# RESOURCE INVENTORY

## Upper Snake River Basin

**Idaho Water Resource Board**
**December, 1998**

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## Upper Snake River Basin

Prepared by: Idaho Department of Water Resources
Water Planning Bureau

Prepared for: Idaho Water Resource Board



December, 1998

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# UPPER SNAKE RIVER BASIN RESOURCE INVENTORY

## PURPOSE

The Upper Snake River Basin Resource Inventory is a compilation of the data and information that was collected as part of the Idaho Water Resource Board's (IWRB) comprehensive basin planning study of the Eastern Snake Plain Aquifer and tributary basins conducted from 1993 to 1996 (Figure 1). The IWRB decided not to complete the aquifer plan pending the resolution of several key concerns such as federal reserved water right claims and basin-wide issues in the Snake River Basin Adjudication. This document is being presented by the board as an up-to-date, comprehensive inventory of the water resources in the Upper Snake River Basin.

## AREA OVERVIEW

### GEOGRAPHY AND CLIMATE

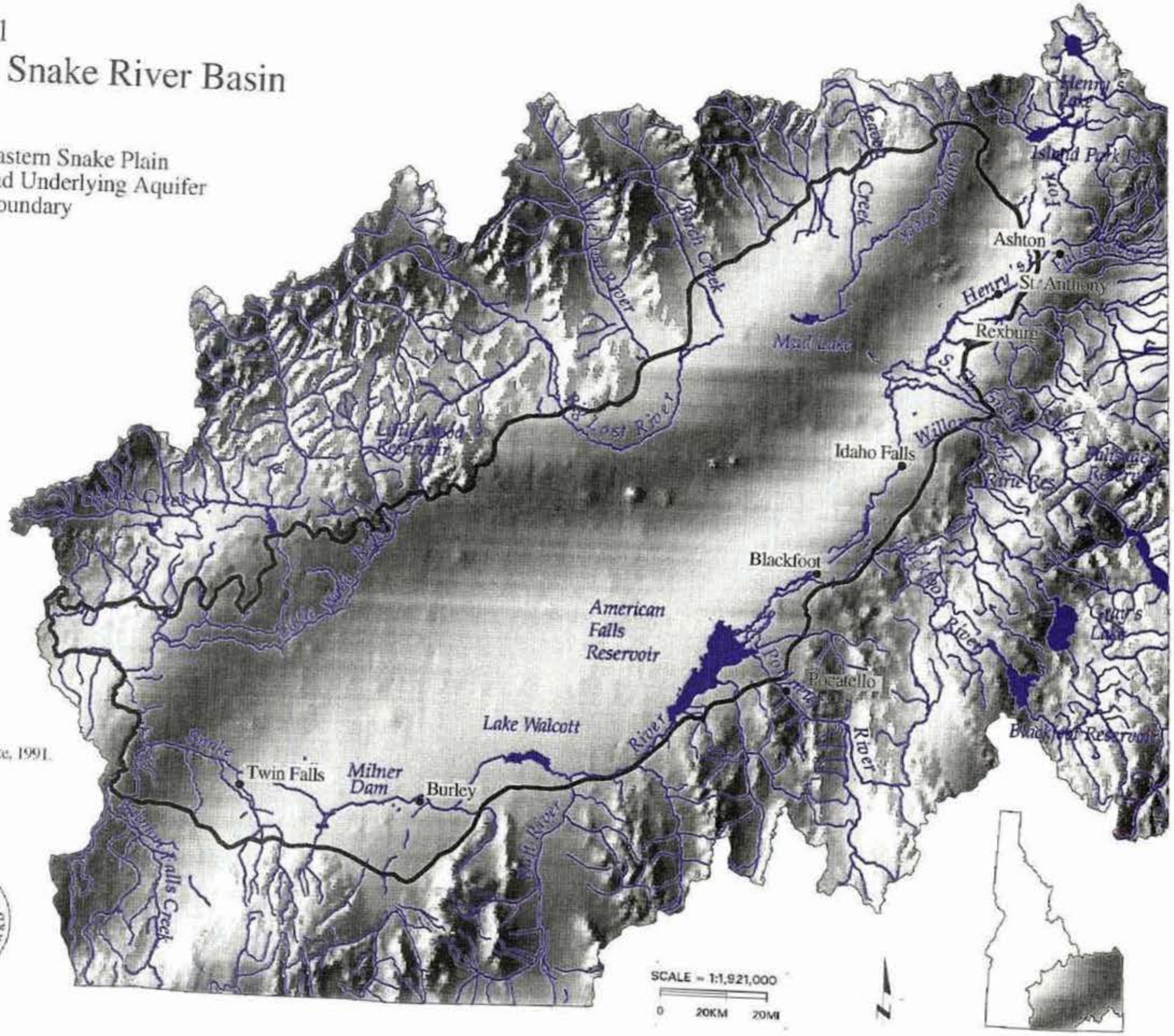
The Upper Snake River Basin encompasses all or parts of 20 counties and about 35 percent of Idaho's land area (28,821 square miles). The Eastern Snake Plain and underlying aquifer occupies 10,796 square miles within the Upper Snake River Basin in Idaho, or approximately 13 percent of the State's total land area. This is larger than the entire States of Maryland (9,838 square miles), New Hampshire (9,304 square miles), Massachusetts (8,257 square miles), or Vermont (9,609 square miles), as well as Lake Erie (9,940 square miles).

The Eastern Snake Plain, part of the Columbia Intermontane Basin physiographic province, averages about 45 miles in width and altitudes average about 2,700 feet above sea level in the west to more than 6,000 feet in the east. Most of the plain area is flat relative to surrounding mountains which range between 7,000 and 12,000 feet altitude (Figure 1).

The Upper Snake River Basin is a region of arid to semi-arid continental climate which is controlled principally by the general atmospheric circulation over the north Pacific Ocean. Migrating storm systems generate summer flows of dry subtropical air across the region, bringing nearly rainless conditions during the growing season and resulting in total precipitation averages of less than ten inches per year. Some areas receive less than five inches each year. On the edges of the plain and in the northeastern part, higher altitudes and orographic effects result in as much as 20 inches of precipitation. Greater precipitation amounts occur in the peripheral mountain areas of the watershed, up to 70 inches annually. Figure 2 shows the annual precipitation distribution across the Basin. Almost all of the surface-water inflow and ground water recharge comes from the storage and release of winter and early spring precipitation in the tributary basins, brought by incursions of cold arctic air lifting unstable oceanic air masses coming in from the Pacific Ocean.

Figure 1
Upper Snake River Basin

Eastern Snake Plain and Underlying Aquifer Boundary




Source: Thelin and Pike, 1991.
Whitehead, 1992.

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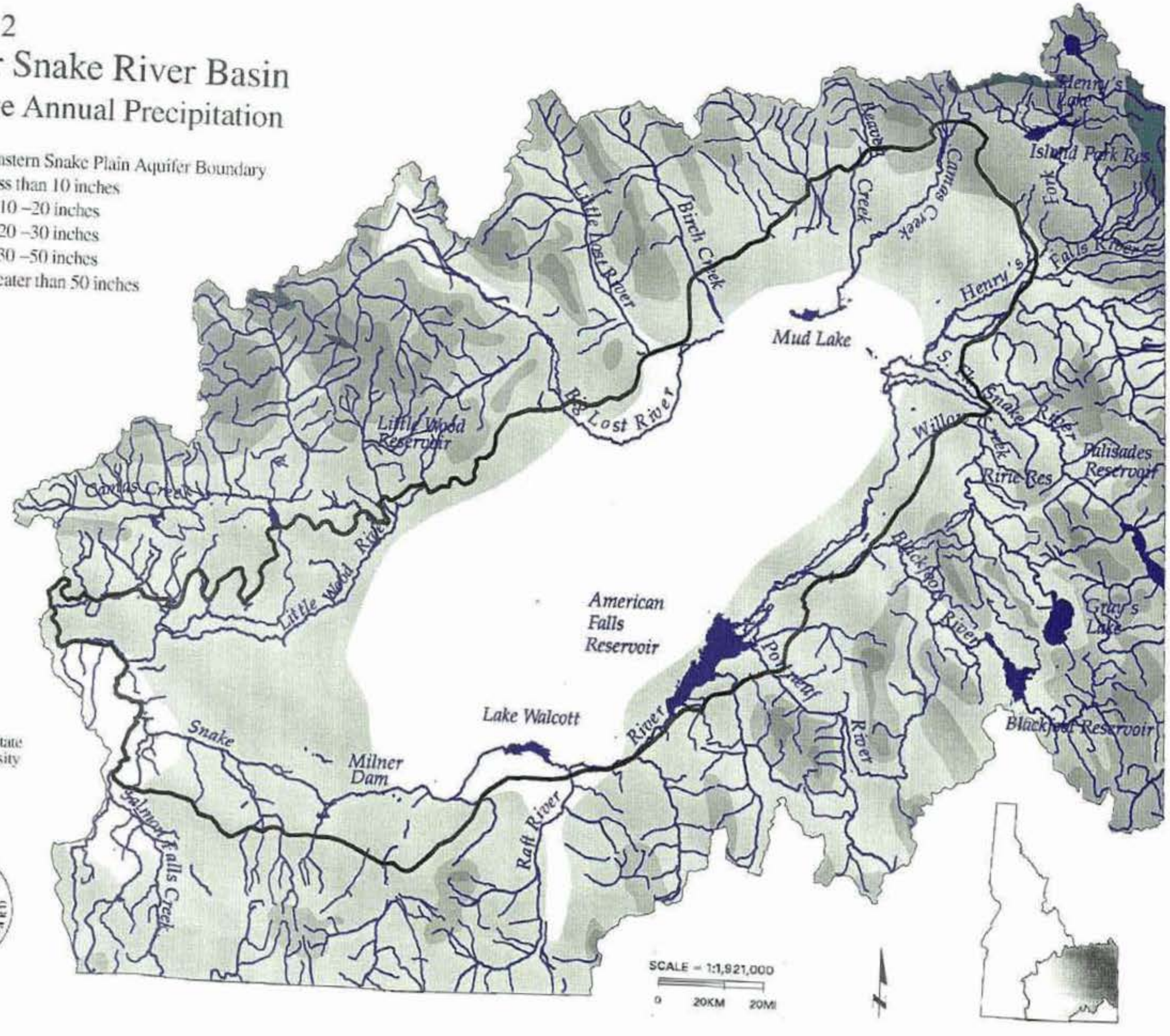
Figure 2
# Upper Snake River Basin
## Average Annual Precipitation

- Eastern Snake Plain Aquifer Boundary
- less than 10 inches
- > 10 – 20 inches
- > 20 – 30 inches
- > 30 – 50 inches
- greater than 50 inches




Source: M. Molnau, State Climatologist, University of Idaho.

Potential evapotranspiration over the Eastern Snake Plain ranges from about 19 to 30 inches per year (Goodell, 1988). Actual evapotranspiration on nonirrigated land is limited by the amount of precipitation. Most of the runoff from rangeland originates from winter precipitation stored as snow. Some runoff also occurs during high intensity or long-duration rainstorms. The 1997 water year recharge from precipitation on the Eastern Snake Plain was estimated to be about 16.5 percent (IDWR, 1997b). Most of the products of evapotranspiration are lost into the overlying very dry atmosphere.

## HYDROGEOLOGY AND SOILS

The Eastern Snake Plain is a structural downwarp, perhaps the track of a volcanic "hot spot" which began some 20 million years ago, and which has subsequently been filled with a series of individual Quaternary basaltic lava flows, each 20 to 25 feet thick with interbedded sedimentary rocks along the margins. The basalt tends to fracture, and the basalt beds are surfaced with gravel and cinder layers ranging between a few inches and several feet in thickness. During the course of thousands of years, water has penetrated the land surface through the fractures and crevices, and moved laterally through the intervening layers of rubble to form one of the largest and most permeable aquifer systems in the world.

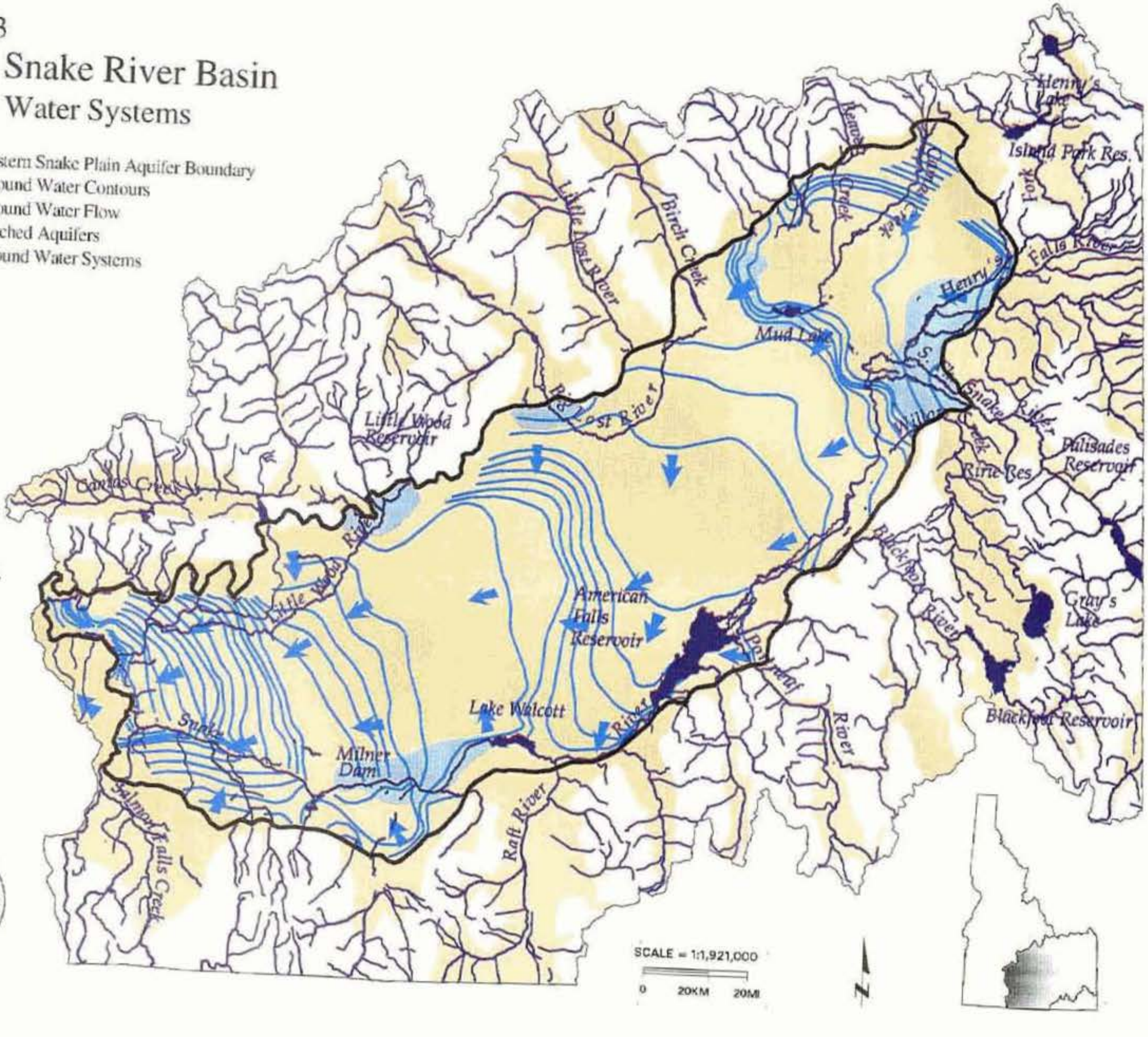
Test drilling to determine the depth of the aquifer has been limited. One drill hole on the Idaho National Engineering and Environmental Laboratory (INEEL) penetrated basalts, tuffs and a hydrothermally altered ash flow to a depth of 10,635 feet (Mann 1986). Basalt sequences extended to a depth of 2,160 feet. Data from that test indicated that the effective base of the aquifer at that point was between 850 and 1,220 feet below the land surface. Another test hole northeast of Wendell was drilled through basalt and sedimentary layers to a depth of 1,123 feet (Whitehead and Lindholm, 1985). Partly as a result of these test holes, our understanding of the amount of pore space in the aquifer is that it decreases with depth, so that the effective depth of the aquifer is probably much less than the depth of the basalt flows (Hackett et al., 1986).

The ground water system underlying the Eastern Snake Plain is recharged by deep percolation from irrigation, leakage from canals, seepage from streams flowing onto and over the plain, underflow from tributary basins and highlands bordering the plain, and to a lesser extent, direct precipitation over the plain. Major components of ground water discharge from the aquifer are springs discharging to the Snake River, seepage to rivers, ground water pumpage, and evapotranspiration. Average horizontal hydraulic conductivity of the upper 200 feet of the basalt aquifer ranges from less than 100 to 9,000 feet per day depending upon local geologic conditions (Lindholm, 1993).

The major ground water flow is generally from northeast to southwest (Figure 3). Most of the tributary drainages contribute water to the regional ground water system. The water table gradient in the Mud Lake area and extending to the southeast is steep and represents an aquifer feature which impedes the subterranean flow like a dam does with surface water. This is referred to as the Mud Lake barrier. Down gradient of the Mud Lake barrier, the ground water moves southwestwards toward the American Falls area. Large springs upstream of the American Falls Dam discharge more than one million acre-feet per year into the Snake River. West of American Falls, another barrier within the Great Rift Zone steepens the flow gradient again. West of the Great Rift Zone, the ground water flow is southwestwards toward the Snake River Canyon, where the aquifer system terminates and the ground water emerges as the Thousand Springs. The Thousand Springs area accounts for about 40 percent of the estimated 9.6 million

Figure 3
# Upper Snake River Basin
## Ground Water Systems

- Eastern Snake Plain Aquifer Boundary
- Ground Water Contours
- Ground Water Flow
- Perched Aquifers
- Ground Water Systems




Source: Graham and Campbell, 1981. Lindholm et. al., 1988.

acre-feet of total annual discharge from the Eastern Snake Plain Aquifer (IDWR, 1997b). Spring discharges in the Thousand Springs reach averaged about 5,200 cubic feet per second of water to the Snake River flows for the period, 1993-1997. The largest of these springs are shown on Figure 4. Historic records of the spring flows illustrate the influence of irrigation practices and are shown on Figure 5.

Perched aquifers have formed in places where impermeable beds underlie major surface water bodies or areas of heavy irrigation. The Egin Bench, Rigby Fan, Mud Lake, and the Burley-Rupert areas overlie perched water bodies. These are typically not far from the surface and may be separated from the regional aquifer by several hundreds of feet.

Soils overlaying the Eastern Snake Plain Aquifer are largely wind-borne (loess) sediments (Soil Conservation Service, 1973). Products of erosion in the mountains are transported into the tributary valleys by gravity and moving water. These are picked up by periodic flood flows and deposited as floodplain alluvium. Wind action has rearranged these materials and carried them throughout the plain where they have formed the present-day soils. These loessial, or wind-blown particles have a wide variety of composition. Most of the silt-loam soils are light in color and of medium texture. Depths range from less than four inches to more than 40 inches. Basalt outcrops are frequent, and the loessial soils, being very fine-grained, are prone to water and wind erosion. In some places, soil cover has never developed or has been eroded away, leaving a barren landscape.

Generalized soil types are shown on Figure 6. Grassland soils range from light to dark in color and develop under arid and semiarid conditions (Ross and Savage, 1967). They typically form under grass, sagebrush, and desert shrub vegetation. On the Eastern Snake Plain, they often evolve from loess or alluvial parent materials, or weathered basalt or rhyolite. Transition soils are formed in sub-humid, grassland-forest transition zones, and are often very dark in color from organic enrichment. They tend to be deeper than three feet, and are usually free of calcium carbonate accumulations. Forest soils are light to dark brown in color and are formed from loess, granitic, or sedimentary rocks. They are found in sub-humid conditions often on quite steep slopes. Rocky soils consist of nearly fresh basaltic lava. Surface irregularities in the basalts often serve as entrapment structures for wind-borne materials which support scattered vegetative growth.

The loess soils are generally good agricultural soils because they are typically well-drained and tend to be relatively free of salt accumulations. However, the lack of precipitation during the growing season in the area has severely limited the amount of natural vegetation produced, and therefore limits the organic residue accumulation that becomes humus. This same aridity on recent soils has also limited the leaching of soluble minerals from the soil. Heavy fertilizer applications have become necessary in some areas to receive maximum crop yields from these very workable soils. Wetter alluvial soils along the streams have developed an organic accumulation conducive to good crop growth.

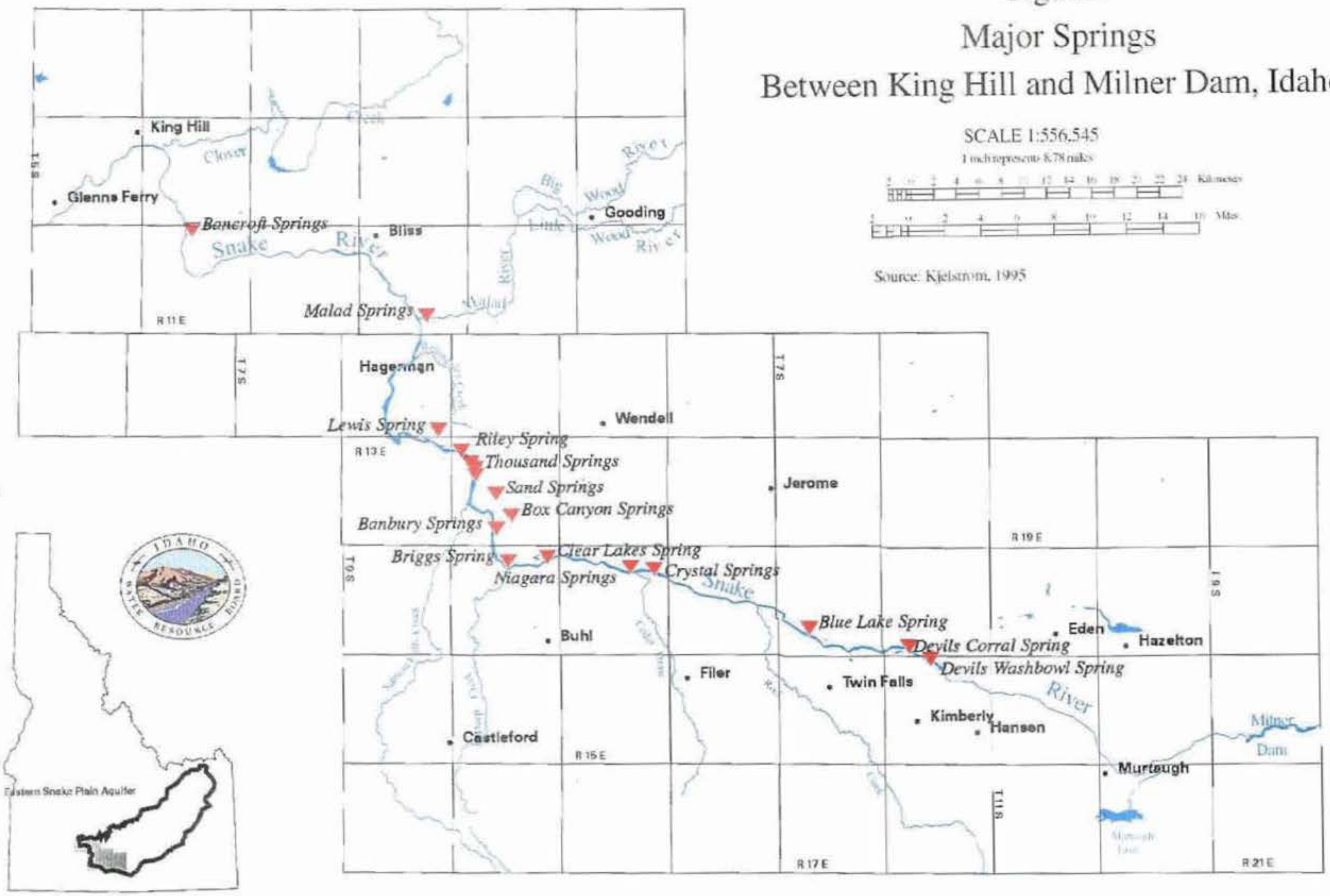



Figure 4
Major Springs
Between King Hill and Milner Dam, Idaho

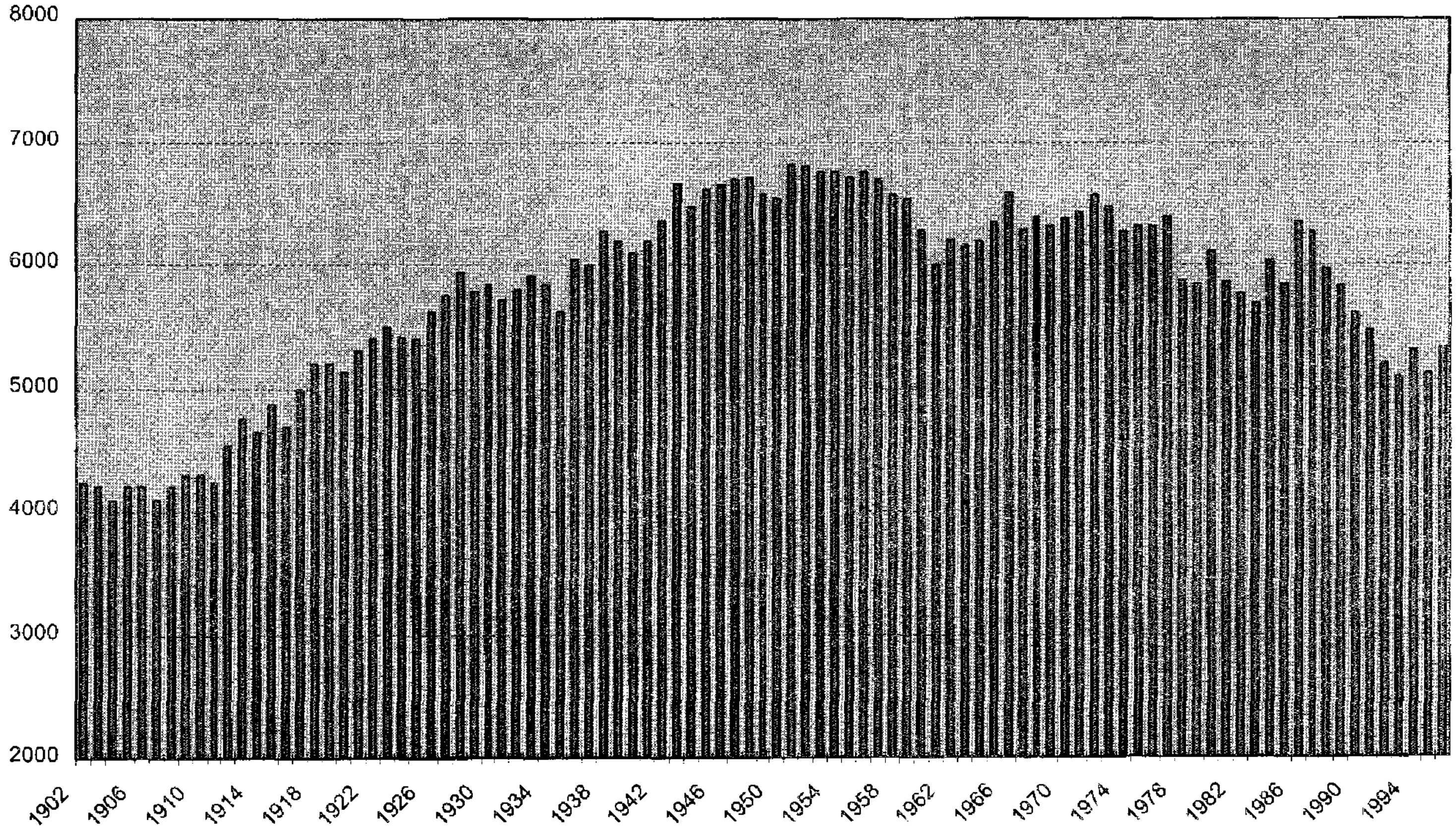
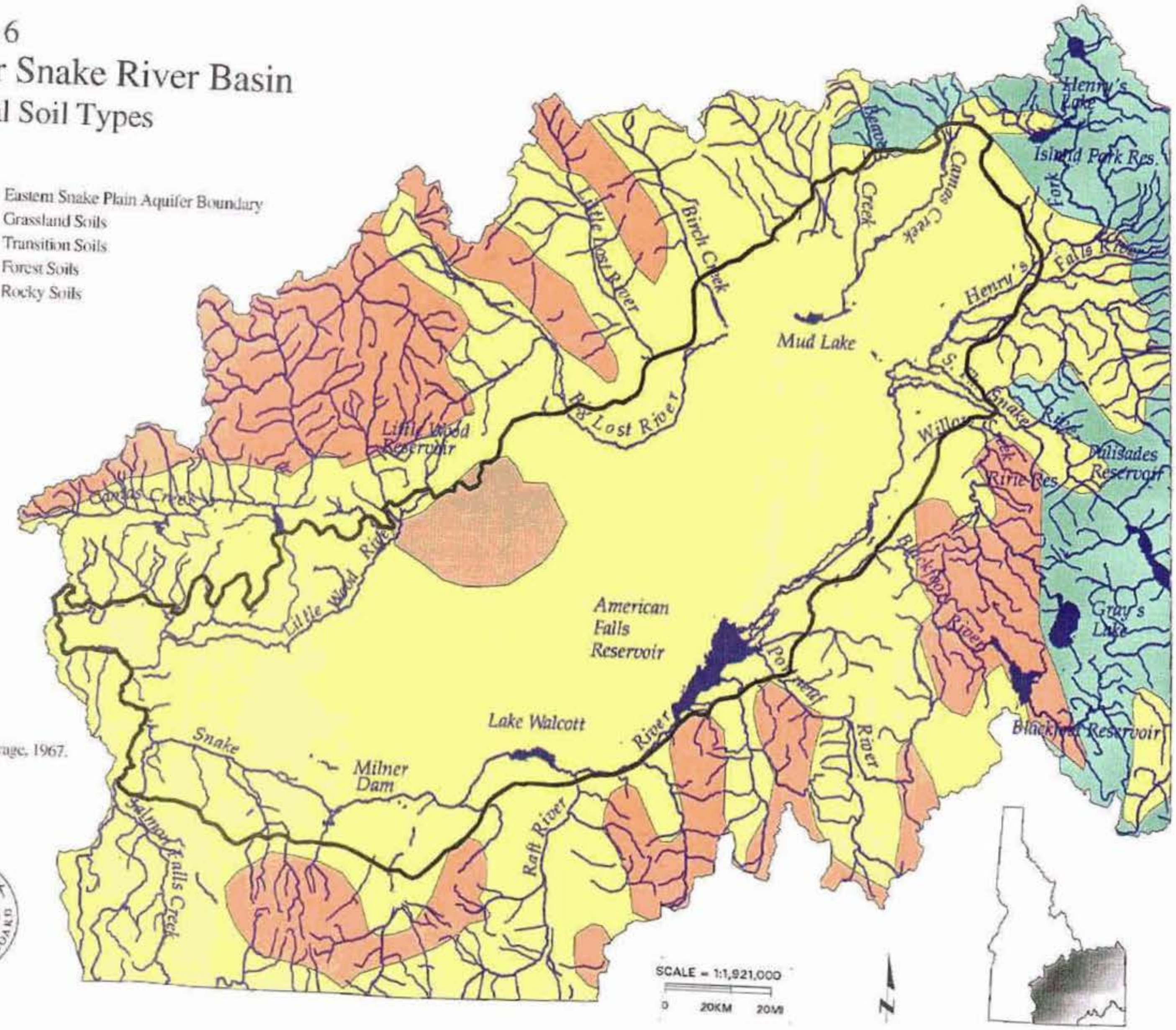



**Figure 5. Average Annual, Spring Discharge to Snake River Between Milner and King Hill.**

Source: Updated by IDWR from Kjelstrom, 1995.

Figure 6
# Upper Snake River Basin
## General Soil Types

- Eastern Snake Plain Aquifer Boundary
- Grassland Soils
- Transition Soils
- Forest Soils
- Rocky Soils




Source: Ross and Savage, 1967.

## LAND OWNERSHIP AND USE

With the advent of the Oregon Territory, all of the land in the Upper Snake River Basin became the public domain of the United States. Through subsequent congressional actions, various mechanisms were established by which these lands could be transferred to individuals, the state, or reserved for federal purposes. The federal homestead, desert land entry, reclamation programs, and other opportunities encouraged individuals and groups to occupy and develop these lands. Some of the forested areas of public domain lands were withdrawn from public transfer and designated as national forests, administered by the U.S. Department of Agriculture (USDA), to sustain timber and forage production in the national interest. Other lands were reserved for the Fort Hall Indian Reservation, the INEEL, National Park Service-administered areas, the Grays Lake, Camas, and Minidoka National Wildlife Refuges, and U.S. Bureau of Reclamation (USBR) projects. The Idaho Statehood Act in 1890 provided for the transfer of portions of the public domain to the state, the proceeds from use of these lands to be used to help fund public schools. Currently, the public domain lands which have not been otherwise reserved or appropriated are administered by the U.S. Bureau of Land Management (BLM) as long-term national resource lands. The present patterns of land ownership, as shown on Figure 7, largely reflect the adjustments in land allocation which have evolved through years of changing economic and social conditions. Current ownership holdings are listed in Table 1 according to categories of administrative jurisdiction.

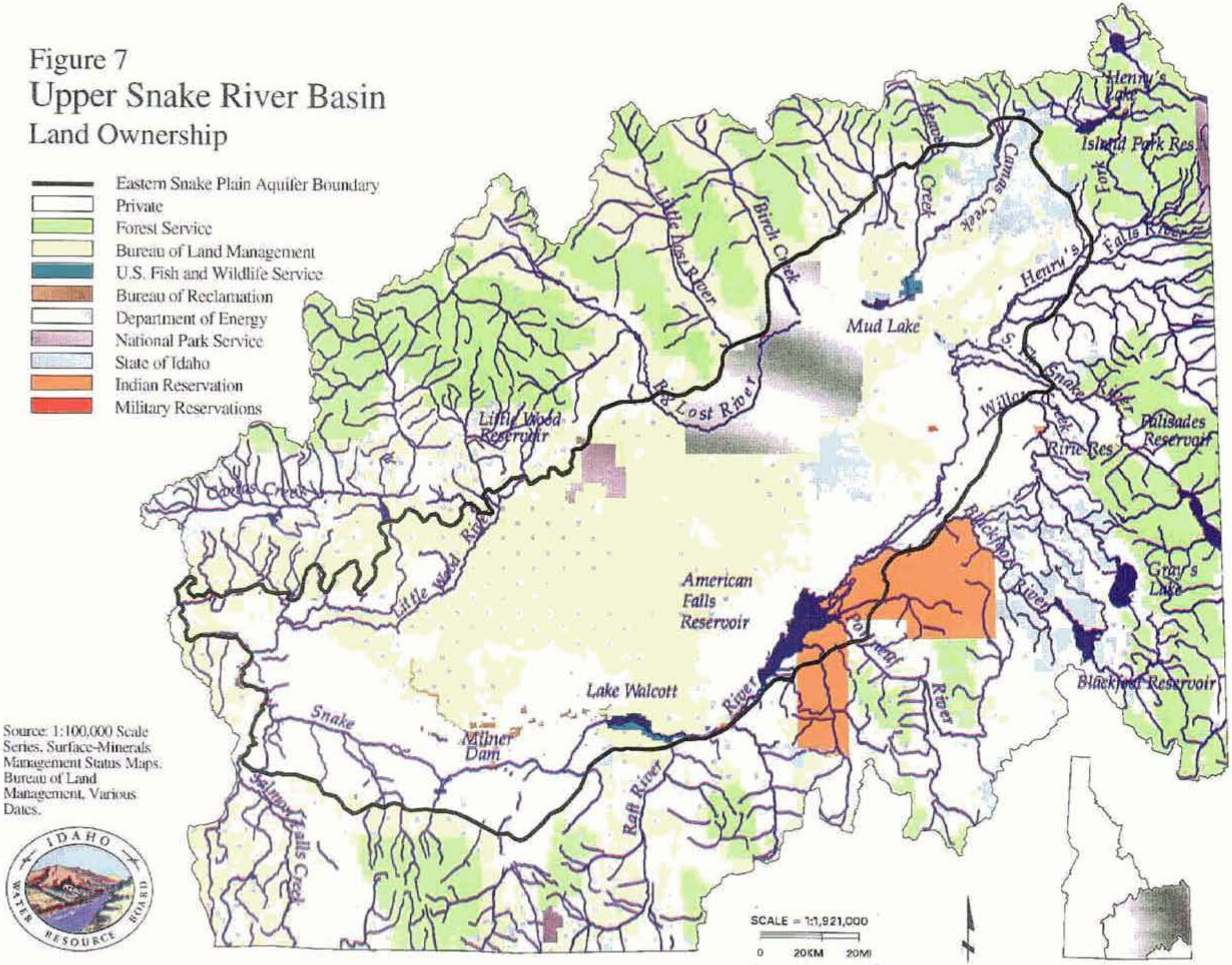
Analysis of Landsat imagery used to prepare the Land Use map reveals that irrigated crops and non-irrigated rangelands dominate the land use patterns in the Upper Snake River Basin (Figure 8). The lands irrigated with Snake River water often extend considerable distances beyond the river where irrigation conveyances reach out many miles to transport water from river diversion points. Similar developments in the broad tributary valleys outside the aquifer also follow this pattern. Domestic

**Table 1. Land Ownership in the Upper Snake River Basin, Idaho, 1997***

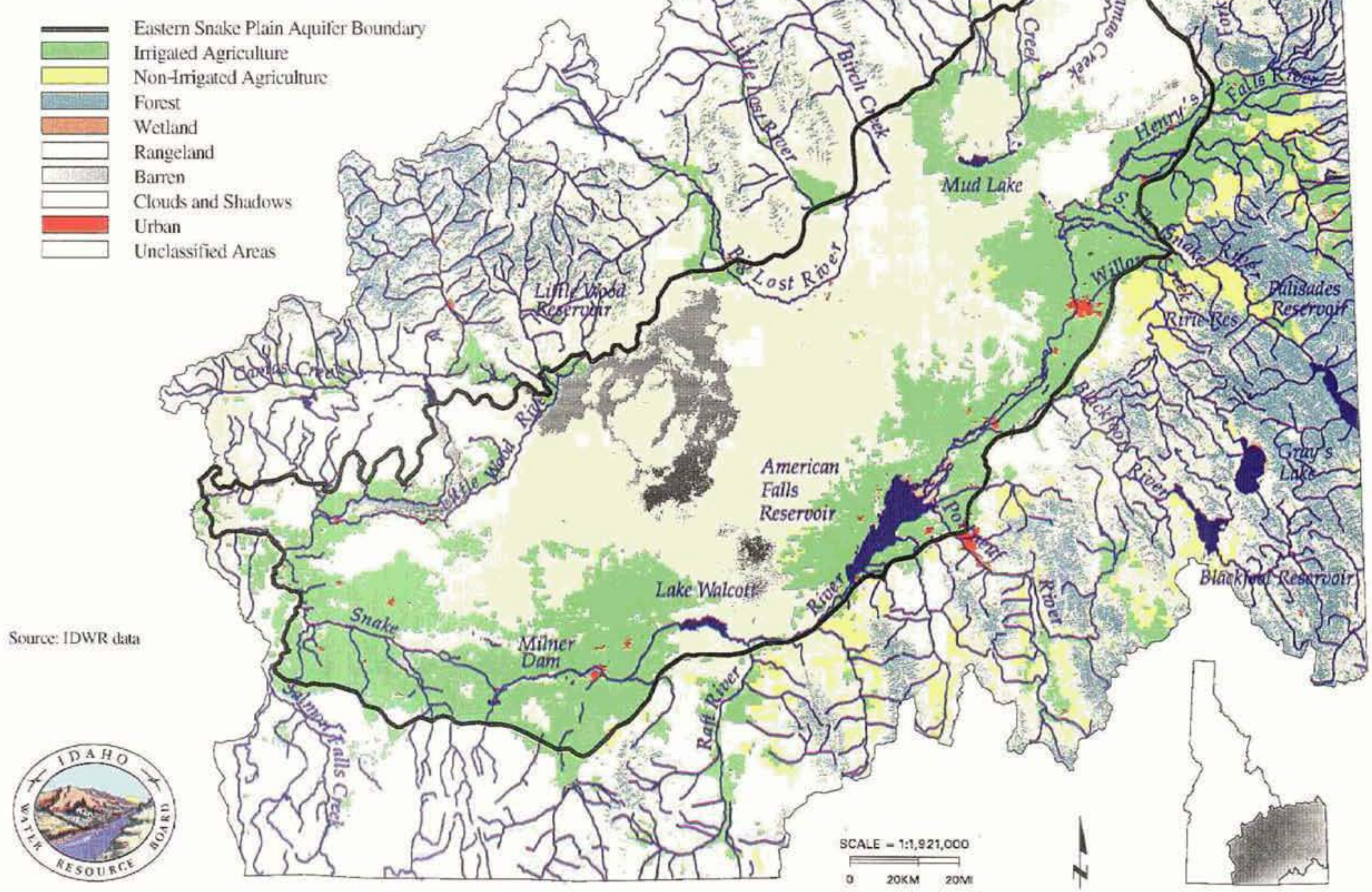
| | Upper Snake River Basin | | Eastern Snake Plain | |
|---|---|---|---|---|
| **Category** | **Acres** | **% of Basin** | **Acres** | **% of Plain** |
| Private | 6,742,012 | 36.5 | 2,922,728 | 42.3 |
| U.S. (BLM) | 5,563,044 | 30.2 | 2,784,627 | 40.3 |
| U.S. ( USFS) | 3,841,400 | 20.8 | 27,082 | 0.4 |
| State | 853,650 | 4.6 | 393,956 | 5.7 |
| U.S. (Dept. of Energy) | 571,748 | 3.1 | 559,787 | 8.1 |
| Indian Reservation | 509,283 | 2.8 | 103,766 | 1.5 |
| Other Federal | 364,545 | 2.0 | 118,134 | 1.7 |

*Calculated from Figure 7.

Figure 7
# Upper Snake River Basin
## Land Ownership



# Figure 8
## Upper Snake River Basin
### Land Use




Source: IDWR data

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livestock grazing on native and improved rangeland predominate on public and private lands where water supplies are not economically sufficient for cultivation, or where the choice has been made to pursue the ranching way of life. Dryland farming occurs in the tributary valleys where hay, grains, and forage crops are produced. Urban and related industrial land uses are increasingly evident in many areas. Large spaces shown on the map as barren are outcroppings of basalt or other rocks and are chiefly of scenic or scientific interest.

Table 2 presents the results of an analysis of land use conducted by the USBR in 1992. The listed categories reflect the focus on developed lands; lands outside of developed areas were listed as unclassified and comprised more than 80 percent of the Upper Snake River Basin. This category did not include lands with native vegetation which were also undeveloped, but were interspersed within developed areas. The classification demonstrated the recent shift from gravity irrigation techniques to sprinkler application methods. In 1992, 69 percent of the 2.9 million irrigated acres were sprinkler irrigated. Over 60,000 acres were classified as urban and built-up, a category which includes residential, commercial, municipal and industrial land uses. Idle lands, comprising over 70,000 acres, were capable of being irrigated in 1992, but were either fallow, or placed in some type of set aside program.

## POPULATION AND ECONOMY

Agriculture continues to be the largest segment of the economy. Retail and wholesale trade, construction, processing of agricultural products, nuclear and high-tech research, health service, financial services, and information-oriented services are among the growth sectors. In 1995, 422,710 people lived in the Upper Snake River Basin, about 36.4 percent of the state total. Distribution of this population is shown on Figure 9.

### *Population*

The Upper Snake River Basin population increased by 15.1 percent from 1980 to 1995. During the same period, the State of Idaho's population increased by 22.8 percent, reaching a total of 1.16 million in 1995. The 1995 population density for the Basin averaged 19.8 persons per square mile, compared to 12.2 persons per square mile for the State and 70.3 persons per square mile for the nation (Idaho Department of Commerce (IDC), 1994; U.S. Bureau of Census, 1993). From 1990 to 1995, the Upper Snake River Basin population increased about 10.6 percent, or approximately 2.0 percent annually (Figure 10).

Following a period of slow population growth between 1980 and 1990, an estimated 8,800 people moved into the Upper Snake River Basin area between 1990 and 1992. This coupled with natural increase (births exceeding deaths) boosted the Basin's total population from 382,200 people to an estimated 422,710 people in 1995. Family size in the Basin dropped from 3.06 in 1980 to 2.95 in 1990 compared with the state averages of 2.85 and 2.73, and the national averages of 2.76 and 2.63 respectively.

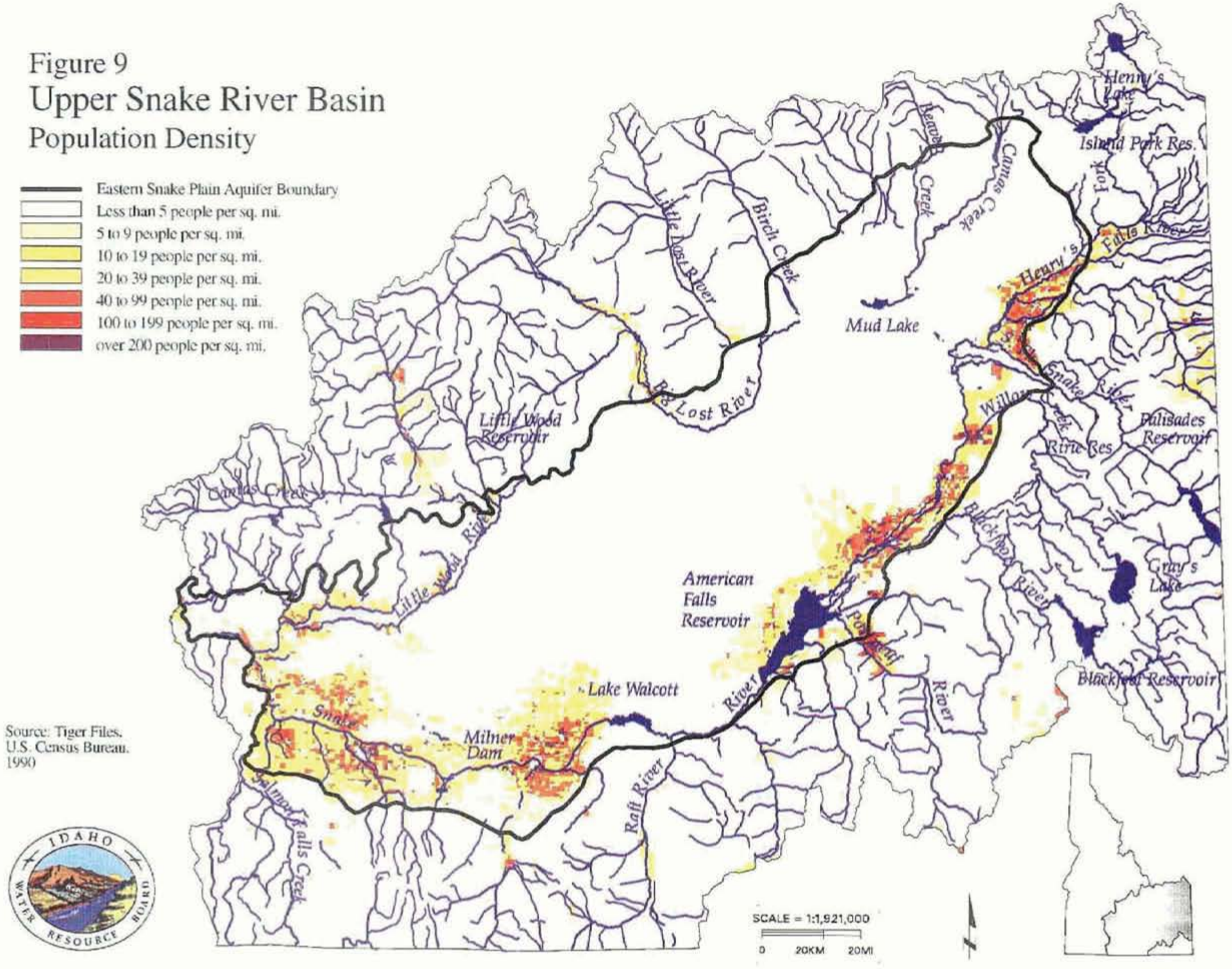
Table 2. Upper Snake River Basin Analysis of Developed Acreage by County

| County | Sprinkler Irrigation | Gravity Irrigation | Native Vegetation[1] | Urban & Built-up[2] | Idle Land[3] | Unclassified | Basin Total | County Total |
|---|---|---|---|---|---|---|---|---|
| Bannock | 43,544 | 20,279 | 2,744 | 10,917 | 183 | 589,030 | 666,697 | 734,690 |
| Bingham | 331,979 | 38,038 | 24,326 | 5,859 | 5,993 | 949,237 | 1,355,432 | 1,355,432 |
| Blaine | 43,693 | 21,427 | 2,385 | 406 | 494 | 1,543,964 | 1,612,369 | 1,697,840 |
| Bonneville | 127,965 | 56,195 | 6,789 | 13,162 | 317 | 1,011,589 | 1,216,017 | 1,216,017 |
| Butte | 64,859 | 13,338 | 2,349 | 488 | 6,750 | 1,343,237 | 1,431,021 | 1,431,021 |
| Camas | 11,709 | 8,874 | | | 481 | 387,394 | 408,458 | 688,608 |
| Caribou | 6,814 | 46,980 | | | | 872,039 | 925,833 | 1,152,876 |
| Cassia | 247,888 | 48,180 | 11,795 | 3,363 | 9,578 | 1,272,116 | 1,592,920 | 1,647,951 |
| Clark | 37,582 | 30,692 | 2,459 | | 1,564 | 1,057,070 | 1,129,367 | 1,129,368 |
| Custer | 19,400 | 10,466 | 290 | | 1,282 | 847,381 | 878,819 | 3,157,712 |
| Elmore | 11,243 | 896 | 63 | | 5,651 | 162,641 | 180,494 | 1,984,683 |
| Fremont | 97,284 | 32,016 | 2,461 | | | 1,082,391 | 1,214,152 | 1,214,152 |
| Gooding | 95,837 | 37,224 | 10,198 | 3,930 | 273 | 322,544 | 470,006 | 470,006 |
| Jefferson | 123,368 | 128,238 | 13,522 | 1,453 | 9,324 | 430,914 | 706,819 | 706,819 |
| Jerome | 138,333 | 48,511 | 7,549 | 3,445 | 1,021 | 185,962 | 384,821 | 384,821 |
| Lemhi | 386 | 387 | | | | 233,757 | 234,530 | 2,922,752 |
| Lincoln | 49,963 | 43,704 | 3,966 | 1,081 | 7,755 | 664,491 | 770,960 | 770,960 |
| Madison | 97,286 | 36,337 | 4,207 | | | 165,162 | 302,992 | 302,992 |
| Minidoka | 156,924 | 50,269 | 11,166 | 4,155 | 3,980 | 263,134 | 489,628 | 489,628 |
| Oneida | 10 | | | | | 57,808 | 57,818 | 768,459 |
| Owyhee | | 218 | 18 | | | 47,849 | 48,085 | 4,925,016 |
| Power | 114,744 | 4,648 | 2,978 | 737 | 378 | 769,416 | 892,901 | 921,786 |
| Teton | 57,582 | 20,081 | 3,996 | | | 206,294 | 287,953 | 287,953 |
| Twin Falls | 102,310 | 209,392 | 9,968 | 11,094 | 17,189 | 838,483 | 1,188,436 | 1,232,988 |
| TOTAL | 1,980,703 | 906,390 | 123,229 | 60,090 | 72,213 | 15,303,903 | 18,446,528 | 31,594,530 |

[1]Native vegetation within the classified area; [2]Includes residential, commercial, industrial and municipal land uses; [3]Idle land is capable of being irrigated, and includes CRP and summer fallow.

Sources: USBR and IDWR, 1992.

Figure 9
Upper Snake River Basin
Population Density



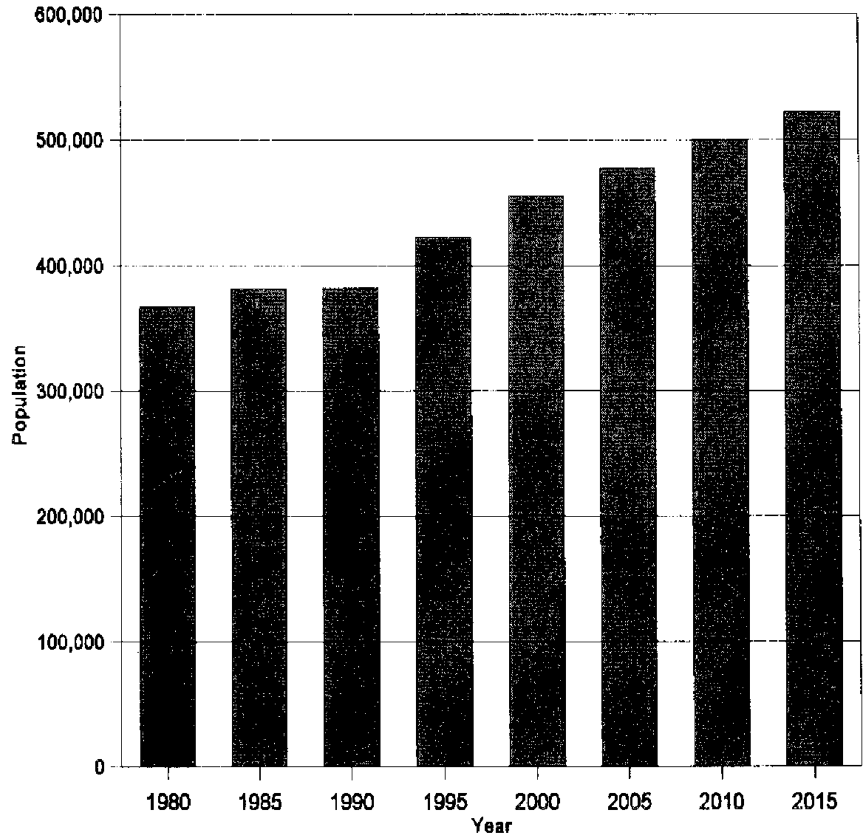



**Figure 10. Population and Projected Population of the Upper Snake River Basin, 1980-2015.**
Sources: IDC, 1994; IDE,1995.

The population of the Upper Snake River Basin is projected to increase 23.6 percent by the year 2015, to 522,400 people. The annual average increase is projected to be 1.1 percent. Bonneville, Madison, Blaine, and Twin Falls counties are likely to attract the majority of migrants, if present trends continue, because the rapidly growing sectors of trade, services, and manufacturing are located mostly in these four counties.

## Rural Rebound

Migration rates indicate the degree to which population change is due to people moving into or out of an area. During the explosive growth of the 1970s, most of rural Idaho shared in the state's growth. The story was different in the 1980s (Table 3), when tough economic times led to slower growth. Table 4 shows that nearly 42,000 more people moved away from the state than moved in throughout the decade. Almost 98 percent of this out-migration came from 31 rural Idaho counties, and 84 percent from the Upper Snake River Basin.

**Table 3. Percentage of Population Change**

| Period | Upper Snake River Basin | State of Idaho |
|---|---|---|
| 1980-1985 | 4.0 | 4.8 |
| 1985-1990 | 0.1 | 1.7 |
| 1990-1995 | 10.6 | 15.3 |

Sources: IDE, 1995; Idaho Power Company, November 1995.

**Table 4. Vital Statistics, Upper Snake River Basin and State of Idaho**

| | 1970-80 | 1980-90 | 1990-92 |
|---|---|---|---|
| Birth Rate[1] | | | |
| **Basin** | 24.6 | 16.0 | 17.8 |
| State of Idaho | 21.3 | 16.3 | 16.2 |
| Fertility Rate[2] | | | |
| **Basin** | 116.6 | 83.8 | 87.5 |
| State of Idaho | 93.8 | 74.3 | 73.1 |
| Net Migration[3] | | | |
| **Basin** | 28,150 | -34,992 | 8,848 |
| State of Idaho | 129,102 | -41,921 | 38,509 |
| % Basin/State | 21.8 | 83.5 | 23.0 |

[1] Birth Rate - Number of live births per 1,000 population per year, [2] Fertility Rate - Number of live births per 1,000 women, 15-44 years of age per year, [3] Net Migration - The residual difference between change of population and the net natural change of births and deaths.
Source: IDC, 1994.

The pattern has changed again with rural areas receiving widespread population gains in the early 1990s. Today, rural growth increasingly depends on an influx of commuters, retirees, vacationers, and manufacturers. The result could be a long-term trend with the pace of rural growth accelerating.

### Population Aging

During the past decade, population aging has attracted nationwide attention. The numbers and relative size of older populations are advancing rapidly. Idaho, for example, has gone from 9.5 percent of the population over age 65 in 1970 to 12 percent in 1990 (Table 5).

**Table 5. Percentage of Total Population at Age 65 and Over**

| | 1970 | 1980 | 1990 |
|---|---|---|---|
| Upper Snake River Basin | 8.6 | 9.3 | 11.5 |
| State of Idaho | 9.5 | 9.9 | 12.0 |

Source: IDC, 1994.

### *Employment*

As in any economy, employment growth in the area is not uniform; some industries have experienced strong growth, some remain unchanged, and some have experienced declines in employment. Selected employment statistics for the Upper Snake River Basin are shown in Table 6.

**Table 6. Selected Employment Statistics, Upper Snake River Basin**

| Industry | 1980 | 1984 | 1988 | 1992 | 80-92 Change% |
|---|---|---|---|---|---|
| **Farm** | | | | | |
| Basin | 23,169 | 23,259 | 18,751 | 18,314 | -20.95 |
| State | 44,229 | 46,063 | 37,376 | 33,821 | -23.53 |
| **Ag.Service, Forestry, & Fisheries** | | | | | |
| Basin | 3,614 | 4,152 | 6,160 | 6,815 | +88.57 |
| State | 6,970 | 8,890 | 12,301 | 14,541 | +108.62 |

Source: IDC, 1994.

Farm employment declined 21 percent in the Basin during the period 1980 to 1992, posting a loss of 4,855 jobs. Productivity gains through the use of more efficient machinery are commonly referenced as the largest contributing factor to this decline. According to Idaho Power Company Economic Forecast, many agricultural producers have cited the cost and shortage of labor as factors in their decision to move to automated technologies which cut labor needs. As crop prices move up and down, the farmer's income fluctuates. Agricultural profits affect all economic sectors.

While farm employment declined in the Upper Snake River Basin, by 1992 employment in agricultural services, forestry, and aquaculture had increased 88 percent, a gain of 3,201 jobs. Basin growth in non-agricultural employment has been positive in recent years. From 1990 to 1995, Upper Snake River Basin non-agricultural jobs increased by 22,040, or by 15.8 percent. In December 1995, the number of non-agricultural jobs totaled an estimated 161,390. Over the same period, state non-agricultural employment increased 25.3 percent and totaled 482,379 in 1995. Figure 11 shows the distribution of non-agricultural employment in the Basin.

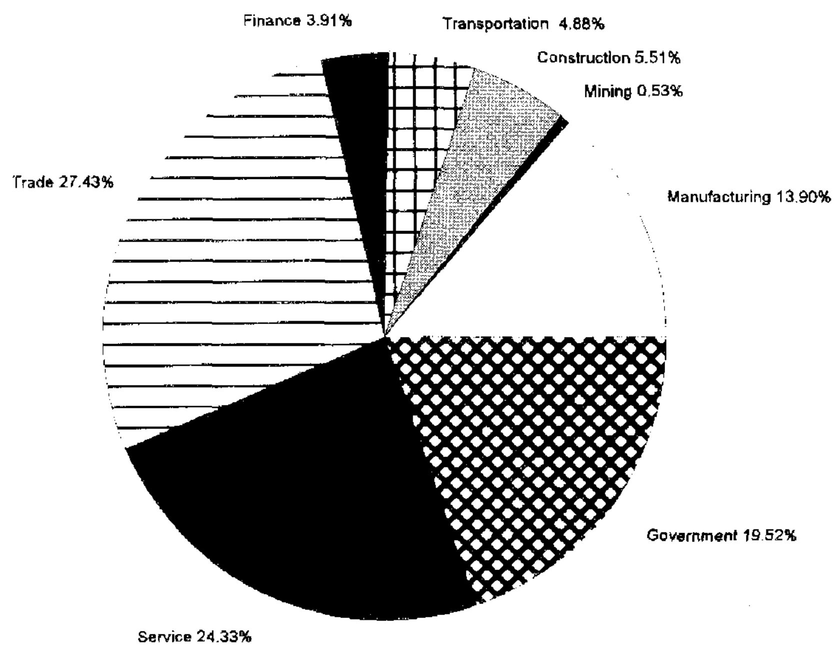



**Figure 11. Distribution of Non-Agricultural Employment, 1995.**
Source: Idaho Power Company, 1995.

### Job Growth

In 1995, construction employment was up by 1,340 jobs from 1990 in the Upper Snake River Basin, an increase of 17.8 percent. The service industry generated the largest number of new jobs, almost 6,660 jobs over the same period. State and local government employment generated a growth rate of 18.4 percent over the period of 1990-1995, and reached 31,460 jobs in 1995.

The number of manufacturing jobs in the Upper Snake River Basin has grown in recent years, while generally declining nationally. By December 1995, manufacturing jobs were estimated at 22,400, a 9.5 percent increase above that of 1990. Employment in wholesale and retail trade in the Basin increased 19.0 percent, from 37,160 in 1990 to 44,220 in 1995.

### Labor Force and Unemployment

Preliminary data from the Idaho Department of Employment (IDE) shows that the Upper Snake River Basin labor force totaled 217,286 in 1995 (Table 7). The unemployment rate for the area was a little higher than the state average. In December 1995, IDE data showed the Basin unemployment rate as 6.3 percent, compared to a state average of 5.9 percent.

**Table 7. Civilian Labor Force and Unemployment Rate in Upper Snake River Basin and State of Idaho, 1991-1995**

| | Upper Snake River Basin | State | U.S. |
|---|---|---|---|
| 1990 | | | |
| Labor Force | 182,145 | 492,000 | |
| Unempl. Rate | 5.9 | 5.9 | 5.5 |
| 1991 | | | |
| Labor Force | 188,292 | 506,000 | |
| Unempl. Rate | 5.9 | 6.1 | 6.7 |
| 1992 | | | |
| Labor Force | 193,718 | 529,000 | |
| Unempl. Rate | 6.8 | 6.4 | 7.4 |
| 1993 | | | |
| Labor Force | 199,387 | 546,000 | |
| Unempl. Rate | 6.4 | 6.2 | 6.8 |
| 1994 | | | |
| Labor Force | 211,181 | 591,000 | |
| Unempl. Rate | 6.0 | 6.2 | 6.1 |
| 1995 | | | |
| Labor Force | 217,286 | 607,700 | |
| Unempl. Rate | 6.3 | 5.9 | |

Sources: IDE, 1994 and 1995.

The civilian labor force in the Upper Snake River Basin accounts for about 37 percent of the state's work force. The Basin, like much of the State, has had substantial labor force growth in 1994 (5.9 percent for the Upper Snake River Basin and 8.2 percent for the State). The rate of growth slowed to 2.9 percent in 1995. The economy in this area has a great deal of seasonality in its need for workers. Agricultural employment, which is a large percentage of the work force, increases in March and continues to grow until November when harvest is over.

### *Personal Income*

Historically, the Upper Snake River Basin's per capita income has been below the U.S. average, but the gap has closed in recent years. In 1985, the Basin per capita income was 77.4 percent of the national average; in 1990, it was 84.6 percent.

Total personal income in the Upper Snake River Basin increased at an average annual rate of 7.64 percent, from $5.6 billion in 1990 to $7.7 billion in 1995 (Figure 12). For the State of Idaho, personal income grew at an annual average rate of 7.1 percent in the same period, to reach $24.6 billion in 1996 dollars. Upper Snake River Basin per capita personal income grew from $15,770 in 1990 to $19,040 in 1995, an increase of 20.7 percent (Figure 13). Personal and per capita incomes (in 1996 dollars) are forecast to grow over the 1995 to 2015 period at annual rates of 5.44 and 4.68 percent respectively.

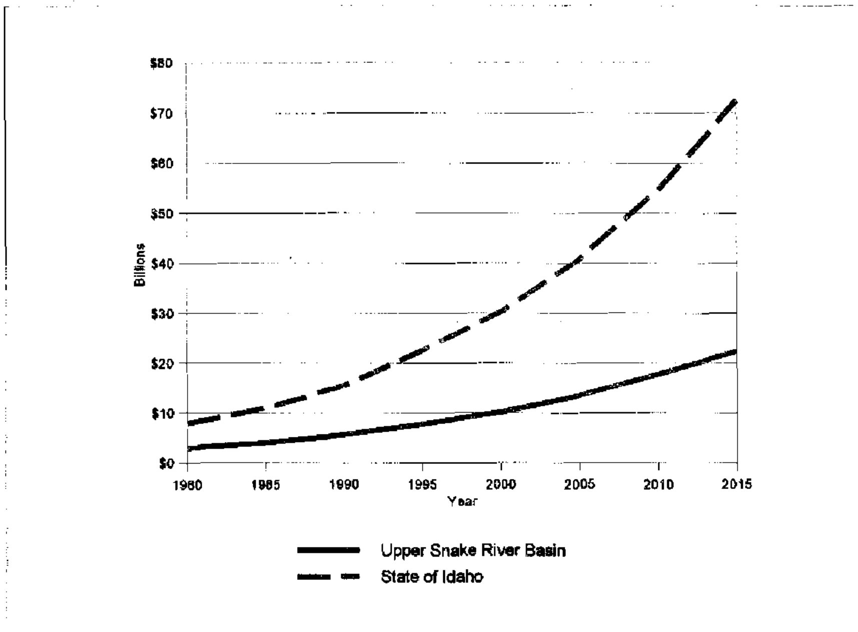



**Figure 12. Total Personal Income**
Source: Idaho Power Company, 1994.

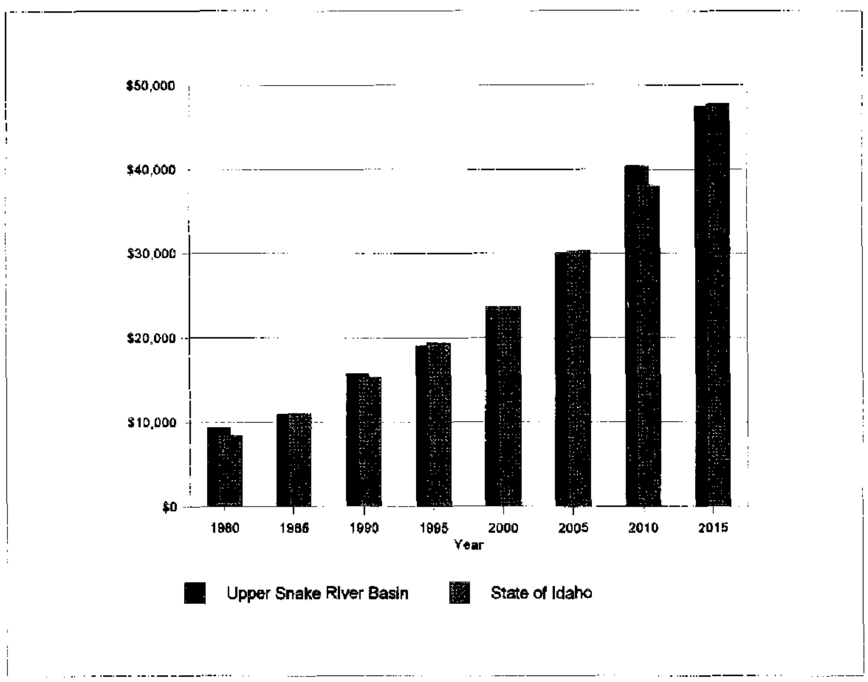



**Figure 13. Per Capita Income Trends.**
Source: Idaho Power Company, 1994.

According to the IDE (1995), primary sources of income in the Upper Snake River Basin are agriculture, including livestock raising; manufacturing; atomic energy research; and recreational travel. Principal manufactured goods include potato and dairy products, cement products, farm equipment, and foundry products.

The median family income of $33,023 in the Upper Snake River Basin is higher than the state median of $32,900 per year, but lower than the national median of $39,700 per year.

**Cost of Living**

A cost of living index compiled by the American Chamber of Commerce Researchers Association sets the national average at 100.0. The Twin Falls area, averaged a composite index of 99.0 in 1995, generally below the national average in the sectors considered. In individual cost of living sectors in 1995, the Twin Falls area scored well below the national average for grocery items (95.9), utilities (82.0), transportation (97.6), and health care (89.2). However, the housing (104.1) and miscellaneous goods and services (102.6) sectors were above the national average. Idaho Falls, was above the national average in every sector with a composite index of 105.3, grocery items (105.8), housing (105.3), utilities (108.1), transportation costs (106.9), health care (104.3), miscellaneous goods and services (102.6). Pocatello in 1994, was above the national average for the composite index (102.9), grocery items (101.9), housing (108.8), and miscellaneous goods and services (105.0).

### *Non-Agricultural Economic Trends*

Population, employment, and personal income trends for the Upper Snake River Basin for the next twenty years are presented in Table 8. Non-agricultural employment grew 15.8 percent from 1990 to 1995 and is estimated to grow another 8.3 percent by the year 2000. Personal income grew 38.2 percent over the period of 1990 to 1995 and is estimated to grow 31.8 percent between 1995 and the year 2000. Non-agricultural employment over the 1995 to 2005 period is expected to increase at an annual rate of 1.7 percent. Manufacturing is expected to increase at an annual rate of 0.8 percent. The wholesale and retail trade and services sectors are projected to grow at annual average rates of 1.7 and 2.7 percent respectively.

**Table 8. Upper Snake River Basin Economic Forecast Summary**

| Category | 1995 | 2000 | 2005 | 2010 | 2015 | 95-15 change% |
|---|---|---|---|---|---|---|
| | | | Values in Thousands | | | |
| Population | 422.71 | 492.84 | 514.90 | 500.40 | 522.40 | 23.58 |
| Households | 145.58 | 160.66 | 172.11 | 184.50 | 196.58 | 35.03 |
| Persons per household | 2.85 | 2.76 | 2.67 | 2.59 | 2.51 | -9.06 |
| Employment | | | | | | |
| Non-Agriculture | 161.39 | 174.76 | 191.06 | 207.09 | 224.75 | 39.26 |
| Manufacturing | 22.40 | 23.65 | 24.17 | 24.62 | 25.91 | 15.67 |
| Mining | 0.85 | 0.85 | 0.85 | 0.86 | 0.86 | 1.18 |
| Construction | 8.88 | 9.49 | 10.41 | 11.20 | 11.94 | 25.82 |
| Trans. Come. & Utilities | 7.86 | 7.89 | 8.01 | 8.09 | 8.21 | 4.06 |
| Finance, Ins. & Real Estate | 6.31 | 6.86 | 7.70 | 8.59 | 9.62 | 40.23 |
| Trade | 44.22 | 47.45 | 52.54 | 57.09 | 65.05 | 47.11 |
| Service | 39.21 | 44.81 | 51.03 | 56.93 | 61.40 | 56.59 |
| Government | 31.46 | 34.15 | 36.71 | 41.25 | 50.78 | 61.41 |
| Income | | | Values in Dollars | | | |
| Personal Income (billion $) | $7.75 | $10.21 | $13.53 | $17.78 | $22.36 | 188.48 |
| Personal Income per capita ($) | $19,040 | $23,630 | $30,060 | $40,390 | $47,520 | 149.58 |

Source: Idaho Power Company, 1995.

## ENERGY SUPPLIES AND CONSERVATION

### *Energy Supplies*

Electrical energy to meet the growing consumer needs in the Upper Snake River Basin is supplied by the Idaho Power Company in the western and central portion of the area, PacifiCorp (formerly Utah Power and Light) in the east, a municipally-owned system serving Idaho Falls, and rural electric cooperatives serving the Raft River, Mackay, and Henrys Fork areas. Some of this energy is produced from hydropower facilities located along the mainstem Snake River and its Henrys Fork and South Fork tributaries. A limited number of co-generation facilities have been developed which utilize waste steam or fuel products from food processing, but total energy production from these sources is small and used mainly for local needs.

Demand for electrical power in the region has been rising slowly since 1990 (Idaho Power, 1996). While residential and business customer numbers have increased -- about 10.6 percent between 1990 and 1995 -- the average per-capita electrical consumption has decreased 1.67 percent. In 1990, electrical consumption per residential customer was 14.34 megawatt hours in the Idaho Power Service area and decreased to an estimated 14.12 megawatt hours in 1995 (Idaho Power Company, 1991; 1995). Irrigation energy use has remained relatively stable. Growth of new irrigated acreage has slowed considerably, due in part to the moratorium imposed on new drilling in response to drought conditions, but horsepower growth has increased as pumping lifts have increased and conversions from gravity irrigation to sprinkler systems continue. The phase out of Bonneville Power Administration's subsidy for the irrigation use of power, beginning in 1998, may have an effect on future power demands (Baker, 1997).

Natural gas is available through Intermountain Gas Company's pipeline along the Snake River transportation and population corridor. Other petroleum products, such as gasoline, heating oil, and LP gas, are provided by major pipelines or are transported throughout the area from terminals located in the larger centers. These commodities are currently available in adequate amounts to meet transportation, space heating, and other energy needs.

### *Energy Conservation Programs*

Available conservation programs designed to increase energy use efficiency play a major role in meeting part of current and future increases in energy requirements within the Upper Snake River Basin. The Northwest Energy Code and locally-adopted building codes support modern conservation standards for new residential and other construction.

Existing facilities are eligible for energy conservation upgrading through several programs sponsored by state and federal agencies, and the utilities industries. These programs promote space and water heating conservation upgrades by providing low-interest loans to fund the installation costs of the conservation measures.

While not part of any established conservation program, conversions to other sources of energy can provide alternatives where electrical supplies may be over-committed. The conversion from electricity to natural gas for space and water heating is taking place in many areas because the public is offered economic incentives to do so. Additionally, Idaho's geothermal, and renewable wood, solar, and wind resources are being used. Geothermal energy is used for space heating in some local areas. There may be some limited potential to harness the geothermal sources for production of electricity in the Raft River, the Island Park caldera, and the Camas Prairie areas, as well as some other scattered locations throughout the Eastern Snake Plain. However, technology problems, uncertain seasonal reliability of the resource, and availability of cheaper alternatives have precluded extensive development. Use of wood for space heating has been popular in some areas, but potential problems with air pollution and a diminishing wood supply limit its expansion potential.

The Upper Snake River Basin has an excellent solar resource with potential as a future source of energy supply. However, solar power is not used extensively in Idaho, primarily due to the costs of development. There are a few small photovoltaic installations on individual facilities, but none are of utility scale. Programs are underway to install solar power units in areas where it would not be cost-effective to construct electric distribution lines. The best commercially available solar cells have an efficiency rate of only about 20 percent so they are not yet very cost effective for large-scale use (IDWR, 1994).

Wind power has not been found commercially feasible in Idaho because winds, while often present, are not of sufficient sustained velocity to constitute a reliable power resource. Even a brief diurnal lull in wind speed can reduce the reliability of wind-powered generators below the threshold of usability.

# WATER RESOURCES

## WATER SUPPLY

Although the water supply for the Eastern Snake Plain Aquifer is dependent upon precipitation and runoff characteristics of the entire Upper Snake River Basin, the following section examines conditions throughout the Idaho portion of the Basin. Annual water yield, the total of streamflow and ground water discharge from the Basin, was estimated to average about eight million acre-feet annually at 1990 development levels (Kjelstrom, 1992a). Some of this originates outside of the state.

Estimates of total ground water in storage are highly variable because the basalt aquifer is heterogeneous and because the storage properties of rocks at depths greater than 500 feet are generally unknown (Lindholm, 1993). Barraclough and others (1981) estimated that the ground water reservoir underlying the Eastern Snake Plain Aquifer stores one billion acre-feet of water. An estimated 200 to 300 million acre-feet of water is stored in the upper 500 feet of the regional aquifer system (Lindholm, 1986). That amount is 20 to 30 times greater than the total storage capacity of all surface reservoirs in the Snake River drainage basin upstream from Weiser, Idaho (Lindholm, 1993).

Surface and ground water in the Upper Snake River Basin are significantly intertwined. Surface streams draining the north side of the basin between the Henrys Fork and the Little Wood Rivers, a straight line distance of 160 miles, terminate on the Snake Plain and percolate into the aquifer. The Big Lost River is the largest of these northern streams that do not directly reach the Snake River. Flow of these streams is absorbed by alluvial deposits in their respective basins or infiltrates alluvial deposits and younger volcanic rocks at the margin of the Snake Plain, becoming part of the ground water resource.

The Snake River alternately contributes water to and receives water from the Snake Plain Aquifer. The most significant discharges occur in the reach from Shelley to Neeley and the reach from Milner to King Hill. The Snake Plain Aquifer currently discharges about 2,660 cubic feet per second (cfs) of water to the Snake River in the Shelley to Neeley reach and about 5,430 cfs in the Milner to King Hill reach (IDWR, 1996a). At some locations the river channel is seasonally above the regional water table and portions of river flows may recharge ground water. See the description of surface/ground water interrelationships later in this section of the report.

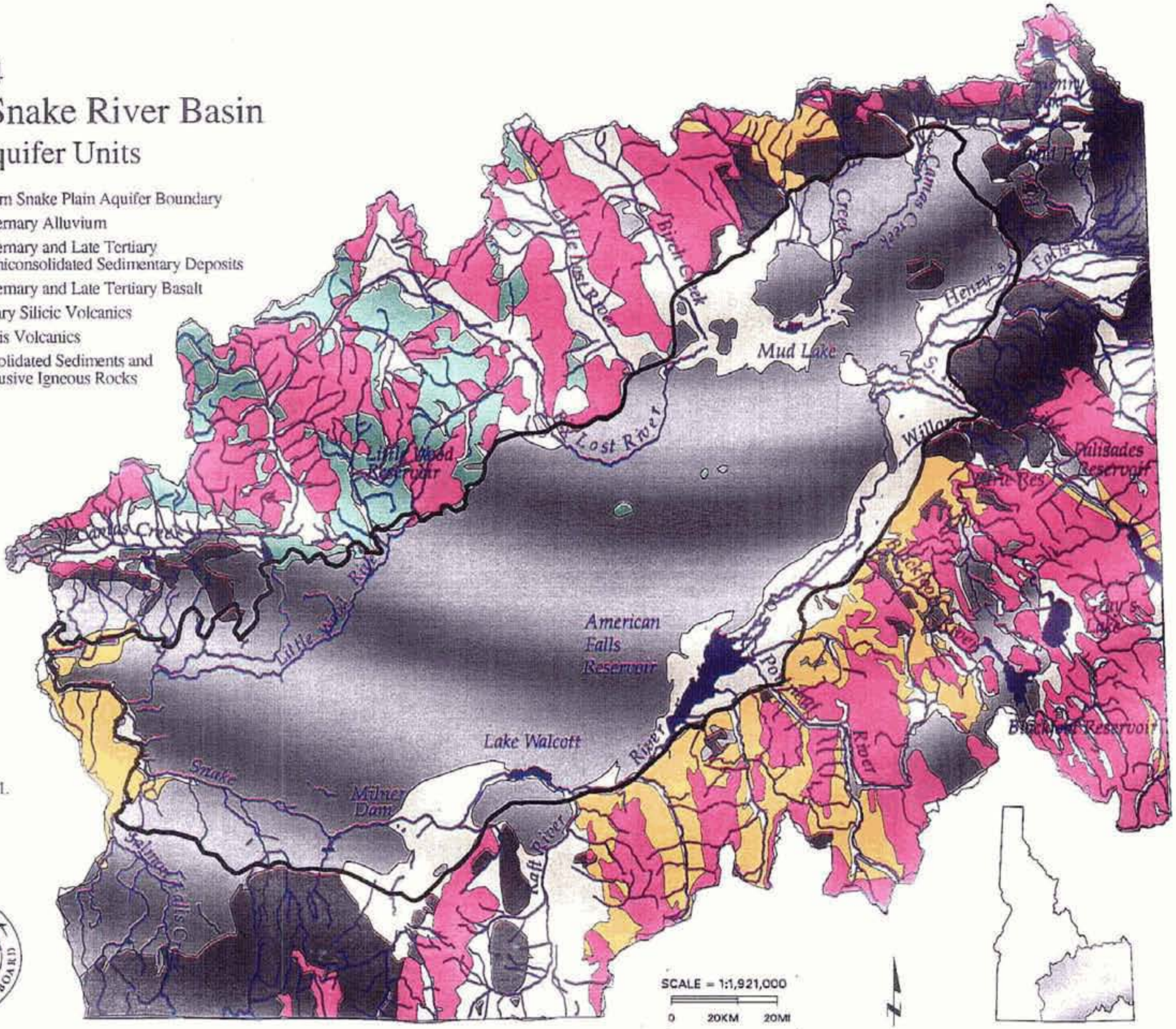
### *Ground Water*

Six water-bearing units have been identified in the Upper Snake River Basin with two of them comprising most of the Eastern Snake Plain Aquifer. These are shown on Figure 14, and are described below. Two units, the Quaternary alluvium and the late Tertiary and Quaternary basalts, support extensive ground water development. The tributary units collectively provide most of the water supplies to these developed areas.

(1) *Quaternary Alluvium.* Alluvial deposits of coarse sand and gravel are extensive alongside the Snake River and its major tributaries. The deposits are extremely permeable and well yields are commonly 1,000-2,500 gallons per minute at depths between 50 and 150 feet.

Figure 14
# Upper Snake River Basin
## Major Aquifer Units

- Eastern Snake Plain Aquifer Boundary
- Quaternary Alluvium
- Quaternary and Late Tertiary Semiconsolidated Sedimentary Deposits
- Quaternary and Late Tertiary Basalt
- Tertiary Silicic Volcanics
- Challis Volcanics
- Consolidated Sediments and Intrusive Igneous Rocks




Source: PNRBC, 1971.

(2) *Quaternary and Late Tertiary Basalts.* Late Tertiary and Quaternary age basalts, belonging chiefly to the Snake River group, constitute the Snake Plain Aquifer east of King Hill, Idaho. The upper surfaces of most Snake River group lava flows are very rough and blocky. Overlying lava flows generally fail to completely fill the cavities, resulting in very permeable interflow zones. Scoria, coarse cinders, or gravel beds, which are good aquifers, may be interbedded with the lava; however, silt or clay interbeds greatly reduce the permeability. Transmissibilities as determined from pump tests averaged five million gallons a day per foot (Mundorff, et al., 1960). Aquifer thickness is largely unknown, but it is generally believed by Idaho Department of Water Resources (IDWR) hydrogeologists that in some areas, the upper several hundred feet can yield 1,000 to 3,000 gallons per minute to wells.

Not all of the younger volcanic rocks are as permeable as the Snake River group. Basalt south of the Snake River in the Twin Falls-Salmon Falls area is somewhat older, probably belonging chiefly to the Idaho group. The transmissibility coefficient of basalt and silicic volcanic rocks in the Salmon Falls area was estimated by Fowler to average about 15,000 gallons per day per foot (Fowler, 1960).

(3) *Quaternary and Late Tertiary Sediments.* Foothills on the south side of the Snake River between Idaho Falls and Lake Walcott and west of Buhl, are predominantly Tertiary and Quaternary sedimentary deposits. Pyroclastic materials and lava flows are interbedded with the sediments. Sand and gravel strata are permeable and yield moderate quantities of water. Wells yield 50 to a few hundred gallons per minute where 50 to 100 feet of the coarser material is saturated.

(4) *Tertiary Silicic Volcanics.* The hydrologic characteristics of Tertiary silicic volcanic rocks in the Upper Snake River Basin vary greatly. Small to moderate quantities of water for domestic and stock use is generally available. Water is frequently under artesian pressure in these units and hot springs are common. On the Rexburg Bench, and at several locations in the Goose Creek-Dry Creek area, and the Salmon Falls Basin, moderately large water yields are obtained from wells penetrating coarse pyroclastics or interbedded basalt. Wells in fractures and underflow zones yield 100 to 2,000 gallons per minute.

(5) *Challis Volcanics.* The Challis volcanic unit consists of a varied assemblage of rocks, chiefly rhyolitic in composition, but they also include some basalt flows, welded tuffs, and pyroclastics. They crop out in large areas north of the Snake Plain. Generally, secondary mineralization has reduced their original porosity. The scant information available suggests that they usually have low permeability.

(6) *Consolidated Sediments and Igneous Intrusives.* A diverse group of rocks comprises the sixth aquifer unit — consolidated sedimentary rocks such as shale, limestone, and sandstone, and intrusive igneous rocks such as granite. These form the mountain ranges but also underlie some basins at relatively shallow depths. Most of these rocks have low permeability and yield only small quantities of water. However, many small springs discharge from this aquifer unit and its chief importance is in supplying a shallow, fairly short-term storage that maintains the base flow of streams draining the mountains.

### *Ground Water Recharge*

Recharge to alluvial deposits and the younger basalts is by infiltration of surface runoff generated on peripheral mountains and highlands and direct precipitation. Prior to extensive irrigation, the recharge was mainly from tributary underflows in the alluvium at the base of mountains, and from the Snake River, Teton River, and the Henrys Fork. After settlement of the area, seepage from irrigation and conveyance facilities became the most significant single source of recharge to the Snake Plain and peripheral basins. As irrigation from surface supplies has diminished and ground water pumping has increased since about 1970, ground water levels and spring flows have also diminished. The decline in spring discharge was shown previously on Figure 5 (pg. 8).

The Tertiary and Quaternary sedimentary deposits and the silicic volcanics crop out extensively in benches and broad uplands, where they are recharged by direct rainfall, by snowmelt, and to some extent by seepage from streams draining the bordering mountain ranges. They discharge by underflow into adjoining lowland aquifers and by seepage into streams which, in turn, recharge aquifers in the basins.

The Challis volcanics and pre-Tertiary rocks are largely confined to mountainous areas. Water recharging to these units is mostly from direct rainfall and snowmelt during spring and early summer. The aquifers primarily sustain flows of the many short streams draining the mountains, but also support the aquifer units underlying the valleys and basins.

Sources of ground water recharge, in order of importance, include: (1) percolation from irrigation (including losses from canals and laterals), (2) underflow from tributary valleys, (3) precipitation, and (4) seepage from streams. Estimated recharge from all sources amounts to 9.75 million acre-feet annually (IDWR, 1997b). Recharge from irrigation accounts for approximately 53.5 percent of total recharge to the Snake Plain Aquifer. Conservatively, this represents about 5.2 million acre-feet. Underflows from tributary valleys contribute more than 2 million acre-feet, or nearly 21 percent, and direct precipitation onto the Eastern Snake Plain accounts for about 16.5 percent of the total recharge to the aquifer. Stream losses amount to 0.9 million acre-feet, or about 9.23 percent of recharge.

### *Surface Water*

The upper Snake River (locally known as the South Fork Snake River) is the main source of surface water in the Upper Snake Basin, providing nearly 60 percent of the total inflow. Stream flow at Heise, upstream of major diversions, averages nearly five million acre-feet (Table 9). Henrys Fork is the largest tributary to the Snake River in the Basin, contributing more than 25 percent of the flow. Measured streamflow of Willow Creek, the Blackfoot River, and the Portneuf River accounts for about 85 percent of the total gain to the Snake River between the Henrys Fork and Neeley. Measured streamflow of Goose Creek, Trapper Creek, and Salmon Falls Creek accounts for about 35 percent of total water contribution from tributary drainage basins between Neeley and Salmon Falls Creek.

**Table 9. Mean Annual Discharge and Streamflow Variation, Water Years 1934-80.**

| Source | Mean Annual Discharge (acre-feet) | Annual Low Stream Flow as a Percentage of Mean Annual Discharge | | Annual High Stream Flow as a Percentage Of Mean Annual Discharge | |
|---|---|---|---|---|---|
| | | Recurrence Interval | | Recurrence Interval | |
| | | 10-year | 50-year | 10-year | 50-year |
| Snake River headwaters at Heise | 4,953,000 | 79 | 67 | 129 | 146 |
| Henrys Fork Basin | 2,226,000 | 78 | 67 | 121 | 134 |
| Eastern tributary basins | 572,000 | 58 | 40 | 142 | 169 |
| Southern tributary basins | 148,000 | 53 | 36 | 158 | 198 |
| Northern tributary basins | 280,000 | 65 | 51 | 133 | 164 |
| Big and Little Wood River Basins | 466,000 | 34 | 22 | 120 | 173 |
| **Total** | **8,645,000** | | | | |
| **Percentage of Total** | | **67** | **59** | **129** | **151** |

Source: Kjelstrom, 1992a.

## Snake River

Although modified by Jackson Lake since 1916, and Palisades since 1957, the historic flow for Heise is used to represent natural flow conditions on the Snake River (Table 10). Sequences of high and low runoff years in the Upper Snake River Basin are illustrated in the hydrographs of Figure 15. At Heise the lowest flow year was 1934, which followed a sequence of years of below normal runoff beginning in 1929. Although flows improved after 1934, the dry period did not end until 1943. The same period was generally dry at King Hill; the driest year was 1935. However, at King Hill, reductions in annual discharge for the sequence of years 1988-1994 equaled the 1930s dry spell. A period of above normal runoff began in 1965 and continued through 1987. Average runoff for the period was 114 percent of the 1911-1994 mean.

**Table 10. Historic Annual Discharge by Water Year, Snake River at Heise and King Hill (x 1,000 acre-feet)**

| Year | Heise | King Hill | | Year | Heise | King Hill | | Year | Heise | King Hill |
|---|---|---|---|---|---|---|---|---|---|---|
| 1911 | 5758 | 8936 | | 1940 | 3566 | 5687 | | 1969 | 5402 | 8541 |
| 1912 | 6049 | 9815 | | 1941 | 3635 | 5646 | | 1970 | 4811 | 7552 |
| 1913 | 6442 | 10381 | | 1942 | 4218 | 6434 | | 1971 | 7276 | 11036 |
| 1914 | 5809 | 9687 | | 1943 | 6183 | 9002 | | 1972 | 6899 | 11477 |
| 1915 | 4022 | 7422 | | 1944 | 4321 | 7592 | | 1973 | 4763 | 9034 |
| 1916 | 5713 | 8992 | | 1945 | 4423 | 6963 | | 1974 | 6459 | 9802 |
| 1917 | 6414 | 11038 | | 1946 | 5466 | 8684 | | 1975 | 5745 | 9804 |
| 1918 | 6830 | 9608 | | 1947 | 5226 | 7769 | | 1976 | 6206 | 10834 |
| 1919 | 4083 | 7769 | | 1948 | 5015 | 7988 | | 1977 | 4007 | 6661 |
| 1920 | 5049 | 7105 | | 1949 | 4841 | 7635 | | 1978 | 4638 | 6446 |
| 1921 | 5930 | 9468 | | 1950 | 5760 | 8552 | | 1979 | 5106 | 7541 |
| 1922 | 5234 | 8646 | | 1951 | 6284 | 9537 | | 1980 | 4741 | 6784 |
| 1923 | 5170 | 7966 | | 1952 | 6036 | 10184 | | 1981 | 4557 | 6475 |
| 1924 | 3770 | 6850 | | 1953 | 4633 | 7481 | | 1982 | 5977 | 8762 |
| 1925 | 5530 | 8258 | | 1954 | 4993 | 6830 | | 1983 | 6612 | 11475 |
| 1926 | 4296 | 7245 | | 1955 | 4091 | 6844 | | 1984 | 6905 | 13117 |
| 1927 | 5782 | 7122 | | 1956 | 6523 | 8565 | | 1985 | 5520 | 10286 |
| 1928 | 6195 | 9441 | | 1957 | 4651 | 8064 | | 1986 | 7176 | 11195 |
| 1929 | 4506 | 7537 | | 1958 | 4349 | 7075 | | 1987 | 4693 | 7980 |
| 1930 | 4419 | 6686 | | 1959 | 4446 | 6266 | | 1988 | 3821 | 5575 |
| 1931 | 3231 | 5885 | | 1960 | 4422 | 6075 | | 1989 | 3892 | 5701 |
| 1932 | 4325 | 5659 | | 1961 | 3682 | 5391 | | 1990 | 4487 | 5794 |
| 1933 | 4323 | 5817 | | 1962 | 4397 | 6106 | | 1991 | 3805 | 5740 |
| 1934 | 2980 | 5411 | | 1963 | 4460 | 6762 | | 1992 | 3950 | 5361 |
| 1935 | 4004 | 5070 | | 1964 | 5063 | 7354 | | 1993 | 3756 | 6009 |
| 1936 | 5103 | 6209 | | 1965 | 6160 | 9052 | | 1994 | 4613 | 5900 |
| 1937 | 3941 | 5874 | | 1966 | 5227 | 7666 | | 1995 | 4317 | 6448 |
| 1938 | 4994 | 7233 | | 1967 | 4571 | 6118 | | 1996 | 7063 | 9166 |
| 1939 | 4006 | 6663 | | 1968 | 4644 | 6859 | | 1997 | 8387 | 12251 |

Source: USGS, 1998.

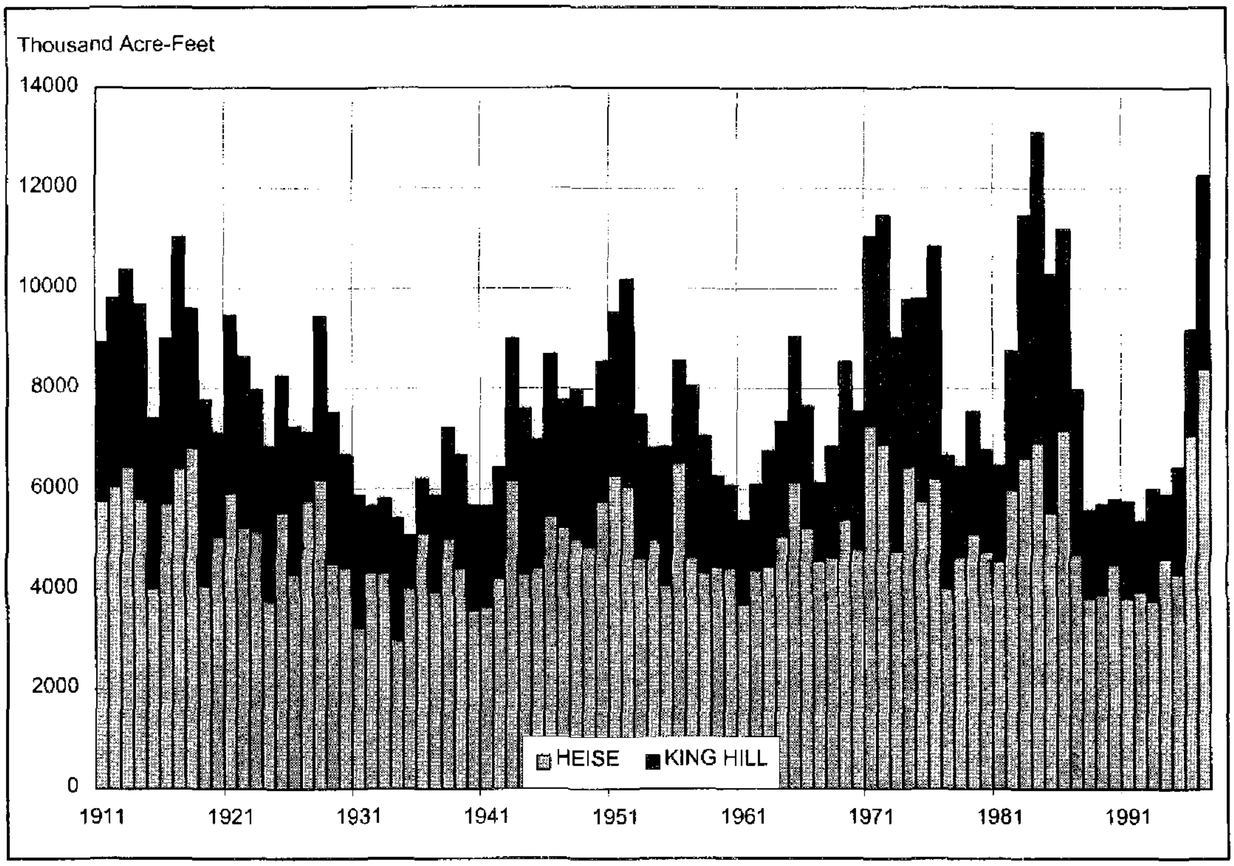



**Figure 15. Historic Annual Discharge, Snake River at Heise and King Hill.**

Flow in the Snake River above Milner Dam varies seasonally owing to climatic variations and water-management practices. Most of the streamflow of the Snake River above Milner Dam is derived from snowmelt in mountain areas. Snake River flows are naturally low from September to April after the accumulated snowpack of the previous season has melted out. High flows are generally associated with snowmelt during the spring. Flow generally peaks in May and June, and gradually recedes to base flow through the summer. Examples of seasonal variations for five different gaging stations on the Snake River are shown in Figure 16.

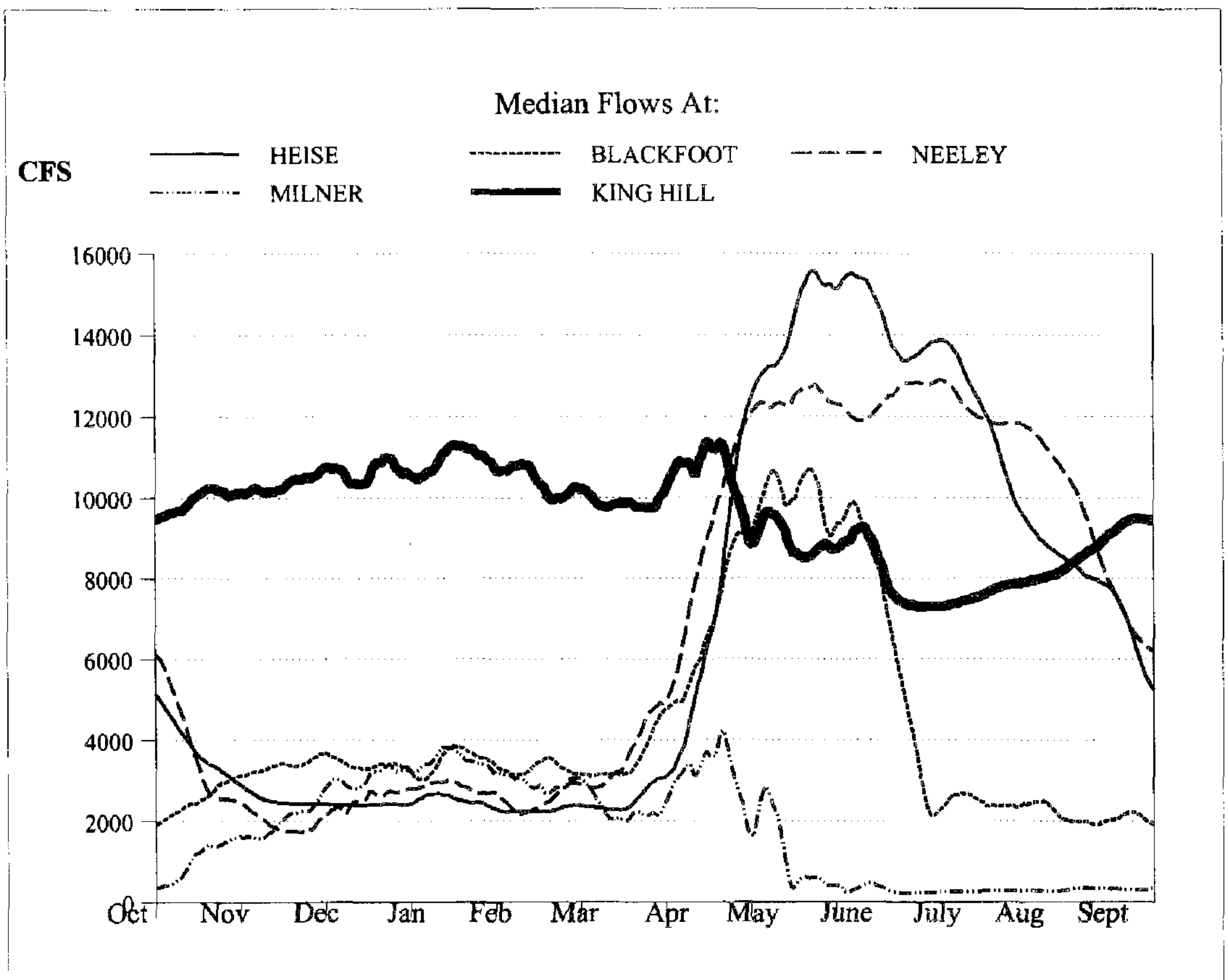



**Figure 16. Snake River Median Flow Calculated from Averaged Daily Historic Flows 1958-93.**

Steady flows prior to spring snowmelt and increased flows during the irrigation season (April to September) result from regulation for irrigation purposes. As regulation has increased, reservoir releases augment base flow in the winter months for power production, and high flows have been diminished by flood control regulation and storage and irrigation diversions. The flows at Heise result from the natural snowmelt sequence as modified by reservoir storage operations at Jackson Lake and Palisades Reservoir. At King Hill, the seasonal hydrograph shape is principally affected by the near-constant discharge of ground water from the Snake Plain Aquifer. It is also affected by the flows which pass Milner Dam in high runoff years, and upstream diversions during the irrigation season.

Low flows occurred at times in the Snake River prior to irrigation and the construction of reservoir storage. Downstream from major irrigation diversions, Snake River flows are generally lowest during the latter part of the irrigation season. Flow in the Snake River at Milner Dam in July and August may, at times, approach zero, however summer flows have increased partly because of water conservation and the requirements for the Milner power plant. Streamflow characteristics, as computed by IDWR, are shown in Table 11. Losses in flows between pairs of gauges between Irwin and Milner show where major irrigation diversions withdraw more water than the normal river gain. The dramatic gain in Snake River flow between Milner and King Hill is largely the result of discharge from the Snake Plain Aquifer in the Thousand Springs area.

**Table 11. Snake River Streamflow Characteristics**

| | Drainage Area | 7-Day Annual Low Flow | 90% Flows Exceed | 50% Flows Exceed | 100-Year Flood | Remarks |
|---|---|---|---|---|---|---|
| Snake River near Irwin (1959-1997) | 5,225 sq. mi | --------- | 1120 cfs | 4620 cfs | 37,000 cfs | Headwaters in Wyoming |
| Snake River at Shelley (1890-1991) | 9,790 sq. mi | 412 cfs | 2200 cfs | 4260 cfs | 40,100 cfs | Irrigation diversions |
| Snake River nr Blackfoot (1910-1993) | 11,310 sq. mi | 116 cfs | 1060 cfs | 3200 cfs | 40,600 cfs | Irrigation diversions |
| Snake River at Milner (1909-1993) | 17,180 sq. mi | 1.1 cfs | 13 cfs | 742 cfs | 31,600 cfs | Irrigation diversions |
| Snake River at King Hill (1909-1993) | 35,800 sq. mi | 4880 cfs | 6970 cfs | 9180 cfs | 38,700 cfs | Downstream from springs |

Sources: Kjelstrom et al., 1996; USGS, 1998.

Under present conditions, the average annual discharge at Milner is 3,224 cfs (an annual volume of 2,334,000 acre-feet), an increase of 890 cfs (650,000 acre-feet) since the early 1970's (IDWR data). Most of this increase is due to reductions in diversions which began after 1977 and continued through the 1980s. The seasonal distribution of Milner flow has also continued to change. Summertime flows of 200 cfs or greater now occur in all but the driest years. This is primarily due to annual releases of up to 45,000 acre-feet of water from Idaho Power Company storage at American Falls Reservoir to maintain a Federal Energy Regulatory Commission (FERC)-mandated 200 cfs flow below Milner Dam. Releases for downstream salmon flows from USBR facilities in the upper Snake above Milner Dam consist of 22,250 acre-feet of water from uncontracted storage, supplemented by the purchase of available rental water of nearly 200,000 acre-feet. Water for salmon from the Upper Snake River Basin totaled about 330,000 acre-feet in 1994, 255,000 acre-feet in 1995, 218,000 acre-feet in 1996, and 214,000 acre-feet in 1997 (IDWR records).

**Tributaries**

Mountain ranges along the north side and east end of the Basin are areas of high precipitation, generally 40 to 60 inches annually. Precipitation on the south and southeast flanks is generally less, but many mountains receive 25 to 40 inches per year at higher elevations. Low flows in tributary streams generally occur during winter months. In the foothills and mountains, streams receive contributions from ground water systems throughout the year. However, during prolonged drought, tributary base flows decrease significantly because most are underlain by pre-Tertiary rocks of relatively low permeability and limited storage capacity. The mountain tributary streams lose part or all of their discharge on reaching an alluvial or basalt aquifer unit. Table 12 summarizes major tributary characteristics.

Table 12. Streamflow Characteristics for Upper Snake River Basin Tributaries

| | Drainage Area | 7-Day Annual Low Flow | 90% Flows Exceed | 50% Flows Exceed | 100-Year Flood | Remarks |
|---|---|---|---|---|---|---|
| Henrys Fork near Ashton (1923-1997) | 1,040 sq. mi | 452 cfs | 792 cfs | 1,340 cfs | 9,500 cfs | Regulated for downstream irrigation |
| Henrys Fork near Rexburg (1909-1997) | 2,920 sq. mi | 190 cfs | 934 cfs | 1,720 cfs | 15,200 cfs | Unregulated tributaries |
| Blackfoot River near Blackfoot (1913-1997) | 1,295 sq. mi | 0 cfs | 46 cfs | 129 cfs | 2,190 cfs | Irrigation diversions |
| Portneuf River near Pocatello (1897-1997) | 1,250 sq. mi | 2.4 cfs | 66 cfs | 240 cfs | 2,930 cfs | Irrigated valleys upstream |
| Raft River near Malta (1955-1997) | 412 sq. mi | 0.33 cfs | 4.7 cfs | 10 cfs | 1,630 cfs | Irrigation upstream |
| Goose Creek & Trapper Creek (1911-1997) | 687 sq. mi | 1 cfs | 16.4 cfs | 37 cfs | 2,650 cfs | Entire flow stored in Oakley Reservoir |
| Big Lost River below Mackay Reservoir, near Mackay (1904-1997) | 813 sq. mi | 23 cfs | 81 cfs | 163 cfs | 3,460 cfs | Regulated for downstream irrigation |
| Big Wood River below Magic Dam, near Richfield (1911-1997) | 1,600 so mi | 0.03 cfs | 3.6 cfs | 62 cfs | 10,400 cfs | Regulated for downstream irrigation |

Sources: Kjelstrom et al., 1996; USGS, 1998.

### Impoundments

Flows in the Snake River and most tributaries are greatly affected by storage facilities. Storage capacity in the Upper Snake River Basin is nearly 5.7 million acre-feet, about 85 percent of which is in Idaho. Management of streamflow within the area is performed primarily to provide water to various users and to prevent damage from flooding. Table 13 lists 26 reservoirs within the study area with individual storage capacities greater than 5,000 acre-feet. Twenty-three of these projects are operated to supply irrigation water with flood control, power, instream flows, and other uses as secondary purposes. Ten of the reservoirs are federal projects. The remaining projects were financed by public non-federal agencies and by private organizations. While only four reservoirs include storage specifically for flood control, all are operated to reduce flooding. Figure 17 shows the locations of storage reservoirs in the Idaho portion of the Upper Snake River Basin.

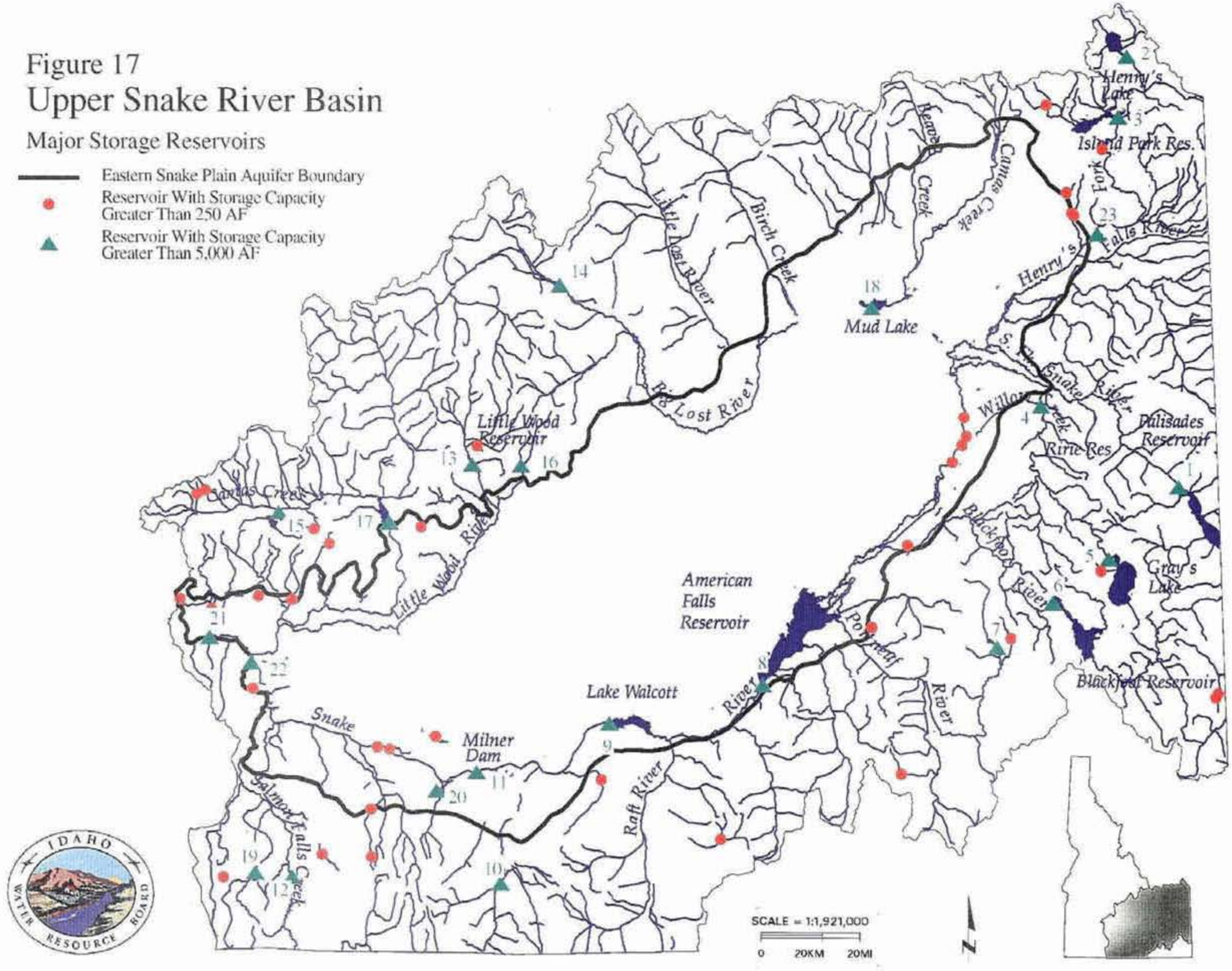
Table 13. Upper Snake River Basin Water Storage Reservoirs with Storage Capacities Greater than 5,000 Acre-feet

| Fig 17 Index | Reservoir | Completed | Stream | Purposes | Total Capacity (Acre-Feet) | Active Storage (Acre-Feet |
|---|---|---|---|---|---|---|
| 0 | Jackson | 1916 | Snake River | IF | - | 847,000 |
| 1 | Palisades | 1957 | Snake River | FIMPRS | 1,401,000 | 1,200,000 |
| 2 | Henrys Lake | 1910 | Henry's Lake Outlet | I | - | 90,400 |
| 3 | Island Park | 1938 | Henrys Fork | I | 135,580 | 135,200 |
| * | Grassy Lake | 1939 | Grassy Creek | I | 15,470 | 15,200 |
| 4 | Ririe | 1976 | Willow Creek | IFRS | 100,541 | 80,500 |
| 5 | Grays Lake | 1924 | Willow Creek | I | - | 40,000 |
| 6 | Blackfoot | 1911 | Blackfoot River | IM | 350,000 | 350,000 |
| 7 | Portneuf | 1912 | Portneuf River | I | 23,700 | 23,700 |
| 8 | American Falls | 1978 | Snake River | IP | 1,672,600 | 1,672,600 |
| 9 | Lake Walcott | 1906 | Snake River | IP | 210,200 | 95,200 |
| 10 | Oakley | 1916 | Goose Creek | I | 77,400 | 77,400 |
| 11 | Milner | 1906 | Snake River | IP | 50,000 | 50,000 |
| 12 | Salmon Falls | 1911 | Salmon Falls Creek | I | 230,650 | 182,700 |
| 13 | Little Wood | 1941 | Little Wood River | IFRS | 30,000 | 30,000 |
| 14 | Mackay | 1918 | Big Lost River | I | 44,400 | 44,400 |
| 15 | Mormon | 1908 | McKinney Creek | I | 19,280 | 19,280 |
| 16 | Fish Creek | 1923 | Fish Creek | I | 12,740 | 12,740 |
| 17 | Magic | 1915 | Big Wood River | I | 191,500 | 191,500 |
| 18 | Mud Lake | 1954 | Camas Creek | I | 44,700 | 44,700 |
| 19 | Cedar Creek | 1920 | Cedar Creek | I | 30,000 | 30,000 |
| 20 | Murtaugh | 1905 | Snake-Offstream | I | 7,720 | 7,720 |
| 21 | Bliss | 1950 | Snake | P | 11,000 | 11,000 |
| 22 | Salmon Falls, Lower | 1949 | Snake | P | 18,500 | 18,500 |
| 23 | Ashton | 1913 | Henrys Fork | P | 9,800 | 9,800 |

* In Wyoming; Purposes: F= flood control; I = irrigation; M = municipal & industrial; P = power; R = recreation; S = fish and wildlife

Sources: USBR, 1997; IDWR 1997a .

Figure 17
## Upper Snake River Basin
Major Storage Reservoirs



### *U.S. Bureau of Reclamation Programs*

Over 72 percent of the total storage capacity of the Upper Snake River Basin reservoirs is in projects managed by the USBR. Early projects were constructed as part of the 1902 Reclamation Act with subsequent authorization of specific facilities by the Secretary of the Interior or the President (USBR, 1996). Since 1939, project feasibility findings had to be approved by Congress and given specific authorization. Defining a project's authorized purpose determines the limits within which a federal facility can be operated. Flood control, recreation, fish and wildlife habitat, and other enhancements are often authorized subsequent to project construction and apply to management of land and water surfaces; they do not authorize reallocation of project water supplies or storage space for these added purposes.

*Minidoka Dam* (Lake Walcott) was authorized for irrigation and power development in 1904 under the Reclamation Act of 1902 and was completed in 1906. The original power plant was completed in 1909 with capacity of 12.4 MW, and a replacement facility in 1997 raised this capacity to about 28 MW. The earthfill dam is 86 feet in height and 4,475 feet long. It stores up to 210,200 acre-feet of water in Lake Walcott which has a shoreline length of 80 miles. Shore lands are managed as part of the Minidoka National Wildlife Refuge by the U.S. Fish and Wildlife Service (USFWS). Lake Walcott State Park, located adjacent to the north dam abutment, is managed by the Idaho Department of Parks and Recreation (IDPR). Water level is maintained at 4,245 feet during the spring/summer irrigation season to provide flows into the main canals of the Minidoka and Burley Irrigation Districts. After irrigation deliveries have been completed, the reservoir is drawn down and maintained at 4,240 feet or lower to protect the spillway from ice damage.

*Jackson Lake Dam* was originally authorized under the 1902 Reclamation Act and was completed in 1907 as a rockfilled crib to provide irrigation flows to the Minidoka Project. The dam was replaced with a concrete gravity structure with earth embankment wings in 1911 and further raised in 1916. It was reconstructed in 1989 under authority of the Reclamation Safety of Dams Act to restore its 847,000 acre-feet of water storage capacity. The dam is 66 feet high and 4,920 feet long. The reservoir has a shoreline of about 70 miles which is managed by the National Park Service (NPS) as part of the Grand Teton National Park. Jackson Lake Dam is operated in conjunction with Palisades Reservoir for flood control. In the late summer or early fall, flood control space is evacuated, lowering the lake to 647,000 acre-feet of storage; normal summer irrigation operation sometimes empties the flood control space. Winter inflow is stored until the 647,000 acre-feet is reached and then is passed to maintain that level. Winter flow releases are generally above 200 cfs. During the spring and summer, inflow is stored until full pool is reached or is released as needed to meet irrigation demands.

*American Falls Dam* is an irrigation and power facility first constructed in 1927 and rebuilt in 1977. It consists of a concrete gravity dam with adjoining earth embankments 86.5 feet high and 2,927 feet long. The reservoir has a storage capacity of 1,672,600 acre-feet, and 80 miles of shoreline managed by the USBR; lands located on the Fort Hall Indian Reservation are managed by the Shoshone-Bannock Tribes. Idaho Power Company owns and operates the 92.3 MW power plant under a FERC license at the dam. A winter minimum release of at least 300 cfs is maintained from November until spring; in recent years the release from December to February has averaged 4,050 cfs. The magnitude of the winter flow depends principally on the amount of carryover storage in American Falls Reservoir and the upstream system. If American Falls is nearly drained at the end of the irrigation season, a flow of about 350 cfs is commonly released to maintain downstream water quality. If carryover storage is good, estimates are made of the amount of unstorable flow expected prior to the irrigation season. The unstorable flow is then released as uniformly as feasible to provide higher winter flows. The primary operation goal is to fill American Falls by April 1. If inflows are higher than normal, or if carryover storage is substantial, winter releases may range upwards to 5,000 cfs. Some flood control operations may be made at American Falls but these are incidental to irrigation operations. Summer releases are determined by downstream irrigation demands and water rental pool leases below Milner Dam.

*Island Park Dam* was completed in 1938, primarily for irrigation of land in the St. Anthony to Rexburg area. It is a 91-foot high earthfill structure, 9,448 feet in length. The dam was rebuilt in 1985 under the Idaho Safety of Dams Program and a powerhouse was added in 1993. Active storage capacity is about 135,000 acre-feet of water. The U.S. Forest Service (USFS) administers lands along the reservoir's 64 miles of shoreline. Winter releases for fish and wildlife enhancement is predicated upon the amount of carryover storage and fall inflows. With good carryover and normal runoff, winter releases of about 500 cfs can be maintained; recent winter releases have ranged between 100 and 300 cfs. Some incidental flood control operation may occur if forecast conditions dictate. In spring and early summer, water is stored with the goal of filling the reservoir in April.

*Grassy Lake Dam* was completed in 1939. It is 118 feet high and 1,170 feet long. The reservoir capacity is 15,470 acre-feet of water, and it has 5 miles of shoreline. Located between Yellowstone and Grand Teton National Parks, the lands around Grassy Lake are administered by the USFS. Water is diverted from Cascade Creek into Grassy Lake during the fall, winter, and early spring, with the goal of filling the pool by early summer. No water is diverted during periods of high inflow, full reservoir conditions, or during the summer months. Grassy Lake does not normally release water in the winter. Irrigation releases are made on demand, usually in July and August. Additional releases are made as necessary to reach winter operation level.

*Palisades Dam* was constructed between 1951 and 1957 for irrigation, power, flood control, and fish and wildlife. The power plant was upgraded in 1994 to increase rated capacity to 176.6 MW. The earthfill dam is 270 feet high and 2,100 feet long. The reservoir has 70 miles of shoreline and a total capacity of 1.4 million acre-feet of water. Adjacent lands are administered by the USFS. A minimum winter outflow of 550 to 750 cfs is usually maintained, depending on the amount of fall carryover storage, predicted inflows, and severity of drought conditions. The usual minimum flow is 1,100 to 1,200 cfs. If carryover storage is good, higher winter releases may be needed to evacuate flood control space. During spring runoff, Palisades is operated in conjunction with Jackson Lake under flood control rules which may require increased releases depending on the forecast. After spring runoff and the flood potential subsides, the goal is to fill the Palisades pool. Releases are made throughout the summer and fall to meet irrigation demands. To the extent possible, releases are directed through the power plant but storage is not specifically released for power production.

*Ririe Dam* and its flood channel were constructed by the U.S. Army Corps of Engineers (COE) between 1970 and 1977 east of Idaho Falls on Willow Creek, and then turned over to the USBR for operation. The reservoir is operated primarily for flood control, although irrigation storage, recreation, and fish and wildlife enhancement are also part of the management equation. The earth and rockfill structure is 253 feet high with a crest length of 1,070 feet. Active storage capacity is 80,500 acre-feet of water, with the top 10,000 acre-feet of space being reserved for emergency flood control functions. Water is stored in Ririe throughout the winter, spring, and early summer. There is no winter flow because of possible ice formation in the flood channel. During summer, the reservoir is maintained as high and as stable as possible for recreation with a release of at least 30 cfs to provide water for natural flow right demands. After Labor Day the reservoir is drawn down to its flood control pool, releasing as much as 45,000 acre-feet of water by the first of November.

## SURFACE/GROUND WATER INTERRELATIONSHIPS

Aquifers underlying most peripheral basins (Figure 18) contribute waters to the Snake Plain Aquifer. Much of the surface discharge from these same basins also becomes recharge to the aquifer (Table 14). Conversely, discharge from peripheral basin aquifers and the Snake Plain Aquifer sustains a major part of streamflow in the Snake River and its tributaries. A key to understanding ground water and surface water relationships in the Upper Snake River Basin is the analysis and quantification of streamflow gains from and losses to the ground water system. Some river reaches gain or lose water throughout the year; other reaches gain water during the irrigation season when water levels in the underlying aquifer are higher than the water stage in the river, but lose water the rest of the year when ground water levels are lower than the water stage in the rivers.

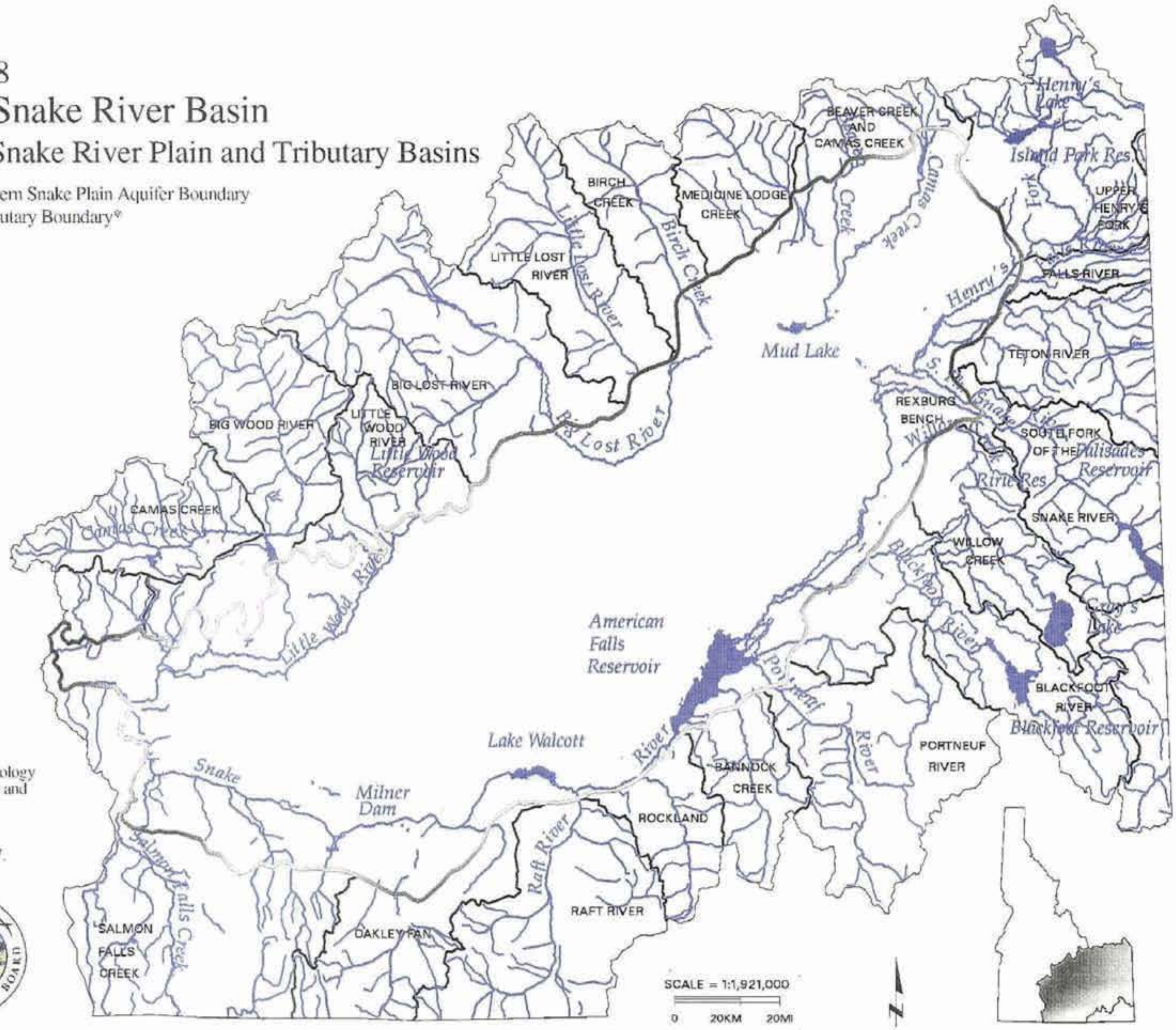
**Table 14. Hydrologic Summary of Tributary Basins**

| Basin | Modeled Area* (square miles) | Precipitation (1000 acre-feet per year) | Computations of Basin Outflow (1000 acre-feet / year) | |
|---|---|---|---|---|
| | | | Surface Water | Ground Water |
| Upper Henrys Fork | 1,060 | 1,732 | 1,088 | Negligible |
| Falls River/ Conant Creek | 520 | 971 | 579 | Negligible |
| Teton River | 890 | 1,058 | 597 | 3 |
| Rexburg Bench | 165 | 158 | 10 | 0 - 19 |
| South Fork, Snake River | 5,750 | 10,216 | 5,022 | Negligible |
| Willow Creek | 650 | 534 | 100 | 0 - 29 |
| Blackfoot River | 930 | 987 | 267 | 0 - 25 |
| Portneuf River | 1,290 | 1,128 | 202 | 49 - 63 |
| Bannock Creek | 410 | 393 | 28 | 22 - 30 |
| Rockland (Rock Creek) | 430 | 295 | 17 | 51 |
| Raft River | 1,510 | 1,248 | Negligible | 84 |
| Oakley Fan | 1,630 | 1,347 | 210 | 215 |
| Camas/Beaver Creeks | 830 | 872 | 37 | 267 |
| Medicine Lodge Creek | 830 | 872 | 41 | 20 - 30 |
| Birch Creek | 600 | 749 | Negligible | 57 - 78 |
| Little Lost River | 840 | 1,147 | 52 | 100 |
| Big Lost River | 1,440 | 1,378 | 74 | 142 - 308 |
| Little Wood River | 480 | 566 | 124 | 13 - 24 |
| Big Wood River | 1,180 | 1,492 | 330 | 38 |
| Camas Creek | 680 | 638 | 128 | 20 |

*Data is based on computer model boundaries, the areas of which may vary somewhat from geographic boundaries.
Source: IDWR, 1997b.

Figure 18
# Upper Snake River Basin
## Eastern Snake River Plain and Tributary Basins

Eastern Snake Plain Aquifer Boundary
Tributary Boundary*




*Modified after hydrology modeling boundaries and hydrologic units.

Source: IDWR, 1997.

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### *Snake River and Snake Plain Aquifer*

All outflows from the Upper Snake Basin leave the area through the Snake River; underflow from the basin is thought to be negligible. However, the Snake River alternately gains and loses in several reaches before finally collecting all surface and ground water discharge near the western end of the region. River reaches where streamflow gains and losses occur are shown on Figure 19.

- On the alluvial fan below Heise, the Snake River loses flow to both the regional and perched aquifers.

- From near Roberts to a point a few miles downstream from Blackfoot, the Snake River loses water to the regional water table. However, the river may receive inflow from local perched aquifers at some places in this reach.

- From a point a few miles downstream from Blackfoot to the upper end of Lake Walcott, the Snake River receives inflow from both regional and perched aquifers. Large quantities of ground water are discharged to this reach. Ground water discharge, mostly from springs influent to American Falls Reservoir, is more than 2,600 cfs.

- From Lake Walcott to about Twin Falls, the river is above the regional water table and loses water to it but receives inflow from perched aquifers in the vicinity of Rupert and Burley.

- From about Twin Falls to the lower end of the subregion, the river is below the regional aquifer system. Ground water discharges approximately 5,400 cfs to the river in this reach (Figure 5, pg. 8). At times when no water flows over Milner Dam, the Snake River is regenerated below that point by inflow from springs discharging from the Snake Plain Aquifer and a few tributary streams.

Discharge of the Thousand Springs has been estimated for the period 1902 to 1996 as shown previously on Figure 5. In 1902 the average discharge of the Thousand Springs was slightly more than 4,200 cfs. In 1913 the annual discharge began to show a significant increase, a trend that generally continued until the late 1940s. From the late 1940s until the mid 1950s discharge of the springs continued to increase, but at a lower rate than had occurred during the previous 35 years. The peak annual average discharge of the springs during this period occurred in 1951 with an average flow of slightly less than 6,900 cfs. After 1951, discharge of the Thousand Springs began to decrease. In 1997 the annual average discharge was approximately 5,400 cfs (refer back to Figure 5). Discharge from the twelve largest springs or groups of springs ranges from 100 to 1,400 cfs per spring.

### *Henrys Fork/ Teton River Basins*

The Teton River in its lower reaches and the Henrys Fork below St. Anthony are above the regional water table and lose water to it, but both receive inflow from perched aquifers. The Snake River for several miles downstream from its junction with the Henrys Fork near Menan Buttes is at about the same level as the regional water table. The river may alternately gain or lose in this reach depending on river stage and other factors. There are no perched aquifers on the north side of the river. On the south side, in places, ground water might be defined as a "perched system."

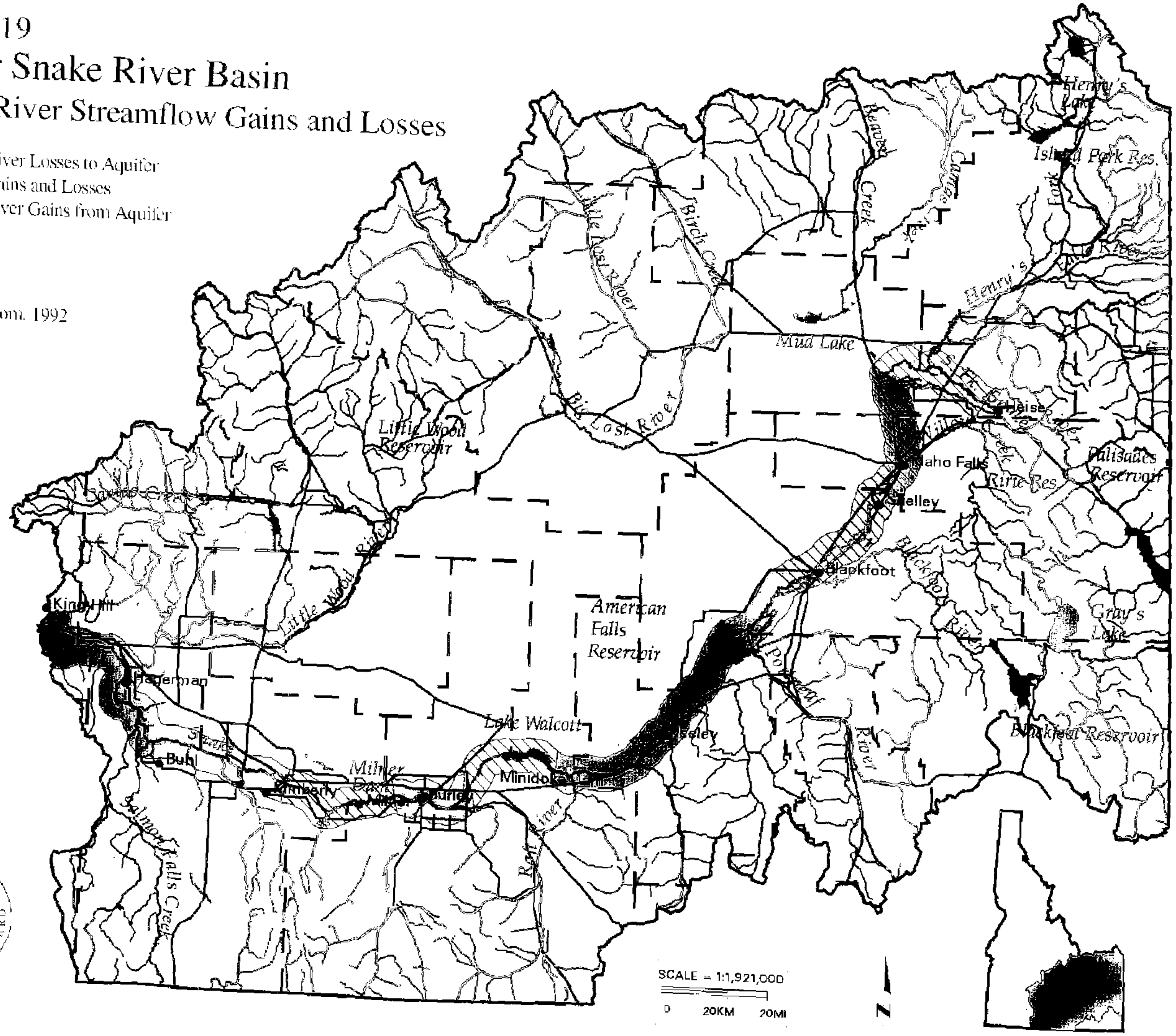
Figure 19

# Upper Snake River Basin

## Snake River Streamflow Gains and Losses

River Losses to Aquifer
Gains and Losses
River Gains from Aquifer

Source: Kjelstrom, 1992



### *Rock Creek and Raft River Basins*

Ground water contribution to the regional aquifer from the south between Neeley and Minidoka is largely seepage from the Rock Creek and Raft River basins. Estimated average annual ground water discharge from the Rock Creek basin to the aquifer is about 50,000 acre-feet. Average annual ground water discharge from the Raft River basin to the aquifer is estimated at 80,000 acre-feet (Garabedian, 1992).

### *Big and Little Lost River Basins*

A distinctive feature of the Lost River Basin is the large interchange of water from surface streams into the ground and from the ground into surface streams. At medium and low flows, all the surface flow in the main stem of the Big Lost River disappears into the ground at the Chilly Sinks. Large quantities reappear in the vicinity of Mackay Reservoir, disappear again at the Darlington Sinks, reappear near Moore, and finally disappear beneath the Snake River Plain downstream from Arco.

The main valleys and some of the larger tributary valleys are partly filled with alluvial sand, gravel, and clay. These materials are moderately porous and permeable. Many mountain tributaries lose their entire flow to alluvial deposits on entering the main valleys. Above Mackay Reservoir on the Big Lost River, these deposits serve as a large underground reservoir, stabilizing inflows to the Big Lost River and Mackay Reservoir. Downstream from Mackay Dam, the water table is often below stream level, and the alluvium serves as a conduit for transmitting water underground from the basin into the Snake Plain Aquifer. During wet years, the aquifer level in the Moore-Arco reach rises and contributes to the Big Lost flows. Water yield estimates indicate that ground water outflows represent 94 percent of total combined surface and groundwater outflow from the basin (Clebsch, et al., 1974).

The Little Lost River basin is similar to the Big Lost River basin. Much of the discharge of tributary valleys reaches the main valley as underground flow, and the alluvium in the valley serves as an underground reservoir, stabilizing the surface discharge of the Little Lost River. In the central part of the valley, about 11 miles up-valley from Howe, the water table is near or at the surface. Downstream, the water table is below river level, and additional water is added to the aquifer by losses from the river and other streams.

### *Big and Little Wood River Basins*

The floors of the valleys of the Big Wood River and its principal tributaries are underlain mostly by coarse, permeable alluvium. An appreciable part of the water yield is discharged by underflow through the permeable alluvium beneath the valley floor. In the upper valley around Ketchum, runoff is principally into the main stem of the Big Wood River. Farther down the valley, runoff from Quigley, Slaughterhouse, and Seamans Creeks sink into the alluvium along the border of the floor of the Big Wood River valley and recharges the local ground water. Seemingly, water rarely reaches the Big Wood River at the surface in these creek channels.

Gauge records show that at successive downstream stations the discharge of the Big Wood River increases steadily in amounts greater than the surface contributions from tributary streams. That increase is ground water that is discharged to the surface stream from the saturated alluvium, where the water table is above the level of the river. Between Bellevue and a point about five miles south of Bellevue the river loses water by percolation into the alluvium. A bypass canal was constructed around the lower part of this reach to salvage water. Between the lower end of the bypass canal and Magic Reservoir the river reach to salvage water. Between the lower end of the bypass canal and Magic Reservoir the river gains water from the ground. Much of the gain is from spring-fed creeks that rise in the alluvium and enter the river a short distance upstream from Magic Reservoir.

A ground water divide south of the bypass canal separates underflow into two parts. The western part is tributary to the Big Wood River main stem and the eastern part is tributary to Silver Creek and the Little Wood River. There are seasonal shifts in the divide, depending on the stage of the river and the status of diversions for irrigation (Smith, 1960).

Silver Creek, a spring-fed stream, rises where the water table in the valley sediments intersects the land surface, and follows an old channel of the Big Wood River. The complex interaction of ground and surface water is clearly demonstrated in seasonal variations of gains and losses along Silver Creek. In some downstream reaches near Picabo, the creek gains flow during periods of high ground water levels and loses flow during periods of lower ground water levels (Moreland, 1977).

The Little Wood River Basin is underlain by silicic volcanic rocks. The larger valleys are partly filled with alluvium and basalt. In its lower reaches, the Little Wood River is above the water table and loses water by percolation from the stream bed. Ground water moves down-valley to join the regional ground water system beneath the Snake Plain.

Large amounts of water percolate into the Snake River basalt from the channels of the Big Wood and Little Wood Rivers where they cross the Eastern Snake Plain. A considerable amount of water diverted from the rivers through canals and onto irrigated fields also percolates into the basalt. The greatest channel losses used to occur in the reach of the Big Wood River between Magic Reservoir and Richfield. Since 1925, the entire natural flow of the Big Wood River, except for flood events, has been diverted through the Lincoln Canal past that reach of the river. The average infiltration loss from the canal between Magic Reservoir and Richfield is 55 cfs (Smith, 1960). In the Little Wood River Basin the reach between the Little Wood River Reservoir and Richfield sustains the largest losses. Except for flood events, the natural flow of the upper Little Wood River has been diverted through its east and west canals since 1923. It has been estimated that annually about 80 percent of the surface water discharge from the mountainous northern half of the Big Wood River Basin percolates into the Eastern Snake Plain Aquifer (Smith, 1960).

## WATER USE

Water resources of the Upper Snake River Basin have been developed extensively for irrigation, power generation, aquaculture, and municipal and industrial supply. Although irrigated agriculture is the largest consumptive user of available water, other offstream and instream uses are also important to the State's economy. Idaho industries, particularly food processing and aquaculture, depend on an ample supply of high quality ground water. Hydroelectric power generation, fish, and the recreation/tourism industry are dependent on river flows. Though small relative to other uses, livestock water and domestic, commercial, and municipal water use are essential to residents of the area.

Availability of water use data varies greatly within the area. Irrigation diversion records exist for that part of the basin within Water District 01 which includes the Snake River main stem and most major tributaries above Milner Dam, except the Raft, Portneuf, and Blackfoot Rivers. Data are also available on water diversions for hydroelectric projects, municipal uses in the larger cities, and for a few industrial enterprises. Elsewhere, measurements and records are inconsistent or unavailable. Therefore, total water use can only be estimated by indirect methods.

### *Consumptive Use*

Water for all uses in the Upper Snake River Basin originates from seasonal precipitation. Some falls directly onto the lands which directly use the water. Some runs off as surface water. Some sinks into the surface and is stored as ground water. An estimated 50 percent of average precipitation in the area is consumed by native vegetation or lost through evaporation. Forests, xerophytic, and phreatophytic vegetation consume, evaporate and transpire an estimated 10 million acre-feet per year. Another million acre-feet per year evaporates from bare ground and open water (Lindholm and Goodell, 1986; IDWR, 1995). Of the water that remains, much is diverted and is consumed by irrigated crops.

**Irrigation**

The economy of the Upper Snake River Basin is based largely on irrigated agriculture. Systematic irrigation in the region began in the 1870s. Acreage under irrigation rapidly increased as a result of congressional passage of the Desert Land Act in 1877, the Carey Act in 1894, and the Reclamation Act in 1902. By 1905, irrigation demand left the Snake River dry for several days in a 10-mile reach near Blackfoot (Kjelstrom, 1986). Through the early 1900s reservoir construction and surface water storage increased the amount of water available for seasonal use. By the end of World War II, farmers irrigated 1.5 million acres in the Basin.

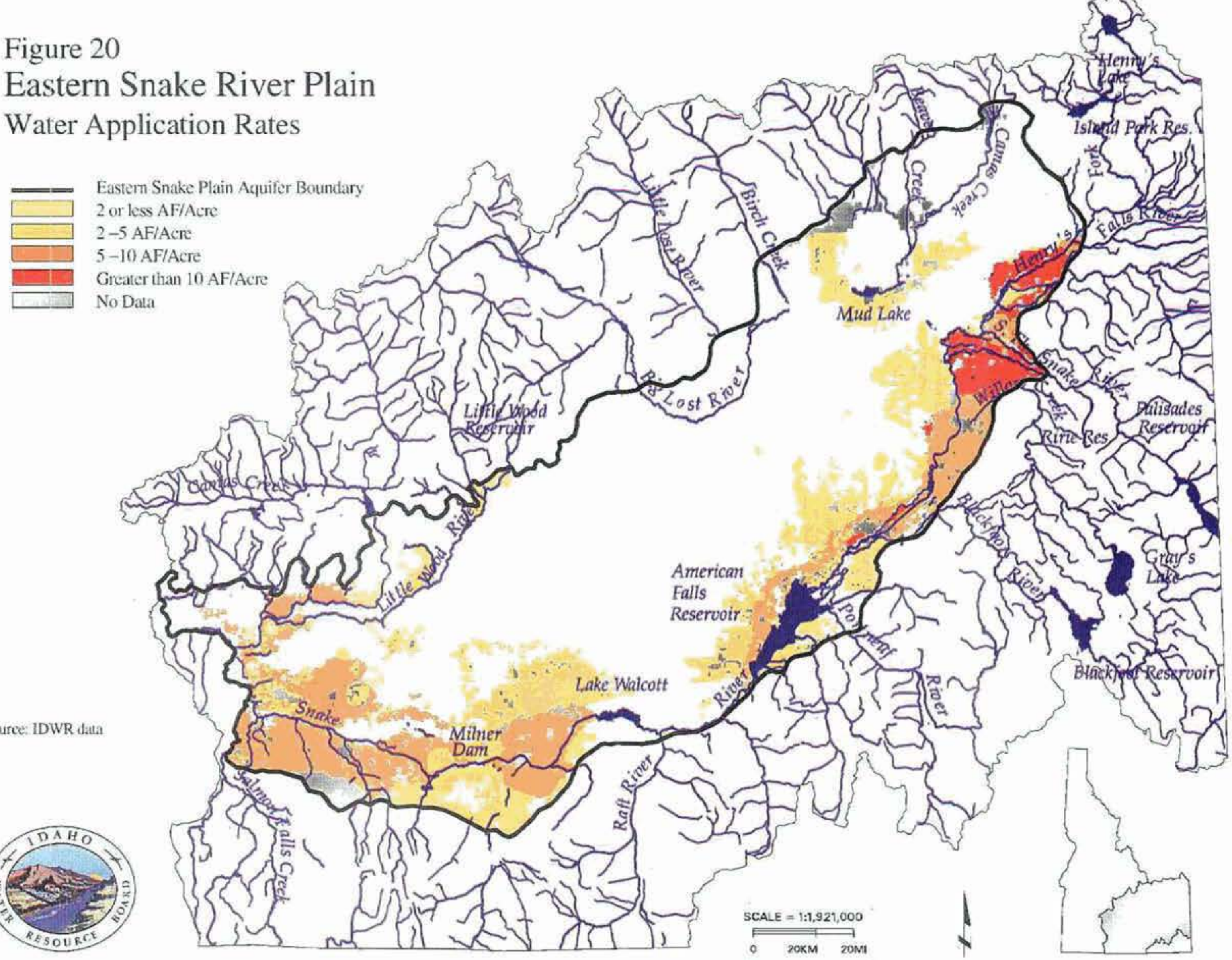
At present, approximately 2.9 million acres in the Upper Snake River Basin are irrigated (USBR and IDWR, 1992). About two-thirds of that acreage is irrigated with surface water and one-third with ground water. Since the 1940s, ground water has supplied a steadily increasing amount of irrigation water. Use of ground water permitted irrigation where surface water was not available or was not adequate or dependable. Ground water, as a supplemental water source, increases the flexibility of on-farm irrigation methods and scheduling.

Two large tracts along the Snake River encompass most of the irrigated land in the area: (1) the lower Henrys Fork Basin downstream to American Falls Reservoir, and (2) the area from Lake Walcott downstream to King Hill. Diversified cropping patterns, including the production of high-value row-crops, are well established on these lands. The smaller irrigated areas, generally located in tributary valleys which have shorter growing seasons, commonly produce forage crops for livestock grazed on rangelands.

> *Henrys Fork Basin* - Natural streamflow supplies most of the one million acre-feet of water diverted annually for irrigation in the Henrys Fork Basin. Annual diversion amounts differ widely within the basin, ranging from one or two acre-feet per acre to more than 20 acre-feet per acre (Figure 20). High losses from these diversions result in significant return flows and recharge to the ground water system.

> *Snake Plain: Palisades to Blackfoot* - Surface irrigated lands between Heise and Blackfoot usually receive adequate water supplies because they have either early priority natural flow rights, or storage, or both, to meet late season needs. More recently irrigated lands west of the Snake River, and areas beyond the reach of canals, depend heavily on ground water pumping. Annual surface water diversions average 3.4 million acre-feet; ground water diversions are approximately 400,000 acre-feet (IDWR, 1995).

# Figure 20
## Eastern Snake River Plain
### Water Application Rates




Source: IDWR data

*East-side Tributaries: Blackfoot, Portneuf and Bannock Creek Watersheds* - Lands irrigated from east-side tributary streams usually suffer late-season shortages. Storage is available on the Blackfoot and Portneuf Rivers, but it is inadequate to supply all the needs of irrigated lands in those river basins. Reservoir storage contributes only 16 percent of the water used for irrigation along the tributaries. Annual surface water diversions average 250,000 acre-feet; ground water diversions are approximately 200,000 acre-feet (IDWR, 1995).

*Snake Plain: American Falls to King Hill* - This area, known as the Magic Valley, contains approximately 800,000 irrigated acres (Goodell, 1988). Since irrigators in this area have good natural-flow rights and own 1.5 million acre-feet of Snake River storage, their lands are generally well supplied with surface water. In 1990, more than 3 million acre-feet of water was diverted from the Snake River to irrigate these lands (IDWR, 1995). Much of the ground water use in this area is north of the Snake River in the North Side Pumping Division of the Minidoka Project. Annual ground water diversions are approximately 650,000 acre-feet.

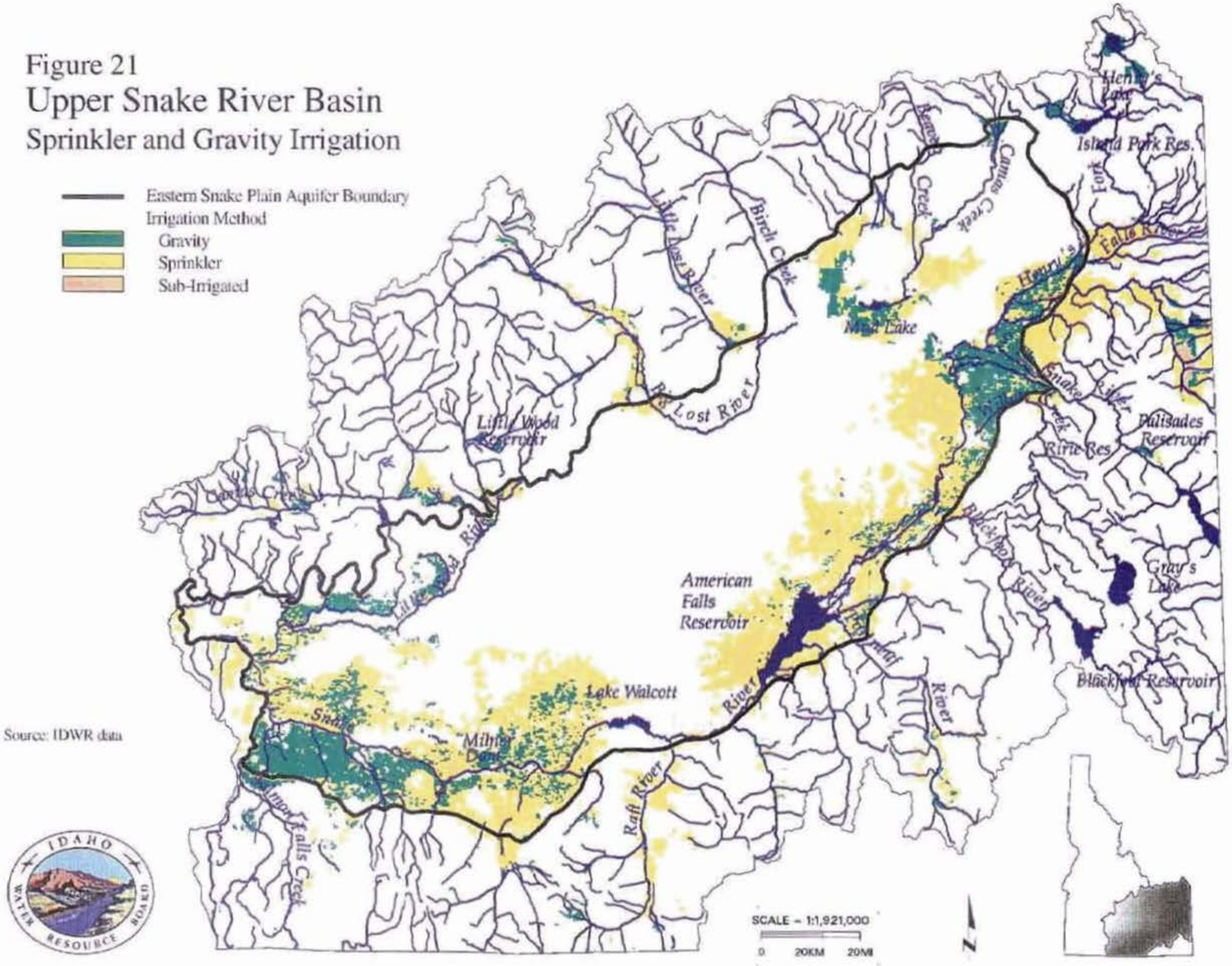
*North-side Tributaries* - This vast area includes all the "lost river" drainages from Camas Creek in Clark County west to the Big and Little Wood Rivers, the Camas Prairie, and lands receiving runoff from the south-side of the Bennett Hills. Streams in this region generally sink into the lava fields of the Snake Plain before reaching the Snake River. Lands in the headwater areas of the tributary streams are heavily irrigated in the spring with natural flows, but usually suffer water shortages later in the growing season. Return flows of irrigation waste water from these upper valleys augment both surface and ground water supplies downstream and on the Snake Plain. Annual surface water diversions are approximately 1.2 million acre-feet (IDWR, 1995). An estimated 400,000 acre-feet of ground water is pumped for irrigation across this area.

*South-side Tributaries: Raft River, Goose Creek, and Salmon Falls Creek Watersheds* - Irrigation water shortages in this area are the most severe in the Upper Snake River Basin. Natural streamflows are limited, and only modest amounts of storage are available. Annual surface water diversions are about 80,000 acre-feet (IDWR, 1995). A large percentage of acreage in this area is irrigated by ground water pumping. More than one million acre-feet is estimated to be pumped from ground water annually.

Sprinkler irrigation has steadily grown in the region. Today, approximately 70 percent of irrigated acreage in the Upper Snake River Basin is watered by sprinklers compared with only 12 percent in 1977 (IDWR, 1995). Figure 21 shows the distribution of sprinkler and gravity irrigation in 1992.

Irrigation waste water return flow from irrigated acreage above Milner Dam is re-diverted for irrigation or sinks into the Eastern Snake Plain. Flows which return to the Snake River below Minidoka Dam are usable within the area only during the irrigation season. Above Minidoka Dam, flows returning during the nonirrigation season are stored whenever space is available.

Figure 21
Upper Snake River Basin
Sprinkler and Gravity Irrigation




Source: IDWR data

Enough reservoir storage space is available to augment natural flows and to fully supply lands diverting from the Snake River under most runoff conditions. Water supplies on the smaller tributary streams contrast sharply with the Snake River supply because there are few major reservoirs on the tributaries. Water shortages range to as much as 60 percent on lands diverting surface water from north-side tributaries. A sequence of extremely dry years, (i.e., 1988 to 1992) caused water shortages nearly everywhere in the Upper Snake River Basin

Ground water pumping on the Eastern Snake Plain is concentrated around Mud Lake, the vicinity of Shattuck Butte near Osgood, on acreage west of Blackfoot and west of American Falls Reservoir, and in the Minidoka Project area north of Burley. About 60 percent of the wells in the Basin are located in these areas; collectively, they account for about 70 percent of all ground water withdrawals from the Upper Snake River Basin (IDWR, 1995).

Surface water diversions have been declining since the mid 1970s (Figure 22). Diversions from the Snake River above Milner have decreased by about 800,000 acre-feet, an average of 50,000 acre-feet per year, since 1980 (IDWR,1995). Approximately 50 percent of the reduction is from diversions between Heise and Neeley. Increases in water application efficiency have aided irrigators in maintaining crop production levels even in extremely short water years. Better efficiency has also made some water available for rental from the water bank.

During the last 20 years irrigated acreage in the Upper Snake River Basin has remained relatively constant at 2.9 million acres. Irrigated acreage increased in ten counties and decreased in eight counties over that time period. Part of the decrease is related to the Conservation Reserve Program of the U.S. Department of Agriculture. Potentially irrigable land remains unirrigated because financial returns are not great enough to attract the necessary capital, land is in federal ownership, and/or water available for new irrigation is limited. Public and political opinion constraining some new developments are also factors.

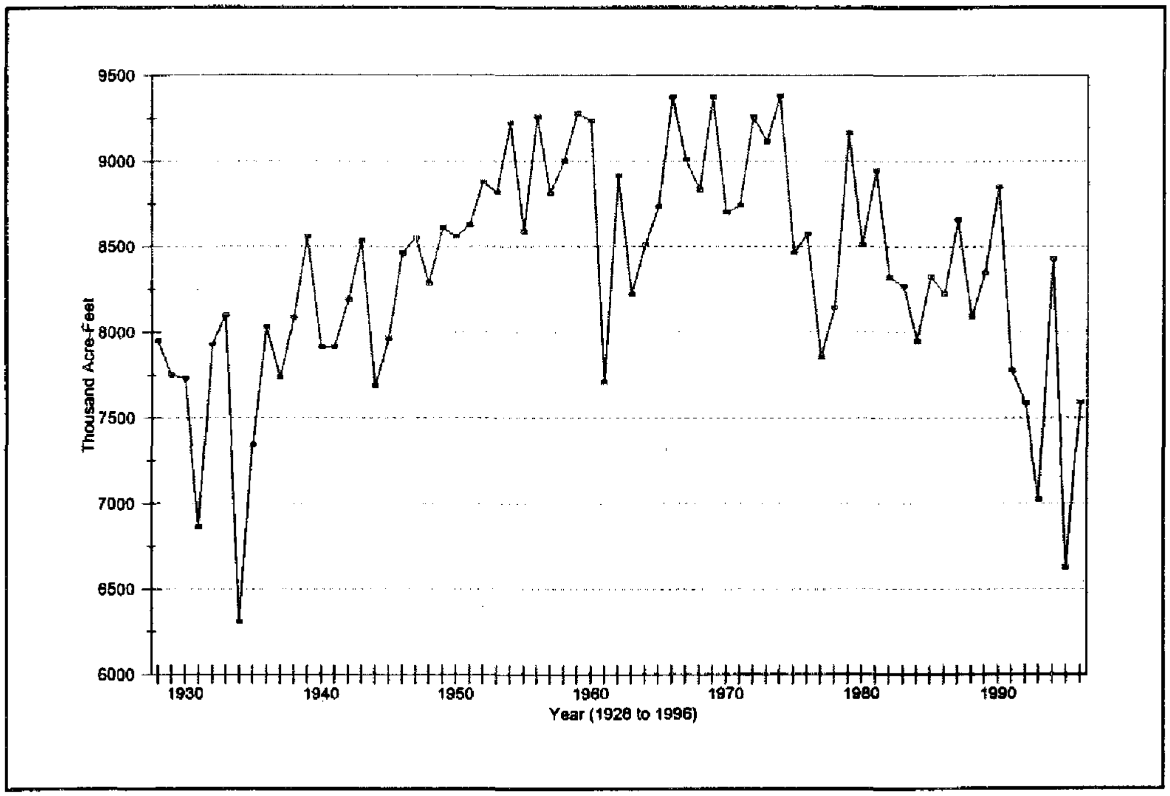



**Figure 22. Total Surface Water Diversions above Milner**

## Irrigation Potential

Several studies and data bases were consulted in identifying areas having some possibility of being irrigated in the future in the Upper Snake River Basin. These include:

- Potentially Irrigable Lands in Idaho, 1970, Idaho Water Resource Board;
- The Natural Resources Conservation Service's (NRCS) STATSGO (State Soil Geographic Data Base) geographic information system computer data base of soil survey information;
- The 1986 Landsat classifications of presently irrigated land, with modifications as reported on recent water rights applications;
- Eastern Snake Plain Aquifer Irrigated Lands from the 1992 U.S. Bureau of Reclamation Classification.

Research of the several data sources indicated that the map of potentially irrigable lands published by the IWRB in 1970 is the most complete, reliable, and useable information available. Among other parameters, the map incorporates the land classes developed by the Soil Conservation Service reflecting physical limitations to irrigation development (shallow or rocky soil, irregular topography, or inadequate drainage). However, the constraints of climate, distance to market, the availability (and cost) of water, and environmental constraints were not considered.

The land areas identified on that map were compared with interpretations of Landsat imagery by Geographic Information System analysts to reveal that the better suited lands are already being irrigated. More than a century of adjustments and readjustments to prevailing economic and technological conditions, along with the practical experience of the people, have determined which lands are irrigable. Also, lands under certain federal administrative jurisdictions such as the BLM, USFS, INEEL, and NPS, in addition to tribal lands within the Fort Hall Indian Reservation, are not considered to be available for irrigation development by the private sector. Areas under state designation as ground water management or critical ground water areas were also not considered because of the shortage of available water at those locations.

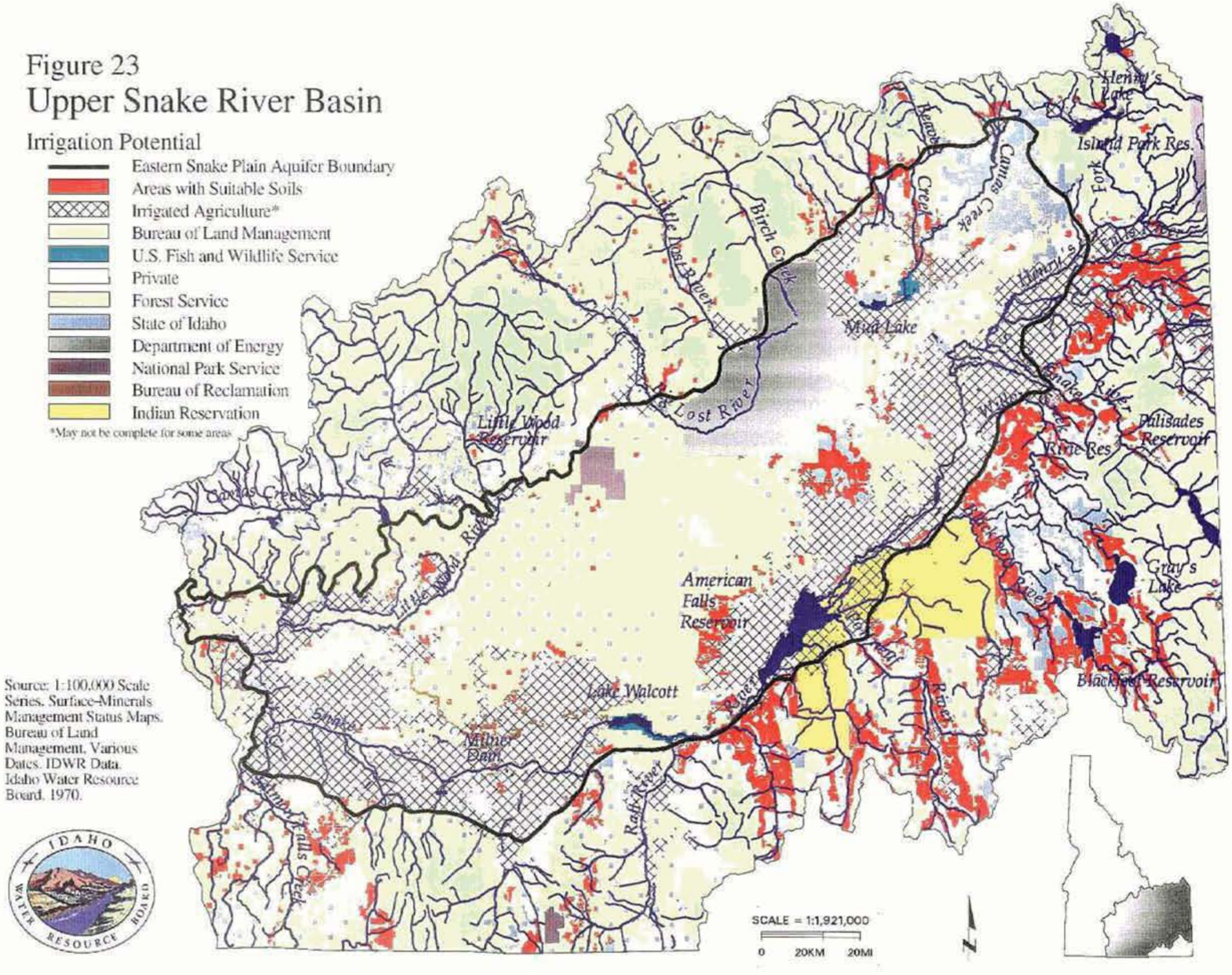
When the present extent of irrigation is combined with the 1970 map of potentially irrigable lands and other restrictions to development, the result is the map of lands having some potential for irrigation. Figure 23 shows a total of 1,290,000 acres of land in the Upper Snake River Basin (approximately 226,000 acres on the Eastern Snake Plain aquifer) that have soil conditions that are suitable for irrigation. This does not include an unknown amount of small, unirrigated tracts inside the area designated as presently irrigated. There are few large, contiguous blocks of undeveloped land remaining that would be practicable for new, large-scale irrigation development. Physical limitations, such as climate, topography, and water supply preclude irrigation expansion in much of the 1,290,000-acre area. The conclusion is that most irrigation expansion will be limited to areas immediately adjacent to already irrigated tracts, in-fills within the larger irrigated areas, and small "islands" of presently nonirrigated or water-short lands within the area shown to be presently irrigated. These include field corners, isolated small tracts, and other pieces that for some other reason have not been irrigated.

**Livestock Water Use**

A cattle and sheep inventory for the Upper Snake River Basin showed more than one million animals (1992 Census of Agriculture). Twenty percent of the cattle are dairy animals. The dairy industry, particularly in the Magic Valley, has expanded rapidly since 1990 and shows indications of continued growth.

The quantity of ground water diverted for livestock in the Basin is estimated at 20,000 acre-feet. The estimate is based on the number of livestock in the basin, livestock type, and average water consumption per head. Livestock water includes water for both stock watering and other on-farm needs. Stock water and other rural water requirements, aside from irrigation, are met largely from individual sources such as wells or ponds. Some canals in the Henrys Fork, Fall River, and Teton River basins divert surface water throughout the year for these purposes.

Figure 23
Upper Snake River Basin



Beef cattle graze public and private rangeland as well as irrigated pasture. The Upper Snake River Basin contains more than 11 million acres of rangeland varying from grassland and sagebrush to coniferous forest. Very few sheep are raised in farm flocks; most are raised in the upland, mountain areas but may winter in valleys. On the range and in the mountains, livestock usually water freely at streams or springs unless watering stations have been developed.

**Domestic, Commercial, Municipal, and Industrial Water Use**

Data for the domestic, commercial, municipal, and industrial (DCMI) water use in the Upper Snake River Basin were taken from the U.S. Geological Survey (USGS) preliminary 1995 water-use estimates. Water-use deliveries are both self-supplied and from public water suppliers. The largest demand for DCMI uses is concentrated near the major population centers of Idaho Falls, Blackfoot, Pocatello, Burley, Jerome, and Twin Falls. The 1995 basin population is estimated to be 419,450. The total DCMI deliveries in 1995 were estimated to be about 334.58 million gallons per day (MGD; 375,000 acre-feet).

Municipal water use estimates are not shown as a separate item since they are included in the water deliveries from public water suppliers. Municipal water use includes domestic, commercial, and industrial use. Municipalities supply water not only to residences and commercial enterprises, but also to schools, fire departments, and municipal parks.

Domestic water use includes drinking, food preparation, washing, sanitation, and lawn and garden watering. Domestic withdrawals include deliveries from public water suppliers and self-suppliers. Public water suppliers provided about 70 percent of the domestic water deliveries in the basin in 1995. Total domestic water deliveries in 1995 were estimated to be about 79.85 MGD (89,000 acre-feet).

Commercial water use can be self-supplied or delivered from public water suppliers. The 1995 commercial water deliveries to hotels, motels, stores, business buildings, hospitals, and state and federal fish hatcheries were estimated to be about 210.11 MGD (235,000 acre-feet). An important component of self-supplied commercial water use in the Upper Snake River Basin is water delivery to state and federal fish hatcheries. These are broken out as a commercial water use by the USGS. Six federal, state, and tribal hatcheries operate in the Eastern Snake Plain area raising trout and salmon for release to streams and lakes. Private hatcheries are reported by the USGS in the Animal Specialties subcategory of Livestock, and are discussed in more detail in the following section.

Industrial water use is both self-supplied and provided by public water suppliers, and incorporates manufacturing processes, cooling, and employee sanitation. The major categories of industrial water use in the Upper Snake River Basin are phosphate processing, food processing, and water use at the INEEL. Food processing industries withdraw relatively large volumes of water for meat packing, fruit, vegetable, and fish preservation, and beet sugar refining. The withdrawals for food processing have a distinct seasonal pattern. Water use for sugar refining and potato processing is highest from September through March, water use for canning and freezing of fruits and vegetables peaks from July through October and water use for milk and the meat and fish processing industries is relatively constant throughout the year. Industrial water withdrawal estimates were 4.99 MGD from public water suppliers and 29.94 MGD from self-suppliers for a total of 34.93 MGD (39,000 acre-feet).

### *Non-Consumptive Use*

Non-consumptive uses include aquaculture, hydroelectric power generation, and instream flows for fish and wildlife habitat preservation and for recreation.

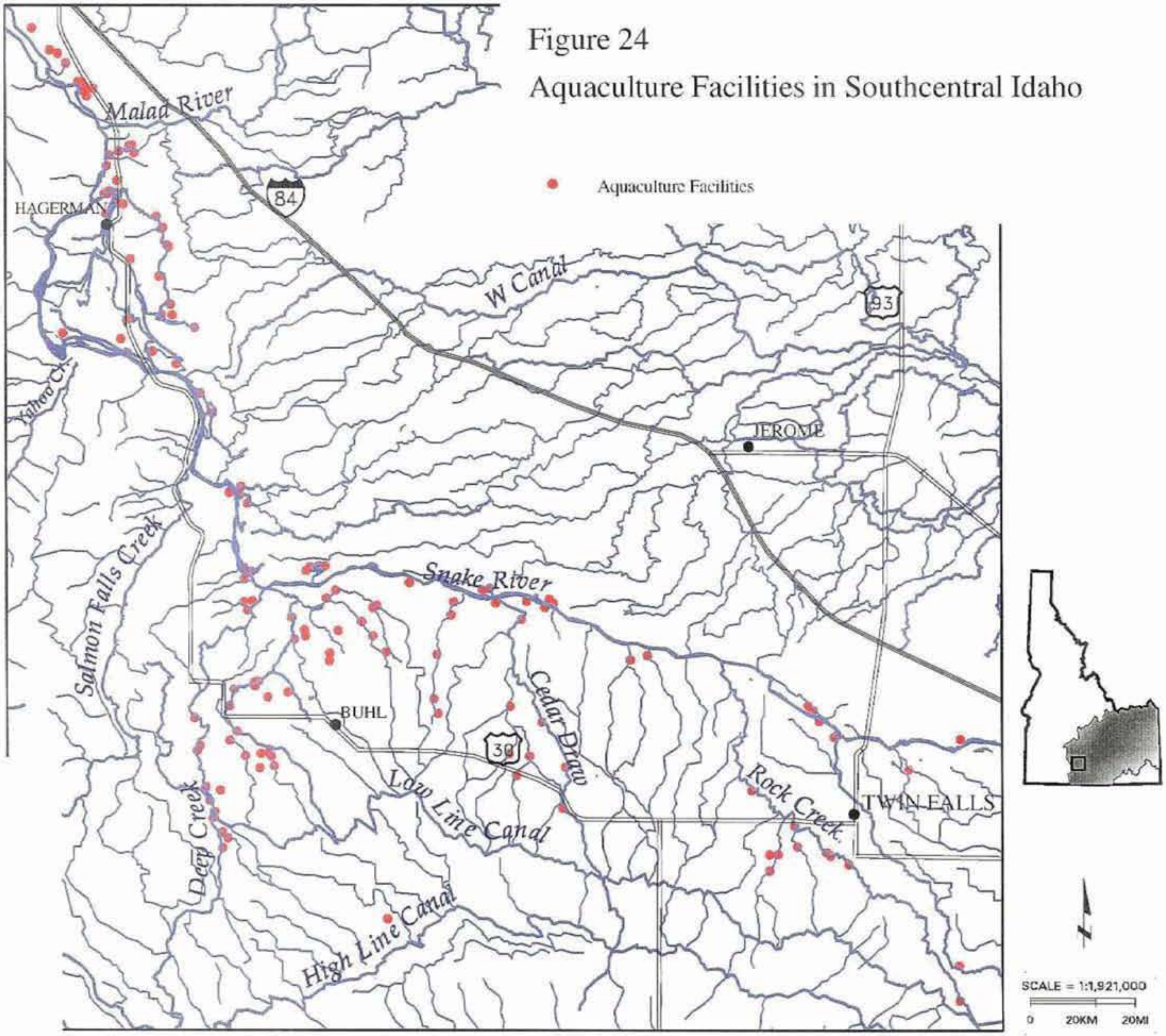
**Aquaculture**

The Idaho aquaculture industry ranks as the third largest food-animal producing business in the state (Brannon and Klontz, 1989). In the Eastern Snake Plain Aquifer area, approximately 2,000 ponds or raceways divert an estimated 1.5 million acre-feet of water annually to raise food fish (IDA, 1996). As discussed earlier, this volume does not include diversions to the six federal, state, or tribal hatcheries using commercial water. No two individual fish raising facilities are alike in pond design, water utilization, fish density per unit of water volume, or fish husbandry methods. However, most of the commercial fish hatcheries use a series of flow-through raceways that continuously pass water through the units.

The first commercial trout (rainbow) hatchery was established by Rea in 1893-94 on a spring creek near his home in the Shotgun Valley area (Brooks, 1986). In 1928 the Snake River Trout Farm at Clear Lake, the first modern raceway farm, began operation. Four trout farms were in production by 1935 and eight had been established by 1950. The early 1970s saw an explosion in development and expansion of aquaculture facilities, with most of the growth occurring in Gooding, Jerome and Twin Falls Counties (Figure 24). While there are more than 125 commercial fish producers in the Eastern Snake Plain area licensed by the Idaho Department of Agriculture (IDA), most of the production comes from about a half dozen major facilities (IDA, 1995; U of I, 1991).

The aquaculture industry relies almost exclusively on natural spring flow for its water source. The larger fish farms use water from springs emerging from the Eastern Snake Plain Aquifer along the northeast canyon wall. An estimated 50 percent of the spring flow along the Snake River between Milner Dam and Bliss Reservoir is utilized for fish production. Many of the smaller farms use water from springs arising south and west of the river, or water from seep tunnels, creeks, or canals.

Figure 24
Aquaculture Facilities in Southcentral Idaho




Source: DEQ, 1997.

**Power Generation**
Approximately half of Idaho's hydroelectric power generating facilities are located in the Upper Snake River Basin. Total installed capacity is greater than 700 megawatts (Table 15). Hydroelectric projects in the area use approximately 40 million acre-feet of water annually to produce on average about three million megawatt hours, or about 30 percent of total hydropower generation in Idaho. Data on Table 15 show the generating capacity, and average annual electric power generation at the larger hydropower installations in the area. Their locations are shown on Figure 25.

The principal source of electric energy in Idaho is hydropower. The Pacific Northwest hydropower system developed around the abundance of flowing water and favorable generating sites. Alternative fuels, such as coal and natural gas have been limited in availability in the region, and nuclear power production has been fraught with unresolved legal and public safety questions. Hydropower is a renewable energy resource, and its development and operations are free from toxic emissions and have few associated waste problems.

Hydropower generation is not without certain problems and limitations. Capital costs are often quite high. These costs make up the majority of hydro energy costs and, once invested, reduce the uncertainties regarding future costs of energy from the project. Therefore, long-term production costs and relative user costs are relatively low. Hydropower projects generally have a longer useful life than other energy producing facilities. Adverse impacts to fish and some forms of recreation have only recently been considered.

Siting, licensing, and designs are often complex and frequently require a long lead time. Hydropower sites are often remote from load centers, requiring long transmission lines. Transmission and the necessary access road costs can render small remote projects commercially infeasible. Because stream flows are affected by vagaries in annual weather conditions, a portion of the average output of most hydropower projects is non-firm energy -- energy that cannot be counted on to meet regular demand. It is available only when physical generating conditions are favorable and not necessarily when, or where, the energy is needed. But, unlike such renewables as wind or solar power, hydropower is rarely intermittent on a daily basis; if it is on in the morning, it will likely be on in the evening. Most hydropower projects have the ability to quickly go on line, increasing production to meet demands.

While most of the commercial electric power used in the Upper Snake River Basin is generated by hydropower, other projects have been actively pursued in the recent past with little result due to unfavorable economics, environment concerns, or public objections. Several small cogeneration plants have limited commercial capacity. Many other large and small potential hydropower sites have been identified but have not yet been found practicable for commercial development.

Most of the generating potential of the existing hydroelectric system is realized during the spring and early summer, coinciding with the major stream runoff season. By late summer, and into the early autumn, electricity demand remains high due to continued irrigation pumping and sustained industrial needs, but stream flows and their corresponding power generation potential have diminished. In the past, this imbalance was countered by increased energy imports, and occasionally by proposals for new run-of-river hydroelectric facilities. In the future, potential hydropower sites will still receive attention from utility developers. Increased water storage capacity dedicated to hydropower production at existing facilities may be proposed, and seasonal imports of electric power from outside the region will continue. It is too early to speculate as to the effects that utility deregulation may have on future open market competition for power supplies.

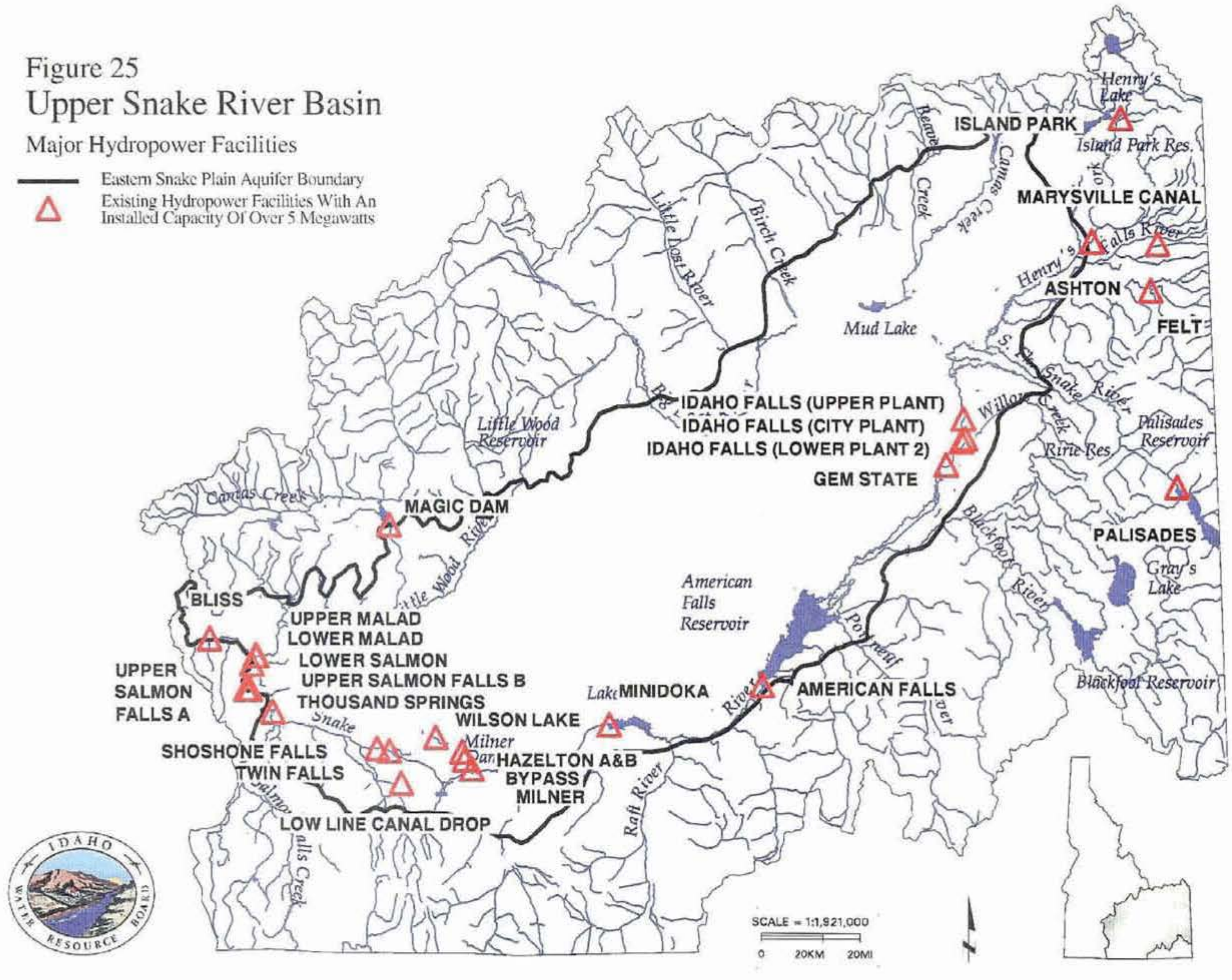
**Table 15. Hydropower Facilities with Capacities Greater than Five Megawatts in the Upper Snake River Basin.**

| Power Plant | Stream | Owner Class | Installed Capacity (MW) | Average Annual Generation (MWH) |
|---|---|---|---|---|
| Bliss | Snake River | Public stockholder utility | 75.0 | 379,300 |
| Malad | Malad River | Public stockholder utility | 21.7 | 180,000 |
| Lower Salmon | Snake River | Public stockholder utility | 60.0 | 270,000 |
| Upper Salmon | Snake River | Public stockholder utility | 34.5 | 312,700 |
| Thousand Springs | Springs | Public stockholder utility | 8.8 | 61,500 |
| Magic Dam | Big Wood R. | Private company | 9.0 | 31,200 |
| Low Line Canal Drop | Canal | Canal company | 8.0 | 46,800 |
| Hazelton A&B | Canal | Canal company | 16.2 | 55,000 |
| Wilson Lake | Canal | Canal company | 8.4 | 28,000 |
| Shoshone Falls | Snake River | Public stockholder utility | 12.5 | 102,000 |
| Twin Falls | Snake River | Public stockholder utility | 43.7 | 275,000† |
| Milner | Snake River | Canal company/private | 59.5 | 180,000 |
| Minidoka | Snake River | Federal government | 12.4 | 94,000 |
| American Falls | Snake River | Public stockholder utility | 92.3 | 400,000 |
| Gem State | Snake River | Municipal utility | 23.4 | 125,000 |
| Lower Plant | Snake River | Municipal utility | 11.0 | 69,270 |
| City Plant | Snake River | Municipal utility | 8.0 | 50,328 |
| Upper Plant | Snake River | Municipal utility | 8.0 | 50,328 |
| Felt | Teton River | Rural electric cooperative | 7.45 | 26,500 |
| Marysville Canal | Canal | Private company | 9.1 | 51,500 |
| Ashton | Henrys Fork | Public stockholder utility | 5.8 | 36,200 |
| Island Park | Henrys Fork | Rural electric cooperative | 6.5 | 11,800 |
| Palisades | Snake River | Federal government | 176.6 | 610,000 |

†Installed capacity increased in 1995; the figure represents potential generation

Sources: FERC, 1988 and 1996; IDWR - Energy Division, 1994.

Figure 25
Upper Snake River Basin
Major Hydropower Facilities



**Fish, Wildlife, and Recreation**
Habitats for resident fish in the Upper Snake River Basin include many clear, cold, small streams in the higher elevations, more than one hundred natural lakes, numerous reservoirs of various sizes including four of more than 16,000 surface acres each, as well as the larger streams such as the Snake River. Total surface water area in the Upper Snake River Basin is about 270,000 acres, including more than 30,000 stream miles. Many stream reaches experience moderate-to-severe flow shortages, accompanied in some cases by deteriorated water quality conditions, which may impact resident fish habitats. Fish, wildlife, and recreation water uses are discussed in subsequent sections of this report.

### *Summary*

Estimates of total ground water storage within the area range from 200 to 300 million acre-feet in the top 500 feet of aquifer depth (Lindholm, 1986). Native vegetation and evaporation from bare ground and water surfaces consume approximately 11 million acre-feet of water per year. Irrigators withdraw about 10 million acre-feet of surface water and 3 million acre-feet of ground water in the basin. Crops consume more than four million acre-feet. Surface return from irrigated acreage within the area is estimated at 8.5 million acre-feet. Stock water diversions approximate 20,000 acre-feet per year. Domestic, commercial, municipal, and industrial demand is about 375,000 acre-feet per year of which approximately 7,400 acre-feet is consumed. Aquaculture diverts an estimated 1.5 million acre-feet per year for fish rearing in the basin (IDA, 1996; Erickson, 1996). Hydroelectric projects in the area divert approximately 40 million acre-feet of water annually, much of which is reused from previous diversions. Fish, wildlife, and recreation use approximately 20 million acre-feet of water annually, most of it originally diverted or withdrawn for some other beneficial use. About 8 million acre-feet of water leave the area as surface runoff; there is no significant ground water underflow leaving the area.

## WATER QUALITY

### *Ground Water Quality*

The Eastern Snake Plain Aquifer is a ground water basin comprised primarily of two integral aquifer systems. Porous zones between the layered basalt flows comprise the primary regional aquifer system, while several alluvial aquifer units are located along its periphery (Neely, 1994). Where unconsolidated alluvial sediments overlay the basalt, they are generally 10 to 200 feet thick. These sediments form the alluvial aquifers when they are saturated. The two aquifer systems are separated vertically by as much as several hundred feet of unsaturated basalt.

The ambient water quality of the regional aquifer is considered to be very good because of its large volume and high recharge rate (Jehn, 1989). Locally however, it is vulnerable to contamination. The porous and permeable nature of the aquifer layers, and the discontinuous overlying soils, provide little opportunity for filtration, sorption or other attenuating effects on pollutants. The Eastern Snake Plain Aquifer is also a sole source of drinking water for many of the 400,000 people living in the basin, and was designated by the Environmental Protection Agency as a Sole Source Aquifer in 1991 (U.S. EPA, 1991; see pg. 118).

**Monitoring and Assessment**
The Eastern Snake Plain Aquifer has been the focus of numerous ground water quality studies and assessment efforts over the past twenty years, some at a regional level, and others at a more local level.

Regional Monitoring and Assessment

The ***Regional Aquifer System Analysis (RASA)*** studies, conducted by the U.S. Geological Survey (USGS) beginning in the mid-1980s, concentrated their efforts on the hydrology, geochemistry, and ground water quality of the Eastern and Western Snake Plain aquifers.

The ***National Water-Quality Assessment Program (NAWQA)*** was implemented in 1991 by the USGS in the Upper Snake River Basin. The goals of the program were to describe the status and trends in quality of the Nation's surface and ground water resources and to provide a sound and scientific understanding of the factors affecting their quality. The upper Snake River Basin was one of the first areas in the country to be studied. The program will be a low intensity effort until 2001, monitoring just a few wells and surface waters in the region. More intensive studies are to begin then and continue for an indefinite period.

***The Statewide Ambient Ground Water Quality Monitoring Program***. In 1990, the Legislature assigned and funded the IDWR to implement a prototype statewide ambient ground water quality monitoring program (Statewide Program) to help determine the magnitude of the problem (Neely and Crockett, 1992). In the initial 1990 effort, water samples were collected from 97 randomly selected wells and springs around the state, ten of those on the Eastern Snake Plain. Results of the monitoring were compared with the *maximum contaminant levels* (MCL) drinking water standards established by the U.S. Environmental Protection Agency (EPA).

Beginning in 1991, the Statewide monitoring program was expanded from 10 to 87 monitoring sites on the Eastern Snake Plain. In 1995, the IDWR summarized the monitoring results of the Statewide Program for the first three years (Crockett, 1995). These results are shown on Table 16, and are described below. Since 1991, the Statewide network of sampling sites has been expanded to include 412 locations on the Eastern Snake Plain and another 235 in the tributary basins (Figure 26).

Local Monitoring and Assessment

***The Fort Hall Ground Water Quality Study*** began when the Shoshone-Bannock Tribes requested assistance of the Natural Resources Conservation Service (formerly Soil Conservation Service) in developing a plan to protect the ground water in the Fort Hall vicinity from agricultural contamination, and to minimize health risks (USDA, 1991).

***The A & B Irrigation District Nitrate Study*** was initiated by the IDWR when high levels of nitrates were detected in ground water wells of the A&B Irrigation District during regular water quality inspection activities in 1995. In cooperation with Idaho Department of Agriculture, historical data were obtained from A&B irrigation district records and the USBR for the period from 1980 through 1995. A report of findings is currently undergoing agency review (Mitchell, 1991).

***U.S. Geological Survey Nitrate in Ground Water Study, Upper Snake River Basin,*** was conducted between 1991 and 1995 under the National Water Quality Assessment (NAWQA) Program to evaluate the extent of nitrate contamination in ground water within the Upper Snake River Basin (Rupert, 1997).

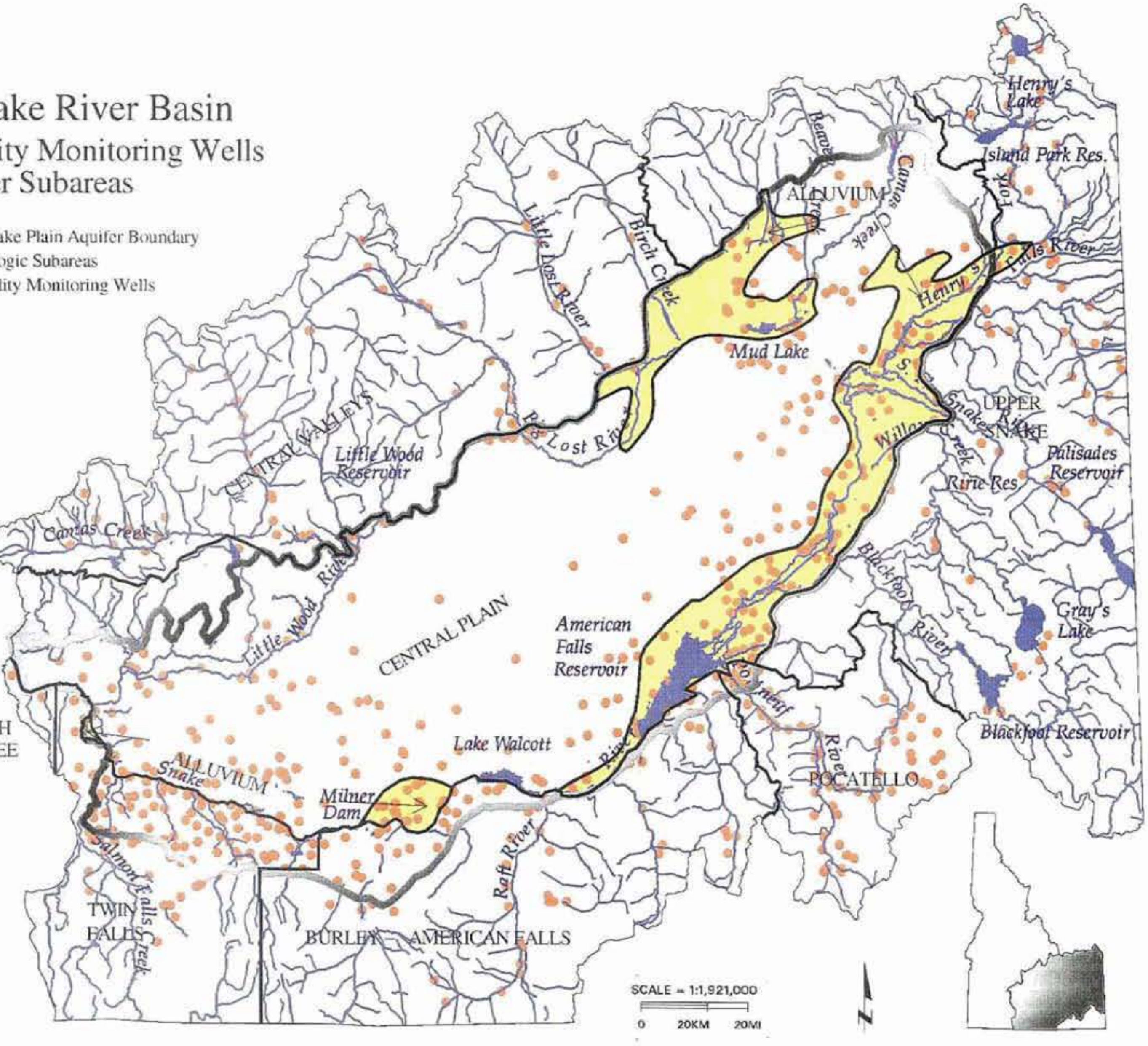
**Table 16. Summary of Analysis for Selected Constituents, 1991 - 1993**

| Aquifer Subarea | Total Dissolved Solids (mg/l) range median | Nitrate (mg/l) as N range median | Sulfate (mg/l) range median | Arsenic ($\mu$g/l) MCL=50 range | Cadmium ($\mu$g/l) MCL=5 range median | Alpha (pCi/l) MCL=15 range/median median | Uranium ($\mu$g/l) # samples range | Radon (pCi/l) range median | Detected Organics (includes VOCS [a] and pesticides [b]) |
|---|---|---|---|---|---|---|---|---|---|
| Central Valleys | 91 - 598<br>190.5 | <0.05-6.0<br>0.34 | 0.4 - 130<br>4.1 | <1-3 | no detections | 0-18.1<br>2.6 | - | <80-<br>2600<br>875 | Naphthalene [a]<br>Chloromethane [a] |
| Alluvial Areas | 141 - 1873<br>307 | <.05-35<br>1.70 | <0.1-620<br>43 | 1-110 | no detections | 0-40<br>1.8 | 1<br>33 | 180-<br>1600<br>590 | Chloromethane [a]<br>Benzene [a]<br>Ethylene Dibromide (EDB) [b]<br>Dichloropropane (DCP) [a]<br>Trichloropropane (TCP) [b] |
| Central Plain Area | 138 - 862<br>299 | <.05-35<br>1.45 | 0.9-150<br>38.5 | 1-34 | 1-35 | 0-18.3<br>2.4 | 1<br>15 | <80-<br>1200<br>234 | Perchloroethlene (Perc) [a]<br>Chloromethane [a]<br>Xylenes [a]<br>Ethylene Dibromide (EDB) [b]<br>Triazine [b] |
| Twin Falls Area | 140 - 1206<br>592 | <.05-19<br>3.70 | 8.3-460<br>110 | 1-33 | no detections | 0.1-43.9<br>7.3 | 9<br>16-45 | 90-848<br>280.5 | Triazine [b]<br>Dacthal [b] |
| Burley - American Falls Area | 159 - 2212<br>387 | <.05-12<br>0.91 | 1.6-430<br>37.5 | 1-7 | no detections | 0-15.8<br>4.55 | 1<br>8 | 120-870<br>475 | Triazine [b] |
| Pocatello Area | 172 - 1027<br>476 | <.05-11<br>1.60 | <0.1-160<br>40 | 1-41 | no detections | 0-17.9<br>3.7 | 1<br><5 | 290-<br>1400<br>479 | Toluene [a]<br>Perchloroethylene (Perc) [a]<br>Trichloroethylene (TCE) [b]<br>Trichloroethane [b]<br>Carbamate [b] |
| Upper Snake Plain Area | 63 - 629<br>243 | <.05-14<br>0.87 | 1.0-150<br>8.85 | 1-7 | no detections | 0-29.2<br>1.3 | 1<br>22 | 176-<br>2668<br>960 | Triazine [b]<br>Carbamate [b] |

Source: Crockett, 1995.

Figure 26
## Upper Snake River Basin
### Water Quality Monitoring Wells And Aquifer Subareas

- Eastern Snake Plain Aquifer Boundary
- Hydrogeologic Subareas
- Water Quality Monitoring Wells
- Alluvium




Source: IDWR Ground Water Monitoring Data.

***Idaho National Engineering and Environmental Laboratory (INEEL) Ground Water Monitoring Program*** began at the site in 1949 and has become more comprehensive over time (Ground Water Quality Council, 1992). Between 1986 and 1988, the USGS conducted measurements of radionuclide and chemical waste constituents in ground water from the Eastern Snake Plain Aquifer at INEEL (Orr and Cecil, 1991).

Subsequent programs have been implemented to monitor potential contamination movements from the site and into the Eastern Snake Plain Aquifer. These programs were started to respond to the public's concerns over possible water contamination from INEEL activities, as well as to learn more about the chemical quality of the aquifer. To meet both objectives, many physical and chemical properties are measured; most of these properties are not related to past or current practices at the INEEL, but provide data necessary in evaluation of over all aquifer water quality. Data have thus far shown that reportable quantities of most site-related contamination have not migrated significantly beyond the site boundaries (Campbell, 1996).

The ***INEEL Oversight Environmental Surveillance Program*** was established in 1993 as a cooperative project of the Idaho Department of Health and Welfare (IDHW) and Idaho State University's Environmental Monitoring Laboratory. Its purpose is to supplement other programs in monitoring air, water, and terrestrial environments at the INEEL and surrounding areas (State of Idaho Oversight Program, 1995). The Oversight Program, now administered by the Idaho Division of Environmental Quality (IDEQ), independently collects data concerning air, water, environmental radiation, and terrestrial biology, both on and off the INEEL site, in order to identify contaminants in the environment that may have originated from INEEL activities. These data are then compared with the results of other monitoring programs for the area and the results are reported on a scheduled basis.

The ***INEEL Ground Water Monitoring Plan*** was developed in 1993 to determine the effects of site operations on ground water quality and quantity, and to determine the levels of compliance achieved under federal, state, and local laws and requirements (Sehlke and Bickford, 1993). Programs are conducted by monitoring a network of 238 new and existing wells on-site and in the vicinity of Department of Energy facilities. Data collected under the program will provide early detection and reporting of ground water contamination originating at the site, maintain surveillance of any contamination discovered, and assist in decisions concerning management and protection of the ground water resource. Monitoring is planned to continue throughout the remaining operational life of the INEEL.

The ***Magic Valley Monitoring Project*** is a joint effort initiated in 1989 by the USGS and the IDWR, and funded by the Department of Energy (Campbell, 1996). This is an effort to monitor radionuclides, chemical constituents (trace elements and nutrients), organic and inorganic compounds, and bacteria in water collected from sites between the southern boundary of INEEL and the Thousand Springs area near Hagerman (USGS, 1989 - 1995). The results are verified with those collected by the Oversight Program (Campbell, 1996). Many parameters have been measured at concentrations above the reporting level but below the Maximum Contaminant Level. These include most of the naturally occurring radionuclides, trace metals and inorganic constituents, some of the nutrients, and a few organic compounds. Most of these were within the concentrations expected to be found in the environment from natural occurrence and were locally generated, not originating at the INEEL.

## *Contaminants in Ground Water*

**Nutrients** - Nutrients evaluated in the Statewide Program were nitrate, nitrite, ammonia and orthophosphorus (Crockett, 1995). Elevated nitrate is the most widespread of preventable contaminants in aquifer water supplies. Potential sources include decaying organic matter, human and animal sewage, and fertilizers. Nitrate concentrations greater than 2.0 milligrams per liter (mg/l) are considered outside the normal range of natural occurrence. The EPA has established a maximum contaminant level of 10 mg/l for public drinking water supplies. Northern Twin Falls County and the alluvium along the southern and northeastern margins of the aquifer were the areas most affected by nitrates.

The Regional Aquifer Systems Analysis studies, completed by the USGS in 1987, identified high nitrate levels in ground water in the Burley, Murtaugh and Minidoka areas. The studies also identified high nitrate values in the Blackfoot region (Parliman, 1987).

The National Water-Quality Assessment Program (Rupert, 1994) found nitrate concentrations exceeding the maximum contaminant level in three areas on the Eastern Snake Plain Aquifer: the INEEL (nitrogen-containing wastewater disposed into an injection well from 1952 - 1984; now disposed through infiltration ponds); the Fort Hall area (ground water recharges from irrigation); and the Burley area (fertilizers, confined animal feeding operations, food processing, and septic tanks draining into a perched aquifer--depth 5 - 30 feet). Wells north of Burley and northwest of Pocatello showed long- term trends of increasing nitrate concentrations. Domestic well water contained the highest median nitrogen concentrations because small domestic wells generally penetrate only the shallowest horizons of the ground water system.

Subsequent investigations of nitrate concentrations in the Upper Snake River basin by the USGS under the NAWQA Program supported earlier findings (Rupert, 1994). Nitrate plus nitrite as nitrogen concentrations were observed to be significantly higher in shallow groundwater than in areas with depths to groundwater in excess of 300 feet. The study concluded that nitrogen concentrations under the A & B Irrigation District were high because of the continual recycling of ground water and the related deep percolation of soluble nitrogen constituents. Based on the measured trend between 1980 and 1995, nitrate-nitrogen concentrations in the underlying ground water could exceed the MCL of 10 mg/l within 10 to 15 years.

The Statewide Program revealed nitrate compounds up to 2.3 times higher than the established MCLs in the Snake Plain alluvial aquifers, primarily along the southern and northeastern margins of the area (Neely and Crockett, 1992). Nitrate and phosphorus concentrations were correlated with land use type by the IDWR for portions of the Upper Snake River Basin. High nitrate concentrations were most closely associated with irrigated agriculture, when compared with dryland agriculture or rangeland areas. No statistical difference was observed in phosphorus content when comparing the identified land use types.

Commencing in 1991, the shallow aquifer underlying the Fort Hall area has been monitored for contaminants by the Soil Conservation Service. This aquifer is the primary source of domestic water on the reservation. Potential sources of the contaminants were identified and evaluated and included: 1) application and disposal of agricultural chemicals; 2) sewage lagoons; 3) landfills; 4) septic tanks; 5) drainage systems; and 6) feedlots. It was also suspected that improperly constructed wells were serving as transport mechanisms for the contaminants. Nitrate was found to be the most widespread contaminant in the alluvium. More than 200 well samples contained nitrate, and 62 samples exceeded the 10 mg/l

MCL by up to 2.8 times. The major sources of ground water nitrate were excessive fertilizer application and disposal.

**Total Dissolved Solids** - (TDS) is the residue left when a water sample is evaporated to dryness; it is an indication of mineralization (Drever 1988 cited in Crockett, 1995). The major contributors to TDS are the common ions of calcium, magnesium, sodium, potassium, bicarbonate, carbonate, chloride, fluoride, and sulfate (Crockett, 1995). Most of these are natural constituents of ground water but they can be elevated by human activities, such as industrial waste, sewage, and agricultural or urban runoff. Fresh water typically contains less than 1000 mg/l Total Dissolved Solids. The area of northern Twin Falls and Cassia counties, as well as the alluvium along the Snake River, the southern tributaries, and the Mud Lake area, had measured values of more than 1000 mg/l of total dissolved solids at more than 5 percent of the sampled sites.

**Trace Elements** - Trace elements are normally found in minor concentrations and measured in *micrograms* per liter ($\mu$g/l), except the compound cyanide, which is measured in milligrams per liter (mg/l). Trace elements included in the Statewide Program were arsenic, cadmium, chromium, copper, iron, lead, manganese, selenium, zinc, and cyanide (Crockett, 1995). Mercury was discontinued from the program in 1994 because of sampling and analytical difficulties. Most of these occur naturally from rock and soil dissolution. The potential man-caused sources for the trace elements in ground water include pesticides, and industrial and mining wastes.

The current MCL for arsenic is 50 $\mu$g/l, but the EPA is reviewing its carcinogenic tendencies and may reduce the standard to 2 - 5 $\mu$g/l. The Twin Falls area had one of the highest median arsenic levels in the state ($\geq$50% sites tested exceeded 5 $\mu$g/l). Cadmium exceeded the MCL (5 $\mu$g/l) at one well located approximately 10 miles west of American Falls Reservoir. Increased concentrations of arsenic, boron, and zinc have been reported in a shallow alluvial aquifer underlying two phosphate ore processing plants on Michaud Flats, near Pocatello (Sehlke, 1996).

**Radioactivity** - Ground water samples were analyzed through the Statewide Program for gross alpha and gross beta-particle activity and for radon (Crockett, 1995). Values of these radionuclides are recorded in picocuries per liter (pCi/l).

Gross alpha is a measurement of alpha radiation, most commonly associated with the presence of uranium. Uranium occurs naturally in rocks and ground water, but can be redistributed through phosphate fertilizers, manufacturing, and disposal of uranium-containing waste (Crockett, 1995). The MCL for alpha-particles in drinking water is 15 pCi/l. The southwestern portion of the Eastern Snake Plain Aquifer area shows elevated alpha radiation. The source for this radioactivity is believed to be the natural radioactive decay process of granite. Gross beta radiation has not been detected in quantities which exceed the EPA standard of 50 pCi/l in this aquifer (Crockett, 1995).

Radon is a naturally occurring radioactive gas that is part of the normal uranium decay process. It is found in rocks, soil, water, and air (Crockett, 1995). Airborne radon that is inhaled may cause or contribute to lung cancer. Radon in ground water can contribute between 2 and 5 percent of the indoor airborne radon through water agitation by such normal water uses as showering and dishwashers (Crockett, 1995). Drinking water standards are currently under review by the EPA. Types of soil and rock, soil permeability and thickness, meteorological factors, and especially construction and ventilation methods, are the most significant factors influencing the concentration of airborne radon in buildings (Gunderson and Wanty, 1991, in Crockett, 1995).

Low-level radioactive waste and small quantities of chemical constituents were injected into deep wells penetrating the aquifer at the INEEL until 1984 when INEEL shifted their disposal of wastes to percolation ponds (Sehlke, 1996). Tritium, the most mobile contaminant, had migrated down-gradient about 7.5 miles from the source areas and extended over an approximate 30 square mile area. The USGS found that detectable concentrations of radionuclide and chemical waste decreased during the period between 1986 and 1988. This included tritium, strontium-90, cobalt-60, cesium-137, and plutonium-238, -239, -240.

For the Magic Valley Monitoring Project no instances of contamination related to the INEEL have been observed through the program since it began (State of Idaho Oversight Program, 1994). During the first five years of the project, only one measurement has exceeded the federal MCL for public water supplies. In 1989, gross alpha-particle radioactivity at one well was reported at 18.73 ±2.46 pCi/l. The MCL is 15 pCi/l. When the well was resampled, the concentration was found to be 1.27 ± 0.54 pCi/l, well below the MCL and within the range of natural concentrations. Monitoring programs are continuing.

**Organic Compounds** - Among the many organic materials which may be found in ground water, the volatile organic compounds and pesticides are of greatest importance to water quality. The Statewide Program tests for volatile organic compounds (VOCs) and pesticides. Non-volatile compounds are tested under other programs as local conditions may warrant. VOCs can include solvents, degreasers, fumigants, and dry-cleaning chemicals used in industries and homes. They also include some pesticides. For example, ethylene dibromide (EDB), dichloropropane (DCP), and tricholopropane (TCP) are pesticides that are detected through the VOC analysis because they possess the properties of VOCs. TCP is a product of DCP breakdown. In general organic compounds can easily penetrate into the ground water, are persistent for long periods, and are very difficult to remove.

Volatile Organic Compound contamination in the Upper Snake River Basin occurs in agricultural and industrial areas, as well as in remote areas where neither influence is obvious. Sixteen percent of the wells sampled in the Portneuf valley south of Pocatello were affected by trichloroethylene (TCE), a substance used in metal degreasing, cleaning of electronic parts, and dry cleaning (Crockett, 1995). Perchloroethylene, or Perc, has been found in wells in the Blackfoot, Chubbuck and Portneuf valley areas in excess of the established MCL of 5 $\mu$g per liter.

A wide variety of organic compounds are used as pesticides to control plants, insects, nematodes, fungi, and other pests. Some are also used as defoliants or desiccants prior to harvest or as growth regulators (Clark, 1994). Different pesticides have markedly different chemical properties that result in different environmental behavior. Some pesticides are soluble in water whereas others are not. Some degrade rapidly in the environment whereas others are resistant to degradation and may persist for long periods. Pesticides that are insoluble, or hydrophobic, and resistant to degradation tend to accumulate on sediments and in the fat tissue of aquatic organisms and can therefore affect water quality conditions long after the applications have ceased. These constituents can reach the ground water resource through excessive application rates or discharge into home and commercial septic and sewer systems. In the Eastern Snake Plain Aquifer area, the organic pesticides cyanazine, 2,4-D, DDT, dacthal, diazinon, dichloropropane, dieldrin, malathion, and metribuzin have been detected in 17 out of 211 wells sampled (Rupert, 1994).

Recent trends in pesticide use have been toward more soluble and less persistent compounds like the triazine and chlorophenoxy-acid herbicides and carbamate insecticides. These compounds typically degrade in soils and water much more quickly than the organochloride insecticides, like DDT and its relatives (Clark, 1994). The estimated half-life of 2,4-D (chlorophenoxy-acid herbicide) in an aerated soil is four to 30 days (Biggar and Sieber, 1987, cited in Clark, 1994). The estimated half-life of carbofuran (carbamate insecticide) is 9 to 11 days.

Pesticides detected in the Eastern Snake Plain Aquifer through VOC analyses were: ethylene dibromide (EDB), 1,2-dichloropropane (DCP), and 1,2,3-trichloropropane (Crockett, 1995). In the Fort Hall community area, EDB exceeded the MCL at four sites in the basalt and alluvium. DCP exceeded the MCL at one location near Fort Hall. DCP's use as a soil fumigant has been discontinued (USDA, 1991). EDB had been used as a pesticide and fumigant, but those uses have been curtailed by the EPA. Pesticide testing through immunoassay methods from 1992 through 1995 revealed detections at 25 of 368 sites tested (7 percent) on the Eastern Snake Plain. In the tributary valleys, immunoassay testing revealed detections at 26 of 343 sites (8 percent). In both cases, triazine comprised over 80 percent of the detections (Crockett, 1997). Other immunoassay detections included alachlor, carbamates carbofuran, and metolachlor. Prior to 1994, pesticide testing via gas chromatography (GC) was very limited; dacthal was detected at one site in the Twin Falls area.

In 1994, the Statewide Program tested some sites with a GC method that provides results for 50 pesticide compounds in the *parts per trillion* range (Crockett, 1997). In the Upper Snake River Basin, 93 of 155 sites tested via this method (60 percent) showed the presence of one or more pesticides. In the tributary valleys (Twin Falls, Burley-American Falls, and some in Portneuf and Upper Snake), 53 of the 97 sites tested via this method (55 percent) showed the presence of one or more pesticides. Triazine was detected at the vast majority of these sites, but detections also included alachlor, carbaryl, diazinon eptic, linuron, metolachlor, metribuzin, permethrin, prometon, and trifluralin.

**Bacteria** - Fecal coliform bacteria are indicators of the presence of human or animal waste which can contribute pathogens to ground water (Crockett, 1995). Although not frequently detected in the Upper Snake River Basin, bacteria in ground water are a concern because of potentially serious and immediate health effects. While fecal coliform bacteria have been detected throughout the area, the highest percentage of detections was in the shallow aquifer alluvium between Burley and Pocatello. Bacteria are a significant ground water quality concern; however, because bacteria do not travel far in ground water, the concern is best addressed at the local and individual level (Crockett, 1995).

### *Ground Water Vulnerability Assessment*

The vulnerability of ground water to contamination is dependent on several factors: depth to water, recharge rate, soil type, and the overlying land use (Jehn, 1989). Infiltration from the land surface is the most common mechanism of ground water pollution. Contaminants continue to migrate downward until they reach the water table; then they may move down the hydraulic gradient, usually with little mixing or dilution. Perched water can occur when downward moving recharge meets an impervious layer. This water can then move laterally, carrying contaminants with it, until it either reaches the edge of the inhibiting layer, is pumped from the aquifer, or is discharged as a spring or seep.

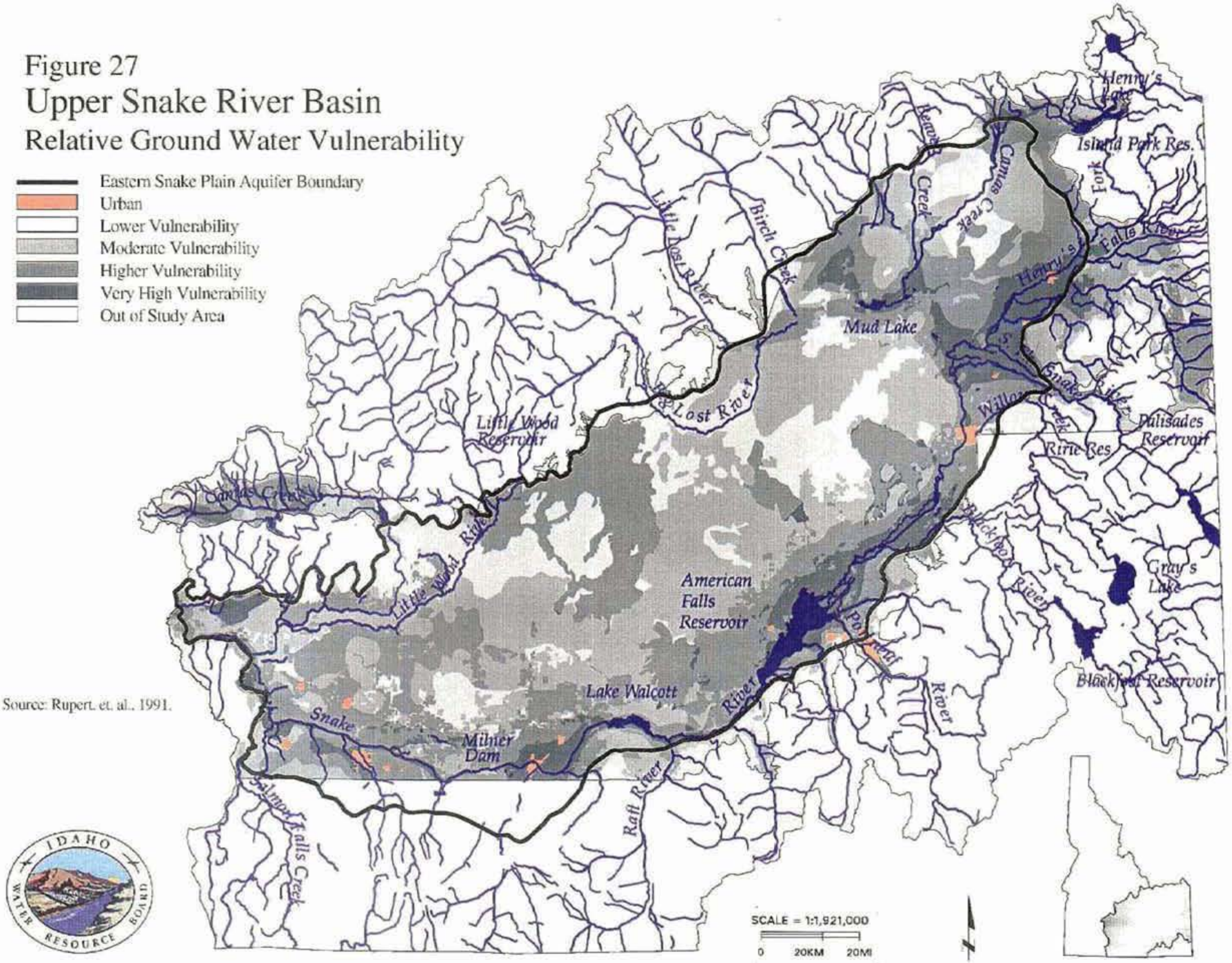
The Idaho Ground Water Vulnerability Project was initiated by the Idaho Division of Environmental Quality (IDEQ) with cooperation from the IDWR, the USGS, and the NRCS (Rupert, et al., 1991). The objective was to rate the Snake River Plain's ground water vulnerability to contamination and develop maps of the relative ground water pollution potential. Vulnerability maps combine information on hydrogeologic and land use characteristics to portray the pre-disposition of particular areas to ground water contamination. The Ground Water Vulnerability map (Figure 27) was generated by merging three characteristics; depth-to-water, land use, and soil attributes, into one map using geographic information system (GIS) techniques.

Evaluation of the depth to first-encountered water below the land surface is a significant element in evaluating susceptibility of ground water to contamination, because areas where the water table is close to the surface typically have a higher probability for ground water contamination. Also, many of the domestic wells in the Eastern Snake Plain Aquifer are constructed into the shallowest water encountered, whether in small perched aquifers or the deeper regional aquifer. The recharge component represents the amount of water that penetrates the land surface and descends to the water table below. Downward moving water may carry contaminants from the surface, therefore the higher the volume of water that penetrates the surface the greater the possibility of contaminants reaching the aquifer. Since precipitation on the Eastern Snake Plain Aquifer is generally less than 10 inches per year, direct precipitation supplies little recharge to the aquifer. Irrigation, along with percolation from surface streams, are therefore much greater components of recharge and potential ground water contamination. Soil characteristics are an important factor in determining ground water susceptibility because they can affect contaminant movement by sorption and filtration.

Total acres in each category were combined with vulnerability ratings, resulting in a categorization of areas vulnerable to ground water contamination from any source. The map does not show areas that will be contaminated, areas that are immune to contamination, or areas that have already been contaminated. Rather, it considers only the ability of water to transport contaminants from the surface to the water table, and it does not consider the individual characteristics of specific contaminants. The map indicates that the areas of greatest vulnerability to ground water contamination are those irrigated lands overlying shallow or perched local aquifers and the areas of recent lava flows which have little or no soil cover to absorb contaminants.

The vulnerability map provides a tool for prioritizing ground water management activities. Areas of higher vulnerability can be given priority for various available protection measures in order to assure that limited resources are effectively used in areas of greatest concern. Many regulatory programs make use of the maps including: underground storage tank, wellhead protection, ground water monitoring, public water supplies, waste water management, and hazardous waste management. The map also provides a valuable data resource for future detailed studies, including formulation of Best Management Practices (BMP's).

Figure 27
# Upper Snake River Basin
## Relative Ground Water Vulnerability



## *Surface Water Quality*

Consideration of surface water quality is important to any assessment of ground water conditions because contamination of one may be directly and conjunctively related to contamination in the other. On the Eastern Snake Plain Aquifer, this concern extends to downstream irrigation and other uses of surface water including recharge sources.

**Surface Water Monitoring and Assessment**

Numerous water quality studies have been conducted on the Snake River and tributaries since 1970. During the mid-1970s the EPA conducted a number of investigations on the Magic Valley reach of the Snake River and some of its tributaries. The studies concluded that a number of contaminants, including nutrients, bacteria, sediment, pesticides, and low oxygen levels affected instream values and uses of water in this reach, particularly during low, hot, summer flow periods (EPA, 1976).

***Comprehensive State Water Plan for the Snake River: Milner Dam to King Hill*** - The Middle Snake River has severe nutrient and sediment pollution from point and nonpoint sources. The primary sources identified included return flows from irrigated agriculture, confined animal feeding operations, hatcheries, hydroelectric development and specific point sources (IDWR, 1993).

***National Water-Quality Assessment Program (NAWQA)*** - The USGS study, initiated in 1991, found that surface water quality in the basin is affected by nonpoint and point sources of pollution (Clark, 1994). Nonpoint source pollution includes runoff from agricultural lands, mining operations, logging activities, construction sites, and city streets (IDHW, 1989). These sources are referred to as "nonpoint" because they cannot be traced to specific identifiable points of entrance into a waterway or aquifer. These pollutants contrast with point source pollutants which are discharged from a specific "point" or stationary location. Common point sources of pollution are discharges from industries and municipal sewage treatment plants.

In the Upper Snake River Basin, the various land and water uses result in increased concentrations of sediment, bacteria, nutrients, and pesticides in the water column; increased organic enrichment; and changes in water temperature (Clark, 1994). Of the 5,732 miles of river evaluated in the Upper Snake River Basin during the 1975 to 1989 period, 2,913 miles were affected by agriculture, 1,766 by hydrologic modification, 197 by construction, 134 by mining, 35 by forest practices, and 109 by other activities, mainly recreation (IDHW, 1989). Many reaches were impacted by more than one pollution source. Point sources of pollution include effluent from municipalities, industries, fish farms, and confined animal feeding operations (CAFOs). Instream water quality assessments conducted from 1982 through 1987 indicated that the overall water quality condition of the Snake River basin was good in the upper reaches and progressively deteriorated downstream.

***Water Quality Limited Streams*** - In compliance with the federal Clean Water Act, the IDEQ compiles a biennial list of streams whose uses are limited because of varying levels of contamination. Of the 29,944 miles of natural streams (excludes canals) in the Upper Snake River Basin, more than 2,433 stream miles (8 percent) have been found to be "water quality limited". Of the Basin's 292 square miles of lake and reservoir area, more than 106 square miles (36 percent) have been similarly designated. These water quality limited waterways were subsequently listed by the EPA under Section 303(d) of the Clean Water Act, and are shown on Figure 28. Pollutants limiting beneficial uses include sediment, nutrients, habitat alteration, oil and grease, pathogens, pesticides, ammonia, dissolved oxygen, thermal modification, and flow alteration (EPA, 1996).

The Clean Water Act requires that the afflicted water bodies be prioritized for Total Maximum Daily Loads (TMDL) for each constituent, based on standards established by the IDEQ. This development process consists of:

- Determining the pollutant load which a stream can assimilate without harm to the designated beneficial uses;
- Estimate the amount of load reduction required to protect the designated uses, based on comparison of the "safe pollutant load" and the current load;
- Allocating the "safe load" among point and nonpoint sources, thus developing the mechanism for shared load reductions.

The water quality limited water bodies of the Upper Snake Basin have been prioritized and TMDL determinations based on these priorities are being formulated in accordance with a nine-year schedule approved by the Federal District Court in March, 1997. A plan for the control of phosphorous in the mid-Snake has been developed by the IDEQ and the major water user industries in the area. It was approved by the EPA in April of 1997 and implementation is underway.

**Contaminants in Surface Water**

***Nutrients*** - Data indicate that nitrate and phosphorus concentrations generally increased in a downstream direction along the Snake River with the highest concentrations at the mouths of tributaries to the Snake River (Clark, 1994). Concentrations of nitrate, total nitrogen, orthophosphate, and total phosphorus were significantly higher at mouths of tributaries affected by agricultural activities and main stem stations than at tributaries not affected by agriculture.

Sampling stations in the central and southern parts of the Henrys Fork basin, near American Falls Reservoir and in the tributary basins southeast of American Falls Reservoir, and near the downstream reaches of the Snake River main stem have the highest concentrations of nitrates and phosphorus, attributed to agricultural practices (Clark, 1994).

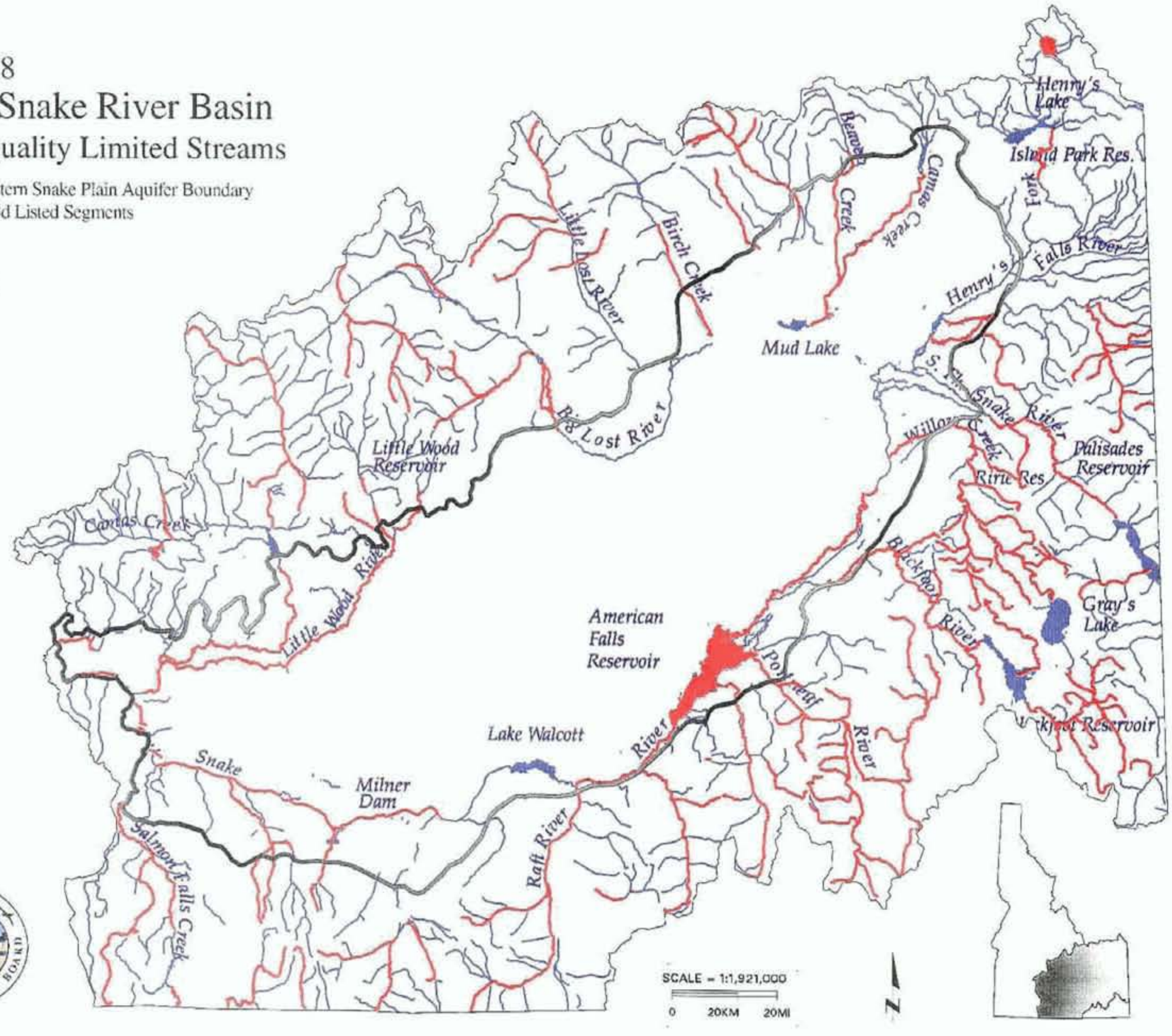
Mean annual loads of nitrogen and phosphorus compounds, as well as suspended sediments, were estimated at four stations in the basin for water years 1984, 1987, and 1989 (Clark, 1994). Except for the effect of differences in stream flow on loads, little information could be extracted from load calculations. At the Snake River near Heise and at King Hill, two to three times as much total nitrogen, phosphorus, and sediment were discharged in 1984 as in 1989 in the larger stream flow volumes. At the Rock Creek station, the large decreases in phosphorus and suspended sediment loads from 1984 to 1987 and from 1987 to 1989 are due largely to changed agricultural and other practices in the area and are not from dilution due to streamflow increases.

Reservoirs trap significant quantities of the suspended sediment and phosphorus, and provide for biological uptake of dissolved nutrients. Most of the sediment and nutrient load measured at the King Hill sampling station is generated by tributaries entering the Snake River below Milner Dam where the cumulative effects from agricultural and other land uses are the most severe (Clark, 1994).

# Figure 28
## Upper Snake River Basin
### Water Quality Limited Streams

Eastern Snake Plain Aquifer Boundary
303d Listed Segments

Source: DEQ, 1997.




Source: DEQ.

Phosphorus concentrations tended to increase in a downstream direction, but large differences between headwaters and downstream stations were not apparent, probably due to retention of phosphorus in Snake River reservoirs and dilution from spring flow (Clark, 1994). Median concentrations of phosphorus did not exceed 0.2 mg/l at any station except near the mouth of the Portneuf River, which may be attributed to phosphate-ore processing plants upstream. Dissolved phosphorus constituents may leach to the ground water and discharge to the river through spring flow. Significant downward trends in phosphorus concentrations were found along Rock Creek, which may be related to the implementation of BMP's in the drainage area.

The amount of fertilizers and pesticides applied to agricultural and range lands depends on cropping patterns and varies from year to year. From 1985 to 1990, fertilizers contributed the largest amounts of nitrogen (115,000 tons or 62%) and phosphorus (45,000 tons or 71%) to basin runoff (Clark, 1994). Areas of greatest fertilizer use were the croplands in the lower Henrys Fork and Teton basins and along most of the Snake River below the Henrys Fork. Agricultural animal wastes were the second largest source of nutrient contributions, accounting for about 30 percent nitrogen and 27 percent phosphorus. Atmospheric nitrogen from rainfall was estimated to account for approximately 10,000 tons (5%) of total annual nitrogen input. Industrial and municipal runoffs were small compared contributors, accounting for 2 percent of nitrogen and 1 percent of phosphorus loads to the basin. Municipal and industrial wastewater treatment facilities added only 0.2 percent of the nitrogen and 0.5 percent of the phosphorus loads to the Snake River annually.

At sampling locations which are not affected by agricultural activities, nitrate concentrations are slightly larger from April to June, possibly due to flushing of residual nitrogen from soils during snowmelt (Clark, 1994). At locations affected by agricultural activities, instream nitrate concentrations are smallest from April to June, due to the effects of dilution from increased streamflows. As snowmelt decreases into summer, ground water, which is a source of nitrogen to streams in parts of the Upper Snake River Basin, becomes increasingly important as a contributor to stream flow, and nitrogen fractions in the water column increase.

At all sampling stations, phosphorus concentrations were largest from April to June (Clark, 1994). Phosphorus concentrations are directly related to concentrations of suspended sediment, due to the presence of insoluble minerals associated with the sediment. Because suspended sediment concentrations are usually largest in the spring as a result of snowmelt and agricultural runoff, phosphorus concentrations in surface waters are usually greatest during the spring.

***Sediment*** - In the Middle Snake (Snake River, Milner to King Hill), suspended sediment is a serious problem. Loads were observed to increase from less than 10 tons/day at Murtaugh Bridge to as high as 350 tons/day at King Hill, during the period of June 1990 - July 1991 (Brockway and Robison, 1992). During that period, it was estimated that 13,000 tons of suspended sediment were deposited between Murtaugh Bridge and King Hill.

The USGS assessed suspended sediments along the Snake River and its tributaries from Wyoming to King Hill as part of the NAWQA program (Clark, 1994). The highest median concentrations of suspended sediment in the area were in tributary drainage basins southeast of American Falls below the Blackfoot and Portneuf Rivers, and near the downstream reaches of the main stem below Rock Creek and Salmon Falls Creek. Median concentrations of suspended sediment there exceeded 80 mg/l, (Clark, 1994). The sampling point near the mouth of Rock Creek had the highest median concentration

(80-100 mg/l) of the six sample locations on the Snake River because the basin is heavily cultivated. Implementation of Best Management Practices (BMPs) between 1982 - 1988 in the Rock Creek Basin reduced the loading of suspended sediment to the Snake River during May through August from nearly 30,000 tons per year to about 6,500 tons per year (Maret, 1990).

***Pesticides*** - Pesticide sampling was concentrated along the Snake River main-stem and at the mouths of the major tributaries or irrigation drains during 1975-1989. The primary pesticides identified were in the organochlorine and organophosphorus groups with small amounts of DDT, DDD, and DDE (organochlorines) found in samples of bottom sediments in the late 1970's. None of the compounds detected in surface water exceeded EPA criteria for human health or for acute toxicity to aquatic life, but concentrations of some elements (chlordane, dieldrin, and heptachlor epoxide) did exceed EPA standards for chronic toxicity (Clark, 1994). Sediment collected near the mouth of the Henrys Fork had the highest levels of pesticides in the basin, including DDT, DDD, and DDE concentrations that exceed 10 $\mu$g/kg (Clark, 1994). Reservoirs and slow-moving reaches on the Snake River trap most of the suspended sediment and settleable chemicals, including some of the pesticides.

***Bacteria*** - The EPA *Upper Snake River Basin Nonpoint Source Basin Status Evaluation* concluded in the mid-1970s that bacteria levels on the Middle Snake River between Milner and King Hill were not acceptable (EPA, 1976). Current efforts are being made through the *Middle Snake River Nutrient Management Plan* for industries along the river to develop innovative ideas for cleaning up or recycling waste streams, which should help reduce the bacteria levels in the river (IDHW, 1995).

## *Status and Trends in Aquatic Life*

### Macro invertebrates

Macro-invertebrate and fish communities have been used most frequently to evaluate the status and trends of stream health in the basin (Maret, 1995). Readily observable changes to the macro invertebrate communities are excellent indicators of potentially long-term aquatic environmental changes, such as siltation and "slug-loads" of short duration pollutants. More than 40% of the macro invertebrates collected from low-gradient riffle habitats during a 1991 study of the Snake River between Shoshone Falls and Hagerman were midges (family Chironomidae*)*. Large populations of these species indicate reduced water quality conditions resulting from point and nonpoint sources of contaminants as well as drought (Hill, 1992c in Maret, 1995).

Five indigenous mollusk species (snails, limpets, and clams) found in the Snake River or adjacent spring habitats are listed as Threatened or Endangered under the federal Endangered Species Act. These species exhibit limited populations and distribution as a result of severe habitat loss (Moseley and Groves, 1992 in Maret, 1995). The list includes the Utah valvata snail, Bliss Rapids snail, Snake River Physa snail, Idaho springsnail, and the Banbury Springs lanx. All are dependent on cold, oxygenated, unpolluted water for survival (Frest, 1992, in Maret, 1995).

### Fish

Historic populations of fish in the Snake River below Shoshone Falls included chinook salmon, steelhead, white sturgeon, cutthroat trout, and Pacific lamprey (Maret, 1995). Currently, Rock Creek and Big Wood River drainages are predominantly rainbow and brown trout fisheries, while the middle Snake River reach is composed of 97 percent non-game species (Hill, 1992, in Maret, 1995). This is attributed to deteriorated water quality conditions resulting from nutrient and sediment loading, elevated water temperature, and excessive plant growth. The white sturgeon still lives in the mid-Snake River, as do channel catfish, largemouth bass, and bluegill. The South Fork of the Snake River is predominantly a cutthroat and brown trout fishery. The lower Henrys Fork, Teton River, Salt River, Portneuf River, Willow Creek, and Blackfoot River are struggling cutthroat fisheries exhibiting habitat degradation, excessive harvesting, and introduction of non-native species (Thurow, et al., 1988 in Maret, 1995).

High concentrations of polychlorinated biphenols (PCB's) were found in tissue samples of fish from the Snake River near Heise and the Henrys Fork near Rexburg between 1976-1982 (Maret, 1995). Tissue samples collected from the Snake River near Twin Falls contained unusually high concentrations of toxaphene (Maret, 1995). Elevated cadmium and mercury concentrations in fish tissues taken from American Falls Reservoir were reported by several studies referenced in Maret (1995). Fish from the Henrys Fork near Rexburg had high concentrations of copper, lead, and mercury. The mercury concentrations exceeded the 1980-81 National Contaminant Biomonitoring Program (NCBP) baseline standards.

Selenium has been reported in tissue samples of fish from the Portneuf River near American Falls Reservoir, and the Snake River near Hagerman; both exceeded NCBP baselines (Maret, 1995). Arsenic concentrations were reported in fish tissue from Spring Creek near Fort Hall, Cedar Draw Creek near Filer, and the Snake River near Hagerman, all exceeding the NCBP baseline. The highest of those were reported from the Snake River sites. Zinc maximum concentration was found in fish tissue from the Portneuf River near American Falls Reservoir, also exceeding the baseline values.

### *Water Quality Issues and Concerns*

The Upper Snake River Basin is in need of a thorough ground and surface water quality evaluation, including continued monitoring, problem assessment, and implementation of innovative solutions. Shallow alluvial ground water systems, including the alluvial system at Fort Hall and the perched aquifer underlying irrigated lands below Minidoka Dam, may have the most immediate need for remediation.

As part of the Fort Hall Study, a plan was developed to implement immediate and long term actions to resolve the problems (USDA, 1991). Immediate action was recommended in the drastic reduction of fertilizer application rates and cleanup of agricultural chemical disposal sites. Longer term action was proposed concerning the application and disposal of agricultural chemicals, and upgrading of domestic septic systems. Carbon filters were installed on several community water supply wells but not on individual systems (Crockett, 1996).

A major area of concern regarding surface water quality in the Upper Snake River Basin is the Middle Snake River. Problems there are related to cumulative impacts from nutrient-laden organic and inorganic material from point and nonpoint sources in the watershed (IDHW, 1996). The *Middle Snake Nutrient Management Plan* was initiated in 1991 by bringing together the major water users in the region to draft a cooperative program for nutrient and sediment reductions (IDHW, 1995).

## *Water Quality Maintenance Programs*

**Basin Advisory Groups and Watershed Advisory Groups**

In 1995, the Idaho Legislature adopted water quality statutes that implemented a process to prioritize watersheds needing pollution management, and to develop water quality action plans through community-based advisory committees. The approach is two tiered, with Basin Advisory Groups (BAGs) developing recommendations to the IDEQ regarding water quality standards and monitoring, pollution budgets, and prioritization of impaired waters. Watershed Advisory Groups (WAGs) then develop specific watershed action plans to ensure compliance with the recommended Total Maximum Daily Load (TMDL). The Upper Snake BAG covers the entire Upper Snake River Basin, within which five WAGs have been formed: Henrys Fork, Mid-Snake, Portneuf, Big Wood, and Lake Walcott.

**Middle Snake River Nutrient Management Plan**

The Mid-Snake nutrient management plan was initiated through concerns of Magic Valley residents that water quality conditions in the Middle Snake River had significantly deteriorated (IDHW, 1995). When the problems were recognized, area residents, businesses, and government agencies drafted a regional solution, entitled the *Middle Snake Nutrient Management Plan* in 1995. The Mid-Snake is defined by that plan as the 92.5 mile reach from Milner Dam to King Hill. Water uses in the region are principally agriculture, food processing, aquaculture, and hydroelectric power production.

The plan defines pollutant reductions needed to meet state water quality standards and a schedule for implementation of pollution control mechanisms, monitoring, and assessment (IDHW, 1995). It identifies nutrient sources; it describes the dynamics of nutrient removal, use and dispersal of the nutrients; and it identifies preventive and remedial actions. It also proposes management actions for water quality factors such as sedimentation and flow. The plan identifies the need to develop acceptable base flow levels to maintain and improve water quality.

Each of six important water user groups developed an industry-specific nutrient management plan, which included target nutrient and sediment reductions, and the actions and monitoring efforts needed to accomplish them (IDHW, 1995). The water user groups included aquaculture, confined animal feeding operations (CAFOs), food processing, hydroelectric power generation, irrigated agriculture, and municipal waste treatment plants. Implementation schedules for each of the user groups defined milestones leading to full implementation within five years following approval of the Mid-Snake Nutrient Management Plan by the EPA.

The user groups have since expanded into the Mid-Snake Watershed Advisory Group, or WAG, which is developing a phased watershed management plan to achieve state Water Quality Standards. The first of the proposed plan elements, concerning phosphorous, was submitted to the EPA in December, 1996. Subsequent phases will address sediment, nitrogen, flows, and other features of concern.

**Injection Well Programs**

An injection well can be any well that is used, or intended to be used, for the subsurface emplacement of fluids. Injection wells are commonly used in Idaho to dispose of irrigation return flows, to remove storm runoff from paved surfaces, and to recharge aquifers. In 1971, the Idaho Legislature passed the Waste Disposal and Injection Well statutes to provide for the permitting and regulation by the IDWR of injection wells 18 feet or greater in depth. In 1984, the State, through the IDWR, was granted primary enforcement responsibility for all known types of injection wells by the EPA. There are some 500 deep injection wells on the Eastern Snake Plain. Most of these wells are used for the disposal of irrigation and surface water runoff.

Since the 1970s, the IDWR has developed and modified the Rules and Regulations for the construction and use of injection wells. Through these rules, numerous geologic, water quality, and well construction factors are considered in permitting injection well practices. The intent of the current program is to restrict injection well use to a level that will protect the ground water resource and the people who rely on it. The Department has also promulgated rules and developed administrative programs to regulate well drilling and the construction of water and other types of wells.

# OTHER RESOURCES

## BIOLOGICAL COMMUNITIES

Native plants, fish, and wildlife of the Upper Snake River Basin are important indicators of the natural environmental conditions that future development will impact. The ecosystem community types are indicated by the vegetation communities shown on Figure 29. Integrated into these communities are the native and introduced plants, fish, and wildlife. Of particular concern are those waning populations that because of habitat loss are species of concern. The communities consist of an interactive system that to some degree is dependent on water quality and quantity.

### *Vegetation*

**Wetlands and Riparian Area** (1.3 % of total area)

The bulrush marsh (*Scirpus acutus, Typha latifolia*) is a major wetland vegetation type in southeastern Idaho (Caicco, 1989). It is found as monotypic stands in shallow water at elevations between 5,000 - 6,000 feet.

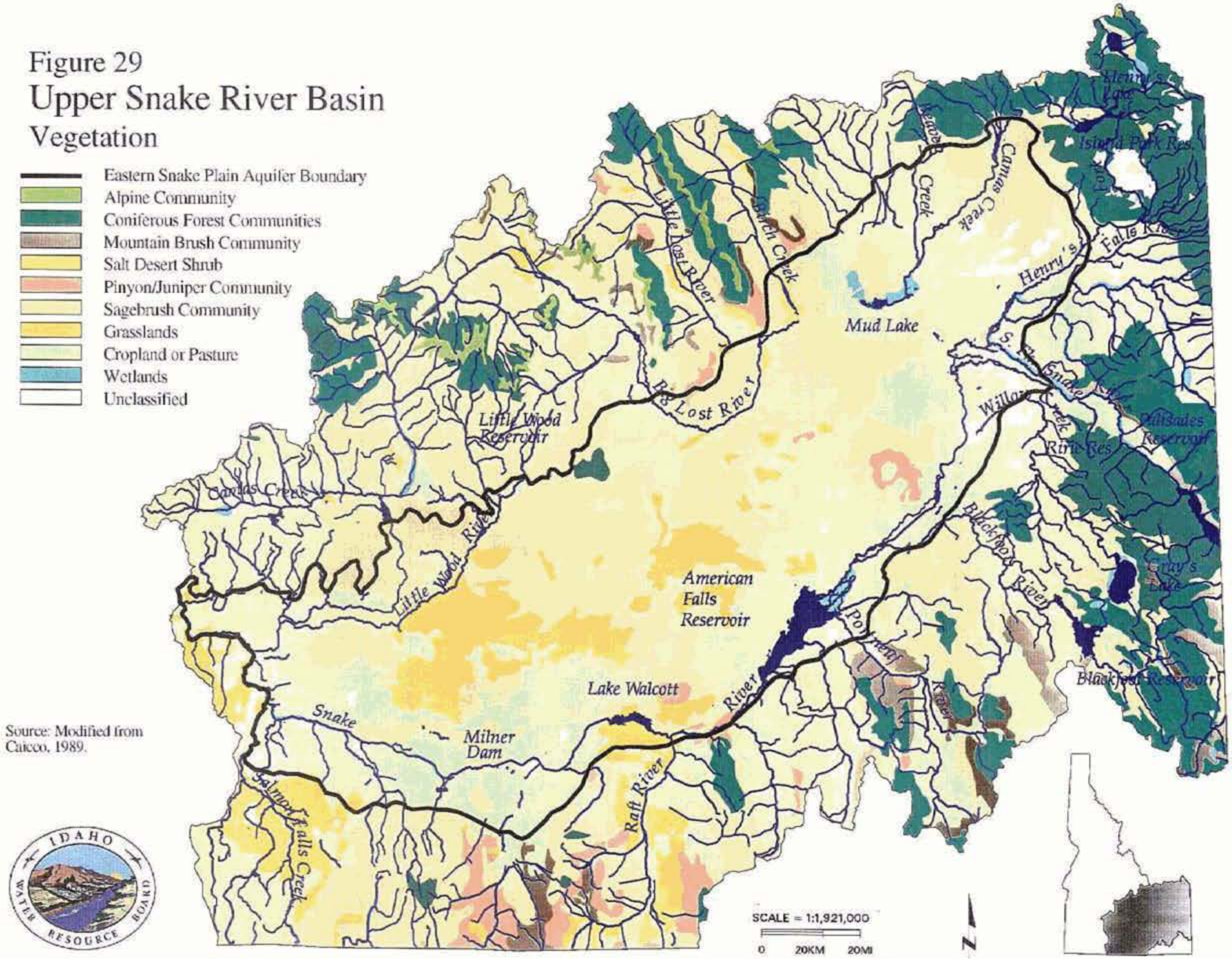
The deciduous riparian forests found on alluvial valley bottoms throughout the Eastern Snake Plain are dominated by two species of cottonwood: black cottonwood (*Populus trichocarpa*) and narrowleaf cottonwood (*Populus angustifolia*). The major type found along the Big Wood River and the Big Lost River is black cottonwood (2,100 - 5,000 feet elevation) while the predominant species in the South Fork Snake River riparian forest is the narrowleaf cottonwood (4,800 - 5,600 feet elevation).

The major riparian vegetative type found along the Teton and upper Henrys Fork rivers, and along the upper Big Lost River, is a mix of willow species (*Salix spp.*) from 4,800 to 6,200 feet elevation. These are tall shrub communities on broad valley floors dominated by Geyer's willow (*Salix geyeriana*).

**Grasslands** (6.5 % of total area)
This community is a major type throughout much of southern Idaho (Caicco, 1989). It consists predominantly of perennial bunchgrass (*Agropyron cristatum*) and is generally found between 2,300 and 5,000 feet in elevation. Vast expanses of rangeland have been planted in crested wheatgrass (*A. spicatum*). Annual grasslands are also common in much of southern Idaho, typically adjacent to the Snake River canyon and found below 5,000 feet elevation. The dominant annual grass is cheatgrass (*Bromus tectorum*) and the principal perennial grass is wild rye (*Taeniatherum caput-medusae*).

**Juniper Woodland** (2.2 % of total area)
This vegetation community is dominated by Utah juniper (*Juniperus osteosperma*) and mountain big sagebrush (*Artemesia tridentata*). These occur as open woodlands of juniper trees with fields of sagebrush in the open areas (Caicco, 1989). In the Albion Mountains and adjacent ranges of south central Idaho, pinyon pine (*Pinus monophylla*) is mixed with the juniper. The juniper woodland ranges between 4,500 and 8,000 feet elevation.

## Figure 29
# Upper Snake River Basin
## Vegetation



**Sagebrush** (44.6 % of total area)
The major vegetation type in the Upper Snake River Basin, the sagebrush community is composed of several shrub species, including mountain big sagebrush (*Artemisia tridentata, A. arbuscula, A. tripartita, A. nova, A. frigida*). These communities occur between 2,500 and 8,000 feet elevation on relatively dry sites (Caicco, 1989). At higher elevations and on wetter north-facing slopes, the sagebrush may be mixed with Douglas fir (*Pseudotsuga menziesii*), quaking aspen (*Populus tremuloides*), and juniper *(Juniperus spp.)*.

**Mountain Brush** (2.2 % of total area)
A diverse tall shrub community consisting of numerous grass and shrub species, mountain brush communities often contain an abundance of dwarf maple (*Acer glabrum*), service berry (*Amalanchier alnifolia*), sagebrush (*Artemesia arbuscula, A. tridentata, A. tripartita*), buckbrush (*Ceanothus velutinus*), mountain mahogany (*Cercocarpus ledifolius*), wild buckwheat (*Eriogonum heracleoides, E. sphaerocephalum*), antelope bitterbrush (*Purshia tridentata*), plums (*Prunus virginiana*), snowberry (*Symphoricarpos oreophilus*), and the blue wild rye (*Elymus glaucus*). This is the major vegetative community at lower to middle elevations (4,500 - 8,000 feet) in the Albion Mountains.

**Salt Desert Shrub** (0.5 % of total area)
This is a mixed-height shrub community of numerous alkali-tolerant shrub species, a major vegetation type along the northern edge of Snake River Plain and in dryer tributary valleys (2,500 - 7,500 feet elev.). Shrub species include sagebrush *(Artemisia spinescens, A. tridentata, A. nuttallii, A. spinosa)*, salt bush (*Atriplex confertifolia)*, rabbitbrush *(Chrysothamnus nauseosus, C. viscidiflorus)*, winterfat *(Eurotia lanata)*, greasewood *(Sarcobatus vermicularis)*, and the grasses: desert saltgrass *(Distichlis stricta*), ricegrass (*Oryzopsis hymneoides*), squirreltail (*Sitanion hystrix*), and needle-and-thread (*Stipa comata*).

**Coniferous Forest Communities** (13.4 % of total area)
Several forest subtypes, dominated by coniferous tree species, and occurring in the mountains surrounding the tributary valleys, have been combined into this one category on the vegetation map.

Douglas fir (*Pseudotsuga menziesii*) communities are the most common forest type in the middle to higher elevations (5,000 - 10,000 feet) throughout the mountains of the Upper Snake River Basin (Caicco, 1989). Douglas fir can exist in monotypic closed canopies or open woodlands with dense shrub layers, or in mixed stands with quaking aspen, limber pine (*Pinus flexilis*), or whitebark pine (*Pinus albicaulis*).

Communities dominated by lodgepole pine (*Pinus contorta*) are a major vegetative type found between 5,000 and 9,500 feet on the mountain slopes along the eastern side of the Basin. They also occur as a minor habitat type in the Lemhi, Lost River, and Pioneer Mountains (Caicco, 1989). Lodgepole communities often include admixtures of quaking aspen, subalpine fir, and Douglas fir, with varying shrub understories.

Minor communities of open woodlands of limber pine in association with antelope bitterbrush (*Purshia tridentata*) occur interspersed in the basalt cinder gardens of the Craters of the Moon National Monument at 5,500 to 6,000 feet elevation. Additional associated shrubs include sagebrush species (*Artemisia tridentata, A. tripartita*), desert-sweet *(Chamaebatiaria millefolium*), rabbitbrush (*Chrysothamnus nauseosus*), ocean-spray (*Holodiscus dumosus*), currant (*Ribes cereum*), and grasses: giant wild rye (*Elymus cinereus*), Thurber needlegrass (*Stipa thurberiana*).

Minor communities of whitebark pine (*Pinus albicaulis*) exist in open woodlands to close-canopied forests with lodgepole pine (*Pinus contorta*) or subalpine fir (*Abies lasiocarpa*) as a major high mountain vegetation type on the moist northern margin of the Upper Snake River Basin, between 7,500 and 11,000 feet elevation.

Also, minor communities of subalpine fir forests are common in the middle to upper elevations (5,000 - 10,000 feet) in the mountains of south central Idaho, the Albion Range, Centennial Range, Smoky Mountains, and Henrys Lake Mountains (Caicco, 1989). These are closed-canopied forests to open woodlands, mixed with lodgepole pine, quaking aspen, Douglas fir, whitebark pine, and Engelmann spruce (*Picea engelmannii*).

**Alpine Community** (0.7 % of total area)
The alpine vegetation community occurs above tree-line from approximately 10,000 to 12,660 feet elevation (Caicco, 1989). This community is composed of dwarf shrubs, grasses, forbs, usually occurring in a complex mosaic on meadows, talus slopes, boulder fields, cliffs, and crevices. This is the major vegetation type in the higher mountains along northern edge of the Upper Snake River Basin. The species include sandwort (*Arenaria obtusiloba*), dryas (*Dryas ocopetala*), buckwheat (*Eriogonum caespitosum, E. ovalifolium*), goldenweed (*Haplopappus suffruticosus*), ivesia (*Ivesia gordonii*), willows (*Salix arctica, S. nivalis*), and grasses: wheatgrass *(Agropyron scribneri)* fescue (*Festuca ovina*), bluegrass (*Poa rupicola*), and the sedges (*Carex elynoides, C. rupestris*).

## *Fish and Wildlife*

Until the early 1900's, the fish and wildlife of the Upper Snake River Basin were plentiful. Salmon and steelhead ran as far as Shoshone Falls on the Snake River, and into Nevada via Salmon Falls Creek (PNWRBC, 1971b). Other native fish including bull trout, cutthroat trout, mountain whitefish, and white sturgeon were common. The large mammals, including elk, mule deer, moose, bighorn sheep, pronghorn, wolf, grizzly, mountain lion, and beaver were abundant, particularly in the valleys tributary to the plain. Sage grouse, sharp-tailed grouse, and a diversity of waterfowl were abundant throughout the region. Beginning in the early 1900's, with the construction of major irrigation diversions and population influxes, the impact on fish and wildlife populations was dramatic. With changing river habitats and emphasis on a larger variety of sport fishing, exotic species were introduced, such as kokanee, arctic grayling, and golden, brown, brook, rainbow, and lake trout. Big game habitats were also altered and their carrying capacities were reduced.

**Fish**
The rainbow *(Oncorhynchus mykiss)*, brook *(Salvelinus fontinalis)*, brown *(Salmo trutta)*, bull *(Salvelinus confluentus)* and cutthroat *(Onchorhynchus clarki)* trout are the principal salmonid, cold water species in the Upper Snake River Basin (PNWRBC, 1971b). The cold water, relatively pristine stream habitats available to resident salmonids, totals about 5,000 miles in the basin. Some of the premier salmonid sport fisheries in the United States are within the basin: the Henrys Fork and South Fork Snake drainages, as well as the Big and Little Wood Rivers and Silver Creek. Warm water species, including various panfish, largemouth and smallmouth bass *(Micropterus salmoides and M. dolomieui)*, and channel catfish *(Ictalarus punctatus)* have done well in the reservoir systems on the area's rivers. White sturgeon *(Acipenser transmontanus)* once occurred in the Snake River downstream from Shoshone Falls, but the populations have declined since the 1880's when demand for smoked sturgeon and caviar caused sturgeon to be over fished (IDFG, 1996). Present populations of sturgeon in the Snake River are restricted to short river reaches, isolated from other populations by dams. Sturgeon harvests have been prohibited since 1970.

**Big Game Species**

***Elk or Wapiti*** *(Cervus canadensis)* are widely distributed, often jointly sharing a sizeable portion of their range with mule deer, and mainly inhabiting the wooded mountains (PNWRBC, 1971b). Summer browsing range for elk is generally between 5,000 and 10,000 feet elevation. They move to lower ridges, south-facing slopes, and valleys for the winter, often with the mule deer. In the central and western part of the upper Snake River basin, elk are often in competition with livestock for winter forage.

***Mule Deer*** *(Odocoileus hemionus)* are common up to about 10,000 feet, wherever there is suitable cover and browse, but the Eastern Snake River Plain is not particularly good deer habitat (PNWRBC, 1971). Their preferred habitat across the eastern and southern portion of the region are the mountain brush and lower conifer forest communities during the summer, and sagebrush-bitterbrush communities in winter. The summer range could support larger deer populations but the available winter range of bottom lands and south-facing slopes is the main factor limiting herd size. In winter, the deer compete with livestock and elk for the available forage supplies.

***White-tailed deer*** *( Odocoileus virginianus)* are not common but a few do exist along the Henrys Fork and South Fork Snake in the deciduous forested bottom lands (PNWRBC, 1971b).

***Moose*** *(Alces alces)* are found throughout the forested portion of the northern and eastern part of the upper Snake River Basin (PNWRBC, 1971b). They utilize a wide variety of habitats from ponds to willow thickets along stream bottoms to wooded ridges. Moose numbers in the area are increasing because of their adaptability to a variety of habitat types. Stream bottoms dominated by cottonwood, willow, birch, spruce, fir, pine and silverberry are a preferred habitat, as are forested areas with fir, spruce, lodgepole pine, aspen, buckbrush, and willow.

***Pronghorn antelope*** *(Antelocapra americana)* exist throughout the upper Snake River Basin, with the heaviest concentrations in the Big and Little Lost Rivers, Birch Creek, Crooked Creek, and Medicine Lodge Creek drainages (PNWRBC, 1971b). These are all high sagebrush valleys with irrigated farms along lower portions of stream courses. Preferred forage species include sagebrush, winterfat, rabbitbrush, bitterbrush, bluegrass, and wheatgrass.

***Bighorn sheep*** *(Ovis canadensis)* occur only in the eastern portion of the basin (PNWRBC, 1971b). They prefer a high rocky habitat, up to 11,000 feet in the summer. During the winter, they move to south-facing slopes and lower elevations, feeding on sagebrush, rabbitbrush, winterfat, and grasses.

***Mountain goats*** *(Oreamnos americana)* are found on rugged peaks of the south end of the Lemhi Mountains, the southern end of the Whiteclouds, and the Snake River Range east of the South Fork Snake River (PNWRBC, 1971b). They are adaptable to the cliffs and exposed rocky habitats of the region, but browse on the mountain brush and sagebrush communities.

***Black bear*** *(Euarctos americanus)* are common in the forested areas of the basin, except the southwestern portion (PNWRBC, 1971b). Black bear habitats typically are characterized by extensive stands of lodgepole pine, except on north slopes where spruce and fir dominate, all usually mixed with aspen species. These provide the variety and quantity of food and cover that bears require. They will also feed regularly in limber pine communities above 8,000 feet elevation where fleshy fruits and rodents may exist.

***Grizzly bear** (Ursus arctos)* that are reported occasionally on the Targhee National Forest area in the eastern portion of the basin, are most likely migrants from Yellowstone National Park (PNWRBC, 1971b). Their habitat seems to be fairly limited to lodgepole pine, spruce, fir, limber pine and aspen, between the elevations of 7,000 and 11,000 feet.

**Upland Game Species**
The upland game habitat varies from the semiarid sagebrush plains to coniferous forests to most types of farmland (PNWRBC, 1971b). The upland species include more than just game species, but data has been most extensively collected for ring-necked pheasant, chukar partridge, Hungarian partridge, valley quail, mountain quail, ruffed grouse, blue grouse, sage grouse, sharp-tailed grouse, mourning dove, and cottontail and pygmy rabbits. The ring-necked pheasant, sage grouse, ruffed grouse, blue grouse, and mourning dove all have different habitat requirements but occur in modest to good populations throughout the area. Species such as Hungarian partridge, valley quail, mountain quail, sharp-tailed grouse, and the rabbits occur in smaller numbers, often in fairly specialized habitats.

**Small Mammals**
Beaver, muskrat, river otter, raccoon, and mink are found throughout the basin, associated with aquatic habitats (PNWRBC, 1971b). The highest populations tend to be in the eastern portion of the basin, where there is greater abundance of riparian forest habitats associated with streams and ponds. Other mammals, including the badger, bobcat, coyote, red fox, spotted and striped skunks, and weasels are less dependent on water and more cosmopolitan in their distributions. Lynx and marten are limited to the forested portions of the northern and eastern mountains.

**Waterfowl**
Most waterfowl species common to the western United States are found at some time during the year in the Upper Snake River Basin (PNWRBC, 1971b). Nesting waterfowl include Canada geese, mallard, gadwall, pintail, baldpate duck, blue-winged teal, cinnamon teal, and redhead duck. Large numbers of Canada geese and mallards winter along the Snake River, and the trumpeter swan is a year-round resident. The predominant waterfowl areas include: Camas National Wildlife Refuge, Grays Lake National Wildlife Refuge, Blackfoot Reservoir, Fort Hall bottoms, and Minidoka National Wildlife Refuge. Of lesser importance, but still very productive for waterfowl, are the wide diversities of smaller aquatic habitats in the basin, including streams, irrigation canals, wet meadows, and marshes.

The major Canada geese nesting areas are Island Park Reservoir, Henrys Fork, Camas National Wildlife Refuge, Grays Lake National Wildlife Refuge, Blackfoot and American Falls Reservoirs, South Fork Snake River, Minidoka National Wildlife Refuge, and Mormon Reservoir. The Snake River reservoirs are concentration points for fall migrating geese, but the two main wintering locations for geese and trumpeter swans are the Henrys Fork River and American Falls Reservoir. Snow geese migrate through the region in the spring and fall en route between wintering grounds in the southwestern United States and their summer ranges in the arctic regions of North America.

**Other Wildlife**
One of the largest nesting populations of greater sandhill cranes *(Grus canadensis)* in the country is at Grays Lake National Wildlife Refuge. In the West, the most critical habitats for songbirds and diverse groups of amphibians, mammals, and insects are the riparian communities that exist along the rivers and streams. This is largely because of the vegetational variety. The cottonwood forest of the South Fork Snake River is the most extensive of such habitats in Idaho and possibly in the entire Intermountain

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## *Threatened or Endangered Species*

Eleven plant and animal species, which are, or have been, inhabitants of the Upper Snake River Basin area, are currently on record with the Conservation Data Center of the IDFG, as having characteristics appropriate for listing under the federal Endangered Species Act. These species, and their listing status, are shown on Table 17. One species of plant, Christ's Indian paintbrush (*Castilleja christii*), a candidate species, is only known from subalpine parkland habitats on Mt. Harrison in the Albion Mountains south of Burley (Moseley, 1996). Of the birds, the threatened bald eagle (*Haliaeetus leucocephalus*) winters and breeds along the South Fork of the Snake River, and to a lesser extent, along the Henrys Fork. Wintering bald eagles also utilize the Middle Snake reach and other riparian communities of tributary valleys, such as the Big Wood River. The bald eagle nesting population along the South Fork of the Snake River is one of the most significant of such populations in the conterminous U.S. (Whitfield, 1993). Between 1988 and 1992, the South Fork nests produced 15% of the entire Greater Yellowstone Ecosystem's total population of eaglets, and it accounted for 60% of the fledglings in 1989, the year after the Yellowstone fire. The endangered peregrine falcon (*Falco peregrinus anatum*) breeds in the basin. Eggs of the endangered whooping crane (*Grus americana*), were unsuccessfully transplanted to sandhill crane nests at Grays Lake Wildlife Refuge between 1975 - 1988, but the few survivors from the program continue to migrate to Grays Lake with the sandhill cranes each year (IDFG, 1993a).

Most of the surface waters of the Upper Snake River Basin are not considered as appropriate habitat for the bull trout (Batt, 1996). According to the IDFG, the bull trout (*Salvelinus confluentus*), was both historically and is currently found in the Little Lost River drainage, but nowhere else in the Upper Snake River Basin area (IDFG, 1993a). The grizzly bear (*Ursus arctos*), listed as threatened, is still considered a component of the Greater Yellowstone Ecosystem. One of the three Grizzly Bear Recovery Areas in Idaho is in the very northeastern corner of the Upper Snake River Basin.

Populations of five mollusc species, all designated as threatened or endangered by the U.S. Fish and Wildlife Service, are found in the Middle Snake and some of its tributaries. Established snail populations are dependent on clean, well-oxygenated, rapidly flowing rivers or large spring habitats (USDI, FWS, 1991). Only eleven known sites in the Middle Snake support remnant populations (Frest and Johannes, 1992).

**Table 17. Species of Concern**

| Common Name | Scientific Name | Status |
|---|---|---|
| **Plants:** | | |
| Christ's Indian paintbrush | *Castilleja christii* | Candidate |
| **Birds:** | | |
| Bald eagle | *Haliaeetus leucocephalis* | Threatened |
| Peregrine falcon | *Falco peregrinus anatum* | Endangered |
| Whooping crane | *Grus americana* | Endangered |
| **Fish:** | | |
| Bull trout | *Salvelinus confluentes* | Threatened |
| **Mammal:** | | |
| Grizzly bear | *Ursus arctos* | Threatened |
| **Molluscs:** | | |
| Utah valvata snail | *Valvata utahensis* | Endangered |
| Idaho springsnail | *Pyrgulopsis idahoensis* | Endangered |
| Banbury Springs lanx | *Lanx spp.* | Endangered |
| Snake River physa snail | *Physa natricina* | Endangered |
| Bliss Rapids snail | *Taylorconcha serpendicola* | Threatened |

Source: IDFG, 1993a.

## SCENIC VALUES AND NATURAL FEATURES

The Eastern Snake Plain Aquifer area is located within the Columbia Intermontane Basin physiographic province. The area is dominated by a young lava plateau. The Rocky Mountains form the northern and eastern borders of the Upper Snake River Basin.

Little weathering has occurred so that much of the basalt and other volcanic materials are exposed. Soil has accumulated in some areas as a result of windblown sand and silt deposits. Irrigated agriculture has located in these areas. The chief erosional features have been along river courses. Most notable are sections of the Snake River canyon, Salmon Falls Creek, the Wood River north of Shoshone, and Malad River near Hagerman.

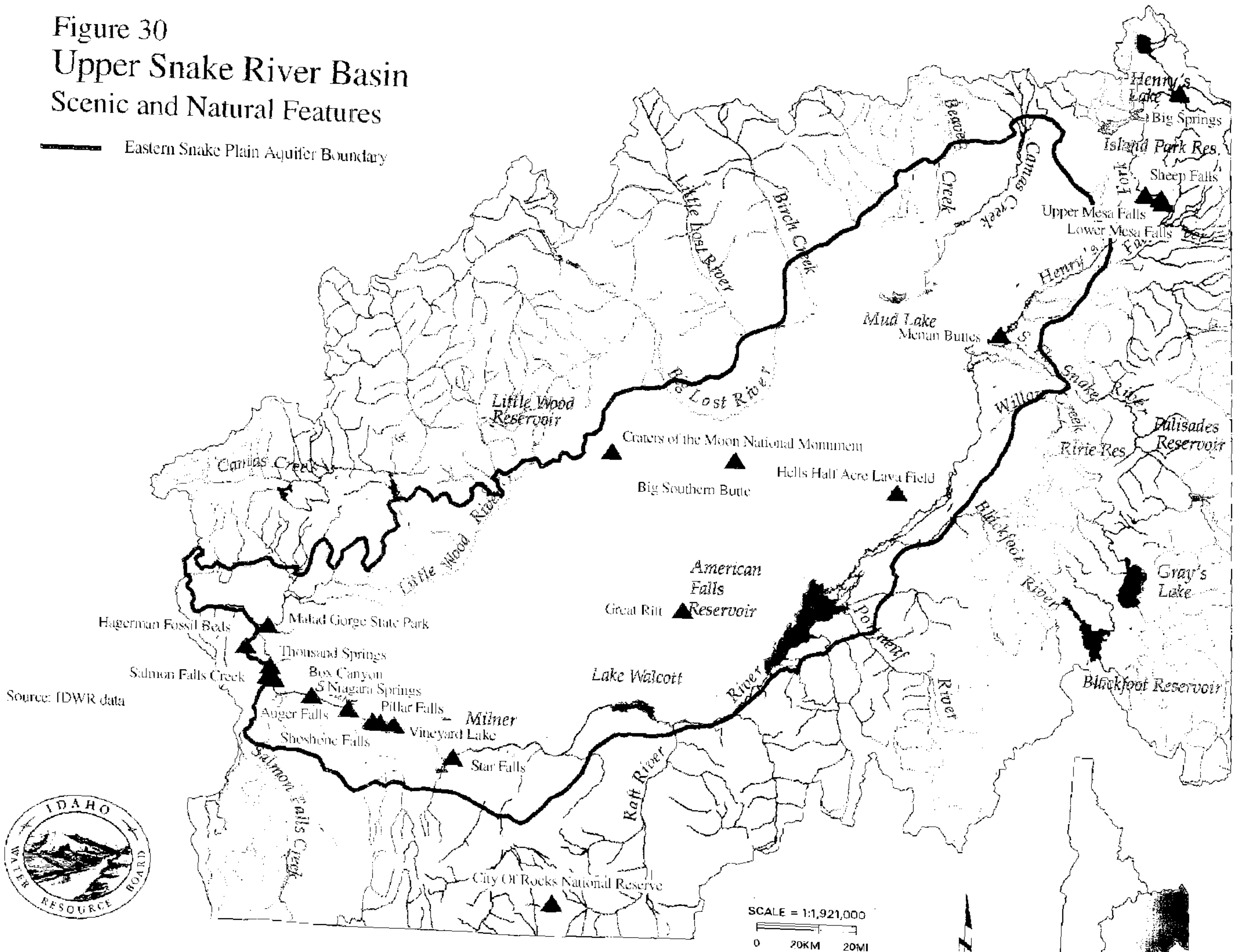
The unique geological history of the area has created many landscape features that are distinct and unique with high public interest in preservation. The most notable features are listed here based on agency designation and management, but this is by no means a complete inventory of important scenic and natural features in the Upper Snake River Basin. They are shown on Figure 30.

### *National Natural Landmarks*

National Natural Landmarks are "sites determined to be one of the best examples of a natural region's characteristic biotic or geologic features" (NPS, 1987). The designation identifies sites with national significance, indicating these sites are significant and unique to the state as well. Primary criteria considered for designation include:

- illustrative character and condition of the site;
- diversity and rarity of features within the site;
- value for science and education (NPS, 1987).

# Figure 30
## Upper Snake River Basin
### Scenic and Natural Features



The National Natural Landmark program is administered by the National Park Service. Although the designation does not change ownership, or place any special restrictions or requirements on the management of the designated area, it does encourage preservation of these areas.

The Upper Snake River Basin contains eight of the eleven National Natural Landmarks designated in Idaho. These include:

- *Big Southern Butte*- The area, located northwest of Blackfoot, is the largest area of volcanic rocks of young age in the United States. The site is an ecological island for lodgepole, aspen, Douglas fir and manzanita -- vegetation not common to the region.

- *Big Springs* - The springs are the source for the Henrys Fork of the Snake River. They are one of only 65 first order springs (exceeds 100 cfs) in the United States, and the only one that emanates from a rhyolite lava flow.

- *Cassia Silent City of the Rocks* (now known as City of the Rocks National Reserve) - The site contains the best examples of bornhardts in the region. Bornhardts are granitic exfoliation domes.

- *Great Rift System* (a portion is in the Craters of the Moon National Monument) - This site provides a geological record of crustal lifting and basaltic volcanism unique in North America. It is also an excellent example of primary vegetation succession on young lava flows.

- *Hagerman Fauna Sites* (now known as Hagerman Fossil Beds National Monument) - The site contains the richest known deposits of Upper Pliocene age terrestrial fossils in the world.

- *Hell's Half Acre Lava Field* - The site, located east of Idaho Falls, is an excellent example of a complete, young, unweathered, fully exposed *pahoehoe* lava flow.

- *Menan Buttes* - The buttes are an example of glassy tuft cones found in only a few places in the world.

- *Niagara Springs* - One of the least developed of the Thousand Springs complex, where the Snake River Plain aquifer flows into the Snake River. It is illustrative of the large volume of water transmitted through the aquifer (NPS, N.D.).

Many of these sites are under the jurisdiction of federal and state agencies with management direction that recognizes and preserves the significant characteristics.

### *Other Scenic and Natural Areas of Interest*

An overview conducted by the State of Idaho identified numerous landscapes in the Upper Snake River Basin with outstanding scenic values (State of Idaho, 1975). Some of these are summarized below. Many of these have been proposed as National Natural Landmarks. Nomination for inclusion in this program is an indication of the public concern or uniqueness of the area.

The scenery of many rivers and canyons in the Basin is distinctive. The South Fork of the Snake River and its cottonwood riparian forest is one of the most extensive and highest quality streamside areas in Idaho (Poccard, 1980). Several islands in the river have been designated as Research Natural Areas (RNAs) including Pine Creek Island RNA, Squaw Creek Island RNA and Reid Canal RNA. Research Natural Areas are places of ecological importance managed for research in maintaining biological diversity. In an evaluation of sites in Idaho, the South Fork of the Snake River received the highest rating for wildlife populations (Poccard, 1980). It has been proposed as a National Natural Landmark, because of its ecological characteristics (Johnson and Pfister, 1982).

Grays Lake is considered a unique geologic and ecological feature and has been proposed for National Natural Landmark designation. The lake is the relict of a much larger lake, documenting the process natural aging process of a major water body. It is considered one of the most magnificent marshes in western North America (Rigby, 1981).

Scenic features along the Henrys Fork of the Snake include famous waterfalls such as Lower and Upper Mesa Falls. These falls, located in the southeastern portion of the Island Park Caldera, were produced as the river cut through basalt flows to exit the caldera. Upper Mesa Falls, dropping 104 feet, has a developed overlook and boardwalk. Lower Mesas Falls is in a more natural state, consisting of a 45-foot plunge. Sheep Falls RNA is a long, cascading rapids located in a shallow, steep-sided canyon of the Henrys Fork. It is characterized by a 30-foot drop along a 50-yard stretch of basaltic outcrops. All three falls have been proposed for National Natural Landmark designation, because of geological and/or ecological significance (Rigby, 1981; Johnson and Pfister, 1982). Island Park Reservoir has also been proposed for designation under the same program because of its important fisheries and wildlife habitat (Johnson and Pfister, 1982). Specifically, it is significant for its diverse assemblage of birds which include bald eagle, red-necked grebe, trumpeter swans, white pelicans, double-crested cormorants, black-crowned night heron, Caspian terns, and osprey.

The Snake River canyon below Milner Dam is deeply incised in steep, columnar basalt cliffs, with interesting falls and rock ledge rapids. The canyon possesses outstanding scenery with numerous springs, rapids, waterfalls, basalt outcroppings, and lush vegetation concentrated at springs and falls throughout its length. Major falls include Twin Falls and Shoshone Falls, the sites of hydro power development. Shoshone Falls is sometimes referred to as the "Niagara of the West" but with its 212-foot drop; it is higher than Niagara Falls (180 feet). Other notable falls remaining in a natural state along this section of the river include Star Falls, Pillar Falls and Auger Falls.

Side canyons along the middle reach of the Snake River offer unique and interesting landscape features associated with the prehistoric Lake Bonneville flood. The Dry Cataracts consist of blind canyons, terraces, plunge pools, and scablands produced by the Lake Bonneville flood about 15,000 years ago. The area includes Devils Corral and Vineyard Creek located on the north side of the Snake River canyon adjacent to Twin and Shoshone Falls. Vineyard Creek has been designated as an Area of Critical

Environmental Concern (ACEC) by the BLM, and is characterized as a spring-fed ecosystem with abundant aquatic vegetation and a 60-foot waterfall. The Dry Cataracts have been considered for designation as a National Natural Landmark (Scott, 1978).

Further downstream in the Hagerman area is the Box Canyon ACEC, managed by the BLM, containing a relatively undisturbed alcove ecosystem providing scenic and nature study opportunities. In the same area, The Nature Conservancy's Thousand Springs Preserve provides important wildlife habitat including springs, riparian bottom lands, marshes and sloughs. The Thousand Springs area was considered for designation as a National Natural Landmark. It is one of the largest of many spring sets where the Snake Plain aquifer drains into the Snake River. Blue Heart Springs and Niagara Springs are both becoming better recognized and accessible as impressive natural features available to the public. However, extensive development of the springs, including hydro power, irrigation and aquaculture, limit their value as natural features.

Other water bodies identified with highly scenic characteristics include Salmon Falls Creek, the Big Wood River, Silver Creek, Big Lost River, Henrys Lake, Warm River, Fall River, Teton River, and the Malad River gorge (State of Idaho, 1975).

St. Anthony Sand Dunes is an area characterized by dunes in all stages of stabilization. In addition, there are several lava tubes in the area. The area was proposed for designation as a National Natural Landmark because of botanical, zoological and geologic features of high value (Daubenmire, 1975).

Balanced Rock, located southwest of Buhl, is an unusual erosional remnant, likely the result of wind and water erosion of the platy volcanic rock. The rock form is considered rare, and has been evaluated for designation as a National Natural Landmark (Scott, 1978).

There are numerous landscape features that have been mentioned as possible National Natural Landmarks associated with volcanism in the area (Rose, 1970). Many of these have already been designated, and were described earlier. Others investigated, but not designated include:

- *Wapi Lava Field* - A massive lava field, located northwest of American Falls, originating from fissures separate from the Great Rift.

- *Malad Canyon* - Located between Bliss and Hagerman, containing one of the largest groups of springs in the world, and site of an Idaho state park.

- *Twin Buttes* - Located east of Idaho Falls, steptoes formed by rhyolite volcanic cones surrounded by younger basalt flows.

- *The Lavas* - Located west of Shelley, containing an assortment of small caves and fissures with solidified lava flows.

- *Lost River Sinks* - Located northeast of Arco, an area where the Little Lost River and Big Lost River disappear under the lava to reappear as spring flows into the Snake River.

## RECREATION

A variety of recreation opportunities are available in the Upper Snake River Basin. Many are located on lands managed by federal and state agencies. Federal agencies which manage public lands in the area include the BLM, NPS, USBR, USFWS, and the USFS. State agencies managing recreational facilities in the area include the IDPR and the IDFG. These areas are shown on Figure 31.

### *U.S. Bureau of Land Management*

Most of the public lands on the Eastern Snake Plain are under the administrative jurisdiction of the BLM. A diversity of recreation activities is available on these public lands. Much of the recreation is dispersed, occurring in areas without developed facilities. Activities include hunting for big game, upland game, upland birds, and waterfowl. Other recreational opportunities are fishing, boating, rock climbing, hiking, sightseeing, picnicking, off-road vehicle use, snowmobiling, and other winter sports. There are some developed sites with campgrounds, picnic areas, trails, and boat access facilities. A summary of the most notable recreation opportunities is provided here.

The BLM manages many of the recreation access sites along the Snake River. Trout fishing on some of these stream segments, particularly the South Fork, attract users from around the nation. Boating and fishing activities have increased significantly during recent years. Numerous boat accesses, camping and picnicking facilities, and hiking trails are provided along these sections. Wildlife observation opportunities are abundant.

The BLM manages two fishing access sites along Silver Creek, a noted wild trout fishery. The Nature Conservancy also manages part of the land along this significant fishery. The BLM sites provide fishing access, and camping is also available at one of the sites.

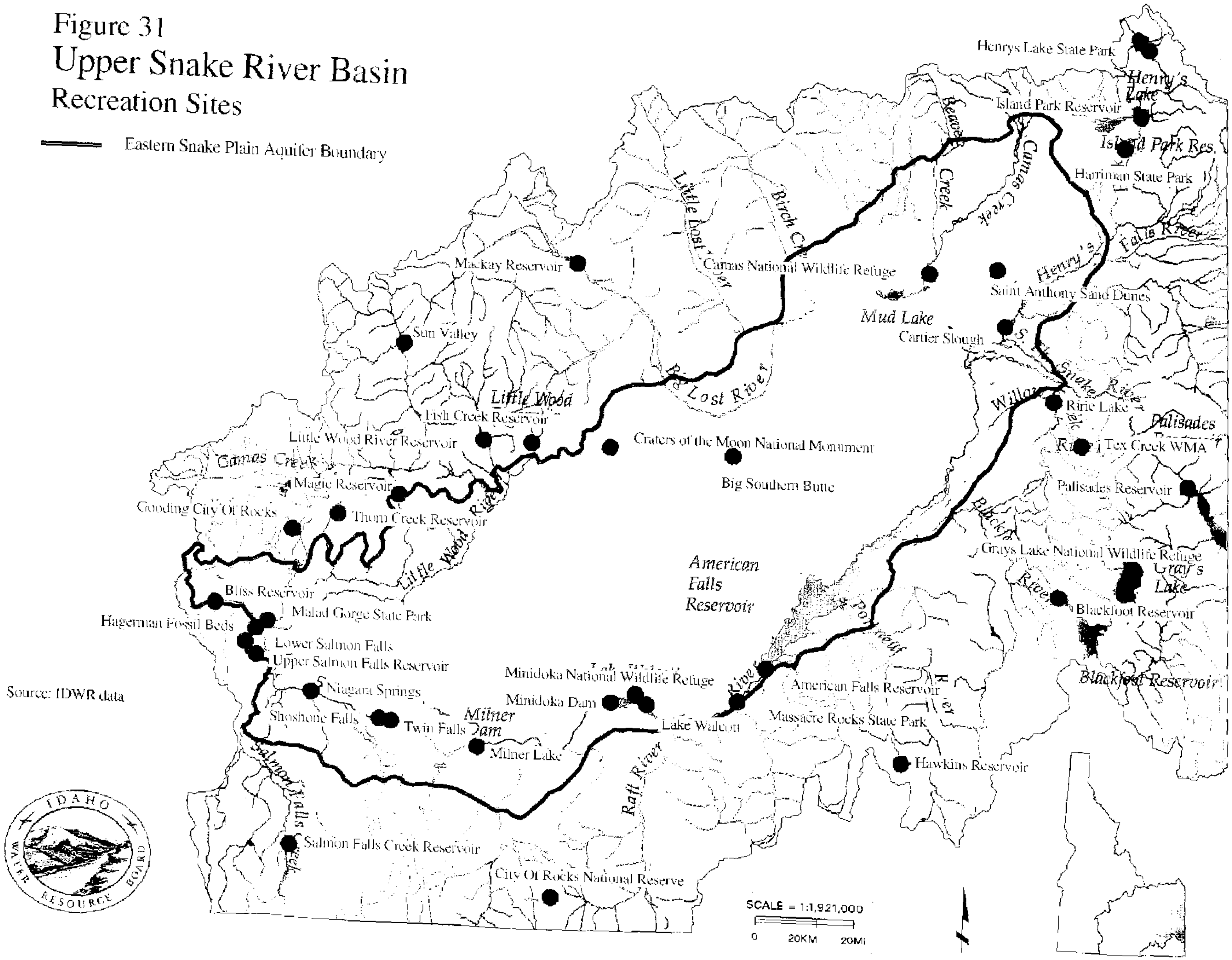
The Big Wood River is another river known for its outstanding fishing opportunities. The BLM manages several recreation sites along this river providing picnicking and trail opportunities associated with Blaine County's Wood River Trail System.

A number of reservoirs are located on public lands which provide water-based recreation. Magic Reservoir, located southwest of Bellevue, is filled by the Big Wood River, Camas Creek, and Rock Creek. Although irrigation storage and delivery are the primary functions of the reservoir, recreation activities are also popular, including fishing, boating, and wind surfing, as well as camping, hunting, and off-road vehicle use on adjacent lands.

Mackay Dam, near the town of Mackay in Custer County, is owned and operated by the Big Lost Irrigation District. Most of the lands along the reservoir are under BLM jurisdiction and provide camping, picnicking, and boat access facilities. The area receives heavy fishing pressures. Some hunting occurs in the fall.

Figure 31
# Upper Snake River Basin
## Recreation Sites

Eastern Snake Plain Aquifer Boundary




Source: IDWR data

Salmon Falls Creek Reservoir, located west of Rogerson, provides irrigation storage, but has also become an important recreation resource. A developed park is located at the dam. The park has boat access, camping, and picnic facilities. The major recreation activity is fishing for planted species such as brown trout, Chinook salmon, yellow perch, black crappie, channel catfish, small mouth bass, and trophy size walleye (BLM, 1989). Water skiing is also a popular recreation activity on the reservoir. Other activities include hunting, sightseeing, rock hounding, picnicking, hiking, horseback riding, cross country skiing, ice fishing, and canoeing.

Along the shores of Milner Reservoir, on the Snake River west of Burley, the BLM provides facilities for boating, picnicking, and camping. Fishing use has increased substantially with the introduction of catfish. Facilities interpreting the two remnants of the Oregon Trail in the area have also been installed by the BLM.

Blackfoot Reservoir was built for the Fort Hall Indian Irrigation Project. A developed campground is located on the reservoir. Other activities include boating and fishing. Several semi-developed camping areas exist along the Blackfoot River providing access to campers, picnickers, and anglers. Downstream of the dam, two sections of the Blackfoot River have become popular intermediate and expert whitewater boating stretches.

Small reservoirs provide important boating and fishing opportunities for the local area. These include Fish Creek, Thorn Creek, and Hawkins reservoirs. Fish Creek Reservoir is located northeast of Carey; Thorn Creek Reservoir is north of Gooding, and Hawkins Reservoir is located near Arimo.

Several notable whitewater boating stretches flow through lands managed by the BLM are found on the Snake River including the Milner, Murtaugh, and Hagerman reaches. Other opportunities are found on the Blackfoot River. Table 20 in the boating section identifies these reaches in more detail.

The St. Anthony Sand Dunes are located on BLM-managed lands west of St. Anthony. The area provides motorized and non-motorized recreation opportunities. A portion of the area is managed as the Sand Mountain Wilderness Study Area in which only non-motorized recreational activities are allowed. Other recreation activities include horseback riding, hiking, camping, hunting, and all-terrain motorcycle play. The area has gained a national reputation as one of the best sand dunes for all-terrain, dune buggy, and motorcycle riding (BLM, 1989).

Gooding City of Rocks is a unique geologic area located in northern Gooding County. Distinctive geologic features, including hoodoos, arches, columns, mushroom caps, and fins are the result of structural deformation and mechanical erosion of welded volcanic tuffs. The area contains many important cultural resources including petroglyphs. Activities include day hiking, mountain biking, nature study, horseback riding, camping, and off-road vehicle use. The BLM is managing this area for possible wilderness designation.

A unique recreation opportunity is provided by the numerous caves found in the Eastern Snake River Plain. The BLM is in the process of identifying and inventorying this resource under the authority of the Federal Cave Resources Protection Act of 1988. Many of the caves have unusual speleological features including lava stalactites and stalagmites, pressure ridges, encased lava tubes, rare hornitoes (spatter cones), extrusion spires, lava tide marks, lava roses, flow tongues, and lava cascades.

Big Southern Butte, located about forty miles northwest of Blackfoot, is a volcanic butte that is popular with hang gliders. The butte has been rated the second in the country for its ideal hang gliding conditions, including near-perfect take-off points and excellent wind conditions, thermals, and updrafts. The butte has been designated as a National Natural Landmark (BLM, 1989).

### *National Park Service*

The NPS has jurisdiction over two sites, both national monuments, in the Upper Snake River Basin.

**Craters of the Moon National Monument** - Basalt lava flows and other volcanic features make the Craters of the Moon a unique recreational opportunity. These features are the result of extensive fissure-type eruptions that occurred about 2,100 to 15,000 years ago. The Monument is located within the Great Rift, a volcanic rift zone extending 60 miles south from the Pioneer Mountains. A variety of interesting geologic features formed by volcanism are found here, including cinder cones, rafted blocks, vents, fissures, spatter cones, lava tubes, tree molds, and vast flows of *pahoehoe* and *aa* lava.

Craters of the Moon was nominated in 1990 for inclusion in the National Historic Landmark Program under the Physical Geology Theme. The Carey Kipuka and portions of the north end of the Monument were nominated for inclusion in the National Natural Landmark System as representative of the Columbia Plateau Natural Region, Low Sagebrush Theme, Low Sagebrush/Idaho Fescue Subtheme. The National Natural Landmark evaluation report states that these areas are "outstanding examples" and are "nationally significant" (NPS, 1991). A proposal is being prepared to designate the Carey Kipuka as a Research Natural Area.

Part of the Craters of the Moon is managed as a Wilderness. The rugged, unique terrain has left the area undeveloped and provides a challenging, isolated and wild wilderness experience. Permits are required to hike into the Wilderness. Visitation to the area averaged 120 user nights per year from 1984-1988. In 1989 there were 82 user nights, and in 1990 there were 68 user nights (NPS, 1991).

Recreational opportunities are available the year around. Facilities include a campground and picnic areas, visitor center, interpretive trails and programs. In the winter, groomed cross country ski trails are available. Visitations to the Craters of the Moon from 1990-1994 are displayed in Table 18.

**Table 18. Visitation at Craters of the Moon National Monument From 1990-1994.**

| Number of Visitors Per Year | | | | |
|---|---|---|---|---|
| 1990 | 1991 | 1992 | 1993 | 1994 |
| 207,766 | 217,879 | 244,806 | 238,508 | 227,918 |

Source: NPS, 1994.

**Hagerman Fossil Beds National Monument** - The Hagerman Fossil Beds National Monument encompasses 4500 acres situated on the west side of the Snake River across from Hagerman. The Monument was designated by Congress in 1988 to protect and preserve the paleontological sites, to provide a research center, and display and interpret the specimens discovered at the monument (Public Law 100-696).

The Monument has acquired international renown for its fossil specimens, some of which have been determined to be 3.5 million years old. Fossils identified include the Hagerman horse (a zebra-like animal), small mammals (beavers, otters and muskrats), and birds. These discoveries have the potential to provide important evolutionary information. To date more than 300 flora and fauna sites have been identified; however, a complete paleontological survey of the entire monument has not been completed. The NPS's management plan for the area provides a long-term program for recreational development of the area. Proposed plans include development of a research/visitor center, visitor contact stations, trails for guided and self-guided tours, and picnic areas (NPS, 1995). Plans will also include interpretation of the Oregon Trail. Hunting and fishing will continue to occur.

Visitation at the Monument is increasing each year, despite the lack of developed facilities. In 1991 approximately 700 people visited the visitor center, located in downtown Hagerman, and participated in tours of the quarry site. In 1995 visitation was 15,000 people (Wilhite, 1995). Similar sites have received between 20,000 and 30,000 visits annually (Wilhite, 1992). If the proposed management plan and facilities are implemented, the Monument is predicted to receive as many as 200,000 visitors annually (NPS, 1995).

### *U.S. Bureau of Reclamation*

The many storage projects managed by the USBR as parts of the Upper Snake System also provide water-related recreation opportunities. These opportunities include boating, fishing, and water play. Many of the sites have developed campgrounds, picnic areas, and boat access sites under management by other agencies. Table 19 lists the USBR sites, facilities, and use estimates for projects within the Upper Snake River Basin.

**Table 19. U.S. Bureau of Reclamation Recreation Facilities in the Upper Snake River Basin.**

| Site | Facilities | 1992 Use Estimates (Recreation Visits) |
|---|---|---|
| American Falls Reservoir | Picnicking, swimming, boating, marinas, camping, fishing, hunting | 184,234 |
| Cartier Slough | Fishing, hunting | 1,500 |
| Island Park Reservoir | Picnicking, swimming, boating, camping, fishing, hunting, winter sports | 99,275 |
| Lake Walcott | Picnicking, swimming, boating, camping, fishing, hunting, historical interpretation | 42,000 |
| Little Wood Reservoir | Picnicking, swimming, boating, camping, fishing, hunting | 30,296 |
| Minidoka Reservoir | Picnicking, historical interpretation | |
| Minidoka Relocation Center Historical Site | Historical interpretation, exhibits, overlooks | |
| Palisades Reservoir | Picnicking, swimming, boating, camping, fishing, hunting, winter sports, tours | 16,000 |
| Ririe Reservoir | Picnicking, swimming, boating, camping, fishing, hunting, visitor center | 74,245 |
| Tex Creek Wildlife Management Area | Hunting | 6,000 |

Source: Winder, 1996; A recreation visit is a person visiting a site for any part of a day.

## *U. S. Fish and Wildlife Service*

Several national wildlife refuges managed by the USFWS are found in the Upper Snake River Basin. National wildlife refuges were established to provide a sanctuary for migratory birds and other wildlife. Secondary benefits include numerous recreational opportunities.

The Camas National Wildlife Refuge is located 36 miles north of Idaho Falls and just west of Hamer. Camas Creek flows through the refuge. Recreational use consists mainly of year around bird watching and seasonal hunting of upland birds and waterfowl (Deutscher, 1995). Other recreation activities include wildlife observation, hiking, photography, cross country skiing, and snowshoeing. Boating is limited to non-motorized, small boats and canoes (USFWS, 1989). Hunting is restricted to geese, ducks, coots, common snipe, pheasants, and sage grouse. Total hunting activities were estimated to be 55-65 hunter visits in 1994 (USFWS, 1994).

Grays Lake National Wildlife Refuge, located about 35 miles north of Soda Springs, is a large shallow marsh. The refuge is home to the largest concentration of breeding greater sandhill cranes in the world. The site was chosen for reintroduction of the endangered whooping crane. The refuge is home to an extensive diversity of waterfowl, water birds, and mammals including Canada geese, Franklin's gulls, grebes, bitterns, rails, curlews, snipes, willets, phalaropes, muskrats, badgers, moose, and mule deer. In addition to wildlife observation, recreation activities include hiking in the northern half of the refuge from October through March, and cross country skiing during the winter. A road circles the marsh providing opportunity for wildlife observation. Other recreation facilities include a visitor center with interpretive exhibits and a scenic overlook nearby with a spotting scope (Carpenter, 1990).

The Minidoka National Wildlife Refuge is associated with the USBR's Minidoka project. The USFWS manages the refuge, which includes the Snake River from Minidoka Dam and all of Lake Walcott, as breeding grounds for birds and other wildlife. There is ample opportunity for wildlife observation. Migratory waterfowl, including ducks, geese, and tundra swans, uses the refuge as a stopover along the Pacific Flyway. The refuge provides habitat for numerous water birds and mammals. Boating and fishing on the lake is limited to certain areas and to certain times of the year. Limited hunting is allowed for ducks, geese, coots, mergansers, pheasants, gray partridge, and cottontails. Trout fishing is another important activity (USFWS, 1988).

### *U. S. Forest Service*

The USFS has jurisdiction of lands along the north, south and eastern perimeters of the Upper Snake River Basin. Portions of the Challis, Caribou, Salmon, Sawtooth, and Targhee national forests are represented. National forest lands have numerous developed campgrounds, picnic facilities, and boat and fishing access sites in the area. Many of these facilities are located along major reservoirs and water courses including Island Park and Palisades reservoirs, and the Henrys Fork, South Fork Snake River, Warm River, Falls River, and Birch Creek. Additionally, numerous dispersed recreation opportunities are possible on national forest lands including hunting, hiking, camping, off-road vehicle use, nature study, sightseeing, mountain biking, and horseback riding.

### *Idaho Department of Parks and Recreation*

Six parks managed by the IDPR are within the Upper Snake River Basin. A brief summary of each follows. Table 20 summarizes the visitation at each of the facilities.

City of the Rocks National Reserve, located west of Almo in the Albion Mountains, is a special reserve on BLM lands which is managed by the IDPR. The Reserve gets its name from the weathered granitic rock formations that take on distinctive shapes. Rock climbers from around the world come to attempt the more than 500 technical climbing routes thus far identified. Camping, mountain biking, and hiking are also popular activities.

**Table 20. Visitation at State Parks within Upper Snake River Basin**

| State Park | 1995 Number of Visitors |
|---|---|
| City of the Rocks | 98,138 |
| Harriman | 30,195 |
| Henrys Lake | 20,246 |
| Malad Gorge | 65,222 |
| Massacre Rocks | 162,403 |
| Niagara Springs | 50,159 |

Source: IDPR, 1996

Harriman State Park, north of Ashton, is located within the Harriman Wildlife Refuge. The abundant wildlife and the outstanding trout fishing opportunities on the Henrys Fork of the Snake, which passes through the park, are the main attractions. Visitors may observe elk, deer, moose, trumpeter swans, bald eagles, Canada geese, osprey, beaver, otter, muskrats, sandhill cranes, and great blue heron. Hiking, horseback riding, mountain biking, cross country skiing, and interpretive programs are other popular activities.

Henrys Lake State Park is located in the north easternmost part of the Upper Snake River Basin, west of Yellowstone National Park. Anglers from around the world are attracted to this scenic high mountain lake to fish for cutthroat and brook trout. Facilities are provided for picnicking, hiking, camping, and boating.

Malad Gorge is named after the spectacular 250-foot deep gorge that the Malad River drops into the Devils Washbowl. Hiking along the gorge and views of the waterfall attract visitors. The park also provides picnicking, mountain biking, and guided outings.

Niagara Springs is a part of the Thousand Springs complex along the Snake River. The springs are designated as a National Natural Landmark. Fishing is possible at the nearby Crystal Springs Lake. Picnicking and wildlife observation are also popular activities.

Massacre Rocks State Park is located near a narrow break in the rocks where immigrants using the Oregon Trail passed. Remnants of the Oregon Trail are visible. The park provides interpretive information about the history of the Oregon Trail, including a skirmish between the Shoshone Indians and pioneers which has given the park its name. Interpretations of past volcanic activity and the Bonneville flood, as well as bird watching, are other recreational opportunities. Camping, picnicking, and boating facilities are provided.

### *Idaho Department of Fish and Game*

The IDFG provides fishing and hunting opportunities in the state through management of fish and wildlife populations, administration of licenses and fees, and promulgation of regulations for these activities. Additionally, they own or have easements for many lands which function as wildlife habitat and Sportsman's Access sites. Sportsman's Access areas are funded from fishing and hunting license fees to secure access for these uses. The areas also provide opportunities for wildlife observation and nature study. More than seventy Sportsmen's Access areas are found in the Upper Snake River Basin (IDFG, 1993b). A number of wildlife management areas are also managed by IDFG. These sites and the activities are listed in Table 21.

**Table 21. State Wildlife Management Areas within the Upper Snake River Basin**

| Site | Activities |
|---|---|
| Carey Lake | boating, fishing, and waterfowl hunting |
| Hagerman | fishing, upland bird hunting |
| Niagara Springs | fishing, waterfowl and upland bird hunting |
| Sterling | waterfowl and upland bird hunting |
| Portneuf | camping, fishing, upland bird and big game hunting |
| Sand Creek | camping, fishing, waterfowl, upland bird and big game hunting |
| Cartier | fishing, waterfowl, upland bird and big game hunting |
| Mud Lake | camping, boating, fishing, waterfowl, upland bird and big game hunting |
| Market Lake | fishing, waterfowl, upland bird and big game hunting |
| Tex Creek | camping, fishing, upland bird and big game hunting |

Source: IDFG, 1993b.

### *Other Reservoirs*

Idaho Power Company operates a series of hydro projects on the Snake River and tributaries that provide a variety of recreation activities. Five reservoirs associated with projects operated by Idaho Power Company are located in the Basin. These include Twin Falls, Shoshone Falls, Upper Salmon Falls, Lower Salmon Falls, and Bliss reservoirs. Additionally, recreation facilities are provided at the Milner, Thousand Springs, and Malad River projects. Popular activities on the reservoirs include motorized boating, water skiing, swimming, and fishing. Day use parks located at the hydro project sites provide picnicking, boat ramps, and sightseeing opportunities. Views of Twin and Shoshone Falls are possible from two of these parks, which at high river flows provide an outstanding display of water, rock, and space.

### *Whitewater Boating*

In addition to the boating activity occurring on the reservoirs, several river reaches provide whitewater opportunities. The most popular white water areas are listed in Table 22. The quality and opportunity to participate in boating on these stretches is largely controlled by the quantity and timing of flows released from dams upstream of these sections. Table 22 also lists the "ideal" flows for the skill level indicated.

### *Fishing*

Fishing occurs on most of the streams and rivers in the Upper Snake River Basin. A random mail survey of anglers purchasing fishing licenses in 1994 named the Snake River, Henrys Lake, and the South Fork Snake River among the more popular fishing waters in the state (IDFG, 1995). Several rivers and streams within the area are recognized as some of the top trout fishing streams in America. In an article listing the top 100 trout fishing streams in America, nine were identified in Idaho (Pero and Yuskavitch, 1989). Of these, four are found within the Upper Snake River Basin. They include the Henrys Fork, the South Fork Snake River, Silver Creek, and the Big Wood River. Many of the tributaries to these rivers are also excellent fishing streams.

### *Other Recreation Activity*

Recreation opportunities are also provided by local agencies and private entities. These include county and city governments, which manage regional and local parks, golf courses, groomed snowmobile and cross country ski trails, and local boat and fishing access. Private entities provide camping, resorts, and outfitted and guided opportunities. Water-oriented recreation sites are provided at facilities operated by utility companies and irrigation districts.

The Sun Valley-Ketchum area attracts people from around the world as a destination ski and winter sports resort. The surrounding area is also managed by the USFS as the Sawtooth National Recreation Area which provides an abundance of recreation opportunities in a spectacular scenic setting including hiking, camping, fishing, hunting, and mountain biking.

## TIMBER

There is no commercially harvestable timber on the Eastern Snake Plain. Some cutting of cottonwoods and other species along the immediate riparian zone of the Snake River and some of its major tributaries has taken place, but primarily for individual use as fence posts and fuel wood. The nearest suitable timber stands for commercial harvest are on the mountain slopes to the north, east, and south of the Plain. These stands are mainly parts of adjacent National Forests and are managed in accordance with the individual forest plans.

**Table 22. Whitewater Boating Opportunities in the Upper Snake River Basin**

| Segment | Put-in/Take-out | Ideal cfs | Skill Level* | Craft |
|---|---|---|---|---|
| **Henrys Fork of the Snake** Coffee Pot | Macks Inn/McCrea Bridge Campground | 1,000 - 2,000 cfs | III - Intermediate | Kayak, canoe, raft, drift boat |
| Box Canyon | Box Canyon Campground/Last Chance | 1,000 - 2,000 cfs | II - Beginner | Kayak, canoe, raft, drift boat |
| Sheep Falls Run | Riverside Campground /Above Mesa Falls | 1,000 - 2,000 cfs | III-IV - Intermediate Advanced | Kayak, canoe, raft |
| Lower Mesa Run | Grandview/Warm River | 1,000 - 2,000 | II - Beginner | Kayak, canoe, raft, drift boat |
| **Falls River** Cave Falls Run | Cave Falls Campground/ Concrete CCC Bridge | 500 - 1,000 | III - Intermediate | Kayak |
| Lower Run | Concrete CCC Bridge/ Kirkham Bridge | 500 - 2,000 | III -IV Intermediate to Advanced | Kayak, canoe, raft |
| **Bitch Creek** Coyote Meadows Run | Coyote Meadows/Highway 32 Bridge | 500 | III-IV - Intermediate | Kayak |
| Canyon | Highway 32 Bridge/Spring Hollow | 600 - 800 | IV-V - Expert | Kayak |
| **Teton River** | Highway 33 Bridge/Felt Dam | 500 - 2,000 | IV-V - Expert | Kayak |
| **Canyon Creek** | Wright Creek/Old Teton Dam Site | 100 - 200 | IV-V - Expert | Kayak |
| **Blackfoot River** Cutthroat Run | Cutthroat Trout Campground /Trail Creek Bridge | 550 | II - Beginner | Kayak, canoe, raft |
| Canyon Run | Trail Creek Bridge/Cedar Creek | 550 cfs | III-IV - Intermediate | Kayak |
| **Snake River - Main stem** Milner | Milner Bridge/ Main Milner Powerhouse | 12,000 - 15,000 | Expert - Class V | Kayak |
| Star Falls | Main Milner Powerhouse /Above Star Falls | - | Beginner - II/III (@ 1200 cfs) | Kayak, small rafts, canoes |
| Murtaugh | Below Star Falls or Murtaugh Bridge/Twin Falls | 10,000 - 15,000 | Advanced Intermediate - Class IV | Kayak, raft |
| Wiley | Below Salmon Falls/Bridge at Bliss | Above 10,000 | Beginner - Class II (III) | Kayak, raft, canoe |
| Bliss | Below Bliss Dam/King Hill | Above 10,000 | Beginner - Class II (III+) | Kayak, raft, canoe |
| **Malad River** | Malad Dam/Confluence with Snake River | 1,000 - 2,000 | Advanced - Class IV | Kayak |

* Based on the international scale of difficulty with Class I being the easiest and Class VI being extremely difficult.
Sources: Amaral, 1990; McClaran and Moore, 1989.

## MINERAL RESOURCES AND MINING

Water is essential to the mining and processing of minerals, however, total water requirements of the industry are small. The primary uses of water by the mining industry are in mineral processing and dust control. The USGS has estimated that the mining industry consumes less than one-half of 1 percent of all diverted water, and recycles the same water several times (USGS, 1990). Since the total water requirements of the industry are relatively small, water supplies for future mineral processing should be adequate. However, ground water is increasingly important to the industry since many newly-worked mineral deposits are not located adjacent to surface water sources. Potential mineral resource development should be considered in future allocations of regional ground water resources.

Historically, many mining areas in the Upper Snake River Basin have been important to the development of the region. Placer gold has been prospected nearly everywhere, but has not been commercially significant during the past 60 years. The "flour" gold of the Snake River is very fine-grained and is readily moved by stream currents; it does not accumulate in minable stream gravels where recovery is practicable. Copper had a brief run from deposits southwest of Mackay and as a by-product of other base metal production near Hailey (USGS, 1964). Mercury was produced in the 1930's from the Juniper Hill mine in Power County, about 15 miles east of American Falls. There, a small pod of cinnabar ore yielded one 44-pound flask of metallic mercury. Manganese has been mined from the Lava Creek area north of Craters of the Moon National Monument and high up on slopes above the Portneuf River. And coal has been produced from the Horseshoe and Pine Creek valleys in the Teton Basin, as well as from the Goose Creek area of southern Cassia County. Both areas have seen only limited commercial production because of low-grade deposits or difficulties in mining.

### *Industrial Minerals*

**Clay** -- Common clay is used to make heavy-clay products such as building brick and tile. Because the shipping costs involved are high, only local clay deposits can be used economically. Clay pits in the Snake River alluvial flood-plain deposits have been worked near Burley and Heyburn as well as at Idaho Falls (U.S. Bureau of Mines, 1991). New deposits could be developed in these areas if economic demand for the product would increase. A small amount of silty clay is being mined by Snake River Pottery near Hagerman, for use in decorative ceramic products and to make custom bath and kitchen tile. Clay deposits here and elsewhere in the region could be used in the future as linings for settling ponds.

**Diatomite** (diatomaceous earth) -- Diatomite has been mined at several sites in the westernmost portion of the Eastern Snake Plain. A large deposit is located on Clover Creek in Gooding County, and smaller deposits are found in Pasadena Valley south of King Hill and near Banbury Springs in Twin Falls County. The quality of the diatomite deposits varies from noncommercial to good because of varying amounts of impurities (U.S. Bureau of Mines, 1991). Deposits are mined by open-pit methods and are seldom free of other sediments and organic debris, so most diatomite requires washing after mining to prepare it for industrial use.

The primary use of diatomite is as a filtering medium in the separation of suspended solids from water, beer, wines, fruit and vegetable juices, dry-cleaning fluids, raw sugar liquors, and other purifying applications. Other uses are as a filler for paint, paper, or rubber, a carrier for pesticides and hazardous liquids, and as insulation for small vessels or electrical products.

**Limestone --** While the Eastern Snake Plain is most often associated with basalt, several extensive limestone deposits also occur in the area. Most of the commercial limestone workings are located in the mountains north and south of the volcanic track, and vary in age from very old to recent hot springs deposits. Outcroppings of the Tertiary age Salt Lake Formation occur along Medicine Lodge Creek in Clark County. Travertine (banded limestone), from hot springs of the same age, is also found in the same area. Many of the public buildings in southeastern Idaho are faced with travertine from the Fall Creek area in Bonneville County.

Lime-bearing rock from the area has been used principally for agricultural limestone, flux, cement rock, and lime for the sugar industry. The principal consumption has been in the cement industry. Cement produced at the Inkom plant, in Bannock County, has met most of the region's needs for many years. It uses local limestone supplies, with shale and iron enrichments coming from several nearby locations. Much of the lime used by sugar industry is produced by the refiners from imported and locally available rock.

**Phosphate rock --** Approximately 150,000 square miles of eastern Idaho and adjacent portions of Wyoming, Utah, and Montana contain the nation's largest reserve of phosphate rock (U.S. Bureau of Mines, 1988). These reserves were formed in ancient oceans that were subsequently buried under younger sediment accumulations. Through later regression of the seas, uplift, and erosion, the ancient marine phosphate rocks are now exposed at the surface in narrow strips along the flanks of ridges and mountains where surface mining can be performed. Commercial grade rock exposures are generally thicker and closer to the surface in Idaho than in the adjacent states.

Minable deposits of phosphate rock have been found in several counties of the Upper Snake River Basin. Their future development is believed to represent one of the major mineral industries of Idaho, and gradual growth seems assured.

**Sand and gravel --** Sand and gravel extraction comprises the largest single mineral industry in the United States. In Idaho, the Idaho Department of Transportation, along with local governments and their contractors, are the largest consumers of aggregates in the State. Major production is from alluvial gravels throughout the region. While constituting a low-cost product, sand and gravel have many uses -- as sub-base, base, and surfacing courses in road construction, as aggregate for concrete, and as embankment material for controlling surface water movement. Production sites tend to be relatively small and local in occurrence, but often extend in chain-like series along the rivers which transport it and near roads and population clusters. Crushed quarry rock production is usually minor and confined to very selected areas where stream washed materials are not available.

**Stone --** Stone and construction materials are highly important commodities to the architectural building and construction industries. Crushed stone, pumice, and volcanic cinders are used in the construction industry as concrete aggregate and admixtures, building blocks, and as plaster aggregate. They are also important in road construction as adjuncts to alluvial sands and gravel. Dimension stone is any stone which is quarried, cut, shaped, and possibly polished for structural, architectural, or ornamental purposes. Travertine deposits at Fall Creek in Bonneville County have already been mentioned. The famous "Oakley stone," or "rocky mountain quartzite" has been mined from the west flank of Middle Mountain, south of Oakley in Cassia County, since about 1948 (Maley, 1987). Basalt boulders of varying sizes are found throughout the volcanic Eastern Snake Plain. These have been promoted as landscape rocks for the "natural" ornamentation popular in many urban areas. The basalt is not usually mined in the traditional sense, but rather is scavenged from where it lies loose on the ground, often on lands administered by the BLM. It is loaded onto flatbed trucks, often with no dressing or trimming, and hauled to local and regional building supply dealers.

### *Oil and Gas*

The Overthrust belt of Wyoming-Utah-Idaho forms part of a single element of the Cordilleran orogenic belt that extends from Alaska to Central America (U.S. Bureau of Mines, 1988). Linear assemblages of very thick sedimentary rocks, which have undergone intensive thrust faulting and folding, typify the Overthrust belt. Two portions of the Cordilleran orogenic belt are producing oil and gas: the Canadian foothills thrust belt and the Wyoming-Utah-Idaho (tri-state) thrust belt.

The broadly explored Canadian portion, and the relatively unexplored tri-state portion, share many characteristics including general structural form and folding activity, reservoirs, depth of burial, and timing of hydrocarbon migration. They differ in their major source rocks and thermal histories. The Canadian portion has been extensively developed. There are 32 fields which have produced 9.3 trillion cubic feet of gas, 143 million barrels of natural gas liquids, and 132 million barrels of oil (U.S. Bureau of Mines, 1988). Since 1975, significant discoveries of oil and gas have occurred in Wyoming and Utah; production is estimated at more than 500 million barrels of oil and 5.5 trillion cubic feet of natural gas.

No commercial production has thus far occurred in the Idaho portion of the tri-state area. Exploration has been unsuccessful in the areas with the greatest potential which are the formations that have exhibited oil and gas resources in the adjacent states. Several test wells have penetrated to 12,000 feet in eastern Madison and Bonneville Counties but with no commercial discoveries. Eastern Idaho may be on the far edge of productive formations, or perhaps future drilling may yield better prospects.

### *Geothermal Water*

At least 380 hot springs and geothermal wells are known to occur in central and southern Idaho (USGS, 1964). Measured water temperatures at 124 inventoried wells and springs range from 12 to 93 degrees Celsius (55° to 200° F.). Surface water temperatures above 90 degrees Celsius (194° F.) were measured at two wells in the Raft River Valley (USGS, 1964). Other areas with high geothermal resource potential in the Upper Snake River Basin include much of the Island Park Caldera in Fremont County, the Camas Prairie area around Fairfield, and along both sides of the Snake River.

## CULTURAL FEATURES

### *Prehistory*

The Upper Snake River Basin geographically links the northwestern Great Plains with the Intermontane Basin area. This placement has influenced the cultural characteristics of populations prehistorically inhabiting the area. Influences from the cultures prevalent in both areas are evident in the archaeological record of the Basin (Butler, 1986).

Prehistoric populations are thought to have inhabited the Upper Snake River Basin as early as 14,500 years ago. These inhabitants lived in small, highly mobile bands which hunted big game, including some now extinct megafauna. Among the species hunted were elephants *(Mammuthus sp.)*, *antiguus),* camel *(Camelops sp.)*, horse *(Equus sp.)*, mountain sheep *(Ovis sp.)*, elk *(Cervus sp.)*, and deer *( Odocoileus sp.)* (Butler, 1986). Rock caves and lava tubes were used for shelter.

Native societies shifted from specialized big game hunting to a more generalized hunting and gathering way of life as the climate became more arid (7,500 to 2,000 years before present). The modern forms of mountain sheep and bison appeared and were relied upon for sustenance. The atlatl, or throwing sticks, along with its short arrow or dart-like projectile, appear in the archaeological record about this time (Butler, 1986).

In search of food, early inhabitants and visitors gradually developed seasonal migratory routes to camas grounds, fishing waters, and other food gathering areas, utilizing natural routes along rivers and through mountain passes. Small Shoshonean groups from northern Utah may have extended their food-collecting activities into southern Idaho as early as the middle of the fifteenth century. However, the main Shoshone occupation came in the late eighteenth century, after their displacement from the High Plains by the Blackfeet (Butler, 1986).

The Snake and other river canyons are believed to have been favored locations for winter camps. This is particularly true of the middle Snake section below Shoshone Falls which historically marked the upper limit of salmon migrations. Fishing areas focused on falls and rapids which provided easy access to fish.

### *History*

An abundance of fur bearing animals along the Snake and its tributaries attracted trappers and fur traders, the first white men in the region, in the early 1800's. The Wilson-Price-Hunt expedition in 1810 to 1812 opened Idaho to American fur trading, and successive European settlement. Beaver hunting expeditions were common in the 1820's, but a decade later the beaver population had been largely decimated.

The 1840's saw the migration of settlers en route to Oregon and California by means of the Oregon Trail. The trail paralleled the Snake River Canyon. Goodale's Cutoff, avoided the hazards of the primary route of the Oregon Trail, by striking northwestwards across the desert from Fort Hall to the Big Lost River, then skirted the northern edges of the plain and the Camas Prairie. This route was used by settlers from the 1850's through the turn of the century.

The birth of modern Idaho occurred with the expansion of the railway system, advances in agricultural technology, and construction of reclamation projects in the early 1900's (Idaho State Historical Society, 1976). Many irrigation projects were developed with some success by local cooperative irrigation companies in the late 1800's and early 1900's in the Upper Snake. The Carey Act of 1894 and Reclamation Act of 1902, provided federal assistance to settle and reclaim the desert, and accelerated the settlement of southern Idaho. During this period, projects supplying water to the Twin Falls tract, the Idaho Falls and American Falls areas, and the Minidoka Project were constructed.

## NAVIGATION

There is no commercial navigation involving items of commerce on water bodies of the Upper Snake River Basin. However, there is a growing population of outfitters providing fishing and boating opportunities who operate on the Teton, Henry's Fork, South Fork, and main Snake River. Their activities are regulated by the Outfitters and Guides Licensing Board. Pleasure boating by individuals is not presently restricted except by local ordinance.

## FLOOD MANAGEMENT

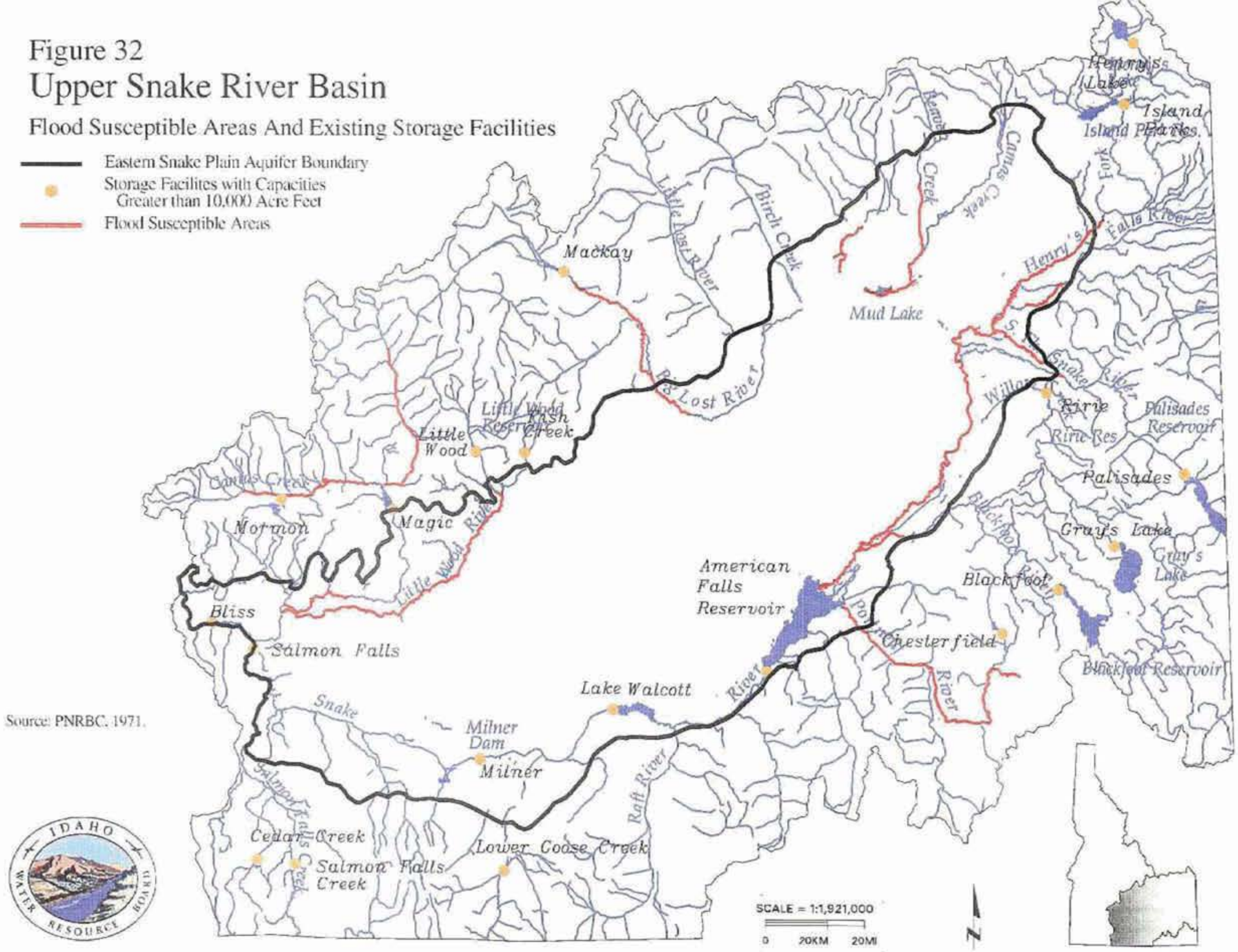
Only a relatively small portion of the Upper Snake River and its tributaries are susceptible to flooding (Figure 32), however, many of the flood-prone areas are intensively populated. Floods here seldom cause loss of life, but often result in extensive damage to lands and buildings, highways, railroads, irrigation facilities, crops, and utilities. Past flood events indicate that spring snowmelt causes the most severe and extensive flooding, as occurred during the spring of 1997. However, one of the largest floods, which caused the most extensive flood damage, occurred as a result of the Teton Dam failure on June 6, 1976.

The largest known natural flood in the region occurred in 1894. Estimated flood peaks were 65,000 cfs at Heise and 77,000 cfs at Milner. Since the completion of Palisades Dam in 1957, flood peaks in excess of 25,000 cubic feet per second at the Heise gauge have occurred on only five occasions, with a maximum recorded flow of 43,500 cfs on June 14, 1997. Near Shelley, flows have exceeded 25,000 cfs since 1957 on nine occasions (excluding the Teton Dam flood) with a maximum flow of 47,800 on June 17, 1997. At Milner, flows in excess of 20,000 cfs have occurred on seven occasions since 1957.

Regulation of the Snake River and some tributaries significantly reduces natural flood flows. The combined active storage capacity of reservoirs in the basin is approximately 4.8 million acre-feet. However, only Jackson Lake, Palisades, Ririe, and the Little Wood Dams were constructed with flood control as a stated benefit. Reservoirs that function for other purposes reduce flood flows through informal flood control operation or incidental storage of flood waters. These projects have an active storage capacity of 3.1 million acre-feet with the largest capacity of 1.5 million acre-feet at American Falls Reservoir. Figure 32 also shows the locations of water storage facilities in the Upper Snake River Basin with capacities greater than 10,000 acre-feet.

Storage projects and levees in the basin protect an estimated 130,000 acres from damage by a 100-year flood event (PNWRBC, 1971a). Jackson Lake Dam, completed in 1909, was the first water project to help reduce flood peaks in the region. Jackson Lake provides incidental reduction of Snake River flood peaks averaging about 5,500 cfs. As farming expanded in the area, irrigators constructed levees along the Snake River and on tributary banks. Most of these works were destroyed by the floods of 1936 and 1943. In 1944, Congress authorized levee construction along the Snake River in the Heise-Roberts area. The project was designed and constructed to provide protection against a flood of 30,000 cfs. It also anticipated protection for sustained irrigation releases from Palisades Dam in the order of 10,000 to 15,000 cfs. Palisades Dam, completed in 1957, provides an average flood peak reduction of about 16,800 cfs (Wirkus, 1996).

Figure 32
## Upper Snake River Basin
### Flood Susceptible Areas And Existing Storage Facilities




Source: PNRBC, 1971.

Seven Flood Control Districts have been formed in the Upper Snake River Basin (Figure 33). Flood Control District goals are (1) to provide for the prevention of flood damage in a manner consistent with the conservation and wise development of our water resources; (2) to construct or propose projects to reduce flooding; and (3) seek to protect and maintain present flood works. Flood Control District No. 1 was organized in Bonneville and part of Bingham counties pursuant to Idaho Code in 1946. Flood Control Districts for the Mud Lake area, and the Blackfoot, Big Wood and Little Wood Rivers were organized during the 1950's. More recently Flood Control Districts have been established for the Raft and Goose Creek drainages.

### *Snake River*

Snake River floods generally occur in the months of April through June, primarily due to spring melting of the accumulated snowpack in higher elevations. Late spring or summer snowmelt floods typically occur as a series of high flows for periods of days or weeks. They can be compounded by warm spring rains that increase snowmelt rates and contribute directly to runoff. Seasonal runoff volumes may be forecast with reasonable accuracy because most of the runoff is derived from snowmelt. Reservoir releases for flood management are dependent on the amount of storage that must be evacuated with respect to runoff forecasts.

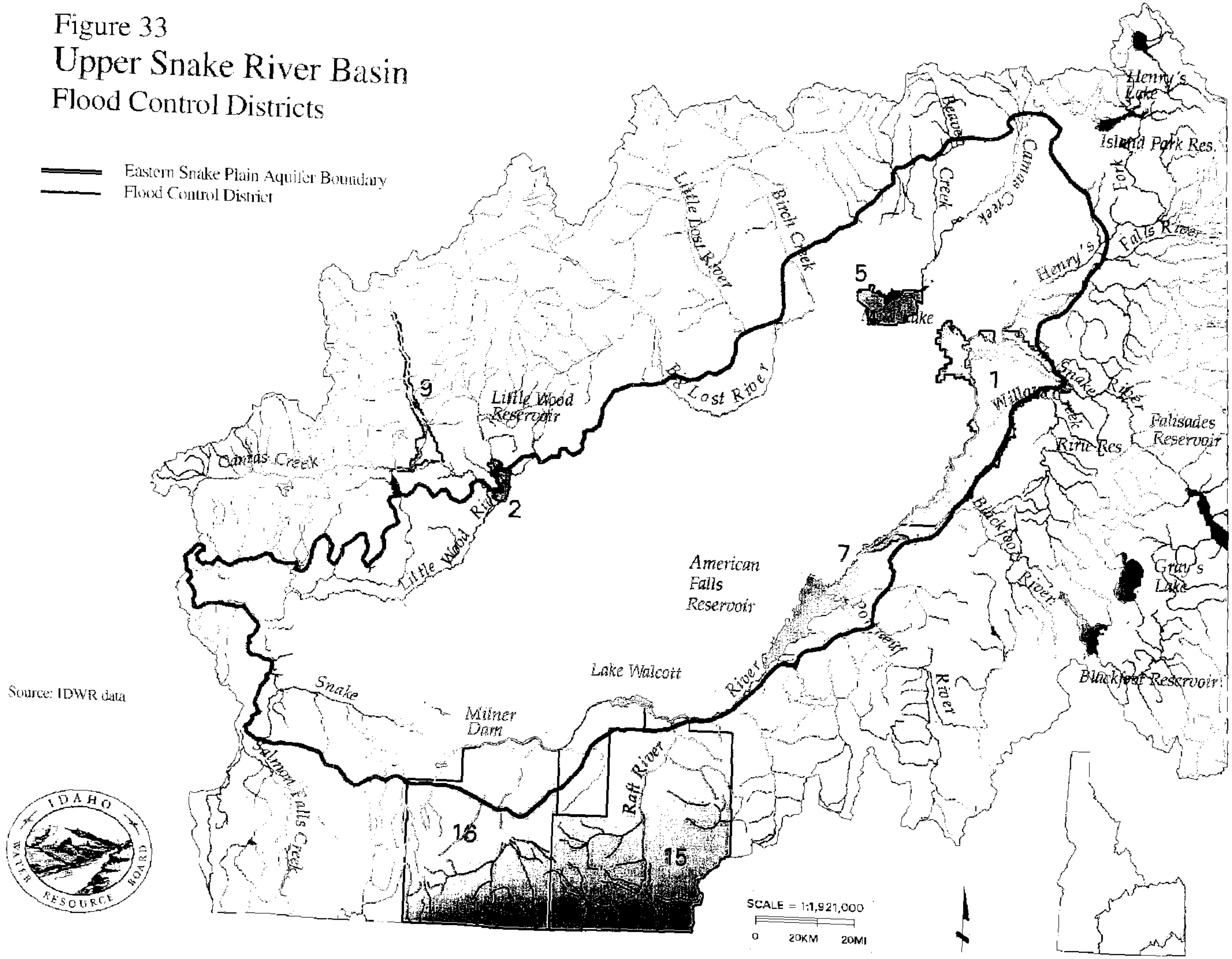
Under a plan formulated by the USBR, the COE, and other interested groups, all but the largest floods are regulated to 20,000 cfs or less at Heise, and the extreme floods will be reduced to the maximum practical extent. Jackson Lake Dam and Palisades Reservoir reduce the estimated 100-year unregulated flood flow of 68,000 cfs at Heise to 29,600 cfs (COE, 1988b). Frequencies of annual flood peaks under existing, regulated conditions are shown in Table 23 for the Snake River at Heise (USGS, 1998). The 1997 flood flow of 43,500 cfs exceeded the 100-year flood flow based on the 1956-97 period of record (after Palisades). Based on the entire 1911-97 period of record, and an unregulated peak of greater than 56,000 cfs, the 1997 event has a frequency of just over 50 years.

**Table 23. Flood Frequency at Heise**

| Exceedence Probability (Percent) | Exceedence Frequency (Years) | Discharges Equaled or Exceeded (Regulated cfs) |
|---|---|---|
| 50 | 2 | 19,700 |
| 20 | 5 | 24,600 |
| 10 | 1 | 28,000 |
| 5 | 20 | 32,400 |
| 2 | 50 | 35,800 |
| 1 | 100 | 39,300 |

Source: USGS, 1998.

# Figure 33
## Upper Snake River Basin
### Flood Control Districts




Source: IDWR data

Between Palisades Dam and the Henrys Fork, the safe channel capacity of the Snake River varies from 15,000 cfs to 30,000 cfs. Flood damage on the main stem, for the most part, is confined to the flood plain between Heise and American Falls Reservoir. Levees protect flood-prone land between Heise and Roberts, near Shelley, and near Blackfoot. However, the stream bed materials, low banks, and gradient induce river meanders. Shifting meanders can erode levees and other man-made works. Sustained high velocity flows cause excessive meandering of the channel and increase flooding risks. Localized winter flooding caused by ice jams is also a problem in this reach.

American Falls Dam has afforded major regulation of Snake River flood flows, although little flood damage is experienced in the reach from the American Falls Dam to Milner Dam. This stretch of the river consists of a series of irrigation diversion pools and canyon reaches. The Snake River, between Milner Dam and King Hill, flows through a deep narrow canyon cut in the Snake River Plain. Developed lands adjoining the river are generally above the elevation of flood discharge. Idaho Power's reservoirs within the reach are for power generation and have no flood storage allocation. There are no levees below American Falls Dam.

### *Flood Prone Tributaries*

Spring thaws, ice jams, and heavy summer thunderstorms cause flooding along Snake River tributaries. Floods along the Henrys Fork, Willow Creek, the Blackfoot River, and the upper areas of the Big and Little Wood River basins are generally the result of spring snowmelt. Flood peaks caused by winter rains are more characteristic in the Portneuf River basin. In the Little Wood River basin from Carey to the confluence with the Big Wood River, nearly all flooding is caused by moderately high discharges when the river channel is severely restricted by ice. Maximum floods on tributaries south of the Snake River and west of the Portneuf basin have been all three types.

**Henrys Fork** - In the Henrys Fork area, flooding is usually the result of spring snowmelt. Floods usually last from several days to several weeks in duration. Flood damage occurs along the lower 22 miles of the Henrys Fork and along the Teton River near Rexburg. Upstream irrigation reservoirs and large irrigation diversions reduce the magnitude of spring and summer flood peaks on the Henrys Fork, however, the bankfull capacity of the lower portion of this river is approximately 5,000 cfs, and a flow of 9,000 cfs causes a general inundation of this reach. A June 1997 flood of 13,600 cfs is the largest recorded flow on the river near Rexburg. Floods on the Teton River are almost an annual occurrence. The Teton River also has a history of ice jam flooding.

**Willow Creek** - Flooding along Willow Creek usually results from spring snowmelt in April and May. These spring snowmelt floods may be augmented by rainstorms. Although Grays Lake provided incidental flood control since its outlet control was constructed in 1924, flooding continued to be a problem. The Grays Lake project was constructed in part to provide irrigation water for the Fort Hall Indian Reservation. Willow Creek branches into tributaries near Idaho Falls; the north branch flows north of the City and the south branch flows through the City. Continued flooding led to the construction of Ririe Dam and Reservoir, by the COE in 1975. Ririe Dam is currently operated by the USBR for flood control on a forecast basis. The flood waters stored during the spring are used for irrigation later during the year.

**Blackfoot River** - Most of the flood damage in the Blackfoot area occurs between the Blackfoot Diversion Dam, located just upstream from the City of Blackfoot, and the mouth of the river. The normal bankfull channel capacity of 500 cfs is exceeded almost every year. Incidental flood management is provided by Blackfoot Reservoir, which was constructed in 1909 to supply irrigation water to the Fort Hall Reservation. Levees have been constructed on the lower reaches of the river near the city of Blackfoot to confine flood waters.

**Portneuf River** - Flooding occurs in reaches along the entire length of the Portneuf River downstream from Portneuf Reservoir and along Marsh Creek. Protection of the Pocatello area is afforded by a local flood control project, but upstream floods damage agricultural lands as well as the towns of Bancroft, Lava Hot Springs and Inkom. The Pocatello project consists of a rectangular concrete channel through the city with reverted levee and channel reaches on both ends where development is less extensive. Downstream from Pocatello, the Portneuf River flood plain consists of brush and pasture land. The normal bankfull channel capacity of 1,000 cfs has been exceeded 13 times since 1970, with a maximum flow of 2,870 cfs on May 17, 1984. A report on the Portneuf River examined various flood control alternatives, including constructing multiple purpose storage reservoirs and enlarging the river channel (COE, 1988a). The feasibility of the Blaser, Topaz, and Marsh Creek dam sites were examined. The study found that these proposals were not then economically justified.

**Mud Lake** - Camas and Beaver Creeks are sources of surface inflow to Mud Lake, which has no effective outlet other than irrigation canals, evaporation, and seepage. Lands along Camas Creek near the lake and along the south side of the lake have flooded. If the volume of inflow exceeds the available storage capacity of the lake, locally constructed dikes around the lake are overtopped and flooding of farm areas south of the lake occurs. The Mud Lake flood plain is principally in crops. Portions of residential and associated developments in the communities of Terreton and Mud Lake, on the fringe of the flood plain, suffer minor damages under extreme flood conditions.

**Big and Little Lost Rivers** - Flooding along the Big Lost River is almost always the result of spring snowmelt. Channel capacities are about 1,500 cfs near Mackay and drop to 500 cfs near Arco. The normal bankfull channel capacity of 1,500 cfs near Mackay has been exceeded 11 times since 1970. Downstream of Arco, the river flows out onto lava fields and into the aquifer. Incidental flood control is provided by Mackay Reservoir, which was constructed for irrigation storage in 1919. A 1991 COE feasibility study examined several methods for reducing flood damages along the Big Lost River. The alternatives included enlarging Mackay Reservoir, regulating Mackay Reservoir for flood control, constructing a multipurpose reservoir at Antelope Creek, diverting flood flows to the Chilly Sinks or Barton Flat areas, and diverting flood flows into the Old Utah Construction Canal and extending the canal into the desert. The feasibility study showed that storage alternatives are not economically feasible at this time. Percolation tests revealed that the control options which included diversions and infiltration of flood flows would not be practicable. Diversion works have also been installed on the INEEL to divert Big Lost flood flows away from important facilities.

On the Little Lost River, low winter stream levels sometimes freeze forming an obstruction to water flows. In such cases, water from the melting tributaries flows on top of the ice and spreads to adjacent lands. The Natural Resources Conservation Service (formerly Soil Conservation Service) constructed facilities to divert these flows into gravel pits north of Howe, from which the flood flows recharge the aquifer.

**Big and Little Wood Rivers** - Most flood events along the Big and Little Wood Rivers result from spring snowmelt, but heavy rain-on-frozen-ground events have occurred. Ice jam flooding is also common during the winter. The flooding problem is compounded because the banks and channels of these rivers are easily erodible. During the course of flooding, the channels may shift several hundred feet laterally, which could impact structures, roads, utilities, irrigation facilities, and other improvements along the river channel. Levees and channel bank improvements have been constructed at various locations on both the Big and Little Wood Rivers, including levees near Bellevue, and channelization of the Little Wood through Gooding. Little Wood Reservoir is operated by the USBR for flood control on a forecast basis. Other irrigation water storage reservoirs, such as Magic Reservoir and Mormon Reservoir, provide incidental flood control. Flooding is a concern both in the fast developing Sun Valley-Ketchum-Hailey area, as well as in the Gooding-Shoshone area. A flood control project for the Gooding-Shoshone area was proposed in 1976. This project is described below.

### *Future Conditions*

Average annual flood damages along the Snake River have been estimated at less than one million dollars (COE, 1996). When river flows reach 36,000 cfs, approximately 270,000 acres, encompassing farmlands, small communities, and urban areas along the Snake River are subject to flooding and significant damage (PNWRBC, 1971; IWRB, 1976; COE, 1996). Damage estimates for the 1997 flood event were estimated at just over 5.4 million dollars (IBDS, 1998).

Irrigation diversion structures, reservoirs, and canal networks can sometimes help to diminish the magnitude of natural flood peaks on many streams by diverting some of the excess flows. However, this capacity is not always available when needed, and the net effect in providing reliable flood protection is therefore not consistent.

Culverts and bridges designed and located in accordance with accepted current engineering standards will pass most expected flood flows, however, many existing culverts and bridges do not meet these criteria. Undersized culverts that do not pass enough floodwater may cause inundation behind the culvert, damaging structures or other improvements. Floodwater that is impounded behind a road embankment due to an undersized culvert may saturate and erode that road embankment, resulting in costly repairs to the culvert, embankment, and road structures. Low bridges may also impound water, causing inundation behind the bridge. Floodwater impounded by a low bridge can overtop the stream channel banks and cause damage to the bridge abutments, approach structures, and road surface. Low bridges may also be damaged by floating debris, such as uprooted trees, during a flood event.

In order to be eligible for federal disaster assistance, the Flood Disaster Protection Act requires local communities to develop long-range hazard mitigation plans to cope with flood damages. These hazard mitigation plans often include location and design controls for buildings to avoid or lessen flood damages. These plans also include measures for flood-proofing or lessening flood damage to public roads, bridges, and utilities. Floodplain management is often the most effective means of flood damage and public cost reduction available when applied at the local level through enforced zoning controls and building codes.

### *Little Wood River Flood Control Project*

A flood control project was studied by the COE for the Shoshone-Gooding area of the Little Wood River. The project would consist of diverting flood waters from the Little Wood River into impoundment areas located in adjacent lava beds. The COE has been asked to redesign the project to accomplish both flood control and aquifer recharge.

**Project History**
A 1976 COE study of the Big and Little Wood Rivers and their tributaries recommended a flood control project which included diverting flood waters out of the Little Wood River by way of the existing Dietrich and Milner-Gooding Canals. In 1986, the Little Wood River Project was authorized for construction under Section 401 of Public Law 99-662, which requires a 75%-25% Federal-Non Federal cost sharing arrangement. The counties of Gooding and Lincoln and the cities of Gooding and Shoshone were the non-federal project sponsors. In 1993, the sponsors terminated the planning studies because the area was in the midst of a severe drought, crippling the agricultural-based economy of the region.

In 1993, an Aquifer Recharge Subcommittee of the Idaho Legislature was formed to identify methods of aquifer recharge. By a letter dated March 31, 1994, the Legislature indicated interest in adding aquifer recharge as a project purpose, in conjunction with flood control, and requested that the COE reopen the terminated study. On July 14, 1994, the IWRB provided a letter in support of reopening the study and for including aquifer recharge as a project purpose. The COE reopened the project study in November of 1994.

During the 1996 Legislative Session, House Concurrent Resolution 34 provided "*that the Water Resource Board shall act as a sponsor and cost-sharing partner with the U.S. Army Corps of Engineers in the evaluation and construction of the Little Wood River Project upon sufficient funding being appropriated to the Water Resource Board and the Department of Water Resources to effectuate this purpose*." The COE has not been funded to initiate the restudy of the Little Wood River Report.

**Original Flood Control Project Description**
The flood control project as originally designed consisted of diversion, channel, and ponding facilities in two separate locations. These facilities would provide diversion of flood waters from the Little Wood River to adjacent lava beds, utilizing the existing Dietrich and Milner-Gooding Canals. Also included in the project were modifications to the Gooding Canal, the Gooding Safetyway, and the X-Canal.

The Dietrich Canal diversion plan consists of replacing a small diversion dam on the Little Wood River about one mile south of Richfield, modifying the existing canal headworks, and enlarging three thousand (3,000) linear feet of the Dietrich canal to increase the hydraulic capacity of the canal. Also included in the project plan at this location is constructing a new 11,500-foot long channel leading from the canal to a new six thousand (6,000) acre-foot capacity infiltration area formed by an impoundment dike. The Dietrich Canal diversion is designed to divert up to 1,500 cfs from the Little Wood River.

The Milner-Gooding diversion plan consists of existing facilities including a diversion structure and a channel leading to a natural ponding area in lava beds, located about 2.5 miles northwest of Shoshone. These facilities were included in the COE project plan, but have since been constructed by the Lower Snake River Aquifer Recharge District as a means of raising local ground water levels. The Recharge District purchases Snake River water and delivers it to this ponding site by way of the Milner-Gooding Canal. During periods of flood flows on the Little Wood River, these facilities can be used to divert up to 600 cfs.

The Gooding Safetyway improvements would consist of a flood-flow gauge device to enable diversion of flood flows north of the City of Gooding onto an adjacent lava bed. The Gooding Canal improvements would consist of making repairs to the existing rock wall of the canal. The X-Canal improvements would consist of installing a gate structure to assist in the control of flood flows.
Besides reducing the impact and public cost of uncontrolled flooding, the water that is diverted to the ponding sites will percolate into the ground and enhance aquifer recharge.

**Flood Control Project Costs and Benefits**
The average annual flood damages to Shoshone and Gooding were estimated by the COE to be $2,236,000 (1992 dollars). The Little Wood River Project as designed for flood control would reduce the average annual flood damages to an estimated $293,000 (1992 dollars). This is an 87 percent reduction in the average annual flood damage.

The total flood control project costs are estimated to be $10,800,000 (year 2000 dollars), with the local project sponsor's share at $2,700,000 (year 2000 dollars). Annual operation and maintenance costs are expected to be $28,000 (year 2000 dollars), for which the local project sponsor would have to assume responsibility. Using the water project federal discount rate and assuming a fifty-year project life before major rehabilitation, total annual project costs would be approximately $835,400 (year 2000 dollars). Contrasted with an average annual flood damage reduction benefit of $1,943,000 (year 1992 dollars), this project has a benefit to cost ratio of approximately 3 to 1.

The COE has been requested to redesign the project to serve as both a flood control and recharge project. If a feasible project can be identified, the IWRB is authorized to act as the local project sponsor. The COE hopes to receive funding and begin the project re-scoping in 2000.

# MANAGEMENT CONSIDERATIONS

Various state, federal, and local entities have roles in the regulation and institutional aspects of water use. Among the constraints imposed by convention, public desire, and legal requirements which pertain to ground water and management of the Eastern Snake Plain aquifer, several will probably be the primary controlling factors in future management decisions in the area. These constraints will play a major role in establishing the base conditions for future aquifer planning.

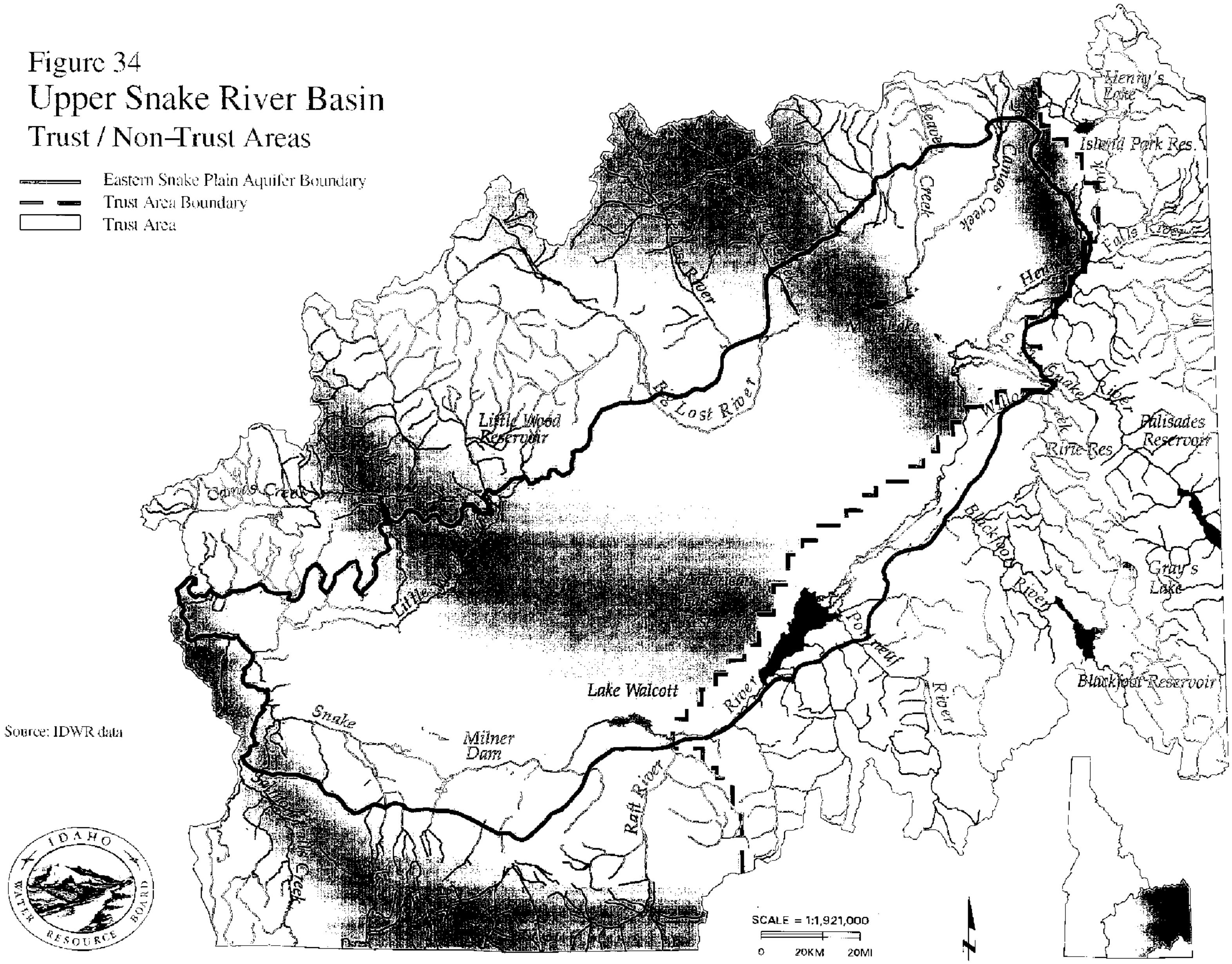
## SWAN FALLS AGREEMENT

The Swan Falls Agreement of 1984 between the State of Idaho and the Idaho Power Company is a major factor in ground and surface water management in the region. Among the provisions of the agreement, as amplified by the State Water Plan (IWRB, 1996), are several items which are specific to future aquifer management. Policy 5A of the State Water Plan recognizes that the Swan Falls Agreement establishes the framework for water management practices, and Policy 5B affirms that certain minimum flows in the Snake River are essential to implementation of the Swan Falls Agreement. These minimum flows, as measured at the Murphy gaging station, have been established in Policy 5B of the State Water Plan as meeting or exceeding 3,900 cfs between April 1 and October 31 (spring and summer flows), and 5,600 cfs during the winter season between November 1 and March 31, of any year. During portions of low-water years, river flows between Milner and Swan Falls Dams consist almost entirely of ground water discharges from the Eastern Snake Plain aquifer. The aquifer serves as the primary reservoir in sustaining the minimum flows.

Under Policy 5C, the State Water Plan recognizes an aspect of the Swan Falls agreement which subordinates certain hydropower water uses to other upstream beneficial water uses. The claimed right of 8,400 cfs at Swan Falls Dam is considered to be the appropriated amount, and any flows between the 3,900/5,600 cfs minimum flow of the agreement and the 8,400 appropriated amount are held in trust by the state. The rights held in trust are subject to depletion by future beneficial upstream users, and the power rights are to be subordinated to these uses if certain conditions spelled out in the Swan Falls Agreement are met. This "trust water" includes only those waters, including groundwater, from areas which are tributary to the Snake River between Milner and Swan Falls Dams. Rights to use water tributary to the Snake River above Milner Dam are not to be administered with rights to use water downstream from Milner Dam (Sec 42-203B, Idaho Code).

Hydrogeology studies accomplished by the IDWR staff were used to guide the selection of the dividing line between the trust and non-trust areas which is located as shown on Figure 34. Natural flows of ground and surface water through the shaded area comprise the trust water which contributes to the minimum flows required under the Swan Falls agreement. Water from this area which may be in excess of the minimum flows, but less than the claimed right of 8,400 cfs, may be reallocated to new uses when it is available. Waters from the nonshaded area are the non-trust waters and are considered tributary to the Snake River upstream of Milner Dam.

Figure 34
# Upper Snake River Basin
## Trust / Non-Trust Areas



## MORATORIUM

On May 15, 1992, the Director of the IDWR ordered a moratorium on the processing and approval of pending and new applications for water development permits in the Snake River Basin above Weiser, Idaho. This moratorium was adopted because of the continuing effects of long-term drought. The drought, in conjunction with changed irrigation practices had resulted in a reduction in aquifer recharge. The need to supplement or replace inadequate surface supplies prompted many water users to pursue ground water as an alternative source of supply. These practices caused concerns regarding the water supply for existing water rights in some areas of the Snake Plain aquifer and from the springs. The moratorium was amended on April 30, 1993 to remove certain basins from the moratorium, but it remains in effect for the entire Upper Snake River Basin until withdrawn or modified by the Director.

The moratorium applies to all applications proposing a consumptive use of water; it excludes developments for domestic purposes, non-consumptive uses, and deepening of existing wells having existing water rights. It allows processing and approval of applications to transfer existing water rights and case-by-case approvals involving the protection of public interest, insignificant consumption of water, or remote locations. Applications are processed if mitigation for expected damages are clearly stated.

In order to address the long-term management of the Snake Plain aquifer, the Legislature authorized studies to examine the implications of changing demands on the aquifer. It was determined that continuation of the moratorium would be appropriate while the studies were undertaken. To do so, the Legislature approved and confirmed the moratorium and ordered it to remain in effect until December 31, 1997. After that date, the Director of the IDWR may continue, modify, or withdraw the moratorium order. To date, no action has been taken to modify or withdraw the moratorium order.

## ADJUDICATION

It became apparent during negotiations of the Swan Falls agreement that the amount of water being used by the rights holders was not well defined. Consequently, the Agreement called for the state to initiate an adjudication process to evaluate all claims for water and place them in an orderly relationship to one another. The Idaho Legislature determined in 1986 that such an adjudication of water rights of the entire Snake River basin was in the public interest. Procedures to carry out the adjudication were established to provide fair, efficient, and impartial methods to judge the rights of all claimants to the proceedings, and to provide adequate state laws necessary to deal with federal and Indian tribal water claims.

In 1908, a U.S. Supreme Court decision (Winters Doctrine) determined that rights to unspecified quantities of water necessary to fulfill the purposes of land reservations (withdrawals) existed for lands set aside by the federal government as Indian Reservations. The priority of these rights were imposed as of the date the lands were withdrawn, which in some cases was well before irrigation or other rights had been established. No specific beneficial uses for this water were designated, nor were points of diversion or use. The Shoshone-Bannock Tribes and the federal government filed numerous claims for reserved water rights in the Upper Snake River Basin. Most of the federal government claims are for stock water in the Snake River and its tributaries.

On behalf of the Shoshone-Bannock Tribes of the Fort Hall Indian Reservation, and as part of the adjudication process, the United States government and the Tribes entered into *The 1990 Fort Hall Indian*

*Reservation Water Rights Agreement* with the State of Idaho. The agreement was approved by the District Court as part of the Snake River Basin Adjudication partial decree in August 1995. It provides water for present and future uses on the Reservation, including water for irrigation, instream flows, hydropower, livestock, as well as for domestic, commercial, municipal, and industrial purposes. It was the first portion of the adjudication to be completed.

Solicitation of water right claims for the adjudication began in February, 1988. The IDWR has been evaluating claims to surface and ground water rights since that time. In order to judicially settle approximately 175,000 separate claims to water rights, a lengthy process is underway. A Director's Report for Reporting Area 5 was completed for domestic and stock water claims in 1996 and submitted to the District Court. This is the same area as IDWR Administrative Basin 35 and includes portions of Power, Bingham, Jefferson, and Bonneville counties on the Eastern Snake Plain Aquifer. That report recommended a total of 2,700 water right claims as valid for domestic and stock water. Of these claims, 102 were for stock water on lands administered by the U.S. BLM. An additional 14 claims were for non-BLM stock water, and the remainder were for domestic or mixed domestic and stock water uses. A Director's Report for domestic and stock water was completed for Basin 34, the Big Lost Basin in Butte and Custer counties, which found more than 3,800 claims filed. More than 2,000 were on BLM lands and nearly 1,400 were on USFS administered lands. More than 700 non-federal claims were also filed, some for diversions on federal lands but with water use being made on non-federal acreages. In Basin 36, which includes portions of Blaine, Gooding, Butte, Jerome, Lincoln, and Minidoka counties, more than 5,100 domestic and stock water claims were filed. About 230 were filed on BLM lands and over 4,900 were from non-federal entities.

## CONJUNCTIVE MANAGEMENT

Water resources which are hydraulically interconnected are presently required by statutes, Board policy, and IDWR rules, to be managed as a single resource (conjunctively). Surface and ground water resources in the Eastern Snake Plain Aquifer have been determined to be hydraulically connected. The main, or regional, aquifer and its tributary aquifers are all functionally linked and naturally discharge to or are recharged by surface water sources. Aquifers serve as underground reservoirs, stabilizing stream discharges during dry periods. The Eastern Snake Plain Aquifer has been designated in conjunctive management rules (IDAPA 37.03.11) as an area having a common ground water supply. As such, diversions or changes in ground water recharge and use affect the flows of surface water resources and availability of ground water supply to other holders of ground water rights. Water uses on the Eastern Snake Plain are affected by this relationship.

## SPRING-FLOWS

Springs emerging from the Eastern Snake Plain Aquifer in the American Falls and Thousand Springs reaches of the Snake River are vital to the regional economies. The springs flowing into the American Falls Reservoir provide an important part of the Snake River flow used by Magic Valley irrigators. In the Thousand Springs area, spring flows are the source of water for much of the State's aquaculture industry. During periods of low runoff, hydropower flows between Milner Dam and the Murphy stream gauge consist almost entirely of aquifer discharge from the Thousand Springs area. Continued efforts to efficiently use ground water, while sustaining aquifer recharge to stabilize ground water levels and spring flows at some acceptable level, in accordance with state law, is reflected in State Water Plan Policy 5H adopted in 1996 by the IWRB. The policy states: *It is the policy of Idaho to seek to maintain spring flows* *in the American Falls and Thousand Springs reaches of the Snake River which will sustain beneficial uses of surface and ground water supplies in accordance with state law* (IWRB, 1996).

The legislature appropriated $945,000 to the IWRB in 1995 to purchase water from the Water Bank for recharge of the Eastern Snake Plain Aquifer and to pay a conveyance fee to those entities that participated in the managed recharge program. The Board's managed recharge program encourages participating entities to use their existing facilities to help recharge the aquifer when their system capacity is not required for irrigation. The additional recharge was estimated to total about 140,000 acre-feet of water in 1995, 210,000 acre-feet in 1996, and over 200,000 acre-feet in 1997.

The 1997 Upper Snake River Basin Study concluded that use of the existing facilities would limit the amount of managed recharge that could be accomplished since the time period when excess capacity for recharge was available was limited. Model studies were run to help evaluate the amount of managed recharge that might be possible and the effect of the recharge on discharges to the Snake River. The recharge sites used in the study are shown on Figure 35.

The legislature funded the Department in 1997 to conduct a study of major managed recharge sites for the Eastern Snake Plain Aquifer. At least five major recharge sites will be identified and evaluated along with the costs to construct and implement the managed recharge project.

## OTHER FEDERAL AND STATE RULES, REGULATIONS, AND POLICIES

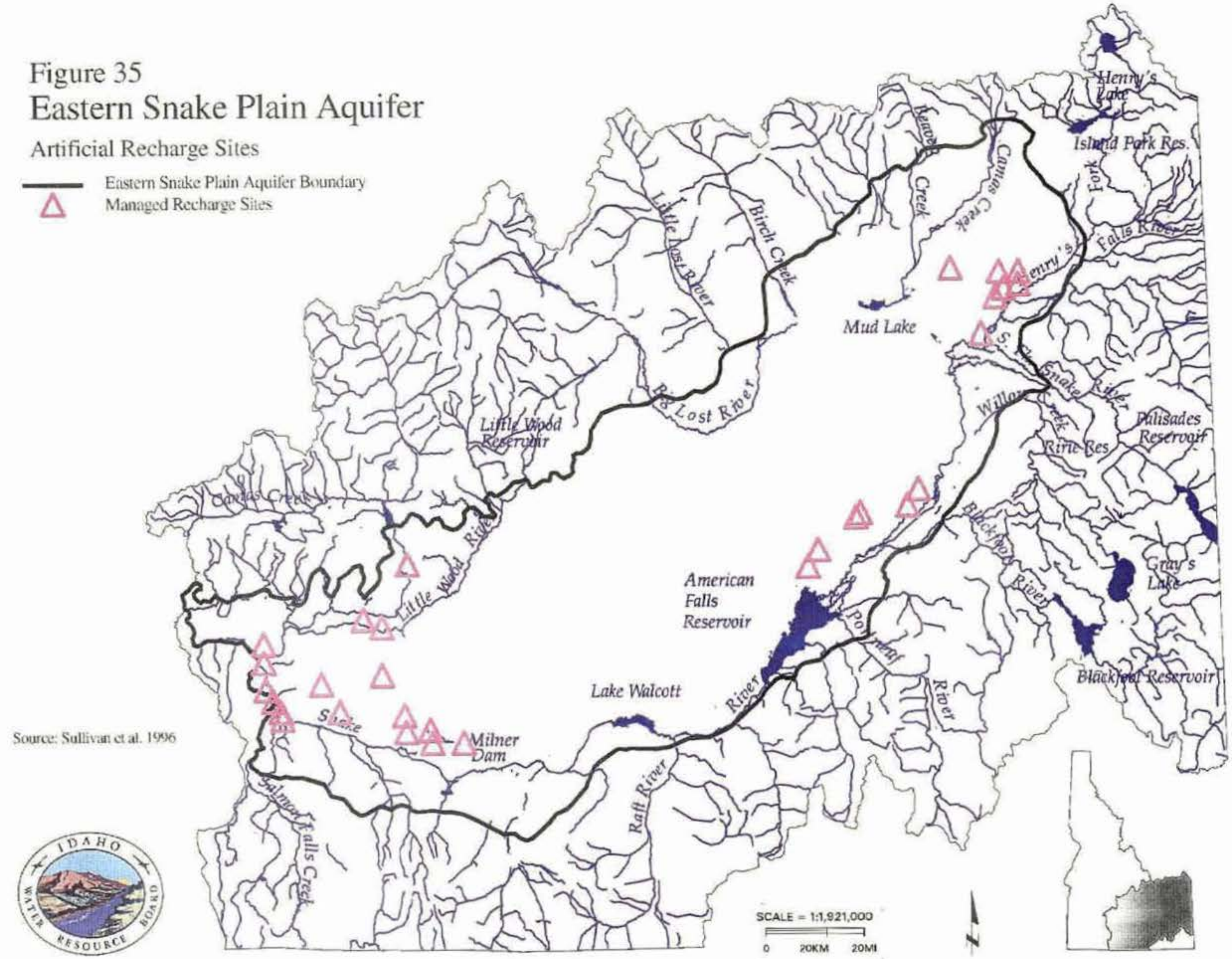
### *Sole Source Aquifer*

The Eastern Snake Plain Aquifer has been designated by the EPA as a sole source aquifer under provisions of the federal Safe Drinking Water Act (U.S. EPA, 1991). This designation came about after petitions in 1977 and 1982 by area residents requested such designation. After conducting and reviewing numerous studies, the EPA in 1990 determined that the Eastern Snake Plain Aquifer supplied all (100%) of the drinking water consumed in the area (U.S. EPA, 1990). The federal guideline is that the aquifer must supply 50 percent or more of the drinking water consumed over the area in order to qualify for designation as a sole or principal source aquifer. The studies also confirmed that no alternative sources, or combination of sources, could economically supply all those who obtain their drinking water from the aquifer.

The consequences of this designation are that no federal financial assistance can be received for any project which could contaminate the aquifer and create a significant hazard to public health. Another provision of the law provides that federal assistance may be authorized to plan or design a project to assure that it will not contaminate the aquifer.

Figure 35
# Eastern Snake Plain Aquifer

Artificial Recharge Sites



### *Endangered Species Act*

The five listed Snake River molluscs have certain habitat requirements that may require consideration in the management of surface and ground water resources. An Aquatic Species Recovery Plan was prepared for the middle Snake River by the USFWS in April 1996. The plan calls for implementing various conservation measures that, in the short term, prevent the extinction or further decline of five mollusc species, and restore viable, self-reproducing colonies of these species over the long term. While the USFWS is not mandated to require other agencies carry out specific actions for endangered species recovery, several tasks have been identified for implementation by designated agencies with authorities in those areas. Among the water management activities suggested by the plan are the stabilization of aquifer discharges at levels necessary to preserve the species cold-water spring habitat, establishment of instream flows for the Snake River for habitat maintenance using purchases and transfers from the Idaho Water Bank, and protective stream designations under State or federal wild and scenic authority. Biennial reviews are scheduled to monitor progress in plan implementation.

### *State Water Plan*

Many policies contained in the State Water Plan apply generally to all waters of the state and define the foundation for future water management and development programs. Others contain measures unique to specific areas, including the ten elements of policy group 5 which deal with the Upper Snake River Basin (IWRB, 1996):

- Policy 5A states that the Swan Falls Agreement establishes the framework for water management in the basin.
- Policy 5B sets forth the minimum average daily flows established by the agreement, and recognizes that the exercise of water rights above Milner Dam may reduce flows at the dam to zero.
- Policy 5C provides for the reallocation of Snake Basin trust water to new beneficial uses.
- Policy 5D reserves a water flow of 150 cubic feet per second from the trust water above Swan Falls Dam for future domestic, commercial, municipal, and industrial (DCMI) consumptive uses.
- Policy 5E specifies that the trust water not reserved for future DCMI shall be reallocated for new and supplemental irrigation requirements.
- Policy 5F recognizes that depletion of stream flows to levels below the established minimum hydropower flows is not in the public interest.
- Policy 5G asserts that the commercial and recreational navigation is provided by established Snake River flows.
- Policy 5H supports maintenance of spring flows in the American Falls and Thousand Springs reaches of the Snake River to sustain beneficial ground and surface water uses.
- Policy 5I promotes new large surface water storage projects upstream from the Murphy gauge provided that the use is in the public interest.
- Policy 5J encourages acquisition of reservoir storage to provide flexibility in maintaining designated minimum stream flows.

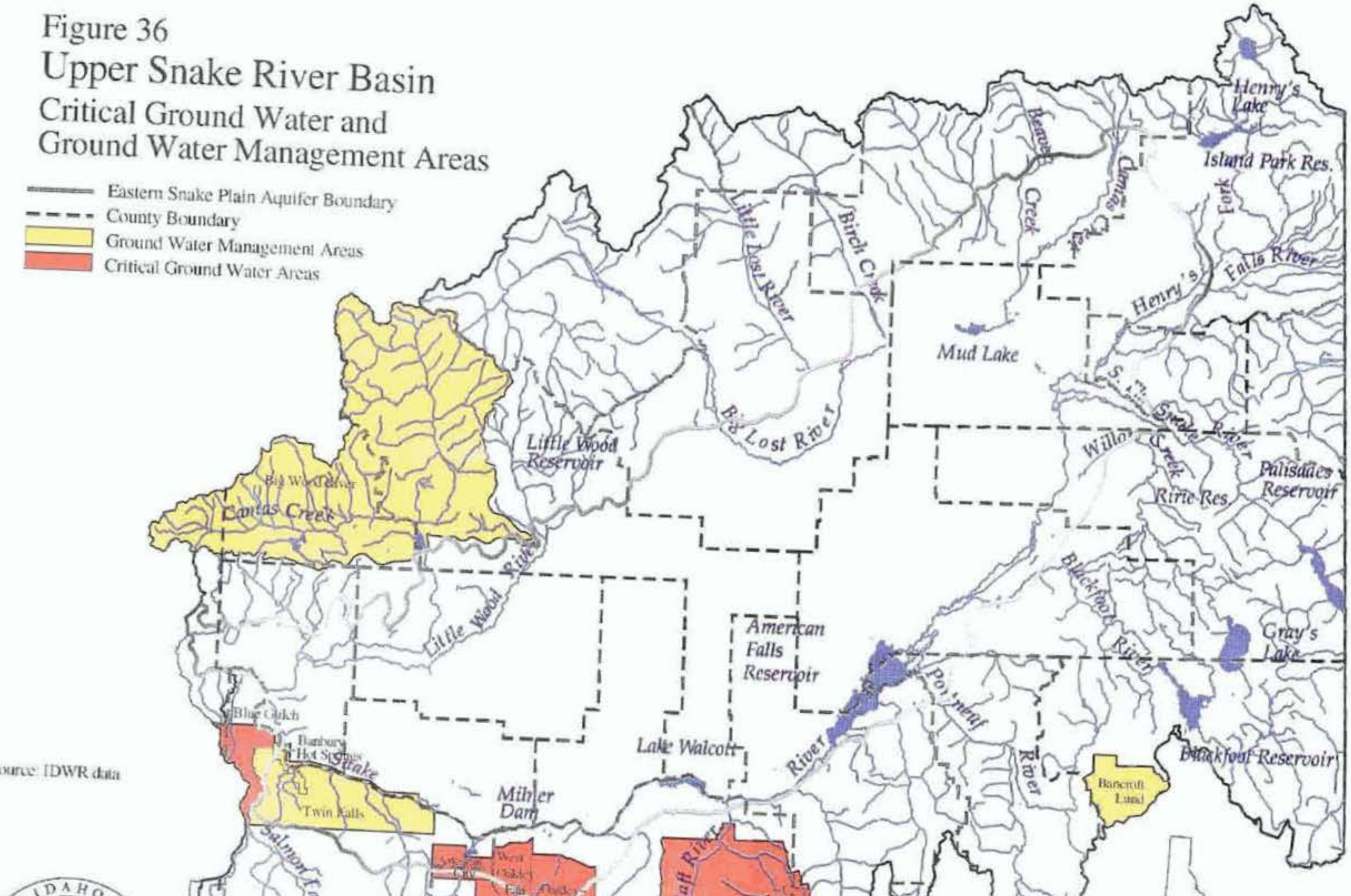
### *Critical Ground Water Areas and Ground Water Management Areas*

The Director of the IDWR has designated several areas in the Upper Snake River Basin for special protection (Figure 36). A Critical Ground Water Area is any ground water basin, or part thereof, not having sufficient ground water to provide a reasonably safe supply for irrigation or other uses at the current or projected rates of withdrawal (Idaho Code, section 42-233a). In Critical Ground Water Areas, approval of an application for a ground water right is predicated upon there being enough water available, on a case by case basis, to meet the beneficial use needs of the applicant without adversely affecting existing water users. When there is insufficient water supply available to meet the existing demands of water rights within the area, the Director may order water right holders, on a time priority basis, to cease or reduce ground water withdrawals. A Ground Water Management Area is any ground water basin, or part thereof, which may be approaching conditions of a Critical Ground Water Area (Idaho Code, section 42-233b). New ground water permits in these areas are also dependent upon the applicant demonstrating that sufficient water is available to meet the new needs without injuring prior users of the resource.

### *Water Measurement Districts*

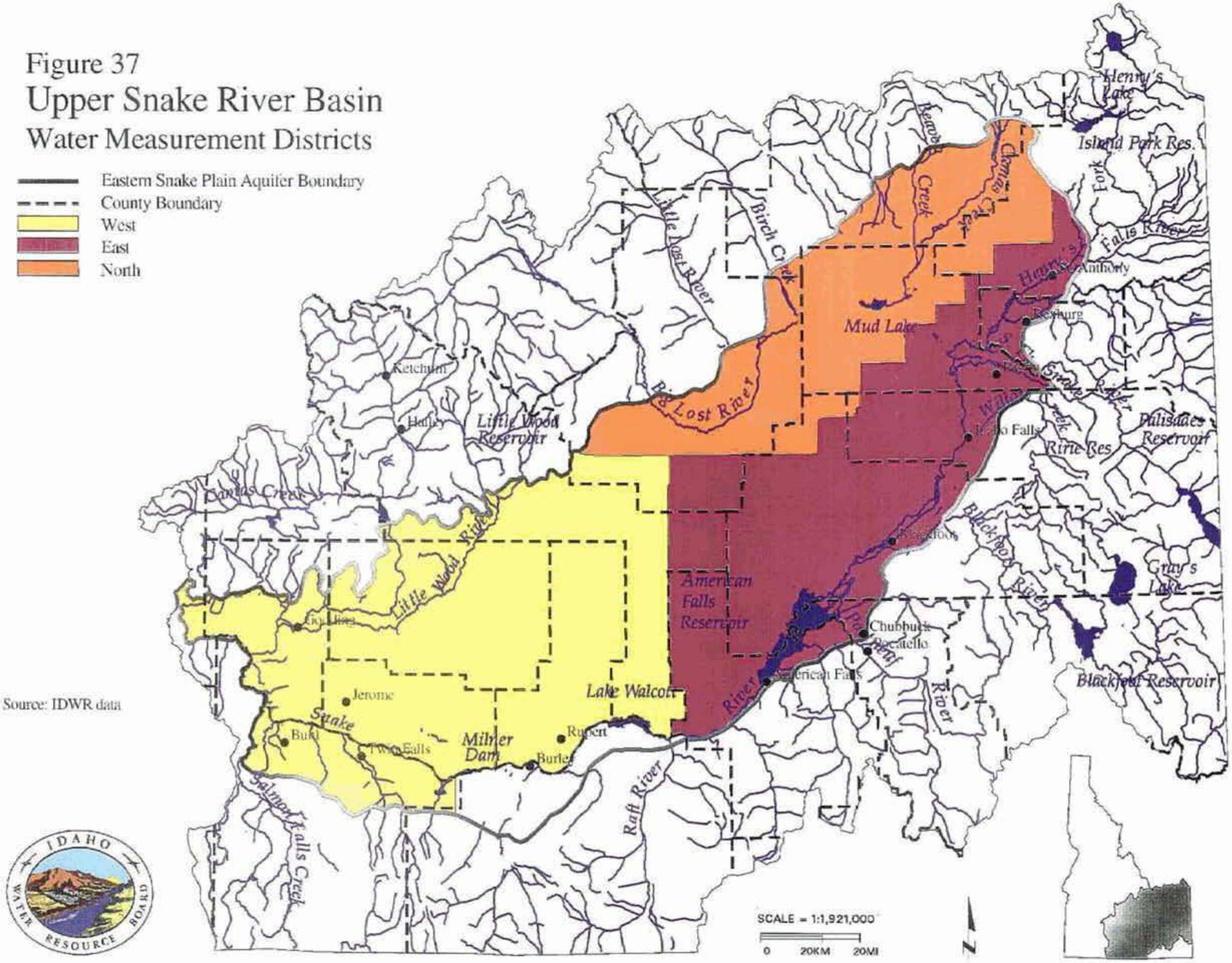
One of the most critical needs for making practicable water management decisions in the future will be the acquisition of reliable water diversion and use data. During the 1995 Legislative session, the Director of the IDWR was authorized to divide the state into water measurement districts in such manner that each defined public water source, or part thereof, would constitute a measurement district (Idaho Code 42-706). Water rights in organized, active water districts already measuring and reporting diversions are excluded from water measurement districts. Ground Water Districts, irrigation districts, hydropower users, aquaculturists, and appropriators of instream flow uses can petition to be excluded provided they measure and record the diversions using appropriate measurement methods and agree to provide detailed annual reports concerning their diversions to the IDWR. Participation is mandatory for all other water users within the designated district, except that domestic and stockwater users are exempt. The water measurement districts are intended to provide an umbrella of coverage ensuring that water diversions in the state would be monitored. Three water measurement districts were formed in late 1996 and are shown on Figure 37. During 1997, the districts began the first phase of a three-year implementation program. Water users met, elected hydrographers, and provided for a budget to begin operation of the districts. Inventories of diversions were made to determine the most appropriate means of measurement, and initial measurements were begun. After the three year period, it is expected that the districts will provide consistent reporting of water diversion data needed for future water management decisions.

Figure 36
Upper Snake River Basin
Critical Ground Water and
Ground Water Management Areas




Source: IDWR data

Figure 37
Upper Snake River Basin
Water Measurement Districts




Source: IDWR data

### *Ground Water Districts*

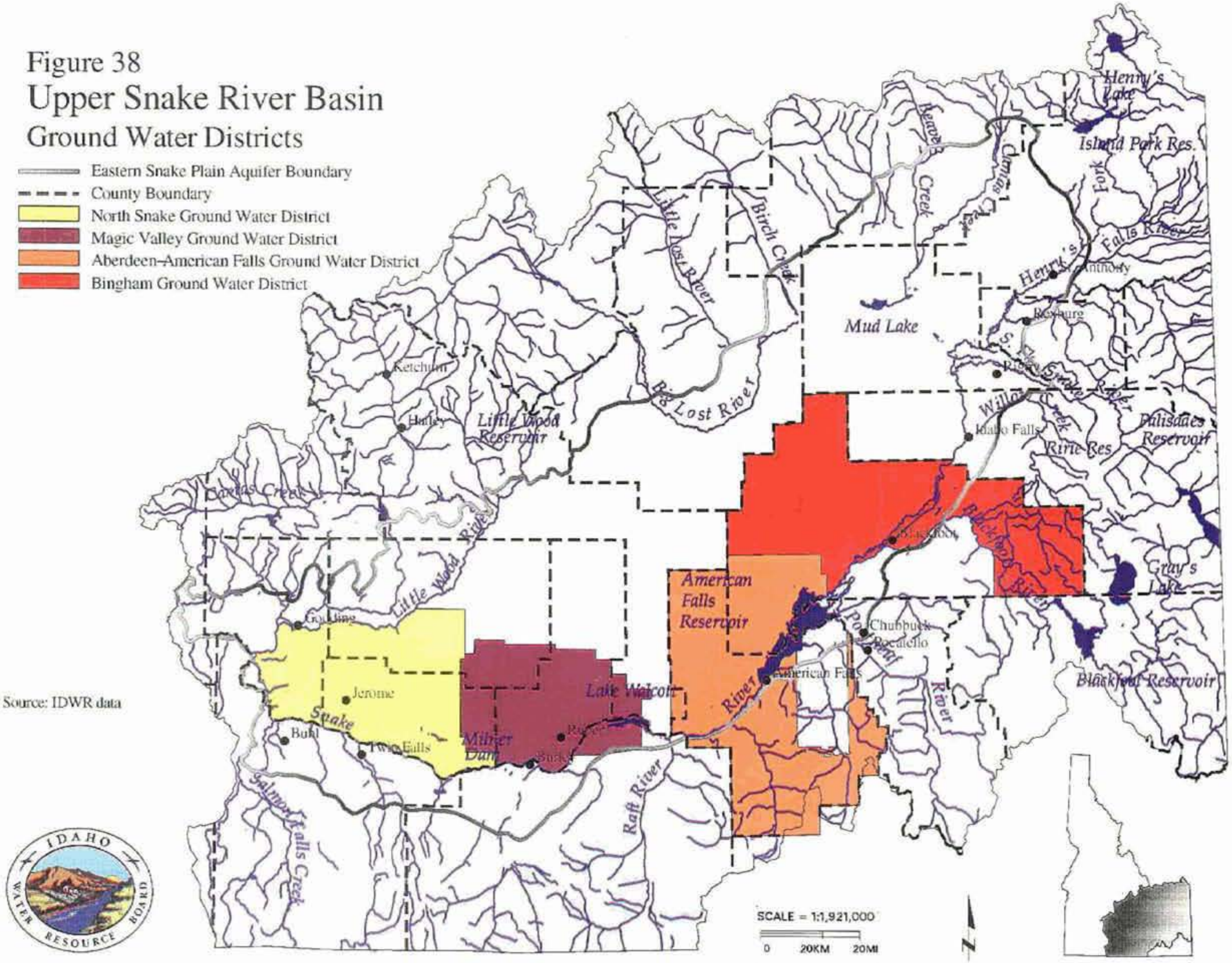
At the same time as it authorized creation of water measurement districts, the 1995 Legislature also approved the establishment of ground water districts (Idaho Code 42-5201 et seq.). Participation is optional with the ground water user. These districts can be smaller or larger than water measurement districts, and are established when the people who use the ground water resource desire to so organize. They are much the same as the older, traditional irrigation districts, but are for groundwater irrigation users. Non-irrigation users of groundwater, such as industrial, domestic, commercial, and municipal users may petition to join a groundwater district and participate in the district's measurement and other programs. An elected board of directors administers the ground water district. It has the authority to conduct ground water monitoring and implement programs to protect the district's ground water resources, and to comply with the requirement for annual reporting of diversions to the IDWR. They also can develop plans to mitigate material injury to senior water users caused by junior ground water use, finance the repair or abandonment of faulty wells, operate water storage and recharge projects, and represent district members in general water rights adjudications.

Four ground water districts were formed in 1996 (Figure 38): the North Snake Ground Water District in Gooding and Jerome Counties; the Magic Valley Ground Water District in southern Minidoka and Blaine Counties; the American Falls-Aberdeen Ground Water District in portions of Power and Bingham Counties; and the Bingham Ground Water District in northern Bingham County. Measurement programs for ground water use were just getting underway in 1997. Water withdrawals will be monitored with flow meters or estimated from power records. Like the water measurement districts, the monitoring reports of the ground water districts will be important tools for subsequent water planning.

### *Basin 36 Measurement Program*

In December 1994, the Director of the IDWR established a measurement program in Basin 36, comprising portions of Gooding, Jerome, Minidoka, and Blaine Counties. Under this directive, water users measured and reported all water diversions to the IDWR in 1995 and 1996. With the formation of the West Water Measurement District in 1996, the measurement and reporting functions for non-irrigation diversions and some surface water diversions were assumed by that new district. Most irrigation wells are measured by the North Snake and Magic Valley Ground Water Districts.

# Figure 38
## Upper Snake River Basin
### Ground Water Districts




Source: IDWR data

# GLOSSARY

**Acre-foot** - the volume of water required to cover 1 acre of land (43,560 ft-2) to a depth of 1 foot; this is equivalent to 325,851 gallons.

**Adjudicated water right** - a water right for which the defining parameters required by law have been determined and decreed by an appropriate court.

**Anadromous** - fish species, such as salmon, that are born in fresh water, spend most of their adult life in the ocean, and return to fresh water to spawn.

**Avoided costs** - Investments and expenses escaped by not building new facilities.

**Base-load electricity** - That part of the total load of an electrical power system which is supplied, as far as possible, by the most efficient connected generating stations, the remaining peak load being supplied intermittently by the more expensive station.

**Basin** - see Upper Snake River Basin.

**Benchmark** - a permanent or temporary reference point of known elevation used for vertical control.

**Benthic invertebrates** - organisms that typically live on the bottoms of streams and lakes.

**Best management practices (BMP)** - state-of-the-art resource management practices that are efficient and effective, practical, economical, and environmentally sound.

**Birth rate** - Number of live births per 1,000 population.

**Board** - the Idaho Water Resource Board (IWRB).

**Bull trout** - common name for *Salvelinus confluentus*, a char native to the Pacific northwest and western Canada.

**Coastal disjunct** - a population of plants or animals that is isolated from its major distribution range, which in this case are the Northwest coastal communities.

**Comprehensive State Water Plan (CSWP)** - the plan adopted by the Board pursuant to section 43-1734A, Idaho Code, or a component of such plan developed for a particular water resource, waterway or waterways and approved by the legislature.

**Consumptive use** - that portion of the annual volume of water diverted under a water right that is transpired by growing vegetation, evaporated from soils, converted to nonrecoverable water vapor, incorporated into products, or otherwise does not return to the waters of the state. Consumptive use does not include any water that falls as precipitation directly on the place of use unless the precipitation is captured, controlled, and used under an appurtenant water right (Idaho Code 42-202B).

**Confluence** - the flowing together of two or more bodies of water.

**Eastern Snake Plain** - area of land surface overlying the Eastern Snake Plain Aquifer as defined by the U.S. Geological Survey's Regional Aquifer-System Analysis (RASA) program.

**Eastern Snake Plain Aquifer** (ESPA) - the main ground water bearing structure beneath the land surface of the Eastern Snake Plain, consisting largely of porous zones situated between successive basalt layers. The Eastern Snake Plain Aquifer as shown in this report differs slightly from the Eastern Snake Plain area of coverage defined in Rule 50 of the "Rules for Conjunctive Management of Surface and Ground Water Resources" of the Idaho Department of Water Resources. Those Rules exclude the area south of the Snake River and west of the line separating Sections 34 and 35, Township 10 South, Range 20 East, Boise Meridian. The area defined in this report also differs from the computer model boundary used in the Upper Snake River Basin Study completed by the IDWR in 1997. It also departs from the "boundary of the active part of model" as defined by Garabedian (1992) in the report "Hydrology and Digital Simulation of the Regional Aquifer System, Eastern Snake River Plain, Idaho" (USGS Professional Paper 1408-F).

**Ecosystem** - a complex system composed of a community of flora and fauna taking into account the chemical and physical environment with which the system is interrelated.

**Endangered species** - any species or subspecies which is in danger of extinction throughout all or a significant portion of its range, other than a species of the Class Insecta determined by the Secretary (of the Interior) to constitute a pest whose protection under the provisions of (the Endangered Species) Act would present an overwhelming and overriding risk to man.

**Evapotranspiration** - the loss of moisture by evaporation from land and water surfaces and transpiration from plants.

**Fertility rate** - Number of live births per 1,000 women, 15-44 years of age.

**Firm power sales** - Sales in which the energy producer has a legally enforceable contract with a utility to provide a specified amount of energy and capacity.

**Head** - the elevational difference between the surfaces of water; usually upstream and downstream of a turbine or pump.

**Hydropower project** - any development which uses a flow of water as a source of electrical or mechanical power, or which regulates the flow of water for the purpose of generating electrical or mechanical power. A hydropower project development includes all powerhouses, dams, water conduits, transmission lines, water impoundments, roads, and other appurtenant works and structures (Idaho Code 42-1731(5)).

**Idaho batholith** - the body of intrusive igneous (volcanic) rock in central Idaho about 250 miles long and a maximum of 100 miles wide. It is approximately 100 million years old.

**Idaho Code** - the Idaho laws, in this case those pertaining to water issues.

**Interim protected river** - a waterway designated pursuant to section 42-1734D or 42-1734H, Idaho Code, as protected for up to two (2) years while a component of the Comprehensive State Water Plan is prepared for that waterway.

**Kilowatt (kW)** - a unit of electric power equal to 1,000 watts, or about 1.34 horsepower.

**Long-Run Average Value of Water in Hydropower Use** - This imputed value of water is the difference between the total (capital plus production) costs of the alternative electricity source and the total costs of hydropower.

**Low-head dam** - a dam with less than 20 meters (66 ft) of head.

**Marginal cost** - The incremental total cost associated with producing one additional unit of output.

**Marginal value product** - The value of additional output generated by an additional unit of variable input.

**Marginal value of water in Hydropower use** - Marginal value (mills per kilowatt-hour) is the difference between the average production costs for CCCT power plant (it used to be a coal-fired steam-electric plant) and the average hydroelectric production costs.

**Marginal value of water in municipal use** - The marginal cost (dollars per acre-foot) is the cost of developing the water supply plus the opportunity cost of the appropriated water. The opportunity cost is the value realized if the water development works are not built. Municipal use, the marginal value depends on how much of it one already has: at the extremes of scarcity and abundance, the marginal value can be infinite or negligible.

**Mean high watermark** - a water level corresponding to the natural or ordinary high watermark and is the line which the water impresses on the soil by covering it for sufficient periods of time to deprive the soil of its terrestrial vegetation and destroy its value for commonly accepted agricultural purposes (Idaho Code 42-3802 (h)).

**Megawatt (MW)** - a unit of electrical power equal to 1,000,000 watts, or about 1,340 horsepower.

**Mill** - A monetary cost and billing unit equal to 1/1000 of the U.S. dollar (equivalent to 1/10 of 1 cent.

**Minimum stream flow** - the minimum flow of water in cubic feet per second of time or minimum lake level in feet above mean sea level required to protect fish and wildlife habitat, aquatic life, recreation, aesthetic beauty, navigation, transportation, or water quality of a stream or lake in the public interest (Idaho Code 42-1502 (f)).

**Montane vegetation** - mountain vegetation dominated by trees, usually conifers (pines, firs), found above scrub but below the subalpine vegetation type.

**Municipal water use** - water for residential, commercial, industrial, irrigation of parks and open space, and related purposes, excluding use of water from geothermal sources for heating, which a municipal provider is entitled or obligated to supply to all those users within a service area, including those located outside the boundaries of a municipality served by a municipal provider (Idaho Code 42-202B (4)).

**Natural river** - a waterway which possesses outstanding fish and wildlife, recreation, geologic or aesthetic values, which is free of substantial existing man-made impoundments, dams or other structures, and of which the riparian areas are largely undeveloped, although accessible in places by trails and roads (Idaho Code 42-1731 (7)).

**Net migration** - The residual difference between change of population during a period of time, and the net natural change of births and deaths.

**Peak-load electricity** - The maximum load on a generating station or power distribution system.

**Penstock** - a conduit used to convey water under pressure to the turbines of a hydroelectric plant.

**Placer or dredge mining** - any dredge or other placer mining operation to recover minerals with the use of a dredge boat or sluice washing plant whether fed by bucket line as a part of such dredge or by a separate dragline or any other method including, but is not limited to, suction dredges which are capable of moving more than two (2) cubic yards per hour of earth material (Idaho Code 42-1731 (4)).

**Preliminary permit** - a FERC authorization granting priority right to file a license application and authorizing the permittee to conduct studies and analyses necessary to prepare a complete license application. A preliminary permit does not permit any construction.

**Public interest** - the affairs of the people in the area directly affected by the proposed use (Idaho Code 42-203A (5)(e)).

**Recreational dredge mining** - operation of vacuum or suction dredges and power sluice equipment in which the nozzle is 5 inches or less, and equipment rated at 15 HP or less, and capable of moving 2 cubic yards of material per hour or less.

**Recreational river** - a waterway which possesses outstanding fish and wildlife, recreation, geologic or aesthetic values, and which might include some man-made development within the waterway or within the riparian area of the waterway (Idaho Code 42-1731 (9)).

**Riparian area** - that area within 100 feet of the mean highwater mark of a waterway (Idaho Code 42-1731 (10)).

**Riparian vegetation** - vegetation that is associated with aquatic (streams, rivers, lakes) habitats.

**River basin** - total drainage or catchment area of a stream (i.e., the watershed).

**River corridor** - the area of varying width along both sides of a study river that may affect the management alternatives for that river.

**River reach** - a continuous section of a river from one point to another; i.e., a stretch of the river.

**Scrub vegetation** - vegetation dominated by shrubs, typically found at elevations below montane (mountain) vegetation.

**State agency** - any board, commission, department, executive agency of the state of Idaho.

**Streambed** - a natural water course of perceptible extent with definite bed and banks, which confines and conducts the water of a waterway which lies below and between the ordinary highwater mark on either side of that waterway (Idaho Code 42-1731 (12)).

**Subalpine vegetation** - mountain vegetation dominated by conifers and just below the alpine tundra vegetation type.

**Total costs of electric utilities** - Total costs = capital costs+production costs (fuel expenses and operation & maintenance)+Depreciation, taxes, and other long-run costs,

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

**Upper Snake River Basin** - the entire drainage area of the Snake River in Idaho above King Hill.

**Vegetation types** - any of several different plant communities that are found in the region of study.

**Vested Rights** - those rights that are fixed and not contingent upon any future actions. For example, a protected river designation cannot interfere with vested property rights made prior to the designation.

**Waterway** - a river, stream, creek, lake or spring, or a portion thereof, and not including any tributary thereof (Idaho Code 42-1731 (13)).

**Water Table** - the highest part of the soil or underlying rock material that is wholly saturated with water. An upper, or perched water table may be separated from a lower one by a dry zone.

**Wetlands** - lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands must have the following three attributes: (1) at least periodically, the land supports predominately hydrophytes; (2) the substrate is predominately undrained hydric soil; and (3) the substrate is on soil and is saturated with water or covered by shallow water at some time during the growing season of each year.

# ABBREVIATIONS AND ACRONYMS

**ACEC** means Area of Critical Environmental Concern.

**BLM** means U.S. Bureau of Land Management.

**BMP** means Best Management Practice.

**BURP** means Beneficial Use Reconnaissance Project.

**CAFO** means confined animal feeding operation (feedlots, dairies).

**CCCT** means the combined cycle combustion turbine which uses a heat recovery steam generator to increase energy producing efficiency of the fuel burned in a combustion turbine. The CCCT costs are based on the 1994 NWPPC interim cost and performance assumptions for combined cycle combustion turbine power plants.

**CSWP** means Comprehensive State Water Plan.

**CFS** means Cubic Foot per Second (ft-3/sec). CFS is a unit of discharge for measurement of a flowing liquid equal to a flow of 1 cubic foot per second, 449 gallons per minute, or 1.98 acre-foot per day.

**COE** means U.S. Army Corps of Engineers.

**DCMI** means Domestic, Commercial, Municipal and Industrial uses.

**DOT** means (Idaho) Department of Transportation.

**EPA** means (U.S) Environmental Protection Agency

**ESPA** means the Eastern Snake Plain Aquifer

**FERC** means Federal Energy Regulatory Commission.

**IDA** means Idaho Department of Agriculture.

**IDC** means Idaho Department of Commerce.

**IDE** means Idaho Department of Employment.

**IDEQ** means Idaho Division of Environmental Quality (within IDHW).

**IDFG** means Idaho Department of Fish and Game.

**IDHW** means Idaho Department of Health and Welfare.

**IDPR** means Idaho Department of Parks and Recreation.

**IDWR** means Idaho Department of Water Resources.

**INEEL** means the Idaho National Engineering and Environmental Laboratory.

**IRIS** means Idaho Rivers Inventory System.

**IWRB** means Idaho Water Resource Board

**LAG** means Local Advisory Group.

**NAWQA** means National Water-Quality Assessment Program

**NPDES** means National Pollutant Discharge Elimination System.

**NPS** means National Park Service.

**PNWRBC** means Pacific Northwest River Basins Commission

**RBP** means Rapid Bioassessment Protocol.

**RNA** means Research Natural Area.

**RVD** means Recreational Visitor Days. One RVD is equivalent to the person spending 12 hours at a particular activity.

**SCCT** means simple cycle combustion turbines which burn natural gas or fuel oil distillate creating hot exhaust gases which are allowed to expand through a power turbine to turn an electric power generator.

**SIBA** means Special Interest Botanical Area.

**USBR** means the U.S. Bureau of Reclamation.

**USDA** means U.S. Department of Agriculture.

**USFS** means U.S. Forest Service.

**USFWS** means U.S. Fish and Wildlife Service.

**USGS** means U.S. Geological Survey.

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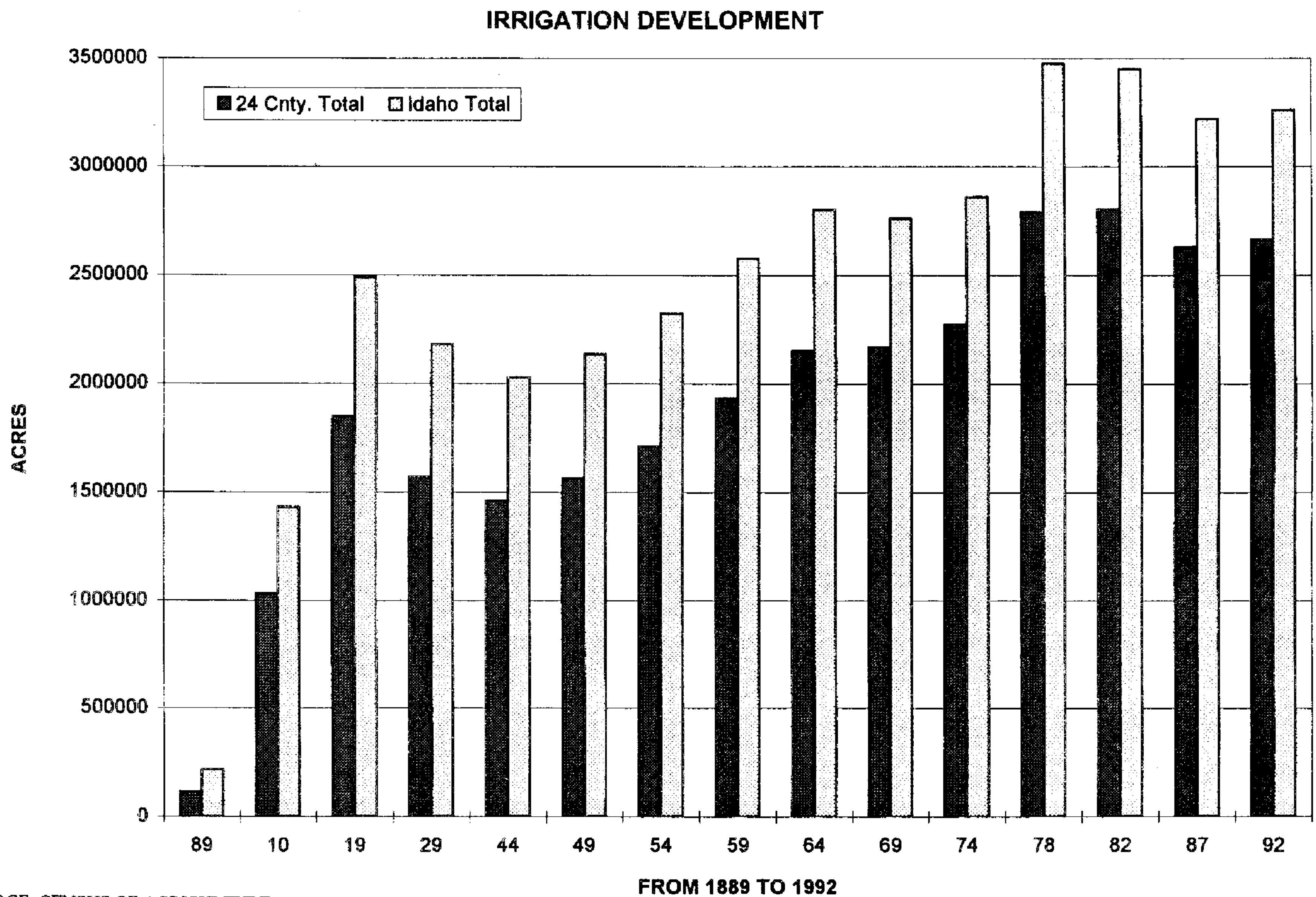
# APPENDIX A: Trends in Irrigation Development




SOURCE: CENSUS OF AGRICULTURE

## Census of Agriculture - Historical Information

| | YEAR | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1889 | 1910 | 1919 | 1929 | 1944 | 1949 | 1954 | 1959 |
| Bannock | | 58,731 | 137,266 | 97,726 | 71,038 | 36,905 | 39,450 | 42,193 |
| Bingham | 40,912 | 193,741 | 177,296 | 163,914 | 154,167 | 157,981 | 183,024 | 225,892 |
| Blaine | | 68,112 | 52,090 | 33,731 | 30,652 | 36,785 | 39,220 | 45,746 |
| Bonneville | | | 110,953 | 98,569 | 98,218 | 108,509 | 116,181 | 119,393 |
| Butte | | | 39,563 | 27,416 | 31,345 | 30,591 | 33,736 | 34,085 |
| Camas | | | 13,272 | 7,108 | 4,063 | 6,057 | 10,087 | 8,406 |
| Caribou | | | 23,825 | 14,692 | 7,866 | 41,360 | 51,451 | 51,882 |
| Cassia | 19,800 | 59,510 | 113,537 | 79,374 | 92,434 | 100,391 | 106,642 | 146,416 |
| Clark | | | 18,851 | 16,292 | 10,903 | 9,453 | 13,207 | 10,374 |
| Custer | 8,570 | 41,889 | 80,141 | 39,346 | 38,201 | 49,669 | 53,102 | 52,802 |
| Elmore | 3,437 | 17,781 | 28,844 | 22,183 | 25,637 | 28,263 | 32,675 | 29,541 |
| Fremont | | 303,163 | 130,044 | 98,273 | 58,709 | 61,268 | 62,478 | 67,656 |
| Gooding | | | 45,408 | 64,115 | 87,053 | 84,676 | 86,878 | 89,407 |
| Jefferson | | | 149,151 | 120,151 | 99,960 | 101,852 | 115,778 | 136,555 |
| Jerome | | | 85,000 | 110,098 | 90,865 | 96,582 | 104,653 | 124,427 |
| Lemhi | 9,984 | 37,916 | 66,905 | 61,278 | 68,180 | 79,211 | 85,195 | 82,386 |
| Lincoln | | 82,684 | 69,620 | 33,140 | 48,224 | 44,748 | 46,783 | 51,484 |
| Madison | | | 54,637 | 55,723 | 43,805 | 58,688 | 61,238 | 66,043 |
| Minidoka | | | 55,259 | 60,000 | 53,880 | 58,088 | 91,832 | 140,247 |
| Onedia | 21,423 | 43,855 | 20,314 | 13,450 | 18,710 | 19,212 | 19,915 | 21,906 |
| Owyhee | 9,076 | 21,771 | 62,933 | 57,608 | 59,594 | 71,665 | 75,054 | 79,754 |
| Power | | | 11,264 | 10,708 | 8,970 | 10,868 | 21,073 | 26,915 |
| Teton | | | 41,385 | 39,014 | 34,556 | 33,152 | 36,007 | 35,972 |
| Twin Falls | | 100,545 | 261,622 | 244,832 | 221,492 | 238,452 | 226,921 | 243,393 |
| **24 Cnty. Total** | **113,202** | **1,029,698** | **1,849,180** | **1,568,741** | **1,458,522** | **1,564,426** | **1,712,580** | **1,932,875** |
| **Idaho Total** | **217,005** | **1,430,848** | **2,488,806** | **2,181,250** | **2,026,280** | **2,137,237** | **2,324,571** | **2,576,580** |

Source: U.S. Bureau of Census, 1889-1992

## Census of Agriculture - Historical Information

| | YEAR | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1964 | 1969 | 1974 | 1978 | 1982 | 1987 | 1992 |
| Bannock | 43,896 | 48,831 | 50,645 | 45,262 | 41,170 | 40,829 | 39,574 |
| Bingham | 248,223 | 249,413 | 269,820 | 303,541 | 292,939 | 306,187 | 307,812 |
| Blaine | 43,258 | 43,800 | 39,039 | 60,213 | 63,005 | 54,441 | 64,283 |
| Bonneville | 133,982 | 137,789 | 135,321 | 152,052 | 148,911 | 147,285 | 153,314 |
| Butte | 39,673 | 48,201 | 51,675 | 71,726 | 77,229 | 65,796 | 56,134 |
| Camas | 8,428 | 9,416 | 13,241 | 18,161 | 20,334 | 13,535 | 7,486 |
| Caribou | 64,322 | 64,456 | 64,616 | 81,357 | 70,269 | 65,980 | 70,201 |
| Cassia | 189,664 | 178,064 | 203,478 | 246,812 | 266,526 | 237,169 | 252,012 |
| Clark | 10,835 | 16,811 | 17,060 | 36,993 | 50,004 | 71,416 | 48,428 |
| Custer | 58,436 | 43,599 | 44,187 | 60,814 | 61,825 | 55,536 | 58,436 |
| Elmore | 37,256 | 52,125 | 69,171 | 97,142 | 93,113 | 74,753 | 75,108 |
| Fremont | 76,508 | 76,810 | 75,631 | 105,537 | 109,576 | 106,397 | 130,845 |
| Gooding | 91,992 | 80,440 | 84,994 | 111,636 | 108,173 | 107,793 | 115,398 |
| Jefferson | 155,602 | 152,803 | 139,613 | 195,494 | 199,331 | 170,453 | 183,956 |
| Jerome | 133,654 | 123,445 | 131,518 | 147,893 | 151,088 | 135,272 | 150,444 |
| Lemhi | 92,491 | 82,659 | 68,374 | 80,453 | 78,765 | 77,646 | 70,300 |
| Lincoln | 53,775 | 46,939 | 51,410 | 71,299 | 80,646 | 64,764 | 59,694 |
| Madison | 70,355 | 82,723 | 90,260 | 109,874 | 111,812 | 116,924 | 127,851 |
| Minidoka | 150,420 | 153,679 | 161,627 | 170,841 | 157,221 | 145,670 | 177,516 |
| Onedia | 23,398 | 25,613 | 25,281 | 40,288 | 34,550 | 31,145 | 28,906 |
| Owyhee | 88,301 | 101,121 | 107,389 | 135,213 | 151,526 | 117,088 | 100,449 |
| Power | 42,840 | 64,005 | 80,808 | 90,815 | 88,861 | 93,889 | 102,892 |
| Teton | 37,139 | 38,165 | 37,225 | 66,791 | 68,363 | 55,392 | 51,358 |
| Twin Falls | 257,930 | 249,052 | 260,155 | 289,218 | 278,144 | 272,367 | 231,351 |
| **24 Cnty. Total** | **2,152,378** | **2,169,959** | **2,272,538** | **2,789,425** | **2,803,381** | **2,627,727** | **2,663,748** |
| **Idaho Total** | **2,801,500** | **2,760,852** | **2,859,047** | **3,475,392** | **3,450,443** | **3,219,192** | **3,260,006** |

Source: U.S. Bureau of Census, 1889-1992

# APPENDIX B: Schematic Diagrams of Modeled River Systems in the Upper Snake River Basin

FIGURE I

**SNAKE RIVER BASIN ABOVE MURPHY**
**SCHEMATIC DIAGRAM OF MODELED SYSTEM**
(Robertson et.al, 1989)

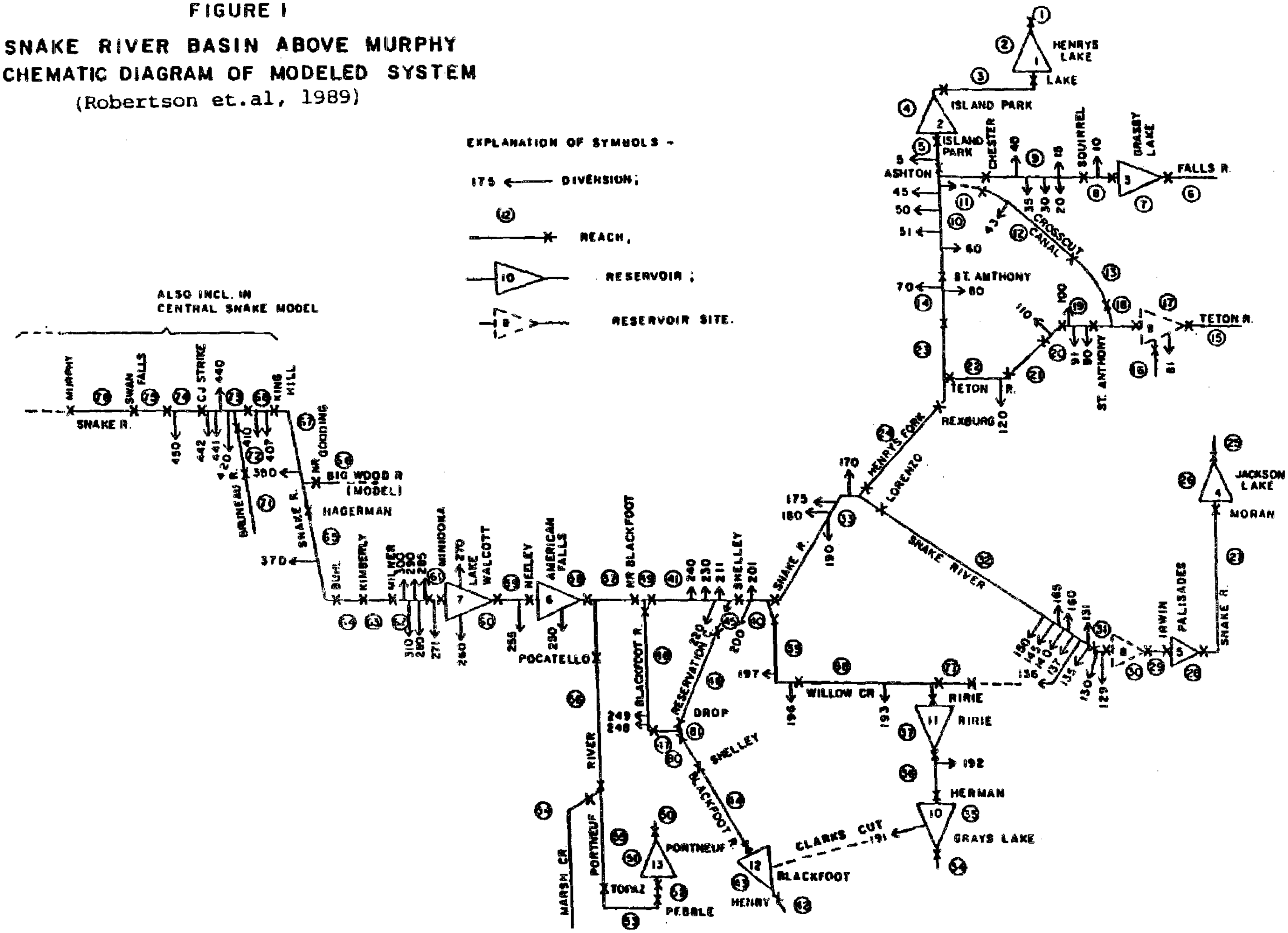
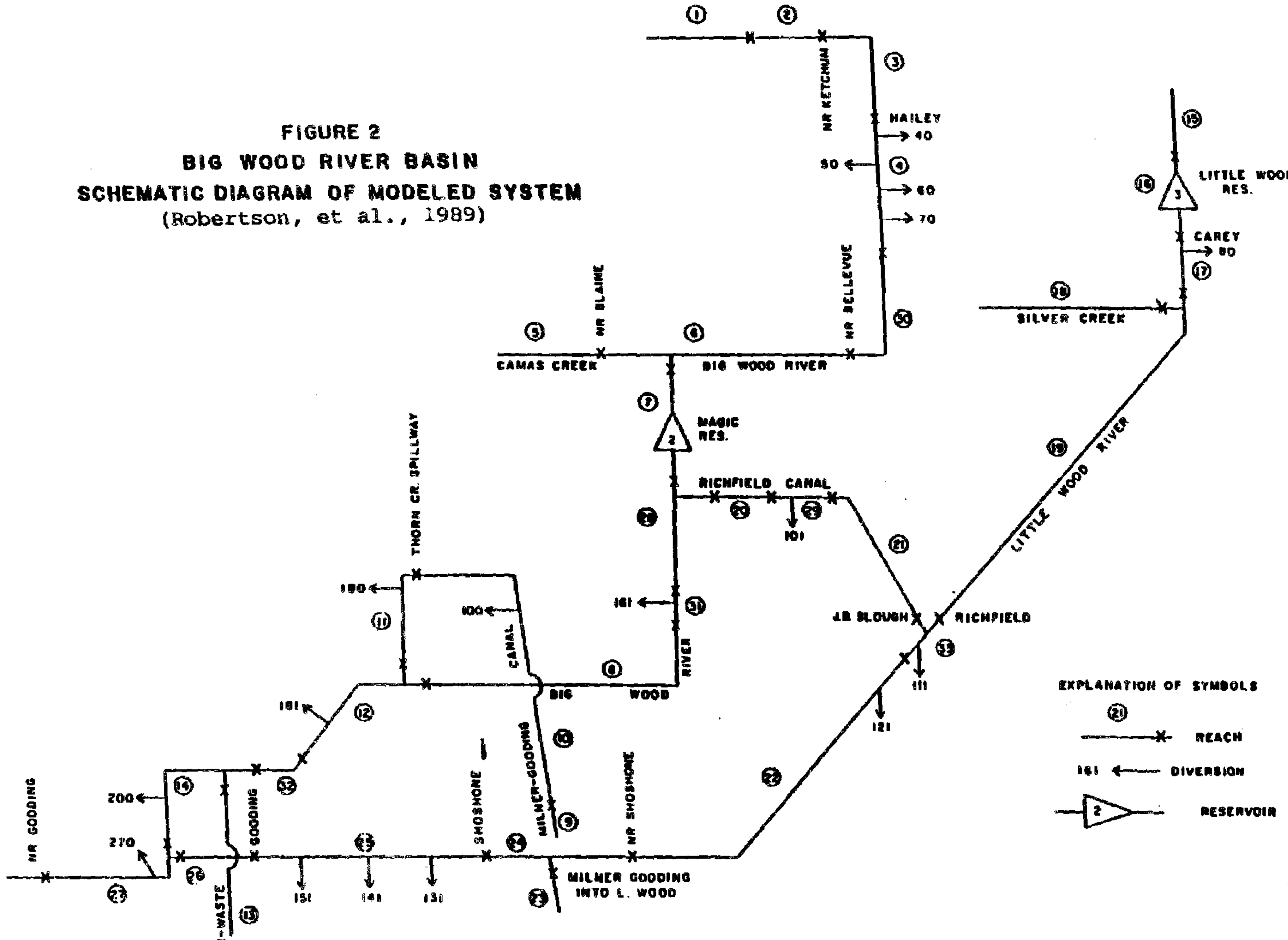


**FIGURE 2**
**BIG WOOD RIVER BASIN**
**SCHEMATIC DIAGRAM OF MODELED SYSTEM**
(Robertson, et al., 1989)



Cost records for this publication are available from the Idaho Department of Water Resources
in accordance with Section 60-602, Idaho Code.
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