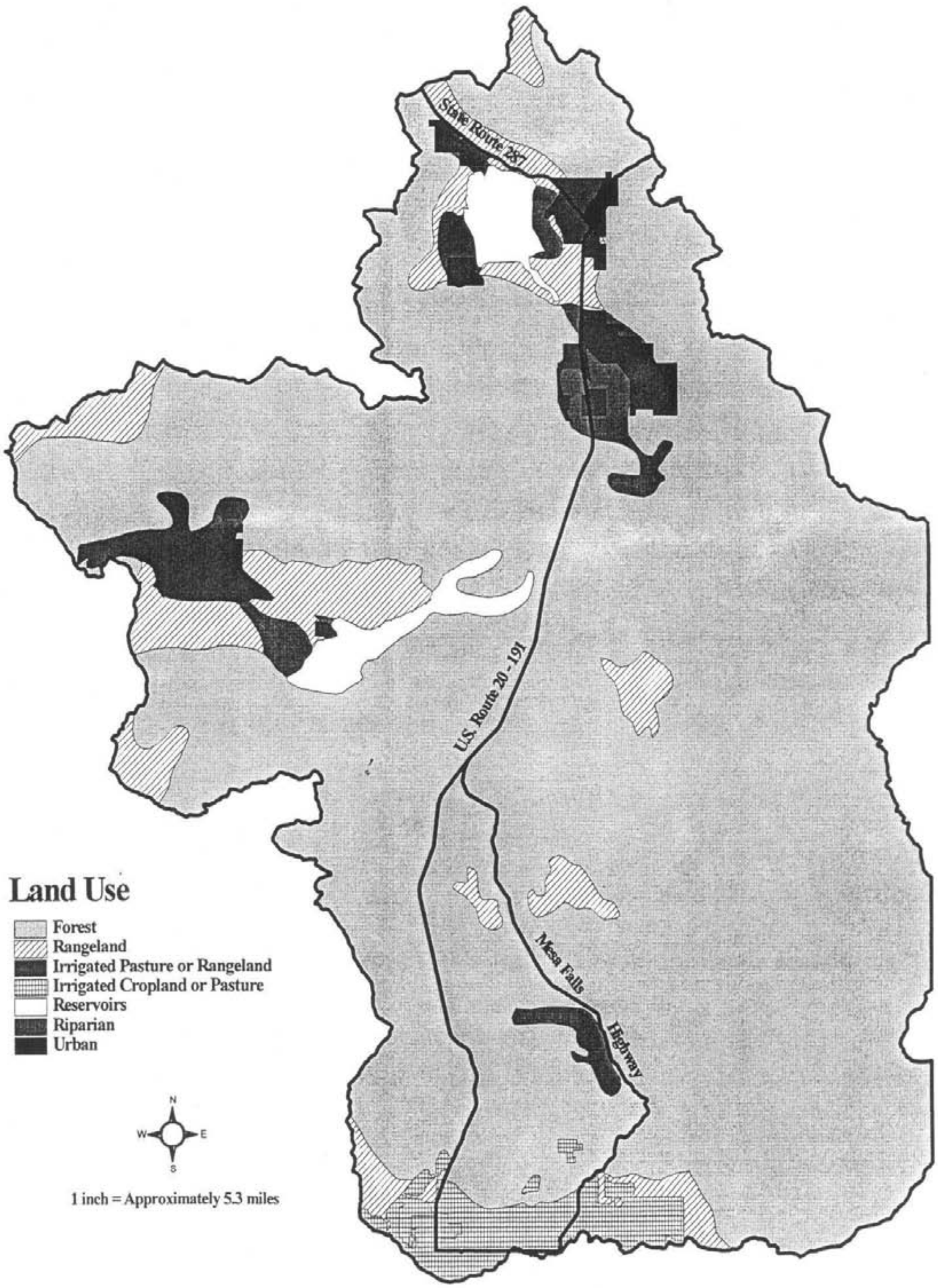


Figure 9. Land use in the Upper Henry's Fork subbasin.

Planning

With the exception of the Sheridan Reservoir area, which is located in Clark County, most of the Upper Henry's Fork subbasin is located in Fremont County. Growth and development are subject to the policies set forth in the *1997 Clark County Comprehensive Land Use Plan*, the *Fremont County Comprehensive Plan, 1997 Edition* and the *Fremont County Development Code, 1997 Edition.*

Most of the privately owned land in the Upper Henry's Fork subbasin is within the Island Park Planning Area described in the *Fremont County Comprehensive Plan, 1997 Edition.* According to the comprehensive plan, the major planning issues for the Island Park Area are 1) the potential for development of thousands of currently vacant lots that were platted in the 1960s and 1970s, 2) water quality, and 3) commercial development. Clean water is described in the comprehensive plan as an urgent issue because "...the fishery is the principal attraction for many visitors, and the principal amenity enjoyed by many residents."

Concerns regarding the effects of individual septic systems on ground and surface water in the Island Park area prompted a facilities planning study in 1975 (Forsgren 1994). The study resulted in construction of two central sewerage systems. The Mack's Inn-Island Park Village system was completed in 1982 and was extended to Aspen Ridge in 1990, and the Pond's Lodge-Last Chance system was completed in 1986. The Mack's Inn-Island Park Village system has already reached its capacity and is currently being upgraded. Additional facilities planning studies have recommended central wastewater collection and treatment systems in the Island Park Reservoir and Henry's Lake areas, but high average user rates and seasonal home use have prevented implementation (Forsgren 1993, 1994). Construction of such facilities does not appear likely in the foreseeable future.

At least two of the policies of the *Fremont County Comprehensive Plan, 1997 Edition* specifically address protection of water quality. First, because exchanges of land between private and public owners have been common, the County adopted a policy to "...encourage land exchanges that place stream and lakeshore corridors, wetlands, wildlife habitat, and other critical areas in public ownership, while placing state and federal lands that are suitable for development in private ownership." Second, the policy regarding maintainenance of natural assets includes provisions for the county to "...continue to seek funding for the construction of central sewerage systems, where needed to protect the areas water quality," and "...use its development code to assure that land development is consistent with the high water quality needed to sustain the Island Park resort industry."

As noted in the previous section, almost three-quarters of the land area of the subbasin is federally owned and managed by the Targhee National Forest. Thus, Forest planning is an integral component of subbasin planning. In 1997, the Forest Service issued its revised forest plan (USDA 1997c) and environmental impact statement (USDA 1997b) for management of the 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. The objectives for fisheries, water, and riparian resources within the upper Henry's Fork subbasin include 1) inventory watershed improvement needs on the Centennial Mountains and Madsion-Pitchstone Plateaus, 2) reassess the health of native cutthroat trout populations within the Centennial Mountains, Madison-Pitchstone Plateaus, and Island Park and determine which watersheds are vital to recovery, and 3) coordinate with subbasin assessments for implementation of state water quality standards and total maximum daily loads.

In 1992, the Idaho Water Resource Board 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 110 miles of streams in the Upper Henry's Fork subbasin for state "recreational" or "natural" protection (Figure 10).

A state recreational or natural waterway is defined by Idaho Code § 42-173 1 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 the riparian area is largely undeveloped. Idaho Code § 4-1734A(6) prohibits the following activities within the stream channel or below the high water mark on "natural" waterways: construction or expansion of dams or impoundments; construction of hydropower projects; construction of water diversion works; dredge or placer mining; alterations of the stream bed; and mineral or sand and gravel extraction within the stream bed (IWRB 1992).

Watershed Advisory Group

Development of the Comprehensive State Water Plan for the Henry's Fork Basin provided an impetus for organization of the Henry's Fork Watershed Council. According to Council literature, "In order to implement the recommendations [of the Basin Plan] an innovative, consensus-building process was sought to include all parties with interests in the watershed." The Council was chartered in 1994 by the Idaho Legislature to:

1. Cooperate in resource studies and planning that transcend jurisdictional boundaries, but still respect the mission, roles, water and other rights of each entity.
2. Review and critique proposed watershed projects and Basin Plan recommendations, suggesting priorities for their implementation by

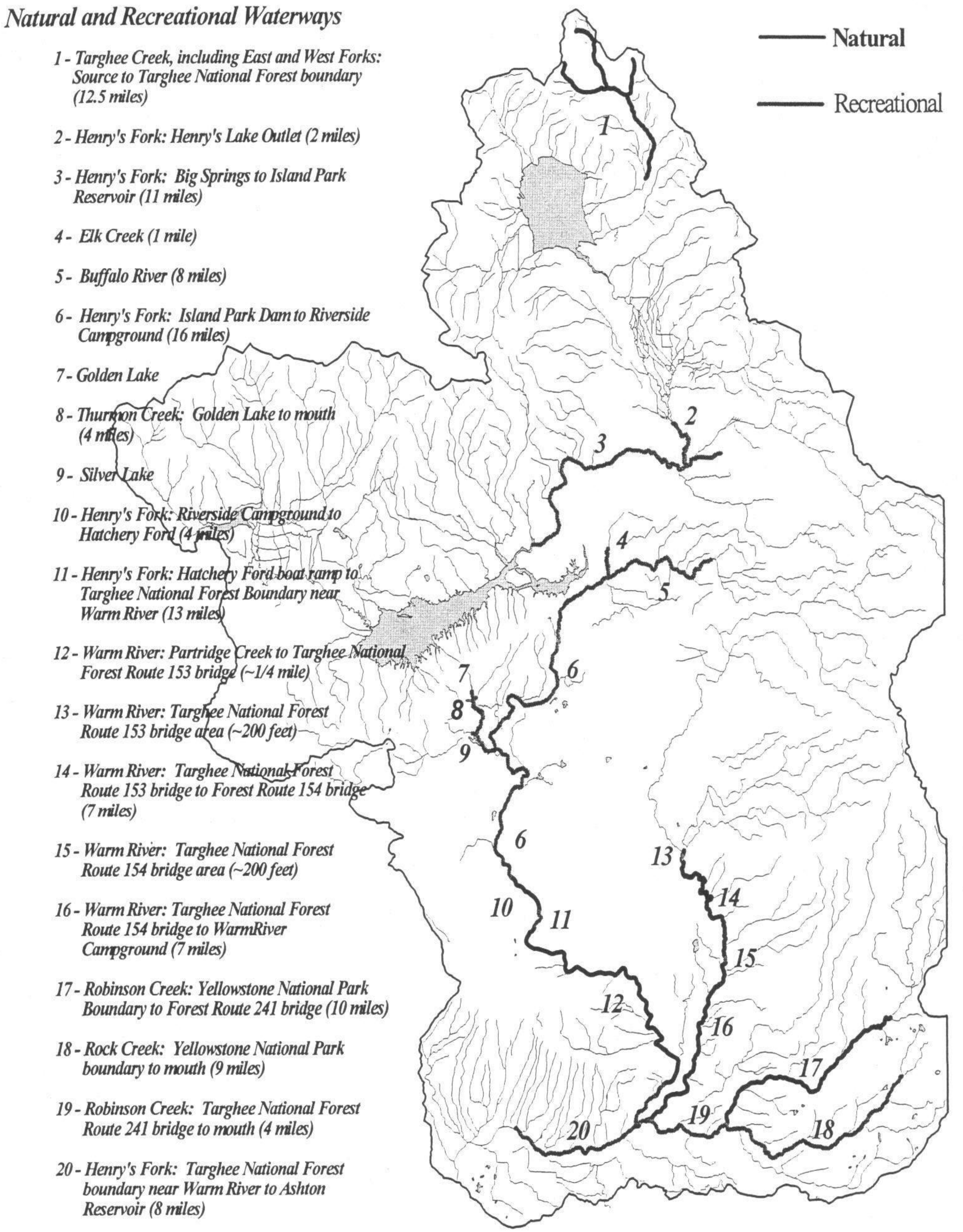


Figure 10. Surface waters protected in 1992 by the Idaho Water Resource Board through designation as Natural or Recreational Waterways.

appropriate agencies.

3. Identify and coordinate funding sources for research, planning and implementation and long-term monitoring programs, with financing derived from both public and private sectors.
4. Serve as an educational resource to the Legislature and the general public...

The first and second responsibilities of the Council are generally accomplished through the Watershed Integrity Review and Evaluation (WIRE) process. Projects brought before the Council for endorsement are evaluated by component groups consisting of citizens, technical specialists, or agency representatives. The component groups evaluate the adequacy with which the project addresses the following: watershed perspective, credibility of research, identification of problem and solution, project management, ecosystem sustainability, social and cultural concerns, promotion of economic diversity, cooperation and coordination of appropriate groups and agencies, and legality. The component groups report their findings to the entire Council, and a decision regarding endorsement of the project is made. This process provides a mechanism for informing participants of the Council about a project, for allowing Council participants to discuss concerns from a variety of perspectives, and for providing feedback to project organizers. This increases the likelihood that potential consequences of a project within the watershed can be more completely addressed.

The Council is currently co-facilitated by the Fremont-Madison Irrigation District and the Henry's Fork Foundation. In 1996, the Administrator of DEQ appointed the Council to serve as a Watershed Advisory Group (WAG), as set forth in Idaho Code § 39-360 1 *et seq.,* to assist DEQ in development of total maximum dai1y loads for the Henry's Fork basin.

Water Quality Concerns and Status

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 USEPA. Any state that fails to issue standards adequate to achieve the goals and purposes of the Clean Water Act is subject to federal water quality standards promulgated by USEPA (Adler 1995). Idaho's water quality standards are published at *IDAPA 16.01.02 - Water Quality Standards and Wastewater Treatment Requirements.*

Designated Uses Idaho's designated uses for surface waters include 1) identification of beneficial uses, and 2) designation of waters for which beneficial uses are to be protected. The following excerpt from Idaho's water quality standards list the following beneficial uses for surface waters:

01. Water Supply.
a. Agricultural: waters which are suitable or intended to be made suitable for the irrigation of crops or as drinking water for livestock;
b. Domestic: waters which are suitable or intended to be made suitable for drinking water supplies;
c. Industrial: waters which are suitable or intended to be made suitable for industrial water supplies. This use applies to all surface waters of the state.

02. Aquatic Life.
a. Cold water biota: waters which are suitable or intended to be made suitable for protection and maintenance of viable communities of aquatic organisms and populations of significant aquatic species which have optimal growing temperatures below 18 degrees C.
b. Warm water biota: waters which are suitable or intended to be made suitable for protection and maintenance of viable communities of aquatic organisms and populations of significant aquatic species which have optimal growing temperatures above 18 degrees C.
c. Salmonid spawning: waters which provide or could provide a habitat for active self-propagating populations of salmonid fishes.

03. Recreation.
a. Primary contact recreation: surface waters which are suitable or intended to be made suitable for prolonged and intimate contact by humans or for recreational

activities when the ingestion of small quantities of water is likely to occur. Such waters include, but are not restricted to, those used for swimming, water skiing, or skin diving.

b. Secondary contact recreation: surface waters which are suitable or intended to be made suitable for recreational uses on or about the water and which are not included in the primary contact category. These waters may be used for fishing, boating, wading, and other activities where ingestion of raw water is not probable.

04. Wildlife Habitats. Waters which are suitable or intended to be made suitable 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.

All surface waters of the state are designated for the uses of industrial water supply, wildlife habitat, and aesthetics. In addition, Idaho has designated beneficial uses for most of the state's large rivers, lakes, and reservoirs. Table 6 is an excerpt of IDAPA 16.01.02.150.01, which designates beneficial uses for waterbodies in the Upper Snake Hydrologic Basin. Listed waterbodies may be "protected for general use" or "protected for future use"; table 6 shows that waterbodies in the upper Henry's Fork subbasin are "protected for general use". The table also shows that each waterbody has been designated a "Special Resource Water," which is defined as a specific segment or body of water which is recognized as needing intensive protection to a) preserve outstanding or unique characteristics, or b) maintain a current beneficial use (IDAPA 16.01.02.003.90).

The beneficial uses of the majority of surface waters in the Upper Henry's Fork subbasin, which are not addressed in Table 6, are addressed in section 101 of the standards, entitled "Undesignated Surface Waters." This section states that "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 Clean Water Act. Section 101 also states that because most of Idaho's waters are presumed to support cold water biota and primary or secondary contact recreation, criteria to protect these uses apply to all undesignated waters. This provision of Idaho's standards has caused confusion when relatively pristine warm waters, such as streams fed by warm springs, have been assessed as water quality impaired because they do not support cold water biota. Such problems can be resolved by performing a beneficial use attainability study and designating the waterbody for appropriate beneficial uses.

Table 6. Excerpt of “Designated Uses Within Upper Snake Hydrologic Basin” (IDAPA 16.01.02.150.01), showing designated uses of waterbodies in the Upper Henry’s Fork subbasin.

Water Body and Boundaries	Beneficial Use						
	Water Supply		Aquatic Biota		Recreation		Special Resource Water[2]
	Domestic	Agricultural	Cold water biota	Salmonid spawning	Primary contact	Secondary contact	
Henry’s Fork Source to Island Park	PGU[1]	PGU	PGU	PGU	PGU	PGU	PGU
Henry’s Fork Island Park Reservoir	PGU	PGU	PGU	PGU	PGU	PGU	PGU
Henry’s Fork Island Park Dam to mouth	PGU	PGU	PGU	PGU	PGU	PGU	PGU
Buffalo River Source to mouth	PGU	PGU	PGU	PGU	PGU	PGU	PGU
Warm River Source to mouth	PGU	PGU	PGU	PGU	PGU	PGU	PGU

[1]Protected for general use (PGU). This phrase is not defined in the standards.
[2]A “Special Resource Water,” is defined as a specific segment or body of water which is recognized as needing intensive protection to a) preserve outstanding or unique characteristics, or b) maintain a current beneficial use (IDAPA 16.01.02.003.90).

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 (IDAPA 16.01.02.200), Surface Water Quality Criteria For Use Classifications (IDAPA 16.01.02.250), and Site-Specific Surface Water Quality Criteria (IDAPA 16.01.02.275). General Surface Water Criteria 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. Surface Water Quality Criteria For Use Classifications specifies numeric criteria protective of recreational uses, aquatic life uses, and domestic water supply uses; the use classifications of agricultural and industrial water supplies, wildlife habitats, and aesthetics are considered protected by the General Surface Water Criteria. Recreational uses are protected by limits on concentrations of fecal coliform bacteria and toxic substances; aquatic life uses are protected by limits on pH, dissolved gas, total chlorine residual, toxic substances, dissolved oxygen, un-ionized ammonia, temperature, turbidity, and intergravel oxygen; and domestic water supplies are protected by limits on toxic substances, radioactive materials, and turbidity. Site-Specific Surface Water Quality Criteria describes the procedures for modifying criteria through site-specific analyses and confirms that site-specific criteria supersede Surface Water Quality Criteria For Use Classification. The site-specific criteria that have been incorporated into state standards address concentrations of dissolved oxygen (IDAPA 16.01.02.276 and 16.01.02.278) and use of waterways as canals (IDAPA 16.01.02.280).

Antidegradation Policy Idaho's Antidegradation Policy (IDAPA 16.01.02.051) 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 accomodate 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

The 1994 § 303(d) list of water quality-limited waterbodies was promulgated by the U.S. Environmental Protection Agency, 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 USEPA was underinclusive (W.D. Wa. Slip op., April 14, 1996). The § 303(d) list developed by the USEPA was based on 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, national forest plans developed by the U.S Forest Service, and comments submitted by the public (USEPA 1994).

Two waterbodies in the Upper Henry's Fork subbasin appear on Idaho's 1994 and 1996 § 303(d) lists: a segment of the Henry's Fork and Henry's Lake. The portion of the 1994 § 303(d) list that pertains to the Henry's Fork subbasin is shown in Table 7; water quality criteria that address the pollutants of concern are listed in Appendix E.

Table 7. Excerpt of the 1994 § 303(d) list showing water quality-impaired waterbodies in the Upper Henry's Fork subbasin.

Waterbody	PNRS[1] Number	Boundaries	Pollutant[2] of Concern	Priority[3]	Sources of Information used to Support Listing
Henrys Fork	60[4]	Buffalo River to Riverside Reach	Sediment	Low	None - no source of information was cited to support listing this segment
Henrys Lake	106		Dissolved oxygen	Low	Upper Snake River Basin Status Report, 1991.

[1]Pacific Northwest Rivers Study
[2]The term *pollutant* is used in this context to describe a parameter suitable for total maximum daily load (TMDL) calculation (USEPA 1996). For example, although dissolved oxygen is not generally considered a pollutant, it is a parameter for which a TMDL can be calculated.
[3]Each waterbody was assigned a priority ranking of low, medium, or high to facilitate development of a TMDL schedule.
[4]The PNRS number for Henry's Fork was changed to 78 on the 1996 §303(d) list.

The 1996 § 303(d) list is substantively identical to the 1994 list, although errors in descriptive information were corrected by DEQ. For the Upper Henry's Fork subbasin, the only difference between the 1994 and 1996 § 303(d) lists is the Pacific Northwest Rivers Study (PNRS) identification number for the segment of the Henry's Fork from Buffalo River to Riverside Reach. This number was changed from 60 on the 1994 list to 78 on the 1996 list.

As shown in Table 7, the 1994 § 303(d) list does not cite a source of information to support designation of the Henry's Fork as water quality impaired. But because the pollutant of concern is sediment, the designation was probably due to a 15-day event in September 1992, during which waters containing high concentrations of suspended solids were discharged from Island Park Reservoir to this segment of the river. In response to a request by the Henry's Fork

Foundation that DEQ investigate possible violations of state water quality standards, DEQ and the Idaho Department of Fish and Game conducted sampling and sponsored investigations by Idaho State University to evaluate the extent and effects of sedimentation downstream of the dam (HFF 1992). The results of these investigations are discussed in the following section.

The justification for placing Henry's Lake on the 1994 §303(d) list included 1) its designation as a stream segment of concern, and 2) a fish kill in 1991 caused by oxygen depletion. Stream segments of concern in the Upper Henry's Fork subbasin, which were identified in 1991 according to a process established by the *Final Agreement to Implement an Antidegradation Policy for the State of Idaho* (IDHW 1993), are listed in the *Upper Snake River Basin Status Report* (IDHW 1991). This list showed that Henry's Lake supported cold water biota, salmonid spawning, and primary and secondary contact recreation, but that these uses were threatened. It also showed that agriculture and/or grazing was the "purpose for designation." A narrative description of Henry's Lake written by the Idaho Department of Fish and Game that appears in the basin status report describes it as a "highly productive lake" that "supports an extensive sport fishery for large, native cutthroat trout." In 1990, the fishery supported a record fishing effort of 344,000 hours and an above-average harvest of 63,000 fish. But in March 1991, approximately 12,000 fish died because sections of the lake were depleted of oxygen. Although dissolved oxygen is generally not considered a pollutant, it is listed as the pollutant of concern for Henry's Lake in the 1994 §303(d) list because USEPA considers it a water quality parameter for which a total maximum daily load (TMDL) can be calculated (USEPA 1996).

During preparation of this subbasin assessment, DEQ issued a draft version of the 1998 § 303(d) list for public comment. This list was a revision of the 1994 and 1996 lists, and incorporated the results of assessments performed using biological data collected in 1994, 1995, and 1996 according to DEQ's beneficial use reconnaissance project (BURP) monitoring protocol for wadable streams (DEQ l995a, 1996a). Assessment of the beneficial use support status of a stream focused primarily on support of cold water biota and salmonid spawning (DEQ 1996b). Because the BURP data and assessment protocol pertained only to wadable streams, Henry's Lake and Henry's Fork were not assessed and these waterbodies remained on the list. Three streams or stream segments in the Upper Henry's Fork were assessed as not supporting cold water biota, so these streams were added to the draft list (Table 8). The pollutant or pollutants responsible for impairment of the water quality of these streams have not been determined and are therefore described as unknown on the draft list.

The Henry's Fork Watershed Council, in its role as Watershed Advisory Group to DEQ for the Upper Henry's Fork subbasin TMDL process, submitted comments to DEQ regarding the proposed list. The Council presented data supporting their recommendations that Henry's Fork from Buffalo River to Riverside Reach, Henry's Lake, Tygee Creek, and Meadow Creek be

Table 8. Excerpt of the draft 1998 § 303(d) list showing water quality-impaired waterbodies in the Upper Henry's Fork subbasin.

Waterbody	WQLSEG[1] Number	Boundaries	Pollutant[2]
Henrys Fork	2078	Buffalo River to Riverside Reach	Sediment
Henrys Lake	2106		Dissolved oxygen
Tygee Creek	5260	Forest Service boundary to Henrys Fork	Unknown
Gamer Canyon	5261	Headwaters to mouth	Unknown
Meadow Creek	5262	Headwaters to Henrys Fork	Unknown

[1]Water quality limited segment number
[2]The term *pollutant* is used in this context to describe a parameter suitable for total maximum daily load (TMDL) calculation (USEPA 1996). For example, although dissolved oxygen is not generally considered a pollutant, it is a parameter for which a TMDL can be calculated.

removed from the list, and that Sheridan Creek from the Yale-Kilgore Road to Island Park Reservoir be added to the list (HFWC 1998). The reasons given by the Council for removing Henry's Lake and segments of the Henry's Fork, Tygee Creek, and Meadow Creek were that the waterbodies "...currently support all beneficial uses, cannot be expected to support some beneficial uses under natural conditions, or support the beneficial use of cold water biota despite macroinvertebrate biotic index (MBI) scores of less than 3.5." The reason for adding the segment of Sheridan Creek was "[t]his segment does not support the beneficial use of salmonid spawning according to temperature criteria exceedances and fish population surveys."

Summary and Analysis of Existing Water Quality Data

Henry's Lake

Henry's Lake is operated by the North Fork Reservoir Company as a storage reservoir for irrigation water used south of the subbasin in the St. Anthony area. The historic lake was part of a marsh system that included approximately 1,100 acres of open water with an average depth of less than five feet and maximum depth of 6.5 feet (Irving 1953). In 1922, construction of Henry's Lake Dam transformed the marsh into a reservoir covering an area of approximately 6,600 acres to an average depth of 12 feet at full capacity. According to the *Report on Henry's Lake Clean Lakes Project* (Montgomery Watson 1996), construction of the dam has temporarily reversed the natural transformation of the lake to a meadow by inundating the historic wetland area around the lake with water:

> ..Henry's Lake can be described as a productive lake and generally classified as mesoeutrophic-eutrophic to eutrophic. Algal blooms typically occur throughout much of the spring, summer, and into the fall with the proper conditions of light, temperature, and nutrients. This process has probably been occurring over several hundreds of years and contributing to the extinction of the lake, given the history of the lake and watershed. The addition of the dam in 1922 probably altered this progression and prolonged the life of the lake.

In addition to functioning as a reservoir, Henry's Lake has historically supported an outstanding native cutthroat trout fishery. Exceptionally high production rates encouraged commercial harvests of fish from approximately 1872 to 1890, when the State banned the sale of wild trout. The Idaho Department of Fish and Game (IDFG) began operating a hatchery on the lake in 1924, and reared brook trout and cutthroat-rainbow trout hybrids for lake stock until the mid-1980s. Although fish are no longer reared at Henry's Lake, the fishery remains an important source of eggs for hatcheries at other locations within the state (Herron 1998). A study conducted in the early 1950s to "establish a criterion for cutthroat trout, as a species, living in an apparently optimal environment" (Irving 1953) is evidence of the capacity of Henry's Lake to support an exceptional fishery. From 1951 to 1971, the lake experienced a dramatic increase in sport fishing, and in 1976 the IDFG implemented trophy trout management (Rohrer 1983).

A decline in the cutthroat fishery, which was first observed in the 1960s, reached its most critical point in 1980 and 1981 with record low spawning runs and catch rates (Rohrer 1981, HLF 1994). Stocking of hatchery fish accounted for 90 percent of cutthroat recruitment, and the drastic decline in natural production was attributed to unclean spawning gravels, loss of fry to irrigation ditches, and dewatering of key spawning tributaries, which was exacerbated by drought conditions occurring from 1976 to 1981. The population decline was not considered a function of adverse limnological conditions such as low dissolved oxygen (Rohrer 1983).

In 1982, the Henry's Lake Enhancement Plan was developed by IDFG with the objective of re-establishing cutthroat trout as the primary species in Henry's Lake. One of the goals of the plan was annual natural production of 2.8 million fry, which was based on 1954-1955 spawning runs. To achieve the goal for natural fry production, the plan recommended obtaining water rights to maintain stream flows, and outlined projects for reducing the loss of fry to irrigation tributaries, improving degraded spawning habitat, and eliminating fish passage barriers (Rohrer 1983). No specific statements regarding the need for water quality improvements were included in the plan.

The fishery appeared to respond well to management efforts throughout the 1980s. Angling effort and catch rate increased from 68,000 hours and 0.2 fish per hour in 1980 to 344,000 hours and 0.5 fish per hour in 1990 (Herron 1998). However, Brostrom and Watson (1988) reported that in 1986-1987, "[t]he condition of Henrys Lake tributaries continue to be marginal for successful spawning and rearing of trout." To compensate for poor natural production, 2 million cutthroat fry were released to the lake from 1981 to 1984, and 1 million were released from 1985 to 1992.

In March 1991, the fishery suffered the first documented water quality-related mortality in almost 40 years. Seasonal oxygen depletion killed approximately 10,000 fish in the vicinity of Hatchery Creek, and possibly as many as 100,000 throughout the lake (Herron 1998). The only other winter kill documented for Henry's Lake was in 1952 when an estimated 3,600 fish presumably were asphyxiated because they congregated in small, open-water areas at the mouths of tributary streams (Irving 1953). Despite the number of fish that were estimated to have died in 1991, creel census data indicate that the incident had only a minor affect on the fishery. The catch rate decreased from 0.5 in 1990 to 0.3 in 1991, but rebounded to 0.6 in 1993 and 1994 (HLF 1994). The IDFG began monitoring winter dissolved oxygen levels in 1992, installed portable surface aerators at four locations, and used air blowers to supplement surface aeration. A shore-based aeration system was placed near the hatchery in 1993. Although calculation of the total volume of dissolved oxygen in the lake in 1993 indicated that it approached a lethal level, a significant fish kill was not observed (DEQ 1994). Artificial aeration to maintatin open-water areas with higher than ambient concentrations of dissolved oxygen appeared to be effective in preventing fish mortality.

The real significance of the 1991 fish kill was that the public and government agencies perceived it as evidence that the quality of the Henry's Lake ecosystem was in decline and, more importantly, were prompted to provide the resources necessary to investigate the causes responsible for this decline. The Yellowstone Soil Conservation District (YSCD) Board of

Supervisors responded by requesting that the Soil Conservation Service, now known as the Natural Resources Conservation Service (NRCS), perform a preliminary investigation to determine agricultural impacts to the lake (SCS 1991). Because of the results of the investigation, the YSCD entered into a State Agricultural Water Quality Project (SAWQP) with DEQ in early 1993 to:

- Assess the status of the beneficial uses of the water bodies within the project area.
- Determine water quality impacts from all activities in the watershed.
- Identify major pollution sources and prioritize activities and critical subwatersheds needing treatment.
- Initiate a Coordinated Resource Management process, as appropriate.
- Develop watershed treatment alternatives and select an alternative to achieve improvements in beneficial uses of the water bodies.

These objectives complemented those of the Clean Lakes Project, which began in 1990 when the Henry's Lake Steering Committee was organized by DEQ to oversee development of a lake management plan. This committee was comprised of representatives of local, state and federal agencies, the North Fork Reservoir Company, Henry's Lake Foundation, Henry's Fork Foundation, local businesses, property owners, and ranchers. The Henry's Lake Clean Lakes Project began in 1992 with funding authorized by Idaho's Nutrient Management Act and § 314 of the Clean Water Act. Although the objectives of the Clean Lakes Project were similar to those of SAWQP, its primary focus was nutrient management.

The Clean Lakes Study concluded that naturally high concentrations of phosphorus in the lake and watershed are responsible not only for high levels of primary production in Henry's Lake, which can result in degraded water quality conditions, but for the continued production of the lake's prized fishery. The phosphorus cycle, elucidated through monitoring and mathematical modeling, was described in the *Report on Henry's Lake Clean Lakes Project* (Montgomery Watson 1996) as follows:

> Data...indicate that much of **the phosphorus input to the lake is attributable to natural processes in both the lake and its surrounding watershed** [emphasis added]. Erosional processes in upper watershed areas contribute large concentrations of suspended solids or sediments to the lake that contain significant portions of bound phosphorus. These sediments are discharged from the tributaries into the lake, covering large portions of the lake bottom. Low winter season dissolved oxygen concentrations in the lake then cause a release of large quantities of the phosphorus bound to the sediments in the lake bottom, which becomes available for the next

> season's algae and macrophyte crop. The die-off of the algae and macrophytes at the end of the summer then begins again the cycle of oxygen depletion and phosphorus release from the sediments. This is the pattern of internal nutrient recycling, and sediment release of phophorus accounts for much of the annual loading in the lake.

The SAWQP report concurred with this finding, concluding that:

> Although water quality conditions at Henry's Lake occassionally create eutrophic conditions such as algae blooms and reduced oxygen concentrations, it is important to understand that **these conditions are inherent to the lake** [emphasis added]. The very factors that create adverse water quality conditions also makes Henry's Lake a world class fishery.

The Clean Lakes Project included calculation of total phosphorus budgets for 1992-1994. Total loads varied substantially between years, but the relative contributions of most sources remained similar. Table 9 shows that the internal lake load (i.e., phosphorus bound to sediment or incorporated in plant tissues) contributed an average of 56 percent of the total phosphorus load for the three-year period, tributary flows contributed approximately 25 percent, atmospheric deposition contributed approximately 13 percent, and groundwater inflow and septic systems each contributed approximately 3 percent (Montgomery Watson 1996). The relatively small contribution from septic systems contradicted public perception that this source was a major contributor of phosphorus to the lake (USDA 1991).

Two of the six major tributaries to Henry's Lake, Duck Creek and Targhee Creek, each contributed approximately 8 percent of the average total phosphorus load for 1992-1994. These streams also showed the greatest between-year variability in relative contributions of phosphorus. The relative contribution of phosphorus from Duck Creek ranged from 4 to 12 percent; the relative contribution from Targhee Creek ranged from 2 to 13 percent.

Consistent with the results for phosphorus, the total suspended solids (TSS) budget developed for 1992-1994 showed that Duck Creek and Targhee Creek also contributed more TSS to the lake than any of the other tributaries (Montgomery Watson 1996). Duck Creek contributed 87,000 to 253,000 kg of TSS per year, or 32 to 43 percent of the TSS from all tributaries and subbasins; Targhee Creek contributed 49,000 to 321,000 kg of TSS per year, or 24 to 49 percent of the TSS from all tributaries and subbasins. According to the Clean Lakes Study, the high TSS load for Duck Creek resulted from high concentrations of TSS and moderate flows whereas the high loads for Targhee Creek resulted from average concentrations of TSS and high flows.

Table 9. Henry's Lake total phosphorus budgets for 1992 through 1994[1].

Source of Inflow	Phosphorus (kg/year)			Percentage of Total Load (%)[2]			Average for 1992-1994[2]	
	1992	1993	1994	1992	1993	1994	kg/year	%
Internal lake load	2,461	7,563	4,129	47	56	66	4,718	56
Duck Creek	604	1,338	253	12	10	4	732	8
Targhee Creek	485	1,825	151	9	13	2	820	8
Hope Creek	60	172	51	1	1	<1	94	1
Howard Creek	30	238	51	<1	2	<1	106	1
Pittsburgh Creek	4	14	5	<<1	<<1	<<1	8	<<1
Timber Creek	22	181	43	<1	1	<1	82	<1
All other subbasins	225	864	218	4	6	4	436	5
Total subbasins	1,430	4,632	772	28	34	12	2,278	25
Atmosphere[3]	852	953	904	16	7	14	903	13
Groundwater	250	250	250	5	2	4	250	3
Septic systems	196	196	196	4	1	3	196	3
TOTAL LOAD TO LAKE	5,189	13,594	6,251				8,345	
OUTFLOW FROM LAKE	1,499	3,266	806				1,857	
LOAD RETAINED IN LAKE	3,690	10,328	5,445				6,488	

[1]Source: *Report on Henry's Lake Clean Lakes Study* (Montgomery Watson 1996).
[2]Values are approximate, so summations may not appear accurate because of rounding errors.
[3]Includes precipitation and dryfall.

The SAWQP report estimated that 7,015 tons of sediment (i.e., suspended solids and bedload material) were delivered to the lake per year under conditions existing in the watershed at the time of the study. Approximately 40 percent of this sediment was produced by natural erosional processes on forest and range lands. The vegetative condition of these lands appeared good, and there was no evidence of accelerated sheet or rill erosion. The remaining 62 percent of sediment delivered to Henry's Lake was produced by accelerated erosional processes along tributary streambanks (26%) and associated irrigation channels (10%), along the lake shoreline (19%), and on pastureland (7%). The apparent cause of accelerated erosion along streambanks and irrigation channels was a combination of livestock activity and high-velocity spring flows acting on unstable streambanks; the cause of lake erosion was frequent severe windstorms acting on unstable shoreline; and the cause of pasture erosion was a combination of poor vegetative condition, mechanical impact from grazing, and irrigation practices (YSCD 1995).

The Henry's Lake Clean Lakes Project included analysis of 55 alternatives for managing total phosphorus loading to and within the lake. These alternatives were formulated at a public workshop and included structural solutions such as construction of wetlands, sediment basins, or filtering systems; nonstructural solutions such as land use controls and public information programs; and implementation of best management practices. Each alternative was evaluated using a set of criteria that included technical feasibility, effectiveness, cost/benefit ratio, social effects, economic effects, environmental effects, and public acceptability. Based on this initial evaluation, each alternative was classified as viable, non-viable, or having benefits other than reductions in phopshorus loading. Viable alternatives or alternatives having other benefits were subjected to additional analysis, including mathematical modeling of potential phosphorus reductions. The following excerpt from the *Report on Henry's Lake Clean Lakes Project* summarizes the results of the analysis:

> ...several of the alternatives do not appear capable of providing reasonable benefits and reductions in nutrient loads [because:]
>
> - Implementation of these alternatives would require large capital investments and/or continued and substantial maintenance costs. Cost-intensive alternatives were not justified given the estimated minor reductions in total phosphorus loads to the lake.
> - The internal recycling/sediment release component of the total phosphorus budget appears to sustain phosphorus loads at high levels even when a nutrient management alternative was estimated to achieve good total phosphorus load removal from watershed components.
> - Nutrient management alternatives can not be unilaterally applied across the watershed and therefore cannot achieve significantly high rates of overall total phosphorus removal.

- Each nutrient management alternative has an estimated removal efficiency which, in some cases, ranges down to 30 percent total phosphorus removal.
- A portion of the total phosphorus loading to the lake is in dissolved form and the majority of alternatives are not capable of removing this fraction.

One of the alternatives that was not recommended for implementation was collection and treatment of the wastewater flow generated by homes around the lake. Analysis showed that 100 percent treatment would have only minimal effects on long-term water quality.

The remaining alternatives, which were found to offer “minor, yet cost-effective” reductions in total phosphorus loads are listed in Table 10. According to the Clean Lakes Project report, these improvements “would probably not eliminate winter seasonal oxygen depletion or summer seasonal algal blooms, however, they may help decrease the frequency and duration of these episodes and improve fish survival...[and] provide secondary benefits to Henry’s Lake and its tributaries.”

In summary, the Henry’s Lake Clean Lakes Project demonstrated that winter depletion of dissolved oxygen is caused by high phosphorus concentrations within the lake, which are in turn caused by predominantly natural processes within the lake’s subbasin. The results of modeling various alternatives to reduce phosphorus loading to the lake indicate that it is not feasible to develop or successfully implement a total maximum daily load for dissolved oxygen or its surrogate, phosphorus. More importantly, the history of fisheries management at Henry’s Lake indicates that observable fish kills, which are the undesirable effects of dissolved oxygen depletion, are uncommon and have apparently had little effect on the Henry’s Lake fishery. Although the 1991 fish kill was dramatic, especially as perceived by the public, the IDFG has demonstrated that the circumstances which contribute to fish kills can be monitored and sometimes altered through mechanical aeration.

The Clean Lakes Project, SAWQP, and IDFG annual reports emphasize improvement of ecosystem function, not control of specific pollutants. It appears that dissolved oxygen was listed as the “pollutant of concern” for Henry’s Lake on the 1994 § 303(d) list because of a dramatic, but unusual event (i.e., the 1991 fish kill) that originated through natural processes. However, the preponderance of information available for Henry’s Lake indicates that the most serious threat to the lake has been, and continues to be, impaired function of lake tributaries for salmonid spawning and fry recruitment. Problems responsible for this impairment, as well as recommendations for correcting the problems, are well defined in the documents previously cited and in the *Henry’s Lake SA WQP Plan of Operations* (YSCD 1996).

Table 10. Recommendations for improving the water quality of Henry's Lake and its tributaries, and expected reductions in phosphorus load due to implementation of each recommended action.

Recommendation	Expected Benefits and Limitations
Implement livestock best management practices	Pasture rest and rotation and wetland filter strips were estimated to reduce total phosphorus less than 5 percent, so these practices were not recommended for major implementation to achieve phosphorus reductions. However, use of pasture rest and rotation wherever possible, and filter strips on marginal pasture bordering the lake and tributaries were encouraged.
Stabilize tributary streambanks	Streambank erosion accounted for only 0.2 to 0.5 percent of total phosphorus loading, so stabilization was not recommended for major implementation to achieve phosphorus reductions. However, "the secondary benefits to the streams warrant that stabilization projects be implemented as practical" to help increase spawning success in the tributaries and improve the lake's fish population and fishery. The Duck Creek riparian restoration demonstration project was cited as a model for future projects.
Stabilize the lake shoreline	Shoreline erosion accounted for only 0.2 to 0.4 percent of total phosphorus loading, so stabilization was not recommended for major implementation to achieve phosphorus reductions. However, shoreline stabilization provides a secondary benefit by reducing sediment load. The Shoreline Protection Demonstration Project at William Frome County Park, completed was cited as a model for future projects.
Continue to divert flows from Rock Creek to pasture land. Implement future diversions along Rock and Targhee Creeks if compatible with water rights and salmonid requirements.	Diversions of storm runoff to pasture land along Rock and Targhee Creeks were shown to have good potential for substantially reducing total phosphorus loads to Henry's Lake. However, this alternative was not recommended for full-scale implementation because the complexities of water rights issues and potential instream impacts on salmonids.
Implement forest and other land-use best management practices	Data from watersheds containing timber sales and field reconnaissance indicated that the majority of loads developed on the forest were natural in origin. Major implementation of forest best management practices would not significantly reduce loads but should be followed to maintain low sediment loads.
Implement public education and information programs	Education and information programs such as distribution of materials on best management practices to homeowners and ranchers was described as a relatively simple action that can indirectly lead to improvement of water quality.
Construct rock-lined overfalls and repair eroded terraces in the upper Rock Creek and Targhee Creek basins using hand tools	Quantitative benefits could not be established, but recommended improvements would produce only minor reductions in phosphorus load. The upper portions of these basins account for much of the total phosphorus loading to Henry's Lake, though the majority of loading appears to be natural. Terraces constructed in 1962 are functioning as intended; recommendations address maintenance needs only.
Continue to aerate portions of Henry's Lake in winter	Aeration treats the symptom of high phosphorus concentrations by providing relief from dissolved oxygen depletion and limiting phosphorus release from sediments in the area aerated.

The *Henry's Lake SA WQP Plan of Operations* (YSCD 1996) describes a 15-year plan for achieving the following estimated benefits:

- 30% annual reduction of sediment and associated nutrients entering the lake and Henry's Lake Outlet;
- restoration of 14.8 miles of riparian area;
- 44% increase in the fishery due to improvements in spawning and rearing habitat; and
- $1.17 million annual increase in the local economy.

Critical areas identified for treatment with best management practices include portions of the Henry's Lake shoreline and segments of tributaries to the lake and lake outlet. The erosion rates of these critical areas are classified as moderate (recession rate of 0.06 to 0.2 feet per year) and severe (recession rate of 0.3 to 0.5 feet per year). Table 11 lists the percentages of waterbody shoreline or streambank classified as slightly, moderately, or severely eroding, and the percentages of the critical areas along each waterbody that are currently under SAWQP contracts for treatment. Because of recent changes in the SAWQP program, funding for treatment of areas already under contract will continue, but SAWQP funding for writing additional contracts has been terminated. The Yellowstone Soil Conservation District, Natural Resources Conservation Service, and Soil Conservation Commission continue to seek funding through alternative programs to treat critical areas that have not yet been addressed with SAWQP funding.

Substantial progress toward implementing water quality and habitat improvement projects has been made. The Henry's Lake SAWQP achieved a three-year goal of treating fifty percent of critical areas on tributaries, and several examples of improvement projects completed on Henry's Lake since 1991 are shown in Table 12. With additional resources, implementation of recommendations could proceed more rapidly. Therefore, the recommendations of this subbsain assessment are as follows:

1. Instead of developing a total maximum daily load for dissolved oxygen, direct resources toward implementation of the recommendations made in the *Report on Henry's Lake Clean Lakes Project* and the *Henry's Lake SA WQP Final Planning Report/Environmental Assessment.*

2. Reconvene the Henry's Lake Steering Committee to provide continuous leadership and coordination for water quality and habitat improvement projects, review progress on the recommendations made in the *Report on Henry's Lake Clean Lakes Project* and the *Henry's Lake SA WQP Final Planning Report/Environmental Assessment,* and revise goals based on evaluations of monitoring data.

Table 11. Percentages of Henry's Lake shoreline and tributary streambanks classified by the *Henry's Lake SA WQP Final Planning Report/Environmental Assessment* (YSCD 1995) as slightly, moderately, or severely eroding. Moderately and severely eroding banks were designated critical areas eligible for receiving funding for treatment. The percentage of total critical area under contract for treatment is shown for each waterbody (Beckman and Bradford 1998).

Waterbody	Length Surveyed (feet)	Percentage of Waterbody Classified Within the Following Erosion Categories			Percentage of Total Critical Area Under Contract[1]
		Slight[2]	Moderate[3]	Severe[4]	
Henry's Lake	107,100	33	37	30	3
Henry's Lake Outlet	49,809	28	35	36	49
Duck Creek	20,811	77	21	1	86
Hope Creek	5,939	95	0	5	0
Howard Creek	28,646	79	14	7	100
Targhee Creek	26,953	48	12	41	100
Timber Creek	12,859	100	0	0	0
Tygee Creek	15,524	55	30	15	0
Twin Creek	11,338	52	48	0	13
Crooked Creek	46,973	100	0	0	0
Stephens Creek	10,702	85	7	7	50
Meadow Creek	12,574	67	33	0	0
Canyon and Jones Creek	17,617	63	13	24	10
Jesse Creek	16,349	17	59	25	19
Enget Creek	2,251	100	0	0	0
Hidden[5] Creek	4,858	33	33	33	0
Rock Creek	4,148	0	100	0	44

[1]Critical area includes portions of the waterbody classified as moderately and severely eroding.
[2]Slight erosion indicated by a lateral recession rate of 0.01 to 0.05 feet per year.
[3]Moderate erosion indicated by a lateral recession rate of 0.06 to 0.2 feet per year.
[4]Severe erosion indicated by a lateral recession rate of 0.3 to 0.5 feet per year
[5]Unnamed on Big Springs 7.5 minute quadrangle map; located east of Island Park golf course.

Table 12. Examples of water quality and habitat enhancement projects implemented at Henry's Lake since 1991.

Project	Cooperators
1991 - 1993: Constructed or rebuilt 4.5 miles of riparian fence on Henry's Lake tributaries; initiated a wetland enhancement project adjacent to Targhee Creek; installed a riparian fence on southeast lake shore to exclude cattle (DEQ 1994).	Idaho Department of Fish and Game, Henry's Lake Foundation
1994 - Completed shoreline protection demonstration project at William Frome County Park, holistic resource management system on Diamond D Ranch, and riparian pastures on Henry's Flat (YSCD 1995).	Yellowstone Soil Conservation District, Idaho Soil Conservation Commission, Diamond D Ranch, Island Park Sportsman's Association, Henry's Lake Foundation, Nature Conservancy
1995 - Diamond D Ranch: completed riparian fencing project on Howard and Targhee Creeks below Highway 87 and shoreline fencing between Howard and Targhee Creeks; installed off-site watering adjacent to Howard Creek, increasing by 80% the amount of water retained in Howard Creek during peak irrigation. Howard Creek Ranch: revegetated riparian area along Howard Creek Ranch grazing exclosure (IDFG1995).	Idaho Department of Fish and Game, Diamond D Ranch, Henry's Lake Foundation, Howard Creek Ranch, Idaho Soil Conservation Commission, Nature Conservancy, volunteers
1997 - Replaced posts and repaired fence on middle section of Duck Creek; purchased solar panel, energizer and electrical components for Kelly Springs fence; built exclosure fence on Duck Creek between County and Forest Service roads; completed shoreline stabilization project on Slash E Ranch adjacent to Targhee Creek (HLF 1998).	Taft and Hartman Ranch, Slash E Ranch, Nature Conservancy, Natural Resources Conservation Service, Henry's Lake Foundation
1997 - Memorandum of Agreement to exchange up to 2,200 acre-feet of water annually in the Upper Snake reservoirs to provide winter flows for fish in Henry's Lake Outlet.	North Fork Reservoir Company, U.S. Bureau of Reclamation, State of Idaho Water District 1, Idaho Department of Fish and Game, Nature Conservancy

3. Implement a long-term, inter-agency monitoring program to identify water quality problems and provide a basis for evaluating the success of projects. Analyze and interpret monitoring data on an annual and multiple-year basis to evaluate trends.

4. Procure funding for implementation of recommended improvement projects.

Henry's Fork: Buffalo River to Riverside Reach

The 15-mile segment of the Henry's Fork from Buffalo River to Riverside begins less than one-half mile downstream of Island Park Reservoir. Built in 1938 by the U.S. Bureau of Reclamation as part of the Minidoka Project, the reservoir supplies water to the Fremont-Madison Irrigation District for use south of the subbasin between Ashton and Rexburg. Besides the Buffalo River, only two named tributaries, Blue Spring Creek and Thurmon Creek, enter this segment of the Henry's Fork. Most of the land surrounding the river is managed by the Targhee National Forest although eight miles of the segment meander through Harriman State Park. Private land ownership is limited, with residential and commercial developments concentrated near the river at Box Canyon, Last Chance, and Pinehaven.

The Henry's Fork below Island Park Darn is known for an abundant and diverse aquatic invertebrate community and the blue ribbon rainbow trout fishery that it supports (ERI 1995*).* It was described in 1979 in Fly Fisherman magazine as "a shrine for some expert fishermen" and "[maybe] the finest trout stream in the United States" (Schwiebert 1979, as cited in Van Kirk 1996). The value placed on the Henry's Fork by the local, national and international community of flyfishers led to the formation of the Henry's Fork Foundation in 1984. Restoration and protection of the Henry's Fork below Island Park Dam were the original objectives of the Foundation, and continue to be of primary interest to the Foundation's national constituency (Van Kirk 1996, Brown 1998).

In October 1992, the Henry's Fork Foundation requested that DEQ investigate possible violations of state water quality standards related to the release of sediment from Island Park reservoir. This release was caused by the following unique combination of circumstances which were described in the Fall 1992 edition the Henry's Fork Foundation Newsletter (HFF 1992).

Following six years of drought, the Bureau of Reclamation notified state agencies that most reservoirs would reach minimum pool in September of 1992. The IDFG requested that the water level in Island Park Reservoir be reduced even more to facilitate eradication of non-game fish by rotenone treatment. The Bureau accomodated the request, and DEQ issued IDFG a short-term exemption from water quality standards for rotenone application at the end of September. The reservoir level was reduced from approximately 2000 acre-feet to 270 acre-feet during the second week of September, 14 days before the rotenone application was scheduled to occur. During the drawdown and until the day of treatment, approximately 350 cfs of water and associated sediment was discharged from the reservoir. According to Ecosystems Research Institute, which was conducting water quality monitoring for Fall River Rural Electric Cooperative, concentrations of total suspended solids reached more than 500 mg/L and the estimated total amount of sediment released was 50,000 tons.

In response to the request by the Henry's Fork Foundation, DEQ sponsored a study of the fate and effects of the sediment event (Minshall and Robinson 1993) and a study of the feasibilty of flushing flow releases to mitigate those effects (HabiTech, Inc. 1994).

Researchers from the Stream Ecology Center at Idaho State University conducted their study in October 1992 to document conditions in the river soon after the sediment release. The objectives of their study were to determine 1) the locations of sediment deposition, 2) the impact of the sediment discharge on aquatic macroinvertebrates, and 3) the relative amounts of organic (decomposable) and inorganic (inert) materials in the sediment (Minshall and Robinson 1993). Because comparable information had not been collected prior to the sediment event, effects were evaluated by comparing data from seven sites downstream of Island Park Dam to data from three upstream reference sites. The downstream sites reached from the confluence of the Buffalo River, 0.2 mile downstream of the dam, to Riverside Campround, 15.3 miles downstream. Two of the reference sites were located on the Henry's Fork upstream of Island Park Reservoir and one reference site was located on the Buffalo River (Figure 11).

The results of the investigation showed that concentrations of sediment and organic matter were highest at two sites downstream of Island Park Dam that were characterized by the investigators as "slow-flow". Although it could not be determined whether these higher concentrations resulted from the sediment event in September, the investigators noted that the colors of the sediment at downstream sites "...suggest[ed] that most of the material was recently derived from the reservoir." If elevated concentrations of sediment and organic matter resulted from the sediment event, the study indicated that deposition was occurring at sampling sites approximately 5.5 and 10 miles downstream of the dam.

Regardless of streambed conditions prior to the sediment event, the study indicated that sediment released from the reservoir had been flushed downstream and deposited at slow-flow sites. The concentration of fine inorganic sediment (i.e., inorganic particles less than 1.4 mm in diameter) at the fast-flow reference site was ~1020 mL/m^2 whereas concentrations at the fast-flow sites 0.2, 2.5, and 15.3 miles downstream of the dam were 493, 459, and 940 mL/m^2. Moving downstream from the dam, concentrations of sediment at slow-flow sites declined relative to reference, then increased. The average concentration of the slow-flow reference sites was ~2770 mL/m^2, the average concentration at slow-flow sites located 3 and 4 miles below the

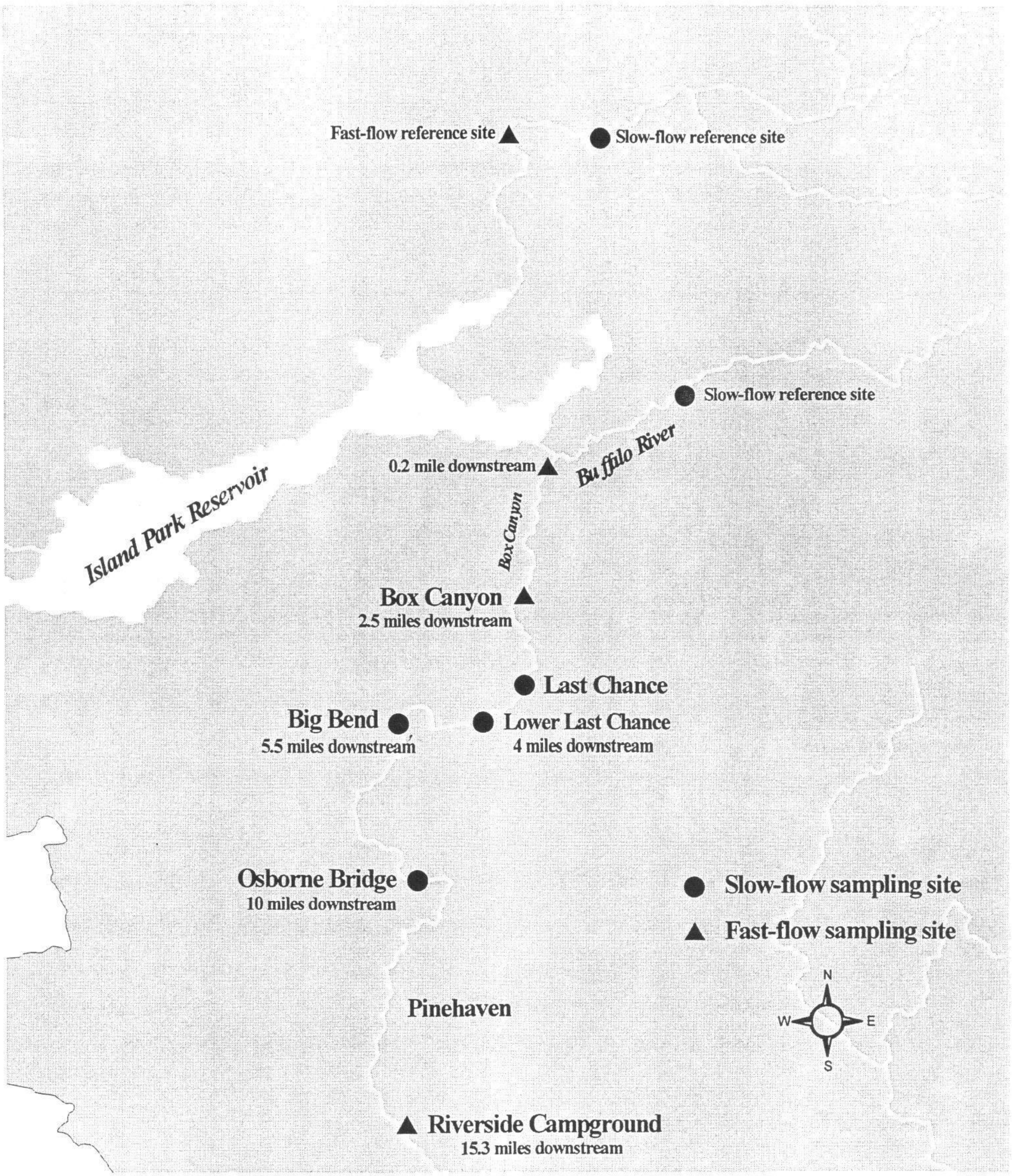


Figure 11. Approximate locations of sites sampled for benthic macroinvertebrates by Robinson and Minshall (1993).

dam dropped to ~1400 mL/m^2, but the average concentration at slow-flow sites located 5.5 and 10 miles below the dam increased more than five times to ~7698 mL/m^2.

Sampling results also indicated that coarse particulate organic matter (CPOM, particles greater than 430 μm in diameter) and fine particulate organic matter (FPOM, particles between 53 and 430 μm in diameter) were flushed downstream. At fast-flow sites, the distribution of both CPOM and FPOM was similar to the distribution of inorganic sediment. The authors concluded that substantial deposition of sediments had occurred at slow-flow sites four and ten miles downstream of the dam, though that conclusion could not be corroborated by instream sediment data prior to the 1992 sediment event.

Biotic metric scores, based on macroinvertebrate samples, were also lowest at the slow-flow sites four and ten miles downstream of the dam. A low biotic metric score indicates an impaired macroinvertebrate community; a high biotic metric score indicates a healthy macroinvertebrate community. Although low biotic metric scores occurred at the downstream slow-flow sites, the biotic metric scores at fast-flow sites downstream of the dam exceeded the scores for reference sites. The highest biotic metric score, 31 out of a possible 35, was at the fast-flow site 2.5 miles downstream of the dam; the next highest scores were at fast-flow sites upstream of the reservoir and downstream of the dam at the confluence of the Buffalo River and at Riverside.

In 1997, DEQ implemented a preliminary beneficial use reconnaissance project (BURP) for large rivers. The large-river protocol, which is still under development, includes sampling of macroinvertebrate communities for calculation of an Idaho Rivers Index (IRI) score. The IRI, which was developed by some of the same researchers who conducted the 1992 sediment effects study, incorporates several biological metrics that are indicative of the quality of a particular aspect of the macroinvertebrate community. Metrics calculated for the Riverside site using data collected in 1992 by Minshall and Robinson (1993), and in 1997 by DEQ, are shown in Table 13. All but one of the metrics changed substantially, with those changes indicating improvement in the overall quality of the macroinvertebrate community.

Table 13. Change in the macroinvertebrate community at Riverside, as indicated by changes in biological metric scores from 1992 to 1997.

Biological metric	Direction of Change that Indicates Improvement	Collection date	
		October 1992[1]	October 1997[2]
Taxa Richness	Increase	19 ± 4 (11 - 24)	36
% Dominance	Decrease	42±23 (21 - 88)	40
EPT[3] Index	Increase	8 ± 3 (3 - 12)	16
% EPT	Increase	42± 14 (21 - 65)	74
% Scrapers	Increase	27 ± 14 (5 - 47)	19
Hilsenhoff Biotic Index	Decrease	4.8 ± 0.8 (4.0 - 5.9)	3.2

[1]Values reported are the mean, standard deviation, and range often samples.
[2]Values reported are for a composite analysis of three samples.
[3]EPT: Ephemeroptera, plecoptera, and trichoptera.

Table 14 lists IRI scores that were calculated using data collected from 1993 to 1997. The raw data used to calculate the scores are from four sources. Scores for the 1992 sediment effects study (Minshall and Robinson 1993) could not be calculated because raw data were not reported. Gregory and Van Kirk (1997) did not count macroinvertebrates that passed through mesh with 1-mm openings, resulting in an underestimate of the abundances of *Baetis spp.* and Chironomidae. Because high numbers of these invertebrates tend to reduce IRI scores, the scores calculated using these data may be slightly inflated.

According to the developers of the IRI, all of the scores listed in Table 14 are indicative of good to excellent water quality. An IRI score of 13 or less indicates degraded water quality, and a score of 16 or greater indicates good to excellent water quality (Royer and Minshall 1996). Lower scores in 1993 and higher scores in 1997 also indicate that water quality improved during this time. Although it cannot be determined whether the low IRI scores in 1993 reflect the sediment event or seasonal variation in macroinvertebrate populations, these data indicate that one year after the sediment event, this segment of the Henry's Fork supported the beneficial use of cold water biota.

Table 14. Idaho River Index (IRI) scores for sites on the Henry's Fork between Buffalo River and Riverside Reach. Scores greater than 16 are indicative of good to excellent water qualty.

Date	Sampling Site and Approximate Location Relative to the Confluence of the Henry's Fork and Buffalo River	IRI Score	Data Source
March 1993	Box Canyon - 2.6 river miles downstream Osborne Bridge - 9.3 river miles downstream	17 17	Ecosystem Research Institute (1995)
1995	Pinehaven - 12.8 river miles downstream	21	Royer and Minshall (1996)
April 1995	Box Canyon Meadows, East Side - 2.3 river miles downstream Box Canyon Meadows, West Side - 2.3 river miles downstream	21 21	Gregory and Van Kirk (1997)
April 1996	Box Canyon Meadows, East Side - 2.3 river miles downstream Box Canyon Meadows, West Side - 2.3 river miles downstream	19 21	Gregory and Van Kirk (1997)
April 1997	Box Canyon Meadows, East Side - 2.3 river miles downstream, Box Canyon Meadows, West Side - 2.3 river miles downstream	21 23	Gregory and Van Kirk (1997)
October 1997	Riverside - 15 river miles downstream	21	DEQ BURP .

The investigation of the feasibility of releasing flushing flows from Island Park Dam to mitigate the effects of the sediment event (HabiTech, Inc. 1994) was also hampered by the absence of pre-1992 instream sediment data. However, the report of the investigation concluded that 1) the streambed was highly embedded with fine sediment, 2) the transport capability of the river was low due to its coarse-grained streambed and minimal available shear stress even at high discharge rates, and 3) the flow needed to mobilize the coarse streambed material associated with fish overwintering habitat along the lateral margins of the river greatly exceeded the historic peak discharge of record. However, the investigation also concluded that removal of fine sediments from spawning grave1s could be achieved with a flow of 2600 cfs for at least nine hours in the vicinity of Last Chance (Figure 11). Daily mean discharges exceeding 2600 cfs were recorded below Island Park Dam on four occassions in both 1994 and 1995 (USGS 1994, 1995), but monitoring to evaluate the effects of these flows on sediment movement was not conducted at the time.

The results of an investigation sponsored by the Henry's Fork Foundation in 1997 indicated that the quality of substrate in the vicinity of Last Chance had improved since 1993 and 1994. Investigators reported that composite median particle size increased from 13 mm in 1993 to 23 mm in 1997; the percentage of finer materials less than 2 mm in diameter decreased from 24 to 16; and the Fredle Index, a measure of spawning gravel quality, improved from 1.9 to 5.5 (Habitech, Inc. 1998). The investigators stated that the results "...strongly suggest improvement over the conditions encountered following the 1992 sediment flow event from Island Park Reservoir, [but] they should not be interpreted as license to continue the management practices which precipitated the 1992 event." The investigators also suggested that "...implementation and enforcement of a 'minimum pool' standard for the reservoir would likely prevent a future re-occurrence" (Habitech, Inc. 1998).

The number of redds constructed by spawning trout should provide an indication of the quality of substrate in the vicinity of Last Chance. Gregory (1997) performed bimonthly redd counts from the end of January through mid-May 1997 in the river and tributaries upstream of Riverside. Fourteen redds were observed in a 75-m area at Last Chance, which was approximately half the number observed in an area of Box Canyon considered to contain a high density of redds (Gregory and Van Kirk 1997). By comparison, no redds were observed in the vicinity of Last Chance during a one-day aerial survey conducted in April 1982, and investigators described the area as having little habitat and a silt substrate (Rohrer 1984). These results appear to indicate that the quality of the substrate improved from 1982 to 1997, despite the 1992 sediment spill. However, this conclusion is confounded by the failure of another 1997 survey to detect any redds in the vicinity of Last Chance (Mitro and Zale 1997). The contradictory results of the 1997 surveys, which were conducted using different sampling techniques, highlight 1) the variability in redds counted due to sampling techniques, and 2) the potential for incorrectly assessing the suitability of a substrate for spawning when redd counts are used as the sole indicator. Although it is difficult to draw specific conclusions regarding the change in substrate quality from 1982 to 1997 based on available redd counts, it is evident from the data collected by Gregory (1997) that salmonid spawning is occurring in the vicinity of Last Chance.

Concerns regarding the effects of the 1992 sediment discharge were exacerbated by a common perception that the rainbow trout population in this segment of the Henry's Fork had seriously declined since the late 1970s. The conditions cited for this decline were lack of spawning habitat and poor overwinter survival, which some observers believed could only be made worse by the sediment release. Recently however, Van Kirk (1996) and Van Kirk and

Gamblin (in preparation) reviewed the management history of the Henry's Fork and the substantial research literature that has accumulated for this segment of the river. They proposed that while the overall number of rainbows has declined, the population of *wild* rainbow trout is stabilizing as it reaches its carrying capacity.

According to Van Kirk and Gamblin (in preparation), management of Island Park Reservoir and fish stocking practices are largely responsible for the population fluctuations observed in the past 20 years. IDFG confirm that the number of rainbow trout in Box Canyon, a three-mile section of the river that serves as an indicator of the population from Island Park Reservoir to Riverside, has declined since 1978. At that time, the number of fish over 9.8 inches was greater than 18,000. But the river was being stocked annually with approximately 30,000 catchable-sized rainbows, and had been throughout the 1960s and 1970s. The stocking program was necessary to compensate for winter dewatering of the river between the dam and the mouth of the Buffalo River. But the dam operation was changed in the early 1970s to permit higher year-round flows, and in 1978, IDFG discontinued stocking operations and implemented wild trout regulations. Numbers of rainbows dropped to approximately 15,000 in 1981; 13,000 in 1987; and 5,000 in 1989. Van Kirk and Gamblin (in preparation) maintain that this decline was due to the loss of stocked fish from the population over time. In 1993, the year after the sediment event, the population of fish below the dam suddenly increased to 12,000. But again, according to Van Kirk and Gamblin (in preparation), this was due to migration of fish from the reservoir during the drawdown. The authors believe that movement of large fish from the reservoir occurred often before construction and modification of a hydroelectric project at Island Park Dam in the early 1990s prevented their passage.

Van Kirk and Gamblin (in preparation) estimate that the carrying capacity of wild rainbow trout in Box Canyon is 3,500 to 4,500 fish over six inches. This is approximately equal to the population estimate for 1996, and slightly lower than the population estimates for 1995 and 1997 (IDFG 1998). Recent studies of spawning success below Island Park Dam have shown that spawning occurs throughout Box Canyon, that the primary spawning area is between the dam and the mouth of the Buffalo River, and that spawning success is not limiting the number of juvenile rainbow trout in the Henry's Fork (Gregory and Van Kirk 1997; Mitro and Zale 1997).

Temperature and dissolved oxygen are continuously monitored in Box Canyon between Island Park Reservoir and the mouth of the Buffalo River. This monitoring is conducted by Fall River Rural Electric Cooperative in accordance with standard procedures for the operation and maintenance of the Cooperative's hydroelectric project at Island Park Dam. In 1995, the hydroelectric project was modified by the addition of an adjustable rubber collar at the reservoir spillway. Raising this collar during the spill period allows the hydroelectric facility to continue operating by drawing water from the hypolimnion of the reservoir. This water is cooler than the spill water that would normally be released, and has the potential for altering the temperature regime in “redd alley,” the portion of Box Canyon heavily utilized for spawning. Concerns regarding the effects of temperature changes have been, and continue to be, addressed by members of the Island Park Hydroelectric Project Rubber Collar Advisory Committee. This committtee includes representatives of Fall River Rural Electric Cooperative, Ecosystems Research Institute (environmental consultant to the Cooperative), Henry’s Fork Foundation, Idaho Department of Fish and Game, Targhee National Forest, DEQ, and others. Fall River Rural Electric Cooperative and the Henry’s Fork Foundation collaborated to fund research in 1995, 1996, and 1997 (Gregory and Van Kirk 1997), and participants of the committee meet at least twice each year to review monitoring data and research results, and to evaluate operations. The work of the committee and Fall River Rural Electric ensure that conditions in the Henry’s Fork immediately below the dam are well monitored and carefully evaluated in an effort to protect-the fishery resource.

Restricted access to spawning tributaries and overwintering habitat, not water quality or sediment deposition, is the primary constraint on recruitment of wild rainbow trout in this segment of the Henry’s Fork (Van Kirk 1996). The Buffalo River provides high-quality spawning gravels, more overwintering refuges for fry, and more constant temperatures to support the growth of fry. But access to the river has been prevented by a small dam near the mouth of the river. In 1996 a fish ladder was installed on the Buffalo River through the cooperative efforts of Buffalo Hydro, Inc., the Henry’s Fork Foundation, IDFG, and the Targhee National Forest. Use of the ladder is currently being monitored to determine whether the Buffalo River will produce the estimated 30,000 one year-old recruits that have been predicted.

Based on this review, DEQ concludes that the segment of the Henry’s Fork from Buffalo River to Riverside supports the beneficial uses of cold water biota and salmonid spawning. Development of a total maximum daily load for sediment is unnecessary because the primary source of sediment loading was a distinct event associated with the drawdown of Island Park Reservoir in 1992. However, precautions must be taken to prevent major sediment releases from Island Park Reservoir in the future. These precautions include

1. Clarification by DEQ that the dam must be operated in a manner that will not violate water quality standards.

2. Requirements by DEQ that turbidity and total suspended solids be monitored during any future drawdown and that cooperators develop and approve a plan for ending the drawdown should a violation of water quality standards occur.

3. Approval of any future drawdown plan by the Henry’s Fork Watershed Council using the Watershed Integrity Review and Evaluation (WIRE) process.

Another precaution that could be negotiated by interested parties, and has been recommended by the Henry's Fork Watershed Council, is establishment of a minimum pool volume for Island Park Reservoir.

Sheridan Creek

Sheridan Creek does not appear on the 1994 § 303(d) list, but it has been identified by the Henry's Fork Watershed Council as its highest priority for restoration in the upper watershed. The Council formed the Sheridan Creek Restoration Committee to develop a restoration plan and to encourage private landowners, public land grazing permittees, and land management agencies to participate in its implementation. In 1997, the Council was awarded a § 319 grant in the amount of $142,000 toward implementation of Sheridan Creek restoration projects. The overall Sheridan Creek restoration project budget is $258,000 including matching cash and in-kind contributions.

Sheridan Creek is the major tributary to the west end of Island Park Reservoir. The significance of Sheridan Creek to the watershed and the reservoir fishery is explained in the following excerpt from the Watershed Council's § 319 grant proposal (HFWC 1996):

> Assessment of all streams in the watershed above Island Park Reservoir and analysis of reservoir fisheries and water quality data determined that the primary cause for the reservoir fishery decline is loss of habitat and connectivity in tributary streams, most notably Sheridan Creek. Historically, Sheridan Creek and its tributaries provided spawning and rearing habitat for wild reservoir trout, thermal refuge for trout from warm reservoir temperatures during the summer months, and a significant source of high quality water to the west end of the reservoir. However, these stream functions have been completely lost on the lower ten miles of Sheridan Creek from unintentional dewatering of the stream channel due to deteriorated diversion structures, loss of connectivity due to inadequate fish passage at diversion points, and loss of riparian vegetation due to livestock grazing along the streambanks.

The Council maintains that dewatering and loss of woody riparian vegetation have contributed to impaired water quality, including deposition of fine sediments and high water temperatures (HFWC 1998). The results of DEQ's 1995 BURP survey of Sheridan Creek were macroinvertebrate scores ranging from 5 in the upper reach at the Targhee Forest boundary to 2.8 in the lower reach in a ditch to which all flow had been unintentionally captured. Habitat index scores (88,17, 65, and 59) were generally low for the ecoregion and included the lowest score recorded for the Upper Henry's subbasin. These scores placed Sheridan Creek in the "needs verification" category of DEQ's waterbody assessment process. But according to the Henry's Fork Foundation 1996 Habitat Assessment Project (Gregory 1997), Sheridan Creek supported the beneficial uses of cold water biota and salmonid spawning on Targhee Forest but not in the lower ten miles of the stream. In September 1998, DEQ conducted fish population sampling at the 1995 BURP survey locations. Three age classes of rainbow trout and several age classes of sculpin were captured at the site near the Targhee Forest boundary. No fish were present at the site with the lowest habitat index score; redside shiners and an unidentified species of sucker were the only fish captured at the two lower sites. These results indicated that salmonid spawning was not a supported beneficial use on the lower ten miles of stream, so addition of this segment of Sheridan Creek to the 1998 § 303(d) list was recommended.

The goals and objectives of the Sheridan Creek restoration project were described in the § 319 grant proposal as follows:

> The goals ... are to 1) restore stream hydrology, channel function and connectivity, 2) improve riparian and aquatic habitat, 3) restore resident and migratory fisheries in Sheridan Creek, and 4) improve water quality in Island Park Reservoir. These goals will be accomplished by repairing and replacing deteriorated diversion structures, implementing improved riparian grazing management practices, revegetating streambanks, and installing an off-stream livestock watering facility. Progress towards achieving habitat and fisheries goals will be assessed by annual monitoring of habitat, water quality and trout populations in Sheridan Creek and Island Park Reservoir.

Figure 12 shows the locations of major features of the Sheridan Creek restoration project. It is DEQ's opinion that the water quality problems associated with Sheridan Creek are being addressed appropriately by the Henry's Fork Watershed Council through its Sheridan Creek restoration project. Grazing plans are being implemented by operators of the Sheridan Golden Eagle Ranch, the Davis Lake Grazing Association, the Idaho Department of Lands, and Harriman State Park (Bradshaw, 1998). Restoration of hydrologic functions over the entire segment of lower Sheridan Creek is likely to exceed the funds available from the §319 grant (Beckman, 1998). Potential additional project funding is being investigated by the Sheridan Creek Restoration Committee.

When fully implemented, the restoration project will restore aquatic life beneficial uses and obviate the need for development of a total maximum daily load. Furthermore, while flow alteration and habitat degradation may impair meeting beneficial uses, DEQ does not consider flow alteration and habitat degradation to be "pollutants" under §303(d) of the Clean Water Act, and thus are not suitable for the calculations of total maximum daily loads. In Idaho, flows are regulated under a separate body of law and regulation from water quality laws and regulations.

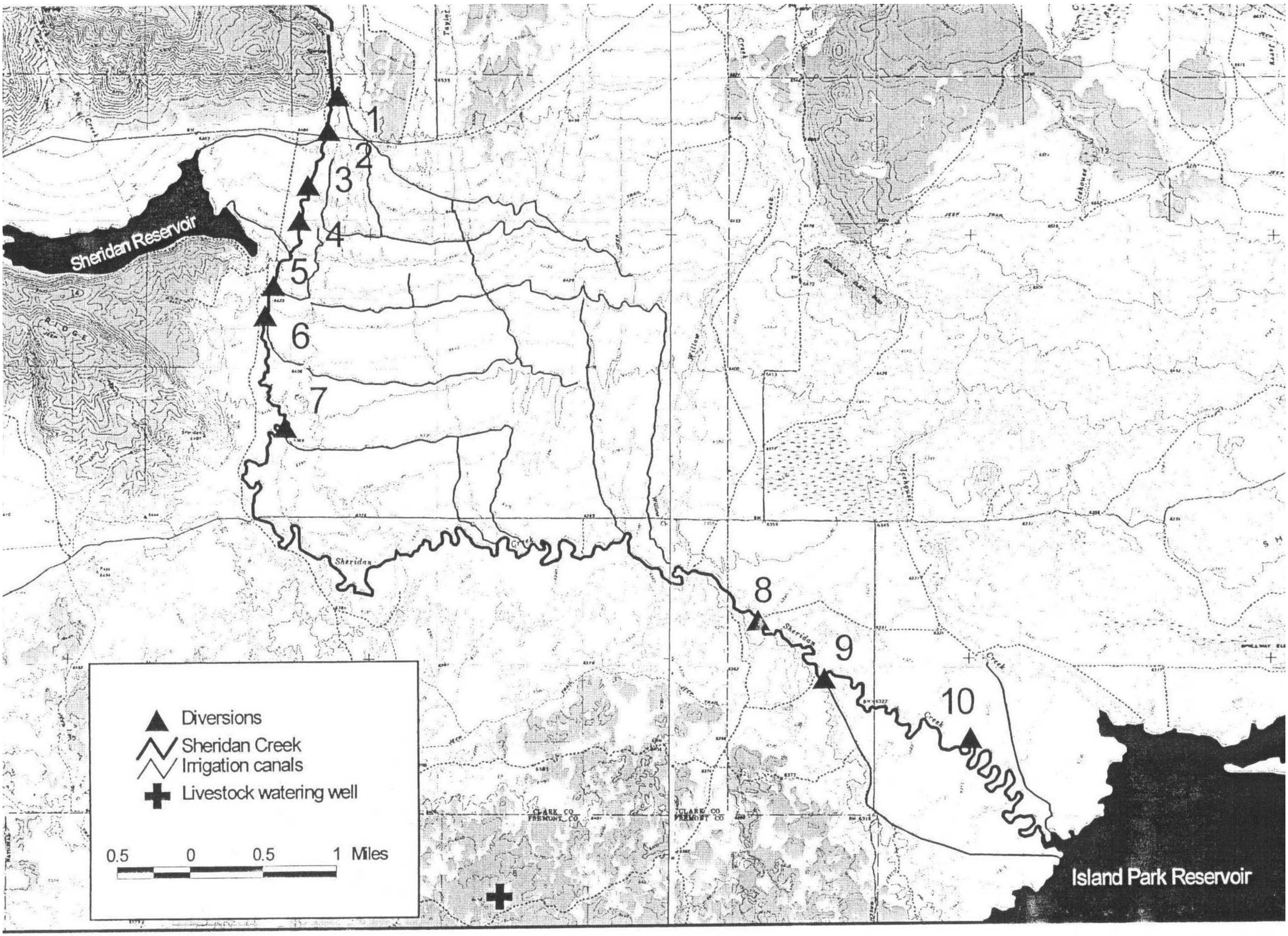


Figure 12. Selected features of the Sheridan Creek restoration project

While habitat can be restored, as in the case of the Sheridan Creek project, it cannot readily be allocated like point and non-point pollutants. To date, USEPA's only determination regarding pollutants suitable for TMDL calculations states that "all pollutants, under the proper technical conditions, are suitable for the calculations of total maximum daily loads" (USEPA 1978). Nothing in the USEPA's 1978 determination indicates that stream features such as flow and habitat were ever contemplated as "pollutants." In summary, although a recommendation was made to add a portion of Sheridan Creek to the 1998 § 303(d) list, neither policy nor practical restoration considerations indicate that a TMDL is required for Sheridan Creek or would be preferable to the ongoing Sheridan Creek restoration efforts.

Assessment of Remaining Waterbodies

In 1997, DEQ completed the first cycle of waterbody assessments based primarily on beneficial use reconnaissance project (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 1996, 1998), is intended to directly evaluate whether a waterbody supports the beneficial uses of cold water biota and salmonid spawning. Support of cold water biota is indicated by the Macroinvertebrate Biotic Index, a quantitative expression of the abundance and diversity of the benthic macroinvertebrate community. Support of salmonid spawning is indicated by the presence of two size classes of fish from a natural population of a single salmonid species.

Three possible assessments of cold water biota can be made using the Macroinvertebrate Biotic Index (MBI): "full support", "not full support", and "needs verification". An MBI score greater than or equal to 3.5 indicates "full support"; an MBI score less than or equal to 2.5 indicates "not full support"; and an MBI score between 2.5 and 3.5 indicates "needs verification". The support status of a waterbody assessed as "needs verification" can be modified using the Reconnaissance Index of Biotic Integrity (RIBI), a qualitative measure of the quality of fish assemblage, and the Habitat Index (HI), a quantitative measure of habitat quality. If the fish assemblage is not impaired, or the Habitat Index (HI) score does not indicate habitat impairment, the stream is reassessed as fully supporting the beneficial use of cold water biota. Because the Upper Henry's Fork is located in the Middle Rockies Ecoregion, an HI score of 81 or more was used to indicate non-impaired habitat conditions (DEQ 1996).

The results of the waterbody assessments provided the basis of DEQ's draft 1998 § 303(d) list. Twenty-four wadeable streams in the Upper Henry's Fork were assessed using BURP data, and MBI scores indicated that three did not fully support the beneficial use of cold water biota. The MBI scores for two streams were within the "needs verification" range, and scores for 19 streams indicated full support for cold water biota.

In 1996 and 1997, the Henry's Fork Foundation conducted fisheries habitat assessments of most of the continuously flowing streams in the Upper Henry's Fork subbasin. The Foundation's habitat assessment protocol was intensive, consisting of 1) division of streams into reaches based on morphological characteristics such as gradient, 2) a walking survey of stream reaches to document features that affect fish habitat and populations, 3) quantitative and qualitative measurements of habitat and water quality parameters within reaches, and 4) collection of macroinvertebrate samples and measurement of DEQ's BURP parameters within one section of each reach (Gregory 1997).

The benthic macroinvertebrate data reported by the Foundation (Gregory 1997, Gregory and Van Kirk 1998) were converted to MBI scores using DEQ MBI Calculation Spreadsheet version 2.1 1 or 3.6. These scores are reported below to provide supplemental information, but they are not considered interchangable with scores generated by DEQ's BURP sampling for two reasons. First, the numbers of invertebrates in DEQ samples tended to be more consistent than the numbers of invertebrates in the Foundation samples, indicating differences in sampling procedures. The mean DEQ sample consisted of 520 individuals with sample sizes ranging from 49 to 1,426 individuals; the mean Foundation sample consisted of 551 individuals with sample sizes ranging from 3 to 3,438 individuals. Six percent of DEQ samples contained less than 100 individuals, whereas 30 percnt of Foundation samples contained less than 100. Whether these discrepancies were caused by differences in sampling and analytical methods or differences in the average size and quality of streams sampled has not been fully investigated. However, the most recent version of the MBI calculation spreadsheet will not calculate an MBI for less than 100 individuals because of the questionable applicability of a multimetric index to such a small population of individuals. Second, DEQ identified individuals to species whenever possible and the Foundation identified individuals only to genus. The increased taxa richness of the DEQ samples is reflected by MBI scores that tend to be a few tenths or hundredths of a unit higher than scores calculated using Foundation data.

All but one of the watersheds in the Upper Henry's Fork subbasin contain streams that were sampled by DEQ or the Henry's Fork Foundation. Streams in the Ashton Reservoir watershed were not sampled because most are intermittent and difficult to access. The results for the remaining eight watersheds are presented below. The MBI scores were calculated using data collected from 1994 through 1997. The MBI scores for samples collected by DEQ in 1997 are considered provisional because they were not generated by the central BURP database, and were not used to develop the draft 1998 § 303(d) list.

Henry's Lake Watershed

The only streams in the Upper Henry's Fork subbasin that were assessed in 1996 as "not full support” for cold water biota are located in the Henry’s Lake watershed. Garner Springs, Meadow Creek, and Tygee Creek were added to the 1998 draft 303(d) list because of low MBI and HI scores (Table 15). However, these streams may be removed from the final list for reasons described below.

According to comments submitted by the Henry’s Fork Watershed Council to DEQ regarding the 1998 draft 303(d) list, the reasons for the low MBI and HI scores for Meadow Creek, and possibly Garner Springs, are the proximity of the sampling sites to headwater springs and the geomorphology of the Henry’s Lake watershed. The Council stated that (HFWC 1998):

> Over 40 percent of the discharge of the Henry’s Fork at Ashton is derived from groundwater inputs that join the main river via a large number of spring creeks (Whitehead 1978). Most of these springs originate along the western edge of the Yellowstone Plateau and within the Island Park Caldera. Geomorphology and hydrology of some of these spring creeks have been described by Anderson (1996) and Benjamin (1997). Although most of these spring creeks are in pristine to near pristine condition, they can display biotic and habitat characteristics that are usually associated with degraded conditions in more typical Rocky Mountain streams. As a group, these spring creeks generally have high width-to-depth ratios, fine substrate derived from decomposed rhyolite and tuff, little or no floodplain development, low invertebrate diversity, and a large number of non-EPT invertebrate taxa (Gregory 1997, Gregory and Van Kirk 1998). Because of constancy of flow and temperature, invertebrate species diversity is generally lower in springs than in non-spring dominated streams (Vannote et al. 1980, Ward and Stanford 1982). Thus, it is probable that many spring creeks in the Henry’s Fork watershed may receive macroinvertebrate biot[ic] index (MB!) scores below the 3.5 required for status as fully supporting cold water biota, even though these streams are essentially in pristine condition.

Although a statistical analysis comparing spring-dominated streams to non-spring dominated streams has not been performed, the low MBI scores for the spring-fed streams appeared to be a function of low species diversity and a disproportionate number of sediment-dwelling chironomid larvae.

The comments submitted by the Council contained a list of 18 streams and two rivers within the Upper Henry’s Fork watershed that are spring-fed and therefore expected to have low MBI scores. This list included Meadow Creek and Reas Pass Creek within the Henry’s Lake watershed. Table 15 shows that both the MBI and HI scores for Meadow Creek, which is a low-gradient stream formed in alluvium on Henry’s Flat, were relatively low and not indicative of full support of cold water biota. However, Reas Pass Creek, which is a high-gradient stream

Table 15. Macroinvertebrate biotic index (MBI) scores for sites in the Henry's Lake watershed sampled by the Division of Environmental Quality (DEQ) and the Henry's Fork Foundation (HFF). Habitat index (HI) scores determined by DEQ are also shown.

Waterbody and Relative Locations of Multiple Sampling Sites	DEQ MBI[1]	DEQ HI[2]	HFF MBI
Canyon Creek	5.5	94	
Duck Creek	4.7	79	
Duck Creek, North Fork	3.7	89	
Enget Creek	4.1	95	
Garner Springs[3]	2.4	73	
Henry's Lake Outlet from Flat Ranch to confluence with Big Springs	3.2	102	3.4
Jesse Creek 1. On Targhee NF 2. On Nature Conservancy Flat Ranch	 4.6 3.7	 92 73	 3.7
Jones Creek			2.2
Meadow Creek 1. Approximately 200 m below headwater spring 2. Approximately 200 m above confluence with Henry's Fork	 2.2 3.3	 78 80	 2.5
No Name[4] Creek			1.8
Reas Pass	2.8	101	
Sawtell Creek	4.2	100	2.5
Stephens Creek			2.3
Targhee Creek 1. Approximately 0.5 mile above Targhee NF boundary 2. Approximately 500 m above Henry's Lake	 5.4 4.5	 95 71	 4.4
Twin Creek 1. Near confluence of headwater tributaries on Targhee NF 2. Approximately 0.6 mile above Meadow Creek Road 3. Approximately 0.1 mile below Meadow Creek Road	 5.4 4.4 3.0	 93 97 82	 3.8
Tygee Creek 1. Near Continental Divide on Targhee NF 2. Below Targhee NF boundary on private land	 3.7 1.8	 115 98	 1.9

[1]$MBI \geq 3.5$ indicates full support of cold water biota; $MBI \leq 2.5$ indicates not full support; $2.5 < MBI < 3.5$ indicates needs verification of status.
[2]$HI \geq 81$ indicates non-impaired habitat conditions.
[3]Sampled 200 m below springs; channel shown on map flowing from spring is not named.
[4]Designation used by Gregory (1997) for an unnamed stream located between Bootjack and Sawtell Creeks; this name does not appear on USGS maps.

underlain by igneous rock on forested land, also had an MBI score within the "needs verification" range, but an HI score indicative of high-quality habitat. This stream was therefore assessed as fully supporting cold water biota.

Gamer Springs is also a low-gradient waterbody located on Henry's Flat. It was mistakenly named "Gamer Canyon" on the 1998 draft 303(d) list, but the spring is located approximately one mile from the mouth of the canyon and there is no surface flow connecting the two. The stream was sampled approximately 0.1 mile below the spring, and lack of sinuosity in the downstream channel indicates that it was man-made. Further evaluation of the channel is required to determine whether it is protected for beneficial uses under IDAPA 16.01.02, and if so, whether it's low MBI score is truly representative of degraded water quality or typical of spring-fed streams in this region.

The Henry's Fork Watershed Council also recommended that the segment of Tygee Creek from the forest boundary to the Henry's Fork be removed from the 1998 draft 303(d) list because the segment is intermittent (HFWC 1998a). The North Fork Reservoir Company has the right to divert 4,000 acre-feet of water from Tygee Creek to Henry's Lake from April 1 to November 1. This is more than the average volume normally discharged by the stream, so this segment of the stream is typically dry, and full support of aquatic life beneficial uses is not attainable due to this hydrologic modification. Because of hydrologic modification, it is not feasible to attain the beneficial uses of cold water biota and salmonid spawning, and the State has authority to remove these designated uses from this segment (40 CFR Part 131.10).

The upper segment of Tygee Creek, from the headwaters to the forest boundary, received DEQ scores indicative of high water quality. The very low MBI score calculated for the site sampled by HFF is inconsistent with DEQ results, and appears to be a function of small sample size. But the water quality of this stream was verified by recent fish surveys which identified this segment as the location of the largest population of Yellowstone cutthroat trout (Oncorhvnchus clarki bouvieri) in the subbasin (Van Kirk and Gregory 1998). Data collected by USFS personnel in 1996 and 1997 indicate that the population is healthy in both size and structure (Delany 1998). Because this population is isolated from nonnative trout by a waterfall that forms a natural fish migration barrier near the forest boundary, these fish will probably have an important role in future species-management programs.

Henry's Lake Outlet, which is the upper segment of the Henry's Fork between Henry's Lake Dam and Big Springs, was sampled using the BURP protocol for wadeable streams because of its shallow depth. Although the MBI scores for the Outlet were within the "needs verification" range, the HI score gave an assessment of full support for cold water biota. However, the land surrounding Henry's Lake Outlet has been utilized for livestock production for more than a century. Grazing, combined with high-velocity spring flows from Henry's Lake, has accelerated streambank erosion and sediment delivery to the Outlet (YSCD 1995, Stumph 1995). The erosion classification of 71 percent of the Outlet downstream of Highway 20 and upstream of Targhee National Forest was moderate or severe (Table 11), making this portion of the Outlet eligible for treatment under Henry's Lake SAWQP (YSCD 1995).

Since 1994, The Nature Conservancy has operated the Flat Ranch, a cattle operation on approximately two sections of land bordering Henry's Lake Outlet. While implementing sustainable grazing methods, the Conservancy has also implemented a number of restoration projects intended to improve streambank stability, riparian vegetation, and fish migration (May 1998). Approximately 8,000 willows have been planted along 4.5 miles of the Outlet to improve the riparian corridor. A partnership among the Nature Conservancy, North Fork Reservoir Company, Water District 1, the Bureau of Reclamation, and the Idaho Department of Fish and Game resulted in an agreement to exchange up to 2,200 acre-feet of water annually in the Upper Snake reservoirs to provide winter flows for fish in the Outlet (Table 11). Restoration of tributaries that flow through the ranch include a fencing project on Twin Creek and rediversion of Jesse Creek to a portion of its original streambed. Improvement projects along the Outlet and its tributaries have also been implemented individually and cooperatively by private landowners, Henry's Lake Foundation, Henry's Fork Foundation, Idaho Department of Lands, Idaho Department of Fish and Game, Idaho Soil Conservation Commission, Yellowstone Soil Conservation District, and the Natural Resources Conservation Service.

Portions of the following tributaries to the Outlet were designated critical areas in the Henry's Lake SAWQP report (YSCD 1995) because of their erosion classifications: Canyon Creek, Jesse Creek, Jones Creek, Hidden Creek[1], Meadow Creek, Stephens Creek, and Twin Creek (Table 11). Jones, Hidden, and Stephens Creeks were not sampled by DEQ, but MBI scores calculated using data collected by HFF for Jones and Stephens Creeks indicated they may not support cold water biota (Table 15). Jesse and Twin Creeks received relatively high MBI scores, but 84 percent of the surveyed streambanks on Jesse Creek and 48 percent of the surveyed streambanks on Twin Creek were classified as moderately and severely eroding. Canyon Creek received a high MBI score, but when Canyon Creek was surveyed together with Jones Creek, 24 percent was classified as severely eroding. As discussed above, Meadow Creek may have received low MBI scores because it is a spring creek, but it was classified as moderately eroding along one-third of its length.

Throughout the process of developing the subbasin assessment, and during review of the draft 1998 § 303(d) list, members of the Henry's Fork Watershed Council and Water Quality

[1]Hidden Creek is a name used by the YSCD (1995) to describe a stream that flows east of Island Park golf course and is un-named on the Big Springs 7.5-minute quadrangle map.

Subcommittee encouraged DEQ to base beneficial use assessments on data available from other agencies and organizations in addition to its own beneficial use reconnaissance project (BURP) data (HFWC 1998a, 1998b). In the case of wadable streams, for which BURP sampling had been conducted, DEQ conducted assessments in a manner consistent with Idaho's water quality standards *(IDAPA 16.01.02.053- Water Quality Standards and Wastewater Treatment Requirements, Beneficial Use Support Status).* In some cases, the assessments by DEQ and information obtained by other agencies and organizations did not appear to be in agreement. For example, as discussed above, MBI scores for Jesse Creek indicated full support of beneficial uses, but Natural Resources Conservation Service (NRCS) personnel documented that 25 percent of the streambanks surveyed were severely eroding. While DEQ does not consider this stream to have impaired aquatic life beneficial uses, the Yellowstone Soil Conservation District considers the stream a critical area for treatment because of eroding streambanks. These conclusions appear inconsistent to many Council members whose objective is to protect the ecological integrity of a waterbody, including components such as habitat quality and flow regime. However, DEQ is constrained to protecting the quality of the water within the waterbody, which is evaluated indirectly through assessment of beneficial use support status. In view of the Council's concerns, additional monitoring is recommended for streams that have been identified as critical areas by the Yellowstone Soil Conservation District.

Lower Henry's Fork Watershed

All of the MBI scores shown in Table 16 for the Lower Henry's Fork watershed (which should not be confused with the Lower Henry's Fork subbasin) were calculated using data collected by the HFF. All but one of the scores indicate a support status of "not full support" or "needs verification", but all of these streams were listed by the Henry's Fork Watershed Council as spring creeks which would be expected to produce low MBI scores, even in pristine condition.

Table 16. Macroinvertebrate biotic index (MBI) scores for sites sampled in the Lower Henry's Fork watershed by the Henry's Fork Foundation (HFF).

Waterbody and Relative Locations of Multiple Sampling Sites	HFF MBI[1]
Antelope Park Canyon, unnamed stream	
1. From springs to Targhee NF-Harriman State Park boundary	3.2
2. From Harriman State Park boundary to confluence with Henry's Fork	2.5
Blue Spring Creek[2]	1.8
Fish Pond, unnamed stream entering and exiting pond on Harriman State Park	3.3
Thurmon Creek	1.7
Middle Thurmon Creek	2.9
East Thurmon Creek	4.3
West Thurmon Creek	2.3

[1]$MBI \geq 3.5$ indicates full support of cold water biota; $MBI \leq 2.5$ indicates not full support; $2.5 < MBI < 3.5$ indicates needs verification of status.
[2]Unnamed on 30X60 minute series topographic map; named on 7.5 minute series topographic map.

Island Park Reservoir Watershed

Invertebrate data for all but two streams in this watershed, Arange Creek and Icehouse Creek, indicated full support of cold water biota (Table 17). The high water quality of Hotel Creek and Yale Creek are important to the Island Park fishery because according to Gregory (1997), these are the only streams that remain connected to the reservoir throughout the year. Hotel Creek was described by Van Kirk and Gregory (1998) as nearly pristine with excellent fish habitat.

Arange Creek was described by Gregory (1997) as having medium- to high-gradients, low sinuosity because of valley confinement, abundant shading, plentiful pools, plentiful large woody debris, stable banks, and a substrate consisting of silt or large sand overlain with pebbles. No human activities influencing the stream were reported, and the invertebrate population was described as highly diverse and typical of small streams. The low MBI score for this stream was probably a function of small sample size.

Table 17. Macroinvertebrate biotic index (MBI) scores for sites sampled in the Island Park Reservoir watershed by the Division of Environmental Quality (DEQ) and the Henry's Fork Foundation (HFF). Habitat index (HI) scores determined by DEQ are also shown.

Waterbody and Relative Locations of Multiple Sampling Sites	DEQ MBI[1]	DEQ HI[2]	HFF MBI
Arange[3] Creek			2.5
Coffee Pot Creek[4]	4.8	89	4.7
Elk Springs Creek[4]			2.2
Henry's Fork River from Flatrock Campground to McCreas Bridge			4.8
Hotel Creek	4.5	94	
Hotel Creek, East Fork			4.7
Hotel Creek, West Fork	4.5	99	
Icehouse Creek			
1. 1 mile above Yale-Kilgore Road on Targhee NF	4.8	89	
2. 1 mile below Yale-Kilgore Road on State Land	4.6	73	
3. 5 miles below Yale-Kilgore Road on State Land	1.7	61	
4. 6 miles below Yale-Kilgore Road on State Land			3.8
Tyler Creek	4.5	110	3.9
Yale Creek			
1. 1.5 mile above Yale-Kilgore Road on Targhee NF, June 1996	4.1	108	
1. 1.5 mile above Yale-Kilgore Road on Targhee NF, July 1996			2.2
1. 1.5 mile above Yale-Kilgore Road on Targhee NF, Sept. 1996	4.8	93	
2. 0.5 mile above Yale-Kilgore Road on private land, June 1996	4.5	76	
2. 0.5 mile above Yale-Kilgore Road on private land, July 1996			3.5
2. 0.5 mile above Yale-Kilgore Road on private land, Sept. 1996	3.9	83	

[1]MBI≥3.5 indicates full support of cold water biota; MBI≤2.5 indicates not full support; 2.5<MBI<3.5 indicates needs verification of status.
[2]HI≥81 indicates non-impaired habitat conditions.
[3]Spelled Arrange in Gregory (1997)
[4]Unnamed on 30X60 minute series topographic map; named on 7.5 minute series topographic map.

The low MBI and HI scores which were recorded by DEQ in 1997 on lower Icehouse Creek, contrasted with the high macroinvertebrate diversity reported by Gregory (1997), indicate that further assessment of this stream is warranted. Both DEQ samplers and Gregory (1997) reported fine silt substrate and heavy livestock grazing on land surrounding the stream. Gregory (1997) did not assess the stream above this lower reach because "irrigation diversions...make it impossible for adfluvial fish from Island Park Reservoir to gain access...".

Sheridan Reservoir Watershed

Macroinvertebrate data indicate that Howard and Willow Creeks, major tributaries to Sheridan Creek, fully support cold water biota (Table 18). Based on observations of multiple year classes of brook trout, the streams also fully support salmonid spawning (Gregory 1997). A narrative description of Myers Creek, and observation of multiple year classes of brook trout, indicates that the stream fully supports cold water biota despite a low MBI score. Macroinvertebrate diversity was described as low or moderate in the lower reaches of Schneider and Taylor Creeks possibly because of embedded substrates (Gregory 1997). The extremely low HI scores of 17 and 59 for two of the segments on Sheridan Creek are consistent with the priority for restoration placed on this stream by the Henry's Fork Watershed Council (refer to previous section entitled, Sheridan Creek).

Table 18. Macroinvertebrate biotic index (MBI) scores for sites sampled in the Sheridan Reservoir watershed by the Idaho Division of Environmental Quality (DEQ) and the Henry's Fork Foundation (HFF). Habitat index (HI) scores determined by DEQ are also shown.

Waterbody and Relative Locations of Multiple Sampling Sites	DEQ MBI[1]	DEQ HI[2]	HFF MBI
Howard Creek	4.1	94	4.2
Myers[3] Creek			3.1
Schneider Creek			3.7
Sheridan Creek			
1. Immediately upstream of Yale-Kilgore Road on private land	5.0	88	3.3
2. 2.5 miles south of Yale-Kilgore Road on private land	4.7	17	
3. 3 miles south of Yale-Kilgore Road on private land	2.8	59	3.3
Taylor Creek			3.1
Willow Creek	5.2	93	4.1

[1]MBI≥3.5 indicates full support of cold water biota; MBI≤2.5 indicates not full support; 2.5<MBI<3.5 indicates needs verification of status.
[2]HI≥ 81 indicates non-impaired habitat conditions.
[3]Spelled Meyers in Gregory (1997).

Thirsty Creek, Buffalo River, Warm River, and Robinson Creek Watersheds

These watersheds are discussed as a group because of their similar hydrologic and geomorphologic characteristics. Most of the streams sampled within these watersheds originate from springs along the western edge of the Yellowstone Plateau, are located almost entirely on the Targhee National Forest, and their condition has been described by the Henry's Fork Watershed Council (1998) as pristine or near-pristine. The Council maintains that low MBI scores reported by Henry's Fork Foundation for Lucky Dog, Chick, Elk, Tom's, Partridge, North Fork of Fish Creek, and upper Snow Creeks (Tables 19, 20, 21, and 22) reflect low invertebrate species diversity typical of spring creeks having relatively constant flow and temperature. The only streams within these watersheds that were not identified as spring creeks are Little Robinson, Porcupine, Robinson, Rock, and Wyoming Creeks. However, except for Wyoming Creek, which needs verification of its support status, the MBI scores for these streams indicate they fully support cold water biota.

Fish, Porcupine, Robinson, and Rock Creeks were designated stream segments of concern in 1990 and 1992 because of past timber harvesting activities (DEQ 1994). A local working committee was convened by Idaho Department of Lands in 1990 to develop water quality objectives for these streams and to determine whether implementation of site specific best management practices were required. The committee determined that the best management practices in place at the time were adequate, and because no additional timbering activity had occurred by mid-1993, the committee chose not to reconvene. In the 1994 Upper Snake Basin Status Report, the Targhee National Forest reported the results of monitoring conducted on these streams from 1989 to 1994. The Forest recommended continued monitoring, but reported that most timber, grazing, and recreation projects in the vicinity of the stream segments of concern had been suspended indefinitely because of potential conflicts with grizzly bear recovery goals.

Table 19. Macroinvertebrate biotic index (MBI) scores for sites sampled in the Thirsty Creek watershed by the Division of Environmental Quality (DEQ) and the Henry's Fork Foundation (HFF). Habitat index (HI) scores determined by DEQ are also shown.

Waterbody and Relative Locations of Multiple Sampling Sites	DEQ MBI[1]	DEQ HI[2]	HFF MBI
Lucky Dog Creek			2.4
Moose Creek			3.9
Thirsty Creek			
1. Approximately 1.5 miles above confluence with Big Springs	4.2	111	
2. Approximately 0.5 mile above confluence with Big Springs	2.6	77	

[1]MBI≥3.5 indicates full support of cold water biota; MBI≤2.5 indicates not full support; 2.5<MBI<3.5 indicates needs verification of status.
[2]HI≥81 indicates non-impaired habitat conditions.

Table 20. Macroinvertebrate biotic index (MBI) scores for sites sampled in the Buffalo River[1] watershed by the Division of Environmental Quality (DEQ) and the Henry's Fork Foundation (HFF). Habitat index (HI) scores determined by DEQ are also shown.

Waterbody and Relative Locations of Multiple Sampling Sites	DEQ MBI[2]	DEQ HI[3]	HFF
Buffalo River			
1. Springs to Targhee NF-private property boundary			4.1
2. Targhee NF-private property boundary to railroad bridge			3.6
3. Railroad bridge to mouth of Elk Creek			3.6
4. Elk Creek to 400 m downstream of Highway 20			3.7
5. 400 m downstream of Highway 20 to confluence with Henry's Fork			3.4
Chick Creek	3.6	98	2.7
Elk Creek			
1. Spring to Targhee NF-private property boundary			2.8
2. Dam at private property-Targhee NF boundary to confluence with Buffalo River			2.9
Tom's Creek			
1. Spring to 200 m downstream of railroad bridge			2.6
2. 200 m downstream of railroad bridge to confluence with Buffalo River			3.2

[1]This watershed is named "Buffalo Creek" according to the USGS cataloging system.
[2]MBI≥3.5 indicates full support of cold water biota; MBI≤2.5 indicates not full support; 2.5<MBI<3.5 indicates needs verification of status.
[3]HI≥81 indicates non-impaired habitat conditions.

Table 21. Macroinvertebrate biotic index (MBI) scores for sites sampled in the Warm River watershed by the Division of Environmental Quality (DEQ) and the Henry's Fork Foundation (HFF). Habitat index (HI) scores determined by DEQ are also shown.

Waterbody and Relative Locations of Multiple Sampling Sites	DEQ MBI[1]	DEQ HI[2]	HFF
Partridge Creek			
1. Segment from confluence of North Fork to mouth of canyon			1.3[3]
2. Segment from mouth of canyon to confluence with Warm River			1.4
Split Creek			2.2
Warm River			
1. Approximately 3 miles below confluence of Split Creek on Targhee NF	2.8	91	
2. At Pineview on Targbee NF	4.3	104	
3. Segment from approximately 3 miles below confluence of Split Creek to Warm River Spring			3.9
4. Approximately 0.5 mile downstream of Warm River Spring on Targhee NF	5.4	94	
5. Segment from Warm River Spring to head of canyon			3.7
6. Segment from head of canyon to mouth of canyon			4.1
7. Segment from mouth of canyon to mouth of Warm River			3.3

[1]MBI≥3.5 indicates full support of cold water biota; MBI≤2.5 indicates not full support; 2.5<MBI<3.5 indicates needs verification of status.
[2]HI≥ 81 indicates non-impaired habitat conditions.
[3]Both reaches were heavily influenced by beaver activity; low macroinvertebrate diversity indicates that stream may have dried up during the drought of the late 1980s to early 1990s (Gregory and Van Kirk 1998).

Table 22. Macroinvertebrate biotic index (MBI) scores for sites sampled in the Robinson Creek watershed by the Division of Environmental Quality (DEQ) and the Henry's Fork Foundation (HFF). Habitat index (HI) scores determined by DEQ are also shown.

Waterbody and Relative Locations of Multiple Sampling Sites	DEQ MBI[1]	DEQ HI[2]	HFF MBI
Fish Creek	4.5	116	3.6
Fish Creek, North Fork	4.5	109	1.8
Little Robinson Creek			3.8
Porcupine	4.0	91	2.9
Robinson Creek			
1. Yellowstone Park boundary to confluence with Little Robinson Creek			3.3
2. Little Robinson Creek to below Targhee NF road 241	4.9	85	4.2
3. Targhee NF road 241 to mouth			3.6
Rock Creek			
1. Approximately 1 mile below Yellowstone Park-Targhee NF boundary	5.8	96	
2. Approximately 0.5 mile above confluence with Shaefer Creek	5.0	95	3.4
Snow Creek			
1. Springs to point at which gradient increases			1.9
2. Gradient increases to confluence with Robinson Creek	6.2	108	3.6
Wyoming Creek			3.1

[1]MBI≥3.5 indicates full support of cold water biota; MBI≤2.5 indicates not full support; 2.5<MBI<3.5 indicates needs verification of status.
[2]HI≥81 indicates non-impaired habitat conditions.

Conclusions and Recommendations

The information presented in this assessment of the Upper Henry's Fork subbasin indicate that development of total maximum daily loads (TMDLs) for two waterbodies appearing on the 1994 § 303(d) list is either not feasible or unnecessary. Seasonal depletion of dissolved oxygen in Henry's Lake is a function of naturally high concentrations of phosphorus in the lake's watershed, and sediment loading in the Henry's Fork between Buffalo River and Riverside Reach was due to a distinct event associated with the drawdown of Island Park Reservoir in 1992. Actions to reduce phosphorus input to Henry's Lake has been analyzed, and those actions that can be reasonably implemented are not expected to eliminate winter oxygen depletion. Recent data indicate that both Henry's Lake and the Henry's Fork support the beneficial uses of cold water biota and salmonid spawning.

Sheridan Creek does not appear on the 1994 § 303(d) list, but it has been identified by the Henry's Fork Watershed Council as its highest priority for restoration because of flow alteration and habitat degradation. Recent data indicate that the lower ten-mile segment of Sheridan Creek does not support the beneficial use of salmonid spawning, and addition of this segment to the 1998 § 303(d) list is therefore appropriate. The Henry's Fork Watershed Council has implemented a habitat restoration project on Sheridan Creek which is intended to restore aquatic life beneficial uses, potentially eliminating the need for development of a TMDL in the future.

Water quality in the remainder of the Upper Henry's Fork subbasin is generally good, and the large number of waterbodies sampled indicate that most of them support aquatic life beneficial uses. Where localized water quality problems exist, they are generally related to riparian habitat quality, streambank stability, and flow connectivity between waterbodies. Good cooperation among management agencies and private landowners, fostered in many cases by the Henry's Fork Watershed Council, make the likelihood of improving habitat conditions very good. DEQ can contribute to ongoing water quality and habitat improvement projects by:

1. Directing resources toward implementation of the recommendations made in the *Report on Henry's Lake Clean Lakes Project* (Montgomery Watson 1996) and the *Henry's Lake SAWQP Final Planning Report/Environmental Assessment* (YSCD 1995).

2. Reconvening the Henry's Lake Steering Committee to provide continuous leadership and coordination for water quality and habitat improvement projects, review progress on the recommendations made in the *Report on Henry's Lake Clean Lakes Project* and the *Henry's Lake SAWQP Final Planning Report/Environmental* Assessment, and revise goals based on evaluations of monitoring data.

3. Conducting additional monitoring of stream segments that have been assessed as “needs verification” by DEQ or have been designated as critical areas by the *Henry‘s Lake SAWQP Final Planning Report/Environmental.*

4. Procuring, or assisting interested groups in procuring, funding for implementation of recommended improvement projects.

Although the Henry’s Fork below Island Park Dam supports beneficial uses, precautions must be taken to prevent major sediment releases from Island Park Reservoir in the future. These precautions include

1. Clarification by DEQ that the dam must be operated in a manner that will not violate water quality standards.

2. Requirements by DEQ that turbidity and total suspended solids be monitored during any future drawdown and that cooperators develop and approve a plan for ending the drawdown should a violation of water quality standards occur.

3. Approval of any future drawdown plan by the Henry’s Fork Watershed Council using the Watershed Integrity Review and Evaluation (WIRE) process.

Another precaution that could be negotiated by interested parties, and has been recommended by the Henry’s Fork Watershed Council, is establishment of a minimum pool volume for Island Park Reservoir.

Throughout the process of developing the subbasin assessment, and during review of the draft 1998 § 303(d) list, members of the Henry’s Fork Watershed Council and Water Quality Subcommittee encouraged DEQ to base beneficial use assessments on data available from other agencies and organizations in addition to its own beneficial use reconnaissance project (BURP) data. This document demonstrates that DEQ relied primarily on data available from other sources for its assessments of Henry’s Lake and Henry’s Fork. In the case of wadable streams, for which BURP sampling had been conducted, DEQ conducted assessments in a manner consistent with Idaho’s water quality standards (*IDAPA 16.01.02.053-Water Quality Standards and Wastewater Treatment Requirements, Beneficial Use Support Status*). In some cases, the assessments by DEQ and information obtained by other agencies and organizations did not appear to be in agreement. In these cases, additional monitoring has been recommended. To assist interested parties in obtaining data and information not compiled in this document, the Henry’s Fork Watershed Council recommended that a list of documents containing relevant information, and a list of agencies and organizations that can supply additional data and information, be appended to this document. These lists are contained in Appendix F.

Citations

Abramovich, R., M. Molnau, and K. Crane. 1998. Climates of Idaho. University of Idaho Cooperative Extension System, College of Agriculture, Moscow, ID.

Adler, R.W. 1995. Filling the gaps in water quality standards: legal perspectives on biocriteria, In: Biological Assessment and Criteria: Tools for Water Resource Planning and Design, W.S. Davis and T.P. Simon, eds. Lewis Publishers, Boca Raton.

Alt, D. and D. Hyndman. 1995. Northwest Exposures: A Geologic Study of the Northwest. Mountain Press Pub., Missoula, MT.

Anderson, E. 1996. Stream geomorphology and hydrology of the upper Henry's Fork watershed. Project completion report to Targhhe National Forest, St. Anthony, ID.

Bailey, R.G. 1995. Description of the ecoregions of the United States. United States Department of Agriculture, Forest Service, Miscellaneous Publication 1391.

Beckman, K. 1998. Personal communication. Natural Resources Conservation Service, St. Anthony, ID.

Beckman, K. and B. Bradford. 1998. Personal communication. Natural Resources Conservation Service and Idaho Area Soil Conservation Districts, St. Anthony, ID.

Benjamin, L. 1997. Hydrologic analysis of upper Henry's Fork basin and probabilistic assessment of Island park Reservoir fill. Master's Thesis, Utah State University, Logan, UT.

Benjamin, L. and R.W. Van Kirk. 1998. Assessing instream flows and reservoir operations on an eastern Idaho river. Revised manuscript submitted to Journal of the American Water Resources Association.

Bradshaw, L. 1998. Personal communication. Natural Resorces Conservation Service, Rexburg, ID.

Brooks, C.E. 1986. The Henry's Fork. Winchester Press, Piscataway. NJ.

Brown, J. 1998. Personal communication. Henry's Fork Foundation, Ashton, ID.

Brostrom, J.K. and L. Watson. 1988. Evaluation of Henry's Lake stocking program. Idaho Department of Fish and Game, Job Performance Report, Project F-71-R-11, Subproject II, Job3.

Christiansen, R.L. and G.F. Embree. 1987. Island Park, Idaho: Transition from rhyolites of the Yellowstone Plateau to basalts of the Snake River Plain. *Geol. Soc. Am. Cent. Field Guide, Rocky Mt. Sect.,* 2, 103-108.

[DEQ] Division of Environmental Quality. 1991. Upper Snake River basin status report: An interagency summary for the basin area meeting implementing the antidegradation agreement. Division of Environmental Quality, Idaho Department of Health and Welfare, Boise, ID.

[DEQ] Division of Environmental Quality. 1994. Upper Snake River basin status report: An interagency summary for the basin area meeting implementing the antidegradation agreement. Division of Environmental Quality, Idaho Department of Health and Welfare, Boise, ID.

[DEQ] Division of Environmental Quality. 1995. Idaho statewide workplan for the 1995 beneficial use attainability and status reconnaissance survey. Idaho Department of Health and Welfare, Division of Environmental Quality, Boise, ID.

[DEQ] Division of Environmental Quality. 1996a. 1996 beneficial use reconnaissance project workplan. Idaho Division of Environmental Quality Beneficial Use Reconnaissance Project Technical Advisory Committee, Boise, ID.

[DEQ] Division of Environmental Quality. 1996b. 1996 water body assessment guidance, a stream to standards process. Idaho Division of Environmental Quality, Watershed Monitoring and Analysis Bureau, Boise, ID.

[DEQ] Division of Environmental Quality. 1998. Idaho “draft”1998 303(d) list package. Idaho Division of Environmental Quality, Watershed Monitoring and Analysis Bureau, Boise, ID.

Delany, D. 1998. Personal communication. Targhee National Forest, St. Anthony, ID.

[ERI] Ecosystems Research Institute. 1988. Island Park Hydroelectric Project FERC No. 2376: environmental assessment. Prepared for Fall River Rural Electric Cooperative, Fall River, Idaho by Ecosystems Research Institute, Logan, UT.

[ERI] Ecosystems Research Institute. 1995. Island Park Hydroelectric Project FERC No. 2376: environmental assessment for the proposed spillway modification. Prepared for Fall River Rural Electric Cooperative, Fall River, Idaho by Ecosystems Research Institute, Logan, UT.

[ERI] Ecosystems Research Institute. 1997. Island Park Hydroelectric Project FERC No. 2973, 1996 water quality data summary. Prepared for Fall River Rural Electric Cooperative, Fall River, Idaho by Ecosystems Research Institute, Logan, UT.

Elle, S. and Corsi 1994. Population estimates for Henrys Fork and tributaries. Idaho Department of Fish and Game, Job Performance Report, Project F-7l-R-l3, Regional Fisheries Management Investigations Job No. 6(IF)-c.

Forsgren Associates/P.A. 1993. Fremont County Facilities Planning Study for the Henry's Lake Area. Rexburg, ID.

Forsgren Associates/P.A. 1994. Fremont County Facilities Planning Study for the Island Park Lake Study Area. Rexburg, ID.

Foster, R.B. 1985. In: Fundamentals of Aquatic Toxicology. Methods and Applications, G.M. Rand and S.R. Petrocelli, eds. Hemisphere Publishing Corporation, Washington, D.C.

Good, J.M. and K.L. Pierce. 1996. Interpreting the Landscape: Recent and Ongoing Geology of Grand Teton and Yellowstone National Parks. Grand Teton Natural History Association, Grand Teton National Park, Moose, WY.

Gregory, J. 1997. Spring spawning on the Henrys Fork and tributaries upstream from Riverside Campground. Project completion report, Henry's Fork Foundation, Ashton, ID.

Gregory, J. 1997. Upper Henrys Fork Habitat Assessment: Headwaters to Island Park Dam, Summer 1996. Project completion report, Henry's Fork Foundation, Ashton, ID.

Gregory, J. and R. Van Kirk. 1997. Box Canyon insect abundance and emergence and rainbow trout spawning assessment: project completion report. The Henry's Fork Foundation, Island Park, ID.

Gregory, J. and R. Van Kirk. 1998. Henrys Fork Habitat Assessment: Island Park Dam to Warm River, Summer 1997. Project completion report, Henry's Fork Foundation, Ashton, ID.

[HFF] Henry's Fork Foundation. 1992. Siltation incident on Henry's Fork leads to state investigation. Henry's Fork Foundation Quarterly Newsletter, Fall 1992, pp. 10-14. Henry's Fork Foundation, Island Park, ID.

HFF. 1997. Excerpt of report on 1996 stream walk.

[HFWC] Henry's Fork Watershed Council. 1996. Sheridan Creek Restoration Project: Nonpoint Source Management Program Grant Proposal. Submitted to DEQ.

[HFWC] Henry's Fork Watershed Council. 1998a. Letter dated 13 July 1998 to Larry Koenig, Division of Environmental Quality, Boise ID.

[HFWC] Henry's Fork Watershed Council. 1998b. Letter dated 10 December 1998 to Chris Mebane, Division of Environmental Quality, Idaho Falls, ID.

[HLF] Henry's Lake Foundation. 1998. Henry's Lake Foundation Newsletter, Fall 1998 Edition. Nampa, ID.

HabiTech, Inc. 1994. Flushing flow investigations; Henrys Fork of the Snake River, 1993-1994. Project completion report for Idaho Division of Environmental Quality, Idaho Falls, ID. HabiTech, Inc., Laramie, WY.

HabiTech, Inc. 1997. Upper Henry's Fork watershed sediment studies: 1996. Project completion report for Henry's Fork Foundation, Ashton, ID. HabiTech, Inc., Laramie, WY.

HabiTech, Inc. 1998. Henry's Fork watershed sediment studies: 1997. Project completion report for Henry's Fork Foundation, Ashton, ID. HabiTech, Inc., Laramie, WY.

Herron, T. 1998. Personal communication. Division of Environmental Quality, Idaho Falls, ID.

Herron, T. 1996. Region 6 Lakes and Reservoirs Investigations: Henrys Lake 1995 Annual Performance Report. Idaho Department of Fish and Game.

[IDFG] Idaho Department of Fish and Game. 1998. Estimated abundance of wild rainbow trout in the Box Canyon section, Henry's Fork Snake River, 1993-1997. 1997 monitoring data, Island Park Hydroelectric Project, Rubber Collar Advisory Committee.

[IDHW] Idaho Department of Health and Welfare. 1997. Idaho Water Quality Standards and Wastewater Treatment Requirements. Revised 12-1-97. (Available on Internet at http://www.idwr.state.id.us/apa/idapal 6/01 02.htm).

[IDL] Idaho Department of Lands. 1978. Geologic Map of Idaho. Idaho Department of Lands, Bureau of Mines and Geology, Moscow, ID.

[ISCS] Idaho State Climate Services. 1998. Internet @ http:/baegis.ag.uidaho.edu/~climate/

[IWRB] Idaho Water Resource Board. 1992. Comprehensive State Water Plan: Henrys Fork.

Irving, Robert. 1953. Ecology of the cutthroat trout, <u>Salmo clarki</u> Richardon, in Henrys Lake, Idaho. M.S. Thesis, Utah State Agricultural College, Logan, Utah.

Jankovsky-Jones, M. 1996. Conservation strategy for Henrys Fork basin wetlands. Idaho Department of Fish and Game, Boise, ID.

Link, P.K. and E.C. Phoenix. 1996. Rocks. Rails. and Trails, Second ed. Idaho Museum of Natural History, Idaho State University, Pocatello, ID.

Lords, K. 1998. Personal communication. Fremont County Planning and Building, St. Anthony, ID.

Maley, T. 1987. Exploring Idaho Geology. Mineral Land Publications, Boise, ID.

May, A. 1998. Personal communication. The Nature Conservancy, Idaho Falls, ID.

Minshall, G.W. and C.T. Robinson. 1993. Final report: Henry's Fork of the Snake River, Idaho, sediment impact study. Idaho State University, Pocatello, ID.

Mitro, M.G and A. V. Zale. 1997. Recruitment of rainbow trout in the Henrys Fork of the Snake River, Idaho: 1997 annual report. Montana State University, Bozeman, MT.

Montgomery Watson. 1996. Idaho Department of Health and Welfare, Division of Environmental Quality, Report on Henry's Lake Clean Lakes Project. Montgomery Watson, Boise, ID.

Robinson, S. 1995. Water quality status report EIRO 95-01: Henry's Lake, Fremont County, Idaho, 1993-1994. Idaho Department of Health and Welfare Division of Environmental Quality, Idaho Falls, ID.

Rohrer, R.L. 1983. Evaluation of Henrys Lake Management Program. Project F-73-R-5, Subproject III, Study III. Idaho Department of Fish and Game, Idaho Falls, ID.

Robrer, R. L. 1984. Henry's Fork Fisheries Investigations. Project F-73-R-5, Subproject IV, Study XI. Idaho Department of Fish and Game, Idaho Falls, ID.

Ross, S.H. and C.N. Savage. 1967. Idaho Earth Science: Geology, Fossils, Climate, Water, and Soils. Earth Science Series No. 1. Idaho Bureau of Mines and Geology, Moscow, ID.

Royer, T.V. and G.W. Minshall. 1996. Development of biomonitoring protocols for large rivers in Idaho: annual report. Prepared for Idaho Department of Health and Welfare Division of Environmental Quality by Idaho State University, Pocatello, ID.

Schwiebert, E. 1979. The Puzzle of the Henrys Fork. Fly Fisherman, Spring Special, 1979.

Stumph, T. 1995. Summary of existing biohydrologic information on the Henry's Lake Outlet and it's *[sic]* tributaries. Report to the Nature Conservancy, contract # IDF0102494-LL.

[USDA] U.S. Department of Agriculture. 1991. Preliminary investigation report, Henrys Lake

Project, Fremont County, Idaho. USDA Soil Conservation Service, Yellowstone Soil Conservation District, Boise, ID.

[USDA] U.S. Department of Agriculture. 1993. Soil survey of Fremont County, Idaho, western part. USDA Soil Conservation Service.

[USDA] U.S. Department of Agriculture. 1997a. Draft Targhee National Forest ecological unit inventory. USDA Forest Service.

[USDA] U.S. Department of Agriculture. l997b. Final environmental impact statement, 1997 revised forest plan, Targhee National Forest. USDA Forest Service, St. Anthony, ID.

[USDA] U.S. Department of Agriculture. 1997c. 1997 revised forest plan, Targhee National Forest. USDA Forest Service, St. Anthony, ID.

[USEPA] U.S. Environmental Protection Agency. 1978. Identification of pollutants suitable for total maximum daily load calculations. Federal Register. Vol 43,. No. 250. pp. 60662-60666. December 28.

[USEPA] U.S. Environmental Protection Agency. 1994. List of waters still requiring total maximum daily loads (TMDLS) -- § 303(d) list for the state of Idaho, decision document. USEPA Region 10, Seattle, WA.

[USEPA] U.S. Environmental Protection Agency. 1996. Draft TMDL program implementation strategy. U.S. Environmental Protection Agency Office of Wetlands, Oceans, and Watersheds, Washington, DC.

[USEPA] U.S. Environmental Protection Agency. 1998. Surf your watershed: index of watershed indicators. Internet@ http://www.epa.gov/surf/HUC/hucinfo/17040202

[USGS] U.S. Geological Survey. 1994. Water Resources Data, Idaho, Water Year 1994: Volume 1. Great Basin and Snake River above King Hill. USGS Water-Data Report ID-94-1, Boise, ID.

[USGS] U.S. Geological Survey. 1996. Water Resources Data, Idaho, Water Year 1995: Volume 1. Great Basin and Snake River above King Hill. USGS Water-Data Report ID-95-1, Boise, ID.

[USGS] U.S. Geological Survey. 1996. Water Resources Data, Idaho, Water Year 1996: Volume 1. Great Basin and Snake River above King Hill. USGS Water-Data Report ID-96-1, Boise, ID.

[USGS] U.S. Geological Survey. 1998. Hydrologic units, hydrologic unit codes, and hydrologic unit names. Internet @ http://txwww.cr.usgs.gov/hcdn/hydrologic_units.html

Ulery, R. 1998. Personal communication. U.S. Geological Survey, Texas District, Austin, TX.

Van Kirk, R. 1996. The Henry's Fork Above Mesa Falls: An Overview of Management History and Implications for Rehabilitation and Restoration. Henry's Fork Foundation, Island Park, ID.

Van Kirk, R. And M. Gamblin. In preparation. The new Henry's Fork: restoring the wild trout fishery that never was.

Van Kirk, R. and J. Gregory. 1998. Island Park Landforms Tell a Fishy Story. Henry's Fork Foundation Newsletter, Winter 1998. Henry's Fork Foundation, Island Park, ID.

Van Kirk, R., and eight others. 1997. Status of Yellowstone Cutthroat Trout in the Upper Henry's Fork Watershed. Henry's Fork Foundation, Ashton, ID.

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences 37:130-137.

Ward, J.V. and J.A. Stanford. 1982. Thermal responses in the evolutionary ecology of aquatic insects. Annual Reviews of Entomology 27:97-117.

Whitehead, R.L. 1978. Water Resources of the Upper Henrys Fork Basin in Eastern Idaho. Water Information Bulletin No. 46, Idaho Department of Water Resources, Boise, ID.

Woods, J. 1998. Personal communication. District VII Health Department, St. Anthony, ID.

[YSCD] Yellowstone Soil Conservation District. 1995. Henry's Lake state agricultural water quality project final report/environmental assessment. Fremont County, ID.

[YSCD] Yellowstone Soil Conservation District. 1996. Henry's Lake state agricultural water quality project plan of operations. Fremont County, ID.

Zaroban, D.W. 1993. Water quality advisory working committee designated stream segments of concern 1992-94. Idaho Department of Health and Welfare, Division of Environmental Quality, Boise, ID.

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 30l(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 which 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 (l)(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), (l)(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 (l)(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 Sportmen'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 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 water bodies.

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:

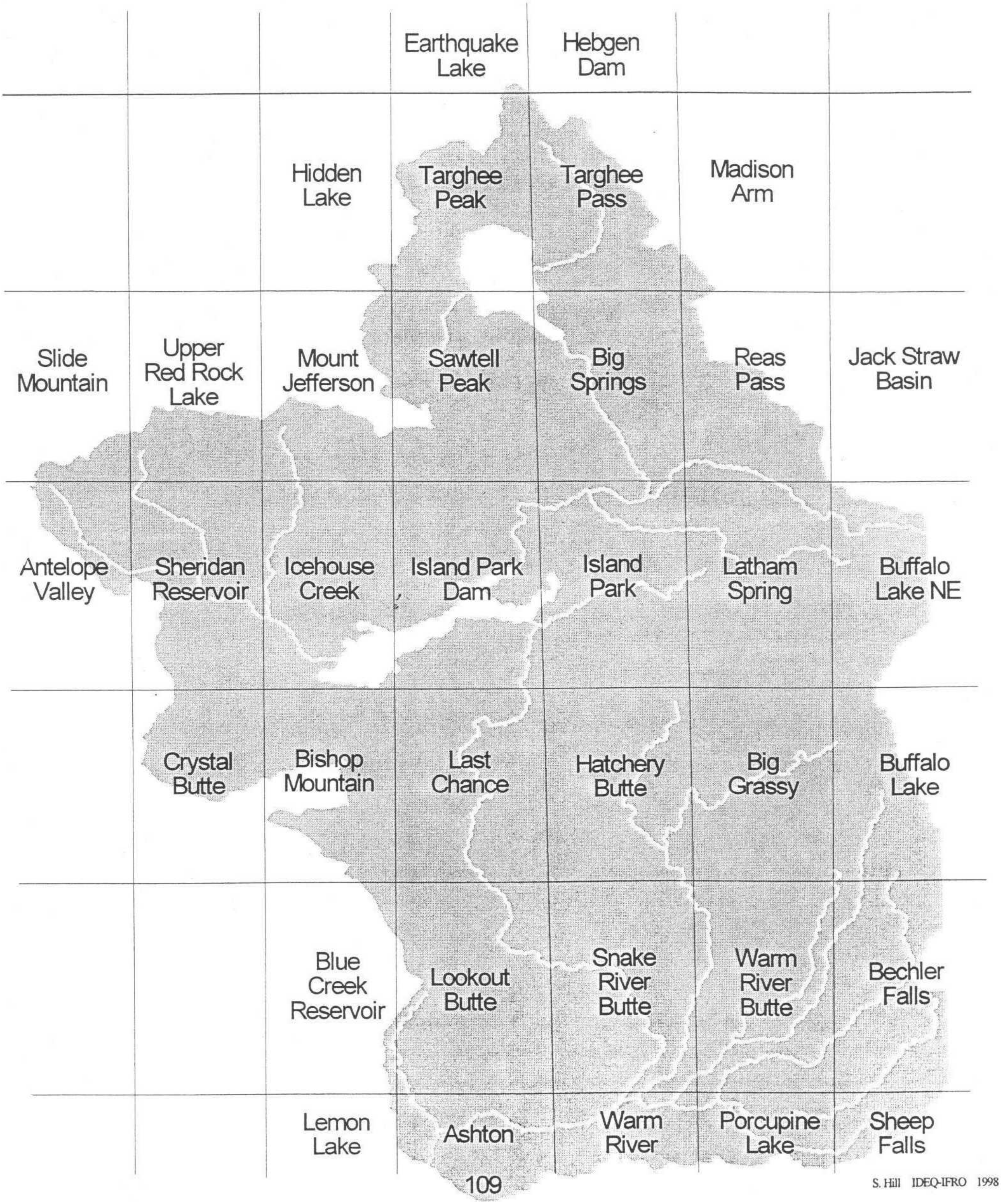
> *"[S]uch a schedule may provide more specific deadlines for the establishment of a few TMDLs for well-studied water quality limited segments in the short-term, and set only general planning goals for long term development of TMDLs for water quality limited segments about which little is known..."*

In May 1996, DEQ and EPA proposed a TMDL development schedule for Idaho to the Court. This proposal included a short-term schedule which 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 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"*. 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 water bodies designated as WQLSs in Idaho. The present record, … suggests that a completion time of approximately five years would be reasonable”.

Appendix C. Names of 7.5 minute quadrangle maps published by the U.S. Geological Survey for the Upper Henry's Fork Subbasin. The gridlines shown in this figure are approximate; refer to "Idaho index to topographic and other map coverage," published by the Survey, for more accurate information.



Appendix D – Table 1. USDA Soil Survey information for the Ashton Reservoir watershed.

General Soil Map Unit and Soil Survey Sheet Number	Detailed Soil Map Unit		Slope and Elevation	Erosion Hazard[2]	Major Use	Dominant Vegetation[3] or Crop	Waterbodies
6 Rexburg-Ririe-Kucera: Deep and very deep, nearly level to moderately steep, well-drained soils found in loess 32, 39, 46, 33, 40, 47	145	Vadnais-Sadorus-Rock outcrop complex: 40% Vadnais loam, 25% Sadorus gravelly loam, 15% contrasting inclusions[4]	2-8 % 5,500 feet	Moderate	Rangeland	Bluebunch wheatgrass, Idaho fescue, antelope bitterbush, mountain big sagebrush, arrowleaf balsamroot	Ashton Reservoir
	103	Rock outcrop-Sadorus complex: 45% rock outcrop, 35% Sadorus gravelly sandy loam, 20% contrasting inclusions[4]	4-50 % 5,500 feet	Severe or very severe	Rangeland	Bluebunch wheatgrass, Idaho fescue, mountain big sagebrush, arrowleaf balsamroot	Henry'e Fork Ashton Reservoir Rattlesnake Creek Box Canyon Kerr Canyon Putney Canyon Willow Canyon Jump Off Canyon Strong Creek
	108	Sarilda-Rock outcrop complex: 60% Sarilda very fine sandy loam, 15% rock outcrop, 25% contrasting inclusions[4]	1-6 % 5,200 feet	Moderate	Rangeland, irrigated cropland	Bluebunch wheatgrass, needle-and-thread, Idaho fescue, mountain big sagebrush, antelope bitterbush; alfalfa, pasture	Ashton Reservoir
	53	Kucera-Sarilda very fine sandy loams: 40% Kucera soil, 40% Sarilda soil, 20% contrasting inclusions[4]	1-4 % 5,300 feet	Slight	Irrigated and nonirrigated cropland, rangeland	Irrigated wheat, barley, and potatoes, and nonirrigated wheat and barley; Bluebunch wheatgrass, Idaho fescue, mountain big sagebrush, needlegrass	
	58	Lavacreek-Rin complex: 55% gravelly loam, 25% silt loam, 20% contrasting inclusions[4]	6-20 % 5,500 feet	Very severe	Irrigated and nonirrigated cropland	Barley, alfalfa, pasture	
	60	Lavacreek-Targhee complex: 40% Lavacreek gravelly loam, 35% Targhee loam, 25% contrasting inclusions	12-60 % 5,600 feet 6,500 feet	Very severe	Woodland	Douglas fir, quaking aspen	Willow Creek Coleman Canyon
	59	Lavacreek-Sadorus complex: 60% Lavacreek gravelly loam, 15% Sadorus gravelly sandy loam, 25% contrasting inclusions[4]	1-40 % 5,600 feet	Severe or very severe	Woodland, grazable woodland, rangeland	Quaking aspen, mountain big sagebrush, Idaho fescue, bluebunch wheatgrass, arrowleaf balsamroot	Jump Off Canyon

Appendix D – Table 1. continued.

General Soil Map Unit and Soil Survey Sheet Number	Detailed Soil Map Unit		Slope and Elevation	Erosion Hazard[2]	Major Use	Dominant Vegetation[3] or Crop	Waterbodies
6 Rexburg-Ririe-Kucera: Deep and very deep, nearly level to moderately steep, well-drained soils found in loess 32, 39, 46, 33, 40, 47	106	Sadorus-Kucera complex: 50% gravelly laom, 30% silt loam, 20% contrasting inclusions	1-6 % 5,250 feet	Moderate	Sadorus gravelly loam: Rangeland Kucera silt loam: irrigated and nonirrigated cropland	Mountain big sagebrush, arrowleaf balsamroot, Idaho fescue, bluebunch wheatgrass, irrigated and nonirrigated alfalfa and barley, irrigated potatoes	
	145	Vadnais-Sadorus-Rock outcrop complex: 40% loam, 25% gravelly loam, 15% contrasting inclusions	2-8 % 5,500 feet -	Moderate	Rangeland	Bluebunch wheatgrass, Idaho fescue, antelope bitterbush, mountain big sagebrush, arrowleaf balsamroot	
	51	Kucera-Lostine silt loams: 55% Kucera soil, 25% Lostine soil, 20% contrasting inclusions	4-8 % 5,200 feet 5,300 feet	Moderate	Irrigated and nonirrigated cropland	Irrigated potatoes, barley, wheat, peas, and alfalfa, nonirrigated barley, wheat, and alfalfa	
	35	Haploxerolls-Rock outcrop complex:: 50% Haploxerolls, 30% Rock outcrop, 20% contrasting inclusions	35-60 % 5,300 feet	Very severe	None: canyonsides, ravines, shoulder slopes		Henry's Fork
	95	Rin-Kucera silt loams: 60% Bin soil, 25% Kucera soil, 15% contrasting inclusions	4-12 % 5,570 feet	Severe	Irrigated and nonirrigated cropland	Irrigated potatoes, wheat, barley, and alfalfa, nonirrigated alfalfa and barley	
	13	Cryoborolls-Haploxerolls-Rock outcrop association: 35% Cryoborolls, 35% Haploxerolls, 10% contrasting inclusions	3 5-65 % 5,500 feet	Very severe	Rangeland, woodland	Douglas fir, aspen, snowberry, and pine reedgrass on north aspects; mountain big sagebrush, bluebunch wheatgrass, and juniper on south aspects	Strong Creek Hale Canyon
	69	Marotz silt loam: 80% soil, 20% contrasting inclusions	1-4 % 5,500 feet	Slight	Irrigated and nonirrngated cropland	Irrigated potatoes, barley, wheat, peas, and alfalfa, nonirrigated barley and alfalfa	
	70	Marotz silt loam: 80 % Marotz soil, 20% contrasting inclusions	4-8 % 5,500 feet	Moderate	Irrigated and nonirrigated cropland	Irrigated barley, wheat, peas, and alfalfa; nonirrigated barley and alfalfa	Henry's Fork

Appendix D – Table 1. continued.

General Soil Map Unit and Soil Survey Sheet Number	Detailed Soil Map Unit		Slope and Elevation	Erosion Hazard[2]	Major Use	Dominant Vegetation[3] or Crop	Waterbodies
	64	Lostine-Marystown silt loams: 45%Lostine soil, 40% Marystown soil, 15% - contrasting inclusions	4-8 % 5,550 feet	Moderate	Irrigated and nonirrigated cropland	Irrigated potatoes, wheat, barley, and alfalfa; nonirrigated barley and alfalfa, nonirrigated clover for green manure	
	54	Kucera-Sarilda silt loams: 40% Kucera soil, 40% Sarilda soil, 20% contrasting inclusions	2-6 % 5,300 feet	Moderate	Irrigated cropland	Wheat, barley, potatoes, and afalfa	
	49	Kucera-Lostinesilt barns: 45% Kucera soil, 45% Lostine soil, 10% contrasting inclusions	0-2 % 5,200 feet	Slight	Irrigated cropland	Potatoes, wheat, barley, alfalfa, peas	
5 Marystown-Robinlee-Greentimber: Very deep, nearly level to moderately steep, well drained soils formed in loess underlain by glacial deposits 40, 47, 41, 48	13	Cryoborolls-Haploxerolls-Rock outcrop association: 35% Cryoborolls, 35% Haploxerolls, 20% Rock outcrop, 10% contrasting inclusions	35-65 % 5,500 feet.	Very severe	Rangeland, woodland	Douglas fir, aspen, snowberry, and pine reedgrass on north aspects; mountain big sagebrush, bluebunch wheatgrass, and juniper on south aspects	Strong Creek Hale Canyon
	24	Greentimber-Marystown-Robinlee silt loams: 40% Greentimber soil, 25% Marystown soil, 20% Robinlee soil, 15% contrasting inclusions	1-4 % 5,400 feet	Slight	Irrigated and nonirrigated cropland	Irrigated potatoes, wheat, and barley; nonirrigated barley	
	76	Marystown-Robinlee-Rexburg hardpan substratum silt loams: 40% Marystown soil, 25% Robinlee soil, 20% Rexburg soil, 15% contrasting inclusions	1-4 % 5,300 feet	Slight	Irrigated and nonirrigated cropland	Irrigated potatoes, wheat, barley and alfalfa; nonirrigated barley and alfalfa	
	50	Kucera-Lostine silt barns: 55% Kucera soil, 25% Lostine soil, 20% contrasting inclusions	2-4 % 5,200 feet	Slight	Irrigated and nonirrigated cropland	Irrigated potatoes, wheat, barley, alfalfa, and peas; nonirrigated barley, wheat, and alfalfa	
	102	Robinlee-Marystown silt loams: 55% Robinlee soil, 25% Marystown soil, 20% contrasting inclusions	1-4 % 5,300 feet	Moderate	Irrigated and nonirrigated cropland	Irrigated potatoes, barley, wheat, alfalfa, and pasture; nonirrigated barley, alfalfa, and pasture	
	62	Lostine silt loam: 85% Lostine soil, 15% contrasting inclusions	1-4% 5,500 feet	Slight	Irrigated and nonirrigated cropland	Irrigated potatoes, wheat, barley, and alfalfa; nonirrigated barley and alfalfa	

Appendix D – Table 1. continued.

General Soil Map Unit and Soil Survey Sheet Number	Detailed Soil Map Unit	Slope and Elevation	Erosion Hazard[2]	Major Use	Dominant Vegetation[3] or Crop	Waterbodies
5 Marystown-Robinlee-Greentimber: Very deep, nearly level to moderately steep, well drained soils formed in loess underlain by glacial deposits 40, 47, 41, 48	51 Kucera-Lostine silt loams: 55% Kucera soil, 25% Lostine soil, 20% contrasting inclusions	4-8 % 5,200 feet 5,300 feet	Moderate	Irrigated and nonirrigated cropland	Irrigated potatoes, wheat, barley, alfalfa, and peas; nonirrigated barley, wheat, and alfalfa	
	74 Marystown silt loam: 80% Marystown soil, 20% contrasting inclusions	8-12 % 5,500 feet	Severe	Irrigated and nonirrigated cropland	Irrigated and nonirrigated barley and alfalfa	
	72 Marystown silt loam: 90% Marystown soil, 10% contrasting inclusions	1-4 % 5,500 feet	Slight	Irrigated and nonirrigated cropland	Irrigated potatoes, wheat, barley, and alfalfa, nonirrigated barley, and alfalfa; nonirrigated clover for green manure	
	75 Marystown Lostine silt loams: 50% Marystown soil, 40% Lostine soil, 10% contrasting inclusions	1-4 % 5,600 feet	Slight	Irrigated and nonirrigated cropland	Irrigated potatoes, wheat, barley, and alfalfa, nonirrigated barley, and alfalfa; nonirrigated clover for green manure	
	92 Rin silt loam: 80%Rin soil, 20% contrasting inclusions	1-4 % 5,700 feet	Moderate	Irrigated and nonirrigated cropland	Irrigated potatoes, wheat, barley, pasture, alfalfa and peas; nonirrigated wheat, alfalfa, pasture, potatoes, and barley	
7 Rin-Tetonia-Greys: Very deep, nearly level to moderately steep, well drained soils formed in loess 41, 48, 29, 49	93 Rin silt loam: 85% Rin soil, 15% contrasting inclusions	4-12 % 5,700 feet	Severe	Irrigated and nonirrigated cropland	Irrigated potatoes, wheat, barley, and alfalfa, nonirrigated barley and alfalfa	
	26 Greys-Robana silt loams: 50% Greys soil, 40% Robana soil, 10% contrasting inclusions	4-12 % 6,000 feet	Severe	Nonirrigated cropland	Barley, alfalfa	

Appendix D – Table 1. continued.

General Soil Map Unit	Detailed Soil Map Unit		Slope (%)	Erosion Hazard[2]	Major Use	Dominant Vegetation[3] or Crop	Waterbodies
	29	Greys-Turnerville silt loarns: 45% Greys soil, 40% Turnerville soil, 15% contrasting inclusions	4-12 % 5,600 feet	Severe	Woodland, grazable woodland, homesites	Quaking aspen, lodgepole pine, blue wildrye, mountain brome, slender wheatgrass, pine reedgrass, elk sedge, big bluegrass, edible valerian, aspen peavine, lupine, sticky geranium, quaking aspen, snowberry, Kentucky bluegrass, Fendler meadowrue, western yarrow, mountain snowberry, low Oregongrape	
	138	Turnerville silt loam: 85% Turnerville soil, 15% contrasting inclusions	1-4 % 5,800 feet	Slight	Woodland, grazable understory, homesites	Lodgepole pine, pine reedgrass, blue wildrye, mountain brome, Kentucky bluegrass, lupine, sticky geranium, Fendler meadowrue, western yarrow, mountain snowberry, low Oregongrape	
	139	Turnerville silt loam: 80% Turnerville soil, 20% contrasting inclusions	4-12 % 5,800 feet	Severe	Woodland, grazable understory, homesites	Lodgepole pine, pine reedgrass, blue wildrye, mountain brome, Kentucky bluegrass, lupine, sticky geranium, Fendler meadowrue, western yarrow, mountain snowberiy, low Oregongrape	

Appendix D – Table 2. USDA Soil Survey information for the Lower Henry's Fork watershed.

General Soil Map Unit and Soil Survey Sheet Numbers	Detailed Soil Map Unit		Slope and Elevation	Erosion Hazard[2]	Major Use	Dominant Vegetation[3] or Crop	Waterbodies
11 Katseanes-Vadnais-Rock Outcrop: Very shallow, deep, and very deep, nearly level to very steep, well-drained soils formed in alluvium 17, 19, 22	46	Katseanes-Rock outcrp-Vadnais complex: 30% Katseanes silt loam, 30% rock outcrop, 25% Vadnais silt loam, 15% contrasting inclusions	1-12 % 6,000 feet	Severe	Rangeland	Idaho fescue, bluebunch wheatgrass, mountain big sagebrush	
	14	Crystalbutte-Vadnais-Katseanes complex: 45% Crystalbutte loam, 20% Vadnais silt loam, 20% Ketseanes silt loam, 15% contrasting inclusions	1-30 % 6,600 feet	Moderate or severe	Rangeland	Idaho fescue, bluebunch wheatgrass, Columbia needlegrass, mountain big sagebrush, antelope bitterbrush, arrowleaf balsamroot	
	41	Judkins gravelly loam: 80% Judkins soil, 20% contrasting inclusions	1-15 % 6,600 feet	Severe	Summer homesites, woodland, grazable woodland	Douglas fir, lodgepole pine, pine reedgrass, bluegrass, western snowberry, lupine, heartleaf arnica, slender meadowrue	
	32	Hagenbarth-Vadnais silt loams: 55% Hagenbarth soil, 25% Vadnais soil, 20% contrasting inclusions	1-12 % 5,700 feet	Severe	Rangeland	Idaho fescue, Columbia needlegrass, Nevada bluegrass, slender wheatgrass, bluebunch wheatgrass, mountain big sagebrush, arrowleaf balsamroot	
	42	Judkins stony silt loam: 85% Judkins soil, 15% contrasting inclusions	1-4 % 6,600 feet	Slight	Woodland, grazable woodland	Lodgepole pine, Douglas fir, pine reedgrass, bluegrass, mountain brome, heartleaf arnica, slender meadowrue	
	8	Booneville-Crystalbutte complex: 45% Booneville gravelly loam, 35% Crystalbutte loam, 20% contrasting inclusions	4-20 % 6,800 feet	Severe	Woodland, Grazable woodland, rangeland	Douglas fir, Idaho fescue, pine reedgrass, mountain snowberry, heartleaf arnica, Columbia needlegrass, Nevada bluegrass, slender wheatgrass, bluebunch wheatgrass, arrowleaf balsamroot, geranium, mountain big sagebrush	
	10	Bootjack silty clay loam: 85% Bootjack soil, 15% contrasting inclusions (Note: Area characterized by this soil unit is known as Antelope Flat)	0-1 % 6,350 feet	Slight	Rangeland, building site development	Kentucky bluegrass, slender wheatgrass, mountain brome, sedge, clover	Unnamed perennial ponds and reservoirs

Appendix D – Table 3. USDA Soil Survey information for the Island Park Reservoir watershed

General Soil Map Unit and Soil Survey Sheet Numbers	Detailed Soil Map Unit		Slope and Elevation	Erosion Hazard[2]	Major Use	Dominant Vegetation[3] or Crop	Waterbodies
11 Katseanes-Vadnais-Rock Outcrop: Very shallow, deep, and very deep, nearly level to very steep, well-drained soils formed in alluvium 17	46	Katseanes-Rock outcrp-Vadnais complex: 30% Katseanes silt loam, 30% rock outcrop, 25% Vadnais silt loam, 15% contrasting inclusions	1-12 % 6,000 feet	Severe	Rangeland	Idaho fescue, bluebunch wheatgrass, mountain big sagebrush	
	144	Vadnais-Rock outcrop-Hagenbarth complex: 30% Vadnais silt loam, 30% rock outcrop, 25% Hagenbarth silt loam, 15% contrasting inclusions	1-12 % 6,600 feet	Moderate to severe, depending on soil	Rangeland	Idaho fescue, Nevada bluegrass, slender wheatgrass, bluebunch wheatgrass, arrowleaf balsamroot, mountain big sagebrush .	
	123	Stringam-Judkins complex: 45% Stringam loam, 35% Judkins gravelly loam, 20% contrasting inclusions	1-6 % 6,550 feet	Moderate	Grazable understory, woodland	Pine reedgrass, blue wildrye, mountain snowberry, low Oregongrape, Douglas Fir, lodgepole pine, slender wheatgrass, bluegrass, lupine	
	32	Hagenbarth-Vadnais silt loams: 55% Hagenbarth soil, 25% Vadnais soil, 20% contrasting inclusions	1-12 % 5,700 feet	Severe	Rangeland	Idaho fescue, Columbia needlegrass, Nevada bluegrass, slender wheatgrass, bluebunch wheatgrass, mountain big sagebrush, arrowleaf balsamroot	
4 Shotgun-Fourme-Henryslake: Moderately deep and very deep, nearly level and gently sloping, very cold, well dreained and poorly drained soils formed in loess and alluvium 9, 10, 11, 12, 14	41	Judkins gravelly loam: 80% Judkins soil, 20% contrasting inclusions	1-15 % 6,600 feet	Severe	Summer homesites, woodland, grazabbe woodland	Douglas fir, lodgepole pine, pine reedgrass, bluegrass, western snowberry, lupine, heartleaf arnica, slender meadowrue	Island Pk Reservoir Yale Creek
	42	Judkins stony silt loam: 85% Judkins soil, 15% contrasting inclusions	1-4 % 6,600 feet	Slight	Woodland, grazable woodland	Lodgepole pine, Douglas fir, pine reedgrass, bluegrass, mountain brome, heartleaf amica, slender meadowrue	Icehouse Creek

Appendix D – Table 3, continued

General Soil Map Unit and Soil Survey Sheet Numbers	Detailed Soil Map Unit		Slope and Elevation	Erosion Hazard[2]	Major Use	Dominant Vegetation[3] or Crop	Waterbodies
4 Shotgun-Fourme-Henryslake: Moderately deep and very deep, nearly level and gently sloping, very cold, well dreained and poorly drained soils formed in loss and alluvium 9, 10, 11, 12, 14	118	Spliten-Shotgun-Rock outcrop complex: 30% Spliten loam, 30% Shotgun loam, 20% rock, outcrop, 20% contrasting inclusions (Note: Area characterized by this soil unit known as Shotgun Valley)	1-12 % 6,350 feet	Moderate	Rangeland, summer homesites	Idaho fesue, bluebunch wheatgrass, mountain brome, mountain big sagebrush	Bishop Lake Icehouse Creek
	110	Shotgun loam: 80% Shotgun soil, 20% contrasting inclusions (Note: Area characterized by this soil unit known as Shotgun Valley)	1-4 % 6,500 feet	Slight	Rangeland	Idaho fesue, mountain brome, slender wheatgrass, arrowleaf balsamroot, mountain big sagebrush	Icehouse Creek Jerry Creek Sheep Creek
	124	Sudpeak-Stringam, gravelly subsoil complex: 40% Sudpeak gravelly clay, 40% Stringam silty clay loam	0-3 % 6,600 feet	Slight	Rangeland, pasture, homesites	Idaho fesue, mountain brome, slender wheatgrass, arrowleaf balsarnroot, mountain big sagebrush	Bunkhouse Creek Icehouse Creek Jerry Creek Sheep Creek
	36	Henryslake gravelly loam: 80% Henryslake soil, 20% contrasting inclusions	0-4 % 6,400 feet	Slight	Rangeland .	Sedge, wheatgrass, mountain brome, tufted hairgrass	Dry Creek East Fk Hotel Creek Hotel Creek Icehouse Creek Island Pk Reservoir W Fork Creek
	21	Fourme loam: 85% Fourme soil, 15% contrasting inclusions	0-4 % 6,500 feet	Slight	Rangeland, hayland,pasture, summer homesites	Idaho fesue, mountain big sagebrush, bluebunch wheatgrass, Nevada bluegrass, arrowleaf balsamroot	Bishop Lake Blue Creek Icehouse Creek Island Pk Reservoir Yale Creek
	127	Targhee-Judkins complex: 45% Targhee loam, 35% Judkins gravelly loam, 20% contrasting inclusions	15-30% 6,600 feet	Very severe	Woodland, grazable understory	Douglas fir, lodgepole pine, pine reedgrass, bluebunch wheatgrass, sticky geranium, serviceberry, mountain snowberry	Yale Creek

Appendix D – Table 3, continued

General Soil Map Unit and Soil Survey Sheet Numbers		Detailed Soil Map Unit		Slope and Elevation	Erosion Hazard[2]	Major Use	Dominant Vegetation[3] or Crop	Waterbodies
4	Shotgun-Fourme-Henryslake: Moderately deep and very deep, nearly level and gently sloping, very cold, well dreained and poorly drained soils formed in loess and alluvium 9, 10, 11, 12, 14	138	Turnerville silt loam: 85% Turnerville soil, 15% contrasting inclusions	1-4 % 5,800 feet	Slight	Woodland, grazable understory homesites,	Lodgepole pine, pine reedgrass, blue wildrye, mountain brome, Kentucky bluegrass, lupine, sticky geranium, Fendler meadowrue, western yarrow, mountain snowberry, low Oregongrape	Blue Creek
		81	Pits, Gravel: Open excavations from which volcanic cinders on basalt plains and gravel and sand on alluvial plains and river terraces are removed	Not specified	Not specified	Not specified	Not specified	

Appendix D – Table 4. USDA Soil Survey information for the Sheridan Reservoir watershed.

General Soil Map Unit and Soil Survey Sheet Numbers	Detailed Soil Map Unit		Slope and Elevation	Erosion Hazard[2]	Major Use	Dominant Vegetation[3] or Crop	Waterbodies
4 Shotgun-Fourme-Henryslake: Moderately deep and very deep, nearly level and gently sloping, very cold, well dreained and poorly drained soils formed in loess and alluvium 9, 10, 11, 12, 14	118	Spliten-Shotgun-Rock outcrop complex: 30% Spliten loam, 30% Shotgun loam, 20% rock outcrop, 20% contrasting inclusions (Note: Area characterized by this soil unit known as Shotgun Valley)	1-12 % 6,350 feet	Moderate	Rangeland, summer homesites	Idaho fesue, bluebunch wheatgrass, mountain brome, mountain big sagebrush	Blind Creek Keg Spring Creek Myers Creek Schneider Creek Willow Creek
	41	Judkins gravelly loam: 80% Judkins soil, 20% contrasting inclusions	1-15 % 6,600 feet	Severe	Summer homesites, woodland, grazable woodland	Douglas fir, lodgepole pine, pine reedgrass, bluegrass, western snowberry, lupine, heartleaf arnica, slender meadowrue	Schneider Creek Willow Creek
	21	Fourme loam: 85% Fourme soil, 15% contrasting inclusions	0-4 % 6,500 feet	Slight	Rangeland, hayland,pasture, summer homesites	Idaho fesue, mountain big sagebrush, bluebunch wheatgrass, Nevada bluegrass, arrowleaf balsamroot	Sheridan Creek Willow Creek
	46	Katseanes-Rock outcrop-Vadnais complex: 30% Katseanes silt loam, 30% rock outcrop, 25% Vadnais silt loam, 15% contrasting inclusions	1-12 % 6,000 feet	Severe	Rangeland	Idaho fesue, bluebunch wheatgrass, mountain big sagebrush	
	110	Shotgun loam: 80% Shotgun soil, 20% contrasting inclusions (Note: Area characterized by this soil unit known as Shotgun Valley)	1-4 % 6,500 feet	Slight	Rangeland	Idaho fesue, mountain brome, slender wheatgrass, arrowleaf balsamroot, mountain big sagebrush	
	128	Tepete-Bootjack complex: 60% Tepete peat, 25% Bootjack silty clay loam, 15% contrasting inclusions	0-1 % 6,650 feet	Slight	Nonirrigated pasture, rangeland	Tufted hairgrass, sedge, shrubby cinquefoil, Kentucky bluegrass, mountain brome, clover	

Appendix D – Table 5. USDA Soil Survey information for the Henry's Lake watershed.

General Soil Map Unit and Soil Survey Sheet Numbers		Detailed Soil Map Unit		Slope and Elevation	Erosion Hazard[2]	Major Use	Dominant Vegetation[3] or Crop	Waterbodies
2	Fourme-Raynoldson-Trude: Very deep, nearly level, very cold, well drained soils formed in alluvium	83	Raynoldson gravelly loam: 80% Raynoldson soil, 20% contrasting inclusions	2-15 % 6,700 feet	Severe[4]	Rangeland, pasture, summer homesites	Idaho fesue, slender wheatgrass, mountain brome, mountain big sagebrush	Henry's Lake Ingals Creek Rock Creek Timber Creek
		36	Henryslake gravelly loam: 80% Henryslake soil, 20% contrasting inclusions	0-4 % 6,400 feet	Slight	Rangeland	Sedge, wheatgrass, mountain brome, tufted bairgrass	Henry's Lake Timber Creek
		47	Kitchell gravelly loam: 85% Kitchell soil, 15% contrasting inclusions	15-55 % 6,900 feet	Very severe	Woodland, grazable woodland, homesites	Douglas fir, pine reedgrass, blue wildrye, mountain brome, Columbia needlegrass, mountain snowberry, low Oregongrape	
		61	Lionhead gravelly loam: 85% Lionhead soil, 15% contrasting inclusions	20-55 % 7,800 feet	Very severe	Rangeband, summer homesites	Idaho fesue, bluebunch wheatgrass, mountain brome, mountain big sagebrush	
		21	Fourme loam: 85% Fourme soil, 15% contrasting inclusions	0-4 % 6,500 feet	Slight	Rangeland, hayland,pasture, summer homesites	Idaho fesue, mountain big sagebrush, bluebunch wheatgrass, Nevada bluegrass, arrowleaf balsamroot	Duck Creek Henry's Lake Hope Creek Jesse Creek
		128	Tepete-Bootjack complex: 60% Tepete peat, 25% Bootjack silty clay loam, 15% contrasting inclusions	0-1 % 6,650 feet	Slight	Nonirrigated pasture, rangeband	Tufted hairgrass, sedge, shrubby cinquefoil, Kentucky bluegrass, mountain brome, clover	Duck Creek Gillman Creek Henry's Lake Hope Creek Kelly Creek
		10	Bootjack silty clay loam: 85% Bootjack soil, 15% contrasting inclusions (Note: Area characterized by this soil unit is known as Antelope Flat)	0-1 % 6,350 feet	Slight	Rangeland, building site development	Kentucky bluegrass, slender wheatgrass, mountain brome, sedge, clover	Henry's Lake

Appendix D – Table 5, continued.

General Soil Map Unit and Soil Survey Sheet Numbers	Detailed Soil Map Unit	Slope and Elevation	Erosion Hazard[2]	Major Use	Dominant Vegetation[3] or Crop	Waterbodies
2 Fourme-Raynoldson-Trade: Very deep, nearly level, very cold, well drained soils formed in alluvium	41 Judkins gravelly loam: 80% Judkins soil, 20% contrasting inclusions	1-15 % 6,600 feet	Severe	Summer homesites, woodland, grazable woodland	Douglas fir, lodgepole pine, pine reedgrass, bluegrass, western snowberry, lupine, heartleaf arnica, slender meadowrue	Rock Creek
	126 Targhee loam: 90% Targhee loam, 10% contrasting inclusions	15-40 % 6,400 feet	Very severe	Woodland, grazable understory, homesites	Douglas fir, lodgepole pine, pine reedgrass, bluebunch wheatgrass, Idaho fescue, bluegrass, sticky geranium, lupine, serviceberry, mountain snowberry	
	125 Targhee loam: 90% Targhee loam, 10% contrasting inclusions	1-15 % 6,400 feet	Severe	Woodland, grazable understory, homesites	Douglas fir, lodgepole pine, pine reedgrass, bluebunch wheatgrass, Idaho fescue, bluegrass, sticky geranium, lupine, serviceberry, mountain snowberry	
	81 Pits, Gravel: Open excavations from which volcanic cinders on basalt plains and gravel and sand on alluvial plains and river terraces are removed	Not specified	Not specified	Not specified	Not specified	
	109 Sawtelpeak silty clay: 75% Sawtelpeak soil, 25% contrasting inclusions	0-2 % 6,450 feet	Slight	Rangeland, irrigated pasture	Sedge, tufted hairgrass, slender wheatgrass, clover	Jesse Creek
	120 Stamp loam: 85% Stamp loam soil, 15% contrasting inclusions	0-4 % 6,400 feet	Slight	Rangeland, summer homesites	Slender wheatgrass, tufted hairgrass, sedges	

Appendix D – Table 5, continued.

General Soil Map Unit and Soil Survey Sheet Numbers	Detailed Soil Map Unit	Slope and Elevation	Erosion Hazard[2]	Major Use	Dominant Vegetation[3] or Crop	Waterbodies
12 Raynoldson-Kitchell-Lionhead: Very deep, gently sloping to very steep, very cold, well drained soils formed in residuum and alluvium	83 Raynoldson gravelly loam: 80% Raynoldson soil, 20% contrasting inclusions	2-15 % 6,700 feet	Severe[4]	Rangeland, pasture, summer homesites	Idaho fesue, slender wheatgrass, mountain brome, mountain big sagebrush	
	61 Lionhead gravelly loam: 85% Lionhead soil, 15% contrasting inclusions	20-55 % 7,800 feet	Very severe	Rangeland, summer homesites	Idaho fesue, bluebunch wheatgrass, mountain brome, mountain big sagebrush	Howard Creek
	47 Kitchell gravelly loam: 85% Kitchell soil, 15% contrasting inclusions	15-55 % 6,900 feet	Very severe	Woodland, grazable woodland, homesites	Douglas fir, pine reedgrass, blue wildrye, mountain brome, Columbia needlegrass, mountain snowberry, low Oregongrape	Dry Fk Targhee Ck Targhee Creek
	128 Tepete-Bootjack complex: 60% Tepete peat, 25% Bootjack silty clay loam, 15% contrasting inclusions	0-1 % 6,650 feet	Slight	Nonirrigated pasture, rangeland	Tufted hairgrass, sedge, shrubby cinquefoil, Kentucky bluegrass, mountain brome, clover	
3 Bootjack-Chickcreek: Very deep, nearly level, very cold, poorly drained soils formed in alluvium	125 Targhee loam: 90% Targhee loam, 10% contrasting inclusions	1-15 % 6,400 feet	Severe	Woodland, grazable understory, homesites	Douglas fir, lodgepole pine, pine reedgrass, bluebunch wheatgrass, Idaho fescue, bluegrass, sticky geranium, lupine, serviceberry, mountain snowberry	
	10 Bootjack silty clay loam: 85% Bootjack soil, 15% contrasting inclusions (Note: Area characterized by this soil unit is known as Antelope Flat)	0-1 % 6,350 feet	Slight	Rangeland, building site development	Kentucky bluegrass, slender wheatgrass, mountain brome, sedge, clover	Crooked Creek Enget Creek Henry's Fork Jones Creek Meadow Creek Stephens Creek
	109 Sawtelpeak silty clay: 75% Sawtelpeak soil, 25% contrasting inclusions	0-2 % 6,450 feet	Slight	Rangeland, irrigated pasture	Sedge, tufted hairgrass, slender wheatgrass, clover	Jesse Creek

Appendix D – Table 5, continued.

General Soil Map Unit and Soil Survey Sheet Numbers	Detailed Soil Map Unit	Slope and Elevation	Erosion Hazard[2]	Major Use	Dominant Vegetation[3] or Crop	Waterbodies
3 Bootjack-Chickcreek: Very deep, nearly level, very cold, poorly drained soils formed in alluvium	126 Targhee loam: 90% Targhee loam, 10% contrasting inclusions	15-40% 6,400 feet	Very severe	Woodland, grazable understory, homesites	Douglas fir, lodgepole pine, pine reedgrass, bluebunch wheatgrass, Idaho fescue, bluegrass, sticky geranium, lupine, serviceberry, mountain snowberry	Garner Springs
	21 Fourme loam: 85% Fourme soil, 15% contrasting inclusions	0-4 % 6,500 feet	Slight	Rangeland, hayland,pasture, summer homesites	Idaho fesue, mountain big sagebrush, bluebunch wheatgrass, Nevada bluegrass, arrowleaf balsamroot	
	120 Stamp loam: 85% Stamp loam soil, 15% contrasting inclusions	0-4 % 6,400 feet	Slight	Rangeland, summer homesites	Slender wheatgrass, tufted hairgrass, sedges	
	119 Stamp sandy loam: 75% Stamp soil, 25% contrasting inclusions	0-4 % 6,300 feet	Slight	Woodland, grazable woodland, summer homesites	Lodgepole pine, slender wheatgrass, Kentucky bluegrass, sedge, mountain brome, common yarrow, lupine	

[4]Assumes that the responses for “Runoff’ and “Hazard of water erosion” wre transposed in the Soil Survey.

Appendix D – Table 6. USDA Soil Survey information for the Buffalo River watershed.

General Soil Map Unit and Soil Survey Sheet Numbers	Detailed Soil Map Unit		Slope and Elevation	Erosion Hazard[2]	Major Use	Dominant Vegetation[3] or Crop	Waterbodies
3 Bootjack-Chickcreck: Very deep, nearly level, very cold, poorly drained soils formed in alluvium 13, 15, 34	137	Trude gravelly loam: 85% Trude soil, 15% contrasting inclusions	0-4 % 6,300 feet	Slight	Rangeland, summer homesites	Bluebunch wheatgrass, Idaho fescue, mountain big sagebrush, Columbia needlegrass	
	10	Bootjack silty clay loam: 85% Bootjack soil, 15% contrasting inclusions	0-1 % 6,350 feet	Slight	Rangeland, building site development	Kentucky bluegrass, slender wheatgrass, mountain brome, sedge, clover	Elk Creek Elk Reservoir
	119	Stamp sandy loam: 75% Stamp soil, 25% contrasting inclusions	0-4 % 6,300 feet	Slight	Woodland, grazable woodland, summer homesites	Lodgepole pine, slender wheatgrass, Kentucky bluegrass, sedge, mountain brome, common yarrow, lupine	Buffalo River
	125	Targhee loam: 90% Targhee loam, 10% contrasting inclusions	1-15 % 6,400 feet	Severe	Woodland, grazable understory, homesites	Douglas fir, lodgepole pine, pine reedgrass, bluebunch wheatgrass, Idaho fescue, bluegrass, sticky geranium, lupine, serviceberry, mountain snowberry	Buffalo River
	11	Chickcreek mucky peat: 90% Chickcreek soil, 10% contrasting inclusions	0-1 % 6,300 feet	Slight	Woodland, grazable woodland, summer homesites	Lodgepole pine, pine reedgrass, tufted hairgrass, sedge bearberry, grouse blueberry	Buffalo River Toms Creek
	120	Stamp loam: 85% Stamp loam soil, 15% contrasting inclusions	0-4 % 6,400 feet	Slight	Rangeland, summer homesites	Slender wheatgrass, tufted hairgrass, sedges	Toms Creek
	12	Chickcreek mucky peat, ponded: 90% Chickcreek soil, 10% contrasting inclusions	0-1 % 6,300 feet	Slight	Rangeland, homesites	Common camas, tufted hairgrass, Nebraska sedge, other sedges, rushes	

Appendix D – Table 6, cContinued.

General Soil Map Unit and Soil Survey Sheet Numbers	Detailed Soil Map Unit	Slope and Elevation	Erosion Hazard[2]	Major Use	Dominant Vegetation[3] or Crop	Waterbodies
3 Bootjack-Chickcreek: Very deep, nearly level, very cold, poorly drained soils formed in alluvium 13, 15, 34	126 Targhee loam: 90% Targhee loam, 10% contrasting inclusions	15-40 % 6,400 feet	Very severe	Woodland, grazable understory, homesites	Douglas fir, lodgepole pine, pine reedgrass, bluebunch wheatgrass, Idaho fescue, bluegrass, sticky geranium, lupine, serviceberry, mountain snowberry	

Appendix D – Table 7. USDA Soil Survey information for the Warm River watershed.

General Soil Map Unit and Soil Survey Sheet Numbers	Detailed Soil Map Unit	Slope and Elevation	Erosion Hazard[2]	Major Use	Dominant Vegetation[3] or Crop	Waterbodies
2 Fourme-Raynoldson-Trude: Very deep, nearly level, very cold, well drained soils formed in alluvium	119 Stamp sandy loam: 75% Stamp soil, 25% contrasting inclusions	0-4 % 6,300 feet	Slight	Woodland, grazable woodland, summer homesites	Lodgepole pine, slender wheatgrass, Kentucky bluegrass, sedge, mountain brome, common yarrow, lupine	Warm River
	137 Trude gravelly loam: 85% Trude soil, 15% contrasting inclusions	0-4 % 6,300 feet	Slight	Rangeland, summer homesites	Bluebunch wheatgrass, Idaho fescue, mountain big sagebrush, Columbia needlegrass	
	10 Bootjack silty clay loam: 85% Bootjack soil, 15% contrasting inclusions	0-1 % 6,350 feet	Slight	Rangeland, building site development	Kentucky bluegrass, slender wheatgrass, mountain brome, sedge, clover	Warm River
	120 Stamp loam: 85% Stamp loam soil, 15% contrasting inclusions	0-4 % 6,400 feet	Slight	Rangeland, summer homesites	Slender wheatgrass, tufted hairgrass, sedges	
	125 Targhee loam: 90% Targhee loam, 10% contrasting inclusions	1-15 % 6,400 feet	Severe	Woodland, grazable understory, homesites	Douglas fir, lodgepole pine, pine reedgrass, bluebunch wheatgrass, Idaho fescue, bluegrass, sticky geranium, lupine, serviceberry, mountain snowberry	
	126 Targhee loam: 90% Targhee loam, 10% contrasting inclusions	15-40 % 6,400 feet	Very severe	Woodland, grazable understory, homesites	Douglas fir, lodgepole pine, pine reedgrass, bluebunch wheatgrass, Idaho fescue, bluegrass, sticky geranium, lupine, serviceberry, mountain snowberry	

Appendix E. Water Quality Criteria

IDAPA 16.01.02, *Water Quality Standards and Wastewater Treatment Requirements*, list the following water quality criteria for sediment and dissolved oxygen:

IDAPA 16.01.02.200.03 Deleterious materials. Surface waters of the state shall be free from deleterious materials in concentrations that may impair designated beneficial uses.

IDAPA 16.01.02.200.05 Floating, Suspended, or Submerged Matter. Surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses.

IDAPA 16.01.02.200.06 Excess nutrients. Surface waters of the state shall be free from oxygen demanding materials in concentrations that would result in an anaerobic water condition.

IDAPA 16.01.02.200.08 Sediment. Sediment shall not exceed quantities specified in Section 250, or in absence of specific sediment criteria, quantities which impair designated beneficial uses. Determinations of impairment shall be based on water quality monitoring and surveillance and the information utilized as described in Subsection 350.02.b.

> *Note: Section 250 allows for specific sediment criteria which have not been established; Subsection 350.02.b describes possible responses if monitoring indicates that water quality criteria are not being met or beneficial uses are being impaired.)*

IDAPA 16.01.02.250.02.c Cold water biota: waters designated for cold water biota are to exhibit the following characteristics:

i. Dissolved Oxygen Concentrations exceeding 6 mg/l at all times.
ii. Water temperatures of 22°C [72°F] or less with a maximum daily average of no greater than 19°C [66°F].
iv. Turbidity, below any applicable mixing zone set by the Department, shall not exceed background turbidity by more than 50 NTU instantaneously or more than twenty-five 25 NTU for more than ten consecutive days.

IDAPA 16.0l.02.250.02.d 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 day minimum of not less than 5.0 mg/l.

(b) Seven day average mean of not less than 6.0 mg/l.

(2) Water-Column Dissolved Oxygen.

(a) One day minimum of not less than 6.0 mg/l or 90% of saturation, whichever is greater.

ii. Water temperatures of 13°C [55°F] or less with a maximum daily average no greater than 9°C [48°F].

IDAPA 16.0l.02.250.0l.a. Primary Contact Recreation: Between May 1 and September 30 of each calendar year, waters designated for primary contact recreation are not to contain fecal coliform bacteria significant to the public health in concentrations exceeding:

i. 500/ml at any time; or

ii. 200/ml in more than ten percent of the total samples taken over a thirty day period; or

iii. A geometric mean of 50/ml based on a minimum of five samples taken over a thirty day period.

Appendix F. Additional Sources of Data and Information for the Upper Henry's Fork Subbasisn

Upper Henrys Fork Subbasin Bibliography

Compiled by Dr. Rob Van Kirk,
Affiliate Faculty, Department of Biological Sciences, Idaho State University

This bibliography includes reports and publications that are available through government agencies, scientific journals, universities, and the Henry's Fork Watershed Center in Ashton. The bibliography does not include any reports from Idaho Division of Environmental Quality, State Agricultural Water Quality Programs, or the Henry's Lake Clean Lakes Study, since these reports are already cited in the Upper Henrys Fork Subbasin Assessment. There are also numerous agency reports that are not included because they are outdated or the information contained in them is summarized in more recent documents. However, several important older documents are included because of the baseline information they contain. The items in this bibliography are arranged under the following headings:

1. Aquatic and Riparian Ecology--General

2. Fish and Fisheries Management

3. Hydrology and Geomorphology

4. Water Quality (including aquatic habitat and invertebrates)

5. Wildlife.

1. AQUATIC AND RIPARIAN ECOLOGY--GENERAL

Angradi, T.R. 1991. Transport of coarse particulate organic matter in an Idaho river, USA. Hydrobiologia 211:171-183.

Angradi, T.R. 1993. Stable carbon and nitrogen isotope analysis of seston in a regulated rocky mountain river, USA. Regulated Rivers: Research & Management 8:251-270.

Ecosystems Research Institute. 1995. Island Park Hydroelectric Project FERC No. 2973: Environmental Assessment for the proposed spillway modification. Project completion report for Fall River Rural Electric Cooperative, Ashton, ID. Ecosystems Research Institute, Logan, UT.

Platts, W.S., F.J. Wagstaff, and E. Chaney. 1989. Cattle and fish on the Henry's Fork. Rangelands 11(2):58-62.

Shea, R.E. 1996. Assessment of aquatic macrophytes at Harriman State Park, Idaho. Project completion report for the Henry's Fork Foundation, Ashton, ID. Department of Biological Sciences, Idaho State University, Pocatello, ID.

Shea, R.E. 1997. Assessment of aquatic macrophytes at Harriman State Park, Idaho. Project completion report for the Henry's Fork Foundation, Ashton, ID. Department of Biological Sciences, Idaho State University, Pocatello, ID.

Shea, R.E., J.A. Kadlec, R.C. Drewien and J.W. Snyder. 1996. Assessment of aquatic macrophytes at Harriman State Park and at other key wintering sites within the Henry's Fork watershed, Idaho. Project completion report for the Henry's Fork Foundation, Ashton, ID. Department of Biological Sciences, Idaho State University, Pocatello, ID.

Vinson, M.R., D.K. Vinson and T.R. Angradi. 1992. Aquatic macrophytes and instream flow characteristics of a rocky mountain river. Rivers. 3:260-265.

2. FISH AND FISHERIES MANAGEMENT

Angradi, T. R. 1990. Foraging ecology of wild rainbow trout *(Oncorhynchus mykiss)* in the Henry's Fork of the Snake River, Idaho. Ph.D. dissertation, Idaho State University, Pocatello, ID.

Angradi, T.R. 1992. Effects of predation risk on foraging behavior of juvenile rainbow trout *(Oncorhynchus mykiss).* Canadian Journal of Zoology 70:355-360.

Angradi, T. and C. Contor. 1989. Henry's Fork Fisheries Investigations. Project F-71-R-12, Subproject III, Jobs 7a and 7b. Idaho Department of Fish and Game, Idaho Falls, ID.

Angradi, T. R. and J.S. Griffith. 1990. Diel feeding chronology and diet selection of rainbow trout *(Oncorhynchus mykiss)* in the Henry's Fork of the Snake River, Idaho. Canadian Journal of Fisheries and Aquatic Sciences 47:199-209.

Brostrom, J. 1987. Henry's Fork Fisheries Investigations. Project F-73-R-8, Subproject IV, Study III, Job 1. Idaho Department of Fish and Game, Idaho Falls, ID.

Brostrom, J. and R. Spateholts. 1985. Henry's Fork Fisheries Investigations. Project F-73-R-7, Subproject IV, Study III, Job 1. Idaho Department of Fish and Game, Idaho Falls, ID.

Contor, C.R. 1989. Diurnal and nocturnal winter habitat utilization by juvenile rainbow trout in the Henry’s Fork of the Snake River, Idaho. Master’s thesis, Idaho State University, Pocatello, ID.

Contor, C.R. and J.S. Griffith. 1994. Nocturnal emergence of juvenile rainbow trout from winter concealment relative to light intensity. Hydrobiologia 299:179-183.

Coon, J. 1977. Henry’s Fork Fisheries Investigations. Project F-66-R-2, Job VII. Idaho Department of Fish and Game, Idaho Falls, ID.

Corsi, C. and S. Elle. 1989. Regional Fisheries Management Investigations. Project F-71-R-12. Idaho Department of Fish and Game, Idaho Falls, ID.

Elle, S. and C. Corsi. 1994. Regional Fisheries Management Investigations. Project F-71-R-l3. Idaho Department of Fish and Game, Idaho Falls, ID.

Gregory, J. 1997. Spring spawning on the Henrys Fork and tributaries upstream from Riverside Campground. Project completion report for the Henry’s Fork Foundation, Ashton, ID. Gregory Aquatics, Mackay, ID.

Gregory, J.S. and J.S. Griffith. 1997. First-winter survival of wild and hatchery cutthroat trout caged in allopatry and in sympatry with brook trout. Department of Biological Sciences, Idaho State University, Pocatello, ID.

Griffith, J.S. and K.A. Meyer. 1993. Abundance and size of age-0 rainbow trout in index sites on the Henry’s Fork of the Snake River, 1987-1993. Project completion report for the Henry’s Fork Foundation, Ashton, ID and the Targhee National Forest, St. Anthony, ID. Department of Biological Sciences, Idaho State University, Pocatello, ID.

Griffith, J.S. and R. W. Smith. 1995. Failure of submersed macrophytes to provide cover for rainbow trout throughout their first winter in the Henrys Fork of the Snake River, Idaho. North American Journal of Fisheries Management 15:42-48.

Griffith, J., M. State, and J. Gregory. 1996. Distribution and first-winter ecology of trout in small streams of the Targhee National Forest. Project completion report for the Henry’s Fork Foundation, Ashton, ID and the Targhee National Forest, St. Anthony, ID. Department of Biological Sciences, Idaho State University, Pocatello, ID.

Grunder, S.A. 1986. Evaluation of Henry’s Lake Trout Stocking Program. Project F-73-R-8, Subproject III, Study IV, Job 1. Idaho Department of Fish and Game, Idaho Falls, ID.

Jeppson, P. 1973. Snake River Fisheries Investigations. Project F-66-R-3, Job III-a. Idaho Department of Fish and Game, Idaho Falls, ID.

Maret, T.R., C.T. Robinson, and G.W. Minshall. 1997. Fish assemblages and environmental correlates in least-disturbed streams of the Upper Snake River Basin. Transactions of the American Fisheries Society 126:200-216.

Meyer, K.A. 1995. Experimental evaluation of habitat use and survival of rainbow trout during their first winter in the Henrys Fork of the Snake River, Idaho. Master's thesis, Idaho State University, Pocatello, ID.

Meyer, K.A., and J.S. Griffith. 1997. Effects of Cobble-Boulder Substrate Configuration on Winter Residency of Juvenile Rainbow Trout. North American Journal of Fisheries Management 17:77.84.

Meyer, K.A., and J.S. Griffith. 1997. First-winter survival of rainbow trout and brook trout in the Henrys Fork of the Snake River, Idaho. Canadian Journal of Zoology 75: 59-63.

Rohrer, R. L. 1983. Henry's Fork Fisheries Investigations. Project F-73-R-4, Subproject IV, Study XI. Idaho Department of Fish and Game, Idaho Falls, ID.

Rohrer, R. L. 1984. Henry's Fork Fisheries Investigations. Project F-73-R-5, Subproject IV, Study XI. Idaho Department of Fish and Game, Idaho Falls, ID.

Rohrer, R.L. 1986. Creel surveys from a kayak on the Henry's Fork of the Snake River, Idaho. North American Journal of Fisheries Management 6:294-295.

Smith, R.W. and J. S. Griffith. 1994. Survival of rainbow trout during their first winter in the Henrys Fork of the Snake River, Idaho. Transactions of the American fisheries Society. 123:747-756.

Spateholts, R. and V. Moore. 1985. Henry's Fork Fisheries Investigations. Project F-73-R-6. Idaho Department of Fish and Game, Idaho Falls, ID.

Van Kirk, R. 1996. The Henry's Fork fishery above Mesa Falls: An overview of management history and implications for rehabilitation and restoration. Henry's Fork Foundation, Ashton, ID.

Van Kirk, R., and eight others. 1997. Status of Yellowstone Cutthroat Trout in the Upper Henry's Fork Watershed. Henry's Fork Foundation, Ashton, ID.

Van Kirk, R., L. Albano, J. Didier, and D. Hayes. 1997. Angler effort and catch on the Buffalo River, 1996 and 1997. Henry's Fork Foundation, Ashton, ID.

3. HYDROLOGY AND GEOMORPHOLOGY

Anderson, E. 1996. Stream geomorphology and hydrology of the upper Henry's Fork watershed. Project completion report for the Henry's Fork Foundation, Ashton, ID and the Targhee National Forest, St. Anthony, ID. Department of Earth Sciences, Idaho State University, Pocatello, ID.

Benjamin, L. 1997. Sheridan Creek hydrology and geomorphology and implications for restoration efforts. Henry's Fork Foundation, Ashton, ID.

Benjamin, L. 1997. Hydrologic Analysis of the Upper Henrys Fork Basin and Probabilistic Assessment of Island Park Reservoir Fill. Master's Thesis, Utah State University, Logan, UT.

Benjamin, L. and R.W. Van Kirk. 1998. Assessing instream flows and reservoir operations on an eastern Idaho river. Revised manuscript submitted to Journal of the American Water Resources Association.

Christiansen, R.L. 1982. Late Cenozoic volcanism of the Island Park area, eastern Idaho, pp 345-368 in Bonnichsen, B. and Breckenridge, R.M. (eds), Cenozoic Geology of Idaho. Idaho Bureau of Mines and geology Bulletin 26.

Christiansen, R.L. and G.F. Embree. 1987. Island Park, Idaho; Transition from rhyolites of the Yellowstone Plateau to basalts of the Snake River Plain. Geological Society of American Centennial Field guide—Rocky Mountain Section, pp 103-108.

HabiTech, Inc. 1994. Flushing flow investigations; Henry's Fork of the Snake River 1993-1994. Project completion report for Idaho Division of Environmental Quality, Idaho Falls, ID. HabiTech, Inc., Laramie, WY.

HabiTech, Inc. 1997. Upper Henry's Fork watershed sediment studies 1996. Project completion report for Henry's Fork Foundation, Ashton, ID. HabiTech, Inc., Laramie, WY.

Myers, S.C. 1997. A Spatial Comparison of Channel Morphology Between Burn, Timber and Old Growth Areas Within the Yellowstone Ecosystem. Master's thesis, Montana State University, Bozeman, MT.

Whitehead, R.L. 1978. Water resources of the Henrys Fork basin in eastern Idaho. Water Information Bulletin 46. Idaho Department of Water Resources, Boise, ID.

4. WATER QUALITY (INCLUDING AQUATIC HABITAT AND INVERTEBRATES)

Clark, G.M. 1994. Assessment of selected constituents in surface water of the Upper Snake River Basin, Idaho and Western Wyoming, water years 1975-89. Water Resources Investigations Report 93-4229. U.S. Geological Survey, Boise, ID.

Clark, G.M., T.R. Maret, M.G. Rupert, M.A. Maupin, W.H. Low, and D.S. Ott. 1998. Water Quality in the Upper Snake River Basin, Idaho and Wyoming, 1992-1995. Circular 1160. U.S. Geological Survey, Denver, CO.

Ecosystems Research Institute. 1987. An evaluation of the existing monitoring program at Island Park Reservoir. Project completion report for Fall River Rural Electric Cooperative, Ashton, ID. Ecosystems Research Institute, Logan, UT.

Ecosystems Research Institute. 1987. Baseline water quality and biological data for Island Park Reservoir and the Henrys Fork River during February, 1987. Project completion report for Fall River Rural Electric Cooperative, Ashton, ID. Ecosystems Research Institute, Logan, UT.

Ecosystems Research Institute. 1992. Annual report: Water quality monitoring results Island Park Hydroelectric Project FERC No. 2973. Project completion report for Fall River Rural Electric Cooperative, Ashton, ID. Ecosystems Research Institute, Logan, UT.

Ecosystems Research Institute. 1993. A water quality summary of the Henrys Fork River and Island Park Reservoir. Project completion report for Fall River Rural Electric Cooperative, Ashton, ID. Ecosystems Research Institute, Logan, UT.

Ecosystems Research Institute. 1993. Potential temperature effects due to spillway modifications on the Henrys Fork River. Project completion report for Fall River Rural Electric Cooperative, Ashton, ID. Ecosystems Research Institute, Logan, UT.

Ecosystems Research Institute. 1993. Annual report: Water quality monitoring results, Island Park Hydroelectric Project FERC No. 2973. Project completion report for Fall River Rural Electric Cooperative, Ashton, ID. Ecosystems Research Institute, Logan, UT.

Ecosystems Research Institute. 1994. Operations and procedures plan, maintenance, and mitigation, Island Park Hydroelectric Project FERC No. 2973. Project completion report for Fall River Rural Electric Cooperative, Ashton, ID. Ecosystems Research Institute, Logan, UT.

Ecosystems Research Institute. 1994. Temperature simulation modeling: Island Park Reservoir and Henrys Fork River, technical summary. Project completion report for Fall River Rural Electric Cooperative, Ashton, ID. Ecosystems Research Institute, Logan, UT.

Ecosystems Research Institute. 1994. Water quality data summary. Project completion report for Fall River Rural Electric Cooperative, Ashton, ID. Ecosystems Research Institute, Logan, UT.

Ecosystems Research Institute. 1995. Water quality data summary. Project completion report for Fall River Rural Electric Cooperative, Ashton, ID. Ecosystems Research Institute, Logan, UT.

Ecosystems Research Institute. 1996. Water quality data summary. Project completion report for Fall River Rural Electric Cooperative, Ashton, ID. Ecosystems Research Institute, Logan, UT.

Ecosystems Research Institute *et al*. 1997. Island Park Hydroelectric Project Rubber Collar Advisory Committee 1997 monitoring data. Project completion report for Fall River Rural Electric Cooperative, Ashton, ID. Ecosystems Research Institute, Logan, UT.

Goodman, K. 1994. 1994 Assessment of water quality on the Henry's Fork of the Snake River. Henry's Fork Foundation, Ashton, ID.

Goodman, K.T. 1995. 1995 Assessment of water quality on the Henry's Fork of the Snake River. Henry's Fork Foundation, Ashton, ID.

Gregory, J. 1997. Upper Henrys Fork Habitat Assessment Headwaters to Island Park Dam Summer 1996. Henry's Fork Foundation, Ashton, ID.

Gregory, J., K. Meyer and R. Van Kirk. 1995. Box Canyon insect abundance and emergence and rainbow trout spawning assessment. Henry's Fork Foundation, Ashton, ID.

Gregory, J. and R. Van Kirk. 1996. Box Canyon insect abundance and emergence and rainbow trout spawning assessment. Henry's Fork Foundation, Ashton, ID.

Gregory, J. and R. Van Kirk. 1997. Box Canyon insect abundance and emergence and rainbow trout spawning assessment. Henry's Fork Foundation, Ashton, ID.

Gregory, J. and R. Van Kirk. 1998. Henrys Fork Habitat Assessment Island Park Dam to Warm River Summer 1997. Henry's Fork Foundation, Ashton, ID.

Griffith, J.S. 1993. Analysis of benthic invertebrates from some Targhee National Forest streams 1991-1992. Project completion report to the Targhee National Forest, St. Anthony, ID. Department of Biological Sciences, Idaho State University, Pocatello, ID.

Maret, T. 1995. Water-quality assessment of the Upper Snake River Basin, Idaho and western Wyoming--summary of aquatic biological data for surface water through 1992. Water Resources Investigations Report 95-4006. U.S. Geological Survey, Boise, ID.

Maupin, M. 1995. Water-quality assessment of the Upper Snake River Basin, Idaho and western Wyoming--environmental setting, 1980-92. Water Resources Investigations Report 94-4221. U.S. Geological Survey, Boise, ID.

Meyer, K.A., and J.S. Griffith, 1994. Habitat selection and factors influencing the distribution of benthic aquatic invertebrates in the Henrys Fork of the Snake River, Idaho. Project completion report for the Henry's Fork Foundation, Ashton, ID. Department of Biological Sciences, Idaho State University, Pocatello, ID.

Minshall, G.W., C.T. Robinson, and T.V. Royer. 1993. Henry's Fork of the Snake River, Idaho, sediment impact study. Department of Biological Sciences, Idaho State University, Pocatello, ID.

Roessler, E.C. 1996. An Assessment of the Nutrient Inputs To and the Trophic State of Island Park Reservoir in Fremont County, Idaho. Master's project report, Duke University, Durham, NC.

5. WILDLIFE

Gale, R.S., E.O. Garton, and I.J. Ball. 1987. The history, ecology and management of the Rocky Mountain population of trumpeter swans. U.S. Fish and Wildlife Service Refuges Division, Denver, CO.

Maj, M.E. 1983. Analysis of trumpeter swan habitat on the Targhee National Forest of Idaho and Wyoming. Master's thesis, Montana State University, Bozeman, MT.

Shea, R. 1992. Monitoring of trumpeter swans in conjunction with trapping efforts at Red Rock Lakes National Wildlife Refuge, Montana and Harriman State Park, Idaho during winter 1990-1991. U.S. Fish and Wildlife Service, Pocatello, ID.

Snyder, J.W. 1991. The wintering and foraging ecology of the trumpeter swan, Harriman State Park of Idaho. Master's thesis, Idaho State University, Pocatello, ID.

U.S. Fish and Wildlife Service. 1998. Trumpeter swan range expansion project--winter 1997-98. U.S. Fish and Wildlife Service, Southeast Idaho Refuge Complex, Pocatello, ID.

Vinson, D. 1991. Baseflow determination for wintering trumpeter swans on the Henry's Fork of the Snake River. U.S. Fish and Wildlife Service, Boise, ID.

Vinson, D. 1991. Trumpeter swan habitat monitoring on the Henry's Fork of the Snake River. U.S. Fish and Wildlife Service, Boise, ID.

Upper Henry's Fork Subbasin
Partial List of Organizations to Contact for Additional Information

Clark Soil Conservation District
263 East 4th North
Rexburg, ID 83440
(208) 356-6931

Division of Environmental Quality
900 North Skyline, Suite B
Idaho Falls, ID 83402
(208) 528-2650

Fall River Rural Electric Cooperative
1150 North 3400 East
Ashton, ID 83420
(208) 652-7431

Fremont County Planning and Building
Courthouse
151 West 1st North
St. Anthony, ID 83445
(208) 624-4643

Fremont-Madison Irrigation District
P.O. Box 15
350 North 6th West
St. Anthony, ID 83445
(208) 624-3381

Harriman State Park
HC 66 Box 500
Island Park, ID 83429
(208) 558-7368

Health Department, District Seven
P.O. Box 490
151 West 1 North
St. Anthony, ID 83445

Henry's Fork Foundation
P.O. Box 550
606 Main Street
Ashton, ID 83420
(208) 652-3567

Henry's Fork Watershed Council
P.O. Box 852
604 Main Street
Ashton, ID 83420
(208) 652-3567

Henry's Lake Foundation
P.O. Box 548
16 12th Avenue South, Suite lB
Nampa,ID 83651
(208) 461-1352

Idaho Department of Fish and Game
1515 Lincoln Road
Idaho Falls, ID 83401
(208) 525-7290

Idaho Department of Lands
3562 Ririe Highway
Idaho Falls, ID 83401
(208) 525-7167

Idaho Department of Water Resources
900 North Skyline, Suite A
Idaho Falls, ID 83402
(208) 525-7161

Idaho Soil Conservation Commission
3562 Ririe Highway
Idaho Falls, ID 83401
(208) 525-7269

Idaho Nature Conservancy
HC 66, Box 227
Island Park, ID 83429
(208) 558-9626

Natural Resources Conservation Service
315 East 5th North
St. Anthony, ID 83445
(208) 624-3341

North Fork Reservoir Company
5669 West 7000 North
St. Anthony, ID 83445

Targhee National Forest
USDA Forest Service
P.O. Box 208
St. Anthony, ID 83445
(208) 624-3151

U.S. Geological Survey
360D
Idaho Falls, ID 83402
(208) 529-4287

Water District 1
900 North Skyline, Suite A
Idaho Falls, ID 83402
(208) 525-7172

Yellowstone Soil Conservation District
315 East 5th North
St. Anthony, ID 83445
(208) 624-3341

Appendix G. Draft Upper Henry's Fork Subbasin Assessment: Responses to Public Comments

The draft version of the Upper Henry's Fork Subbasin Assessment was available for public comment from October 23, 1998 through November 23, 1998. The draft was mailed to members of the Henry's Fork Watershed Council Water Quality Subcommittee and other interested parties, and was available for comment at the November 17, 1998 public meeting of the Henry's Fork Watershed Council and the November *5*, 1998 public meeting of the Upper Snake Basin Advisory Group. A notice advertising the availability of the draft, major conclusions, and request for comments was published in a weekly Fremont County newspaper for the duration of the comment period.

Comments were received from:

Chairman, Upper Snake Basin Advisory Group
Henry's Fork Watershed Council
Henry's Fork Watershed Council Water Quality Subcommittee
Henry's Lake Foundation
Yellowstone Soil Conservation District

Most of the following comments were received during the public comment period. Comments from the Henry's Fork Watershed Council were submitted in draft form during the comment period and in final form following the comment period. Because the Henry's Fork Watershed Council served as the Watershed Advisory Group to DEQ for the assessment, receipt of comments from the Council were not restricted to the comment period; these comments are attached.

The following comments have been organized and compiled into specific themes to reduce duplication. The comments listed may not represent the original comments verbatim. Each comment is followed by a response explaining whether the comment was incorporated in the document, and if so, how it was incorporated.

Comment *Factual information errors occur in two figures and one table.*
Response These errors have been corrected.

Comment *Because 82% of the subbasin is managed by the Forest Service, and because urbanization is apparent from the increasing numbers of building and sewer permits issued by Fremont County, forestry and urbanization should be listed as land uses on page 1.*
Response These uses have been added. Recreational development has been used to describe the major causes of urbanization, which are land use for construction of seasonal homes and development associated with recreation.

Comment	*Why wasn‘t the Targhee National Forest Ecological Unit inventory summarized in the assessment document?*
Response	The inventory was not received until the draft document was almost complete, so time constraints precluded summarizing the information contained in it for the subbasin assessment. This has been explained in the Soils section.
Comment	*A more explicit discussion of the natural processes contributing to lake extinction would be helpful for understanding eventual ecological changes in Henry‘s Lake.*
Response	This has been addressed in the Henry’s Lake section.
Comment	*Explain the Henry’s Fork Watershed Council Watershed Integrity Review and Evaluation (WIRE) process and how this process can contribute to protection of water quality.*
Response	This has been addressed in the Watershed Advisory Group section.
Comment	*Because 86 percent of the subbasin is publicly owned, and most of the public land is managed by the Forest Service, any future management plans will need to include the management of forest lands.*
Response	This has been addressed in the Planning section.
Comment	*The plan should state that construction of recommended central sewerage systems in the Henry’s Lake and island Park areas are not expected in the foreseeable future.*
Response	A statement to that effect has been added to the Planning section.
Comment	*Why were data submitted to DEQ by various agencies and organizations not included in the subbasin assessment?*
Response	The assessments of Henry’s Lake and Henry’s Fork were based primarily on data and information gathered by agencies and organizations other than DEQ. Time constraints and the scope of the document precluded analysis and synthesis of *all* available data, particularly on streams for which beneficial use reconnaissance data were available.
Comment	*Strengthen the document by acknowledging those landowners and organizations whose erosion control efforts and streambank protection investments have contributed to recovery of Henry’s Lake.*
Response	This was addressed in Table 11 of the draft and Table 12 of the final document. Although this list is not all-inclusive or exhaustive, specific information that could be added to the table was not submitted during the comment period. Landowners were not specifically named in the interest of protecting their privacy.

Comment *The water quality monitoring capabilities of the Island Park Hydroelectric Project and Fall River Electric's investment in the spillway collar should be recognized.*

Response These have been addressed in the Henry's Fork section.

Comment *Because Sheridan Creek does not fully support beneficial uses, it should be added to the 303(d) list.*

Response An explicit statement to that effect has been added to the Sheridan Creek section.

Comment *Please add a list of the more prominent studies and datasets available for the upper Henry's Fork subbasin.*

Response A bibliography and list of agencies and organizations that can provide additional information has been added as appendix F.

Comment *The fact that habitat quality, stream degradation and flow inadequacy are not thoroughly discussed as relevant factors in stream health is a continuing concern of the Henry's Fork Watershed Council.*

Response Statements acknowledging this concern have been included in the Henry's Lake section. However, fully addressing this concern is beyond the scope of the subbasin assessment.